STATE
OF
ILLINOIS

COUNTY
OF
COOK

METROPOLITAN
SANITARY
DISTRICT
OF
GREATER
CHICAGO

CITY
OF
CHICAGO

DEVELOPMENT OF A FLOOD AND POLLUTION CONTROL PLAN FOR THE CHICAGOLAND AREA

FLOOD CONTROL COORDINATING COMMITTEE

DECEMBER, 1972

FLOOD CONTROL COORDINATING COMMITTEE

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SYSTEM STUDY FUNDED BY

* METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO
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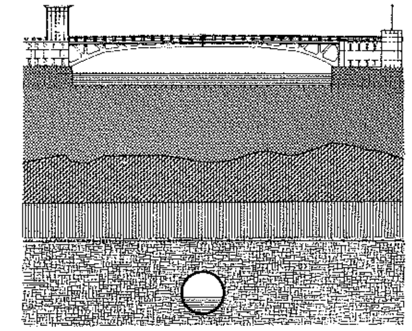


TABLE OF CONTENTS

PREFACE

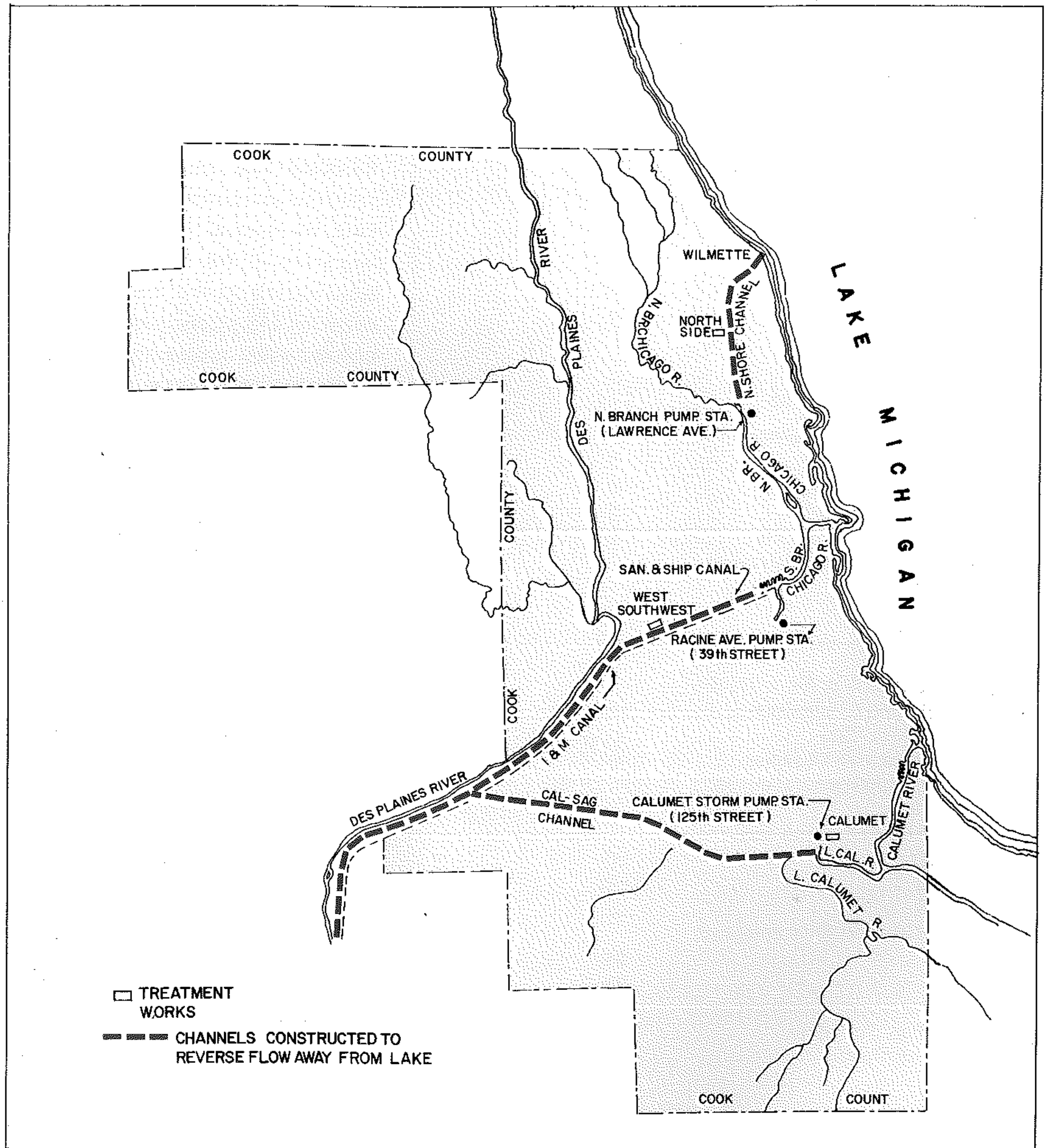
In order to comply with established waterway quality standards by the Illinois Pollution Control Board and the Metropolitan Sanitary District of Greater Chicago, and to eliminate the flooding and associated release of floodwater into Lake Michigan, a two-fold program of attack will be required. First, the massive upgrading and enlargement of the sewage treatment facilities, and second, the interception, detention and subsequent treatment of polluted water spilled from combined sewers in time of storms.

The presentation contained herein deals primarily with the problems of waterway flooding and pollution control related to combined sewer spillages.

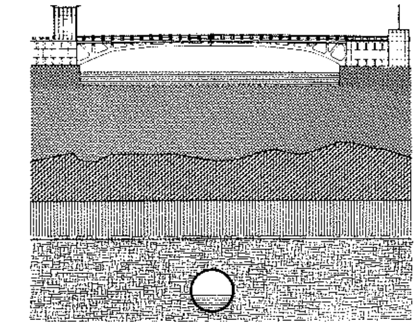
The recommended solution to flood and pollution control, includes a comprehensive pattern of tunnels under the existing waterways, or "Underflow Tunnels," which will intercept and convey the mixed sewage and storm water runoff to large storage reservoirs constructed in existing or new rock quarries. There the combined flow will be detained, aerated and subsequently pumped through upgraded sewage treatment plants before passing to the Chicagoland waterways.

The recommended "Chicago Underflow Plan" has been programmed to be completed within a ten-year construction period, beginning in 1973, at an estimated cost of one billion, two hundred twenty-three million dollars.

EXHIBIT 1—CANAL SYSTEM



HISTORICAL BACKGROUND



NINETEENTH CENTURY PROBLEMS

The history of the development of drainage and sewerage of the Chicago Metropolitan Area dates back to the early decades of the nineteenth century. From the beginning, the type of drainage was that of "combined" sewers, conveying in the same conduit systems, the combined flow of stormwater runoff and household and industrial wastes, which was generally considered, by most cities at that time, to be the most logical and practical scheme of urban drainage. These initial systems of "combined" sewers have now spread their lines to serve 375 square miles of the Metropolitan Area, having a total length of more than 5,000 miles.

For many decades from 1833 to 1900, all or most of the pollution originating within the growing City and some adjacent areas spilled, untreated, from the combined sewer outlets into the Chicago River and Lake Michigan.

Although the deepening of the small Illinois and Michigan Canal in the year 1871 allowed partial diversion of some of this pollution into the Mississippi River Watershed, it was not until after the formation of the Sanitary District of Chicago in 1889 now named The Metropolitan Sanitary District of Greater Chicago, that a major and successful effort was made toward pollution and flood control.

THE CANAL SYSTEM

The original program of the Sanitary District of Chicago produced the Sanitary and Ship Canal, completed on January 16, 1900 and its two tributary canals, the North Shore Channel in 1910 and the Calumet-Sag Canal in 1922. See Exhibit 1. Intercepting conduits and pumping stations completed in 1907 intercepted all open discharge of polluted waters into Lake Michigan, and delivered this pollution to the Chicago River System at Lawrence Avenue and at 39th Street and to the Calumet-Sag Channel at 127th Street. Clean water withdrawn from Lake Michigan at the points shown in Exhibit 1, diluted the pollution and conveyed the mixture southwestward through the new canal system into the drainage basin of the Illinois River, and thence to the Mississippi River. This reversal of the direction of flow in the Chicago and Calumet Rivers was widely publicized . . . first as a great achievement but later as lake diversion, considered unfair by other states bordering on the Great Lakes. Dilution ratios for the untreated sewage, equal to 3⅓ cfs per 1,000 population were recommended to maintain what was then considered a sufficient level of sanitation, pending the development of sewage treatment facilities, which began in the twenties with the completion of the initial stages of the Calumet Sewage Treatment Works in 1922 and North Side Sewage Treatment Works in 1927. Construction was, however, limited by the economic capabilities of the growing city.

HISTORICAL BACKGROUND

CONTROLLED LAKE DIVERSION

Three decades after the completion of the Sanitary and Ship Canal, an edict of the United States Supreme Court in April, 1930, established a rigid schedule of reduced lake diversion for dilution purposes. The goals of pollution control were drastically advanced and an accelerated program of sewage treatment was adopted, culminating in what was then termed "complete" treatment of all the sewage in the Sanitary District area. More rigid limitations of lake diversion was recently established by the United States Supreme Court in 1967, limiting the total withdrawal to 3,200 cfs average flow including domestic water supply and runoff from the Chicago and Calumet River Drainage Area, originally tributary to Lake Michigan.

WORLD'S LARGEST FACILITIES FOR POLLUTION CONTROL

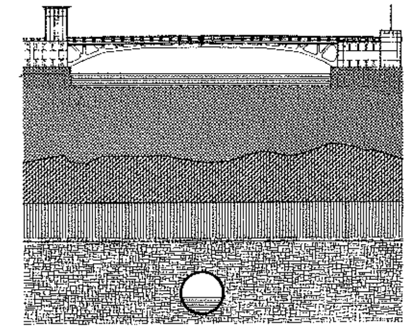
The restrictions imposed by the Supreme Court decision in 1930 resulted in the construction of the world's largest facilities for control of water pollution, but which, by themselves, are now considered insufficient.

The Metropolitan Sanitary District of Greater Chicago now serves more than 5,500,000 persons living in an 860 square mile area which includes the City of Chicago, and 117 adjacent communities within Cook County. The industrial load which must also be collected and treated is equivalent in pollutional content, to approximately 4,500,000 additional persons, making a total population equivalent of approximately 10,000,000 persons.

THE EXPANDING PROBLEM

The burgeoning population and industrial growth, coupled with the restricted dilution imposed by the edicts of the Supreme Court, have created an imbalance in the oxygen conditions of the waterways so that the so-called "complete" treatment of sewage must now be upgraded, and all or most of the combined-sewer spillage must be captured and routed through the upgraded treatment plants.

Also, the increased proportion of impervious surfaces, in the form of roofs and pavements and the more rapid conveyance of runoff by auxiliary outlet sewers have so greatly increased the peak runoff rates from the combined-sewer drainage areas as to greatly overload the flow capacity of the open watercourses (including the Sanitary and Ship Canal) and make necessary the reversal of flow in the main waterways during periods of high stormwater runoff. Exhibit 1 shows the points where the surcharge of polluted backflow is released into Lake Michigan from the North Shore Channel, the Chicago River, and the Calumet River. These backflows are now occurring at increasing frequencies, thus reinstating the basic problem of lake pollution which plagued the city government a century ago.



EVALUATION OF ALTERNATIVE SYSTEMS

FLOOD CONTROL COORDINATING COMMITTEE

Recognizing the existence of many possible solutions to the problems of flood control and water pollution abatement, officials of the State of Illinois; the County of Cook; the Metropolitan Sanitary District of Greater Chicago and the City of Chicago formed a Flood Control Coordinating Committee.

They appointed a Technical Advisory Committee on November 2, 1967 to study the merits of the several leading alternative plans. After many meetings in years 1967-1968, the committee could not arrive at a final recommendation.

The Flood Control Coordinating Committee was reactivated in November, 1970 by officials who were determined that progress must be made in the development of a flood and pollution control plan. A new Technical Advisory Committee was appointed and directed to make an impartial evaluation of all possible alternative solutions.

Under the financial sponsorship of the Metropolitan Sanitary District of Greater Chicago; The State Institute for Environmental Quality; and the Department of Public Works, City of Chicago, a systems study was undertaken to develop a plan for that part of the Chicagoland Area served by combined sewers.

A team of engineers from the City, Metropolitan Sanitary District, County, State and Federal agencies was enlisted and a number of consulting engineering firms and individuals hired to perform this engineering task. Advisory Groups of engineers were established in Sewage Treatment, Geology and Water Supply, Power, Alternative Systems, Benefits and Financing.

The aim of the systems study was to develop a plan to eliminate the deleterious effect of the spillage of mixed sewage and storm water from the combined sewers into the surface waterways of the Chicago metropolitan area. Such systems must provide for compliance with the standards established by the Illinois Pollution Control Board and the Metropolitan Sanitary District of Greater Chicago. Also, the plan must provide flood control benefits for the several surface waterways without the release of flood waters into Lake Michigan at the Wilmette Controlling Works, the mouth of the Chicago River, or through the Calumet River.

TWENTY-THREE ALTERNATIVES

After a thorough search of records and extensive investigation, twenty-three separate alternatives were identified for study. See Exhibit 2.

Early evaluation by the Technical Advisory Committee led to the recommendation that six of the original twenty-three alternatives should not receive further study, namely: K, L, M, N, P and T.

EXHIBIT 2—ALTERNATIVES

ALTERNATE A:

ORIGINAL DEEP TUNNEL PLAN WITH MINED AND SURFACE STORAGE IN THE CALUMET AREA

The original deep tunnel plan as outlined in the Harza-Bauer Report of May, 1968, proposed a series of tunnels in Niagaran and Galena-Platteville Rock Strata, to convey combined sewage to a single storage location in the Calumet Vicinity. Mined storage volumes would be provided in the Galena formation. Surface storage, in conjunction with mined storage, could accommodate peaking power generation. (See Ap) Captured combined sewer overflows would be treated at the Calumet Sewage Treatment Plant and at a new plant constructed in the Calumet vicinity.

ALTERNATE B:

DEEP TUNNEL PLAN WITH MINED AND SURFACE STORAGE IN THE CALUMET AND STICKNEY AREAS

The plan proposed in the Harza-Bauer Report of November, 1968, included a series of tunnels in Niagaran and Galena-Platteville to convey combined sewage to storage locations in the vicinity of the West-Southwest and Calumet Sewage Treatment Plants. Mined storage volumes were to be provided in the Galena-Platteville formation. Surface storage in conjunction with the mined volumes could accommodate peaking power generation, (See Bp).

ALTERNATE C:

DEEP TUNNEL PLAN WITH MINED AND SURFACE STORAGE IN THREE LOCATIONS: CALUMET, WEST-SOUTHWEST AND NORTH SIDE SEWAGE TREATMENT PLANT AREAS

This plan is a modification and adaption of Alt. A and Alt. B. It comprises a series of tunnels in Niagaran and Galena-Platteville to convey combined sewage to the vicinities of the three major sewage treatment plants; Calumet, West-Southwest and North Side Sewage Treatment Plant areas. Mined storage in the Galena-Platteville and pumping to either surface reservoirs or to constructed quarries was optional. Captured combined sewer overflows would be treated at the existing West-Southwest, Calumet and North Side Sewage Treatment Plants.

ALTERNATE D:

STATE OF ILLINOIS DIVISION OF WATERWAYS PLAN

Waterway improvements plan outlined in the Illinois Division of Waterways Report of November, 1968, included channel improvements and treatment of combined sewer overflows. Combined sewer overflow volumes retained in the detention basins would be returned to MSDGC interceptors for treatment at existing sewage treatment plants. Waterway improvements comprised widening and deepening, lowering the Calumet Sag Canal and the Chicago Sanitary and Ship Canal up to Throop Street by ten feet and removal of Brandon Road Lock and Dam.

ALTERNATE E:

COMPOSITE PLAN

The composite plan, outlined in the City of Chicago, Bureau of Engineering Report of September, 1968, included a series of tunnels in Niagaran and Galena-Platteville to convey overflows to the vicinities of the West-Southwest, Calumet, North Side and O'Hare Sewage Treatment Plants. Volumes of mined storage, surface storage, pit or quarry storage, tunnel capacity and pumping capacity were optimized. Mined storage areas at several locations were included to reduce tunnel sizes. Captured combined sewer overflows would be treated at the West-Southwest, Calumet, North Side and O'Hare Sewage Treatment Plants.

ALTERNATE F:

CHICAGO UNDERFLOW PLAN—LOCKPORT

The underflow plan as outlined in the City of Chicago, Bureau of Engineering Report of May, 1970, included a series of conveyance and storage tunnels to increase conveyance to Lockport, to provide the required storage volumes in the tunnel systems, and to provide for the treatment of the captured volumes either through existing plants or new facilities at Lockport. The system would have an outlet below the Lockport Dam. Tunnels slope to existing sewage treatment plants where captured combined sewer overflows would be pumped to treatment.

ALTERNATE G:

CHICAGO UNDERFLOW PLAN—SINGLE QUARRY

Quarry storage plan proposed by the City of Chicago, Bureau of Engineering comprised a series of tunnels in the Niagaran formation to convey combined sewage to a pit in the McCook Area. Flow into the pit would be by gravity during storms. The tunnels would be dewatered by pumping the tunnel volume to the pit. Captured combined sewer overflows would be treated at the West-Southwest Sewage Treatment Plant.

ALTERNATE H:

CHICAGO UNDERFLOW PLAN—TWO QUARRIES

Two quarry plan proposed by the City of Chicago, Bureau of Engineering, is a modification of Alt. G and comprises a series of tunnels in the Niagaran formation to convey combined sewage to pits in the McCook and Calumet Area. Flow into the pits would be by gravity. The tunnels would be dewatered by pumping into the pits. Captured combined sewage would be treated at the West-Southwest and Calumet Sewage Treatment Plants.

ALTERNATE J:

CHICAGO UNDERFLOW PLAN—THREE QUARRIES

The three quarry plan, a further modification of Alt. G, also proposed by the City of Chicago, Bureau of Engineering is similar to Alt. H; Stearns quarry however, has been added to provide additional storage volume and improve hydraulic behavior of the system.

ALTERNATE K:

LEFFLER PLAN

The Leffler Plan comprises the construction of a series of dikes in Lake Michigan to develop flood ponds with a total area of about 14,680 acres: 3,800 acres for the North Shore Channel, 2,560 acres for the Chicago River, 8,320 acres for the Calumet River.
The plan visualized the development of an uninterrupted highway from Wilmette to 95th Street, a series of swimming, skating ponds, a local sight seeing highway and a series of small boat harbors and a depository for river dredgings.

ALTERNATE L:

MEISSNER PLAN

Flood control plan outlined in the Meissner Engineers Report of August, 1958, comprised channel improvements, surface reservoirs and discharges to Lake Michigan (possibly into reservoirs). More than 100,000 acre feet of surface storage along waterways and in Lake Michigan would be provided. Channel capacity would be increased to 56,000 c.f.s.

ALTERNATE M:

RAMEY-WILLIAMS CHANNEL IMPROVEMENT PLAN

Flood control plan outlined in Metropolitan Sanitary District of Greater Chicago Report of April, 1959, was presented to correct inadequacies of the main channel outlet at Lockport. Widening improvements to the Chicago Sanitary and Ship Canal would increase the outflow at Lockport to 30,000 c.f.s. without attaining flood stages in the waterway.

ALTERNATE N:

SHEAFFER PLAN

The Sheaffer Plan proposes the abandonment of the existing sewage treatment plants and the conveyance of all combined sewage to areas in Central Illinois for treatment in aerobic treatment cells with spray irrigation of effluent on under-productive farmland. This plan would be a supplement to the several containment systems.

ALTERNATE P:

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO FLOOD CONTROL STUDIES

Flood control project outlined in the MSDGC Report of July, 1964, proposed flow diversions to the Des Plaines River and Willow Springs and at Sag Junction, removal of the rock humps at Summit and utilization of quarries, clay pits and surface storage for flood water storage.

ALTERNATE Q:

FOUR STORAGE PLAN

The four storage plan is a further development of the three storage locations and three quarry plans. The plan comprises a series of separate zone tunnels and conveyance structures and storage at the four major sewage treatment plants: West-Southwest, Calumet, North Side and proposed O'Hare. Tunnels would be dewatered by pumping to surface or pit storage at the North Side, West-Southwest, Calumet and O'Hare Sewage Treatment Plants. Storage at the West-Southwest and Calumet areas would be in pits; at the O'Hare plant, surface storage would be provided. The North Side area storage would be in mined areas and a surface reservoir.

ALTERNATE R:

McCOOK, CALUMET AND O'HARE STORAGE PLAN

The McCook, Calumet and O'Hare storage plan comprises a series of separate zone tunnels and conveyance structures and storage at West-Southwest, Calumet and O'Hare sewage treatment plants. Tunnels would be dewatered by pumping at the West-Southwest and proposed O'Hare locations. The plan would provide quarry storage at the West-Southwest plant, surface storage at the O'Hare plant and mined and surface or pit storage in the Calumet Area.

ALTERNATE S:

CHICAGO UNDERFLOW PLAN McCOOK AND O'HARE STORAGE

The McCook and O'Hare storage plan comprises a series of tunnels and conveyance structures and storage at the West-Southwest and O'Hare Sewage Treatment plants. Tunnels would be dewatered by pumping at the West-Southwest and O'Hare plants. The plan provides pit storage at the West-Southwest plant and surface storage at the O'Hare plant.

ALTERNATE T:

SEPARATE SYSTEM OF SANITARY SEWERS

The sewer separation plan as outlined in the City of Chicago, Bureau of Engineering Report of April, 1971, (revised), developed a cost estimate for the separation of sanitary and industrial wastes from storm water by the construction of parallel sanitary sewers. The proposed separate sanitary sewers would drain into existing MSDGC interceptors for conveyance to the existing sewage treatment plants.

ALTERNATES Ap, Bp, Cp, Qp, Rp:

PUMPED-STORAGE

These alternates are variations of Alternates A, B, C, Q, and R, to include pumped-storage power as a source of revenue benefits.

EVALUATION OF ALTERNATIVE SYSTEMS

Alternatives K, L, M and P are basically limited to flood control and would not meet the water quality standards now required for the surface waterways of the Chicago Region.

If Alternative N were to be considered, it would require a collecting system and local storage facilities not unlike those contained in many of the other alternatives. Therefore, the Sheaffer Plan (Land Disposal) is considered an extension of these systems and has been given no further consideration in this study.

The cost of Separation, Alternative T, including all public sewers and plumbing alterations in both private and public buildings was estimated for the existing combined sewer drainage areas at upwards of four billion dollars. The disruption of public streets and required plumbing alterations would be enormous and would result in no flood control. Alternative T was dropped from the study.

STANDARD MODIFICATIONS

The remaining seventeen alternatives systems were then subjected to exhaustive comparative evaluations.

Retaining the principal features of each of these alternative systems, four standard modifications "Mods" were made of each system, gauged to achieve flood control and no backflow to Lake Michigan. These were based on a complete repetition of the precipitation patterns which occurred during a twenty-one year period, 1949 to 1969, inclusive and which period included the largest storms of record. Computer studies applied the impact of such a repetition upon a maximum future land use. Mods 2, 3 and 4 were sized and tested to meet the following requirements:

Mod 1 (Storage Varied)—Original Plan (proposed by various authors).

Mod 2 (120,000 AF)—Contain largest storms of record.

Mod 3 (50,000 AF)—Prevent backflow to Lake Michigan without waterway channel improvements.

Mod 4 (20,000 AF)—Capture one year storm and make waterway improvements to prevent backflow to Lake Michigan.

EVALUATION OF ALTERNATIVE SYSTEMS

EVALUATION OF SUBSYSTEMS

Various subsystem elements were evaluated, including cost of expanding existing treatment plants; cost of new treatment plants for various capacity and effluent requirements; cost of tunnels of various sizes using drill and blast methods and machine mining methods, both lined and unlined; cost of near surface collecting sewers and drop shafts to various levels; cost of construction of pits or quarries for the storage of overflow waters; cost of mining, "room and pillar method" for storage space in various rock strata; cost of surface storage facilities; cost of aeration in waterways, pits or quarries, mined chambers, surface reservoirs and tunnels; cost of waterway dredging and other waterway improvements; requirements for protecting the aquifer and filtered water tunnels; strength of rock and drillability in various formations; rock coring to determine the location and elevation of strata; limitation of rock blasting charges with relation to surface damage; coefficient of friction in lined, machine mined and unlined conveyance tunnels; deterioration of rock with time; effect of earthquakes on mined areas or tunnels; maximum permissible velocities of flow through lined and unlined tunnels. These subsystems have been used in the formation, evaluation, and cost of the Alternative plans.

Each of the Alternatives plans were evaluated for various levels of storage (Mod. 2, 3 and 4) as to the present worth capital cost and the annual cost, including maintenance, operation and in some systems revenue. Statements of the benefits and the environmental impact for each Alternative were prepared.

Exhibit 2 summarizes the basic cost data, relocation problems and land and easement requirements for all alternatives, and for each of their modifications.

EVALUATION REPORT OF ALTERNATIVE SYSTEMS

In January, 1972, an interim report entitled "Evaluation Report of Alternative Systems" was submitted by the Technical Advisory Committee to the Flood Control Coordinating Committee. This report presented the system's evaluation with regard to present worth capital cost; annual cost, including maintenance, operation, equipment replacement and in some systems revenue; land acquisition; underground easements; benefits; relocation of people and industries; and statements of the environmental impact both for the construction period and for the permanent facility, for all seventeen alternatives and for three separate modifications. Exhibit 3 shows the Summary Evaluation Table.

EXHIBIT 3—EVALUATION TABLE

MOD 2—CONTAIN STORM OF RECORD

	A	Ap	B	Bp	C	Cp	D	E	F	G	H	J	Q	Qp	R	Rp	S
Cost (Present Worth), Millions of Dollars	2815	3137	2211	2523	2183	2491	2680	2071	3615	1923	1557	1554	1551	1583	1580	1894	1843
Equivalent Annual Cost, Millions of Dollars	239	223	194	182	193	179	243	183	294	162	137	138	138	133	149	157	157
Equiv. Annual Tangible Ben. Millions of Dollars	47	47	47	47	47	47	43	47	47	47	47	47	47	47	47	47	47
Benefit-Cost Ratio*	0.56	0.60	0.69	0.73	0.69	0.74	0.55	0.73	0.45	0.82	0.97	0.96	0.96	1.00	0.89	0.85	0.85
Land Acquisition, Acres	400	2000	600	1800	1100	2000	5000	800	1600	600	800	600	1300	700	800	900	800
Underground Easement, Acres	2000	3200	1600	3400	1800	3600	-	1600	-	-	-	-	400	700	300	1200	-
Relocate People & Industries	Small	Medium	Small	Medium	Large	Large	Large	Medium	Small	Small	Small	Small	Large	Large	Medium	Large	Medium

MOD 3—STORAGE TO PREVENT LAKE BACKFLOW WITHOUT WATERWAY IMPROVEMENTS

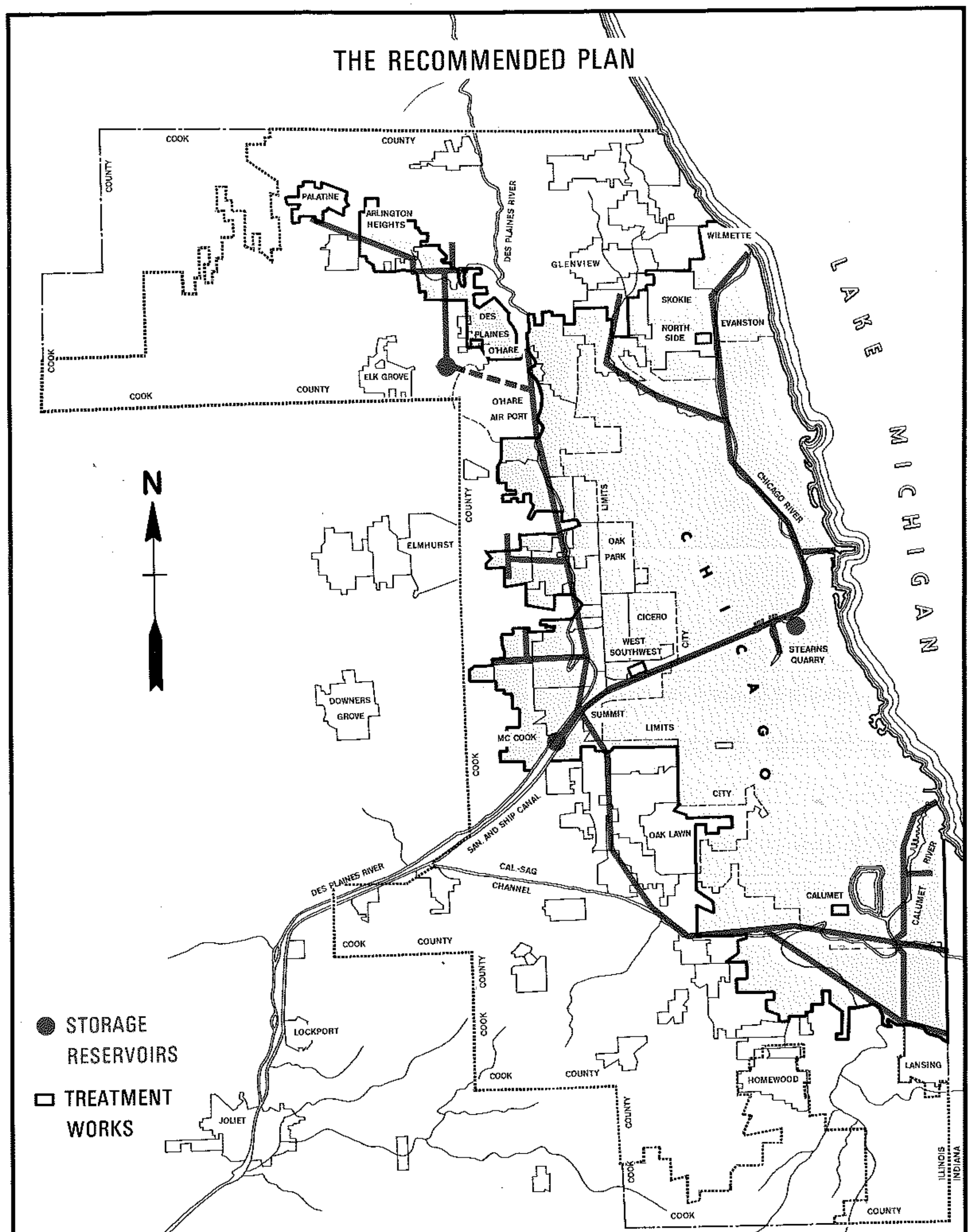
	A	Ap	B	Bp	C	Cp	D	E	F	G	H	J	Q	Qp	R	Rp	S
Cost (Present Worth), Millions of Dollars	1621	1957	1360	1637	1380	1676	1589	1401	1834	1002	912	921	1014	1070	1040	1195	979
Equivalent Annual Cost, Millions of Dollars	148	139	129	120	129	121	159	129	156	90	85	86	97	93	103	103	89
Equiv. Annual Tangible Ben. Millions of Dollars	46	44	46	44	46	44	44	46	44	44	44	44	44	44	46	44	44
Benefit-Cost Ratio*	0.57	0.61	0.66	0.71	0.66	0.70	0.54	0.66	0.55	0.94	1.00	0.99	0.88	0.91	0.82	0.82	0.95
Land Acquisition, Acres	300	1100	400	1200	400	1400	3600	500	1100	400	400	400	500	500	500	600	500
Underground Easement, Acres	300	1900	300	2000	700	2100	-	500	-	-	-	-	500	400	100	700	-
Relocate People & Industries	Small	Medium	Small	Medium	Small	Large	Large	Medium	Small	Small	Small	Small	Medium	Large	Medium	Large	Medium

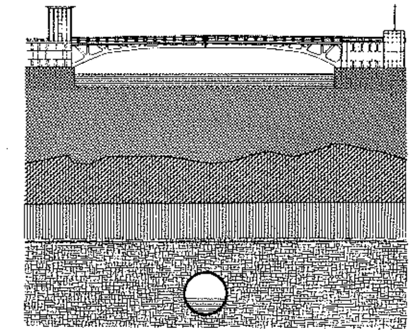
MOD 4—CAPTURE ONE-YEAR STORM AND MAKE CHANNEL IMPROVEMENTS TO PREVENT LAKE BACKFLOW

	A	Ap	B	Bp	C	Cp	D	E	F	G	H	J	Q	Qp	R	Rp	S
Cost (Present Worth), Millions of Dollars	1804	-	1533	-	1484	-	1532	1470	1530	1377	1356	1366	1367	-	1363	-	1346
Equivalent Annual Cost, Millions of Dollars	150	-	129	-	124	-	146	122	124	115	115	116	118	-	120	-	115
Equiv. Annual Tangible Ben. Millions of Dollars	57	-	57	-	57	-	57	57	57	57	57	57	57	-	57	-	57
Benefit-Cost Ratio*	0.77	-	0.89	-	0.93	-	0.79	0.94	0.93	1.00	1.00	0.99	0.97	-	0.96	-	1.00
Land Acquisition, Acres	-	-	-	-	-	-	2500	100	200	200	400	400	400	-	200	-	200
Underground Easement, Acres	1000	-	1000	-	1000	-	-	1000	-	-	-	-	200	-	300	-	-
Relocate People & Industries	Small	-	Small	-	Small	-	Large	Medium	Small	Small	Small	Small	Medium	-	Medium	-	Medium

*Note: It is the announced policy of the Metropolitan Sanitary District and the City of Chicago to strive for the elimination of all discharges of wastewater to the Lake, so as to protect the public water supply, maintain the Lake as a great natural resource and guarantee its continued use as an economic and recreational asset to the Metropolitan Area and all other areas adjoining it. Therefore, it may be assumed that the least cost project is justified and that the benefits of that project are equal to the least costly Alternative in each Mod.

EXHIBIT 4—RECOMMENDED PLAN





RECOMMENDED PLAN

RECOMMENDATION OF FLOOD CONTROL COORDINATING COMMITTEE

After extensive review of the evaluation report, the Flood Control Coordinating Committee unanimously agreed that the "Chicago Underflow Plan" (Alternatives "G", "H", "J" and "S"—Mod 3) are less costly and would be more environmentally acceptable to the community than any of the other plans presented. Detailed studies and layouts along the lines of these plans were then continued to develop the final plan.

RECOMMENDED PLAN

The system recommended herein, a composite of the several Underflow Plan Alternatives, is outstanding in its relative storage economy and simplicity. It will capture the total runoff from all of the record meteorological sequences of history, if they were to recur on future ultimate developed drainage basins, except for the peak few hours of three of the most severe storm events. The system will convey these captured combined sewer flows through high velocity, out-of-sight underflow tunnels below the routes of the existing surface water-courses to large pit-type detention reservoirs. Exhibit 4 shows the general location of the conveyance tunnel system and storage reservoirs.

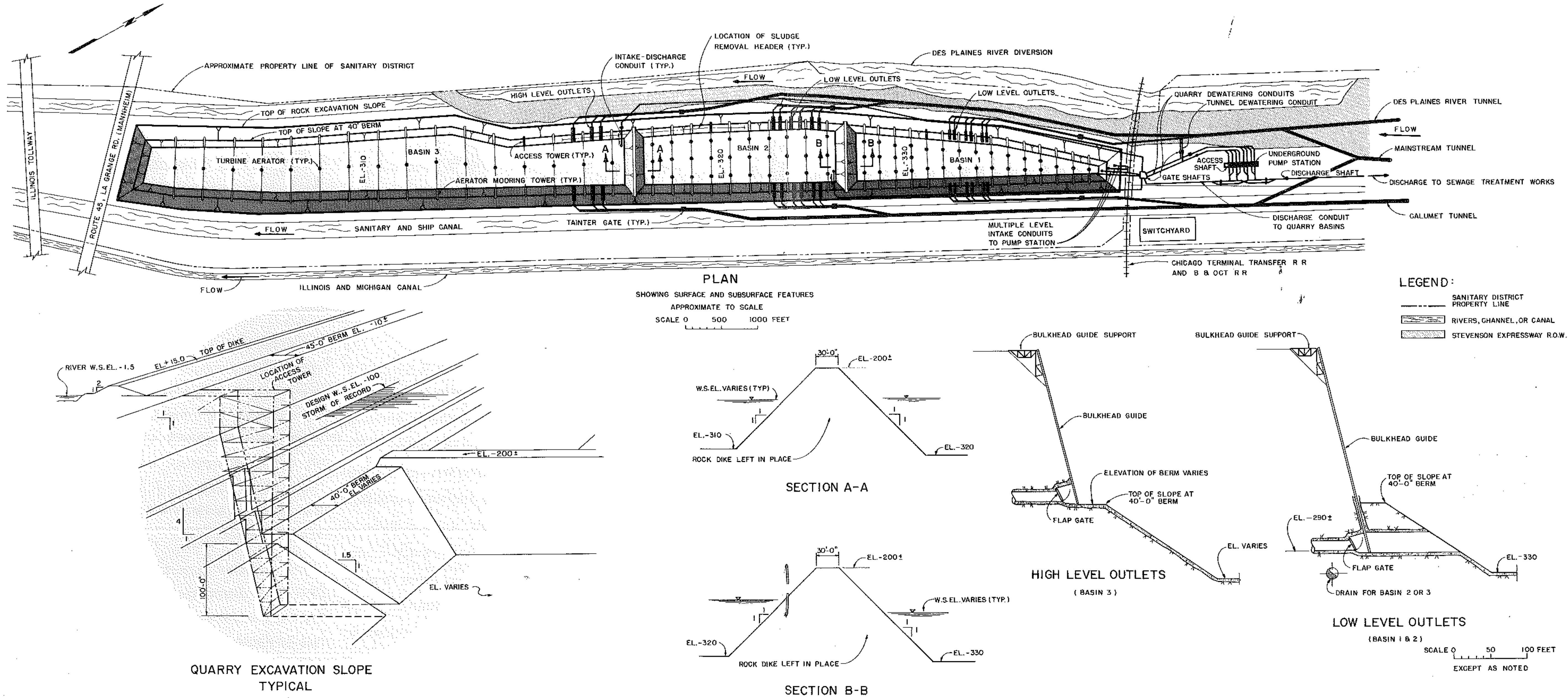
STORAGE RESERVOIR FACILITIES

The primary storage reservoir is located in the area now occupied by the sludge lagoons of the Metropolitan Sanitary District in the McCook-Summit area. This reservoir will be in the form of a 300 to 330 feet deep rock quarry, with a maximum water depth of approximately 200 feet, in the heaviest storm event, and water surface dimensions averaging about 1,000 feet wide by 2½ miles long. Total storage capacity of the reservoir with the water surface at its maximum level of —100 CCD, will be 57,000 acre-feet.

Exhibit 5 shows the general layout of the reservoir, conduits and pumping facilities. The lower 100 feet of depth of the reservoir will be divided into three basins by transverse dikes, providing two small basins, each with a volume of 5,000 acre-feet for the more frequent small runoff periods. The larger runoff volumes will flood the remaining basin and the water surface will rise in elevation over the entire reservoir.

The dewatering pumping station shown on Exhibit 5 will discharge from the storage reservoir to the West-Southwest Treatment Plant at an average rate of about 700 c.f.s. The station's total capacity will be 2400 c.f.s. in order to dewater the conveyance tunnels and Stearns Quarry into the reservoir within three days following a storm.

EXHIBIT 5—RESERVOIR LAYOUT



RECOMMENDED PLAN

Computer studies indicate that the storage utilized in Basins 1 and 2 will exceed their combined volume (10,000 acre-feet) at an average frequency of six or seven times per year and that these two basins alone will entrap more than 70% of the annual combined sewer spillage containing over 95% of the annual Suspended Solids.

The use of a deep pit storage basin of such magnitude and depth requires that aeration be provided to insure positive odor control by floating equipment. This is necessary because the range of liquid levels varies over 200 feet. It is proposed to use submerged turbine aerators provided with a downflow draft tube with air injection below the propeller.

The submerged turbine aerators will be provided with a bar screen to prevent large ice chunks from being drawn into the draft tube and damaging the blades. The aerators will be provided with legs to protect the draft tube and will need a minimum of 20 feet of water to operate. When floating at greater depths, it is considered that active aeration will be limited to the upper 50 feet of the water in storage.

Aerators, in the heaviest rainfall year will be in near continuous operation in or above Basins 1 and 2. A lesser amount of aeration on an intermittent schedule will be required in Basin No. 3.

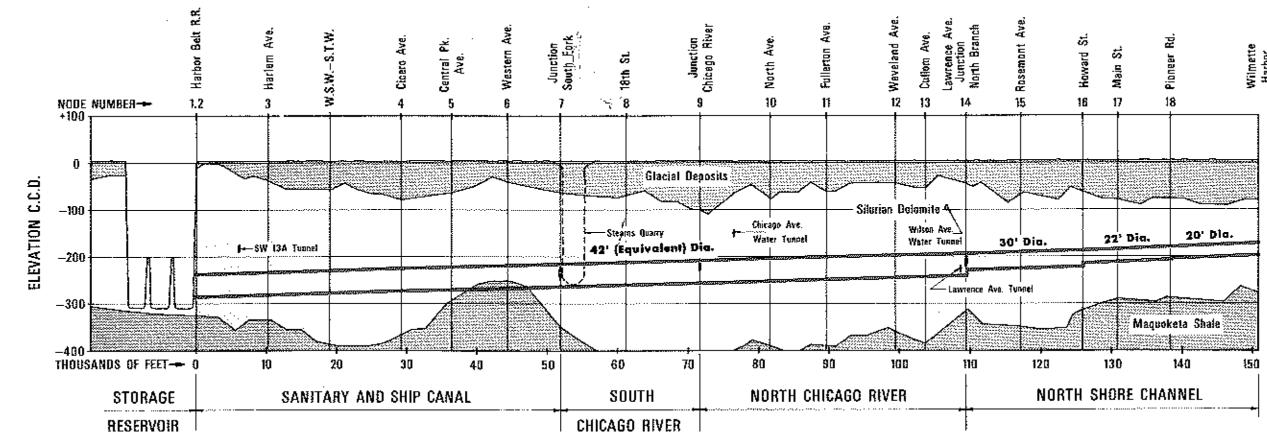
An aerated reservoir of lesser depth and volume of 1,800 acre-feet, will be provided near the proposed O'Hare Water Reclamation Plant, to serve the combined sewered area of the suburban communities to the northwest.

Another reservoir will utilize the existing Stearns rock quarry in the vicinity of 28th and Halsted Streets. This reservoir will provide approximately 4,000 acre-feet of storage space and will be used only during record storm events to flatten out the peak discharge through the conveyance tunnels.

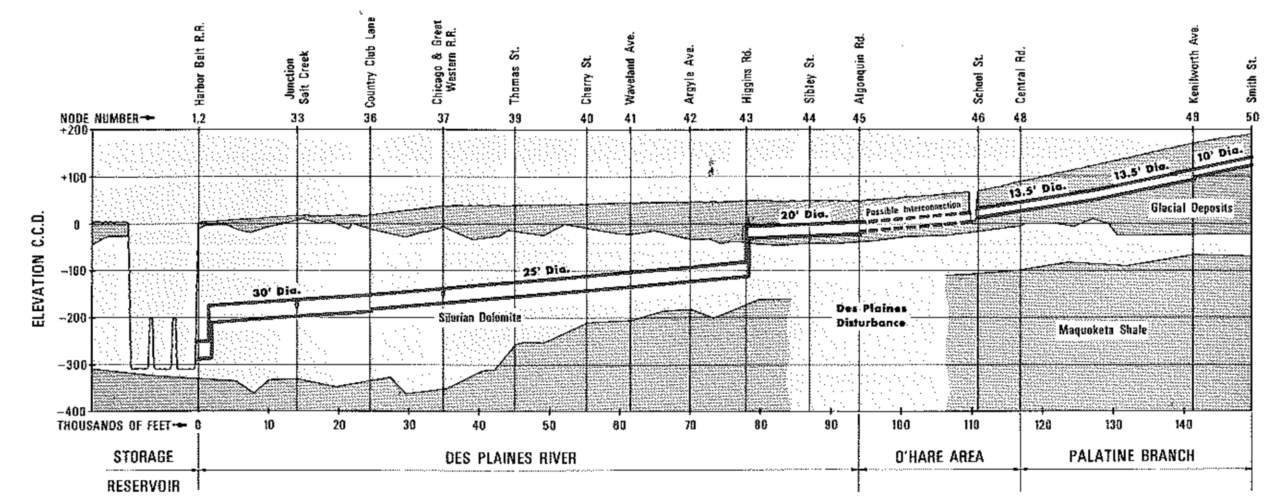
UNDERFLOW CONVEYANCE TUNNELS

There are approximately 120 miles of underflow conveyance tunnels intercepting 640 sewer overflow points in the 375 square mile area served by combined sewers. Most of the conveyance tunnels will be constructed in the Silurian Dolomite rock formation 150 to 300 feet below the surface of the waterways. In some areas, the smaller tunnels will be constructed in the clay overburden. See Exhibit 6 and 7 for profile of the underflow tunnels.

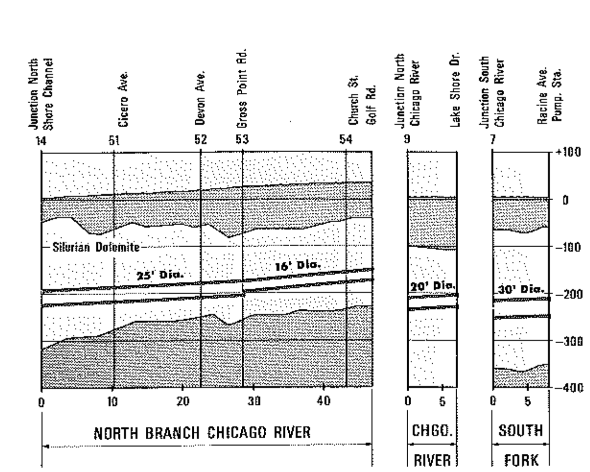
EXHIBIT 6—TUNNEL PROFILES



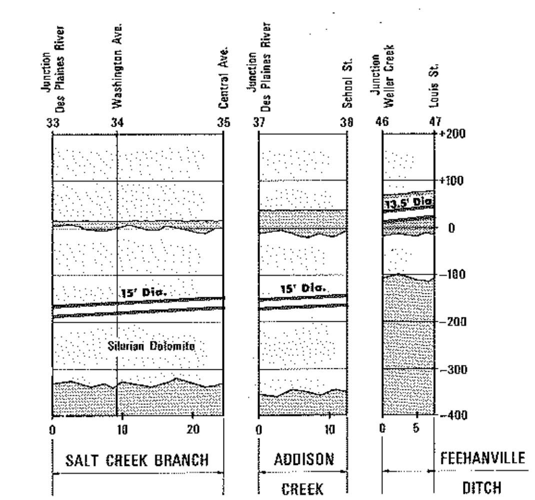
MAINSTREAM SYSTEM



DES PLAINES RIVER SYSTEM

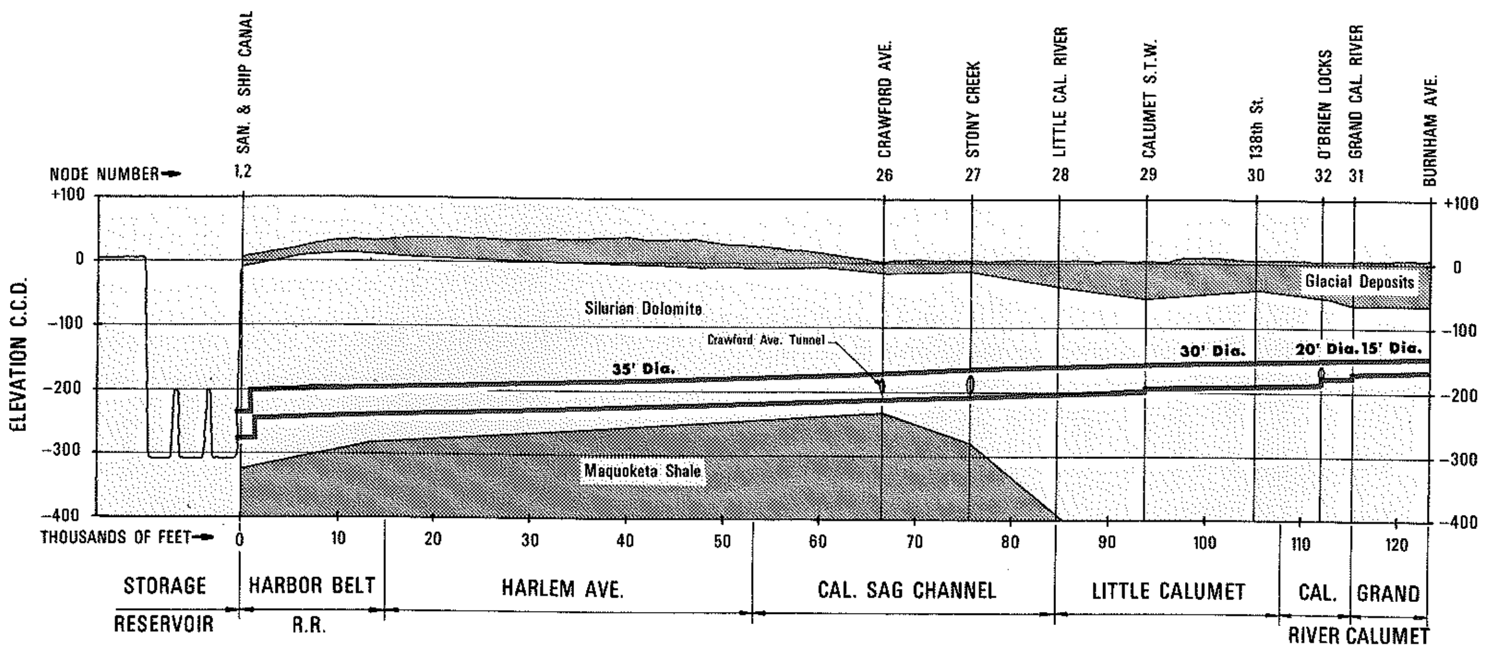


MAINSTREAM BRANCHES

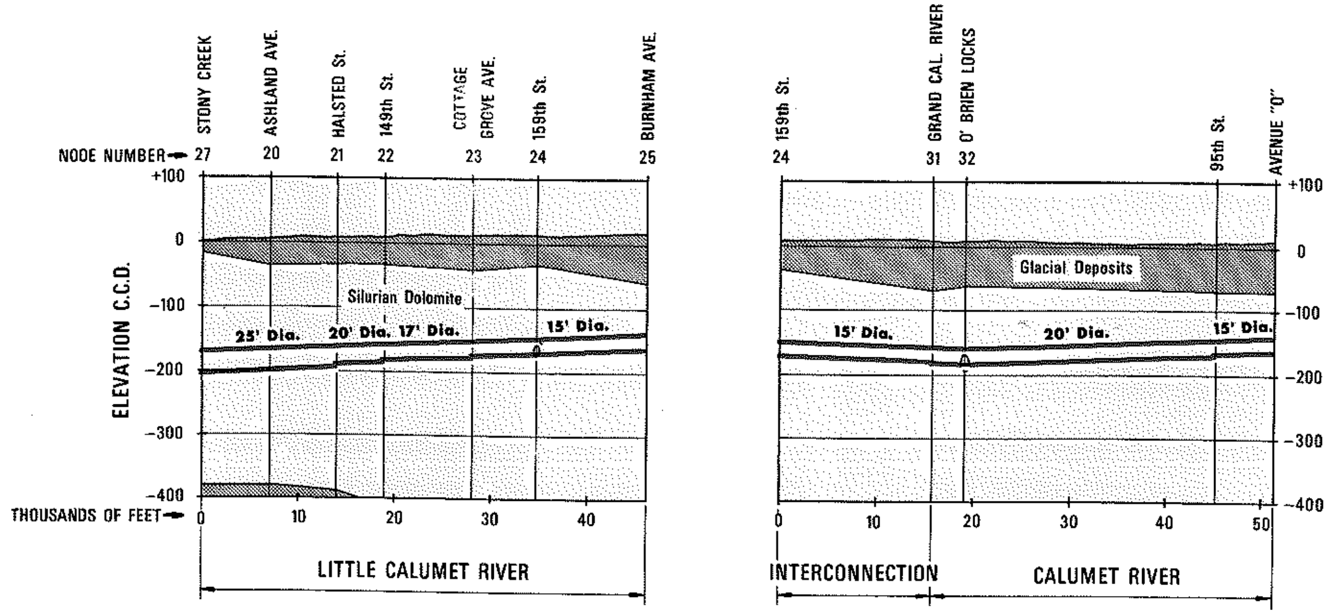


DES PLAINES RIVER BRANCHES

EXHIBIT 7—TUNNEL PROFILES



CALUMET SYSTEM



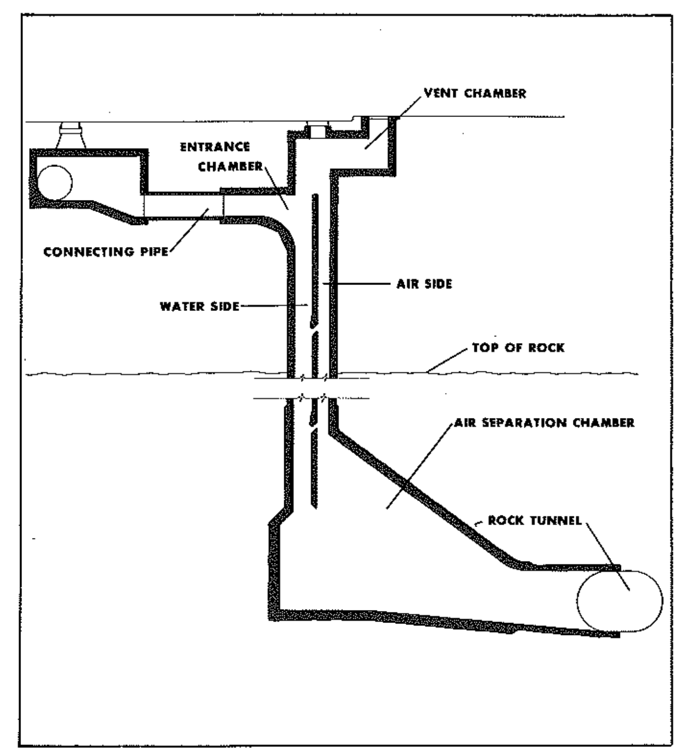
CALUMET BRANCHES

RECOMMENDED PLAN

The tunnels will in general be drilled by mining machine (moles), except for the largest sizes which will probably be constructed by the conventional drill and blast method.

Three main conveyance tunnel systems fork out from the primary reservoir facility located in the McCook-Summit area. See Map, Exhibit 4. The Des Plaines Tunnel System extends north along the Des Plaines River to the Village of Des Plaines, thence northwest terminating at the Village of Palatine. The Mainstream Tunnel System extends under the Sanitary and Ship Canal, the North and South Branches of the Chicago River and the North Shore Channel to the Wilmette controlling works. The Calumet Tunnel System extends south and southeasterly along public right-of-way to the Sag Channel, thence eastward under the Little Calumet, Grand Calumet and Calumet Rivers to near the State Line. The storage space in the conveyance tunnel system is 9,100 acre-feet.

EXHIBIT 8—SHAFT



DROP SHAFTS

The spillages will be delivered to the underflow tunnels by hundreds of vertical drop shafts, capturing the present spillage from the existing riverbank sewer outlets of five thousand miles of near-surface sewer systems. A typical drop shaft is shown in Exhibit 8.

The drop shafts will have a split vertical shaft, one side for water and the other side for air. The center dividing wall will have slots to insufflate air in the falling water. This reduces the impact when the air-water mixture hits bottom. An air separation chamber is provided to reduce the amount of air entering the tunnel. At the top, a vent chamber will allow air to escape during filling and to be drawn in during dewatering.

GROUNDWATER PROTECTION AND RECHARGE

The Recommended Plan is sited in rock units of the Silurian System of the geologic strata underlying the Chicagoland area. These limestone and dolomite rock units, together with the hydraulically interconnected overlying glacial drift, comprise the so-called shallow aquifer of the region.

The preservation of groundwater quality and quantity can be achieved by establishing or maintaining two physical conditions throughout the project area: high piezometric level within the aquifer in relation to hydraulic grade levels in subsurface project features, and adequate limitation of groundwater infiltration into the subsurface excavations.

High piezometric levels within the aquifer will provide protection against exfiltration from tunnels and storage excavations, thus preserving groundwater quality. These levels occur naturally in much of the project area, and must be established by recharge systems in other parts of the project area. The differential head provided by high piezometric levels within the aquifer will tend to cause infiltration into underground excavations. The limitations of the quantity of this infiltration can be realized in some parts of the project area, by relying principally upon the natural low permeabilities which are known to exist within the lower dolomitic rock formations. A low leakage rate can be achieved by grouting of only major fractures and fissures in the rock. In other areas, extensive grouting and/or lining of the tunnels will be required to prevent high infiltration rates.

Additional data on protection of groundwater and limitation of infiltration into tunnels and storage areas is available in the Technical Reports.

OPERATION

The general operation of the Underflow System is as follows: Rainfall runoff and/or snow-melt enters the sewer system mixing with household and industrial wastes. This combined flow travels through the sewers to a control or diversion chamber located near the waterways. In dry weather or very minor rainfall periods all of the flow is diverted to the existing interceptor for conveyance to the sewage treatment plants.

In storm runoff periods exceeding the interceptor or treatment plant capacity, storm overflow passes through the drop shafts to the large conveyance tunnels under the waterways. Flow is conveyed to the storage reservoirs. At McCook, it will first enter the primary basins Nos. 1 and 2. If flow exceeds 10,000 acre-feet, the capacity of the two primary basins, spillage will occur to basin No. 3. Immediately after the flows in the conveyance tunnels have subsided, the dewatering pumps are turned on at the principal reservoir site to pump the water in the tunnels to the reservoir. The pumps have capacity to perform this operation in two days. If the Stearns Quarry is filled, it will require a total of three days. Flushing water may then be taken in from the waterway at selected drop shafts to cleanse the conveyance tunnels.

The combined sewer overflows will be detained in the storage basins from the maximum single storm for up to 50 days. The most frequent occurrence for a single storm, however, will range between 2 and 10 days. Overflow water will be in the reservoir from the sequence of rainfall events for much longer periods. Computer simulation studies show that in a recurrence of the heaviest water year, 1954, the basins would have live detention water for 288 days out of 365 days. This is based on the average dewatering rate to the treatment plant of 700 c.f.s. in the dry weather post rainfall periods.

In the post storm period, the dewatering pumps will be operated to pump the stored water to the treatment plant. Pumping will be at a variable rate which, when added to the plant's raw sewage influent will equal 1.5 times the dry weather flow. This will require expansion of the existing treatment plant facilities.

In the very large storms, when the stored water has undergone prolonged aeration, pumping at rates in excess of those acceptable by the secondary and tertiary treatment units can be routed directly to the chlorination facilities and then to the waterways.

If the storm is of a magnitude that will exceed the storage or conveyance capacity, gates at the drop shafts on selected gravity sewer systems can be operated to force the water to overflow at such selected locations to the waterways. Thus, in these rare events, priority protection can be given to small streams and the low elevation pumped areas.

The solids that have been deposited in the aerated storage basin have to be removed periodically. It is estimated that a two to three year period will be allowed for solids storage. The solids in this period of time will be stabilized to the extent that further digestion should not be necessary. The aeration equipment in the basin can be used to aerobically digest recently deposited solids that might occur immediately prior to a planned quarry cleaning operation.

The settled material will be removed by a floating dredge discharging through a pipe system with other sludge to the Metropolitan Sanitary District land reclamation.

BENEFITS

A brief listing of anticipated benefits to be derived from completion of the system of flood and pollution control proposed herein, includes the following:

1. Protection of the valuable water resources of Lake Michigan from flood release of river water as now required through the existing Chicago River, the North Shore Channel and the Calumet River into Lake Michigan.
2. Achieving and maintaining acceptable water quality (in accordance with regulations of the Illinois Pollution Control Board and the Metropolitan Sanitary District) in the open waterways known as the Chicago River and its branches, the Sanitary and Ship Canal, the North Shore Channel, the Calumet-Sag Channel, and those portions of the Calumet River, Des Plaines River, Salt Creek and other open waterways, under the jurisdiction and control of the Metropolitan Sanitary District of Greater Chicago.
3. Reduction of surface and basement flooding by underground backwaters or overbank flooding.
4. Improvement of recreational values of all surface waterways.
5. Increase in property values due to general improvement of environment.

POST CONSTRUCTION ENVIRONMENTAL IMPACT

The surface environmental disturbances of project features after construction will be minimal. Most elements of the project are located underground. Features on the surface are generally to be located in areas that are already in industrial use. Quarry and surface reservoirs are already surrounded by lands that would provide an effective barrier to urban encroachment.

Since odor nuiances must be avoided, all reservoirs expected to detain water for over 3 days will be designed with sufficient mechanical aeration equipment to oxidize matter contained in the combined sewer overflow from the maximum storm.

Conveyance tunnels will be located in the Niagaran Group about 300 feet below the ground surface. Ground water levels in the Niagaran aquifer should be above the proposed tunnels in most places. These high ground water levels will cause water flow into the tunnels and consequently there will be no danger of aquifer pollution. The quantities of water infiltrating into the tunnels would be small in relation to the aquifer potential and there would be no adverse effects on the long term water supply. In areas such as McCook where the upper aquifer is overdeveloped and water levels are low, the aquifer would be recharged with potable water to prevent exfiltration of polluted water from tunnels and reservoirs.

It is expected that little or no fish kills would occur during overflow periods. In the first place, the prevalent dry weather Disolved Oxygen (DO), temperature during the summer and ammonia-nitrogen levels in the Mainstream Waterway and Calumet Sag Channel would not be conducive to game fish life. In other watercourses, warm water biota, and native game fish would not be greatly affected by the short dips in DO during the infrequent overflow events.

COST

The total cost of the recommended Chicago Underflow Plan is estimated as follows:

Surface Collection and Drop Shafts	$ 93,000,000
Tunnels	567,200,000
Storage Facilities	350,000,000
Pumping Stations	38,000,000
	$1,048,200,000
Contingencies	100,000,000
	$1,148,200,000
Engineering, Legal, Administrative	75,000,000
Total Project Cost (1972 Base)	$1,223,200,000

The total of the equivalent annual operating and maintenance costs, replacement of equipment costs and water costs for aquifer protection is estimated at $13,600,000 per year.

RECOMMENDED PLAN

RECOMMENDED PLAN

FUNDING

The total Flood and Pollution Control Program consists of two major parts: the recommended Chicago Underflow Plan for correction of the combined sewer overflow problem; and a series of other projects (identified by the MSD) whose principal objectives are an increase in treatment levels, efficiencies, and capacities at plants, and extension and capacity increase of interceptor sewer facilities. It has been determined that construction of both program parts is required to meet water quality standards of the Illinois Pollution Control Board. Moveover, both program parts must be considered in financial analyses since their construction will be funded from the same sources for the most part. The total project costs of the facilities of the program have been estimated at $2,653.4 million with $1,223 million required for the Chicago Underflow Plan and $1,430.4 million required for the enlargement and upgrading at treatment facilities and other work related thereto. The base year for the project cost estimates is 1972.

Three basic construction schedules were examined to evaluate the effects of variation of time and program implementation; a 5-year, 10-year and 15-year program. In each of these cases, a 6 percent per annum construction cost escalation was included as a factor.

A 10-year construction program is recommended for adoption as the plan implementation schedule. Exhibit 9 indicates the division of awards between the Chicago Underflow Plan and the combination of the numerous other projects of the recommended 10-year program.

Shown in Exhibit 9 is a schedule of existing and pending allocation of funds from local, State and Federal sources totalling $1,429,000,000. This includes a Federal allocation based on the provisions of the House Bill H.R. 11896, which is now in committee to resolve the differences between it and the Senate Bill S.2770 (On October 18, 1972, just prior to printing of the report, the Federal Water Pollution Control Act Amendments of 1972 became law). State and local matching funds would be defrayed out of the $750 million State Bond Issue passed on November 3, 1970 and the MSD $380 million Bond Issue approved on September 22, 1969.

Other funding beyond that provided by these sources is required. For the purpose of this analysis, this funding is assumed to be forthcoming from continuation of local, State and Federal funding programs in the later years of the 10-year plan implementation schedule.

A more extensive description of the sources of funds and their estimated amounts is contained in the Technical Reports.

EXHIBIT 9—FINANCING

DIVISION OF AWARDS

FUNDING OF PROGRAM

	MSDGC PROJECT				FEDERAL FWPCA			STATE		MSDGC		OTHER *	
Year	Underflow	Other	Unescalated	Escalated 6%	Existing	HR.11896	Future	$750 Mill. Bond Issue	Future	$380 Mill. Bond Issue	Future	Future	TOTAL
1972	–	117.5	117.5	117.5	43.0	40.0	–	20.0	–	14.5	–	–	117.5
1973	122.3	261.1	383.4	406.0	–	208.0	–	96.0	–	82.0	–	20.0	406.0
1974	200.0	300.0	500.0	562.0	–	248.0	–	145.3	–	128.7	–	40.0	562.0
1975	250.0	250.0	500.0	595.0	–	290.0	–	83.7	48.5	29.8	83.0	60.0	595.0
1976	200.0	150.0	350.0	442.0	–	–	220.0	–	50.0	–	90.0	82.0	442.0
1977	159.0	120.0	279.0	372.0	–	–	180.0	–	42.0	–	65.0	85.0	372.0
1978	88.5	75.0	163.5	232.0	–	–	120.0	–	30.0	–	45.0	37.0	232.0
1979	99.5	50.0	149.5	224.8	–	–	120.0	–	30.0	–	30.0	44.8	224.8
1980	50.0	46.5	96.5	153.8	–	–	80.1	–	22.0	–	16.5	35.2	153.8
1981	50.0	28.5	78.5	132.6	–	–	65.1	–	19.5	–	15.0	33.0	132.6
1982	3.7	31.8	35.5	63.6	–	–	40.1	–	8.0	–	5.5	10.0	63.6
EXISTING OR PENDING (FUNDING)					829.0			345.0		255.0			1,429.0
ADDITIONAL FUTURE (FUNDING)							825.3		250.0		350.0	447.0	1,872.3
TOTAL	1,223.0	1,430.4	2,653.4	3,301.3	1,654.3			595.0		605.0		447.0	3,301.3

AS COMPILED - AUGUST, 1972

*INCLUDES POSSIBLE FEDERAL FUNDING FOR FLOOD CONTROL, RECREATION, URBAN DEVELOPMENT AND REIMBURSEMENT FOR PREVIOUSLY COMPLETED MSDGC PROJECTS.

NOTE:
ALL NUMBERS ARE IN MILLIONS OF DOLLARS.

CONSTRUCTION SCHEDULE

The Underflow Project has been scheduled over a ten-year construction period, commencing in 1973 and totally operational by the end of 1982. See Exhibit 10.

The construction has been divided into a completely operational first phase, followed by a second phase which would complete all elements of the plan.

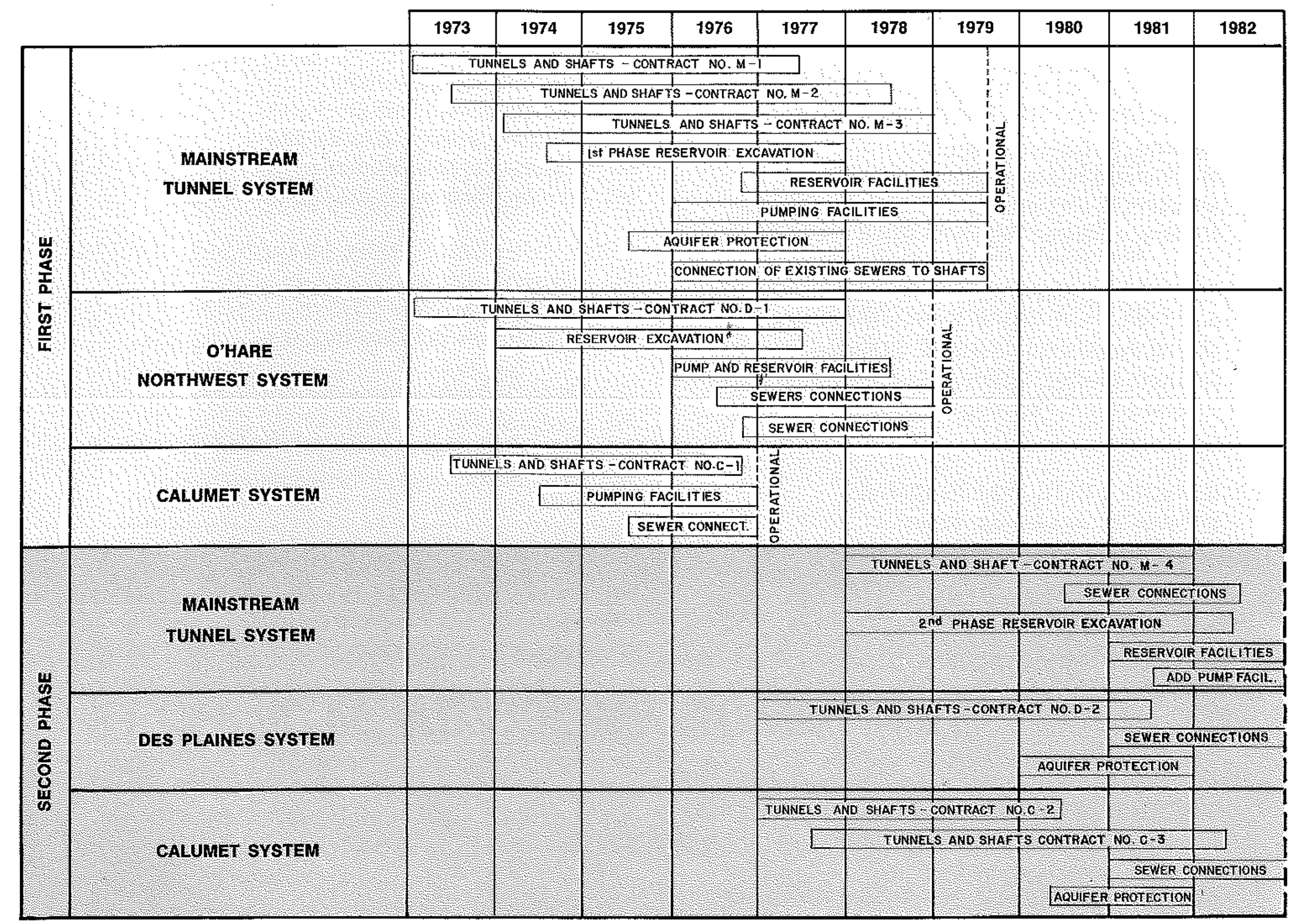
The first phase of the Mainstream System would include the entire main tunnel, with drop shafts, from the reservoir facilities in the McCook-Summit area to Wilmette, and a portion of the reservoir and pumping station facilities. With this portion operational, it would provide about 95 percent reduction of the pollution load spilled from the combined sewers in the area served. Because of the relatively small storage (14,000 acre-feet in tunnel and reservoir), overflow would still occur 1 to 2 times per year but considerable improvement in the Mainstream waterway quality will be evident.

The first phase of the Des Plaines System designated as the O'Hare Northwest System will be the entire tunnel, reservoir and pumping station system, leading to the O'Hare Water Reclamation Plant, now under design. Full benefits will be received when that system is made operational.

In the Calumet System, the first phase would include the construction of the conveyance tunnel from the 95th Street Pumping Station along the Calumet and Little Calumet Rivers to the outlet of the 125th Street Pumping Station. This would eliminate all spillage, Lake-side, of the O'Brien Locks.

ENGINEERING DETAILS

As in all major projects, the final arrangement and dimensions of many components must be left open for possible adjustment or revision during detailed engineering design in the contract preparation stage. Some of the features which will require further study are: the feasibility of separating the Calumet System from the Mainstream System, if economical and environmentally acceptable locations for storage reservoirs can be found in the Calumet area; the elimination of the long length of tunnels to the Palatine area, if other suitable solutions of handling the combined sewer overflow problems for that area can be found; the exact tunnel configuration and alignment in many areas; the exact location of pumping stations and reservoir facilities; the details of the aeration and sludge handling facilities; the desirability of raising the freeboard level at the Wilmette Controlling Works; the alignment and location of the near surface collecting sewers and drop shaft facilities, and many other details.



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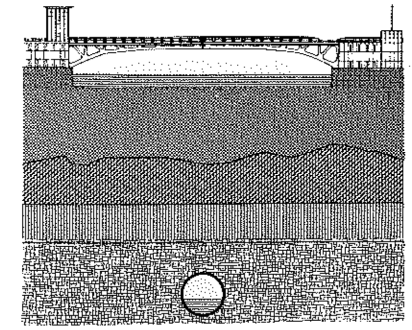

PROJECT DATA SUMMARY

Combined Sewer Systems

Area Served	375 Square Miles
Sewer Mileage	5,000
Sewer Outlets	640
Communities Served	57

Recommended Facilities

Tunnels, Length	120 Miles
Tunnels, Diameter	10 to 42 Feet
Tunnels, Inside Volume	9,100 Acre-Feet
Reservoirs, Location & Storage Volume	
McCook	57,000 Acre-Feet
Stearns Quarry	4,000 " "
O'Hare Water Reclamation Plant	1,800 " "
Total Detention Storage	71,900 Acre-Feet
Equivalent Depth over Combined-Sewer Area	3.6 Inches
Dewatering Rate	
Tunnels to Reservoir (Maximum)	2,400 c.f.s.
Reservoir to Treatment Plant (Average)	700 c.f.s.

Projected Operational Statistics from 21 Year Computer Simulation

Number of Combined Sewer Overflows	3
Reduction in Combined Sewer Overflow Quantity	98.1%
Reduction in Combined Sewer Overflow Pollutants	99.9%

Meets State and Federal E.P.A. Waterway Standards
No Backflows of Waterways into Lake Michigan.

This Report is Condensed from the "Summary of Technical Reports" August 1972

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