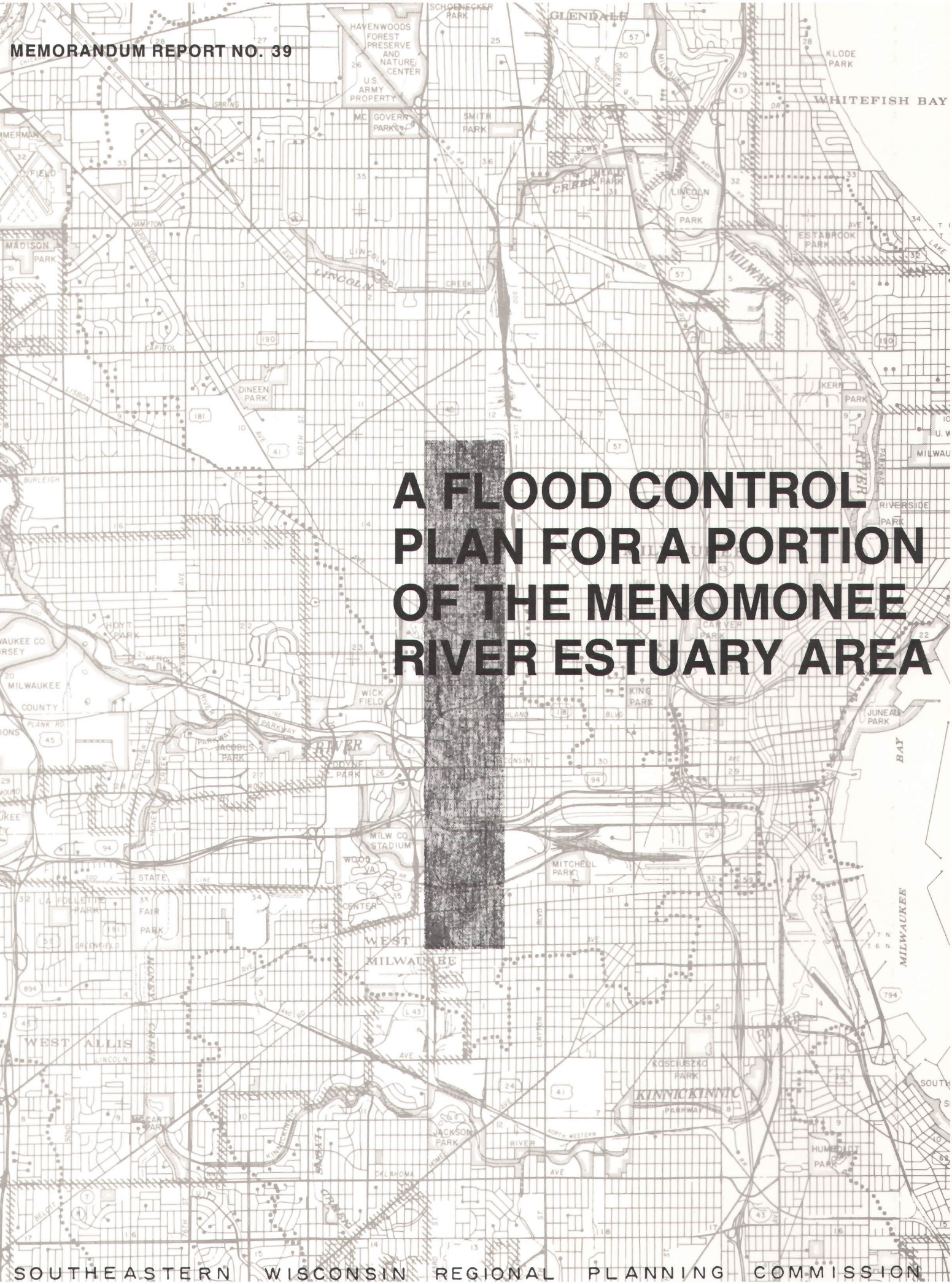
MEMORANDUM REPORT NO. 39



A FLOOD CONTROL PLAN FOR A PORTION OF THE MENOMONEE RIVER ESTUARY AREA

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

KENOSHA COUNTY

Leon T. Dreger
Francis J. Pitts
Sheila M. Siegler

RACINE COUNTY

David B. Falstad
Jean M. Jacobson,
Secretary
Earl G. Skagen

MILWAUKEE COUNTY

Irene M. Brown
Harout O. Sanasarian
Jean B. Tyler

WALWORTH COUNTY

John D. Ames
Anthony F. Balestrieri
Allen L. Morrison,
Vice-Chairman

OZAUKEE COUNTY

Allen F. Bruederle
Alfred G. Raetz
Elroy J. Schreiner

WASHINGTON COUNTY

Daniel S. Schmidt
Patricia A. Strachota
Frank F. Uttech,
Chairman

WAUKESHA COUNTY

Richard A. Congdon
Robert F. Hamilton
William D. Rogan,
Treasurer

CITY OF MILWAUKEE OFFICIALS

MAYOR

John O. Norquist

COMMON COUNCIL

Robert A. Anderson
Steven Cullen
Thomas P. Donegan
Wayne P. Frank
Paul A. Henningsen
Marlene Johnson
John R. Kalwitz
Chris A. Krajniak
Michael R. McGee
Mary Anne McNulty
Michael Murphy
Thomas G. Nardelli
Marvin Pratt
Donald F. Richards
Annette E. Scherbert

COMMISSIONER OF PUBLIC WORKS

John R. Bolden

CITY ENGINEER

John A. Erickson

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION STAFF

Kurt W. Bauer, PE, AICP, RLS . . . . . .Executive Director
Philip C. Evenson, AICP . . . . . .Assistant Director
Kenneth R. Yunker, PE . . . . . .Assistant Director
Robert P. Biebel, PE . . . . . .Chief Environmental Engineer
John W. Ernst . . . . . .Information Systems Manager
Gordon M. Kacala . . . . . .Chief Economic Development Planner
Leland H. Kreblin, RLS . . . . . .Chief Planning Illustrator
Donald R. Martinson . . . . . .Chief Transportation Engineer
Bruce P. Rubin . . . . . .Chief Land Use Planner
Roland O. Tonn, AICP . . . . . .Chief Community Assistance Planner
Joan A. Zenk . . . . . .Administrative Officer

Special acknowledgement is due Mr. Michael G. Hahn, SEWRPC Principal Water Resource Engineer, for his efforts in the conduct of this study and in the preparation of this report.

MEMORANDUM REPORT
NUMBER 39

A FLOOD CONTROL PLAN FOR A PORTION OF THE MENOMONEE RIVER ESTUARY AREA

CITY OF MILWAUKEE MILWAUKEE COUNTY, WISCONSIN

Prepared by the

Southeastern Wisconsin Regional Planning Commission
P. O. Box 1607
Old Courthouse
916 N. East Avenue
Waukesha, Wisconsin 53187-1607

June 1989

Inside Region $2.50
Outside Region $5.00

(This page intentionally left blank)

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

916 N. EAST AVENUE • P.O. BOX 1607 • WAUKESHA, WISCONSIN 53187-1607 • TELEPHONE (414) 547-6721
TELECOPIER (414) 547-1103

Serving the Counties of: KENOSHA
MILWAUKEE
OZAUKEE
RACINE
WALWORTH
WASHINGTON
WAUKESHA

June 21, 1989

Mr. John R. Bolden
Commissioner of Public Works
City of Milwaukee
Room 612, Municipal Building
841 N. Broadway
Milwaukee, Wisconsin 53202

Dear Mr. Bolden:

In 1987, the City of Milwaukee asked the Southeastern Wisconsin Regional Planning Commission to assist the City in the conduct of a study of the overland flooding problems existing in an area bounded on the north by the Menomonee River, on the south and east by the South Menomonee Canal, and on the west by N. 11th Street (extended). The western boundary of the study area was subsequently extended to S. 27th Street. The need for this study was emphasized by the record high Lake Michigan levels that occurred in 1986. The Regional Planning Commission, working in cooperation with the City's engineering staff, has now completed the requested study, and is pleased to provide to you herewith a recommended flood control plan for the area concerned.

The plan presented herein is consistent with regional as well as local land use development and flood control objectives, and is intended to serve as a guide to public officials in the making of sound decisions over time concerning the provision of flood control and stormwater drainage facilities within the area concerned.

The Regional Planning Commission is particularly appreciative of the contributions of the staff of the City Bureau of Engineers and Department of Public Works during the preparation of the plan. The Commission staff stands ready to assist the City in securing the adoption of the plan and in promoting its implementation over time.

Sincerely,

Kurt W. Bauer
Executive Director

(This page intentionally left blank)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF MAPS

Chapter I

INTRODUCTION

By letter dated April 10, 1987, the City of Milwaukee requested that the staff of the Southeastern Wisconsin Regional Planning Commission assist the City in the conduct of a study of measures for protection against overland flooding of an area bounded on the north by the Menomonee River, on the south and east by the South Menomonee Canal, and on the west by N. 11th Street (extended). The study was to include: 1) identification of flood-prone areas and related flood damage problems under existing and future land use and channel conditions; 2) development of alternative means of abating identified flooding and flood damages; 3) determination of necessary modifications to the existing stormwater drainage system to provide adequate drainage of interior areas with alternative flood protection works in place; 4) estimation of capital and operation and maintenance costs for each alternative; and 5) selection of a recommended plan.

Comments on a preliminary draft of this report were provided by the City in a letter dated January 31, 1989. These comments were reviewed by Commission staff in a March 1, 1989, meeting with City Engineers' staff. The city comments have all been addressed in this final version of this report.

STUDY AREA

The study area consists of land in the City of Milwaukee bounded on the north by the Menomonee River, on the south and east by the South Menomonee Canal, and on the west by S. 27th Street. The study area boundaries are shown on Map 1. Flood protection alternatives were developed for the area east of S. 16th Street. The original request from the City of Milwaukee defined the western flood protection boundary as N. 11th Street (extended); however, because of the need to extend structural flood control measures to the west of N. 11th Street (extended) in order to obtain a workable engineering solution to the flooding problem, alternative plans were developed to provide flood protection for the area east of S. 16th Street. As shown on Map 1, the study area considered for the development of alternatives to provide protection east of S. 16th Street includes some area west of S. 16th Street. That area is included because certain proposed flood control measures would have an impact on the drainage of stormwater runoff from those western areas, and stormwater drainage measures to alleviate those impacts were included in the alternative plans. The total drainage area affecting the area east of S. 16th Street is 166 acres. In addition, approximate costs were developed for a plan for providing flood protection to the area between S. 27th Street and S. 16th Street. The total drainage area affecting the area east of S. 27th Street and west of S. 16th Street is 163 acres.

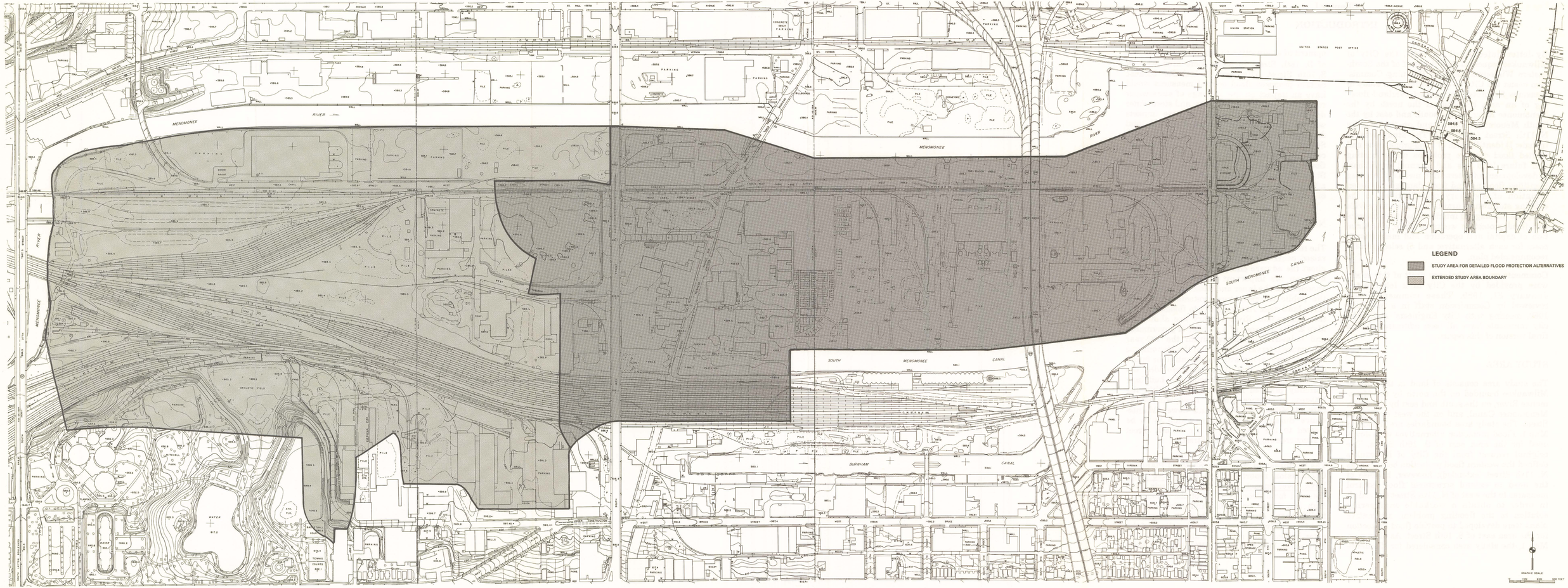
NEED FOR STUDY

The record high lake levels that occurred in 1986 raised concerns by public officials and others about the adverse effects such lake levels could have on the important land uses lining the shorelines of the inner and outer harbors, and on the public infrastructure systems supporting those land uses. Areas subject to flooding along the Menomonee River estuary are shown on Map 2. The presence of a number of government and industrial buildings within the 100-year recurrence interval floodplain of the Menomonee River estuary, along with the potential for future development in that floodplain, provided the impetus for this study. Among the buildings currently planned for construction within the 100-year recurrence interval floodplain is the City of Milwaukee Street and Sewer Maintenance Bureau headquarters, which is to be located to the northeast of the S. 6th Street viaduct crossing at W. Canal Street.

The Southeastern Wisconsin Regional Planning Commission report entitled Milwaukee High Lake Level Impact Study Prospectus sets forth the need for a detailed study of the impacts of high lake levels on public and private lands, facilities, and structures in the central business district of Milwaukee, along the shorelines of the outer harbor, and along the shorelines of the Milwaukee, Menomonee, and Kinnickinnic River

Map 1

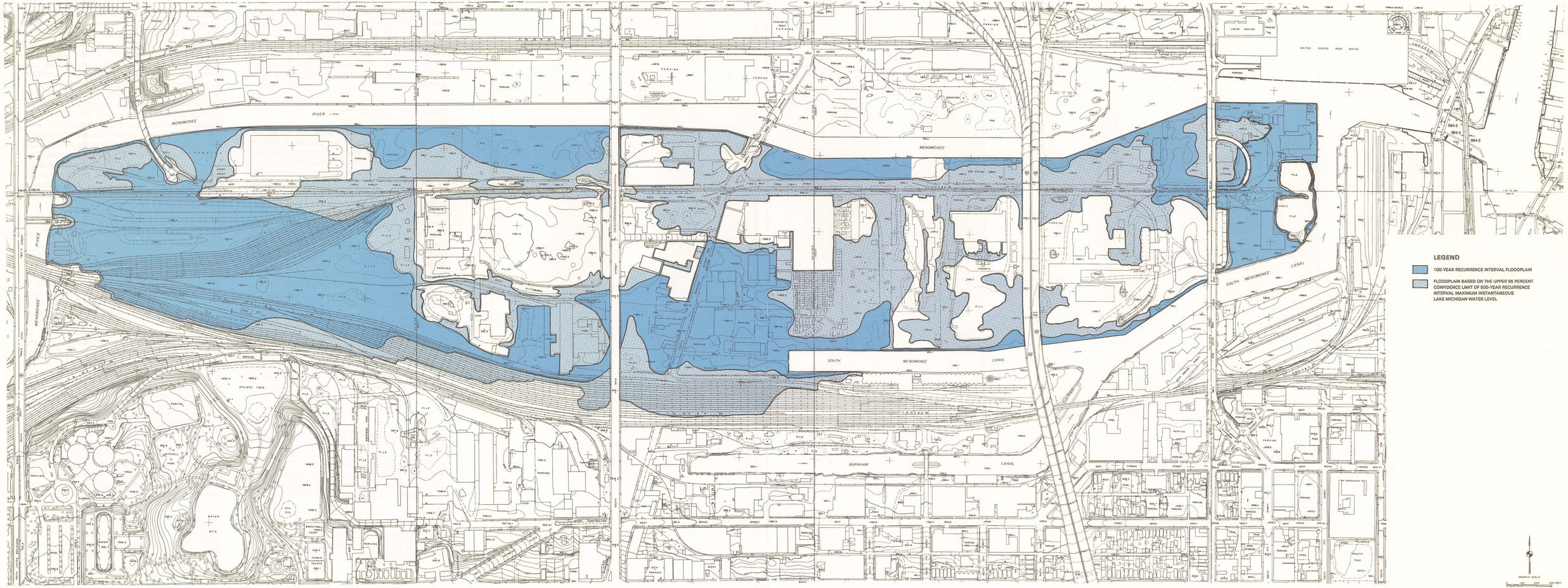
MENOMONEE RIVER ESTUARY STORMWATER DRAINAGE AND FLOOD CONTROL SYSTEM PLAN STUDY AREA



Source: SEWRPC.

Map 2

AREAS SUBJECT TO FLOODING WITHIN THE MENOMONEE RIVER ESTUARY STUDY AREA



Source: SEWRPC.

estuaries.[1] The undertaking of such a study is recommended in the Milwaukee Harbor estuary study.[2] The recommended high lake level impact study has not yet been funded or authorized; however, the study presented herein addresses the effects of overland flooding and storm sewer backups due to potential high lake levels for a portion of the study area recommended in the prospectus.

PRIMARY DATA SOURCES

Stormwater runoff rates from the study area were estimated using the Rational Method. Runoff coefficients were determined from data given in a paper included in SEWRPC Technical Record, Volume 2, No. 4, entitled "Determination of Runoff for Urban Storm Water Drainage System Design." Rainfall intensity-duration-frequency data were extracted from Regional Planning Commission files. For alternatives incorporating detention storage of runoff, volumes were determined using a procedure of the Metropolitan Sanitary District of Greater Chicago which is based on the Rational Method.[3] Probable future land use conditions were estimated from discussions with personnel in the Milwaukee Department of City Development, the Milwaukee Bureau of Bridges and Public Buildings, the Milwaukee Bureau of Engineers, and representatives of businesses located within the study area. Data on existing land uses, ground cover, building elevations, and pertinent physical features of the area were collated using Commission 1 inch equals 400 feet scale, ratioed and rectified aerial photographs prepared in 1985, and Commission 1 inch equals 200 feet, two-foot contour interval topographic maps prepared in 1982. Additional data on building elevations and physical features were obtained from a 1 inch equals 25 feet, 0.1-foot contour interval topographic map prepared by the Wisconsin Electric Power Company of the area immediately adjacent to the Company's valley power plant, from field inspections and interviews of city personnel and representatives of businesses, from architectural drawings of buildings owned by the City of Milwaukee, and from a preliminary draft report on high-water damage assessment prepared for the City of Milwaukee.[4] Drainage basin boundaries were delineated on 1 inch equals 400 feet topographic maps prepared by photographically reducing the 1 inch equals 200 feet Commission maps. Features of the existing stormwater drainage facilities and detailed street and railway grade elevations in the vicinity of the intersection of W. Canal Street and S. 6th Street were obtained from city files.

GENERAL WATERSHED DRAINAGE CHARACTERISTICS

Stormwater drainage of the study area is predominantly accomplished through storm sewers, although portions of the area drain directly to the Menomonee River or the South Menomonee Canal through overland flow, or through overland flow which concentrates in short drainage channels. There are 15 storm sewer outfalls in the study area, ranging in diameter from 12 inches to 42 inches. There is also one 48-inch-diameter combined sewer overflow. A diversion structure for the Crosstown 7 near surface collector of the Milwaukee Metropolitan Sewerage District's deep tunnel project is located northwest of the intersection of W. Canal Street and S. 16th Street. That diversion structure is designed to accept surcharge from the 48-inch main interceptor sewer, reducing the frequency of operation of the 48-inch overflow. With the exception of the 30-inch storm sewer outfall located in N. Emmber Lane, the storm and combined sewer outfalls are normally submerged. Land slopes in the study area are relatively flat, with the overall study area slope from west to east being only four feet per mile.

---

[1] *SEWRPC, Milwaukee High Lake Level Impact Prospectus, December 1987.*

[2] *SEWRPC Planning Report No. 37, A Water Resources Management Plan for the Milwaukee Harbor Estuary, Volume Two, Alternative and and Recommended Plans, December 1987.*

[3] *Dr. G. V. V. Rao, "Methods for Sizing Stormwater Detention Basins—A Designer's Evaluation," Proceedings of National Symposium on Urban Hydrology and Sediment Control, University of Kentucky, 1975.*

[4] *Arnold and O'Sheridan, Inc., Heike Design Associates, Inc., and Warzyn Engineering, Inc., "High Water Damage Assessment for City of Milwaukee" (Preliminary Draft), June 1988.*

EXISTING AND FUTURE DEVELOPMENT CONDITIONS

Existing development in the study area is primarily in industrial, government, and utility land uses. In the area east of S. 16th Street, open areas are primarily located immediately adjacent to the Menomonee River and the South Menomonee Canal. In the area west of S. 16th Street there is more interior open land, with considerable area in railway yards. Based on discussions with personnel of the City and of existing businesses within the study area, it was assumed that the area east of S. 16th Street would be completely developed in similar industrial, government, utility, and transportation uses under future plan design conditions. Based on City of Milwaukee Common Council Resolution No. 881420, which was adopted in November 1988, and on a proposal advanced by the Office of the Mayor in November 1988, it was assumed that new development in the area west of S. 16th Street would include light manufacturing, office, retail, hotel, and recreational development.

(This page intentionally left blank)

Chapter II

ALTERNATIVE DRAINAGE AND FLOOD CONTROL SYSTEM PLANS

INTRODUCTION

Alternative drainage and flood control system plans were developed for the following two estuary levels:

1. The 100-year recurrence interval maximum instantaneous Lake Michigan water level of 584.3 feet National Geodetic Vertical Datum (NGVD) as determined by the U. S. Army Corps of Engineers.[1] This 100-year recurrence interval lake level is essentially the same as the 100-year lake level of 584.5 feet NGVD set forth in the Regional Planning Commission's Milwaukee Harbor estuary study in published 1987. The Corps of Engineers 100-year lake level will be adopted for future Commission studies until such time that additional data merit a revision of the level. For the study area east of S. 16th Street, a total of 30 acres of land are located within the 100-year recurrence interval floodplain. An additional 60 acres of land are located within that floodplain in the study area between S. 27th Street and S. 16th Street.

2. The upper 95 percent confidence limit of the 500-year recurrence interval maximum instantaneous Lake Michigan water level, which will subsequently be referred to as the 500-year recurrence interval level. That elevation of 585.9 feet NGVD represents the instantaneous maximum level assuming a two-foot increase in overall water levels under the scenario that envisions that Lake Michigan is in a long-term rising trend. A lake level of 585.9 feet NGVD is considered to be an upper limit for potential high lake levels. For the study area east of S. 16th Street, a total of 94 acres of land is located within the floodplain for the upper 95 percent confidence limit of the 500-year recurrence interval lake level. About 84 acres of land is located within the 500-year floodplain in the additional study area between S. 27th Street and S. 16th Street.

Water surface profile computations performed by the Commission staff for the Milwaukee Harbor estuary study show that the 100- and 500-year recurrence interval levels in the Menomonee River are the same as the corresponding Lake Michigan levels from the mouth of the river upstream through the N. 25th Street bridge. Between N. 25th Street and N. 27th Street, the water surface elevations begin to increase above the lake levels.

Additional lake levels utilized in this study are the two-year recurrence interval maximum instantaneous lake level of 581.1 feet NGVD, and the 100-year recurrence interval daily mean maximum lake level of 583.9 feet NGVD. The combination of the two-year instantaneous level with a 100-year storm occurring over the study area was used to size gravity storm sewer outlets to convey runoff with dikes and floodwalls in place. The 100-year daily mean maximum lake level was used in the floodproofing alternative to determine drainage and grading measures necessary to prevent long-term flooding of streets and parking areas.

For both the 100- and 500-year recurrence interval lake levels, six alternative drainage and flood control plans were developed for the study area east of S. 16th Street. To the maximum extent possible, the alternatives for the 100-year recurrence interval estuary level were designed so that the additional measures required to provide protection to the 500-year level could be added with a minimum of alteration to the system designed for 100-year estuary level conditions. Alternatives 1A through 1E incorporate structural measures for drainage and flood control under 100-year recurrence interval estuary levels. Alternatives 2A through 2E incorporate the additional structural measures necessary to provide protection to the 500-year level. For example, the measures of Alternative 2A could be added to the measures of Alternative 1A to provide flood protection up to a 500-year level. As stated previously, the upper

---

[1] *U. S. Army Corps of Engineers, Revised Report on Great Lakes Open-Coast Flood Levels, Phase I, Detroit, Michigan, 1988.*

95 percent confidence limit of the 500-year recurrence interval Lake Michigan level is also the instantaneous maximum level assuming a two-foot increase in overall water levels under a scenario that envisions that Lake Michigan is in a long-term rising trend. Therefore, the 500-year-level recommended plan can be considered a contingency plan to be implemented if the lake enters a period of long-term rise.

DRAINAGE AND FLOOD CONTROL CRITERIA

The following criteria and assumptions were adopted for the design of the drainage and flood control measures considered for this study:

1. Structural interior drainage measures should be designed to provide protected areas with relief from flooding during critical combinations of interior rainfall-exterior estuary level events. The critical combinations used for this study were a two-year recurrence interval interior storm occurring over the study area while the lake level is at elevations that would impede the capacity of the storm sewer outlets, all of which are impeded at the 100-year recurrence interval lake level; and a two-year recurrence interval estuary level with a 100-year recurrence interval interior storm. If the estuary level and interior storm were completely independent events, their joint probability of occurrence would be the product of their individual probabilities. For a 100-year storm and a two-year estuary level, the joint probability of occurrence would be 0.5 percent, corresponding to a 200-year recurrence interval, if the two events were completely independent. In reality, the two events may be somewhat dependent; therefore, their joint probability of occurrence is greater than 0.5 percent.

   A two-year interior storm was used to size pumping and storage facilities for conditions under which the backwater gates on the storm sewer outfalls would be closed owing to high estuary levels, and overland flow paths to the estuary would be blocked by dikes and floodwalls. In such a situation, stormwater runoff from the interior could not be passed by the outfalls, or through overland flow, without developing a differential head which would create flooding of interior protected areas. Because of differing manhole and stormwater inlet elevations, outflow from all storm sewer outfalls would not be impeded at the same lake elevation. Those outfalls with the lowest inlets would become impeded at about a seven-year recurrence interval maximum instantaneous lake level, but most of the outlets would not become impeded until lake levels occurred with recurrence intervals ranging from 50 years to more than 100 years. Therefore, in all cases, the level of protection achieved by pairing a two-year interior storm with the appropriate frequency lake level would provide a level of protection against a combination of events with a joint recurrence interval in excess of two years but less than 200 years because the events are not entirely independent. On this basis, the general application of a two-year recurrence interval storm was judged to be appropriate for the level of detail of this system plan. During the final design of individual pumping facilities, consideration would be given to selection of a site-specific design storm which would enable the attainment of a level of protection consistent with design objectives.

   The two-year estuary level with a 100-year interior storm and with flood protection works in place was used to size new or replacement storm sewers to provide gravity flow outlets for interior storm runoff. Such outlets would be required where the dikes, floodwalls, or fill block the overland flow path or open channel outlet to the estuary which was available prior to construction of flood barriers.

2. Dikes and floodwalls were designed to have a top elevation equal to the 100-year recurrence interval estuary level plus two feet. That top elevation provides adequate freeboard for the 100-year water level, and also contains the 95 percent confidence limit of the 500-year recurrence interval maximum instantaneous water level with an adequate freeboard of 0.4 foot.

3. Earth dikes were designed to have slopes of one vertical on three horizontal and six-foot top widths.

4. Floodwalls were assumed to be constructed of concrete.

5. Stormwater pumping facilities were not called for in an alternative plan in those instances where provision of a gravity drainage outlet was practicable.

6. Combined stormwater storage and pumping facilities were sized to permit the stored stormwater to be pumped from the storage facility within one hour of the cessation of inflow.

7. The construction of dikes and floodwalls or the placement of fill on the river and canal banks would not affect the 100- or 500-year recurrence interval estuary levels because the hydraulic floodway is contained within the existing channel limits, and because, with estuary water levels essentially determined by the Lake Michigan level, the loss of overbank storage with dikes, floodwalls, or fill in place would have an insignificant effect on estuary levels.

8. All new and replacement storm sewers were assumed to be reinforced concrete pipe.

9. Most of the existing storm sewer outfalls have stop plank chambers which can be used to manually block the connection between the storm sewer and the estuary. These chambers could be used to block the storm sewers in the event of high lake levels; however, because backwater gates act automatically and permit some storm sewer outflow under surcharged conditions, the installation of backwater gates is recommended in this plan.

ALTERNATIVE STORMWATER DRAINAGE AND FLOOD CONTROL PLANS

Six alternative plans were developed for protection of the study area up to a 100-year recurrence interval maximum instantaneous Lake Michigan level. Six companion plans were developed to extend protection to a 500-year lake level, if such extension were judged to be necessary in the future. The alternatives considered various combinations of dikes, floodwalls, filling, pumping and storage of stormwater, and floodproofing.

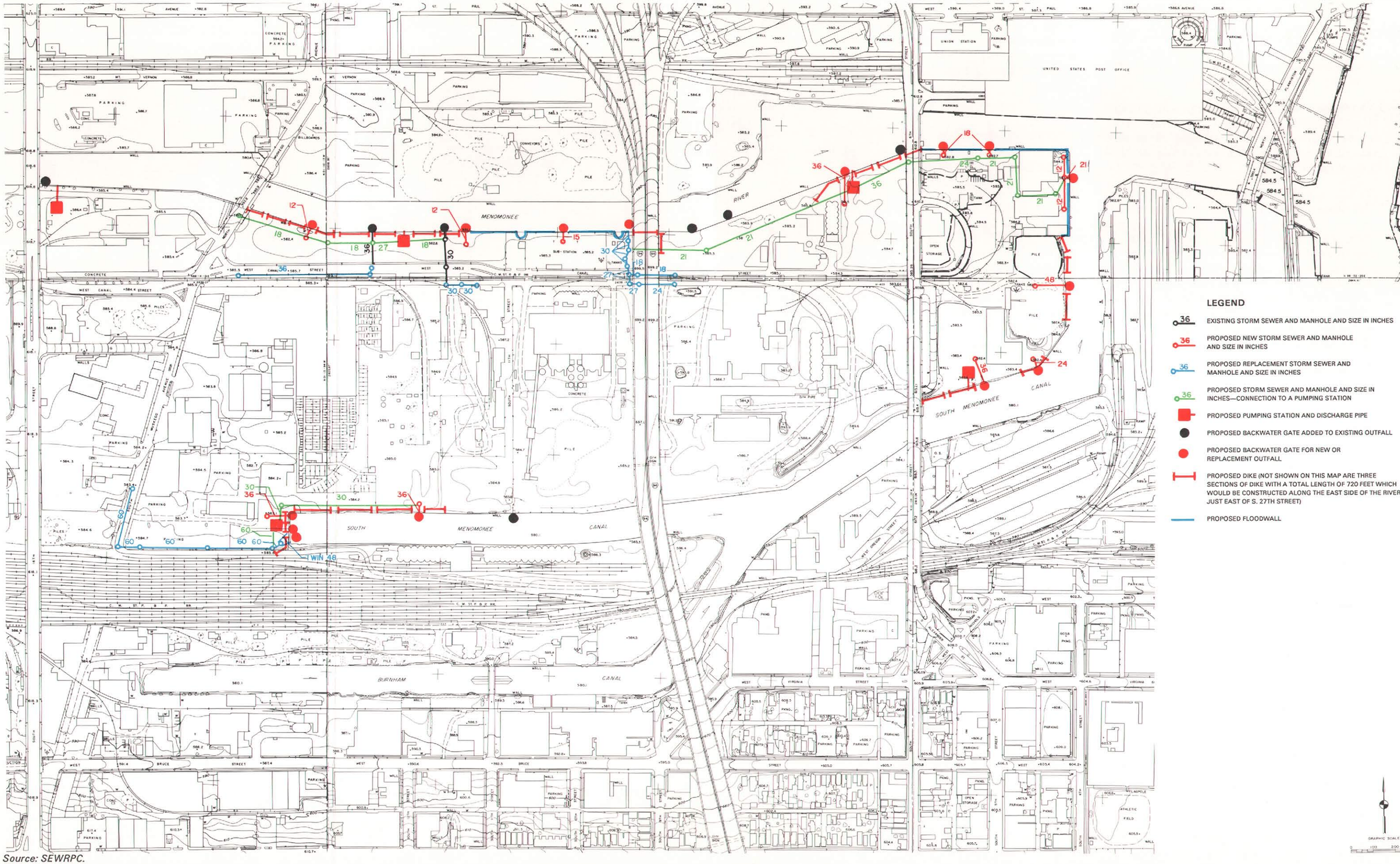
The itemized costs for the alternatives include land acquisition for pumping stations, where applicable. It is assumed that, owing to the benefits to private property owners which would result from the provision of flood protection and the associated drainage measures, easements on private property will be readily granted and no condemnation of property by the City would be necessary.

Alternative 1A—Dikes, Floodwalls, and Centralized Stormwater Pumping Facilities to Provide Flood Protection to a 100-Year Recurrence Interval Lake Michigan Level

The components of Alternative Plan 1A are shown on Map 3. The alternative plan calls for the construction of 4,390 lineal feet of dike, ranging up to about six feet in height above grade; 1,985 lineal feet of floodwall, ranging up to about 3.5 feet in height above grade; five stormwater pumping stations, ranging in capacity from 20 to 60 cubic feet per second (cfs); 3,665 lineal feet of storm sewers connecting existing outfalls, or areas of potential ponding, with pumping stations and ranging in diameter from 18 to 36 inches; 2,390 lineal feet of storm sewer replacing existing storm sewers and ranging in diameter from 18 to 60 inches; 1,110 lineal feet of new storm sewer, ranging in diameter from 12 to 48 inches; five backwater gates for existing storm sewer or combined sewer outfalls; and 14 backwater gates for new or replacement storm sewer outfalls. In addition, a bulkhead is provided in the 21-inch-diameter storm sewer located along the west side of S. Emmber Lane, south of W. Canal Street. At the manhole at the southwest of the intersection of S. Emmber Lane and the approach to the James E. Groppi Unity Bridge (16th Street viaduct), the storm sewer is hydraulically connected to both the Menomonee River to the north and the South Menomonee Canal to the south. The storm sewer to the north of the manhole is owned by the City of Milwaukee and flows to the north. The sewer to the south flows to the south. That sewer is owned by the Peck Meat Packing Corporation and only collects runoff from Peck property. By constructing a bulkhead to block the hydraulic connection, the need for backwater gates on two existing 30-inch-diameter storm sewer outfalls and one existing 36-inch-diameter storm sewer outfall, all discharging to the Menomonee River, can be eliminated. The capital and operation and maintenance costs for Alternative Plan 1A are given in Table 1.

Map 3

ALTERNATIVE 1A—DIKES, FLOODWALLS, AND CENTRALIZED STORMWATER PUMPING FACILITIES ALONG THE MENOMONEE RIVER ESTUARY: 100-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL



Source: SEWRPC.

Table 1

COST ESTIMATES FOR FLOOD CONTROL ALTERNATIVES FOR THE MENOMONEE RIVER ESTUARY: 100-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL

Flood Control Alternative	Capital	Amortized Capital[a]	Annual Operation and Maintenance	Total
1A Dikes, Floodwalls, and Centralized Stormwater Pumping Facilities				
Dikes	$ 398,000	$ 25,300	$ 2,400	$ 27,700
Floodwalls	500,000	31,800	1,100	32,900
Stormwater Drainage	1,034,000	65,700	100	65,800
Pumping Stations[b]	3,098,000	205,900	30,000	235,900
Storm Sewer Connections to Pumping Stations	666,000	42,300	1,400	43,700
Backwater Gates	73,000	4,600	2,000	6,600
Land Acquisition	41,000	2,600	0	2,600
Total	$5,810,000	$378,200	$37,000	$415,200
1B Dikes, Floodwalls, and Decentralized Stormwater Pumping Facilities				
Dikes	$ 398,000	$ 25,300	$ 2,400	$ 27,700
Floodwalls	500,000	31,800	1,100	32,900
Stormwater Drainage	1,034,000	65,700	100	65,800
Pumping Stations[b]	3,587,000	238,400	60,000	298,400
Storm Sewer Connections to Pumping Stations	88,000	5,600	200	5,800
Backwater Gates	73,000	4,600	2,000	6,600
Land Acquisition	51,000	3,200	0	3,200
Total	$5,731,000	$374,600	$65,800	$440,400
1C Dikes, Floodwalls, Filling, and Centralized Stormwater Pumping Facilities				
Dikes	$ 201,000	$ 12,800	$ 1,300	$ 14,100
Floodwalls	500,000	31,800	1,100	32,900
Fill for 100-Year Protection	666,000	42,300	0	42,300
Additional Fill for 500-Year Protection	264,000	16,800	0	16,800
Stormwater Drainage	941,000	59,800	100	59,900
Pumping Stations[b]	2,666,000	177,200	30,000	207,200
Storm Sewer Connections to Pumping Stations	518,000	32,900	1,100	34,000
Backwater Gates	59,000	3,800	2,000	5,800
Land Acquisition	41,000	2,600	0	2,600
Total	$5,856,000	$380,000	$35,600	$415,600
1D Dikes, Floodwalls, Filling, and Decentralized Stormwater Pumping Facilities				
Dikes	$ 201,000	$ 12,800	$ 1,300	$ 14,100
Floodwalls	500,000	31,800	1,100	32,900

Table 1 (continued)

Flood Control Alternative	Capital	Amortized Capital[a]	Annual Operation and Maintenance	Total
1D (continued)				
Fill for 100-Year Protection	$ 666,000	$ 42,300	$ 0	$ 42,300
Additional Fill for 500-Year Protection	264,000	16,800	0	16,800
Stormwater Drainage	941,000	59,800	100	59,900
Pumping Stations[b]	3,141,000	208,700	54,000	262,700
Storm Sewer Connections to Pumping Stations	88,000	5,600	200	5,800
Backwater Gates	59,000	3,800	2,000	5,800
Land Acquisition	48,000	3,000	0	3,000
Total	$5,908,000	$384,600	$58,700	$443,300
1E Dikes, Floodwalls, Filling, and Centralized Stormwater Storage and Pumping Facilities				
Dikes	$ 201,000	$ 12,800	$ 1,300	$ 14,100
Floodwalls	500,000	31,800	1,100	32,900
Fill for 100-Year Protection	666,000	42,300	0	42,300
Additional Fill for 500-Year Protection	264,000	16,800	0	16,800
Stormwater Drainage	941,000	59,800	100	59,900
Pumping Stations[b]	1,012,000	67,300	30,000	97,300
Storage Facilities	1,904,000	120,900	16,000	136,900
Storm Sewer Connections to Pumping Stations	518,000	32,900	1,100	34,000
Backwater Gates	59,000	3,800	2,000	5,800
Land Acquisition	89,000	5,700	0	5,700
Total	$6,154,000	$394,100	$51,600	$445,700
3 Floodproofing				
Floodproofing of 13 Structures	$ 306,000	$ 19,400	$ 0	$ 19,400
Fill for Protection of New Buildings in the 100-Year Floodplain	503,000	32,000	0	32,000
Additional Fill Protection of New Buildings in the 500-Year Floodplain	499,000	31,700	0	31,700
Parking Lot Regrading and Repaving	379,000	24,100	0	24,100
Street Grade Raises	171,000	10,900	0	10,900
Railway Grade Raises	293,000	18,600	0	18,600
Floodwalls	116,000	7,400	300	7,700
Pumping Station[b]	88,000	5,800	6,000	11,800
Storm Drainage Including Backwater Gates	8,000	500	300	800
Total	$2,363,000	$150,400	$6,600	$157,000

[a] *Amortized capital cost is based on an interest rate of 6 percent and a project life of 50 years.*

[b] *Amortized capital cost includes the replacement of pumps and appurtenant equipment after 25 years of operation.*

Source: SEWRPC.

Alternative 1B—Dikes, Floodwalls, and Decentralized Stormwater Pumping Facilities to Provide Protection to a 100-Year Recurrence Interval Lake Michigan Level

The components of Alternative Plan 1B are shown on Map 4. The alternative plan calls for the construction of 4,390 lineal feet of dike, ranging up to about six feet in height above grade; 1,985 lineal feet of floodwall, ranging up to 3.5 feet in height above grade; 10 stormwater pumping stations, ranging in capacity from 7 to 45 cfs; 510 lineal feet of storm sewers connecting existing outfalls with pumping stations and ranging in diameter from 18 to 27 inches; 2,390 lineal feet of storm sewer replacing existing storm sewer and ranging in diameter from 18 to 60 inches; 1,110 lineal feet of new storm sewer, ranging in diameter from 12 to 48 inches; five backwater gates for existing storm sewer or combined sewer outfalls; and 14 backwater gates for new or replacement storm sewer outfalls. In addition, a bulkhead is provided in the 21-inch-diameter storm sewer located along the west side of S. Emmber Lane, south of W. Canal Street. The capital and operation and maintenance costs for Alternative Plan 1B are given in Table 1.

Alternative 1C—Dikes, Floodwalls, Filling, and Centralized Stormwater Pumping Facilities to Provide Protection to a 100-Year Recurrence Interval Lake Michigan Level

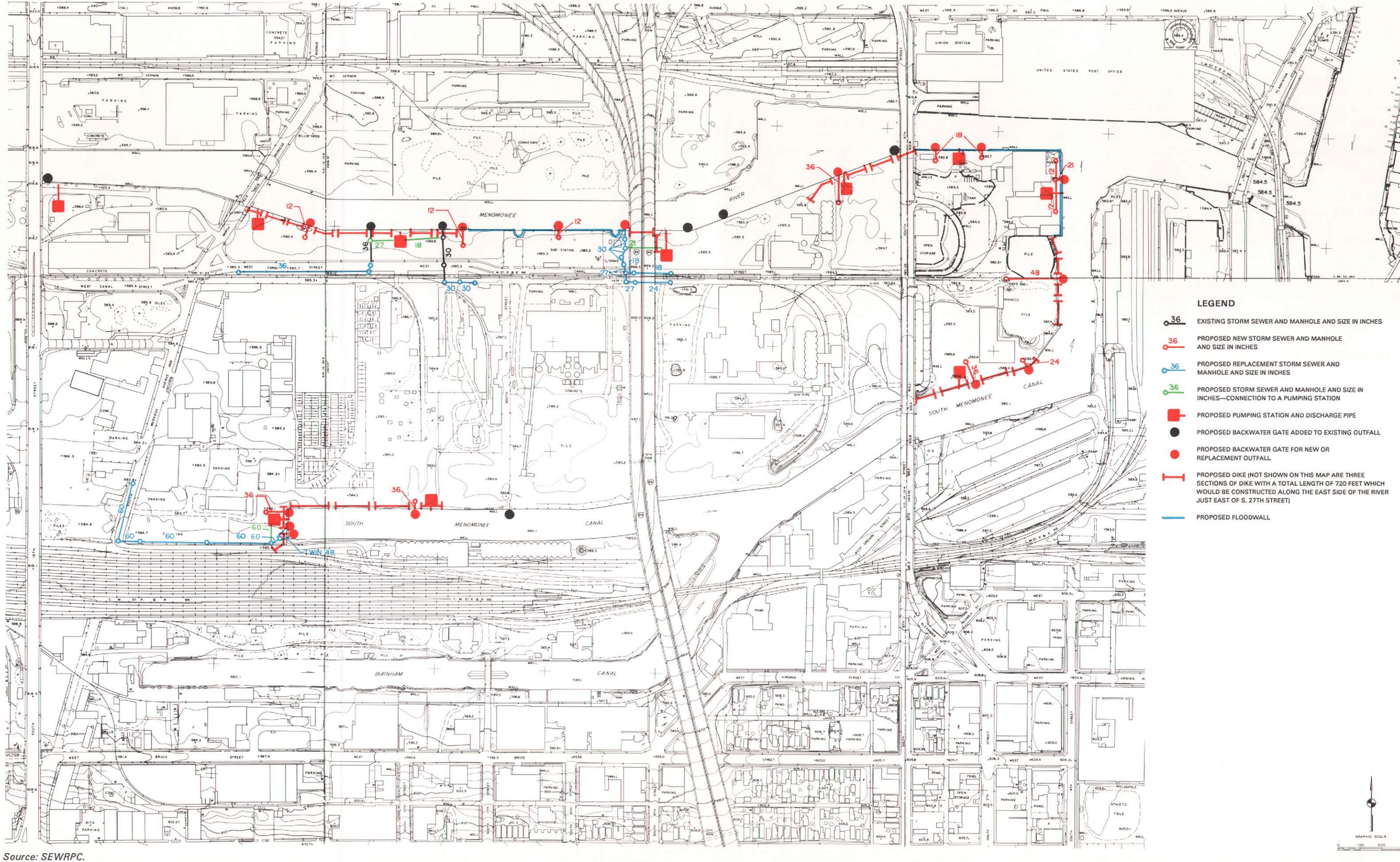
The components of Alternative Plan 1C are shown on Map 5. The alternative plan calls for the construction of 2,240 lineal feet of dike, ranging up to about six feet in height above grade; 1,985 lineal feet of floodwall, ranging up to about 3.5 feet in height above grade; five stormwater pumping stations, ranging in capacity from 20 to 55 cfs; 2,965 lineal feet of storm sewers connecting existing outfalls, or areas of potential ponding, with pumping stations and ranging in diameter from 18 to 36 inches; 2,390 lineal feet of storm sewer replacing existing storm sewer and ranging in diameter from 18 to 60 inches; 850 lineal feet of new storm sewer, ranging in diameter from 12 to 48 inches; five backwater gates for existing storm sewer or combined sewer outfalls; 10 backwater gates for new or replacement storm sewer outfalls; and the placement of 45,600 cubic yards of fill for the purposes of providing a barrier to floodwaters, elevating new development in the 100-year recurrence interval floodplain, and facilitating the conveyance of stormwater runoff to the estuary through overland flow. In addition, a bulkhead is provided in the 21-inch-diameter storm sewer located along the west side of S. Emmber Lane, south of W. Canal Street. This alternative plan also calls for all new construction within the 500-year recurrence interval floodplain to be constructed on fill to a height of 586.3 feet NGVD. If this alternative plan were implemented with new construction on fill being required only within the 100-year floodplain, and it was subsequently found that implementation of the 500-year-level protection phase of the plan was necessary, new structures constructed outside the 100-year floodplain but within the 500-year floodplain could require additional flood protection measures. Therefore, the cost of construction on fill within the 500-year floodplain is included under this initial phase alternative. Assuming complete development of existing open areas, 16,300 cubic yards of fill would be required in addition to the 45,600 cubic yards needed for protection to the 100-year estuary level. The capital and operation and maintenance costs for Alternative Plan 1C are given in Table 1.

Alternative 1D—Dikes, Floodwalls, Filling, and Decentralized Stormwater Pumping Facilities to Provide Protection to a 100-Year Recurrence Interval Lake Michigan Level

The components of Alternative Plan 1D are shown on Map 6. The alternative plan calls for the construction of 2,240 lineal feet of dike, ranging up to about six feet in height above grade; 1,985 lineal feet of floodwall, ranging up to 3.5 feet in height above grade; nine stormwater pumping stations, ranging in capacity from 7 to 45 cfs; 510 lineal feet of storm sewers connecting existing outfalls with pumping stations and ranging in diameter from 18 to 27 inches; 2,390 lineal feet of storm sewer replacing existing storm sewer and ranging in diameter from 18 to 60 inches; 850 lineal feet of new storm sewer, ranging in diameter from 12 to 48 inches; five backwater gates for existing storm sewer or combined sewer outfalls; 10 backwater gates for new or replacement storm sewer outfalls; and the placement of 45,600 cubic yards of fill for the purposes of providing a barrier to floodwaters, elevating new development within the 100-year floodplain, and facilitating the conveyance of stormwater runoff to the estuary through over-

Map 4

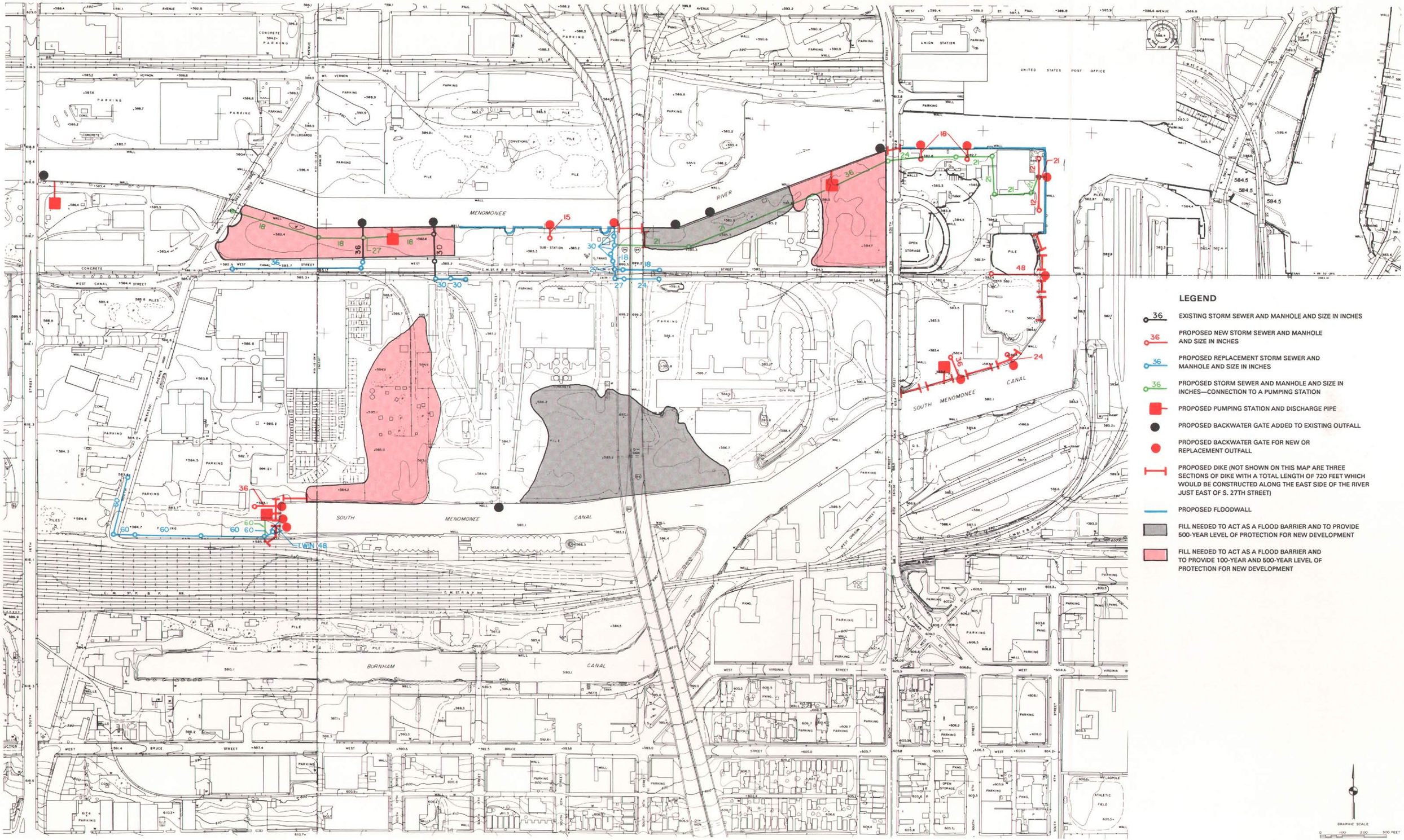
ALTERNATIVE 1B—DIKES, FLOODWALLS, AND DECENTRALIZED STORMWATER PUMPING FACILITIES ALONG THE MENOMONEE RIVER ESTUARY: 100-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL



Source: SEWRPC.

Map 5

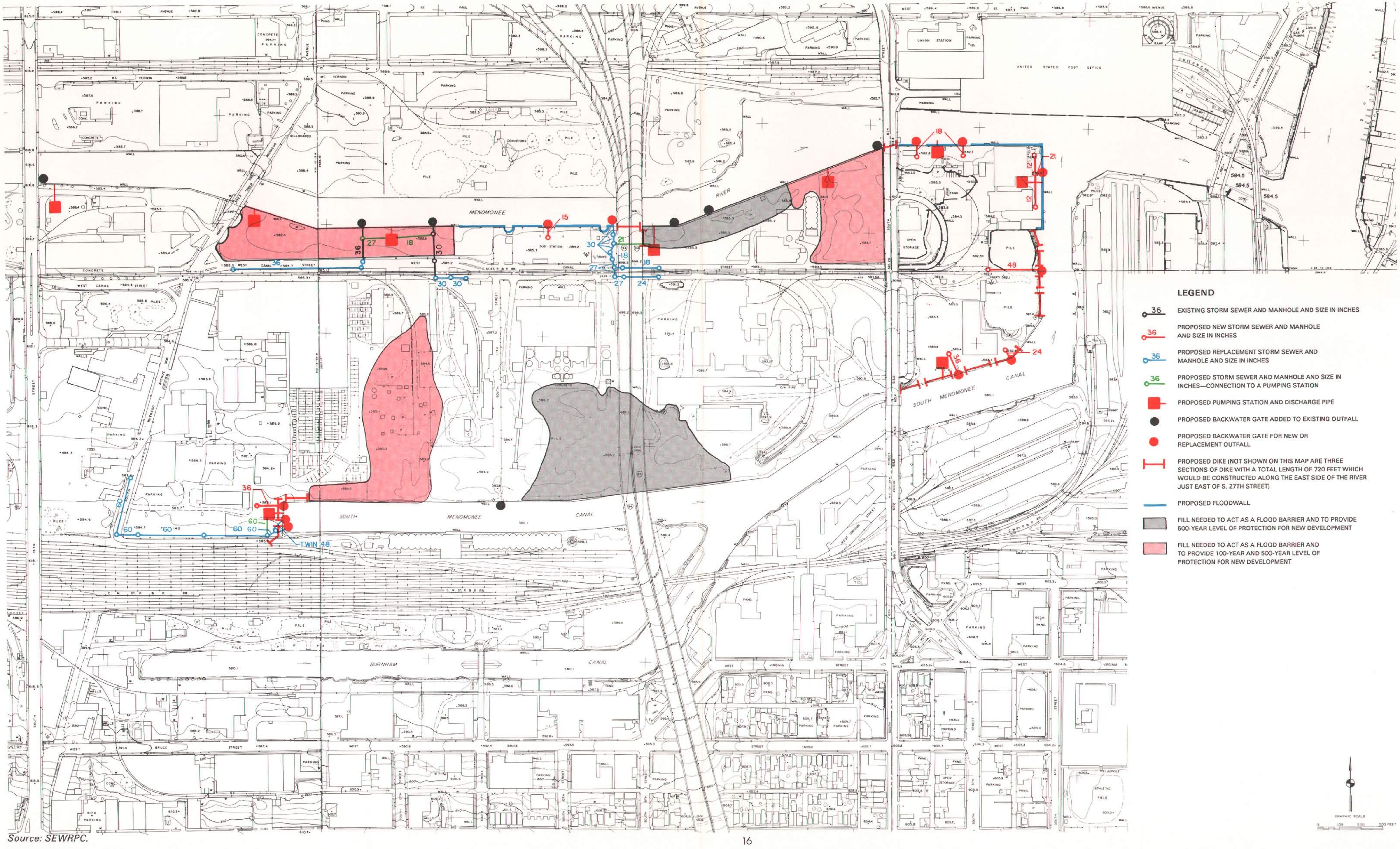
ALTERNATIVE 1C—DIKES, FLOODWALLS, FILLING, AND CENTRALIZED STORMWATER PUMPING FACILITIES ALONG THE MENOMONEE RIVER ESTUARY: 100-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL



Source: SEWRPC.

Map 6

ALTERNATIVE 1D—DIKES, FLOODWALLS, FILLING, AND DECENTRALIZED STORMWATER PUMPING FACILITIES ALONG THE MENOMONEE RIVER ESTUARY: 100-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL



Source: SEWRPC.

land flow. In addition, a bulkhead is provided in the 21-inch-diameter storm sewer located along the west side of S. Emmber Lane, south of W. Canal Street. The alternative plan also calls for all new construction within the 500-year recurrence interval floodplain to be constructed on fill to a height of 586.3 feet NGVD. Assuming complete development of existing open areas, 16,300 cubic yards of fill would be required in addition to the 45,600 cubic yards needed for protection to the 100-year estuary level. The capital and operation and maintenance costs for Alternative Plan 1D are given in Table 1.

Alternative 1E—Dikes, Floodwalls, Filling, and Centralized Stormwater Storage and Pumping Facilities to Provide Protection to a 100-Year Recurrence Interval Lake Michigan Level

The components of Alternative Plan 1E are shown on Map 7. The alternative plan calls for the construction of 2,240 lineal feet of dike, ranging up to about six feet in height above grade; 1,985 lineal feet of floodwall, ranging up to 3.5 feet in height above grade; five stormwater storage and pumping facilities with pumping capacities ranging from 4 to 16 cfs and storage volumes ranging from 0.29 to 1.24 acre-feet; 2,965 lineal feet of storm sewers connecting existing outfalls, or areas of potential ponding, to pumping stations and ranging in diameter from 18 to 36 inches; 2,390 lineal feet of storm sewer replacing existing storm sewer and ranging in diameter from 18 to 60 inches; 850 lineal feet of new storm sewer, ranging in diameter from 12 to 48 inches; five backwater gates for existing storm sewer or combined sewer outfalls; 10 backwater gates for new or replacement storm sewer outfalls; and the placement of 45,600 cubic yards of fill for the purposes of providing a barrier to floodwaters, elevating new development within the 100-year floodplain, and facilitating the conveyance of stormwater runoff to the estuary through overland flow. In addition, a bulkhead is provided in the 21-inch-diameter storm sewer located along the west side of S. Emmber Lane, south of W. Canal Street. The alternative plan also calls for all new construction within the 500-year recurrence interval floodplain to be constructed on fill to a height of 586.3 feet NGVD. Assuming complete development of existing open areas, 16,300 cubic yards of fill would be required in addition to the 45,600 cubic yards needed for protection to the 100-year estuary level. The capital and operation and maintenance costs for Alternative Plan 1E are given in Table 1.

Alternative 2A—Dikes, Floodwalls, and Centralized Stormwater Pumping Facilities to Provide Protection to a 500-Year Recurrence Interval Lake Michigan Level

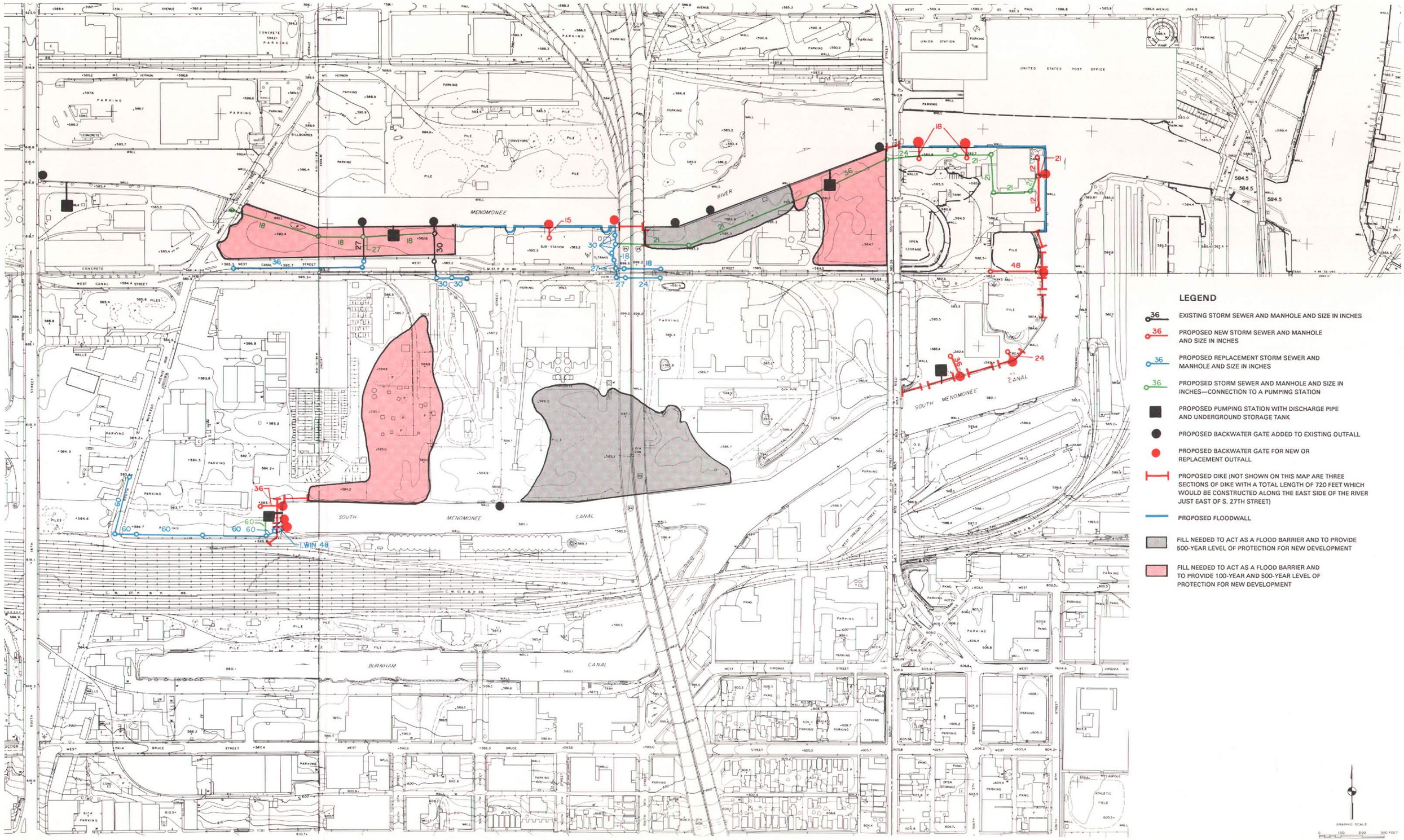
Alternative 2A is an expansion of Alternative 1A for the purpose of providing flood protection to a 500-year recurrence interval lake level. The components of Alternative Plan 2A that are required in addition to the components of Alternative Plan 1A are shown on Map 8. The alternative plan calls for the construction of an additional 4,375 lineal feet of dike, ranging up to about 2.5 feet in height above grade; an additional 80 lineal feet of one-foot-high floodwall; 410 lineal feet of street grade raise and repaving, ranging in height from 0.2 foot to 2.0 feet above the existing grade; 100 lineal feet of railway crossing reconstruction; approximately 48,800 square feet of parking lot grade raise and repaving, ranging in height from 2 to 2.3 feet above the existing grade; two additional stormwater pumping stations, with capacities of 10 and 35 cfs; 820 lineal feet of storm sewers connecting existing outfalls with pumping stations and ranging in diameter from 15 to 24 inches; an additional 1,770 lineal feet of storm sewer replacing existing storm sewer and ranging in diameter from 24 to 60 inches; an additional 150 lineal feet of new 12-inch-diameter storm sewer; six backwater gates for existing storm sewer outfalls; and eight backwater gates for new or replacement storm sewer outfalls. In addition, instead of calling for 700 lineal feet of 21-inch-diameter storm sewer connector to a pumping station as does Alternative Plan 1A, Alternative 2A calls for 24-inch-diameter storm sewer. Also, unlike Alternative Plan 1A, which calls for 110 feet of 18-inch-diameter pumping station connector, Alternative Plan 2A instead calls for a 21-inch-diameter storm sewer. The capital and operation and maintenance costs for Alternative Plan 2A are given in Table 2.

Alternative Plan 2B—Dikes, Floodwalls, and Decentralized Stormwater Pumping Facilities to Provide Protection to a 500-Year Recurrence Interval Lake Michigan Level

Alternative 2B is an expansion of Alternative 1B for the purpose of providing flood protection to a 500-year recurrence interval lake level. The components of Alternative Plan 2B that are required in addition to the components of Alternative Plan 1B are shown on Map 9. The alternative plan calls for the construction of an additional 4,375 lineal feet of dike, ranging up

Map 7

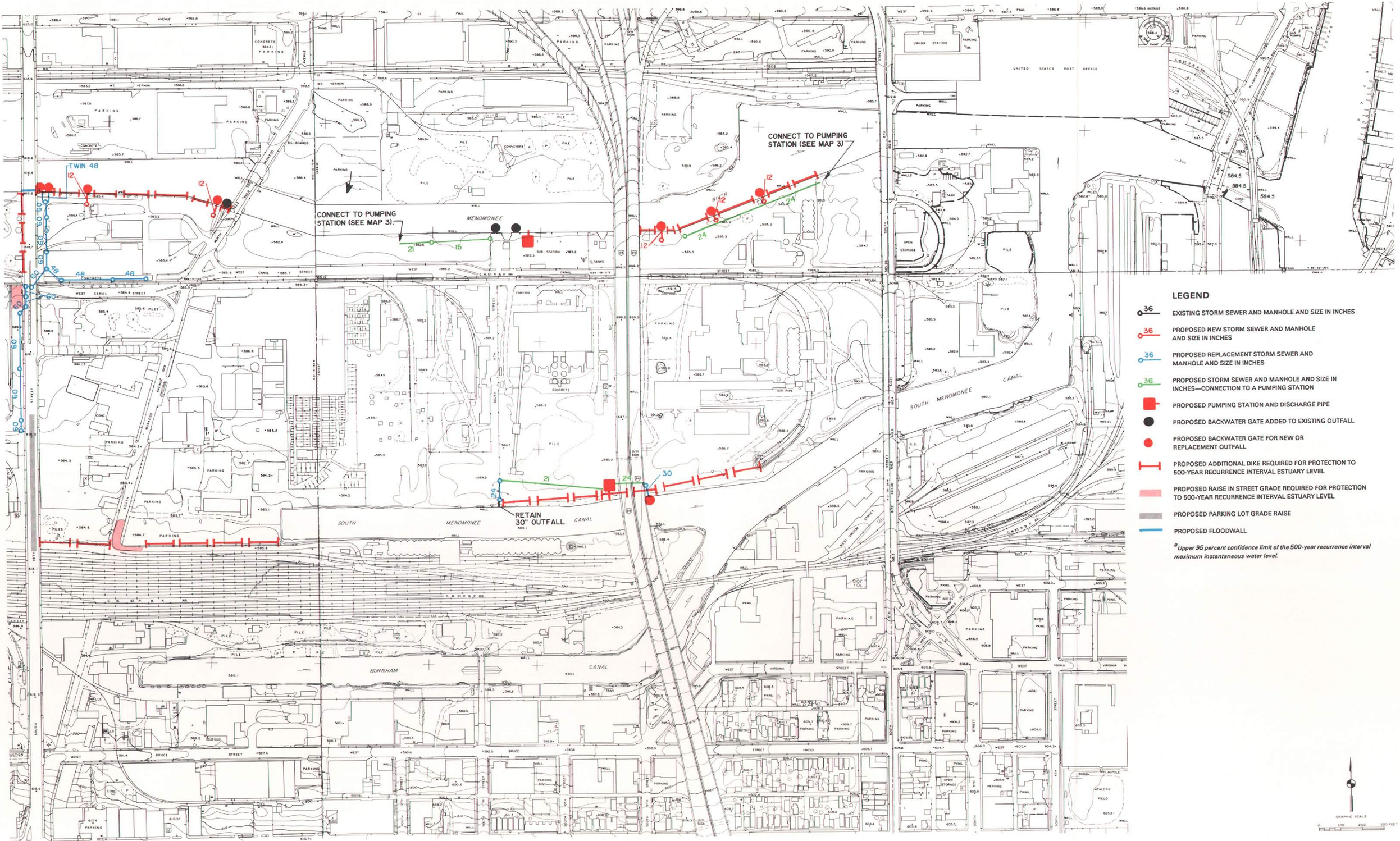
ALTERNATIVE 1E—DIKES, FLOODWALLS, FILLING, AND CENTRALIZED STORMWATER STORAGE AND PUMPING FACILITIES ALONG THE MENOMONEE RIVER ESTUARY: 100-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL



Source: SEWRPC.

Map 8

ALTERNATIVE 2A—ADDITIONAL DIKES, FLOODWALLS, AND CENTRALIZED STORMWATER PUMPING FACILITIES ALONG THE MENOMONEE RIVER ESTUARY TO PROVIDE PROTECTION TO A 500-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL[a]



[a] Upper 95 percent confidence limit of the 500-year recurrence interval maximum instantaneous water level.

Source: SEWRPC.

Table 2

COST ESTIMATES FOR FLOOD CONTROL ALTERNATIVES FOR THE MENOMONEE RIVER ESTUARY ADDITIONAL COSTS FOR PROTECTION TO A 500-YEAR RECURRENCE INTERVAL LAKE MICHIGAN LEVEL

Flood Control Alternative	Capital	Amortized Capital[a]	Annual Operation and Maintenance	Total
2A Dikes, Floodwalls, and Centralized Stormwater Pumping Facilities				
Dikes	$ 193,000	$ 12,300	$ 1,500	$ 13,800
Floodwalls	13,000	800	100	900
Street Grade Raises	50,000	3,200	0	3,200
Railway Crossing Reconstruction	80,000	5,100	0	5,100
Parking Lot Grade Raises	88,000	5,600	0	5,600
Stormwater Drainage	725,000	46,000	0	46,000
Pumping Stations[b]	810,000	53,800	12,000	65,800
Storm Sewer Connections to Pumping Stations	149,000	9,500	400	9,900
Backwater Gates	23,000	1,500	1,000	2,500
Land Acquisition	6,000	400	0	400
Total	$2,137,000	$138,200	$15,000	$153,200
2B Dikes, Floodwalls, and Decentralized Stormwater Pumping Facilities				
Dikes	$ 193,000	$ 12,300	$ 1,500	$ 13,800
Floodwalls	13,000	800	100	900
Street Grade Raises	50,000	3,200	0	3,200
Railway Crossing Reconstruction	80,000	5,100	0	5,100
Parking Lot Grade Raises	88,000	5,600	0	5,600
Stormwater Drainage	725,000	46,000	0	46,000
Pumping Stations[b]	958,000	63,700	18,000	81,700
Storm Sewer Connections to Pumping Stations	41,000	2,600	200	2,800
Backwater Gates	23,000	1,500	1,000	2,500
Land Acquisition	10,000	700	0	700
Total	$2,181,000	$141,500	$20,800	$162,300
2C Dikes, Floodwalls, Filling, and Centralized Stormwater Pumping Facilities				
Dikes	$ 99,000	$ 6,300	$ 800	$ 7,100
Floodwalls	13,000	800	100	900
Street Grade Raises	50,000	3,200	0	3,200
Railway Crossing Reconstruction	80,000	5,100	0	5,100
Parking Lot Grade Raises	88,000	5,600	0	5,600
Stormwater Drainage	704,000	44,700	0	44,700
Pumping Stations[b]	466,000	31,000	12,000	43,000
Storm Sewer Connections to Pumping Stations	41,000	2,600	200	2,800
Backwater Gates	6,000	400	300	700
Land Acquisition	6,000	400	0	400
Total	$1,553,000	$100,100	$13,400	$113,500

Table 2 (continued)

Flood Control Alternative	Capital	Amortized Capital[a]	Annual Operation and Maintenance	Total
2D Dikes, Floodwalls, Filling, and Decentralized Stormwater Pumping Facilities				
Dikes	$ 99,000	$ 6,300	$ 800	$ 7,100
Floodwalls	13,000	800	100	900
Street Grade Raises	50,000	3,200	0	3,200
Railway Crossing Reconstruction	80,000	5,100	0	5,100
Parking Lot Grade Raises	88,000	5,600	0	5,600
Stormwater Drainage	704,000	44,700	0	44,700
Pumping Stations[b]	466,000	31,000	12,000	43,000
Storm Sewer Connections to Pumping Stations	41,000	2,600	200	2,800
Backwater Gates	6,000	400	300	700
Land Acquisition	6,000	400	0	400
Total	$1,553,000	$100,100	$13,400	$113,500
2E Dikes, Floodwalls, and Centralized Stormwater Storage and Pumping Facilities				
Dikes	$ 99,000	$ 6,300	$ 800	$ 7,100
Floodwalls	13,000	800	100	900
Street Grade Raises	50,000	3,200	0	3,200
Railway Crossing Reconstruction	80,000	5,100	0	5,100
Parking Lot Grade Raises	88,000	5,600	0	5,600
Stormwater Drainage	704,000	44,700	0	44,700
Pumping Stations[b]	70,000	4,700	12,000	16,700
Storage Facilities	263,000	16,700	4,500	21,200
Storm Sewer Connections to Pumping Stations	41,000	2,600	200	2,800
Backwater Gates	6,000	400	300	700
Land Acquisition	9,000	600	0	600
Total	$1,423,000	$ 90,700	$17,900	$108,600
4 Floodproofing				
Floodproof 19 Structures	$ 225,000	$ 14,300	$ 0	$ 14,300
Floodwalls	81,000	5,100	300	5,400
Total	$306,000	$19,400	$300	$19,700

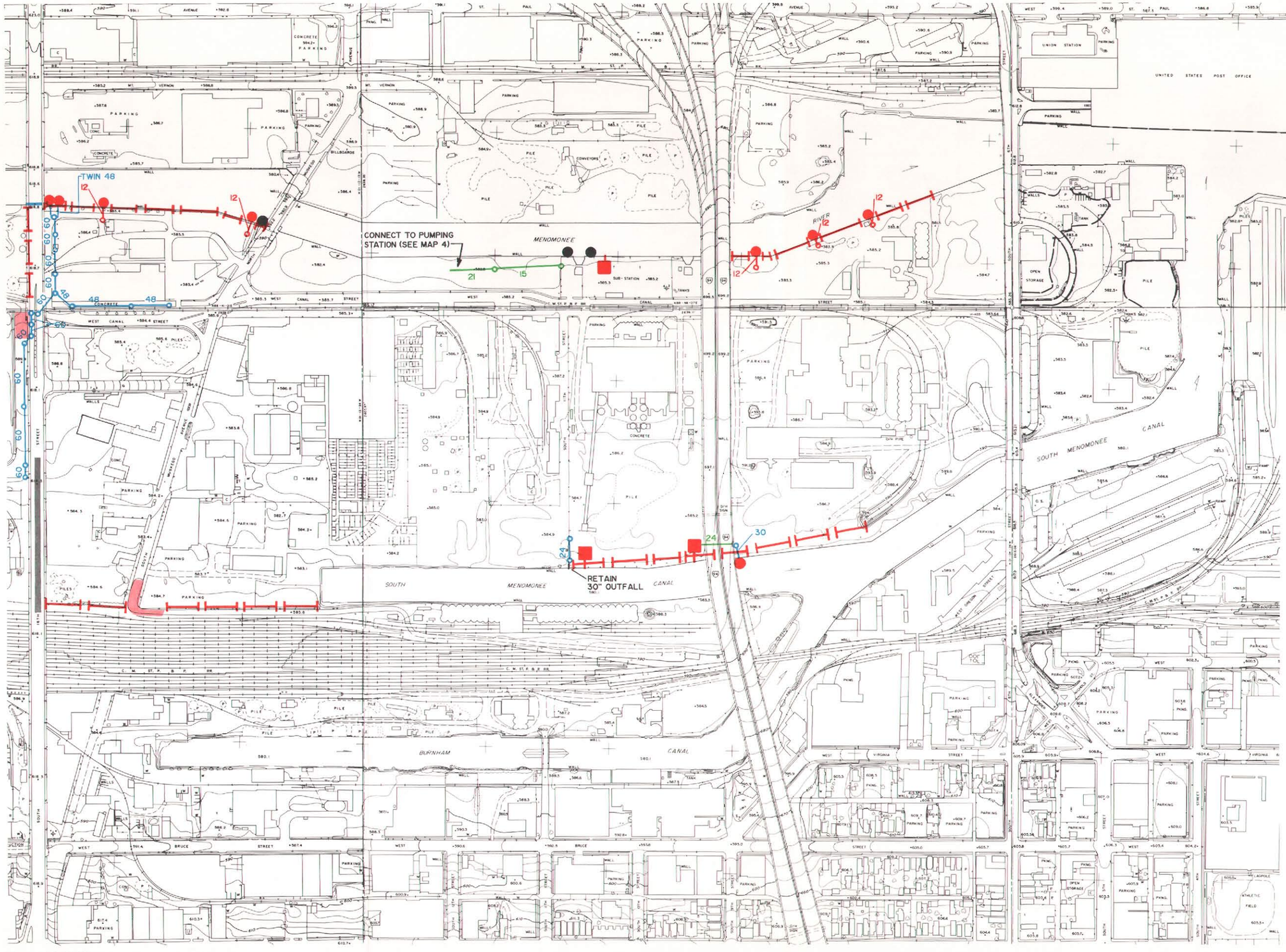
[a] *Amortized capital cost is based on an interest rate of 6 percent and a project life of 50 years.*

[b] *Amortized capital cost includes the replacement of pumps and appurtenant equipment after 25 years of operation.*

Source: SEWRPC.

Map 9

ALTERNATIVE 2B—ADDITIONAL DIKES, FLOODWALLS, AND DECENTRALIZED STORMWATER PUMPING FACILITIES ALONG THE MENOMONEE RIVER ESTUARY TO PROVIDE PROTECTION TO A 500-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL[a]



[a] *Upper 95 percent confidence limit of the 500-year recurrence interval maximum instantaneous water level.*

Source: SEWRPC.

to about 2.5 feet in height above grade; an additional 80 lineal feet of one-foot-high floodwall; 410 feet of street grade raise and repaving, ranging in height from 0.2 foot to 2.0 feet above the existing grade; 100 lineal feet of railway crossing reconstruction; approximately 48,800 square feet of parking lot grade raise and repaving, ranging in height from 2 to 2.3 feet above the existing grade; three additional stormwater pumping stations, with capacities ranging from 10 to 25 cfs; 390 lineal feet of storm sewer connecting existing outfalls with pumping stations and ranging in diameter from 15 to 24 inches; an additional 1,770 lineal feet of storm sewer replacing existing storm sewer and ranging in diameter from 24 to 60 inches; an additional 150 lineal feet of new 12-inch-diameter storm sewer; six backwater gates for existing storm sewer outfalls; and eight backwater gates for new or replacement storm sewer outfalls. In addition, instead of calling for 110 feet of 18-inch-diameter connector to a pumping station as does Alternative Plan 1B, Alternative Plan 2B calls for a 21-inch-diameter storm sewer. The capital and operation and maintenance costs for Alternative Plan 2B are given in Table 2.

Alternative Plan 2C—Dikes, Floodwalls, Filling, and Centralized Stormwater Pumping Facilities to Provide Protection to a 500-Year Recurrence Interval Lake Michigan Level

Alternative 2C is an expansion of Alternative 1C for the purpose of providing flood protection to a 500-year recurrence interval lake level. The components of Alternative Plan 2C that are required in addition to the components of Alternative Plan 1C are shown on Map 10. The alternative plan calls for the construction of an additional 2,370 lineal feet of dike, ranging up to about 2.5 feet in height above grade; an additional 80 lineal feet of one-foot-high floodwall; 410 lineal feet of street grade raise and repaving, ranging in height from 0.2 foot to 2.0 feet above the existing grade; 100 lineal feet of railway crossing reconstruction; approximately 48,800 square feet of parking lot grade raise and repaving, ranging in height from 2 to 2.3 feet above the existing grade; two additional stormwater pumping stations, each with a capacity of 10 cfs; 310 lineal feet of 15-inch-diameter storm sewer connecting an existing outfall with a pumping station; an additional 1,720 lineal feet of storm sewer replacing existing storm sewer and ranging in diameter from 24 to 60 inches; an additional 60 lineal feet of new 12-inch-diameter storm sewer; six backwater gates for existing storm sewer outfalls; and four backwater gates for new or replacement storm sewer outfalls. In addition, instead of calling for 110 feet of 18-inch-diameter connector to a pumping station as does Alternative Plan 1C, alternative Plan 2C calls for a 21-inch-diameter storm sewer. The capital and operation and maintenance costs for Alternative Plan 2C are given in Table 2.

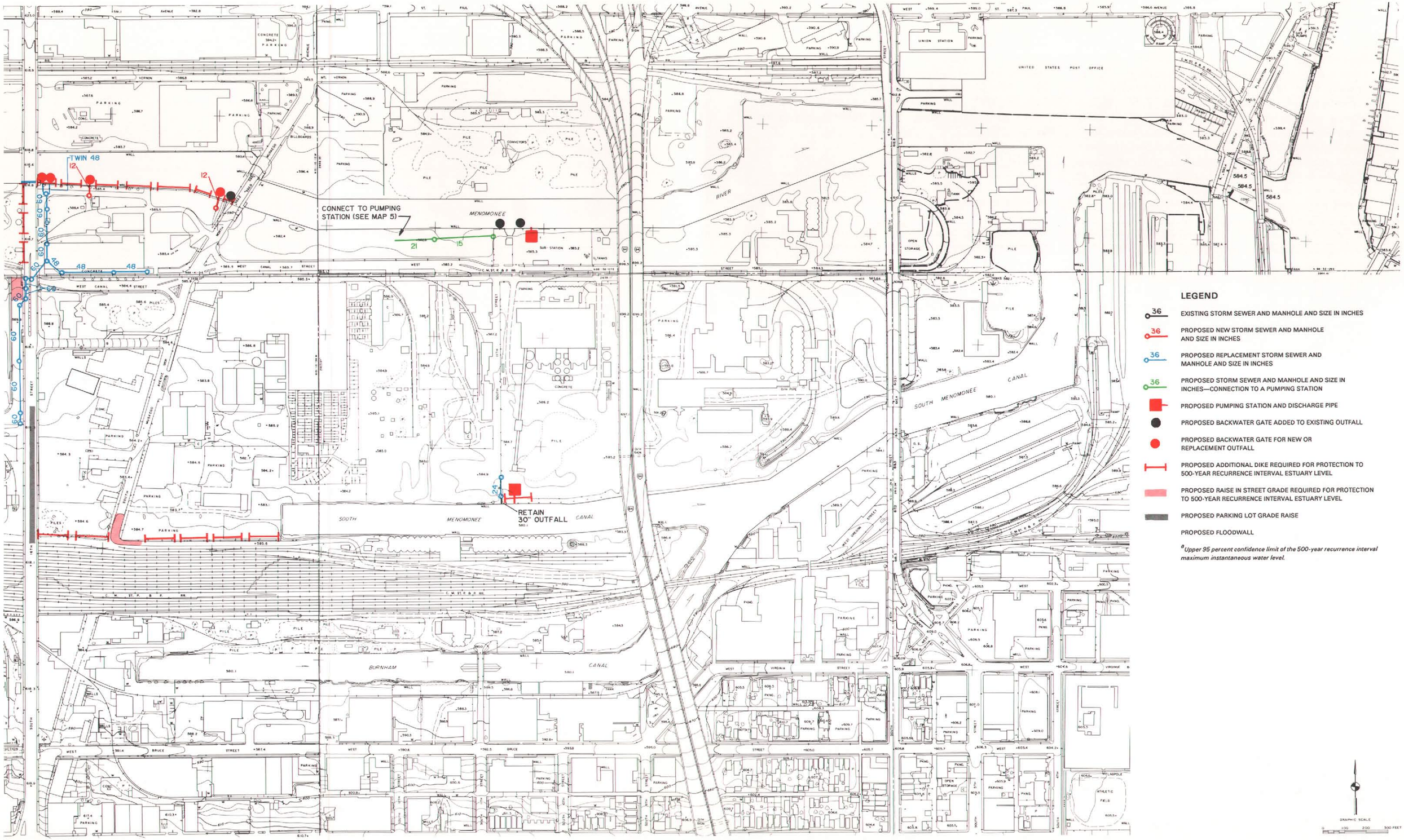
The filling within the 500-year recurrence interval floodplain called for in Alternative Plan 1C would be essential to the proper functioning of Alternative Plan 2C. Under 500-year lake level conditions, the fill would serve as a flood barrier and a termination point for adjacent flood barriers. Therefore, if this 500-year protection alternative were implemented and the indicated amount of filling within the 500-year floodplain had not occurred at the time this alternative was to be implemented because the area had not been developed, it would be necessary to provide flood protection and stormwater drainage facilities in those areas originally designated to be filled. Such facilities would be similar to those shown for Alternative 2B on Map 9.

Alternative Plan 2D—Dikes, Floodwalls, Filling, and Decentralized Stormwater Pumping Facilities to Provide Protection to a 500-Year Recurrence Interval Lake Michigan Level

Alternative 2D is an expansion of Alternative 1D for the purpose of providing flood protection to a 500-year recurrence interval lake level. The components of Alternative Plan 2D that are required in addition to the components of Alternative Plan 1D are shown on Map 11. The alternative plan calls for the construction of an additional 2,370 lineal feet of dike, ranging up to about 2.5 feet in height above grade; an additional 80 lineal feet of one-foot-high floodwall; 410 feet of street grade raise and repaving, ranging in height from 0.2 foot to 2.0 feet above the existing grade; 100 lineal feet of railway crossing reconstruction; approximately 48,800 square feet of parking lot grade raise and repaving, ranging in height from 2 to 2.3 feet above the existing grade; two additional stormwater pumping stations, each with a capacity of 10 cfs; 310 lineal feet of 15-inch-diameter storm sewer connecting an existing outfall with a pumping station; an additional 1,720 lineal feet of storm sewer replacing existing storm sewer and ranging in diameter from 24 to 60 inches;

Map 10

ALTERNATIVE 2C—ADDITIONAL DIKES, FLOODWALLS, FILLING, AND CENTRALIZED STORMWATER PUMPING FACILITIES ALONG THE MENOMONEE RIVER ESTUARY TO PROVIDE PROTECTION TO A 500-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL[a]

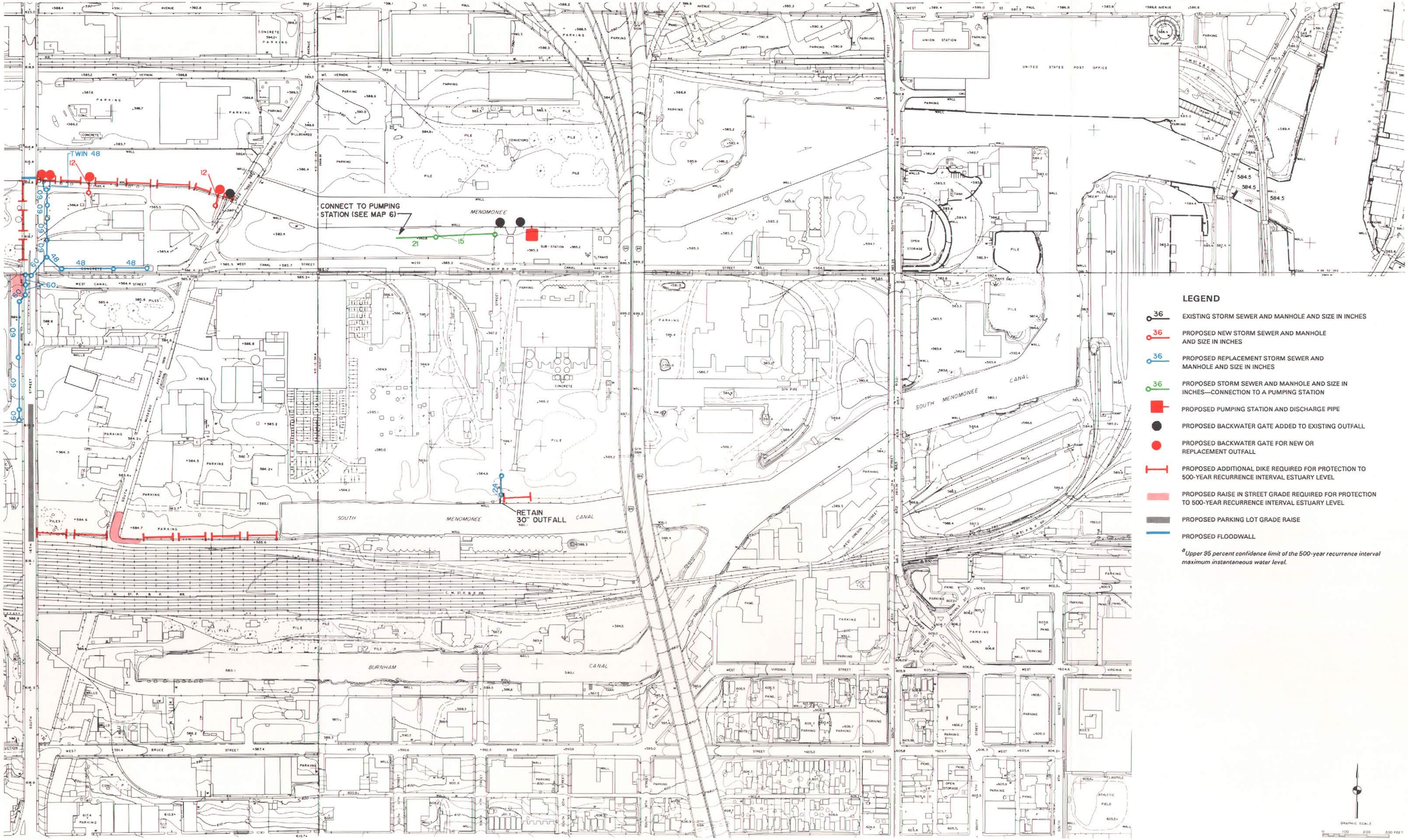


[a] *Upper 95 percent confidence limit of the 500-year recurrence interval maximum instantaneous water level.*

Source: SEWRPC.

Map 11

ALTERNATIVE 2D—ADDITIONAL DIKES, FLOODWALLS, FILLING, AND DECENTRALIZED STORMWATER PUMPING FACILITIES ALONG THE MENOMONEE RIVER ESTUARY TO PROVIDE PROTECTION TO A 500-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL[a]



Source: SEWRPC.

an additional 60 lineal feet of new 12-inch-diameter storm sewer; six backwater gates for existing storm sewer outfalls; and four backwater gates for new or replacement storm sewer outfalls. In addition, instead of calling for 110 feet of 18-inch-diameter connector to a pumping station as does Alternative Plan 1D, Alternative Plan 2D calls for a 21-inch-diameter storm sewer. As under Alternative Plan 2C, if the specified filling in the 500-year floodplain had not occurred at the time this alternative was to be implemented, flood protection and drainage facilities would have to be provided in those areas originally designated to be filled. The capital and operation and maintenance costs for Alternative Plan 2D are given in Table 2.

Alternative Plan 2E—Dikes, Floodwalls, and Centralized Stormwater Storage and Pumping Facilities to Provide Protection to a 500-Year Recurrence Interval Lake Michigan Level

Alternative 2E is an expansion of Alternative 1E for the purpose of providing flood protection to a 500-year recurrence interval lake level. The components of Alternative Plan 2E that are required in addition to the components of Alternative Plan 1E are shown on Map 12. The alternative plan calls for the construction of an additional 2,370 lineal feet of dike, ranging up to about 2.5 feet in height above grade; an additional 80 lineal feet of one-foot-high floodwall; 410 feet of street grade raise and repaving, ranging in height from 0.2 foot to 2.0 feet above the existing grade; 100 lineal feet of railway crossing reconstruction; approximately 48,800 square feet of parking lot grade raise and repaving, ranging in height from 2.0 to 2.3 feet above the existing grade; two stormwater storage and pumping facilities with pumping capacities of 2 cfs and 3 cfs and storage volumes of 0.06 and 0.21 acre-feet, respectively; 310 lineal feet of 15-inch-diameter storm sewer connecting an existing outfall with a pumping station; an additional 1,720 lineal feet of storm sewer replacing existing storm sewer and ranging in diameter from 24 to 60 inches; an additional 60 lineal feet of new 12-inch-diameter storm sewer; six backwater gates for existing storm sewer outfalls; and four backwater gates for new or replacement storm sewer outfalls. In addition, two of the stormwater storage facilities called for in Alternative Plan 1E would be larger in size under this alternative. Also, instead of calling for 110 feet of 18-inch-diameter connector to a pumping station as does Alternative Plan 1E, Alternative Plan 2E calls for a 21-inch-diameter storm sewer. As under Alternative Plan 2C, if the specified filling in the 500-year floodplain had not occurred at the time this alternative was to be implemented, flood protection and drainage facilities would have to be provided in those areas originally designated to be filled. The capital and operation and maintenance costs for Alternative Plan 2E are given in Table 2.

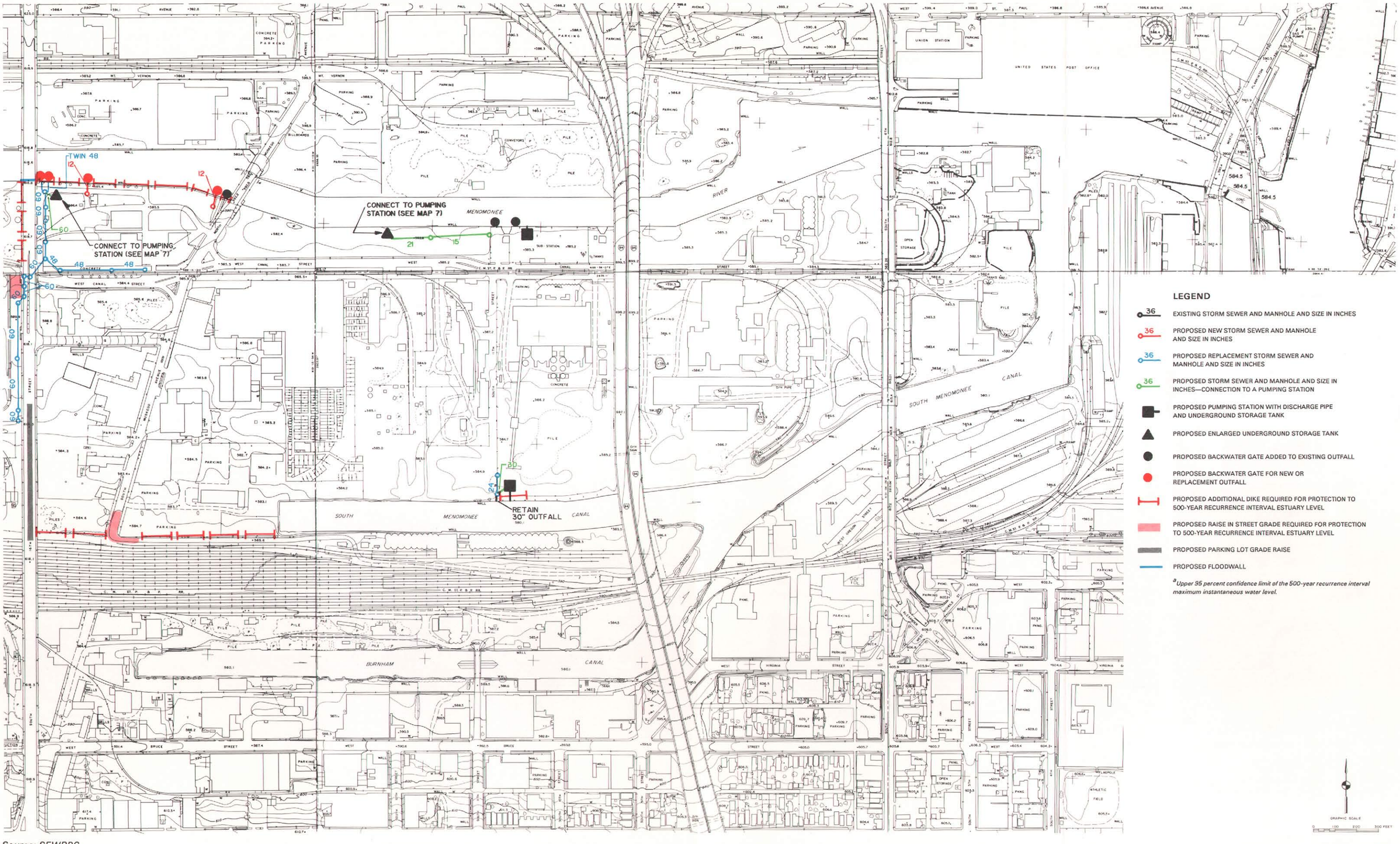
Alternative Plan 3—Floodproofing to Provide Protection to a 100-Year Recurrence Interval Lake Michigan Level

The components of Alternative Plan 3 are shown on Map 13. Floodproofing measures may include the installation of backwater valves in sanitary or storm sewer building connections; the operation of sump pumps to remove any floodwaters that enter the basement of a structure through foundation drains or other openings; the installation of waterproof seals at structural joints; the reinforcement of walls and floors to withstand hydrostatic loads, uplift loads, and impact loads from debris carried by floodwaters; the construction of earthen berms or masonry walls around a structure or cluster of structures; the installation of glass block in basement window openings and flood shields over doorways, windows, or other structure openings; and the elevation of electrical machinery and equipment above flood stage.

The alternative plan calls for floodproofing 13 structures that are located wholly or partially within the 100-year recurrence interval floodplain, regrading and repaving 163,300 square feet of parking and material storage areas along with the placement of approximately 7,100 cubic yards of fill, raising 1,200 lineal feet of street and associated storm sewer inlets and manholes to a maximum height of about one foot above the existing grade; raising 910 lineal feet of railway track a maximum of 1.4 feet above the existing grade, including reconstruction at street crossings; raising 400 lineal feet of railway spur a maximum of one foot above the existing grade; raising the existing storm sewer manholes and inlets located east of S. 6th Street; constructing 550 lineal feet of floodwall with a maximum height of 2.5 feet above the existing grade to protect the electrical substation at the Wisconsin Electric Power Company (WEPCo) valley power plant; constructing 40 lineal feet of 15-inch-diameter storm sewer with a backwater gate to provide gravity drainage for the WEPCo substation during periods of normal or low estuary

Map 12

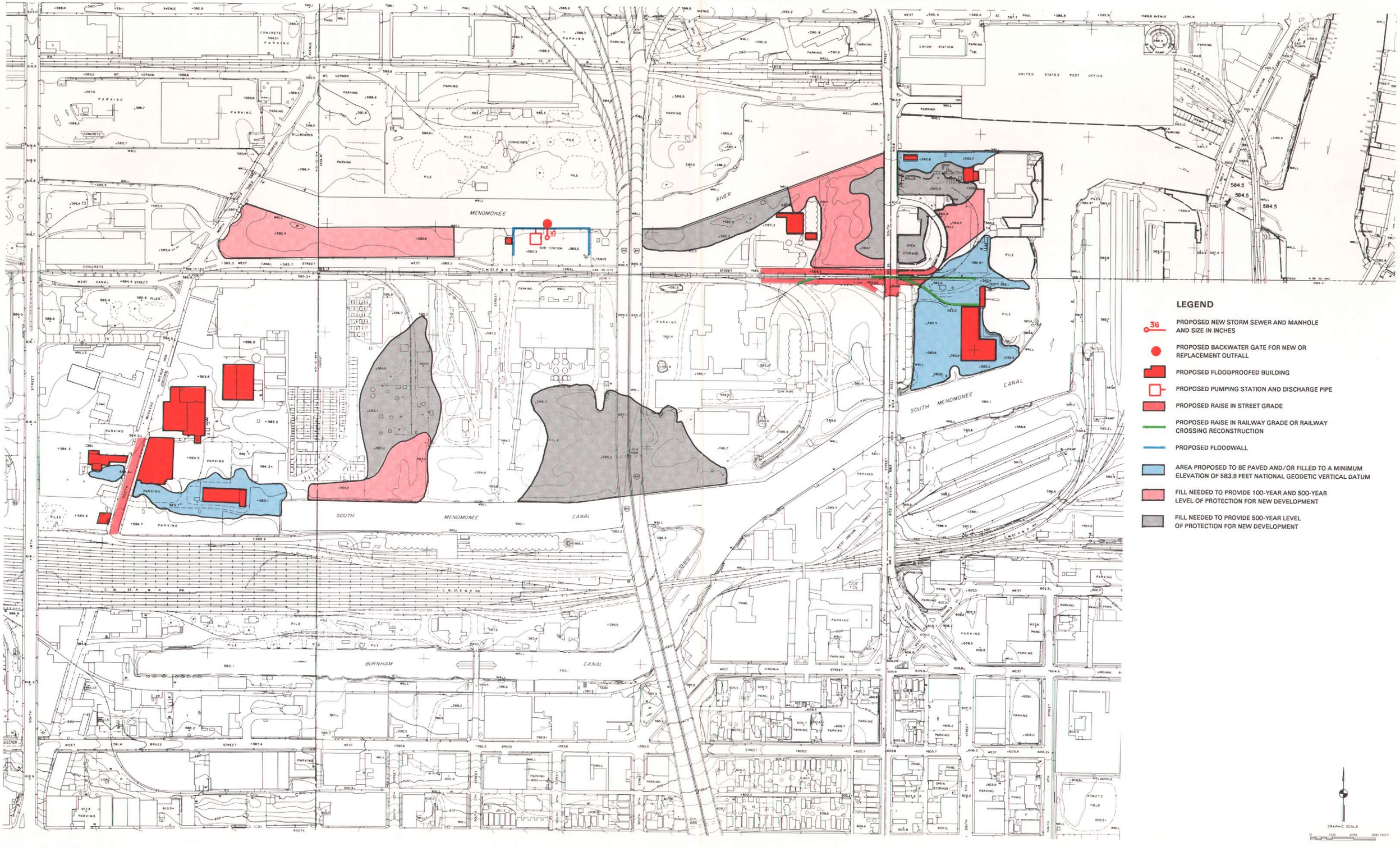
ALTERNATIVE 2E—ADDITIONAL DIKES, FLOODWALLS, AND CENTRALIZED STORMWATER STORAGE AND PUMPING FACILITIES ALONG THE MENOMONEE RIVER ESTUARY TO PROVIDE PROTECTION TO A 500-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL[a]



Source: SEWRPC.

Map 13

ALTERNATIVE 3—FLOODPROOFING: 100-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL



Source: SEWRPC.

levels; constructing one pumping station with a capacity of 5 cfs to serve the WEPCo substation during periods of high estuary levels; and placing 62,000 cubic yards of fill in areas of future development. Under existing conditions, the minimum clearance between the railway and the S. 16th Street viaduct is 20.7 feet. That minimum clearance would be maintained under this alternative.

As required by Chapter NR 116 of the Wisconsin Administrative Code, the floodproofing alternative plan provides for floodproofing protection to an elevation 2.0 feet above the 100-year recurrence interval flood elevation of 584.3 feet NGVD, and the plan assumes that all new construction within the 100- and 500-year recurrence interval floodplains would be constructed on fill to a height of 586.3 feet NGVD. By floodproofing and filling to elevation 586.3 feet NGVD, protection is provided for a 500-year recurrence interval water level with 0.4 foot of freeboard. If this alternative for the initial phase of the plan were implemented with new construction on fill being required only within the 100-year floodplain, and it was subsequently found that implementation of the 500-year-level protection phase of the plan was necessary, new structures constructed outside the 100-year floodplain but within the 500-year floodplain could require additional flood protection measures. Therefore, the cost of construction on fill within the 500-year floodplain is included under this initial phase alternative. The regrading, repaving, and filling of existing parking lot and material storage areas and the street and railway grade raises are called for to prevent the occurrence of long-term standing water in streets, parking lots, and building access areas. In these areas, fill would be placed and grades raised to elevation 583.9 feet NGVD, which is the 100-year recurrence interval daily mean maximum lake level. Therefore, on the average, standing water in street, parking, and access areas would not be encountered for more than one day under 100-year recurrence interval lake levels. The capital costs for Alternative Plan 3 are given in Table 1.

Alternative Plan 4—Floodproofing to Provide Protection to a 500-Year Recurrence Interval Lake Michigan Level

The components of Alternative Plan 4 that are required in addition to the components of Alternative Plan 3 are shown on Map 14. The alternative plan calls for floodproofing 19 additional structures that are located wholly or partially within the 500-year recurrence interval floodplain and constructing an additional 500 lineal feet of one-foot-high floodwall to protect the electrical substation at the WEPCo valley power plant. The alternative plan provides for floodproofing protection to an elevation of 586.3 feet NGVD, and assumes that all new construction within the 500-year recurrence interval floodplain would be constructed on fill to a height of 586.3 feet NGVD. The costs of providing fill within the 500-year floodplain are assigned to Alternative Plan 3, rather than Alternative Plan 4. The capital costs for Alternative Plan 4 are given in Table 2.

COMPARISON OF ALTERNATIVE PLANS

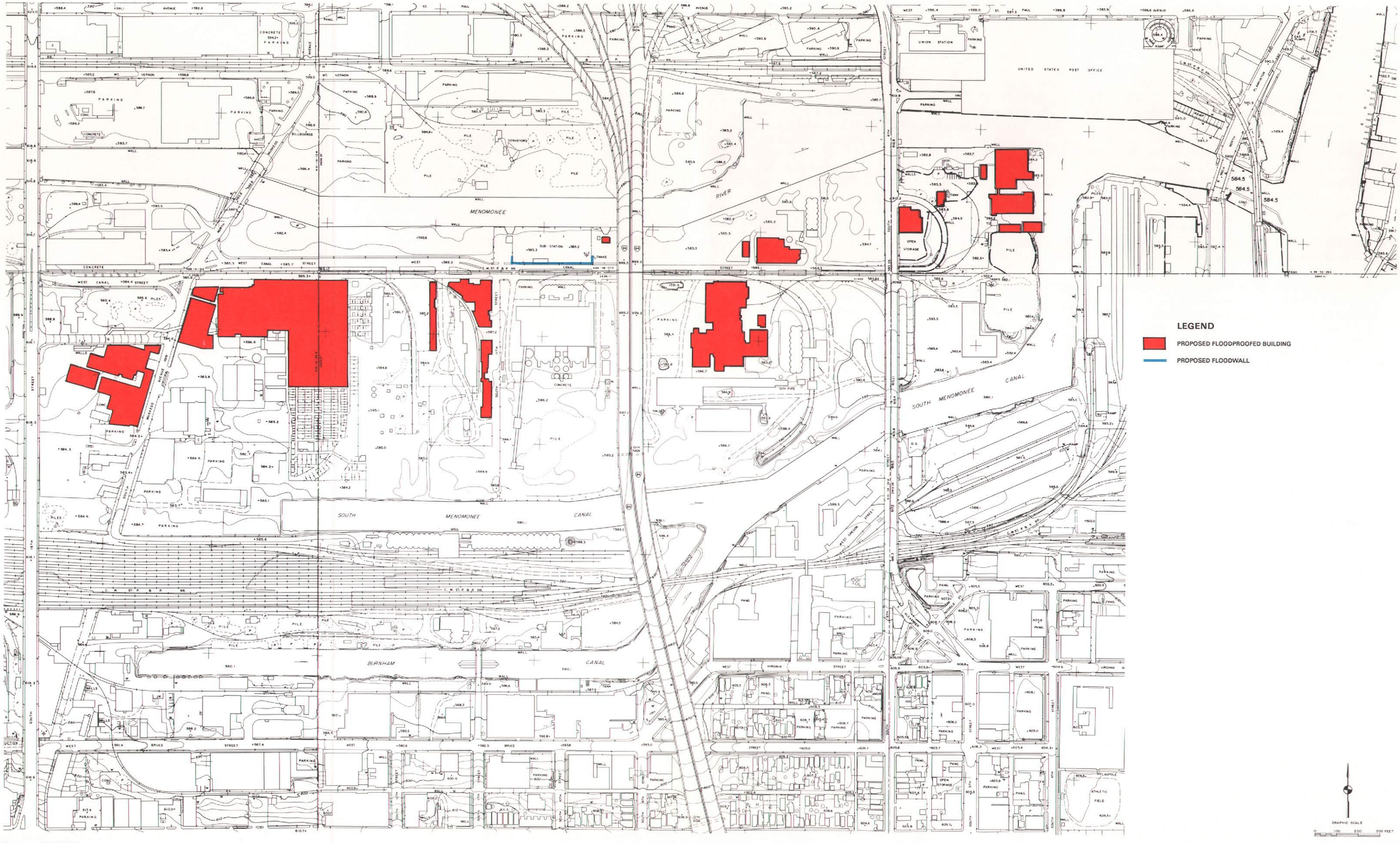
Alternative Plans 1A, 1B, 1C, 1D, 1E, and 3, which were designed to provide flood protection under 100-year recurrence interval lake level conditions, were compared with respect to their ability to eliminate flood damages and to provide adequate stormwater drainage. Following that comparison, the additional measures necessary to provide protection to the upper 95 percent confidence limit of the 500-year recurrence interval maximum instantaneous water level, which were included in Alternative Plans 2A, 2B, 2C, 2D, 2E, and 4, were considered in conjunction with their companion plans from the 100-year recurrence interval group.

Benefit-cost ratios for each alternative are given in Tables 3 and 4. The annual cost used to calculate the benefit-cost ratio for Alternative 3, Floodproofing, excludes the cost of providing fill for new construction, because the fill is not required to provide flood protection, and flood control benefits, for existing structures. Its function would be to provide benefits for new construction. Because the magnitude of those benefits is unknown, it is appropriate that neither the benefits nor their associated costs be included in the tabulation of annual benefits.

For floodproofing alternatives for both the 100- and 500-year recurrence interval protection levels, the annual benefits are somewhat less than the corresponding benefits for the structural alternatives, because there are some residual damages which result from relatively short-term flooding of streets, parking lots, and building access areas under the floodproofing alterna-

Map 14

ALTERNATIVE 4—ADDITIONAL FLOODPROOFING TO PROVIDE PROTECTION TO A 500-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL



Source: SEWRPC.

Table 3

BENEFIT-COST ANALYSIS FOR THE MENOMONEE RIVER ESTUARY PROTECTION TO A 100-YEAR RECURRENCE INTERVAL ESTUARY LEVEL

Alternative	Total Annual Cost	Total Annual Benefits	Annual Benefits Minus Annual Costs	Benefit-Cost Ratio	Economic Ratio Greater than One
1A Dikes, Floodwalls, and Centralized Stormwater Pumping Facilities	$415,200	$4,800	$-410,400	0.012	No
1B Dikes, Floodwalls, and Decentralized Stormwater Pumping Facilities	440,400	4,800	-435,600	0.011	No
1C Dikes, Floodwalls, Filling, and Centralized Stormwater Pumping Facilities	415,600	4,800	-410,800	0.012	No
1D Dikes, Floodwalls, Filling, and Decentralized Stormwater Pumping Facilities	443,300	4,800	-438,500	0.011	No
1E Dikes, Floodwalls, Filling, and Centralized Stormwater Storage and Pumping Facilities	445,700	4,800	-440,900	0.011	No
3 Floodproofing	93,300[a]	4,100	-89,200	0.044	No

[a]*Cost excludes fill provided for new development.*

Source: SEWRPC.

tives. As discussed in the sections describing floodproofing Alternative Plans 3 and 4, means are provided to minimize those residual damages.

Comparison of Alternative Plans to Provide Flood Protection to a 100-Year Recurrence Interval Lake and Estuary Level

Structural Alternative Plans 1A through 1E would all provide a similar level of protection from floods and stormwater runoff. With the exception of limited flooding in several relatively small areas immediately adjacent to the estuary, the entire study area would be protected from overland flooding during 100-year recurrence interval estuary levels. Stormwater drainage from the interior protected area would be removed through gravity flow or pumping, preventing inundation of structures and enabling access to buildings during the combined occurrence of a 100-year estuary level and storms with recurrence intervals up to two years, or of a two-year estuary level and storms with recurrence intervals up to 100 years.

Of the five structural alternative plans, Alternative Plan 1B, Dikes, Floodwalls, and Decentralized Stormwater Pumping Facilities, has the lowest capital cost, but the highest annual operation and maintenance costs, placing it third lowest in average annual cost. Alternative Plan 1C, Dikes, Floodwalls, Filling, and Centralized Stormwater Pumping Facilities, has the lowest annual operation and maintenance costs and the third lowest capital cost, placing it second lowest in average annual cost. Alternative Plan 1A, Dikes, Floodwalls, and Centralized Stormwater Pumping Facilities, has the second lowest capital and annual operation and maintenance costs, placing it lowest in average annual costs. The average annual costs of Alternative Plans 1A and 1C are essentially equal and their capital costs are within 1 percent. The average annual cost of Alternative 1B is $440,400, which is somewhat greater than the $415,000 average annual cost of Alternatives 1A and 1C. The benefit-cost ratios of the structural alternatives are all essentially equal, being either 0.011 or 0.012. Alternative Plan 1C was

Table 4

BENEFIT-COST ANALYSIS FOR THE MENOMONEE RIVER ESTUARY PROTECTION TO A 500-YEAR RECURRENCE INTERVAL ESTUARY LEVEL

Alternative	Additional Annual Cost	Additional Annual Benefits	Annual Benefits Minus Annual Costs	Benefit-Cost Ratio	Economic Ratio Greater than One
2A Dikes, Floodwalls, and Centralized Stormwater Pumping Facilities	$153,200	$5,200	$-148,000	0.034	No
2B Dikes, Floodwalls, and Decentralized Stormwater Pumping Facilities	162,300	5,200	-157,100	0.032	No
2C Dikes, Floodwalls, Filling, and Centralized Stormwater Pumping Facilities	113,500	5,200	-108,300	0.046	No
2D Dikes, Floodwalls, Filling, and Decentralized Stormwater Pumping Facilities	113,500	5,200	-108,300	0.046	No
2E Dikes, Floodwalls, and Centralized Stormwater Storage and Pumping Facilities	108,600	5,200	-103,400	0.048	No
4 Floodproofing	19,700	4,700	- 15,000	0.24	No

Source: SEWRPC.

selected for further comparison with Alternative Plan 3, Floodproofing, because Plan 1C places less reliance on stormwater pumping and more reliance on gravity drainage than does Plan 1A, thereby reducing the risk of mechanical or electrical malfunction.

By definition, a floodproofing plan is intended to protect structures and structure contents and to ensure continuation of utility services during a given flood event. Alternative Plan 3 would provide protection for buildings and their contents during the instantaneous maximum 100-year recurrence interval estuary level; however, that alternative would not provide the same degree of protection for streets, parking areas, and building access areas as would Alternative Plan 1C. With the exception of the WEPCo substation, Alternative Plan 3 does not prevent instantaneous 100-year recurrence interval floodwaters from inundating certain streets, parking and open areas, and building access areas located within the 100-year recurrence interval floodplain as shown on Map 2. The duration of such inundation should, however, be less than one day owing to the proposed street and railway grade raises and filling which would raise transportation routes and building access areas above the daily mean maximum 100-year recurrence interval estuary level of 583.9 feet NGVD. Under Alternative Plan 3, overland flow paths to the estuary would not be blocked by structural flood control works except at the WEPCo substation. As a result, the existing stormwater drainage system would be unchanged except for minor alterations to accommodate street grade raises and filling, and to convey runoff from the substation area.

The capital cost of Alternative Plan 3 is $2,363,000, the annual operation and maintenance cost is $6,600, the average annual cost is $157,000, and the benefit-cost ratio is 0.044. These costs compare with a capital cost of $5,856,000, an annual operation and maintenance cost of $35,600, an average annual cost of $415,600, and a benefit-cost ratio of 0.012 for Alternative Plan 1C. Alternative Plan 1C, which is essentially the least costly structural plan, and Alternative Plan 3, which is the least costly

plan overall, were considered further in combination with their companion plans for protection to a 500-year recurrence interval level.

Comparison of Alternative Plans to Provide Flood Protection to a 500-Year Recurrence Interval Lake and Estuary Level

Alternative Plans 2A through 2E would all provide a similar level of protection from floods and stormwater runoff. The entire study area would be protected from overland flooding during 500-year recurrence interval estuary levels. Stormwater drainage from the interior protected area would be removed through gravity flow or pumping, preventing inundation of structures and enabling access to buildings during the combined occurrence of a 100-year estuary level and storms with recurrence intervals up to two years, or of a two-year estuary level and storms with recurrence intervals up to 100 years.

As shown in Tables 2 and 4, of the five structural alternative plans, Alternative Plan 2E, Dikes, Floodwalls, and Centralized Stormwater Storage and Pumping Facilities, has the lowest capital and average annual costs and the highest benefit-cost ratio. The additional drainage and flood control measures and costs required for Alternative Plans 2C, Dikes, Floodwalls, Filling, and Centralized Stormwater Pumping Facilities, and 2D, Dikes, Floodwalls, Filling, and Decentralized Stormwater Pumping Facilities, are identical, and those plans have the lowest annual operation and maintenance costs and the second highest benefit-cost ratios. Alternative Plan 2C is the companion alternative to Alternative Plan 1C; it could most readily be implemented in a second stage following implementation of Alternative Plan 1C. The average annual cost of Alternative Plan 2C is only about 5 percent greater than the average annual cost of Alternative Plan 2E. The combined capital and average annual costs of Alternative Plans 1C and 2C are the lowest, and the combined benefit-cost ratio is the highest, of all the structural alternatives. Therefore, Alternative 2C was selected for further comparison with Alternative Plan 4, Floodproofing.

The general comments in the preceding section regarding Alternative Plan 3 also apply to Alternative Plan 4, with the exception that Alternative 4 would provide flood protection up to the 95 percent confidence limit of the instantaneous 500-year recurrence interval estuary level. The capital cost of Alternative Plan 4 is $306,000, the annual operation and maintenance cost is $300, the average annual cost is $19,700, and the benefit-cost ratio is 0.24. These costs compare with a capital cost of $1,553,000, an annual operation and maintenance cost of $13,400, an average annual cost of $113,500 , and a benefit-cost ratio of 0.046 for Alternative Plan 2C.

Consideration of Providing Pumping Capacity to Discharge a 25-Year Recurrence Interval Storm

In a letter dated January 31, 1989, the City of Milwaukee requested that a 25-year recurrence interval storm, rather than a two-year recurrence interval storm, be used to size the stormwater pumping stations in order to reduce the amount and frequency of stormwater ponding in protected areas. The city staff felt that such a level of protection was warranted owing to the critical nature of the public and private facilities located in the study area.

The cost of providing pumping capacity for a 25-year recurrence interval storm was estimated for Alternatives 1C and 2C, which have the highest combined benefit-cost ratio of all the structural alternatives considered, and for Alternative 3, Floodproofing. The costs for the three alternatives are itemized in Table 5. The only differences between the costs in Table 5 and those in Tables 1 and 2 are for pumping stations, storm sewer connections to pumping stations, and land acquisition. For Alternative 1C, an additional pumping station would be constructed east of the intersection of W. Canal Street and S. 6th Street. That station would pump 25-year storm runoff in excess of the capacity of the existing storm sewers which would be connected to proposed pumping stations located west of S. 6th Street.

A comparison of Table 1 with Table 5 shows that the provision of pumping capacity for a 25-year storm would increase the capital cost of Alternative 1C by about 37 percent to $7,994,000. The total annual cost would increase 36 percent to $563,400. The benefit-cost ratio would, however, remain at about 0.01. The capital cost of Alternative 2C would increase by about 4 percent to $1,616,000. The total annual cost would increase about 4 percent to $117,700, and the benefit-cost ratio would decrease from 0.05 to 0.04. The cost of Alternative 3 would increase by about 1 percent to $2,385,000. The total annual cost would increase about 1 percent to $158,500. However, the benefit-cost ratio would remain at about 0.04.

Table 5

COST ESTIMATES FOR FLOOD CONTROL ALTERNATIVES 1C, 2C, AND 3 FOR THE MENOMONEE RIVER ESTUARY: 100-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL WITH STORMWATER PUMPING CAPACITY FOR A 25-YEAR STORM

Flood Control Alternative	Capital	Amortized Capital[a]	Annual Operation and Maintenance	Total
1C Dikes, Floodwalls, Filling, and Centralized Stormwater Pumping Facilities				
Dikes	$ 201,000	$ 12,800	$ 1,300	$ 14,100
Floodwalls	500,000	31,800	1,100	32,900
Fill for 100-Year Protection	666,000	42,300	0	42,300
Additional Fill for 500-Year Protection	264,000	16,800	0	16,800
Stormwater Drainage	941,000	59,800	100	59,900
Pumping Stations[b]	4,698,000	312,200	36,000	348,200
Storm Sewer Connections to Pumping Stations	620,000	39,400	1,100	40,500
Backwater Gates	59,000	3,800	2,000	5,800
Land Acquisition	45,000	2,900	0	2,900
Total	$7,994,000	$521,800	$41,600	$563,400
2C Dikes, Floodwalls, Filling, and Centralized Stormwater Pumping Facilities				
Dikes	$ 99,000	$ 6,300	$ 800	$ 7,100
Floodwalls	13,000	800	100	900
Street Grade Raises	50,000	3,200	0	3,200
Railway Crossing Reconstruction	80,000	5,100	0	5,100
Parking Lot Grade Raises	88,000	5,600	0	5,600
Stormwater Drainage	704,000	44,700	0	44,700
Pumping Stations[b]	520,000	34,600	12,000	46,600
Storm Sewer Connections to Pumping Stations	50,000	3,200	200	3,400
Backwater Gates	6,000	400	300	700
Land Acquisition	6,000	400	0	400
Total	$1,616,000	$104,300	$13,400	$117,700
3 Floodproofing				
Floodproofing of 13 Structures	$ 306,000	$ 19,400	$ 0	$ 19,400
Fill for Protection of New Buildings in the 100-Year Floodplain	503,000	32,000	0	32,000
Additional Fill for Protection of New Buildings in the 500-Year Floodplain	499,000	31,700	0	31,700
Parking Lot Regrading and Repaving	379,000	24,100	0	24,100
Street Grade Raises	171,000	10,900	0	10,900
Railway Grade Raises	293,000	18,600	0	18,600
Floodwalls	116,000	7,400	300	7,700
Pumping Station[b]	110,000	7,300	6,000	13,300
Storm Drainage Including Backwater Gates	8,000	500	300	800
Total	$2,385,000	$151,900	$ 6,600	$158,500

[a] *Amortized capital cost is based on an interest rate of 6 percent and a project life of 50 years.*

[b] *Amortized capital cost includes the replacement of pumps and appurtenant equipment after 25 years of operation.*

Source: SEWRPC.

For Alternative 1C, the provision of pumping capacity for a 25-year recurrence interval storm would require an aggregate capacity of 360 cfs for all pumping stations, as compared with an aggregate capacity of 188 cfs for pumping a two-year recurrence interval storm. For Alternative 2C, the additional aggregate pumping capacity required would increase from 29 cfs to 37 cfs. For Alternative 3, the capacity of the single pumping station would increase from 5 cfs to 9 cfs.

Use of a 25-year design storm for pumping may be expected to result in similar cost increases for all structural alternatives considered, and would increase the cost of the floodproofing alternative to a lesser degree; therefore, the floodproofing alternative becomes even more desirable in comparison to the structural alternative.

RECOMMENDED PLAN

Recommended Plan for the Portion of the Study Area East of S. 16th Street

The combined capital, annual operation and maintenance, and average annual costs of Alternative Plans 3 and 4 are the lowest, and the combined benefit-cost ratio is the highest, of all the alternative plans considered. Because the combination of Alternative Plans 3 and 4 provides the same level of flood damage protection to buildings as the combination of Alternative Plans 1C and 2C at a considerably lower cost, and because the combination of Alternative Plans 3 and 4 essentially permits the existing stormwater drainage system to function as originally designed, it is recommended that Alternative Plan 3 be implemented to provide flood protection for the study area up to a 100-year recurrence interval water level in the estuary, and that Alternative Plan 4 be established as a contingency plan to be implemented in the future should it be found that Lake Michigan is in a long-term rising trend. Because the existing buildings to be floodproofed are owned by a relatively small number of organizations, including the City of Milwaukee, it should be possible to implement the measures of the recommended plan in a coordinated and effective manner. When new structures are constructed on fill, careful consideration should be given to the impacts of the fill on overland flow patterns for stormwater runoff in excess of the capacity of the existing stormwater drainage system.

Implementation of the plan is recommended despite the low benefit-cost ratios because, in addition to the quantified benefits attributable to protection of structures and their contents, the plan provides certain unquantifiable secondary benefits accruing from the protection of essential government services, electric utility operation, and industrial production. For example, inadequate flood protection of the WEPCo substation at the valley power plant could disrupt electrical service in the Milwaukee area. Also, a substantial proportion of the capital cost of the recommended floodproofing alternative is for grade raises to prevent long-term flooding of streets, railways, parking lots, and building access areas. Although not practical to quantify, the benefits resulting from providing measures to preserve access to government, industrial, and commercial facilities would be substantial. Finally, constructing new buildings on fill within the 100- and 500-year recurrence interval floodplains will permit development without the provision of additional flood protection. Such development could produce substantial benefits in terms of provision of essential government services, expansion of the City's tax base, and creation of employment. Since the recommendation provides for floodproofing, each individual property owner can judge the benefits and costs associated with the recommendation and make a decision with regard to implementation.

The recommended plan for protection to the 100-year recurrence interval estuary level is shown on Map 13. The plan calls for floodproofing 13 structures which are located wholly or partially within the 100-year recurrence interval floodplain; placing approximately 7,100 cubic yards of fill; regrading and repaving 163,300 square feet of parking and material storage areas; raising 1,200 lineal feet of street and associated storm sewer inlets and manholes to a maximum height of 1.0 foot above the existing grade; raising 910 lineal feet of railway track a maximum of 1.4 feet above the existing grade, including reconstruction at street crossings; raising 560 lineal feet of railway spur a maximum of 1.0 foot above the existing grade; raising the existing storm sewer manholes and inlets located east of S. 6th Street; constructing 550 lineal feet of floodwall with a maximum height of 2.5 feet above the existing grade to protect the electrical substation at the Wisconsin Electric Power Company valley power plant; constructing 40 lineal feet of 12-inch-diameter storm sewer with a backwater gate to provide gravity drainage for the WEPCo substation during periods of normal or low estuary levels; constructing one pumping station with a capacity of 9 cfs to serve the WEPCo substation during periods of high

estuary levels; and placing 62,000 cubic yards of fill in areas of future development. All floodproofing measures should be designed to protect against backflow into buildings from connections to private or public storm sewers which discharge to the estuary. All proposed grade raises are solely for the purpose of preventing the occurrence of long-term standing water in streets, parking lots, and building access areas, and along railway tracks. The existing minimum clearance of 20.7 feet between the railway tracks and the S. 6th Street viaduct would be maintained. The City plans to rehabilitate or reconstruct the viaduct in 1992. The plan to raise street and railway grades along W. Canal Street in the vicinity of the viaduct should be considered during the design phase of the planned rehabilitation or reconstruction of the viaduct.

The portion of the recommended plan to be implemented if the water level of Lake Michigan enters a period of long-term rise calls for floodproofing 19 additional structures which are located wholly or partially within the 500-year recurrence interval floodplain and constructing an additional 500 lineal feet of one-foot-high floodwall to protect the electrical substation at the WEPCo valley power plant.

The recommended plan provides for floodproofing protection to an elevation of 586.3 feet NGVD and assumes that all new construction within the 500-year recurrence interval floodplain would be constructed on fill to a height of 586.3 feet NGVD. If the initial phase of the plan for protection to a 100-year estuary level were implemented with new construction on fill being required only within the 100-year floodplain, and it was subsequently found that implementation of the 500-year-level protection phase of the plan was necessary, new structures constructed outside the 100-year floodplain, but within the 500-year floodplain, could require additional floodproofing measures. Therefore, construction on fill is recommended within the 500-year floodplain under the initial plan phase.

Consideration of Additional Flood Protection Measures for the Area Between S. 27th Street and S. 16th Street

Because protection of this area was not included in the project scope defined by the City of Milwaukee, the flood protection measures considered for this area are not incorporated in the recommended plan, but are designed so that they could be incorporated at a future time if so desired by the City. For compatibility with the recommended plan, a floodproofing plan was developed for the portion of the study area between S. 27th Street and S. 16th Street, as shown on Map 15.

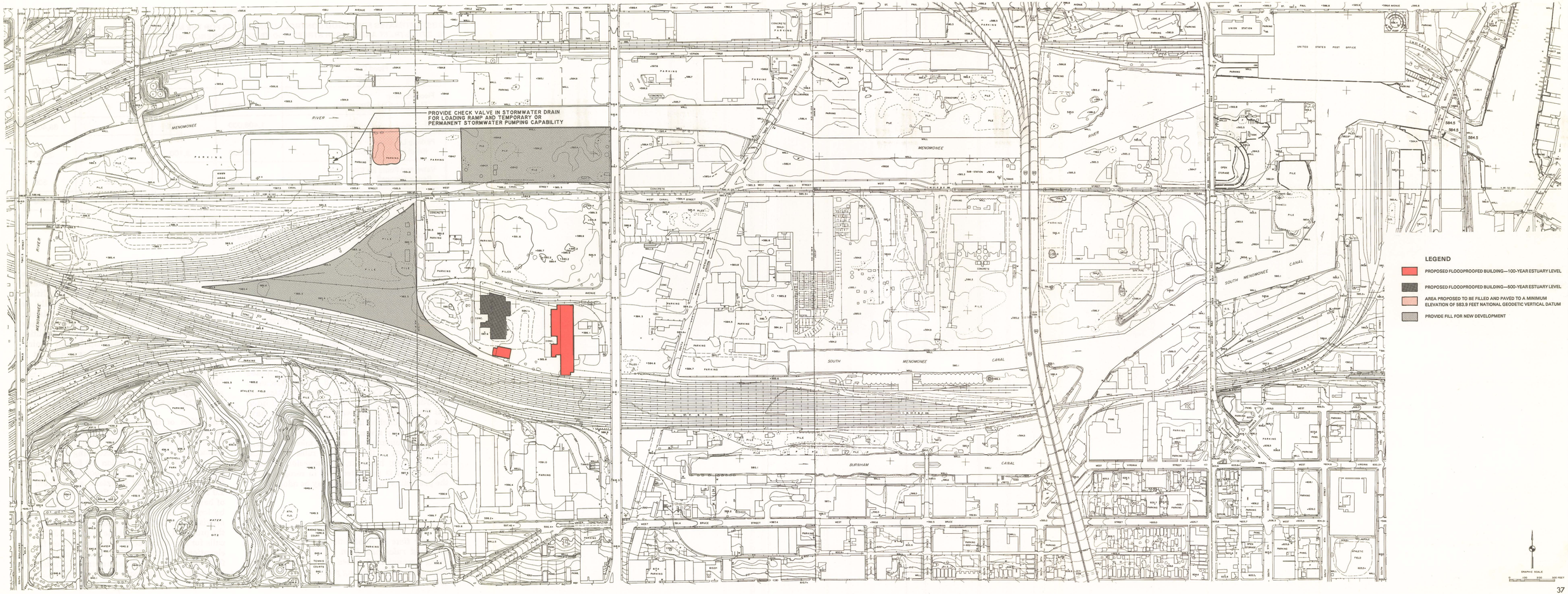
As shown on Map 15, protection from a 100-year recurrence interval estuary level could be provided by floodproofing two existing structures, placing 87,000 cubic yards of fill, and regrading and repaving 40,800 square feet of parking lot. The regrading and repaving of the existing parking lot is required to prevent the occurrence of long-term standing water. Fill would be placed and the grade raised to elevation 583.9 feet NGVD, which is the 100-year recurrence interval daily mean maximum lake level. Approximate capital costs for this plan are given in Table 6. Protection to a 500-year recurrence interval estuary level would require floodproofing of one additional building, at a capital cost of about $6,000.

The below-grade loading dock ramp at the City of Milwaukee Central Repair Garage located at 2142 W. Canal Street is drained by a storm sewer inlet grate with a top elevation of 583.4 feet NGVD. That elevation is 0.9 foot below the 100-year lake level and 2.5 feet below the upper 95 percent confidence level of the 500-year lake level. The entrance to the ramp is at elevation 587.1 feet NGVD, which is higher than both the 100- and 500-year lake levels. Therefore, because the stormwater drain for the ramp is connected to the estuary through a storm sewer, localized flooding of the 35-foot-wide by 80-foot-long ramp could occur at lake levels having a recurrence interval of 25 years or more. It is therefore recommended that a check valve be provided in the outlet pipe for the ramp drain in order to block the connection between the drain and the storm sewer in the event of high lake levels. Permanent or temporary pumping capability would also be necessary to maintain access to the ramp by evacuating stormwater which could collect in the ramp during periods when the valve is closed. Because the entrance to the ramp is about 0.5 foot below the first floor elevation of the repair garage, it is unlikely that stormwater runoff would pond to a level that would cause flooding of the garage. The costs of the recommended valve and pumping facilities are included in Table 6.

The benefit-cost ratio for providing protection to a 100-year recurrence interval estuary level, calculated with the cost of fill for new develop-

Map 15

FLOODPROOFING PLAN FOR THE AREA BETWEEN S. 16TH STREET AND S. 27TH STREET



Source: SEWRPC.

Table 6

COST ESTIMATES FOR FLOOD CONTROL ALTERNATIVES FOR THE MENOMONEE RIVER ESTUARY BETWEEN S. 27TH STREET AND S. 16TH STREET: 100-YEAR RECURRENCE INTERVAL LAKE MICHIGAN WATER LEVEL

Flood Control Alternative	Capital	Amortized Capital[a]	Annual Operation and Maintenance	Total
Floodproofing Floodproof Two Structures	$ 13,000	$ 800	$ 0	$ 800
Fill	1,408,000	89,400	0	89,400
Parking Lot Grade Raise and Repavement	49,000	3,100	0	3,100
Valve and Pump for City Central Repair Garage[b]	3,000	200	100	300
Total	$1,473,000	$93,500	$100	$93,600

[a]*Amortized capital cost is based on an interest rate of 6 percent and a project life of 50 years.*

[b]*Amortized capital cost of pump assumes replacement after 25 years of operation.*

Source: SEWRPC.

ment excluded as under Alternative 3, is 0.018. The incremental benefit-cost ratio for providing the additional protection necessary for a 500-year estuary level is 0.61. The overall benefit-cost ratio for protection from estuary levels with recurrence intervals up to 500 years is 0.071.

Relationship of Recommended Plan to the Proposed Changes to Chapter NR 116 of the Wisconsin Administrative Code

The State of Wisconsin has issued proposed changes to Chapter NR 116 of the Wisconsin Administrative Code which address "critical use facilities" within the 500-year recurrence interval floodplain. At present, those changes have not been published in the Administrative Code; therefore, they are not in effect.[2] The Regional Planning Commission staff has taken a position in opposition to the proposed rules for critical use facilities; however, a discussion of their applicability is presented here in recognition of the possibility that the rules may be adopted.

The proposed rules define critical use facilities as hazardous waste disposal facilities; public water supply or public water treatment facilities; hospitals; group homes for the mentally or physically handicapped or impaired; prisons; nursing homes; police, fire, and emergency service operations; and any additional facilities clearly identified in a municipal flood zoning ordinance as being of critical importance. It is possible that certain city buildings located within the study area may be classified as critical use facilities because of their function as emergency service operations or because of their designation by the City as being of critical importance.

The effect of the proposed rules would be to require that any new or reconstructed critical use facility be located on fill, with the finished surface of the lowest floor, excluding a basement or crawlway, at an elevation 2.0 feet above the 500-year recurrence interval flood elevation. The fill would be required to extend a minimum of 1.0 foot above the 500-year flood level. The floor of basements or crawlways would be required to be located above the 500-year flood level. The provisions of this plan would be consistent with the proposed rules in that the recommended plan calls for new construction to be located on fill at elevation 586.3 feet NGVD. That elevation is 1.1 feet above the 500-year recurrence interval maximum instantaneous lake level of 585.2 feet

[2]*At the time of publication of this report the proposed rules had been withdrawn and were being reconsidered based on comments made during the public hearing process.*

NGVD.[3] Thus, a new critical use facility constructed within the study area would comply with the proposed rules, assuming it had no basement or crawlway and the finished surface of the lowest floor was constructed 0.9 foot above the fill.

Existing critical use facilities within the study area would be in compliance with the proposed rules if they had a flood hazard warning and evacuation plan, allowed only uses not associated with high flood damage potential on floors below an elevation 2.0 feet above the 500-year flood level, had provisions for access by wheeled vehicles during a 500-year flood, and were certified by a registered professional engineer or architect as being able to withstand the forces of a 500-year flood.

IMPLEMENTATION OF THE RECOMMENDED PLAN

The recommended plan is designed to be implemented in two phases: the first phase to be implemented at this time to provide protection to a 100-year recurrence interval estuary level, and the second phase to be implemented in the future if it is found that Lake Michigan water levels are in a long-term rising trend. Implementation of the plan will require the cooperation of the private landowners and the City of Milwaukee in order to completely floodproof structures within the study area.

The total capital cost of the first phase of the recommended plan is $2,385,000, which can be broken down into $69,000 per acre of land that is currently developed within the 100-year floodplain; and $45,000 per acre of land that is currently undeveloped within the 500-year floodplain. The total capital cost of the second, or contingency, phase of the recommended plan is $306,000, or $6,000 per acre of land that is currently developed within the area between the 100- and 500-year floodplain limits. Under the second phase, the additional cost for undeveloped land within the 500-year floodplain would be zero because the first phase would require filling for new development within the 500-year floodplain in order to permit implementation of the second phase without floodproofing new buildings constructed outside the 100-year recurrence interval floodplain but below the 500-year recurrence interval level of 585.9 feet NGVD. The nature of the recommended floodproofing approach permits implementation of the plan in parts through the division of the study area into independent subareas. Implementation of the components of the plan called for in a given subarea would provide flood control protection for that subarea regardless of what measures are taken elsewhere. For protection to 100-year recurrence interval estuary levels, the following six subareas, which are shown on Map 16, were identified:

1. The City of Milwaukee property located east of the 6th Street viaduct and north of W. Canal Street (extended).
2. The property located east of the 6th Street viaduct and south of W. Canal Street (extended).
3. The area located north of W. Canal Street between N. 6th and N. 7th Streets (extended).
4. The WEPCo substation located north of W.Canal Street between S. 11th Street (extended) and the IH 94 bridge.
5. The area along S. Emmber Lane, south of W. Canal Street.
6. Areas to be filled prior to new development.

A breakdown of the costs for implementing the portion of the recommended plan for protection to 100-year estuary levels in each of the six subareas is given in Table 7.

As shown on Map 16, the following two additional subareas were identified under the second phase of the recommended plan which would provide protection to a 500-year recurrence interval estuary level.

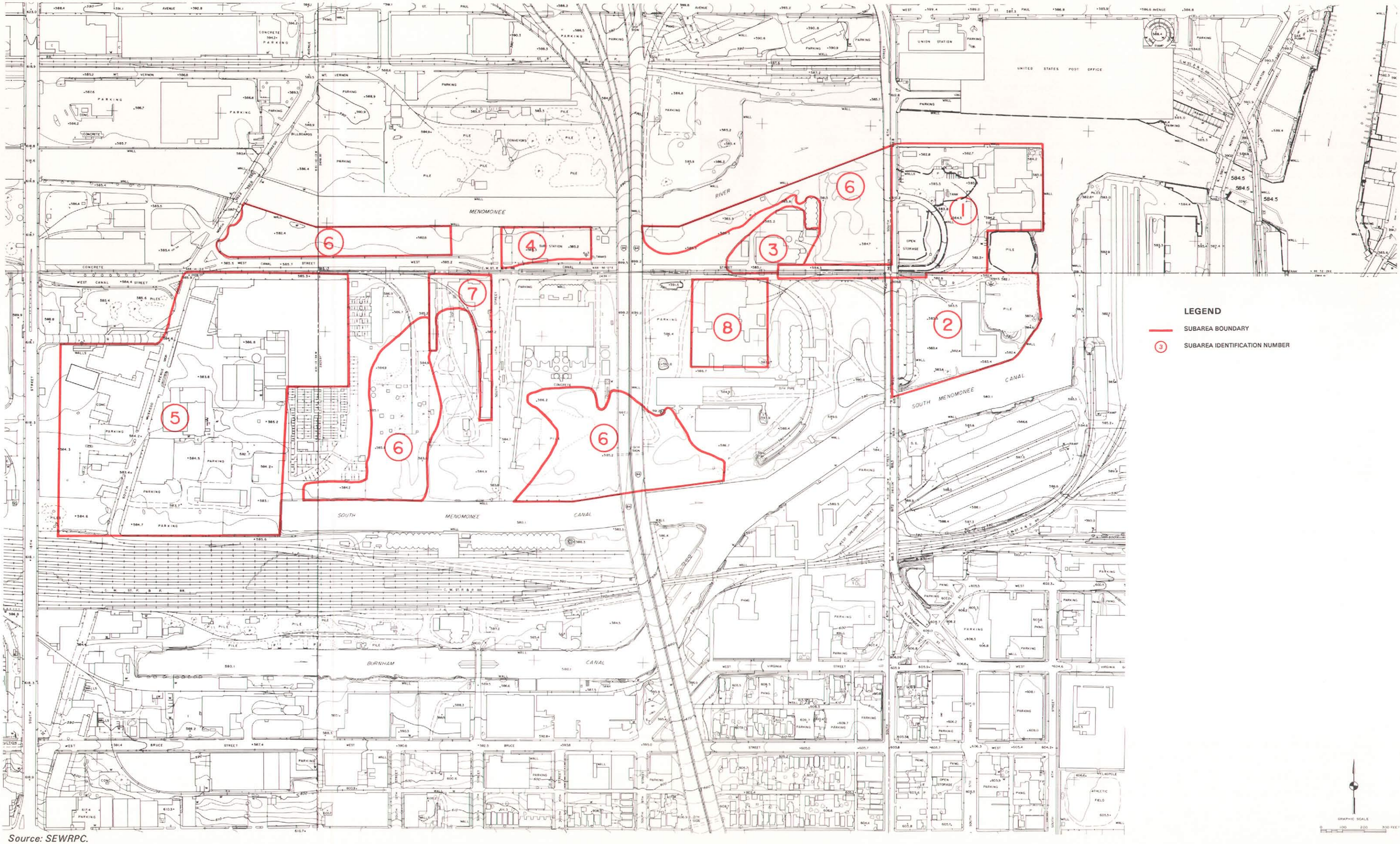
7. The area located southwest of the intersection of W. Canal Street and S. 11th Street.

---

[3] *The proposed rules utilize the 500-year recurrence interval flood level, as opposed to the upper 95 percent confidence limit of the 500-year recurrence interval level. With the exception of this evaluation of the compliance of the plan with the proposed rules, the upper 95 percent confidence limit of the 500-year recurrence interval flood level is used throughout this plan.*

Map 16

SUBAREAS FOR IMPLEMENTATION OF THE RECOMMENDED STORMWATER DRAINAGE AND FLOOD CONTROL SYSTEM PLAN FOR THE MENOMONEE RIVER ESTUARY EAST OF S. 16TH STREET



Source: SEWRPC.

Table 7

COSTS BY SUBAREA OF RECOMMENDED FLOODPROOFING PLAN FOR PROVIDING PROTECTION TO 100-YEAR RECURRENCE INTERVAL ESTUARY LEVELS

Subarea	Floodproofing Cost	
	Capital	Total Annual[a]
1. W. Canal Street and City of Milwaukee Property Northeast of Intersection of S. 6th Street and W. Canal Street	$ 560,000	$ 35,600
2. Southeast of S. 6th Street and W. Canal Street	179,000	11,400
3. North of W. Canal Street Between N. 6th and 7th Streets (extended)	29,000	1,900
4. WEPCo Substation	234,000	21,800[b]
5. Along S. Emmber Lane south of W. Canal Street	381,000	24,200
6. Areas to be Filled Prior to New Development	1,002,000	63,600
Total	$2,385,000	$158,500

[a]Includes amortized capital cost based on an interest rate of 6 percent and a project life of 50 years and annual operation and maintenance cost.

[b]Includes the replacement of pumps and appurtenant equipment after 25 years of operation.

Source: SEWRPC.

Table 8

ADDITIONAL FLOODPROOFING COSTS FOR PROVIDING PROTECTION TO 500-YEAR RECURRENCE INTERVAL ESTUARY LEVELS

Subarea	Floodproofing Cost	
	Capital	Total Annual[a]
1. W. Canal Street and City of Milwaukee Property Northeast of Intersection of S. 6th Street and W. Canal Street	$77,000	$ 4,900
2. Southeast of S. 6th Street and W. Canal Street	0	0
3. North of W. Canal Street Between N. 6th and 7th Streets (extended)	15,000	1,000
4. WEPCo Substation	81,000	5,400
5. Along S. Emmber Lane South of W. Canal Street	51,000	3,200
6. Areas to be Filled Prior to New Development	0	0
7. Southwest of the Intersection of W. Canal Street and S. 11th Street	16,000	1,000
8. South of W. Canal Street Between IH 94 and N. 7th Street (extended)	66,000	4,200
Total	$306,000	$19,700

[a]Includes amortized capital cost based on an interest rate of 6 percent and a project life of 50 years and annual operation and maintenance cost.

Source: SEWRPC.

8. The area located south of W. Canal Street between the IH 94 bridge and N. 7th Street (extended).

A breakdown of the costs for implementing the second phase of the recommended plan for protection to 500-year estuary levels in each applicable subarea is given in Table 8.

The January 31, 1989, letter from the City of Milwaukee requested that a cost apportionment by property owner be provided for the recommended plan and the other alternative plans considered for this study. The estimated costs of implementing the recommended plan were apportioned between the affected property owners in the study area as set forth in Tables 9 and 10. Because the costs of all structural alternatives are similar, the costs for structural Alternative Plans 1C and 2C were selected as being representative of the structural alternatives. Those cost apportionments are provided in Tables 11 and 12. Map 17 delineates the individual properties within the study area and shows the 100- and 500-year recurrence interval floodplain boundaries.

Table 9

RECOMMENDED FLOODPROOFING PLAN TO PROVIDE 100-YEAR RECURRENCE INTERVAL PROTECTION FOR THE AREA EAST OF S. 16TH STREET: ASSIGNMENT OF COSTS TO AFFECTED PROPERTY OWNERS

Property Owner	Cost of Control Measure									Total Capital Cost	Amortized Capital[d,e]	Annual Operation and Maintenance	Total Annual Cost
	Floodproofing	Fill in 100-Year Floodplain[a]	Fill in 500-Year Floodplain[a]	Parking Lot Regrading and Repaving	Street Grade Raises	Floodwalls	Pumping Stations[b]	Storm Drainage	Railway Grade Raises				
Construction Aggregates Corp.	$ 2,000	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ 2,000	$ 100	$ --	$ 100
Morton Norwich Products, Inc.	35,000	--	--	127,000	--	--	--	--	--	162,000	10,300	--	10,300
City of Milwaukee	15,000	15,000	15,000	159,000	108,000	--	--	7,000	--	319,000	20,300	--	20,300
City of Milwaukee Redevelopment Authority	--	302,000	58,000	--	--	--	--	--	--	360,000	22,900	--	22,900
Marquette Cement Co.	--	--	--	--	--	--	--	--	--	0	0	--	0
WEPCo	--	60,000	185,000	--	--	116,000	110,000	1,000	--	472,000	30,300	6,600	36,900
Milwaukee Tallow Co., Inc.	--	--	--	--	--	--	--	--	--	0	0	--	0
St. Mary's Wisconsin Cement, Inc.	29,000	30,000	72,000	--	--	--	--	--	--	131,000	8,300	--	8,300
Sidney J. Cohen-Trustee	--	--	16,000	--	--	--	--	--	--	16,000	1,000	--	1,000
Schneider Fuel & Supply Co.	--	71,000	153,000	--	--	--	--	--	--	224,000	14,300	--	14,300
Aldrich Chemical Co.	19,000	--	--	--	--	--	--	--	--	19,000	1,200	--	1,200
Peck Meat Packing Corp.	206,000	25,000	--	93,000	63,000	--	--	--	--	387,000	24,600	--	24,600
Railway Users (unapportioned)	--	--	--	--	--	--	--	--	293,000	293,000	18,600	--	18,600
Total	$306,000	$503,000	$499,000	$379,000	$171,000	$116,000	$110,000	$8,000	$293,000	$2,385,000	$151,900	$6,600	$158,500

[a]Fill is to be provided for new development. These amounts represent approximate maximum costs. Actual costs will depend on amount of new development.

[b]Pumping capacity provided to pass a 25-year recurrence interval storm.

[c]Pumping station sized for 25-year storm.

[d]Amortized capital cost is based on an interest rate of 6 percent and a project life of 50 years.

[e]Amortized capital cost of pumping stations includes the replacement of pumps and appurtenant equipment after 25 years of operation.

Source: SEWRPC.

Table 10

RECOMMENDED FLOODPROOFING PLAN TO PROVIDE ADDITIONAL PROTECTION TO A 500-YEAR LEVEL FOR THE AREA EAST OF S. 16TH STREET ASSIGNMENT OF COSTS TO AFFECTED PROPERTY OWNERS

Property Owner	Control Measures		Total Capital Cost	Annual Amortized Capital[a]	Total Operation and Maintenance	Annual Cost
	Floodproofing	Floodwall				
Construction Aggregates Corp.	$ --	$ --	$ 0	$ 0	$ --	$ 0
Morton Norwich Products, Inc.	--	--	0	0	--	0
City of Milwaukee	77,700	--	77,700	4,900	--	4,900
City of Milwaukee Redevelopment Authority	--	--	0	0	--	0
Marquette Cement Co.	--	--	0	0	--	0
WEPCo	--	81,000	81,000	5,100	300	5,400
Milwaukee Tallow Co., Inc.	66,000	--	66,000	4,200	--	4,200
St. Mary's Wisconsin Cement, Inc.	15,100	--	15,100	1,000	--	1,000
Sidney J. Cohen-Trustee	16,200	--	16,200	1,000	--	1,000
Schneider Fuel & Supply Co.	--	--	0	0	--	0
Aldrich Chemical Co.	--	--	0	0	--	0
Peck Meat Packing Corp.	50,000	--	50,000	3,200	--	3,200
Soo Line Railroad Co.	--	--	0	0	--	0
CMC Real Estate Corp.	--	--	0	0	--	0
Railway Users (unapportioned)	--	--	0	0	--	0
Total	$225,000	$81,000	$306,000	$19,400	$300	$19,700

[a]*Amortized capital cost is based on an interest rate of 6 percent and a project life of 50 years.*

Source: SEWRPC.

The following criteria were applied to allocate the capital and operation and maintenance costs of the recommended floodproofing plan among the individual property owners:

1. As previously stated, it would be possible to achieve flood protection at individual sites within the study area through the independent implementation of portions of the recommended plan. That feature of the plan permits the determination of the costs of providing flood protection and stormwater drainage benefits for an individual property. The measures for which costs could be assigned to individual property owners include structure floodproofing, the provision of fill for new development, parking lot regrading and repaving, floodwall and pumping station construction, and the installation of private storm sewers.

2. The costs of raising public street grades and associated minor modifications to the public stormwater drainage system were assigned to the City of Milwaukee.

3. The costs of railway grade raises were not specifically assigned. It is assumed that those costs, which comprise about 17 percent of the total capital cost of the recommended plan to provide 100-year protection, would be apportioned among the users of the railway according to agreements to be negotiated between the Soo Line Railroad and the users.

The following criteria were applied to allocate the capital and operation and maintenance costs of Alternative Plans 1C and 2C among the individual property owners:

1. The structural flood control measures that were considered would function as an integrated system which would provide general flood protection and stormwater drainage benefits for the entire protected area; therefore, it is generally not possible to assign the costs of components of a structural alternative to an individual property owner. The capital costs of measures that would provide general benefits

Table 11

ASSIGNMENT OF COSTS TO THE PROPERTY OWNERS WITHIN THE FLOODPLAIN ALTERNATIVE 1C—DIKES, FLOODWALLS, FILLING, AND CENTRALIZED STORMWATER PUMPING FACILITIES TO PROVIDE PROTECTION TO A 100-YEAR RECURRENCE INTERVAL LAKE MICHIGAN LEVEL

Property Owner	Percent of 100-Year Floodplain Area	Capital Cost												
		Dikes	Floodwalls	Fill	Storm Drainage	Pumping Stations	Storm Sewer Connection to Pumping Stations	Backwater Gates	Land Acquisition	Private Storm Sewers	Total Capital Cost	Amortized Capital[b,c]	Annual Operation and Maintenance	Total Annual Cost
Construction Aggregates Corp.	0.3	$ 600	$ 1,500	$ 2,800	$ 1,400	$ 14,100	$ 1,900	$ 200	$ 100	$ --	$ 22,600	$ 1,500	$ --	$ 1,500
Morton Norwich Products, Inc.	9.5	19,100	47,500	88,400	43,100	446,300	58,900	5,600	4,300	--	713,200	46,600	--	46,600
City of Milwaukee	11.5	23,100	57,500	107,000	52,200	540,300	71,300	6,800	5,200	--	863,400	56,400	41,600	98,000
City of Milwaukee Redevelopment Authority	14.1	28,300	70,500	131,100	64,000	662,400	87,400	8,300	6,300	--	1,058,300	69,400	--	69,400
Marquette Cement Co.	0.7	1,400	3,500	6,500	3,200	32,900	4,300	400	300	--	52,500	3,400	--	3,400
WEPCo	10.2	20,500	51,000	94,900	46,300	479,200	63,200	6,000	4,600	--	765,700	50,000	--	50,000
Milwaukee Tallow Co., Inc.	0.0	0	0	0	0	0	0	0	0	--	0	0	--	0
St. Mary's Wisconsin Cement, Inc.	5.6	11,300	28,000	52,100	25,400	263,100	34,700	3,300	2,500	--	420,400	27,500	--	27,500
Sidney J. Cohen-Trustee	0.0	0	0	0	0	0	0	0	0	--	0	0	--	0
Schneider Fuel & Supply Co	5.3	10,700	26,500	49,300	24,100	249,000	32,900	3,100	2,400	--	398,000	26,000	--	26,000
Aldrich Chemical Co.	5.9	11,900	29,500	54,900	26,800	277,200	36,600	3,500	2,700	--	443,100	29,000	--	29,000
Peck Meat Packing Corp.	36.9	74,100	184,500	343,000	167,500	1,733,500	228,800	21,800	16,600	487,000	3,256,800	212,000	--	212,000
Total	100.0	$201,000	$500,000	$930,000	$454,000	$4,698,000	$620,000	$59,000	$45,000	$487,000	$7,994,000	$521,800	$41,600	$563,400

[a] *Pumping capacity provided to pass a 25-year recurrence interval storm.*

[b] *Amortized capital cost is based on an interest rate of 6 percent and a project life of 50 years.*

[c] *Amortized capital cost of pumping stations includes the replacement of pumps and appurtenant equipment after 25 years of operation.*

Source: SEWRPC.

Table 12

ASSIGNMENT OF COSTS TO THE PROPERTY OWNERS WITHIN THE FLOODPLAIN ALTERNATIVE 2C—DIKES, FLOODWALLS, AND CENTRALIZED STORMWATER PUMPING FACILITIES TO PROVIDE ADDITIONAL PROTECTION TO A 500-YEAR RECURRENCE INTERVAL LAKE MICHIGAN LEVEL

Property Owner	Percent of Incremental 500-Year Floodplain Area[a]	Capital Cost													
		Dikes	Floodwalls	Street Grade Raises	Railway Crossing Reconstruction	Parking Lot Grade Raises	Storm Drainage	Pumping Stations[b]	Storm Sewer Connection to Pumping Stations[b]	Backwater Gates	Land Acquisition	Total Capital Cost	Amortized Capital[c,d]	Annual Operation and Maintenance	Total Annual Cost
Construction Aggregates Corp.	0	$ 300	$ 0	$ 200	$ --	$ 300	$ 2,100	$ 1,600	$ 200	$ 0	$ 0	$ 4,700	$ 300	$ --	$ 300
Morton Norwich Products, Inc.	0	0	0	0	--	0	0	0	0	0	0	0	0	--	0
City of Milwaukee	11	10,800	1,400	5,500	--	9,600	76,900	56,500	5,200	700	700	167,300	10,800	13,400	24,200
City of Milwaukee Redevelopment Authority	6	6,100	800	3,100	--	5,500	43,600	32,200	3,100	400	400	95,200	6,100	--	6,100
Marquette Cement Co.	2	2,100	300	1,100	--	1,800	14,800	10,900	1,100	100	100	32,300	2,100	--	2,100
WEPCo	13	13,300	1,700	6,600	--	11,800	94,300	69,700	6,700	800	800	205,700	13,400	--	13,400
Milwaukee Tallow Co., Inc.	7	6,700	900	3,300	--	6,000	47,900	35,400	3,400	400	400	104,400	6,700	--	6,700
St. Mary's Wisconsin Cement, Inc.	6	5,900	800	3,000	--	5,300	42,200	31,200	3,000	400	400	92,200	5,900	--	5,900
Sidney J. Cohen-Trustee	8	8,300	1,100	4,100	--	7,400	59,100	43,700	4,200	500	500	128,900	8,300	--	8,300
Schneider Fuel & Supply Co	4	3,800	500	1,900	--	3,300	26,800	19,800	1,900	200	200	58,400	3,800	--	3,800
Aldrich Chemical Co.	1	900	100	500	--	800	6,300	4,700	500	100	100	14,000	900	--	900
Peck Meat Packing Corp.	31	30,600	4,100	15,500	--	27,200	217,500	160,700	15,500	1,800	1,800	474,700	30,700	--	30,700
Soo Line Railroad Co.	5	4,800	600	2,400	--	4,200	33,800	25,000	2,400	300	300	73,800	4,800	--	4,800
CMC Real Estate Corp.	6	5,400	700	2,800	--	4,800	38,700	28,600	2,800	300	300	84,400	5,400	--	5,400
Milwaukee Metropolitan Sewerage District	0	0	0	0	--	0	0	0	0	0	0	0	0	--	0
John Hennes Trucking Co.	0	0	0	0	--	0	0	0	0	0	0	0	0	--	0
Alex Horn & Armin Nankin	0	0	0	0	--	0	0	0	0	0	0	0	0	--	0
Railway Users (unapportioned)	0	0	0	0	80,000	0	0	0	0	0	0	80,000	5,100	--	5,100
Total	100	$99,000	$13,000	$50,000	$80,000	$88,000	$704,000	$520,000	$50,000	$6,000	$6,000	$1,616,000	$104,300	$13,400	$117,700

[a]500-year recurrence interval floodplain area outside 100-year floodplain area.

[b]Pumping capacity provided to pass a 25-year recurrence interval storm.

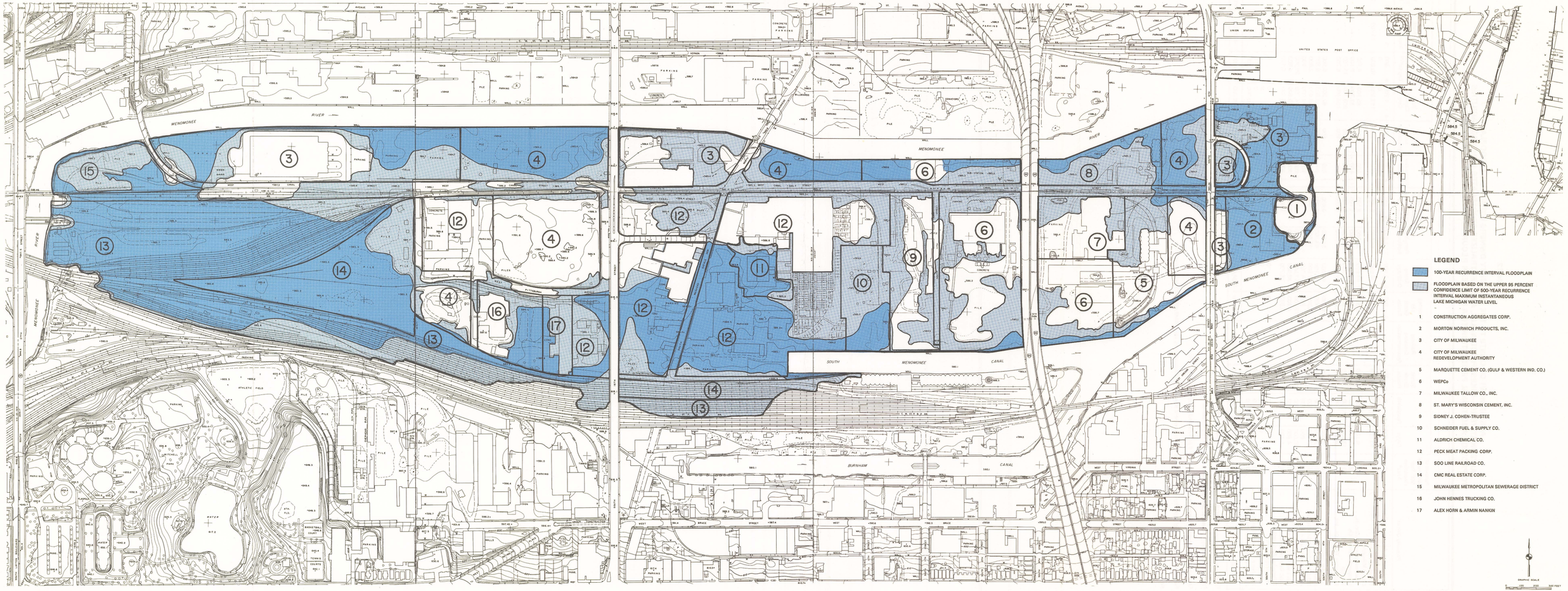
[c]Amortized capital cost is based on an interest rate of 6 percent and a project life of 50 years.

[d]Amortized capital cost of pumping stations includes the replacement of pumps and appurtenant equipment after 25 years of operation.

Source: SEWRPC.

Map 17

PROPERTY OWNERS WITHIN THE MENOMONEE RIVER ESTUARY STUDY AREA



Source: SEWRPC.

Table 13

COMPARISON OF COSTS TO INDIVIDUAL PROPERTY OWNERS UNDER THE RECOMMENDED FLOODPROOFING PLAN AND UNDER STRUCTURAL ALTERNATIVES

Property Owner	Total Annual Cost			
	Recommended Floodproofing Plan		Structural Alternatives	
	100-Year Protection	500-Year Protection	Alternative 1C 100-Year Protection	Alternative 2C 500-Year Protection
Construction Aggregates Corp.	$ 100	$ --	$ 1,500	$ 300
Morton Norwich Products, Inc.	10,300	--	46,600	--
City of Milwaukee	20,300	4,900	98,000	24,200
City of Milwaukee Redevelopment Authority	22,900	--	69,400	6,100
Marquette Cement Co.	--	--	3,400	2,100
WEPCo.	36,900	5,400	50,000	13,400
Milwaukee Tallow Co., Inc.	--	4,200	--	6,700
St. Mary's Wisconsin Cement, Inc.	8,300	1,000	27,500	5,900
Sidney J. Cohen-Trustee	1,000	1,000	0	8,300
Schneider Fuel & Supply Co.	14,300	--	26,000	3,800
Aldrich Chemical Co.	1,200	--	29,000	900
Peck Meat Packing Corp.	24,600	3,200	212,000	30,700
Soo Line Railroad Co.	--	--	--	4,800
CMC Real Estate Corp.	--	--	--	5,400
Railway Users (unapportioned)	18,600	--	--	5,100
Total	$158,500	$19,700	$563,400	$117,700

Source: SEWRPC.

to all property owners within the 100-year or 500-year floodplains were assigned according to the proportion of an individual owner's property located within the floodplain. Because that property would be protected and removed from the floodplain as a result of the implementation of the measures considered, it was considered reasonable to apportion costs based on the relative amount of area to be protected. Components that were included as providing a general benefit included dikes; floodwalls; public and private street grade raises for the purpose of providing flood barriers; fill that would serve as a flood barrier and would provide for adequate stormwater drainage, eliminating the need for stormwater pumping; pumping stations; storm sewer connections to pumping stations; public storm sewers; backwater gates; and land acquisition for the construction of pumping stations.

2. The costs of upgrading existing private storm sewers were assigned to the private owners.

3. To ensure adequate functioning of the interrelated general benefit components, it would be desirable for them to be operated and maintained by the City of Milwaukee. All annual operation and maintenance costs were therefore assigned to the City of Milwaukee.

Table 13 compares the relative costs to individual property owners of the recommended plan with the costs of structural Alternatives 1C and 2C. It can be seen that in all instances the recommended plan has a lower cost to each property owner than the structural alternative.

An apportionment among individual property owners of the costs of providing 100-year protection for the area between S. 27th Street and S. 16th Street is given in Table 14. Costs are assigned according to the floodproofing cost apportionment criteria listed above. For 500-year protection, an additional $6,000 floodproofing cost would be assigned to the John Hennes Trucking Company.

Table 14

RECOMMENDED FLOODPROOFING PLAN TO PROVIDE 100-YEAR RECURRENCE INTERVAL PROTECTION FOR THE AREA WEST OF S. 16TH STREET: ASSIGNMENT OF COSTS TO AFFECTED PROPERTY OWNERS

Property Owner	Control Measure				Total Capital Cost	Amortized Capital[a]	Annual Operation and Maintenance	Total Annual Cost
	Floodproofing	Fill in Floodplain	Parking Lot Regrading and Repaving	Pumping[a]				
City of Milwaukee	$ --	$ --	$49,000	$ --	$ 49,000	$ 3,100	$ --	$ 3,100
City of Milwaukee Redevelopment Authority	--	422,000	--	3,000	42,500	27,000[b]	100	27,100
Soo Line Railroad Co.	--	50,000	--	--	50,000	3,200	--	3,200
CMC Real Estate Corp.	--	936,000	--	--	936,000	59,400	--	59,400
John Hennes Trucking Co.	3,800	--	--	--	3,800	200	--	200
Alex Horn & Armin Nankin	9,200	--	--	--	9,200	600	--	600
Total	$13,000	$1,408,000	$49,000	$3,000	$1,473,000	$93,500	$100	$93,600

[a] *Amortized capital cost is based on an interest rate of 6 percent and a project life of 50 years.*

[b] *Amortized capital cost of pump assumes replacement after 25 years of operation.*

Source: SEWRPC.