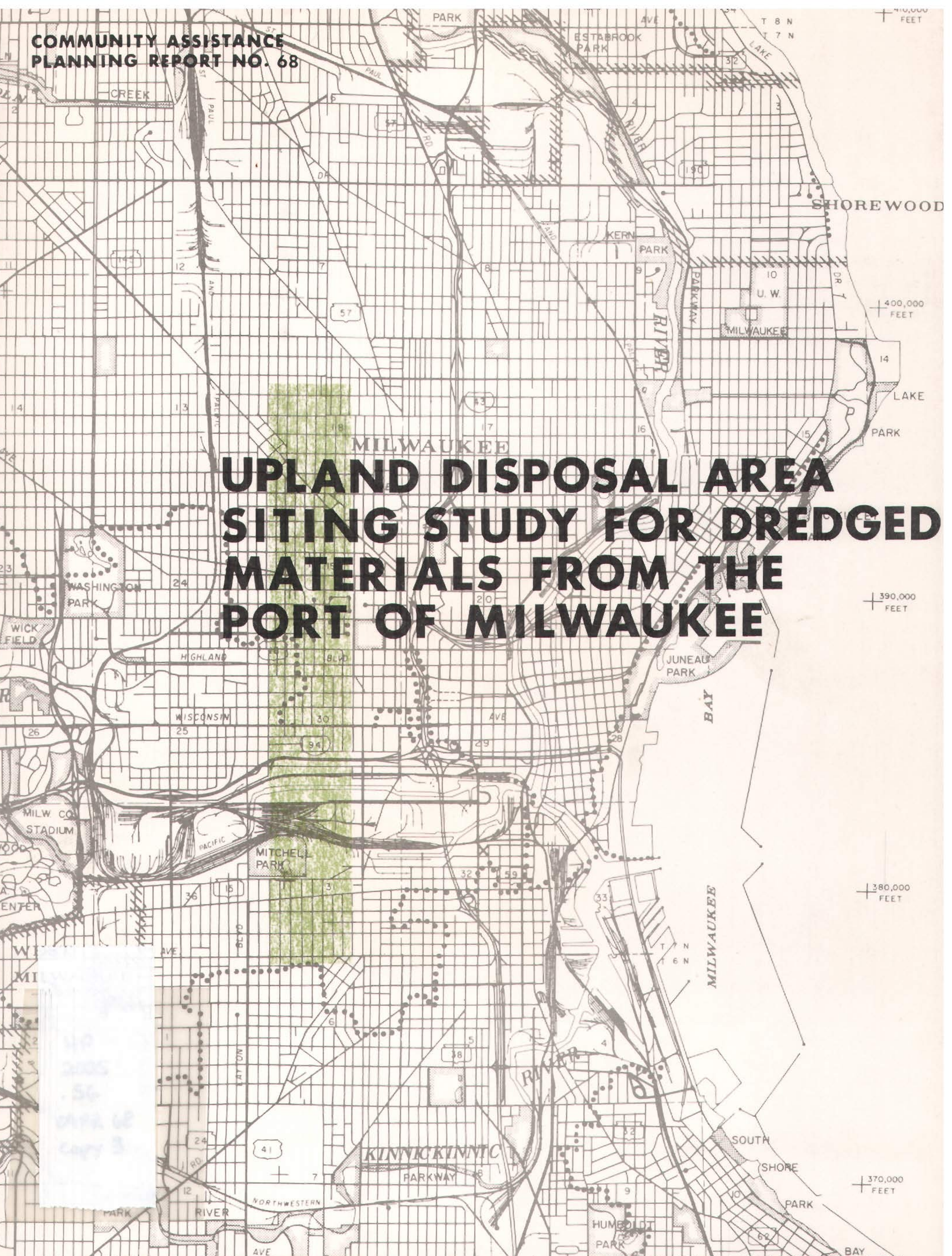
COMMUNITY ASSISTANCE PLANNING REPORT NO. 68

UPLAND DISPOSAL AREA SITING STUDY FOR DREDGED MATERIALS FROM THE PORT OF MILWAUKEE



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COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 68

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December 1981

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December 7, 1981

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500 N. Harbor Drive
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On April 27, 1981, the Port of Milwaukee requested the Southeastern Wisconsin Regional Planning Commission to undertake a study of potential upland alternatives for disposing of or using in an environmentally safe manner materials dredged from the Milwaukee Harbor area, generated as a result of the Port Authority maintenance dredging program. The Commission agreed to undertake the requested study, utilizing funds made available from the Wisconsin Coastal Management Program to the Milwaukee Harbor Commission, and funds from the Commission's continuing environmental planning program. The findings of the study are presented in this report.

The report sets forth the need for and purpose of the study, describes the physical characteristics of the Milwaukee Harbor, including the level of existing harbor and dredging activities, and presents a brief summary of historic dredging and dredged material disposal practices. The basic inventory data essential to a sound study of upland disposal sites for dredged materials, including data on the natural and man-made resources of southeastern Wisconsin, the composition and quantity of dredged materials, and the existing federal and state regulations pertaining to the disposal of dredged materials in upland sites, are presented. Also included is a general evaluation of the methods for disposing of dredged materials at upland sites, and a discussion of the procedures followed and criteria used to evaluate potential upland disposal sites for dredged materials. In addition, the alternative and recommended methods and costs for disposal of dredged material from the Milwaukee Harbor are evaluated.

During the preparation of this report, members of the Commission staff met with members of the Harbor Commission on August 31, 1981, and November 10, 1981, to discuss the findings and recommendations of the study and to receive comments and suggestions concerning the depth and scope of the study. In addition, the Commission staff discussed the preliminary draft of the report with members of the U. S. Environmental Protection Agency, Region V, staff. The findings and recommendations of this report reflect the comments and suggestions of those agencies.

The inventory information, alternatives assessment, and recommendations presented in this report constitute a necessary first phase in the investigation of feasible methods for disposal of dredged materials from the Milwaukee Harbor. However, the ultimate selection of a specific method or methods of disposal and/or reuse of dredged materials from the harbor will require the conduct of detailed studies to evaluate the recommended means for disposal or reuse of the dredged material with respect to economic, social, environmental, technological, and regulatory considerations. It should be emphasized that considerable information on the soundness of the alternative disposal methods has been obtained through the preparation of this report. In its continuing role in the coordination of comprehensive planning and plan implementation within southeastern Wisconsin, the Regional Planning Commission stands ready to assist the Harbor Commission in its conduct of further studies to evaluate the recommended means for disposal or reuse of dredged material from the Milwaukee Harbor.

Respectfully submitted,

Kurt W. Bauer
Executive Director

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Table of Contents

	Page
CHAPTER I - INTRODUCTION AND BACKGROUND	1
CHAPTER II - INVENTORY FINDINGS	7
The Geographic Planning Unit and Planning Period	7
Transportation Facilities	8
Land Use	11
Land Value	11
Natural Resource Base	17
Geology	17
Groundwater Resources	17
Soils	21
Surface Water Resources	21
Environmentally Significant Areas	25
Review of the Legislation, Rules, and Regulations Pertaining to the Disposal of Dredged Materials	25
Federal Laws	25
State Laws	27
Local Regulations	28
Quantity and Characteristics of Dredged Materials from the Milwaukee Harbor	31
Estimated Quantity of Dredged Materials	31
Characteristics of Dredged Materials	33
CHAPTER III - UPLAND DISPOSAL OPTIONS	39
Use of a Landfill or Lagoon Designed Exclusively for Dredged Material Disposal	39
Disposal of Dredged Material in General Refuse Sanitary Landfills	42
Daily Soil Cover	44
Gas and Leachate Barriers	44
Landfill Liner or Final Cover Material	44
Land Application	45
Use of Dredged Materials as Fill	46
Conclusion	47
CHAPTER IV - SITING ANALYSIS FOR UPLAND DISPOSAL OF DREDGED MATERIAL	49
Introduction	49
New Landfill or Lagoon Siting Analysis	50
Criteria for Disposal Area Siting	50
Geology	51
Groundwater	51
Soils	51
Surface Water	52
Environmentally Significant Areas	52
Urban Areas	52
Transportation Base	53
Airports	53
Historical and Archaeological Sites	53
Methodology of General Area Selection Process For a New Landfill or Lagoon	53

Page

Milwaukee Metropolitan Sewerage District (MMSD)
Site-Specific Analysis 53
County Solid Waste Management Studies 54
Regional Wastewater Sludge Management Plan 54
Existing Landfill Locational Considerations 57
Land Application Siting Considerations 57
Other Criteria and Land Application Area Siting Considerations 59
Methodology for General Agricultural Site Selection Process 60
Milwaukee Metropolitan Sewerage District Site-Specific Analysis 60
Regional Wastewater Sludge Management Plan 60
County Farmland Preservation Plans 60
Use of Dredged Material as Fill 62

CHAPTER V - DESCRIPTION OF UPLAND DISPOSAL ALTERNATIVES 67
Alternative 1A: Disposal of Dredged Material in a Landfill Designed Exclusively for Dredged Material Disposal 68
Alternative 1B: Disposal of Dredged Material in a Lagoon Designed Exclusively for Dredged Material Disposal 70
Alternative 2: Disposal of Dredged Material in an Existing Landfill Along with Other Solid Wastes 71
Alternative 3: Application of Dredged Material as a Soil Conditioner 73
Alternative 4: Use of the Dredged Material as Fill 74
Alternative 5: Disposal and Reuse of Dredged Material by Multiple Methods 75

CHAPTER VI - COMPARISON OF ALTERNATIVES AND CONCLUSIONS 77
Alternative 1A: Disposal of Dredged Material in a Landfill Designed Exclusively for Dredged Material Disposal 77
Alternative 1B: Disposal of Dredged Material in a Lagoon Designed Exclusively for Dredged Material Disposal 79
Alternative 2: Disposal of Dredged Material in an Existing Landfill Along with Other Solid Wastes 80
Alternative 3: Application of Dredged Material as a Soil Conditioner 81
Alternative 4: Use of the Dredged Material as Fill 81
Alternative 5: Disposal and Reuse of Dredged Material by Multiple Methods 82
Comparison of Upland Disposal Alternatives to Other Methods of Dredged Material Disposal 83
Conclusions 84

CHAPTER VII - SUMMARY 87
Alternatives Considered 87
New Landfill or Lagoon Site Alternative 88
Existing Landfill Site Alternative 88
Land Application Site Alternative 88
Fill Material Use Alternative 89
Evaluation of Alternatives 89
Special-Purpose Landfill or Lagoon Disposal 90
Disposal in Existing Landfills 91
Disposal on Agricultural Lands 91
Disposal as a Fill Material 92
Disposal by Multiple Methods 92
Conclusions 93

APPENDICES

Appendix Page

A Unit Costs Utilized in the Development of Estimates for Disposal Alternatives and Economic Analyses.................. 97

LIST OF TABLES

Table Page

Chapter II

1 Distribution of Existing and Proposed Land Use in the Region by County: 1970 and 2000............................ 13
2 Existing and Forecast Land Use in the Region: 1970 and 2000........ 15
3 Reported Land Acquisition Costs by Land Use: 1970-1980............. 16
4 Average Agricultural Land Sale Prices by Type of Sale by County: 1980.................................... 18
5 Suggested Zoning Districts for a Typical Southeastern Wisconsin Community.......................... 29
6 Summary of Quantities of Dredged Materials from the Milwaukee Harbor: 1960-1980............................... 32
7 Quality of Sediments in the Milwaukee Harbor...................... 34
8 Soil Fractions and Nutrients in Sediments of the Milwaukee Harbor.. 35
9 U. S. Environmental Protection Agency Sediment Pollution Categories Using Bulk Sediment Analysis................. 36

Chapter V

10 Principal Features and Costs of Management Alternatives for Upland Disposal and Reuse of Dredged Materials for the Milwaukee Harbor.. 69

Chapter VI

11 Comparison of Principal Features and Costs of Upland Disposal and Reuse of Dredged Materials for the Milwaukee Harbor............ 78

LIST OF FIGURES

Figure Page

Chapter II

1 Map and Cross-Section of Bedrock Geology in the Region............ 19

Chapter III

2 Types of Landfills Potentially Suitable for Dredged Materials Disposal................................... 40
3 Example of a Lagoon Potentially Suitable for Dredged Materials Disposal................................... 43

Chapter VI

4 Summary Implementation Schedule for Adoption of an Integrated Upland Dredged Material Disposal System................. 85

LIST OF MAPS

Map		Page
	Chapter I	
1	Milwaukee Harbor Area	2
2	Jurisdictional Responsibility for Harbor Dredging Maintenance in the Milwaukee Area	4
	Chapter II	
3	Arterial Streets and Highways in the Region: 1972	9
4	Status of Railway Lines in Southeastern Wisconsin: December 31, 1979	10
5	Generalized Existing Land Use in the Region: 1975	12
6	Thickness of Glacial Deposits and the Location of Bedrock Outcrops in the Region	20
7	Depth to Seasonal High Groundwater Levels in the Region	22
8	Soil Suitability for Landfill Construction for Sections 1, 2, 3, 10, 11, and 12 in the Town of Sugar Creek, Walworth County	23
9	Watersheds and Surface Water Resources of the Region	24
10	Primary Environmental Corridors in the Region: 1973	26
11	Sediment Quality in the Milwaukee Harbor	37
	Chapter IV	
12	Generalized Suitability Ratings for Special-Purpose Landfill or Lagoon Siting for Dredged Materials Disposal in Southeastern Wisconsin	55
13	Existing Active Sanitary Landfill Sites in the Region: 1980	58
14	General Siting Analysis Results for Use of Dredged Material on Agricultural Land	63
15	Existing and Planned Urban Development Within the Year 2000 Sewer Service Area in the Region	66

Chapter I

INTRODUCTION AND BACKGROUND

The Milwaukee Harbor area is comprised of two distinct hydraulic units: the inner harbor and the outer harbor. As shown on Map 1, the inner harbor is delineated as the lower reaches of the Kinnickinnic River, the Menomonee River, and the Milwaukee River--bounded upstream by the limits of the hydraulic backwater effects of the lake and harbor, and downstream by the mouth of the Milwaukee River--at the terminus of the confined shipping channel, immediately east of the Daniel T. Hoan Memorial Bridge crossing. The upstream limits are the crossing of Buffalo Street on the Milwaukee River, the Falk Corporation dam on the Menomonee River, and the crossing of Becher Street on the Kinnickinnic River. The outer harbor is delineated by the inner harbor and shoreline on the west, and by the Lake Michigan breakwater on the east. Thus, the inner harbor normally discharges into the outer harbor.

The inner harbor has depths ranging from 7 feet to 29 feet, an approximate surface area of 227 acres, and a volume of about 220 million cubic feet. The outer harbor has depths ranging from 4 feet to 36 feet, a surface area of approximately 1,300 acres, and a volume of about 1,300 million cubic feet.

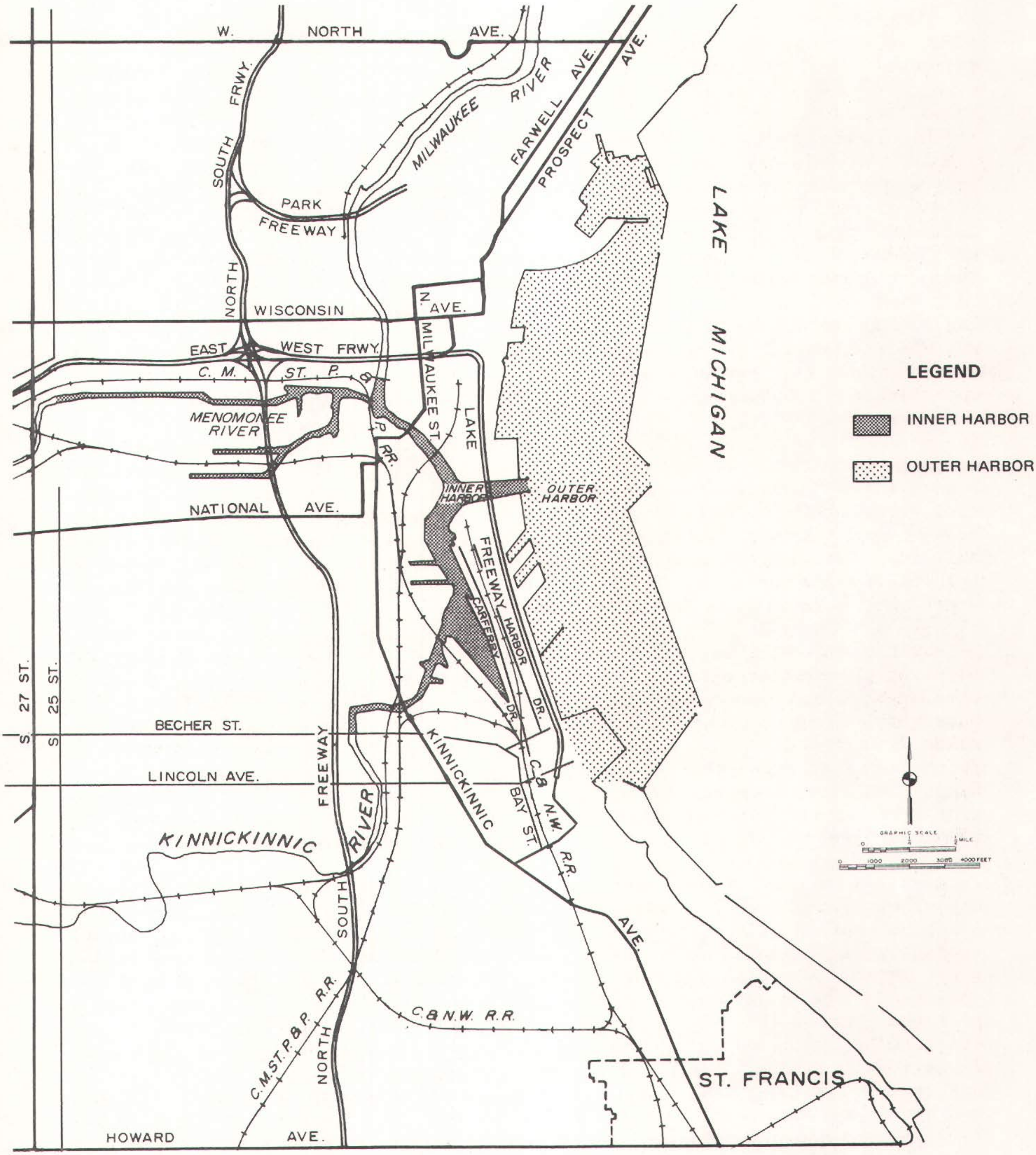
The Kinnickinnic, Menomonee, and Milwaukee Rivers, which discharge into the inner harbor, drain watersheds that have a combined area of approximately 850 square miles. These rivers have a combined mean annual flow of about 520 cubic feet per second (cfs) discharging into the inner harbor area. Of this total, a mean annual flow of about 410 cfs, or 79 percent, is contributed by the Milwaukee River; a mean annual flow of about 90 cfs, or 17 percent, is contributed by the Menomonee River; and a mean annual flow of about 20 cfs, or 4 percent, is contributed by the Kinnickinnic River.

In addition to receiving the discharge from the inner harbor, the outer harbor receives the discharge from the Jones Island sewage treatment plant. In 1978, the Jones Island sewage treatment plant had a mean flow of 198 cfs. Thus, the outer harbor superficially resembles a small lake with two tributaries--the inner harbor and the Jones Island sewage treatment plant outfall--and four points of discharge--the four openings along the 5.3-mile-long breakwater. Hydraulically, the outer harbor is much more complex than the inner harbor, since the influences of Lake Michigan provide for multiple-layered and multiple-directional flow at each of the five openings.

Because the Milwaukee Harbor is situated at the confluence of Lake Michigan and the Kinnickinnic, Menomonee, and Milwaukee Rivers, the relatively quiescent waters of the harbor afford slower stream velocities, with attendant increases in the settling rates of suspended sediment and associated pollutants deposited on the harbor bottom. The waters of these three rivers are polluted to some extent throughout much of their lengths, but are grossly polluted in the inner harbor. This pollution is due largely to combined and separate sewer overflows, industrial wastewater discharges, runoff from both urban and rural land uses, and decomposing aquatic plant growth stimulated by nutrient pollution from sewage treatment plant effluents and other nutrient sources contributed upstream from the Milwaukee area. Such polluted wastes may be deposited and accumulate in the Milwaukee Harbor. As a result, the aquatic environment and the associated fish and other aquatic life in much of the Milwaukee Harbor are characteristic of a grossly polluted aquatic habitat.

Map 1

MILWAUKEE HARBOR AREA



Source: SEWRPC.

Sedimentation in the harbor is a hindrance to commercial navigation and related activities in the Port of Milwaukee, and adversely affects the water quality and aesthetics of the harbor and of Lake Michigan itself. Commercial vessels, for example, cannot operate at full capacity if shallower waters, which are the result of sediment accumulation in the channels and mooring slips, must be negotiated. In order to accommodate the draft of large sea-going commercial ships, the channels of the St. Lawrence Seaway are intended to be uniformly constructed and maintained at 27 feet below established low-water datum, International Great Lakes Datum (IGLD). Accordingly, harbors and ports serving such vessels should be constructed and maintained at 27-foot depths.

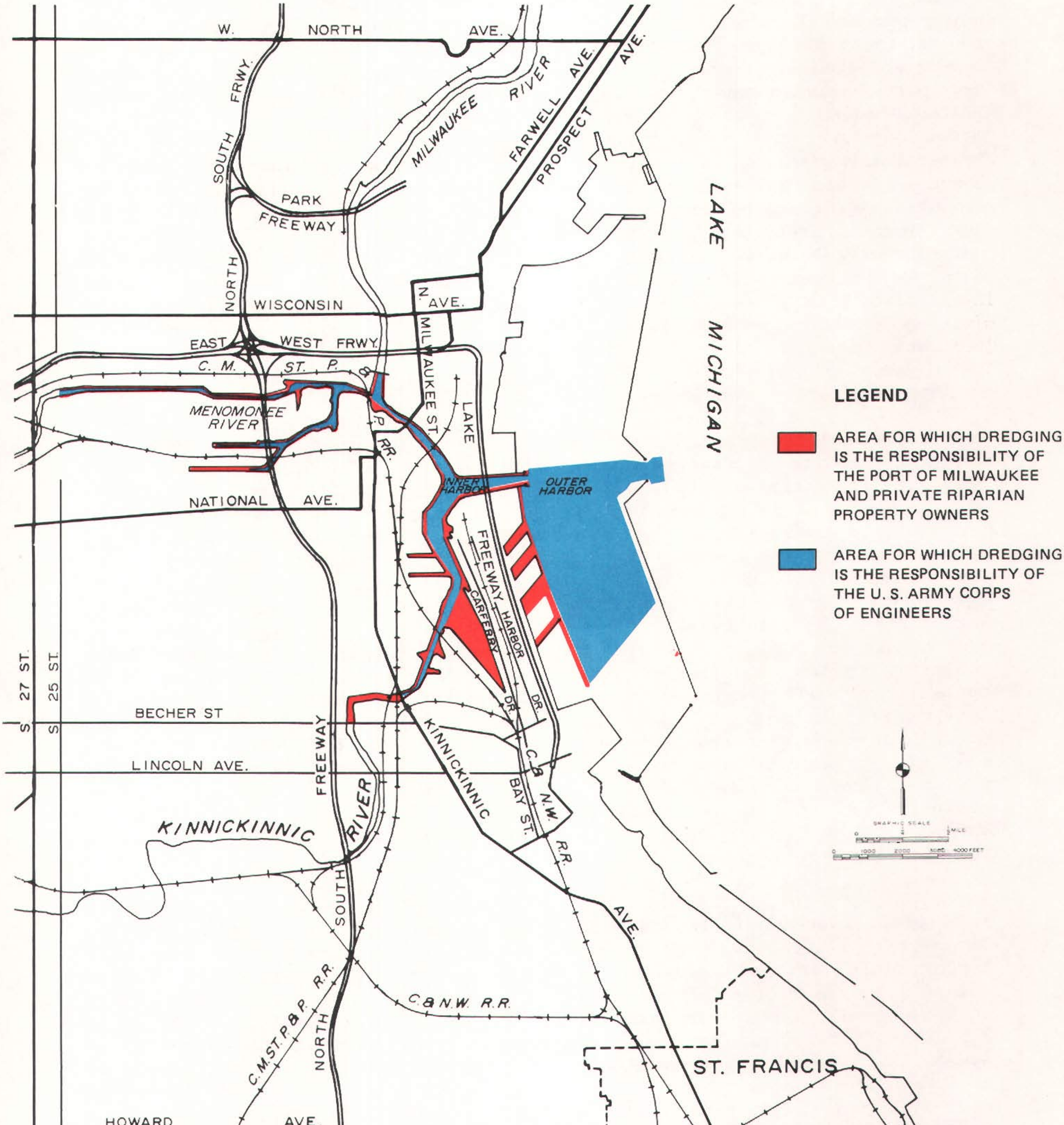
By agreement with the federal government, the City of Milwaukee, through the Board of Harbor Commissioners, is charged with the responsibility of providing and maintaining depths of at least 27 feet below IGLD between channel limits and terminal facilities, and in berthing areas within the Port of Milwaukee. A corresponding elevation is maintained within the channels by the U. S. Army Corps of Engineers (COE) to designated project limits. In addition, private facilities located in the Milwaukee Harbor are required to maintain the minimum depths for a distance of 75 feet beyond the mooring berths. Map 2 indicates the areas of responsibility for the maintenance of minimum depths in the Milwaukee Harbor by the federal government, by the City of Milwaukee, and by private riparian property owners.

Previously, minimum water depths were maintained in Milwaukee Harbor by dredging, loading the dredged materials into scows, and transporting the scows to a specified deep-water portion of Lake Michigan where the dredged materials were released and allowed to sink. In the mid-1960's, however, with an increasing awareness of, and concern over, water quality problems in the Great Lakes, the disposal of dredged materials in the open waters of Lake Michigan came under question. In November 1969, the U. S. Environmental Protection Agency (EPA) took core and bottom sediment samples in the northern outer harbor area. The results of this sampling effort indicated that the overlying silt layer was heavily polluted and that the underlying clay was moderately polluted. Although the samples extracted by the EPA may not have been representative of all the materials in the Milwaukee Harbor, the EPA recommended that dredged materials be placed in a confinement disposal facility and not dumped into the open waters of Lake Michigan. In 1970, the Wisconsin Department of Natural Resources instituted regulations to prohibit the dumping of polluted dredged materials in state waters, citing the need for further evaluation of the environmental impacts of dredging and the disposition of such materials on navigation, fish and other aquatic life, water quality, and the general public interest.

In response to the prohibition on the disposal of polluted dredged materials in the open waters of Lake Michigan, the COE in 1975 constructed a confined disposal facility along the shoreline in the southern portion of the outer harbor. This confined disposal facility was intended to provide an interim solution to the problem of the disposal of polluted materials from dredging while a longer-term solution was found. The confined disposal facility in the Milwaukee Harbor covers an area of approximately 44 acres and has an estimated capacity of 1.6 million cubic yards of dredged materials--sufficient to enclose the amount of material anticipated to be dredged over a 10-year period. At the end of this 10-year period in the mid-1980's, when its use as a disposal area ceases, the area is intended to be regraded, landscaped, and converted to public use.

Map 2

JURISDICTIONAL RESPONSIBILITY FOR HARBOR DREDGING MAINTENANCE IN THE MILWAUKEE HARBOR AREA



Source: SEWRPC.

Since the confined disposal facilities will serve only for a limited time period, and since disposal in the open waters of Lake Michigan is presently prohibited, alternative solutions to the problem of the disposal of dredged materials from the Milwaukee Harbor area must be identified. Several alternative long-term disposal methods are presently being investigated under ongoing studies, including the reevaluation by the Corp of Engineers of open-water disposal for selected dredged materials, and the evaluation of near-shore disposal sites utilizing two demonstration projects funded in part under the federal Coastal Zone Management Program. The disposal of dredged materials in upland areas offers one other such potential solution. The disposal of dredged materials in upland areas may be accomplished through deposition in special-purpose, engineered, sanitary landfills; through deposition in conventional, multiple-purpose, sanitary landfills; or through the treatment of agricultural or other lands with the dredged materials used as a soil amendment. It is also possible that dredged materials may find application as a building material or be reused in other ways. Prior to determining the practicality of disposing of dredged materials in upland areas, however, it is necessary to characterize the nature and quantity of the materials to be dredged from the Milwaukee Harbor area. This topic is among those reviewed in the following chapter.

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Chapter II

INVENTORY FINDINGS

This chapter summarizes the inventory data pertinent to the sound evaluation of potential upland disposal sites for dredged materials from the Milwaukee Harbor area. Included within this chapter is a definition of the logical geographic planning unit for the study; the identification of the study planning period; a description of the man-made and natural features of the study area pertinent to the identification and evaluation of upland dredged material disposal sites, including a description of existing land uses in the Region and of the supporting transportation system; a summary of the regulatory framework relating to the disposal of dredged materials; and a description of the composition and characteristics of bottom materials in the Milwaukee Harbor area.

In addition to forming the basis for this specific report and analysis, this chapter of the report is intended to provide the Port of Milwaukee and other agencies with a knowledge of available data and data sources which could be used in the conduct of more detailed inland disposal area siting studies.

THE GEOGRAPHIC PLANNING UNIT AND PLANNING PERIOD

Planning relating to the upland disposal of dredged materials from the Milwaukee Harbor area could conceivably be carried out on the basis of various geographic units, including areas defined by governmental jurisdiction such as city or county boundaries. However, since the upland sites for the disposal of dredged materials can probably best be accommodated in more rural areas, it would not be practicable to limit the geographic extent of this analysis to the City of Milwaukee, or even to Milwaukee County. Moreover, the major land-based transportation systems comprise areawide systems serving the larger metropolitan complex of southeastern Wisconsin, which functions as a single socioeconomic unit.

Accordingly, and in recognition of the substantial data base available, the entire seven-county Southeastern Wisconsin Region is considered herein to be the basic geographic unit for the purpose of identifying potential upland disposal sites for dredged material. It is also recognized that since transportation costs for the cartage of dredged materials to upland disposal sites depend in part on the haul distance, it is important to identify potential sites located as close as possible to the Milwaukee Harbor area in order to reduce disposal costs.

A planning period of up to the year 2000 has been chosen for the alternatives presented. However, the service life, or operational utility, of the disposal facilities is assumed to be 15 years, since the need for and use of those facilities is not envisioned until after 1985. A planning period of about 20 years is considered to be appropriate because first, the involved agencies must effectively organize operations to meet dredged material disposal needs over a reasonable future period, and second, there are substantial data for forecast conditions through the year 2000.

TRANSPORTATION FACILITIES

Access to and egress from the Milwaukee Harbor area are provided by a number of freeway and arterial street facilities. As shown on Map 1, IH 794, Carferry Drive, E. Bay Street, E. Lincoln Avenue, and S. Harbor Drive constitute the major surface transportation facilities connecting the Milwaukee Harbor area to the extensive regional arterial street and highway system. The existing surface transportation facilities in and around the Milwaukee Harbor area, therefore, are adequate to provide for the ready transport of dredged materials to upland areas by motor truck. Map 3 indicates the arterial street and highway network within the Region.

In addition to being served by the arterial street and highway system, the Milwaukee Harbor area is served by three major railroads: the Chicago, Milwaukee, St. Paul & Pacific Railroad Company (the Milwaukee Road), the Chicago & North Western Transportation Company, and the Soo Line Railroad Company through a reciprocal switching agreement with the Milwaukee Road. Carferry service across Lake Michigan operated by the Grand Trunk Western Railroad Company was discontinued during 1978, and the last carferry service serving the Port of Milwaukee--operated by the Chessie System (Chesapeake & Ohio Railway Company) between Milwaukee and Ludington, Michigan--ended during October 1980. During the summer season of 1981, the State of Michigan contracted with the Chessie System for the provision of autoferry service between Milwaukee and Ludington using the existing carferrys and dock facilities. This passenger demonstration project, however, did not handle railway freight cars. The Milwaukee Harbor area is also served by approximately 72 common carrier trucking companies. Map 4 indicates the common carrier railway freight lines within the Region.

As of 1980, there were 23 airports open for public use in the Region. Of these, seven airports were publicly owned and 16 were privately owned. Chapter NR 180.13(3a) of the Wisconsin Administrative Code states that:

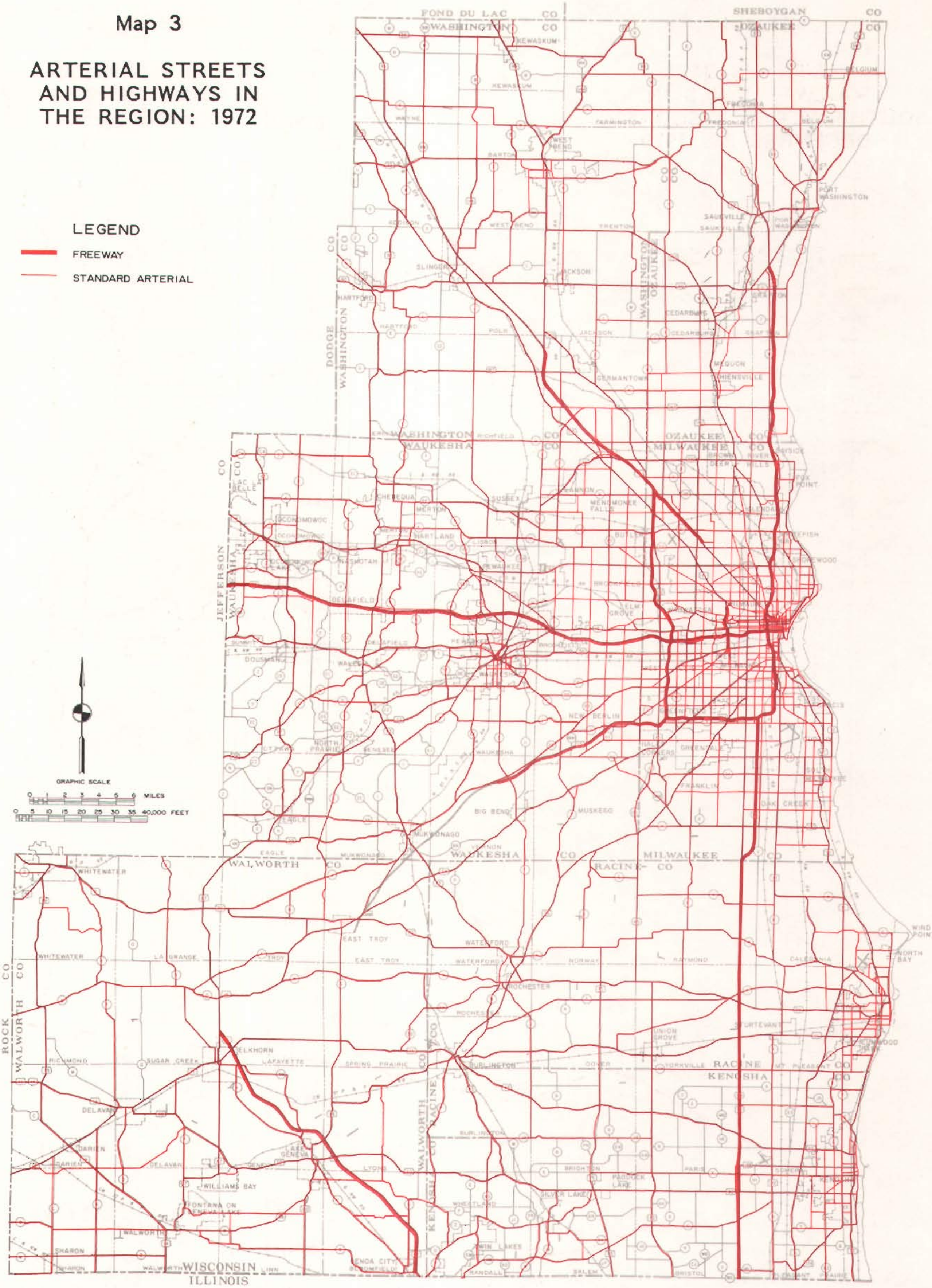
> No person shall establish, construct, operate, maintain, or permit the use of property for a solid waste land disposal facility within 10,000 feet of any airport runway, used or planned to be used by turbojet aircraft, or within 5,000 feet of any airport runway used only by piston-type aircraft or within such other areas where a substantial bird hazard to aircraft would be created, unless a waiver is granted by the Federal Aviation Administration.

This regulation was established to ensure that bird species that are typically attracted to and gather at landfill sites are kept away from airport traffic patterns and approaching and departing aircraft. Aircraft collision with birds may cause serious accidents. Turbo-powered aircraft are particularly susceptible to serious collision damage owing to the sensitive nature of the exposed engine turbine and to the extreme dependence of such high-powered aircraft on engine thrust to maintain flight. The Wisconsin law is patterned after the Federal Aviation Administration (FAA) regulation, which recommends that similar buffer zones be maintained between landfills and airports for the safety of air traffic.

Because of the expected methods of operation, a landfill designed to handle only dredged materials is not expected to result in severe problems with respect to attraction of birds to areas near airports; therefore, the buffer

Map 3

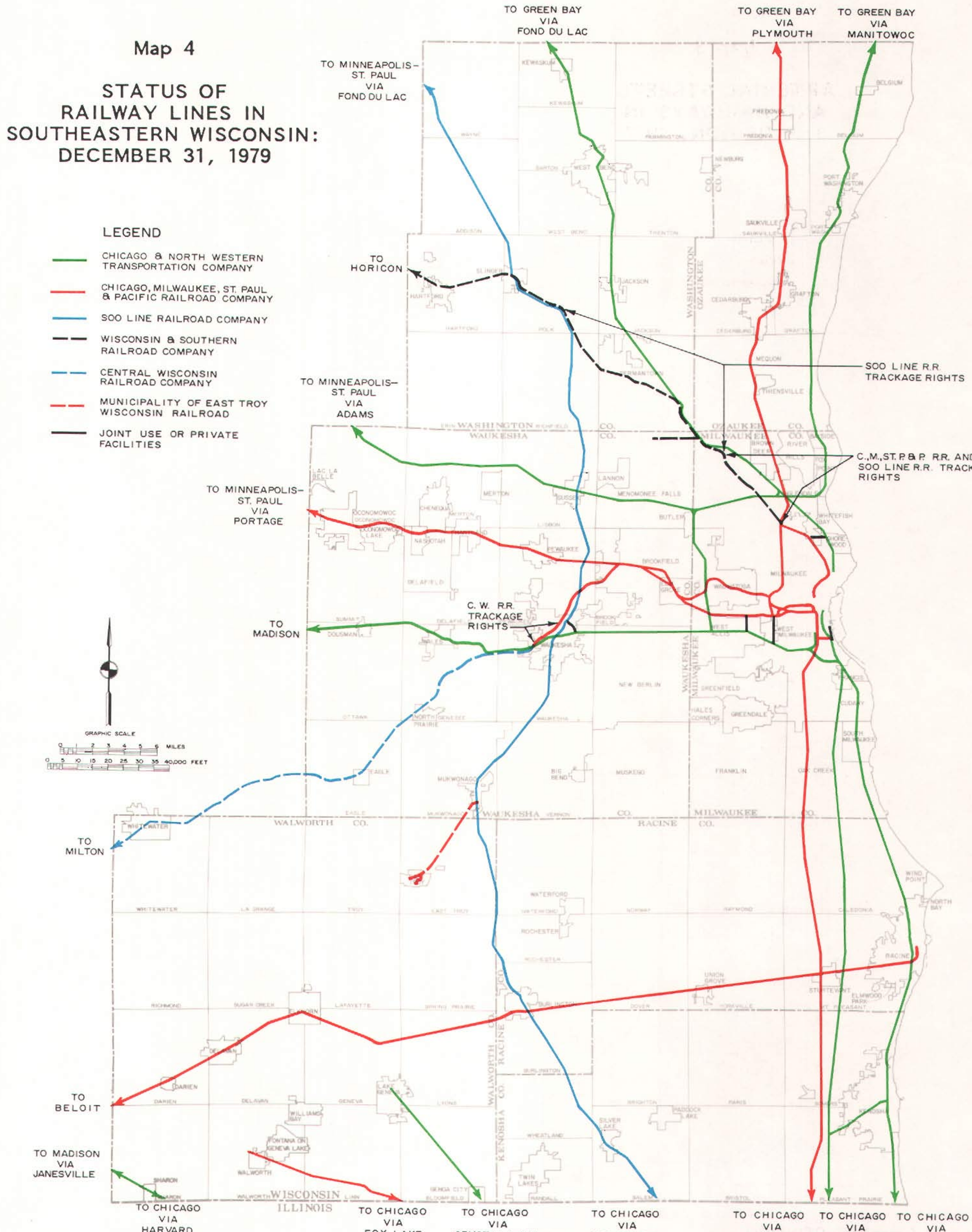
ARTERIAL STREETS AND HIGHWAYS IN THE REGION: 1972



Source: SEWRPC.

Map 4

STATUS OF RAILWAY LINES IN SOUTHEASTERN WISCONSIN: DECEMBER 31, 1979



Source: SEWRPC.

zone requirements for these airports were not considered in the siting analysis included in this study for landfills to receive only dredged materials. More detailed, site-specific studies should investigate this criterion for each specific site where the buffer zone may be a factor in order to obtain the needed Department of Natural Resources and FAA agreement on the applicability of the criterion.

LAND USE

The potential disposal of dredged materials from the Milwaukee Harbor area in upland areas may be expected to impact upon, and be impacted by, existing and forecast land use patterns in the Region. Accordingly, an understanding of existing land use patterns, and of the trends in such patterns, is important to the sound evaluation of potential upland disposal sites.

The distribution of land uses within the Region as of 1975 is shown on Map 5. Existing land uses as of 1970 and planned land uses in the Region to the year 2000 are summarized in Table 1 and Table 2. It may be seen in Table 1 that, although southeastern Wisconsin is a highly urbanized Region, less than 20 percent of its total area is devoted to urban-type land uses. The largest land use category within the Region is agriculture, which occupies about 75 percent of the total rural area and about 60 percent of the Region as a whole. The next largest land use category is open lands, including water and wetlands, which occupy about 25 percent of the rural area of the Region and about 20 percent of the total area of the Region. More than 80 percent of the total area of the Region, therefore, is devoted to rural land uses, including agriculture, woodlands, wetlands, other open lands, and surface waters.

Of the area of the Region devoted to urban uses, residential land occupies the greatest proportion, about 48 percent of the total urban area of the Region and about 9 percent of the Region as a whole. Land devoted to transportation occupies about 33 percent of the urban area of the Region, or about 6 percent of the total area. A very small amount of land was devoted to urban commercial and industrial economic activities--about 5 percent of the urban land in the Region, or about 1 percent of the Region as a whole.

Under the adopted regional land use plan for the year 2000, agriculture and open land uses may be expected to account jointly for about 76 percent of the total area of the Region, down from about 81 percent in 1970. It is expected that 113 square miles of rural land use in the Region will be converted to urban land use between 1970 and the year 2000. The adopted land use plan envisions that new urban development will occur primarily in planned neighborhood units at medium-density population levels--that is, about four dwelling units per net residential acre, or about 5,000 persons per gross square mile.

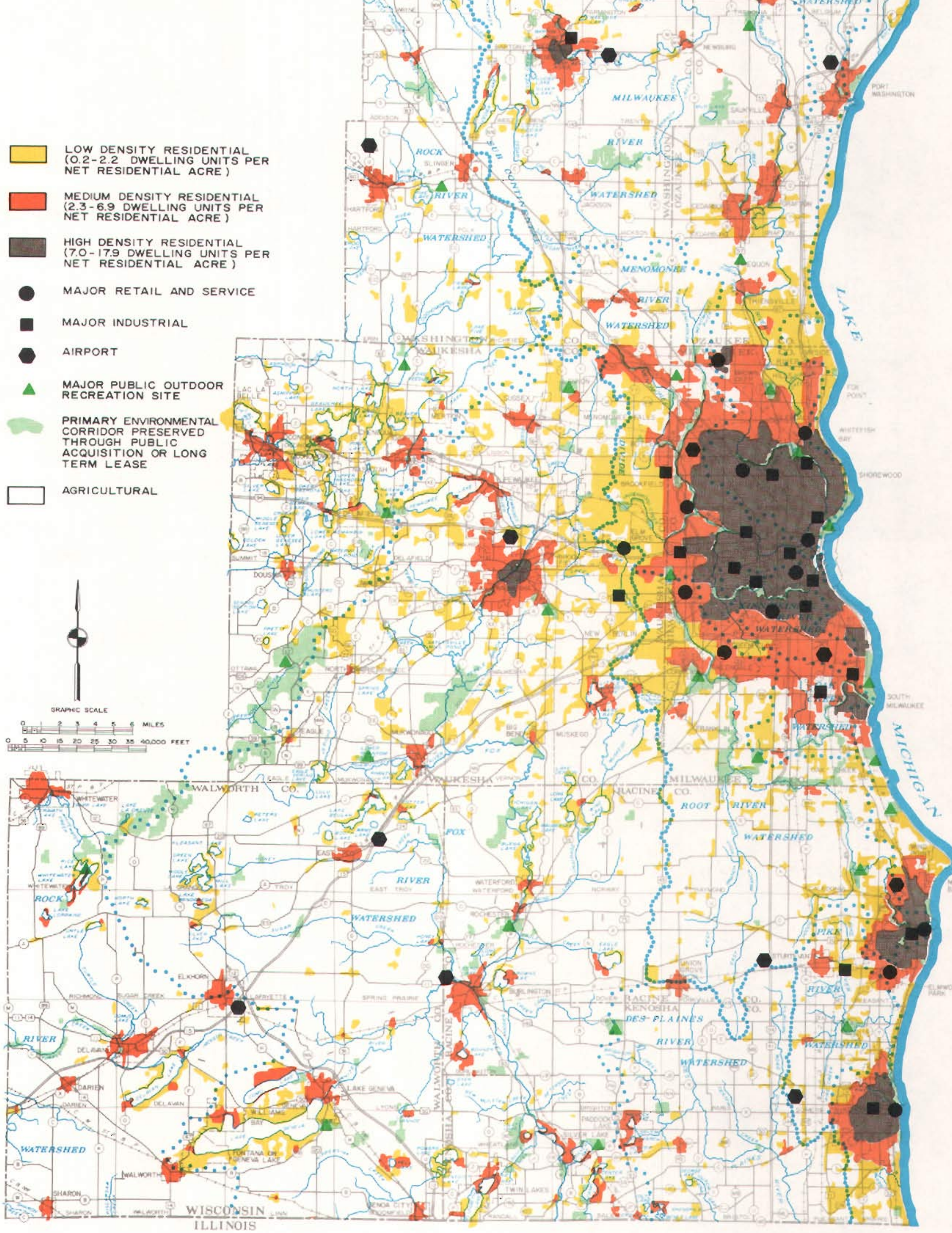
LAND VALUE

Data on land values within the Region are provided in Table 3. It should be noted, however, that these land values are highly generalized and are representative only of the prices at which such lands were sold in the year indicated. Actual land acquisition costs will, of course, depend on the individual site selected and current market rates.

More detailed information on the costs of agricultural lands in the Region by county is available from the U. S. Department of Agriculture, Bureau of

Map 5

GENERALIZED EXISTING LAND USE IN THE REGION: 1975



Source: SEWRPC.

Table 1

DISTRIBUTION OF EXISTING AND PROPOSED LAND USE IN THE REGION BY COUNTY: 1970 AND 2000

County	Year	Major Land Use Category									
		Residential[a]		Commercial		Industrial[b]		Transportation[c]		Governmental[d]	
		Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Kenosha	1970 2000 Change	13,476 16,807 3,331	7.5 9.4 24.7	504 538 34	0.3 0.3 6.8	811 1,161 350	0.5 0.7 43.2	8,932 11,512 2,580	5.0 6.5 28.9	1,326 1,415 89	0.7 0.8 6.8
Milwaukee	1970 2000 Change	45,631 53,545 7,914	29.4 34.6 17.3	2,875 3,071 196	1.9 2.0 6.8	4,899 6,894 1,995	3.2 4.4 40.7	35,441 39,057 3,616	22.9 25.2 10.2	7,502 7,713 211	4.8 5.0 2.8
Ozaukee	1970 2000 Change	12,321 16,730 4,409	8.2 11.2 35.8	331 374 43	0.2 0.2 13.0	443 926 483	0.3 0.6 109.0	8,055 9,977 1,922	5.4 6.7 23.9	939 1,052 113	0.6 0.7 12.0
Racine	1970 2000 Change	16,625 19,324 2,699	7.6 8.9 16.2	574 657 83	0.3 0.3 14.5	1,099 1,897 798	0.5 0.9 72.6	12,442 14,122 1,680	5.7 6.5 13.5	1,744 1,816 72	0.8 0.8 4.1
Walworth	1970 2000 Change	13,409 15,435 2,026	3.6 4.2 15.1	593 657 64	0.2 0.2 10.8	827 1,275 448	0.2 0.3 54.2	12,020 13,841 1,821	3.3 3.7 15.1	1,192 1,240 48	0.3 0.3 4.0
Washington	1970 2000 Change	11,524 16,014 4,490	4.1 5.7 39.0	299 340 41	0.1 0.1 13.9	434 819 385	0.2 0.3 88.7	11,289 14,529 3,240	4.1 5.2 28.7	916 1,038 122	0.3 0.4 13.3
Waukesha	1970 2000 Change	43,275 56,996 13,721	11.6 15.3 31.7	1,341 1,578 237	0.4 0.4 17.7	1,525 3,378 2,213	0.4 0.9 145.1	21,251 27,833 6,582	5.7 7.5 31.0	3,009 3,305 296	0.8 0.9 9.8
Region	1970 2000 Change	156,261 194,851 38,590	9.1 11.3 24.7	6,517 7,215 698	0.4 0.4 10.7	10,038 16,710 6,672	0.6 1.0 66.5	109,430 130,871 21,441	6.3 7.6 19.6	16,628 17,579 951	1.0 1.0 5.7

Table 1 (continued)

County	Year	Major Land Use Category									
		Recreational		Rural Residential[e]		Agricultural		Open Lands[f]		Total	
		Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Kenosha	1970	2,670	1.5	--	--	113,928	64.0	36,453	20.5	178,100	100.0
	2000	2,929	1.6	1,484	0.8	106,912	60.1	35,342	19.8	178,100	100.0
	Change	259	9.7	1,484	--	-7,016	-6.2	-1,111	-3.1	--	--
Milwaukee	1970	9,911	6.4	--	--	28,607	18.4	20,199	13.0	155,065	100.0
	2000	10,432	6.7	--	--	20,180	13.0	14,173	9.1	155,065	100.0
	Change	521	5.3	--	--	-8,427	-29.5	-6,026	-29.8	--	--
Ozaukee	1970	1,657	1.1	--	--	100,491	67.0	25,776	17.2	150,013	100.0
	2000	2,339	1.6	1,243	0.8	92,502	61.6	24,870	16.6	150,013	100.0
	Change	682	41.1	1,243	--	-7,989	-7.9	-906	-3.5	--	--
Racine	1970	2,586	1.2	--	--	147,207	67.7	35,285	16.2	217,562	100.0
	2000	2,933	1.3	1,797	0.8	140,964	64.8	34,052	15.7	217,562	100.0
	Change	347	13.4	1,797	--	-6,243	-4.2	-1,233	-3.5	--	--
Walworth	1970	4,275	1.2	--	--	261,744	70.8	75,922	20.4	369,982	100.0
	2000	5,054	1.4	2,115	0.6	255,270	69.0	75,095	20.3	369,982	100.0
	Change	779	18.2	2,115	--	-6,474	-2.5	-827	-1.1	--	--
Washington	1970	1,664	0.6	--	--	186,466	66.9	66,141	23.7	278,733	100.0
	2000	2,360	0.8	7,318	2.6	170,719	61.4	65,596	23.5	278,733	100.0
	Change	696	41.8	7,318	--	-15,747	-8.4	-545	-0.8	--	--
Waukesha	1970	6,219	1.7	--	--	201,676	54.3	93,349	25.1	371,645	100.0
	2000	7,101	1.9	8,349	2.2	173,793	47.0	88,952	23.9	371,645	100.0
	Change	882	14.2	8,349	--	-27,883	-13.8	-4,397	-4.7	--	--
Region	1970	28,982	1.7	--	--	1,040,119	60.4	353,125	20.5	1,721,100	100.0
	2000	33,148	1.9	22,306	1.3	960,340	55.9	338,080	19.6	1,721,100	100.0
	Change	4,166	14.4	22,306	--	-79,779	-7.7	-15,045	-4.3	--	--

[a]Includes all residential areas, developed and under development.

[b]Includes all manufacturing, wholesaling, and storage.

[c]Includes off-street parking areas of more than 10 spaces.

[d]Includes institutional land uses.

[e]The 1970 rural residential acreage is included in the land use inventory as part of the urban residential land use.

[f]Includes woodlands, quarries, and water and wetlands, as well as unused and other open lands.

Source: SEWRPC.

Table 2

EXISTING AND FORECAST LAND USE IN THE REGION: 1970 AND 2000

Land Use Category	Existing 1970			Planned 2000		
	Acres	Percent of Major Category	Percent of Region	Acres	Percent of Major Category	Percent of Region
Urban						
Residential.......	156,261	47.7	9.1	194,851	48.7	11.3
Commercial........	6,517	2.0	0.4	7,215	1.8	0.4
Industrial........	10,038	3.1	0.6	16,710	4.2	1.0
Transportation....	109,430	33.4	6.3	130,871	32.6	7.6
Governmental......	16,628	5.1	1.0	17,579	4.4	1.0
Recreational......	28,982	8.7	1.7	33,148	8.3	1.9
Subtotal	327,856	100.0	19.1	400,374	100.0	23.2
Rural						
Residential.......	--	--	--	22,306	1.7	1.3
Agricultural......	1,040,119	74.7	60.4	960,340	72.7	55.9
Open Lands........	353,125	25.3	20.5	338,080	25.6	19.6
Subtotal	1,393,244	100.0	80.9	1,320,726	100.0	76.8
Total	1,721,100	100.0	--	1,721,100	--	100.0

Source: SEWRPC.

Table 3

REPORTED LAND ACQUISITION COSTS BY LAND USE: 1970-1980

Agency	Year	Dollars per Acre						
		Agricultural Land	Wetlands	Woodlands	Other Open Lands[a]	Developable Land (noncorridor)	Industrial Land	Commercial Land
U. S. Department of Agriculture, Soil Conservation Service......	1975	1,800[b]	--	--	--	--	--	--
U. S. Department of Agriculture, Soil Conservation Service......	1980	1,700-2,200	650[b]	2,200[b]	--	--	--	--
Wisconsin Department of Natural Resources..........	1980	--	300-750	1,500-2,200	--	--	--	--
SEWRPC								
Milwaukee River Watershed Study.............	1970	--	300	700	--	--	--	--
Ozaukee County Park Plan......	1975	--	400	20,000 (high-value developable)	--	--	--	--
Pewaukee Park Plan...........	1980	--	500	16,000 (high-value developable)	--	--	--	--
New Berlin Park Plan..........	1980	1,200-3,000	500-900	2,200-7,500	--	3,000-12,000	--	--
Kenosha Park Plan............	1975	800-1,500	400-1,000	1,500-10,000	800-10,000	1,200-20,000	--	--
Kenosha Park Plan............	1980	--	500-1,500	2,200-15,000	1,200-15,000	3,000-30,000	--	--
Association of Commerce (Washington, Ozaukee, Milwaukee, and Waukesha Counties)....................	1980	--	--	--	--	--	20,000-60,000	20,000-60,000
Association of Commerce (Racine, Kenosha, and Walworth Counties)...........	1980	--	--	--	--	--	15,000-50,000	15,000-50,000

[a] Includes unused lands within the environmental corridor, not considered agricultural.

[b] Average cost per acre.

Source: SEWRPC.

Statistics, and is presented in Table 4 for the year 1980. As may be seen in this table, the value of agricultural land sold for agricultural use in 1980 ranged from a low of about $2,000 per acre in Racine and Washington Counties to a high average of about $2,300 per acre in Ozaukee County, with a regional average of about $2,100 per acre. As also indicated in Table 4, the value of agricultural land sold for development purposes ranged from about $2,800 per acre in Kenosha County to about $8,800 per acre in Waukesha County, with a regional average of about $5,000 per acre. In general, the per-acre cost of agricultural land in the Region during 1980 ranged from about $2,100 in Kenosha County to $5,100 in both Milwaukee and Waukesha Counties.

NATURAL RESOURCE BASE

Many of the criteria utilized in the selection of dredged material disposal sites have their foundation in an understanding of the natural resource features of the study area, as these features are characterized in quantitative data in the SEWRPC files, obtained over two decades of planning activity. A summary description of these features is available in Chapter III of SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volume One, Inventory Findings, September 1978. The detailed data summarized in that report are referenced herein, but are not repeated. However, the Region's natural and man-made features most directly related to the location of dredged material disposal areas are highlighted in the following sections.

Geology

The bedrock underlying the Region consists of Cambrian and Devonian period rocks that attain a thickness in excess of 1,500 feet along the eastern limits of the Region. The bedrock geology of the Region is shown in Figure 1 by means of a map of the surface of the bedrock supplemented with a representative vertical section. As shown on Map 6, the depth to bedrock in the Region varies from more than 500 feet in areas in the western portion of the Region to less than 20 feet in the north-central portion of the Region. Other related mapping is available illustrating the elevation of the bedrock and the type of glacial deposits above the bedrock. Knowledge of the type of glacial deposits provides insight into the potential for use as a landfill or lagoon dredged material disposal site. The depth to bedrock and the type of bedrock are also important considerations in the siting of these facilities. These considerations are discussed in Chapter IV.

Groundwater Resources

Large areas of the Region depend upon the groundwater reservoir as a source of potable and industrial water supplies. Consequently, protection of the quality of the groundwater is an important consideration in the siting of a dredged material disposal facility. The principal sources of groundwater, listed in order from the land surface downward, are: 1) the sand and gravel aquifer, 2) the shallow limestone aquifer, and 3) the deep sandstone aquifer. Because of their relative nearness to the land surface and their intimate hydraulic interconnection, the first two aquifers are often considered to be a single aquifer commonly known as the "shallow aquifer." The third aquifer is commonly known as the "deep aquifer."

Table 4

AVERAGE AGRICULTURAL LAND SALE PRICES BY TYPE OF SALE BY COUNTY: 1980

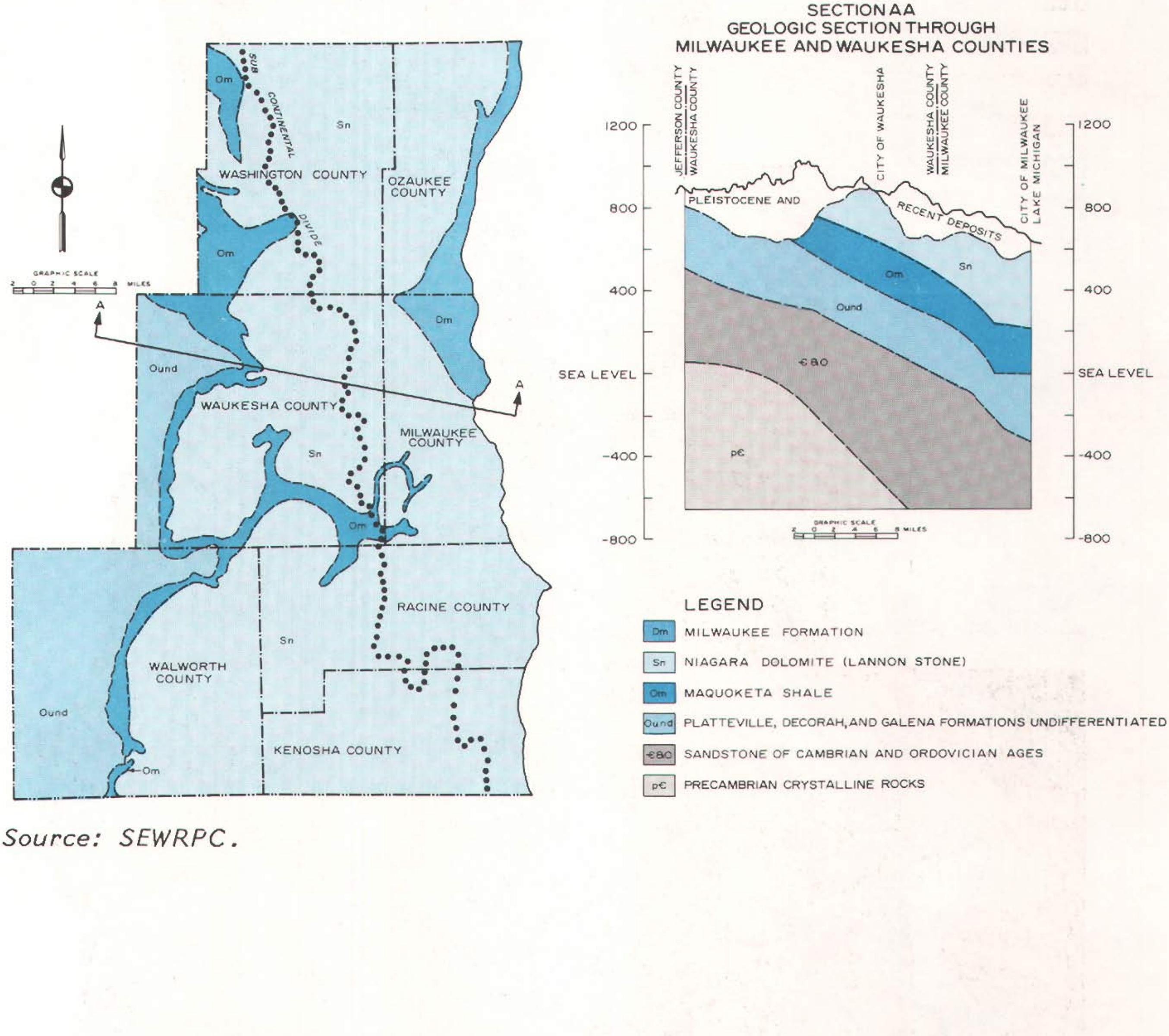
Type of Sale	Dollars per Acre							
	Kenosha	Milwaukee	Ozaukee	Racine	Walworth	Washington	Waukesha	Average for All Counties
Sale of Agricultural Land for Agricultural Land Use...	2,085	2,104	2,259	1,984	2,070	2,030	2,143	2,071
Sale of Agricultural Land for Development Purposes....	2,777	7,938	5,162	3,614	3,505	4,997	8,777	5,010
Average of All Sales.........	2,138	5,092	3,377	2,396	2,210	2,708	5,083	2,605

NOTE: All costs are in 1980 dollars.

Source: Wisconsin Department of Agriculture, Bureau of Statistics.

Figure 1

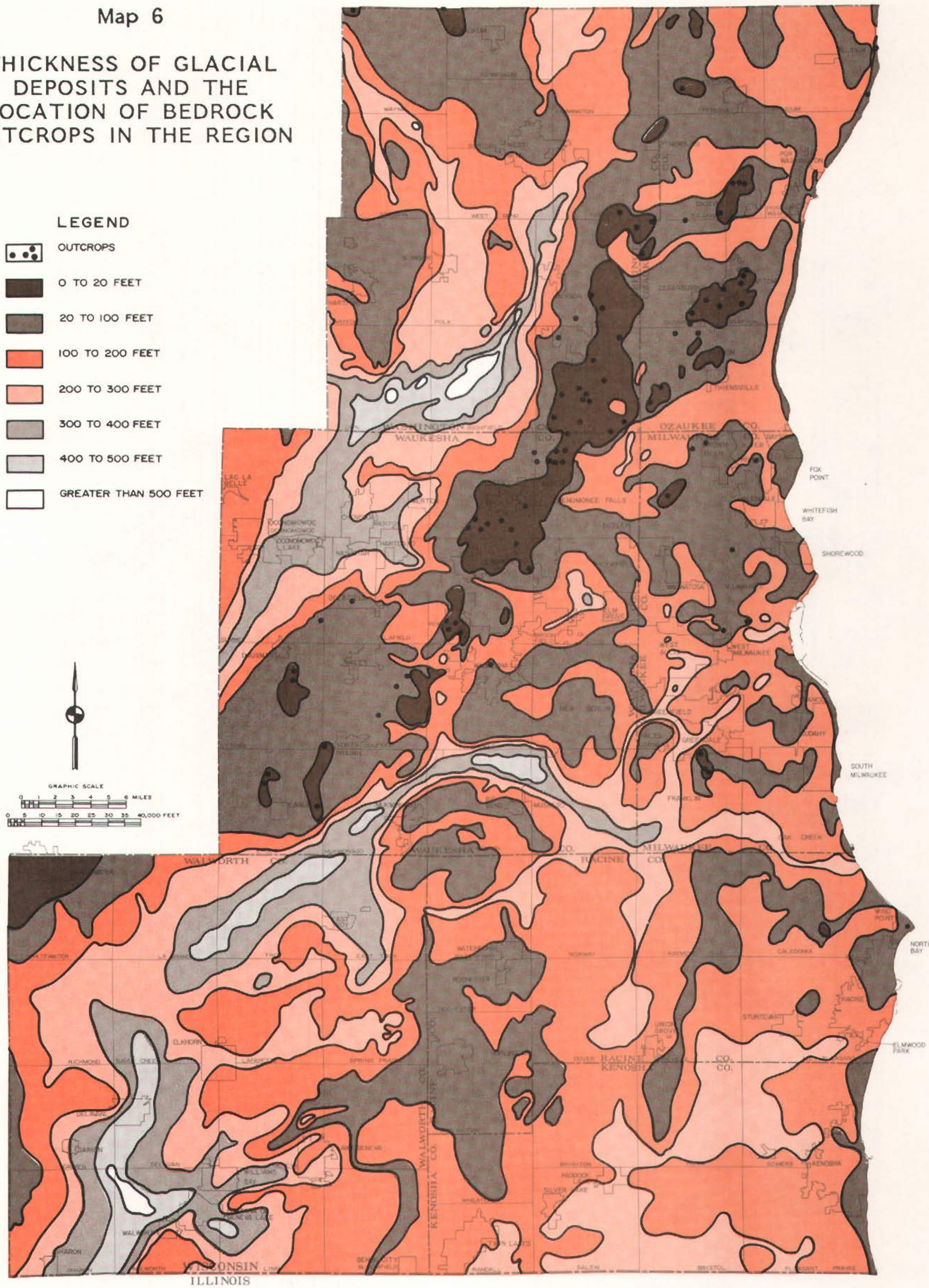
MAP AND CROSS-SECTION OF BEDROCK GEOLOGY IN THE REGION



Source: SEWRPC.

Map 6

THICKNESS OF GLACIAL DEPOSITS AND THE LOCATION OF BEDROCK OUTCROPS IN THE REGION



Source: *T. O. Friz, Man and the Materials of Construction, How They Interrelate in the Seven Counties of Southeastern Wisconsin, Ph.D. Dissertation, University of Wisconsin-Madison, Wisconsin, 1969.*

A layer of relatively impermeable shale separates the limestone and sandstone aquifers in most of the Region. The shale is not present in the western part of the Region, and it is in this area that recharge of the deep aquifer occurs. It is, accordingly, particularly important to avoid the pollution of the recharge water in this area.

Map 7 shows the estimated depth to seasonal high groundwater throughout the Region. Seasonal high groundwater is defined as the average of the highest annual groundwater levels over the period of record available. This depth to the water table is an important consideration in analyses of locations for dredged material disposal sites. The direction of groundwater flow is another important consideration. A generalized map of the groundwater flow patterns is available. However, local variation in the regional flow patterns is often significant, and must be considered on a site-specific basis in any landfill or lagoon disposal facility siting.

The source of all groundwater in the Region is the precipitation which infiltrates and recharges the groundwater reservoir. The amount of water that infiltrates depends upon the type of soil. Recharge is least in areas covered by fine-grained clayey till, greater in silty-sandy till, and greatest in areas covered by sand and gravel.

Soils

In identifying areas having potential for the location of dredged material disposal sites, soils are an important consideration, both with respect to the potential for groundwater pollution and with respect to the suitability of the surficial material for landfill construction. In order to assess the suitability of the diverse soils found in southeastern Wisconsin for various uses, the Southeastern Wisconsin Regional Planning Commission in 1963 negotiated a cooperative agreement with the U. S. Soil Conservation Service under which detailed operational soil surveys were completed for the entire seven-county Planning Region. The findings of these soil surveys were set forth in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin. The soil surveys not only mapped the soils within the Region in great detail, but provided data on the physical, chemical, and biological properties of the soils and, more importantly, provided interpretations of the soil properties for planning, engineering, agricultural, and resource conservation purposes. Interpretations of the soil properties for landfill construction are available. Map 8 is a sample of the detailed soils maps with soils interpretation for suitability for landfill construction.

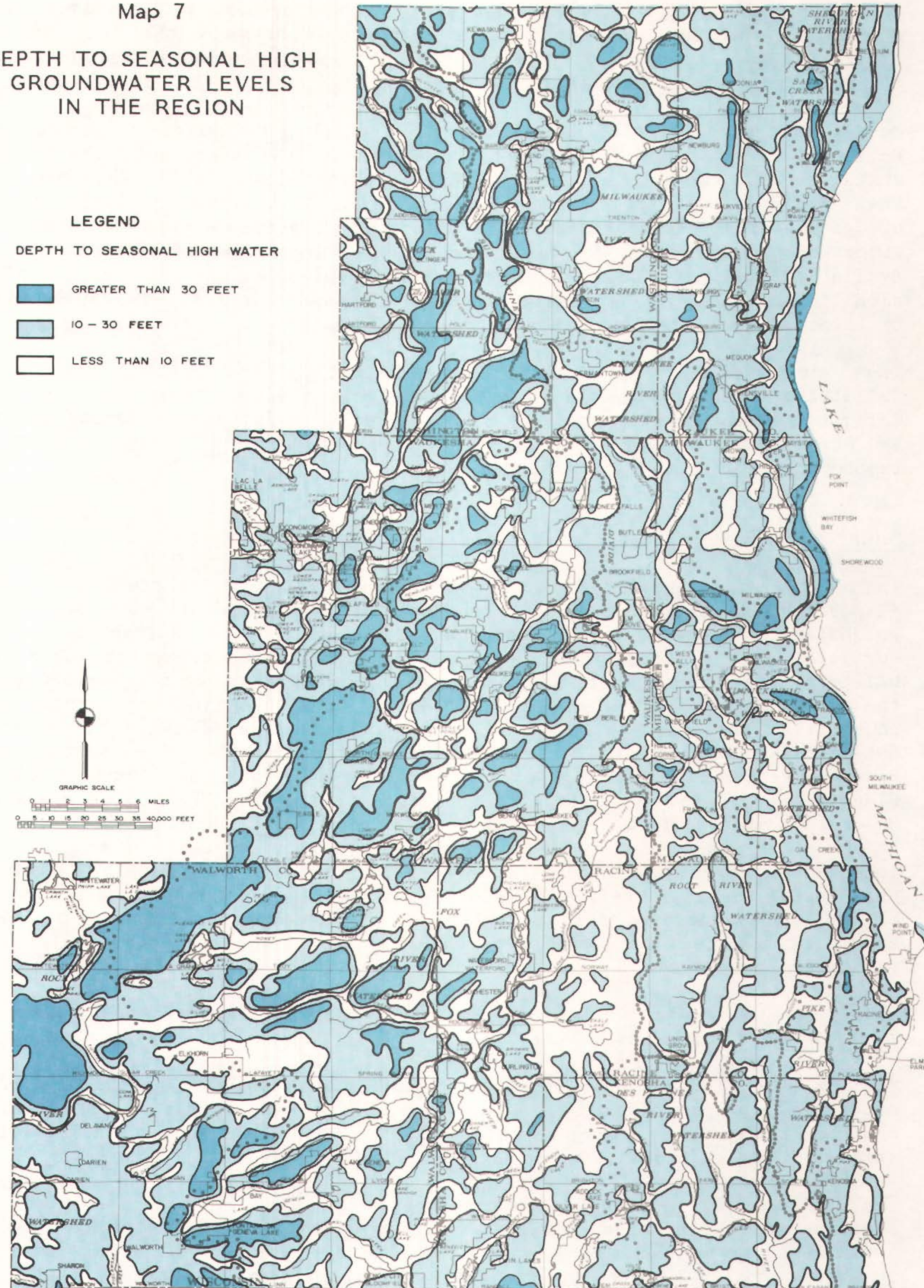
Surface Water Resources

Surface waters are another important consideration in the siting of dredged material disposal facilities. State regulations for floodland and shoreland management preclude siting of a landfill within 300 feet of a navigable stream, river, or floodplain, or within 1,000 feet of a lake.

The surface waters of the Region are depicted on Map 9. These consist of, in addition to Lake Michigan, 100 major inland lakes having a surface area of 50 acres or more, innumerable minor lakes having a surface area of less than 50 acres, and 1,148 miles of perennial streams and watercourses.

Map 7

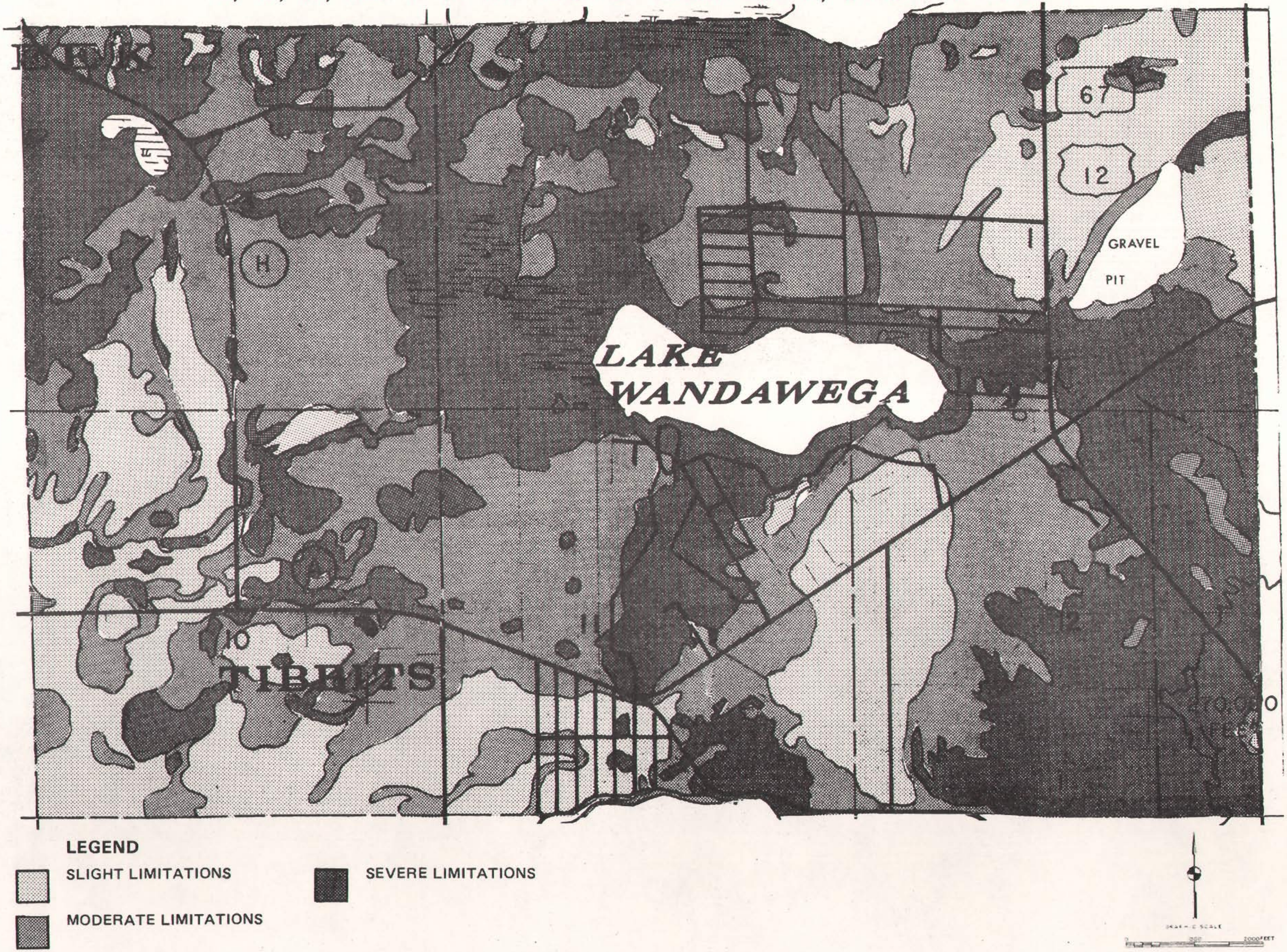
DEPTH TO SEASONAL HIGH GROUNDWATER LEVELS IN THE REGION



Source: U. S. Geological Survey and SEWRPC.

Map 8

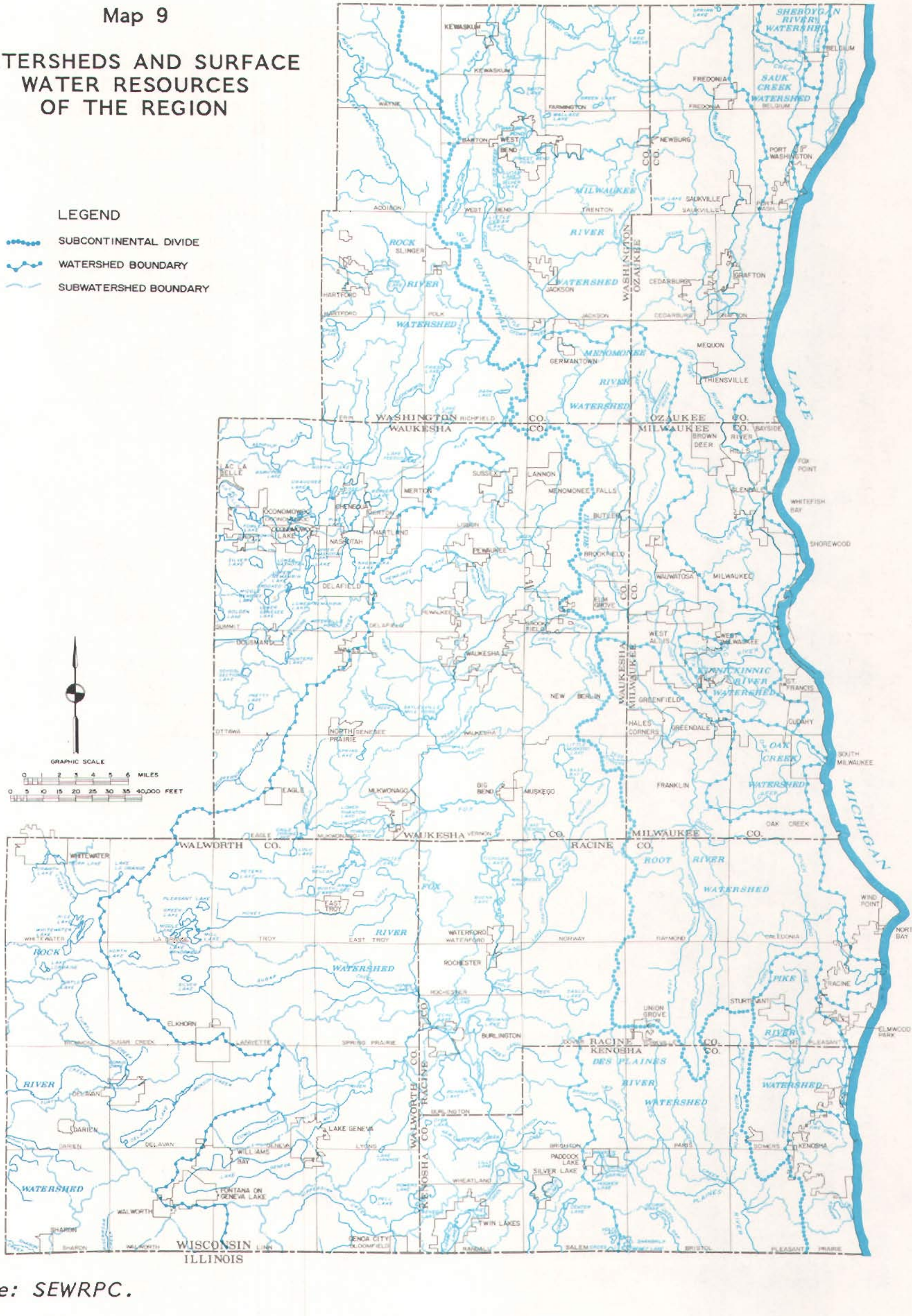
SOIL SUITABILITY FOR LANDFILL CONSTRUCTION FOR SECTIONS 1, 2, 3, 10, 11, AND 12 IN THE TOWN OF SUGAR CREEK, WALWORTH COUNTY



Source: SEWRPC.

Map 9

WATERSHEDS AND SURFACE WATER RESOURCES OF THE REGION



Source: SEWRPC.

Environmentally Significant Areas

The siting of dredged material disposal facilities requires consideration of environmentally significant areas. Any new landfill site or expansion of an existing site must be accomplished in conformance with state criteria for the protection of environmentally significant areas. Environmentally significant areas include environmental corridors, woodlands, wetlands, floodlands, groundwater discharge and recharge areas, designated natural areas, and certain types of wildlife habitat. Generally, none of these areas would be considered desirable for landfill or lagoon siting. However, woodlands are often used effectively as buffer zones for landfills. Mapping showing the location and extent of all of these areas is available. As an example, Map 10 shows the location and extent of the primary environmental corridors within the Region. More detailed, updated delineations of these corridors are also available at the Commission offices on ratioed and rectified aerial photographs at a scale of 1" = 400'. The process for delineating these corridors is described in the article by Bruce P. Rubin and Gerald H. Emmerich, Jr., in the SEWRPC Technical Record, Volume 4, No. 2, March 1981.

REVIEW OF THE LEGISLATION, RULES, AND REGULATIONS PERTAINING TO THE DISPOSAL OF DREDGED MATERIALS

Federal Laws

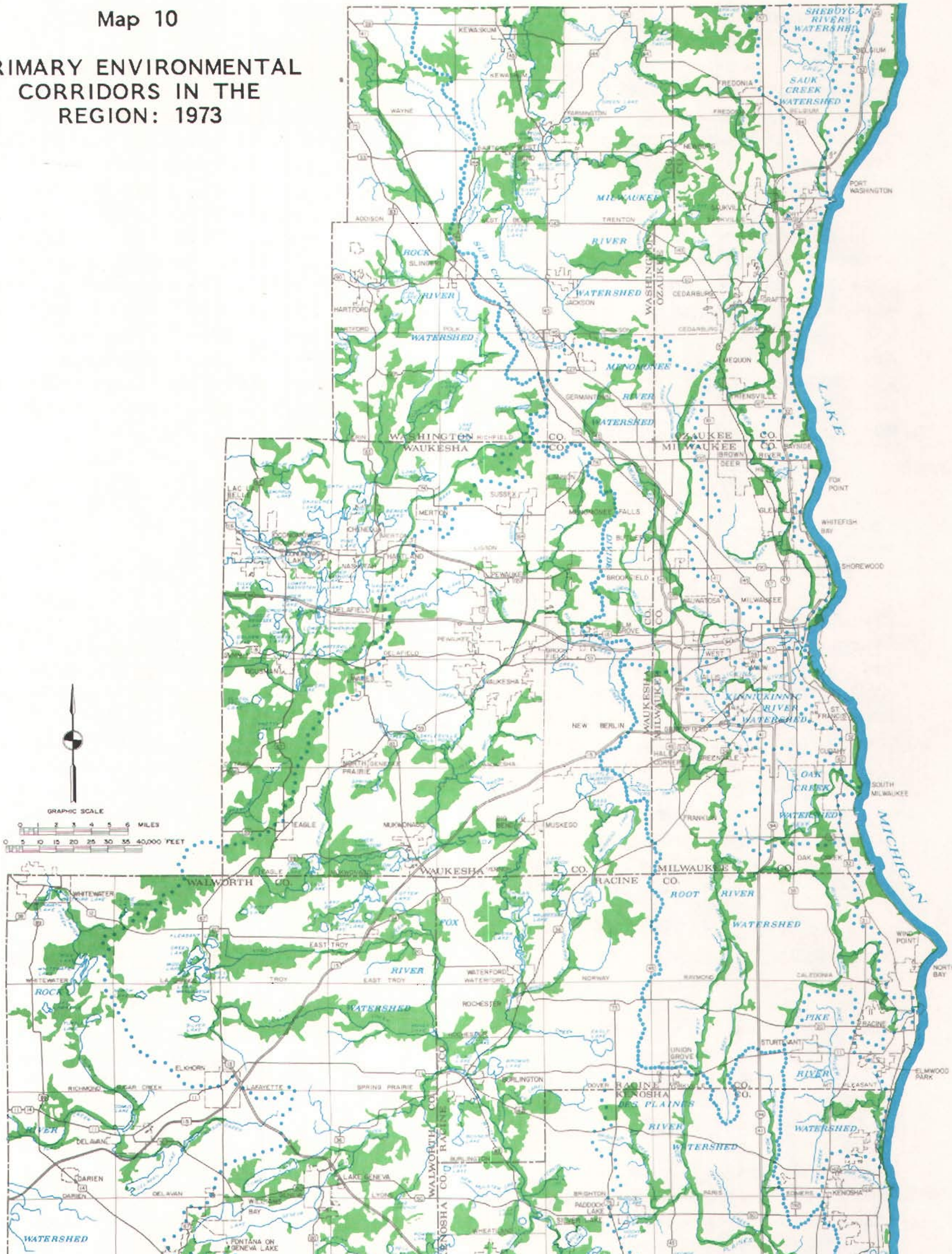
The first major federal legislation affecting dredging projects in the United States was embodied in the River and Harbor Act of 1899. This Act consolidated and codified the numerous pieces of legislation concerning the use of navigable waters as enacted by Congress during the preceding 100 years. Stemming from the authority granted in this Act, the Department of the Army, through the Corps of Engineers, established a permit program in order to monitor filling, dredging, and construction projects in the navigable waters of the United States over which the Corps has jurisdiction. For more than half a century, the emphasis of the permit program was focused on the impact of proposed projects on navigation, with little or no attention given to the impact of such projects on the environment. Thus, dredging activities were not subject to a detailed regulatory effort by the U. S. Army Corps of Engineers.

In 1958, however, the Fish and Wildlife Coordination Act was adopted by Congress as a result of the growing concern about habitat destruction caused by either the dredging or filling of nursery and feeding areas available for marine life. This Act stipulates that whenever any body of water is in any way modified, such as by dredging, the responsible department or agency must first consult with the U. S. Department of the Interior, Fish and Wildlife Service, as well as with the applicable state agency. This Act thus represents the first major federal legislation relating water resource development objectives to the conservation of wildlife resources.

Under the National Environmental Policy Act (NEPA), adopted by Congress in 1969, an environmental assessment is required to be prepared prior to the issuance of any federal permit. Under provisions of the Act, the preparation of such assessments is to be coordinated with federal and state agencies and concerned public and private interest groups in order to provide an opportunity for all interests concerned to comment on the anticipated environmental impacts. Where significant adverse environmental, economic, or social impacts are expected, a full environmental impact statement is required. As a result

Map 10

PRIMARY ENVIRONMENTAL CORRIDORS IN THE REGION: 1973



Source: SEWRPC.

of this Act, each permit application for a proposed dredging project must be accompanied by sufficient information to allow the Corps of Engineers to make an assessment of the primary environmental impacts of the project, as well as any associated secondary impacts.

In 1970 Congress adopted the Federal Water Pollution Control Act, and in 1972 it adopted major amendments to that Act. The provisions of the amendments of 1972 included establishment of a permit system to be administered by the U. S. Environmental Protection Agency (EPA) for the purpose of regulating the discharge of pollutants into surface waters of the United States. The principal objective of the Act was to eliminate the discharge of pollutants into the nation's waters by 1985. In order to attain this objective, the Act prohibited the discharge of any pollutant from a point source unless a permit was obtained. The Act also granted the EPA the authority to issue such permits, under Section 402, provided that certain criteria and conditions were met. The EPA permit program is administered under the National Pollutant Discharge Elimination System (NPDES). The goal of the NPDES is to eliminate pollution at its source through the development, implementation, and enforcement of water quality standards and effluent limitations.

The Federal Water Pollution Control Act amendments of 1972 also provided for the establishment of a permit system, under Section 404, to be administered by the U. S. Army Corps of Engineers working in cooperation with the EPA, in order to regulate the disposal of dredged or fill materials into surface waters of the United States, including navigable waters and adjacent wetlands. Thus, the Corps of Engineers and the EPA share responsibilities concerning the disposal of dredged materials, the Corps being the sole agency authorized to grant dredging or filling permits, and the EPA having an overriding authority with regard to the environmental effects of the disposal of dredged materials, acting on the advice of the U. S. Fish and Wildlife Service and the Wisconsin Department of Natural Resources.

The disposal of dredged materials in open waters is regulated under Section 404 of that Act. Since dredgings are specifically included under the definition of a pollutant, the effluents from land-based dredged materials disposal sites may be subject to regulation as a point source under the NPDES. Although the Corps of Engineers remains the sole regulating body responsible for administering permits for dredging projects, the authority granted the EPA through the administration of the Federal Water Pollution Control Act places environmental criteria on an equal basis with navigational criteria in the evaluation of applications for dredging permits.

State Laws

Three years after the National Environmental Policy Act was adopted by Congress, the State of Wisconsin, in April 1972, enacted the Wisconsin Environmental Policy Act (WEPA), Section 1.11 of the Wisconsin Statutes. As with the parallel federal legislation, the WEPA requires an environmental impact assessment for any major state action affecting the quality of the environment, with a full, formal environmental impact statement required for certain of these situations where significant environmental impacts are identified. Dredging in the navigable waters of the State of Wisconsin and attendant disposal procedures are defined as major actions and must therefore meet the requirements of the WEPA. The Wisconsin Statutes, under Section 30.20, also require that, prior to the initiation of any dredging project in the navigable waters of the State of Wisconsin, a permit for such activity be obtained from the Department of Natural Resources.

Chapter 377, Laws of 1977, Wisconsin Statutes, defines dredged materials as a solid waste and makes the disposal of such dredged materials subject to the solid waste disposal rules contained in Chapter NR 180 of the Wisconsin Administrative Code. Chapter NR 180, "Solid Waste Management," sets forth specific requirements for the disposal of dredged materials in both landfill sites and land spreading sites. In general, Chapter NR 180.13(4) requires that a permit be obtained from the Wisconsin Department of Natural Resources prior to the disposal of more than 3,000 tons of dredged materials in landfill sites. An exemption to this requirement, however, may be granted by the Department if, as a result of a field evaluation of the landfill site, it can be demonstrated that the dredged materials will not contribute to environmental pollution--particularly in terms of contamination of surface or groundwaters.

Chapter NR 180 allows the application of nonhazardous dredged materials on agricultural or silvicultural sites if the material can be demonstrated to have soil conditioning or fertilizer value, and providing the dredged material is applied as a soil conditioner or fertilizer in accordance with accepted agricultural practices. Although a specific land spreading plan need not be prepared and approved for dredged materials with soil conditioner or fertilizer value--as is the case with most other forms of solid waste--written approval for such practices must be obtained from the Department of Natural Resources pursuant to Chapter NR 180.14 of the Wisconsin Administrative Code. The transport of dredged materials from the source to the disposal site is exempt from the collection and transportation service licensing requirements of Chapter NR 180.

As noted above, Chapter NR 180 prescribes regulations for the disposal of nonhazardous solid wastes. If, however, the dredged materials contain hazardous waste products, such materials must be disposed of pursuant to the regulations set forth in Chapter NR 181, "Hazardous Waste Management."

Local Regulations

Wisconsin Statutes grant to local units of government the authority to regulate by ordinance any conditions bearing upon the health, safety, and welfare of the community. Under their police powers, local units of government may also exercise regulatory authority over the disposal of dredged materials within their boundaries. Planning for the potential disposal of dredged materials at upland sites must, therefore, be cognizant of the need to conform to local zoning ordinances and other regulations of cities, villages, towns, or counties.

Table 5 presents typical zoning districts which may be used by communities in southeastern Wisconsin. The disposal of dredged materials would be most compatible with the uses typically permitted in the M-2 Heavy Industrial District, A-1 Agricultural Preservation District, and A-2 Agricultural Holding District. It is important to note, however, that Table 5 presents a generalized zoning scheme, and that actual local zoning ordinances may differ in detail and, therefore, must be considered on a case-by-case basis in the development of any site-specific dredged material disposal project. Details regarding the local zoning in rural areas are generally best obtained from county planning agencies, and in urban areas from the city and village planning agencies.

Table 5

SUGGESTED ZONING DISTRICTS FOR A TYPICAL SOUTHEASTERN WISCONSIN COMMUNITY

Zoning District	Permitted Land Uses
R-1 Residential (low density)	Single-family dwellings
R-2 Residential (medium density)	Single-family dwellings
R-3 Residential (high density)	Two-family dwellings
R-4 Residential Multi-family	Multiple-family dwellings of three or more units per building
B-1 Community/Neighborhood Business District	Clothing, drug, gift, grocery, and hardware stores; barber and beauty shops; bars and restaurants; and similar uses
B-2 Central Business District	Any use permitted in the B-1 District; book, camera, department, jewelry, music, shoe, and stationery stores; bowling alleys and dance halls; dental and medical clinics; theaters; and similar uses
B-3 Professional Office District	Administrative and public service offices; professional offices of a lawyer, doctor, dentist, clergy, engineer, and similar professions; studios for photography, painting, music, dance, or other recognized fine art; and real estate and insurance offices
B-4 Highway Business District	Service stations, automotive sales and service, motels and hotels, building and supply stores, and similar uses normally serving a regional area
M-1 Industrial (light)	Processing, manufacturing and/or storage of: baked goods; dental, engineering, and scientific instruments and equipment; knit goods; and similar uses
M-2 Industrial (heavy)	Processing, manufacturing, and/or storage of: auto and aircraft parts, metal products, farm machinery, and ship and boat buildings. Also included in this district are sewage treatment plants, landfill sites, and extractive uses

Table 5 (continued)

Zoning District	Permitted Land Uses
I-1 Institutional	Schools, colleges, churches, hospitals, libraries, public administrative offices, fire and police stations, water storage tanks and towers, and similar uses
P-1 Park District	General recreation facilities, auditoriums, amusement parks, fairgrounds, golf courses, historic and monument sites, hunting and fishing clubs, zoos, and similar uses
A-1 Agriculture Preservation District	General farming, including crop production, dairying, and keeping and raising of domestic livestock. Minimum farm acreage--35 acres
A-2 Agriculture Holding District	Crop production, livestock, orchards, hobby farms. This district is intended to provide for the continuation of general farming and related uses in those areas of the Region that are not yet committed to urban development. It is further intended that this district protect lands contained therein from urban development until their orderly transition into urban-oriented districts is required. Minimum five acres
C-1 Conservancy District (lowland)	Wetland, riverbank, and lakeshore protection
C-2 Conservancy District (upland)	Woodland, steep slope, and scenic topography protection
FC Floodplain Conservancy District	Preserve in essentially open space and natural uses lands which are unsuitable for intensive urban development purposes because of poor natural soil conditions and periodic flood inundation
PUD Planned Unit Development Overlay District	The PUD Planned Unit Development Overlay District is intended to permit development that will, over a period of time, be enhanced by coordinated area site planning, diversified location of structures, and/or mixing of compatible uses

Source: SEWRPC.

QUANTITY AND CHARACTERISTICS OF DREDGED MATERIALS FROM THE MILWAUKEE HARBOR

Estimated Quantity of Dredged Materials

As previously noted and as shown on Map 2, maintenance dredging in the Milwaukee Harbor is divided into three different areas of responsibility: the federal government, the City of Milwaukee, and private riparian property owners. The federal government, through the COE, maintains channels in certain areas designated as "federal project waters," as shown on Map 2. The City of Milwaukee, through the Board of Harbor Commissioners, conducts maintenance dredging between the federal project water limits and terminal facilities and in berthing areas within the Port of Milwaukee. Private facility operators in the Milwaukee Harbor are required to maintain depths for a distance of 75 feet beyond mooring berths.

Quantities of materials dredged for both maintenance and new work projects since 1961 are listed in Table 6. Since that time, about 5,446,500 total cubic yards, or about 272,325 cubic yards per year, of material has been dredged from the harbor. Of that total, 1,498,200 cubic yards, or 27 percent, was dredged for maintenance, while 3,948,300 cubic yards, or 73 percent, was new work dredging--that is, work beyond normal maintenance activities.

Dredging in the Milwaukee Harbor was conducted during two separate time periods. The first period covers from 1961 through 1970, when dredged materials were disposed of in the open waters of Lake Michigan. Dredging from 1961 through 1970 in the Milwaukee Harbor area generated an average of 471,460 cubic yards per year of bottom materials and sediment. The total amount of material dredged during this period was 4,714,600 cubic yards, or 86 percent of the 5,466,500 cubic yards dredged between 1961 and 1980.

From 1971 through 1974, no significant dredging activity took place in the Milwaukee Harbor area. The most recent dredging project in the Milwaukee Harbor was conducted by the U. S. Army Corps of Engineers from 1975 to 1978. The Corps, dredging only in federal project waters, deposited the bottom materials in the confined disposal facility at the southern end of the outer harbor. An annual average of about 183,000 cubic yards of bottom materials was removed from within those project limits in the harbor and placed in the confined disposal facility under this project. The total amount of material dredged during this period was 731,900 cubic yards, or 14 percent of the total amount of material dredged between 1961 and 1980.

No significant dredging has taken place in the Milwaukee Harbor since 1978. It is estimated by the Harbor Commission that the established channels and slips of the outer end of the municipal mooring basin of the inner harbor of the Port of Milwaukee that lie beyond the federal channel project limits will require the removal of approximately 198,000 cubic yards of bottom sediments in order to maintain average water depths of 27 feet below International Great Lakes Datum (IGLD). As presently envisioned, the approximately 198,000 cubic yards of dredged materials resulting from the initial maintenance activity will be placed in the Corps of Engineers' confined disposal facility. As of November 1981, the Port of Milwaukee had contracted for maintenance dredging of 116,000 cubic yards, or 60 percent of the material, with the remaining 82,000 cubic yards, or 40 percent, to be contracted for at a later date.

Table 6

SUMMARY OF QUANTITIES OF DREDGED MATERIALS FROM THE MILWAUKEE HARBOR: 1960-1980

Period of Activity	Disposal Method	Maintenance Dredging Quantity (cubic yards)		New Work Dredging Quantity (cubic yards)		Total Dredging Quantity (cubic yards)	
		Total	Annual Average	Total	Annual Average	Total	Annual Average
1961 through 1970	Open water	766,300	76,630[a]	3,948,300	394,830	4,714,600	471,460
1971 through 1974	--	--	--	--	--	--	--
1975	Confined disposal facility	159,000[b]	159,000	--	--	159,000	159,000
1976	Confined disposal facility	306,800[b]	306,800	--	--	306,800	306,800
1977	Confined disposal facility	57,700[b]	57,700	--	--	57,700	57,700
1978	Confined disposal facility	208,400[b]	208,400	--	--	208,400	208,400
1979	--	--	--	--	--	--	--
1980	--	--	--	--	--	--	--
Total	--	1,498,200	74,910	3,948,300	19,740	5,446,500	272,325

[a]Comprised of 41,800 cubic yards of material dredged by the U. S. Army Corps of Engineers, and 34,830 cubic yards of material dredged by private riparian owners and the Port of Milwaukee.

[b]Material primarily dredged by the U. S. Army Corps of Engineers.

Source: U. S. Environmental Protection Agency, U. S. Army Corps of Engineers, Port of Milwaukee, and SEWRPC.

This study is directed at the analysis of upland disposal sites for material generated as a result of maintenance dredging within the portions of the Milwaukee Harbor that are the responsibility of the Harbor Commission. It is estimated that this maintenance dredging will result in the removal of about 50,000 cubic yards per year of material, which can be considered for disposal or reuse at upland sites. This estimated amount results from all Harbor Commission and private riparian owner dredging as well as limited amounts of other maintenance dredging, such as that required in the federal project waters which are the responsibility of the U. S. Corps of Engineers. The period of this study extends through the year 2000. It is expected that materials dredged through 1985 will be disposed of in the present Corps of Engineers' confined disposal facility. Thus, for the study period it is estimated that 50,000 cubic yards per year for the 15-year period of 1986 through the year 2000, or a total of 750,000 cubic yards, could potentially be considered for disposal at upland sites. This is the amount estimated to be needed for dredging by the Port of Milwaukee. The disposal of materials dredged in federal project waters is estimated to be over and above this amount. However, the study results should be useful in providing data to others performing dredging in areas outside the jurisdiction of the Port of Milwaukee.

Characteristics of Dredged Materials

There have been a number of analyses performed to determine the composition and pollutant content of the sediments in the Milwaukee Harbor. Table 7 presents a summary of the potential pollutant concentrations found in the sediment analyses conducted by the Milwaukee Metropolitan Sewerage Commission, the U. S. Environmental Protection Agency, and the Wisconsin Department of Natural Resources. Table 8 presents selected data on the type of soil fractions and nutrient content in the harbor sediment as reported by the International Joint Commission Reference Group. With regard to the solids content of the dredged material by weight, sample analyses indicate that the solids content has varied from 13 to 87 percent, with an average of about 50 percent.

The EPA has developed informal guidelines for evaluating disposal sites in the Great Lakes for dredged materials. When reviewed in light of these guidelines, sediment quality may be classified as unpolluted, moderately polluted, or highly polluted. The range of values for certain pollutant species under each of the three levels of classification are presented in Table 9. The pollution ratings for sediments in the Milwaukee Harbor, as shown in Table 7, are based on the values presented in Table 9.

It should be noted that the designation of dredged materials as being unpolluted, moderately polluted, or heavily polluted and the disposal requirements resulting from this designation are not based solely on the numerical concentration of a single pollutant species. In making this determination for any specific dredged materials disposal project, the EPA also takes into account the naturally occurring, or "background," concentrations of pollutants in the sampling area, the corresponding pollution levels in the potential disposal area, the size of the project, the location and hydraulic character of the disposal area proposed, and the concentrations of other pollutant species in order to estimate the impact that the dredged material will have on the environment. It should also be noted that the appropriateness of various test procedures for determining pollutant concentrations--that is, either a bulk sediment test, bioassay, elutriate test, or a combination of these--is currently under review by the regulatory agencies.

Table 7

QUALITY OF SEDIMENTS IN THE MILWAUKEE HARBOR

Location	Date	Sediment Oxygen Demand (grams per meter squared per day)	Total Volatile Solids (percent)	Chemical Oxygen Demand	Total Kjeldahl Nitrogen	Oil and Grease	Lead	Zinc	Ammonia	Phosphorus	Iron	Nickel	Manganese	Arsenic	Cadmium	Chromium	Barium	Copper	Mercury	Polychlorinated Biphenyls	Pollution Rating: Unpolluted	Pollution Rating: Moderate	Pollution Rating: Heavy
Inner Harbor																							
Milwaukee River																							
Humboldt Avenue	--	2.9	2.6	182,000	--	--	509	376	272	1,090	14,400	--	--	--	13	--	--	91	--	--	--	--	X
Walnut Street	--	7.3	3.9	171,000	--	--	645	641	464	1,760	20,100	--	--	--	21	--	--	240	--	--	--	--	X
Commerce Street-1	January 21, 1976	--	--	88,000	--	--	640	560	--	--	20,000	80	520	0.04	15	0.05	--	130	--	--	--	--	X
	March 9, 1976	--	--	48,000	--	--	150	580	--	--	24,000	80	140	0.04	11	0.05	--	130	--	--	--	--	X
	May 1, 1976	--	--	77,000	--	--	880	820	--	--	19,000	92	520	0.04	12	0.05	--	190	--	--	--	--	X
Commerce Street-2	January 21, 1976	--	--	93,200	--	--	510	430	--	--	18,000	78	470	0.04	16	0.05	--	110	--	--	--	--	X
	March 9, 1976	--	--	59,000	--	--	150	630	--	--	22,000	120	580	0.04	19	0.05	--	210	--	--	--	--	X
	May 1, 1976	--	--	65,000	--	--	560	480	--	--	18,000	64	560	3.20	12	0.05	--	110	--	--	--	--	X
Commerce Street-3	January 21, 1976	--	--	76,200	--	--	560	480	--	--	21,000	40	520	0.04	12	0.05	--	130	--	--	--	--	X
	March 9, 1976	--	--	50,000	--	--	140	560	--	--	30,000	66	760	0.04	10	0.05	--	120	--	--	--	--	X
	May 1, 1976	--	--	51,000	--	--	480	420	--	--	17,000	56	520	0.04	8	0.05	--	88	--	--	--	--	X
Highland Boulevard	--	4.7	3.7	232,000	--	--	555	559	453	1,760	20,400	--	--	--	17	--	--	170	--	--	--	--	X
Wells Street	February 10, 1976	--	--	--	--	--	775	600	--	--	--	30	--	--	6.25	16.50	--	125	1.06	9.6	--	--	X
	March 9, 1976	--	--	56,000	--	--	110	610	--	--	34,000	83	630	0.04	13	0.05	--	180	--	--	--	--	X
Marine Bank Plaza	--	4.7	2.4	160,000	--	--	2,000	404	306	1,320	19,000	--	--	--	15	--	--	120	--	--	--	--	X
River Junction	June 21, 1973	--	12.4	82,200	4,150	7,910	320	310	--	--	--	--	--	--	--	--	--	--	0.50	--	--	--	X
	--	6.8	2.9	137,000	--	--	331	248	249	1,130	21,200	--	--	--	19	--	--	71	--	--	--	--	X
Broadway Street	May 8, 1975	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	26	--	--	X
Coast Guard Ships	--	4.7	3.3	138,000	--	--	397	595	475	2,280	21,200	--	--	--	21	--	--	126	--	--	--	--	X
Menomonee River																							
Layton Boulevard	June 21, 1973	--	10.2	64,900	3,490	10,200	280	270	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Great Lakes Coal	--	4.1	3.7	162,000	--	--	605	594	745	1,200	25,700	--	--	--	16	--	--	168	--	--	--	--	X
Valley Plant-3	January 21, 1976	--	--	85,600	--	--	660	590	--	--	24,000	78	550	0.04	23	0.05	--	170	--	--	--	--	X
	March 9, 1976	--	--	59,000	--	--	150	560	--	--	23,000	72	700	0.04	10	0.05	--	130	--	--	--	--	X
	May 1, 1976	--	--	47,000	--	--	560	440	--	--	22,000	68	680	0.04	12	0.05	--	120	--	--	--	--	X
S. Muskego	--	3.9	4.7	168,000	--	--	547	655	229	1,630	26,700	--	--	--	21	--	--	185	--	--	--	--	X
Post Office	--	--	2.8	118,000	--	--	393	350	214	1,070	22,500	--	--	--	16	--	--	105	--	--	--	--	X
Menomonee Branch																							
Valley Plant-1	January 21, 1976	--	--	90,100	--	--	460	460	--	--	33,000	77	420	0.04	15	0.05	--	160	--	--	--	--	X
	March 9, 1976	--	--	72,000	--	--	160	690	--	--	28,000	130	770	0.04	16	0.05	--	170	--	--	--	--	X
	May 1, 1976	--	--	99,000	--	--	480	520	--	--	30,000	72	560	0.04	12	0.05	--	160	--	--	--	--	X
Menomonee Branch-6th Street Valley Plant-2	June 21, 1976	--	12.6	79,100	3,260	9,830	350	390	--	--	--	--	--	--	--	--	--	--	0.60	--	--	--	X
	January 21, 1976	--	--	72,600	--	--	420	420	--	--	18,000	77	500	0.04	15	0.05	--	120	--	--	--	--	X
	March 9, 1976	--	--	55,000	--	--	100	500	--	--	30,000	80	640	0.04	12	0.05	--	150	--	--	--	--	X
	May 1, 1976	--	--	68,000	--	--	520	400	--	--	23,000	60	600	0.04	12	0.05	--	110	--	--	--	--	X
Kinnickinnic River																							
Chase Avenue	May 8, 1975	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3.6	--	--	--
1st Street	--	1.8	3.8	156,000	--	--	1,170	1,160	268	973	27,100	--	--	--	21	--	--	154	--	--	--	--	X
Great Lakes Marina	--	7.7	4.4	177,000	--	--	1,040	1,350	318	1,350	27,800	--	--	--	16	--	--	138	--	--	--	--	X
STH 32	June 21, 1973	--	11.9	136,000	2,300	7,030	370	340	--	--	--	--	--	--	--	--	--	--	0.40	--	--	--	X
Continental Grain	--	3.3	4.5	254,000	--	--	743	1,030	207	1,430	21,400	--	--	--	13	--	--	113	--	--	--	--	X
Municipal Mooring Basins	February 10, 1976	--	--	--	--	--	670	850	--	--	--	32	--	--	11.2	530	--	118	0.55	9.7	--	--	X
	--	4.1	3.1	172,000	--	--	631	969	314	1,870	31,300	--	--	--	17	--	--	139	--	--	--	--	X
U. S. Great Lakes Facility	--	1.8	3.9	151,000	--	--	367	587	221	1,630	24,200	--	--	--	16	--	--	103	--	--	--	--	X
	June 21, 1973	--	13.0	113,000	3,660	7,090	410	550	--	--	--	--	--	--	--	--	--	--	0.40	--	--	--	X
Jones Island Ferry	June 21, 1973	--	11.6	71,700	4,460	7,420	340	230	--	--	--	--	--	--	--	--	--	--	0.40	--	--	--	X
	--	--	2.4	138,000	--	--	198	295	214	997	17,700	--	--	--	37	--	--	59	--	--	--	--	X
Outer Harbor																							
South Shore Yacht Club	--	1.3	2.2	71,200	--	--	42	190	88	260	9,467	--	--	--	16	--	--	23	--	--	--	X	--
Disposal Area	June 21, 1973	--	12.8	136,000	5,660	4,080	25	70	--	--	--	--	--	--	--	--	--	--	0.40	--	--	--	X
Southeast End of Harbor	June 21, 1973	--	8.6	44,300	2,850	2,300	160	390	--	--	--	--	--	--	--	--	--	--	0.90	--	--	--	X
Near Lower Docks	June 21, 1973	--	8.3	161,000	300	3,460	120	220	--	--	--	--	--	--	--	--	--	--	0.60	--	--	--	X
South of River Mouth	June 21, 1973	--	22.0	205,000	1,520	19,100	470	1,100	--	--	--	--	--	--	--	--	--	--	1.80	--	--	--	X
At River Mouth	June 21, 1973	--	3.5	29,100	1,020	483	45	130	--	--	--	--	--	--	--	--	--	--	0.40	--	--	X	--
Mid Gap	--	3.5	6.6	90,000	--	--	158	426	208	2,440	18,900	--	--	--	26	--	--	80	--	--	--	--	X
South of Central Gap	June 21, 1973	--	8.9	49,000	3,670	5,000	220	460	--	--	--	--	--	--	--	--	--	--	0.40	--	--	--	X
Inside Central Gap	June 21, 1973	--	14.4	180,600	4,530	7,120	431	510	--	--	--	--	--	--	--	--	--	--	1.50	--	--	--	X
Out of Central Gap	June 21, 1973	--	3.7	15,600	314	260	54	111	--	--	--	--	--	--	--	--	--	--	0.90	--	X	--	--
Municipal Pier	--	1.1	2.4	84,500	--	--	168	516	224	1,920	20,500	--	--	--	22	--	--	85	--	--	--	--	X
McKinley Marina	--	2.6	1.8	67,000	--	--	77	141	54	740	11,500	--	--	--	12	--	--	33	--	--	--	X	--

NOTE: Values in milligrams/kilogram unless otherwise noted.

Source: U. S. Environmental Protection Agency and Milwaukee Metropolitan Sewerage District.

Table 8

SOIL FRACTIONS AND NUTRIENTS IN SEDIMENTS OF THE MILWAUKEE HARBOR

Station Number on Map 11	Percent of Oven-Dried Weight				
	Sand	Silt	Clay	Total Nitrogen	Total Phosphorus
1	54	40	6	0.21	0.19
2	28	66	6	0.25	0.30
3	20	72	8	0.20	0.34
4	16	76	8	0.12	0.27
5	6	80	14	0.13	0.18
6	34	56	10	0.12	0.08

Source: R. Bannerman, J. G. Konrad, and D. Becker, Effects of Tributary Inputs on Lake Michigan During High Flow, U. S. Environmental Protection Agency Document No. EPA-905/9-79-029-J, 1979.

Map 11 indicates the sediment quality in the Milwaukee Harbor. As may be seen on Map 11, sediment in the Milwaukee Harbor may be classified as being predominantly heavily polluted from the lower reaches of the Kinnickinnic, Menomonee, and Milwaukee Rivers, and in the main channel to the central opening in the outer harbor breakwater. Therefore, means for averting potential groundwater and surface water contamination must be considered in the disposal of dredged materials from the Milwaukee Harbor in upland sites. If the dredged material continues to have characteristics which indicate that it is heavily polluted, then special disposal methods and sites will need to be considered on a case-by-case basis. It should be stressed that the classification system currently being utilized (see Table 9) categorizes the dredged material as to its suitability for open water disposal and not for other disposal methods. As discussed in Chapter III, additional investigations may be needed to adequately identify the suitability of dredged material for various upland disposal alternatives. Many disposal options, such as application on agricultural land, may not be practical if the dredged material is uniformly classified as heavily polluted.

It is also possible that the regulation and management of pollutant materials may result in improved sediment quality in the future. Because of this possibility, the study has provided information on upland disposal methods which would be dependent upon improved quality.

Table 9

U. S. ENVIRONMENTAL PROTECTION AGENCY SEDIMENT POLLUTION CATEGORIES USING BULK SEDIMENT ANALYSIS

Parameter	Concentration		
	Nonpolluted	Moderately Polluted	Highly Polluted
Arsenic (milligrams/kilogram dry weight)...	<3	3-8	>8
Barium (milligrams/kilogram dry weight)...	<20	20-60	>60
Cadmium (milligrams/kilogram dry weight)...	--[a]	--[a]	>6
Chromium (milligrams/kilogram dry weight)...	<25	25-75	>75
Copper (milligrams/kilogram dry weight)...	<25	25-50	>50
Iron (milligrams/kilogram dry weight)...	<17,000	17,000-25,000	>25,000
Lead (milligrams/kilogram dry weight)...	<40	40-60	>60
Manganese (milligrams/kilogram dry weight)...	<300	300-500	>500
Mercury (milligrams/kilogram dry weight)...	--[a]	--[a]	≥1
Nickel (milligrams/kilogram dry weight)...	<20	20-50	>50
Zinc (milligrams/kilogram dry weight)...	<90	90-200	>200
Ammonia (milligrams/kilogram dry weight)...	<75	75-200	>200
Chemical Oxygen Demand (milligrams/kilogram dry weight)...	<40,000	40,000-80,000	>80,000
Cyanide (milligrams/kilogram dry weight)...	<0.10	0.10-0.25	>0.25
Oil and Grease (milligrams/kilogram dry weight)...	<1,000	1,000-2,000	>2,000
Total Polychlorinated Biphenyls (milligrams/kilogram dry weight)...	--[a b]	--[a b]	≥10
Phosphorus (milligrams/kilogram dry weight)...	<420	420-650	>650
Total Kjeldahl Nitrogen (milligrams/kilogram dry weight)...	<1,000	1,000-2,000	>2,000
Volatile Solids (percent by weight)................	<5	5-8	>8

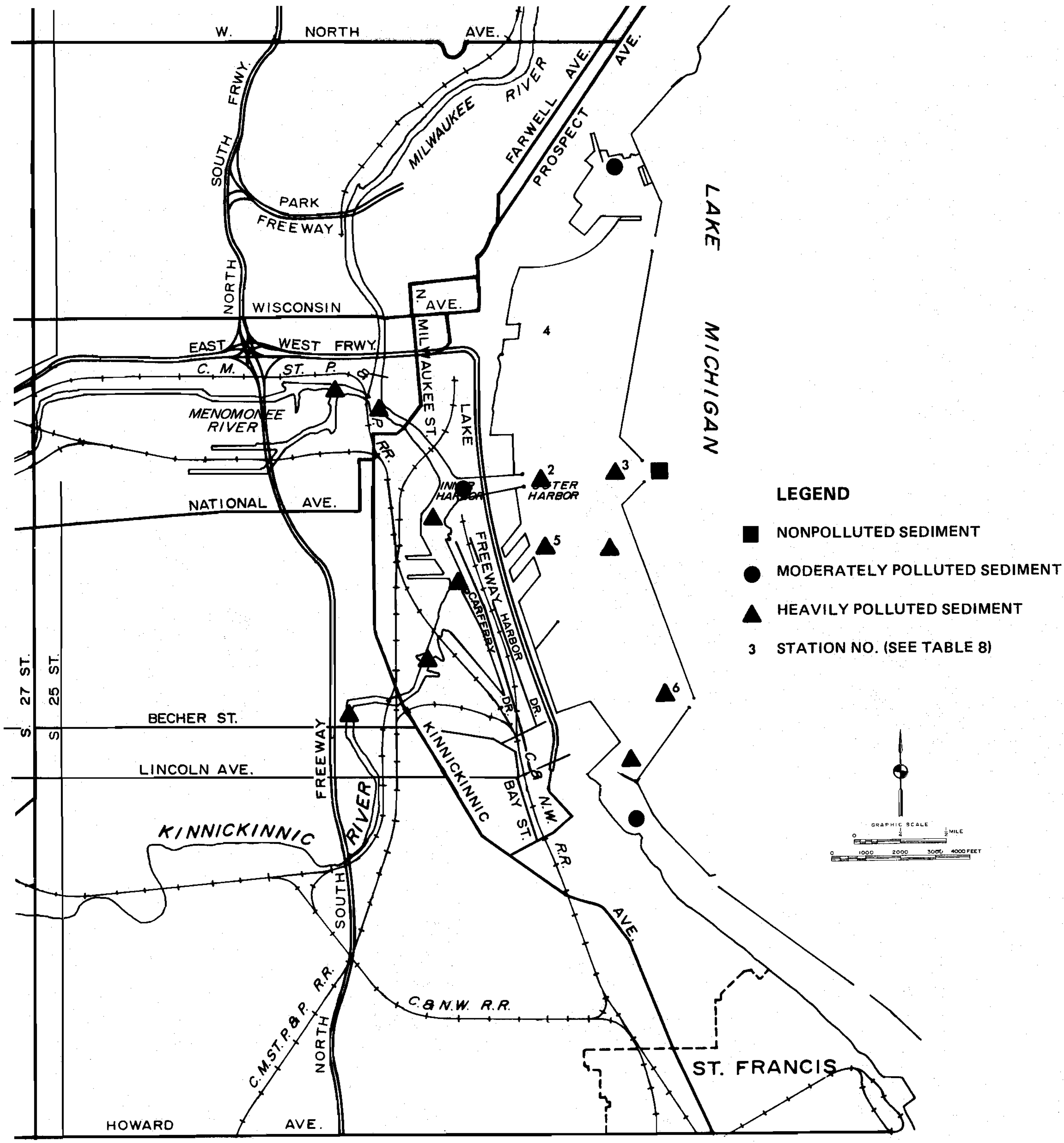
[a]Lower limits have not been established. This table presents EPA criteria for open-water disposal of dredged material.

[b]Total PCB's ranging from 1 to 10 milligrams/kilogram dry weight are subject to classification on a case-by-case basis.

Source: U. S. Environmental Protection Agency, Region V, Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments, April 1977.

Map 11

SEDIMENT QUALITY IN THE MILWAUKEE HARBOR



Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

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Chapter III

UPLAND DISPOSAL OPTIONS

This chapter evaluates alternatives for disposing of dredged materials in upland areas. Specifically, the following four alternatives are examined: the disposal of dredgings in a special-purpose landfill or lagoon; the disposal of dredgings in a general refuse sanitary landfill; the surface spreading of dredgings on agricultural lands; and the use of dredgings as a fill material.

As previously noted, the materials required to be dredged from the Milwaukee Harbor at the present time are generally classified as heavily polluted, which limits their current potential for productive uses. However, it is anticipated that proposed water pollution abatement measures may result in the improvement of the quality of the sediments deposited in the harbor area over time. It is also possible that selective dredging to provide for segregation of the dredged materials may result in the generation of some dredged materials which would be classified as unpolluted. Because there is a possibility for improved quality, information has been provided herein on upland disposal methods which in some cases may be prohibited if the materials dredged are heavily polluted.

USE OF A LANDFILL OR LAGOON DESIGNED EXCLUSIVELY FOR DREDGED MATERIAL DISPOSAL

The alternative calling for the disposal of dredged materials in a secure landfill or lagoon designed to meet all needed environmental protection measures offers particular advantages for dealing with dredged materials classified as polluted. Two options can be considered: a sanitary landfill and a lagoon system.

Sanitary landfilling is an engineered method of disposing of solid wastes on land in a manner that minimizes environmental hazards and nuisances. Various engineering modifications may be applied in the development of an environmentally safe sanitary landfill for the disposal of materials which are considered to present potential environmental problems. Limiting the types of materials to be landfilled can have advantages, including the enhanced ability to predict leachate generation rates and character; the ability to specifically design the landfill for a well-defined and relatively uniform material; and the ability to operate equipment and to follow procedures which are specially designed to handle the specific type of material.

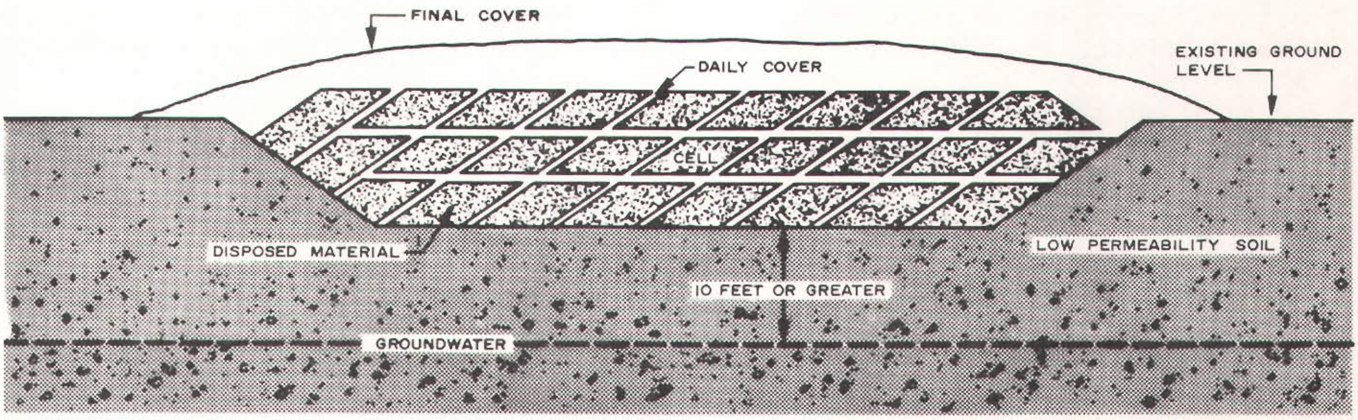
Landfills are generally constructed as one of four types or modifications of those types: 1) a natural attenuation landfill, 2) a zone of saturation landfill, 3) a clay-lined landfill, and 4) a shallow lift landfill. The type of construction will depend upon the site details and the quantity and quality of the dredged material. Illustrations of these four landfill types are provided in Figure 2.

The natural attenuation landfill is one constructed over natural in-place soils in such a way that a very limited amount of leachate is generated; upon leaving the landfill structure, the leachate is essentially treated and

Figure 2

TYPES OF LANDFILLS POTENTIALLY SUITABLE FOR DREDGED MATERIALS DISPOSAL

NATURAL ATTENUATION LANDFILL



ZONE OF SATURATION LANDFILL

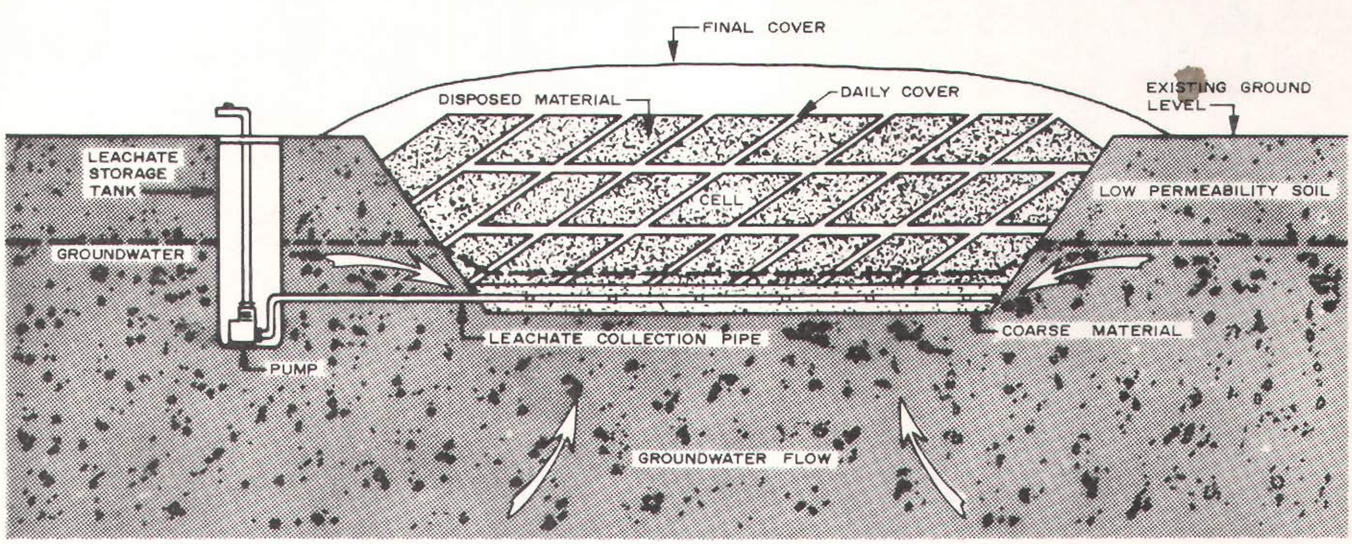
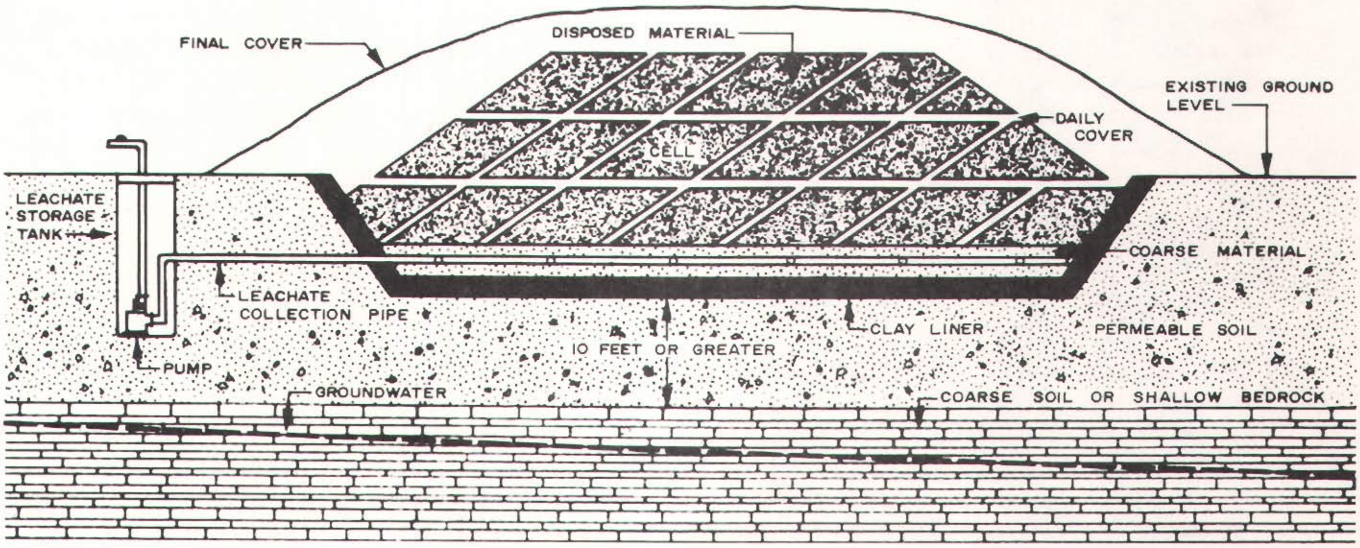
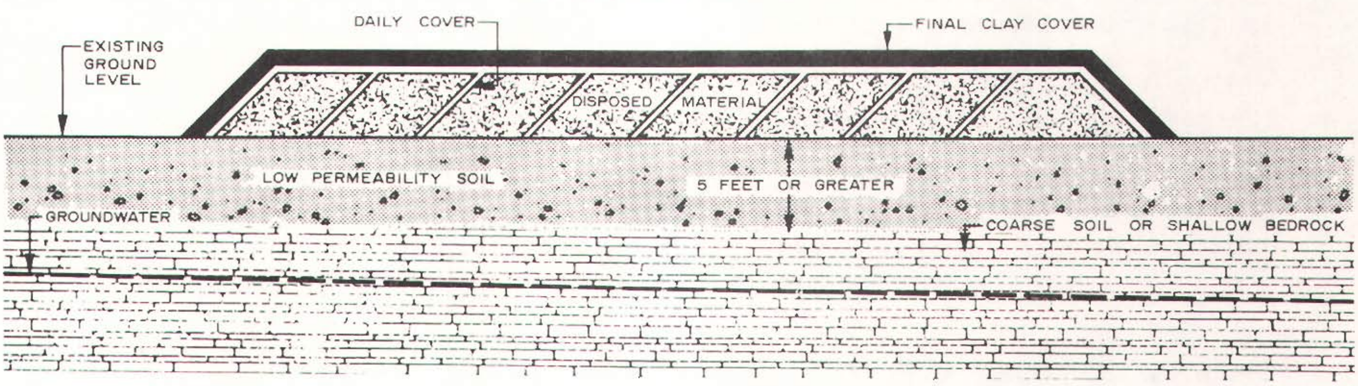


Figure 2 (continued)

CLAY-LINED LANDFILL



SHALLOW LIFT LANDFILL



Source: SEWRPC.

purified as it passes through the underlying soils. Adequate amounts of underlying heavy soils such as clays and silts are necessary for this type of landfill, as is a minimum depth of about 20 feet to groundwater or to bedrock.

A zone of saturation landfill is one constructed in an area where suitable soils exist but the groundwater table is relatively high. The landfill is developed by the excavation into clay soils below the groundwater table. The soils on the site should generally be composed of clay materials, such that the rate of infiltration to the landfill does not exceed the surface evaporation rates. Natural sand and silt seams should be isolated from the waste mass to avoid locally high rates of infiltration. A leachate collection system is needed to remove leachate for treatment. During and after the filling operations, groundwater will infiltrate the landfill, diluting somewhat the leachate normally generated. The direction of groundwater flow is by design into the landfill since the groundwater elevation is higher than the elevation of the leachate in the landfill. This is different from a natural attenuation-type landfill, in which the leachate is discharged into the groundwater reservoir following treatment by a liner. This landfill type also generally affords potential for monitoring of the groundwater quality impacts.

If in-place soils are not adequate for construction of a natural attenuation landfill, a clay-lined landfill can then be constructed to minimize the migration of leachate from the landfill. Leachate is then collected from the landfill and treated prior to disposal.

A landfill similar to the natural attenuation landfill is the shallow lift landfill. This type of landfill provides for the placement of a layer of waste on the land surface, above grade, over a natural clay type of soil generally with a low permeability. The depth of the clay is generally at least 10 feet. The material landfilled is then covered with a final layer of relatively impermeable soil.

With the various engineering options available, it appears that a sanitary landfill could represent an environmentally safe disposal alternative for dredged materials. The landfill has advantages in that it can be operated year-round rather than being dependent upon the availability of agricultural land or construction fill needs.

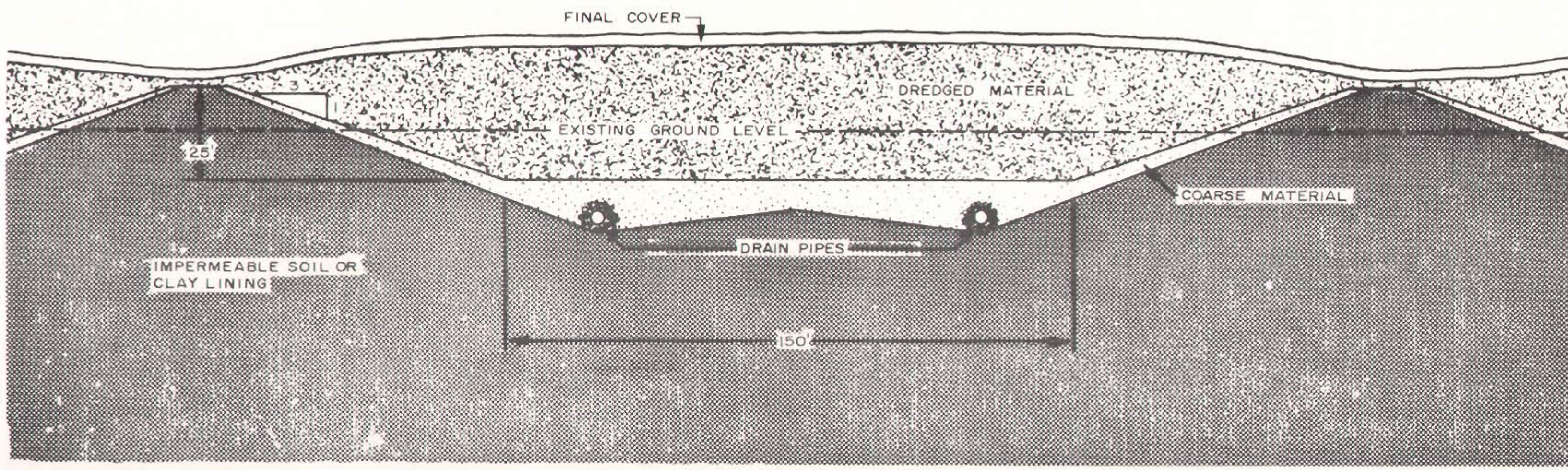
Another option for disposal is a lagoon constructed in a manner similar to an engineered landfill. The lagoon could have a clay liner, a leachate collection system, and a system for supernatant drawoff. When sediments have become dewatered in the lagoon over time, and have consolidated, the sites can be covered with topsoil or other material suitable for planting. Figure 3 indicates one type of lagoon construction.

DISPOSAL OF DREDGED MATERIAL IN GENERAL REFUSE SANITARY LANDFILLS

General refuse sanitary landfills may provide suitable disposal facilities for dredged materials from the Milwaukee Harbor area. Moreover, the dredged materials may have several potential, cost-effective applications in solid waste management, since such materials are essentially a soil mixture with a high water content that can be reduced. The substitution of dewatered dredged materials for soil may therefore be feasible for daily cover material, gas and leachate barriers, liners, and final cover materials, particularly in areas considered marginal for sanitary landfill development because of the lack of soil materials with suitable properties for the aforementioned uses.

Figure 3

EXAMPLE OF A LAGOON POTENTIALLY SUITABLE
FOR DREDGED MATERIALS DISPOSAL



Source: SEWRPC.

Daily Soil Cover

As a daily cover material, dewatered dredged materials could serve to prevent fly and insect emergence from, and rodent burrowing in, the solid wastes; to act as a control of surface water infiltration; to prevent internal solid waste fires; and to enhance the aesthetics of the landfill operation. The suitability of dredged materials as a cover material depends on the distribution of the various-sized soil particles after dewatering. The characteristics of a desirable cover material are easy workability, moderate cohesion, and significant strength. A mixture of sand, silt, and clay has been used as a suitable cover material. When compacted, the granular, coarse particles are held together by the binding action of the silt and the cohesion of the clay. The fines--smallest soil particles--also serve to reduce the permeability of the cover material. Soils which are not suitable for use as cover are highly organic soils and peat.

The use of dewatered dredged material is feasible at general refuse landfills because such materials can be easily hauled, spread, and compacted by conventional earth-moving equipment. The use of dredged materials as a slurry or as a semisolid for cover, however, is not feasible, because of onsite handling and storage problems. Neither slurry nor semisolid dredged materials will remain on the slope of the working face of a landfill, and drying the material in place would involve periods of time during which the surface would be unworkable. Increased rates of leachate generation would also occur, unless special measures were applied to control the water released from the dredged materials into the solid waste.

Gas and Leachate Barriers

As solid waste decomposes under anaerobic conditions, dangerous or toxic gases such as methane and hydrogen sulfide are produced. To prevent the development of health and safety hazards near sanitary landfills, these decomposition gases must be confined laterally to the boundaries of the landfill. Also, water seeping through solid waste may become contaminated. The contamination of surface and groundwater by solid waste leachate must be averted by either collection and treatment or prevention of its production. Depending on their permeability, dredged materials may be used as suitable gas and leachate barriers in sanitary landfills.

In order to control the lateral migration of decomposition gases from within a sanitary landfill, a vertical barrier is constructed by excavating a relatively narrow--typically one- to four-foot-wide--trench around the landfill to a depth below the lowest solid waste. The trench is backfilled with impervious soil, compacted, and saturated with water.

Landfill Liner or Final Cover Material

In order to prevent leachate production by groundwater or by infiltrating surface water, an impervious liner extending from beneath the solid waste to the surface is constructed around a sanitary landfill. One commonly used liner material is clay soil, compacted to form a membrane about five feet thick, completely sealing the bottom and sides of the sanitary landfill. In addition, following completion of the filling operation, the landfill is typically capped with about 12 inches of coarse sand and gravel, about 12 inches of relatively impermeable clay, and about 6 inches of topsoil. For use as a liner or for use as the impermeable portions of the final cover material in a sanitary landfill, the dredged material would have to be fairly well segregated into fractions of mostly silt- and clay-sized particles, and would have to have a moderate to slow permeability: i.e., less than 0.002 inch per hour.

The flow of water through soil is highly dependent on the size, shape, arrangement, and gradation of particles. Fine-grain, compacted, dredged material samples have been shown to be highly impervious to water. The use of fine-grained dredged material would require that the material be dewatered to near optimum moisture content and then carefully compacted.

In summary, dredged material that has been partially dewatered to the point that it has a water content comparable to that of similar natural soil generally has the physical and engineering properties required to be suitable for several uses in a sanitary landfill operation. Construction of cover, liners, and gas barriers is technically feasible based on a comparison of the properties of suitable natural soils with the properties of dried dredged material.

LAND APPLICATION

A fourth alternative for the upland disposal of dredged materials is to use these materials to beneficially amend marginal lands for agricultural purposes or to improve the productivity of existing agricultural lands. The physical and chemical characteristics of soils can be altered through the addition of dredged materials, to render the water and nutrient levels more favorable for crop production. The potential benefits associated with adding dredged materials to marginal soils include increased water-holding capacity, increased organic (humus) and nutrient content, enhanced tilth, and increased hydraulic conductivity to improve drainage.

Many of the natural soils in the Southeastern Wisconsin Region are comprised of fine-textured clay particles. Those bottom sediments having a high sand content would be the type of dredged material most beneficial to conditioning such clay soils. As shown in Table 8 in Chapter II of this report, sediment analyses at selected locations in the Milwaukee Harbor indicated that the sand content of the bottom materials ranged from 6 percent on a dry weight basis in the middle of the outer harbor near the mooring slips to 54 percent at the junction of the inner and outer harbors. Table 8 also indicated that the total nitrogen and total phosphorus content of the bottom sediments was, in all samples, less than one-half of 1 percent. Based upon these data, it may be concluded that dredged materials from the Milwaukee Harbor area would have greater application as a soil conditioner than as a soil fertilizer in agricultural lands in southeastern Wisconsin. However, as noted earlier, because of the high concentrations of heavy metals presently in the bottom sediments in the harbor, it is probable that future dredged materials would be acceptable for agricultural spreading purposes only if the concentrations of contaminants have been reduced and the suitability of the materials for this reuse has been clearly established by documented sampling studies. Therefore, if the heavy metal concentrations in these sediments are reduced in the future, then agricultural spreading of dredged materials from the Milwaukee Harbor may be a viable disposal alternative.

USE OF DREDGED MATERIALS AS FILL

Dredged materials are comprised of a varying mixture of sand, silt, and clay particles. Such materials have been successfully applied in various construction projects across the country. Such uses for dredged materials have included beach nourishment, shore protection, breakwater construction, and wildlife habitat development. Also, dredged materials can serve as fill for the reclamation or rehabilitation of sand and gravel pits, and as fill for the construction of roadways and airport runways. The productive use of dredged material is dependent upon the composition and quality of the material.

Dredged materials have been used for creating or enhancing recreational facilities such as golf courses, tennis courts, and baseball fields. An example of such application of dredged material is the East Potomac Park in Washington, D. C. Dredged material was also used in the construction of Grant Park in Chicago, Illinois. Pelican Island in Galveston, Texas, is a dredged material disposal site which contains not only recreational land uses, but also port terminals, manufacturing land uses, commercial offices, a shipyard, and a college.

Dredged materials have also been used as common fill material for highway construction in California, Georgia, Pennsylvania, and Texas. Fill is used chiefly for highway construction, since standard arterial facilities normally conform to the existing grade of the natural terrain, and therefore include only limited use of cut-and-fill techniques. The principal use of fill in normal highway construction in southeastern Wisconsin would be in the building of overpasses. Under the SEWRPC-adopted transportation plan, as amended in 1981, approximately 41 additional miles of freeway facilities are proposed for construction in the Region by the year 2000.

Another project illustrating the potential for use of dredged material as a fill is the Lake Michigan shoreline stabilization study conducted by the Milwaukee County Park Commission in 1979 and 1980. This study focused on alternative methods of stabilizing about 3.5 miles of Lake Michigan shoreline from the mouth of Oak Creek in the City of South Milwaukee south to Oakwood Road in the City of Oak Creek. Although not an upland use since the fill would be used mainly for shoreline stabilization, this project does illustrate the large amounts of fill materials that could be needed in this type of project. Three alternative plans were developed, with the amount of fill needed ranging from 5.5 million to 14 million cubic yards.

The use of dredged materials from the Milwaukee Harbor area as a construction material may be a potentially viable, partial long-term solution to the disposal of a portion of some of the dredged materials from the Milwaukee Harbor. However, it is not expected that this will be a total solution owing to the intermittent need for such materials, and the fact that portions of the dredged material would be unsuitable for use in construction. Moreover, the glacial geology of the Region affords an abundant supply of sand and gravel from existing mineral extraction operations located across the entire Region.

In numerous situations, the application of dredged material has provided for the development or enhancement of terrestrial and aquatic wildlife habitat. Often, these sites were chosen for ease of transport of dredged materials or other circumstances that made them economically and technically desirable for spoil disposal. However, some disposal areas have been designed to improve existing habitat or create additional productive areas for wildlife. As is discussed in Chapter IV, economic and environmental considerations make use of selection criteria, an important aspect in choosing future disposal areas and the type of material which can be used at such sites. Potential disposal areas located next to existing wildlife habitat may supply a needed habitat component, such as additional nesting cover or feeding areas, which could be lacking in the adjacent existing area. The indigenous plants and animals on and adjacent to a proposed disposal site should also be evaluated as part of the disposal site selection criteria. Knowledge of existing plant species on or adjacent to the potential disposal site will facilitate the selection of plant species to be established on the site and the species of wildlife for which the potential habitat improvement is designed.

In summary, it appears that the use of dredged materials as a fill for various types of projects in upland areas, such as recreation land enhancement, wildlife habitat, or light industry development, has the potential to be a viable alternative for dredged material disposal. However, the potential uses and site conditions are so varied that each use would need to be evaluated with respect to feasibility on a case-by-case basis.

CONCLUSION

Based upon the above discussion, it appears that all of the options considered have potential as a disposal method for at least a portion of the dredged material. The economic and environmental costs of these alternatives are further evaluated in Chapters IV and V.

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Chapter IV

SITING ANALYSIS FOR UPLAND DISPOSAL OF DREDGED MATERIAL

INTRODUCTION

Potentially feasible methods for the disposal of materials from the Milwaukee Harbor as discussed in Chapter III of this report are as follows:

1. Disposal in a new landfill or lagoon specially designed and exclusively used for dredged materials.

2. Disposal in an existing or new general refuse sanitary landfill, jointly with other solid wastes. This alternative includes the potential for use of the dredged material for daily cover and other beneficial uses in landfills.

3. Surface application on land as a soil conditioner.

4. Use as a fill material for highways, light industrial or commercial complexes, recreation land, and wildlife habitat areas.

The ultimate selection of a specific site for the application of any of these techniques will require that detailed studies be conducted to evaluate the economic, social, environmental, and technological considerations on a site-by-site basis. The conduct of these site-specific studies is time-consuming and expensive. However, considerable information on the soundness of alternative disposal methods can be obtained by proceeding through a first phase, or general area phase, of the site selection process prior to site-specific analyses. Thus, the entire process of selecting a specific site is most logically envisioned as a two-phase approach. The first phase, or general area phase, which is the subject of this report, is used to select portions of the study area with a high potential for the location of disposal sites. The second, or site-specific, phase considers the possibility of actual sites at a more detailed level of analysis.

This chapter of the report is directed at providing the Harbor Commission with a general indication of where upland disposal sites could best be located within the Southeastern Wisconsin Region. The analysis is also directed at the selection of a representative sample of general upland areas for disposal sites for use in the preparation of cost estimates for the alternatives.

The analyses recognized that the quality of dredged materials may in the future be acceptable for the disposal and reuse methods discussed herein. This improvement in the quality of dredged material would occur as a result of improved regulation and control of many pollutants and the segregating of dredged materials to better match the "unpolluted" and "polluted" dredged materials to suitable methods of disposal. Therefore, information is being provided for upland disposal options which may not be practical if the dredged material quality does not improve over time.

Criteria which can be utilized in determining whether the pollutant concentrations in the dredged material could preclude the implementation of any of the following alternatives involving disposal in landfills are described in

Chapter NR 181 of the Wisconsin Administrative Code, which sets forth Wisconsin's hazardous waste management rules. Criteria used for initial site selection for disposal areas are also described in Chapter NR 181, and would be similar to those presented below for conventional landfills, as presented in Chapter NR 180 of the Wisconsin Administrative Code. The differences between conventional and hazardous waste disposal site development are apparent in the engineering, construction, operation, maintenance, closure, and long-term care procedures.

The identification of potential upland sites for the disposal or reuse of dredged material requires the establishment and application of specific criteria to be used in evaluating potential sites. The criteria selected for use in this siting analysis are based upon data which are readily available from existing sources. Below is a discussion of the criteria to be considered for each feasible disposal alternative selected for use in the study. Following the discussion of criteria, the methodology used in applying the criteria is presented.

The criteria utilized have their foundation in an understanding of the man-made and natural resource features of the study area, as those features are characterized in quantitative data in the SEWRPC files. Chapter III included a brief description of these features, with emphasis on those features most directly related to the location of dredged material disposal areas.

NEW LANDFILL OR LAGOON SITING ANALYSIS

The siting of a new landfill or lagoon for the exclusive disposal of dredged materials or a new landfill for the disposal of dredged material in conjunction with other solid wastes relies upon data available on geology, groundwater, soils, topography, surface water resources, environmentally significant areas, existing and planned urban development, and transportation systems.

The size of a dredged material disposal site would vary depending upon the proposed dredging effort and site life, the site topography, the type of landfill method, and the depth of fill. The following assumptions have been made in order to estimate the limits of the area needed for a landfill or lagoon:

- The total amount of dredged material to be deposited at the site is 750,000 cubic yards, equivalent to the estimated amount of 50,000 cubic yards to be generated annually over 15 years--1986-2000--of maintenance dredging.

- The average depth of the fill is 30 feet, exclusive of the final cover.

- The ratio of dredged material to other covering soils or other material is five to one.

Assuming these conditions and a buffer zone around the landfill of 300 feet, a site area of about 60 acres would be required.

Criteria for Disposal Area Siting

The criteria utilized in the analyses are generally based upon the requirements set forth in Chapter NR 180 of the Wisconsin Administrative Code and upon other pertinent engineering requirements for landfill or lagoon sites. The discussions in the following sections are directed toward dividing the Region into areas with no potential for the location of a dredged material landfill or lagoon; areas with limited potential for such location; and areas with a high potential for such location.

Geology: The following are the main geologic considerations for landfill or lagoon siting:

- Bedrock Depth--A depth to bedrock of greater than 50 feet would be ideal, while greater than 20 feet is generally considered the practical minimum distance in southeastern Wisconsin in order to reduce the potential for groundwater contamination. Areas with depths of less than 20 feet to bedrock are considered to have no potential for the location of a new dredged material landfill or lagoon.

- Bedrock Type--The Maquoketa shale functions as an aquiclude or vertical flow barrier and is present in most of the Region. The areas in the western portion of the Region where the Maquoketa shale is not present are important groundwater recharge areas where water percolates downward through glacial deposits into the sandstone aquifer--the major source of groundwater supply in the Region. Because of the importance of this sandstone aquifer recharge area to the groundwater supplies of southeastern Wisconsin and northeastern Illinois, the recharge area is considered to have a somewhat limited potential for a new dredged material landfill.

- Glacial Deposit Type--The types of glacial deposits present in an area are an indication of its suitability for landfill construction. Generally, glacial ground moraine and end moraines are most likely to contain materials best suited for landfill construction. However, this consideration is too variable for general screening purposes and must be evaluated on a site-by-site basis. Thus, this factor is not used in the general area phase analysis.

Groundwater: Groundwater considerations in landfill or lagoon siting include the following:

- Groundwater Depth--Areas with a depth of less than 10 feet to groundwater are considered to have a limited potential for landfill or lagoon siting because of engineering and construction requirements needed to provide for groundwater protection.

- Well Locations--Chapter NR 180 of the Wisconsin Administrative Code requires that landfills be located at a horizontal distance of more than 1,200 feet of any public or private water supply well unless special conditions exist which indicate that contamination will not occur. This factor is discussed further in a later section on existing urban development in landfill siting.

- Flow Direction--Generalized mapping of the groundwater flow patterns is available. However, local variation in the regional flow patterns is often significant, and this aspect of landfill siting must be developed on a more site-specific basis.

Soils: In selecting areas for landfill sites, data from the detailed soil surveys described in Chapter II are an important consideration, since they may be indicative of the subsurface conditions--below the five- to six-foot depth of the soil samples--and since the soil type indicates the surficial material available for construction at the sites. Because of the highly localized variation in soils in the Region, this consideration is not included in the general area phase of the analysis, but would be considered in a later site-specific analysis.

Surface Water: With regard to the surface waters of the Region, the locational criteria for the siting of a solid waste land disposal site are set forth in Chapter NR 180 of the Wisconsin Administrative Code, which does not permit a landfill within the following areas:

- Within 1,000 feet of any navigable lake, pond, or flowage.

- Within 300 feet of a navigable river or stream.

- Within a floodplain.

- Within wetlands.

- Within an area where, according to the findings of the Department of Natural Resources, there is a reasonable probability that disposal of solid waste will have a detrimental effect on surface water.

The areas covered by the first four of the above-noted limitations were categorized in the general area phase siting study as having no potential for a landfill or lagoon. The fifth factor noted above can be properly considered only in site-specific studies.

Environmentally Significant Areas: The siting of a solid waste management facility requires consideration of environmentally significant areas. Environmentally significant areas which would have no potential for a dredged material landfill or lagoon include primary environmental corridors, woodlands, wetlands, floodlands, groundwater discharge and recharge areas, and specially designated natural areas and selected types of wildlife habitat. However, woodlands are often used effectively as buffer zones for landfills.

Urban Areas: The following two considerations relate landfill or lagoon siting to existing urban development:

- Chapter NR 180 of the Wisconsin Administrative Code requires a separation of at least 1,200 feet between a landfill and any public or private water supply source. This limit may be increased or decreased if justified by site-specific groundwater studies. For purposes of landfill or lagoon site selection, a distance of about one-quarter mile, or 1,320 feet, from existing residential and commercial urban development and industrial areas--where groundwater wells would be found--was considered an approximate limit for general siting analyses. Areas located within this distance of residential and commercial urban development were considered to have no potential for a new landfill or lagoon location.

- The Wisconsin Administrative Code states that solid waste land disposal sites may not be established within 1,000 feet of the nearest edge of the right-of-way of any state trunk highway or interstate or federal aid primary highway, or of the boundary of any public park, unless the site is screened by natural objects, plantings, fences, or other appropriate means so as not to be visible from the highway or park. Tree plantings, berms, and other site modifications are relatively simple engineering modifications that provide adequate screening from roads and parks. Therefore, this consideration was not used to eliminate areas as potential landfill sites.

Transportation Base: The transportation systems of the Region have a direct impact on the site selection process. A maximum haul distance of 30 miles was used as a criterion for identifying areas classified as having a high potential for the location of a landfill or lagoon site.

Airports: The Federal Aviation Administration (FAA) and Chapter NR 180 of the Wisconsin Administrative Code prohibit sanitary landfill development within 5,000 feet of the ends of runways where propeller-driven aircraft are used and 10,000 feet where jet aircraft are used. In considering a specific site near airports for landfill development, the FAA should be contacted to determine if a site would interfere with operations of the airport. The main concern expressed by the FAA is the bird attraction problems associated with municipal waste. However, this is not expected to be a problem at landfills receiving only dredged materials, and this criterion was therefore not considered in the general area phase analysis.

Historical and Archaeological Sites: The Wisconsin State Historical Society reports that 186 historic and archaeological sites within southeastern Wisconsin have been either listed or deemed eligible for inclusion on the National Register of Historic Places. Thousands of other sites of historic or archaeologic importance have been identified in the Region, and the potential exists for the discovery or designation of additional areas. Regulations require that detailed analyses be conducted by the State Historic Preservation Officer, should a project have the potential to adversely affect a historically or archaeologically important site or area. As such, siting of a landfill or lagoon facility for dredged material disposal may require such a site-specific analysis. Such an analysis can best be done as specific sites are investigated rather than on a large, general area basis. These analyses should be conducted prior to detailed site selection because of the time involved in the historic and archaeologic inventory and analysis.

Methodology of General Area Selection Process For a New Landfill or Lagoon

Several studies have been conducted in southeastern Wisconsin which are directly related to landfill siting. These studies have generally involved a first phase or general area phase landfill siting study, and have incorporated all or portions of the above-cited criteria. A brief discussion of these studies follows.

Milwaukee Metropolitan Sewerage District (MMSD) Site-Specific Analysis: As part of the Milwaukee pollution abatement program facility planning studies, an analysis of sites available for landfills and for land application was conducted. In that study, areas in southeastern Wisconsin which had no potential for landfill or land application sites were delineated. The screening of areas with low potential for landfill or land application sites was based on excluding from the potential areas all of the following:

- Wetlands:
- 100-year recurrence interval floodlands;
- Recreational areas;

- Wastewater sludge land application areas specifically recommended by SEWRPC to be used by sewage treatment plants located outside Milwaukee County; and

- Urban areas.

Copies of the mapping results of that categorization are available in MMSD and SEWRPC files.

County Solid Waste Management Studies: Ozaukee, Racine, Washington, and Waukesha Counties have completed county solid waste management plans which include a general area landfill site selection process utilizing basically the same criteria discussed above. Walworth County is in the process of conducting such a study. Copies of the mapped results of these county landfill siting studies are available in the SEWRPC files.

Regional Wastewater Sludge Management Plan: In 1978 SEWRPC prepared a regional sludge management plan which evaluated alternative sludge disposal and utilization methods, including landfill of sludge solids. That study recommended the use of land application as the primary method of sludge disposal for most public sewage treatment plants in the Region, with landfilling as a supplementary back-up disposal method. The study delineated specific areas for land application of sludges from each of the public sewage treatment plants in the Region. The results of this study are documented in SEWRPC Planning Report No. 29, A Regional Wastewater Sludge Management Plan for Southeastern Wisconsin, July 1978.

A two-step screening process was used to categorize areas of the Region with regard to their potential for use as a dredged material landfill. This process first identified certain areas within the Region which were considered unsuitable for a landfill because of existing or planned land uses or special conditions. As previously discussed, these areas include existing urban areas, wetlands, 100-year recurrence interval floodlands, areas with depths of less than 20 feet to bedrock, environmental corridors, and areas specifically identified in the regional sludge management plan for use for sludge application by sewage treatment plants located outside Milwaukee County. As shown on Map 12, this analysis resulted in the identification of about 1,910 square miles, or 71 percent of the area of the Region, as having no potential for the siting of a dredged material landfill. The second step in the process of identifying those areas with the best potential for a landfill was the consideration of known subsurface conditions.

As previously mentioned, depth to groundwater is an important consideration in the evaluation of the potential suitability of areas for landfill siting. Consequently, the depth to groundwater was reviewed in 779 square miles of the Region, or 29 percent of the area of the Region remaining after the first screening. Areas with a depth to seasonal high groundwater of less than 10 feet were considered to have limited potential for landfill siting because of the increased cost of construction and operation of a landfill in these areas. As a result of this second phase screening, an additional 185 square miles, or about 7 percent of the area of the Region, was classified as having limited potential for landfill siting. These areas are also shown on Map 12. The remaining 594 square miles, or 22 percent of the Region, was determined to have a high potential for landfill siting for dredged material disposal. Approximately 250 square miles, or 32 percent of the area with the best potential for a landfill for dredged materials, is within 30 road miles of the Milwaukee Harbor. It should be noted that while this analysis is based upon

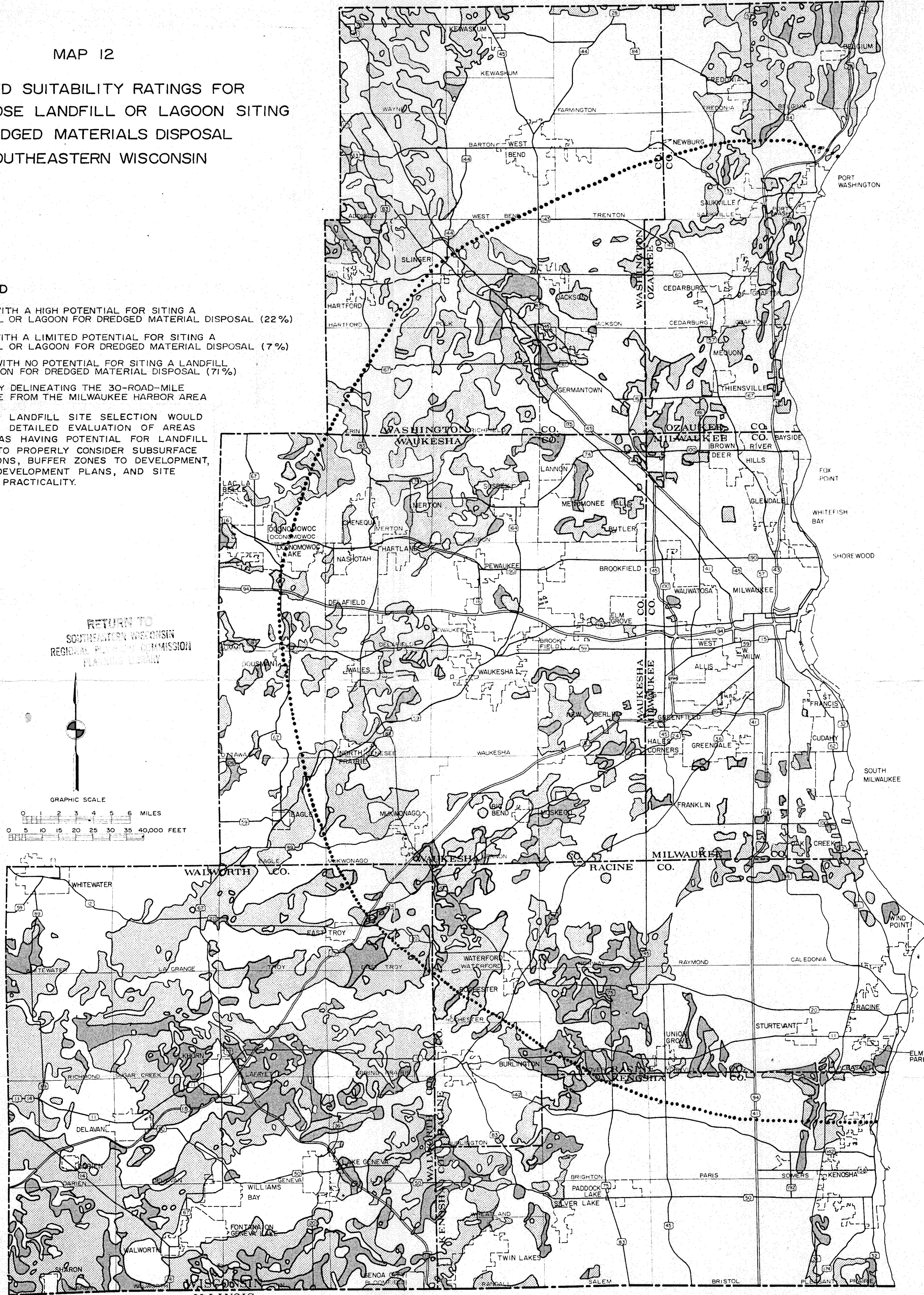
MAP 12

GENERALIZED SUITABILITY RATINGS FOR SPECIAL–PURPOSE LANDFILL OR LAGOON SITING FOR DREDGED MATERIALS DISPOSAL IN SOUTHEASTERN WISCONSIN

LEGEND

- AREAS WITH A HIGH POTENTIAL FOR SITING A LANDFILL OR LAGOON FOR DREDGED MATERIAL DISPOSAL (22%)
- AREAS WITH A LIMITED POTENTIAL FOR SITING A LANDFILL OR LAGOON FOR DREDGED MATERIAL DISPOSAL (7%)
- AREAS WITH NO POTENTIAL FOR SITING A LANDFILL OR LAGOON FOR DREDGED MATERIAL DISPOSAL (71%)
- •••••• BOUNDARY DELINEATING THE 30-ROAD-MILE DISTANCE FROM THE MILWAUKEE HARBOR AREA

NOTE: FURTHER LANDFILL SITE SELECTION WOULD REQUIRE DETAILED EVALUATION OF AREAS NOTED AS HAVING POTENTIAL FOR LANDFILL SITING TO PROPERLY CONSIDER SUBSURFACE CONDITIONS, BUFFER ZONES TO DEVELOPMENT, LOCAL DEVELOPMENT PLANS, AND SITE LAYOUT PRACTICALITY.



Source: MILWAUKEE METROPOLITAN SEWERAGE DISTRICT and SEWRPC

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generalized regional data, the actual siting of a landfill requires more detailed, site-specific analysis. Localized conditions may result in the identification of small areas within each category noted as being more or less suitable for a landfill than indicated in the above analysis.

EXISTING LANDFILL LOCATIONAL CONSIDERATIONS

As previously noted, the potential uses of dredged material in landfills include cover material, gas barrier and vent material, impervious lining material, leachate collection liners, and leachate collection underdrains. The suitability of dredged material for each of these uses was evaluated by comparing the makeup of the dredged material with the properties of soil known to be suitable for use in sanitary landfills. The basic findings are that most dredged material can be considered for many productive uses at a solid waste sanitary landfill. Coarse-grained dredged material can be used for gas vents, leachate drains, and portions of the cover material, while fine-grained materials can be used for gas barriers, impervious liners, and covers. Another possibility is the use of landfills for disposal by placement of the dredged material in the landfill along with other solid wastes without consideration of its beneficial uses.

In southeastern Wisconsin, this material can potentially be located at existing landfills or new landfills. Siting for a new landfill was considered in the previous section. The locations of the existing, active landfills in the Region are shown on Map 13 and are recorded as Memorandum No. DSA-1 in the SEWRPC files.

There are two, large commercial landfills located within and adjacent to Milwaukee County. For cost estimating purposes, the Metro Disposal Service landfill in the City of Franklin, Milwaukee County, and the Waste Management landfill in the Village of Germantown, Washington County, have been assumed to be the locations for existing landfill disposal.

LAND APPLICATION SITING CONSIDERATIONS

A potential alternative for the productive use of dredged material is the surface application of dredged materials to amend marginal agricultural land or farmland where productivity can be improved through use of soil-conditioning measures. Generally, agricultural lands having the most potential for this alternative are characterized by poor drainage and low fertility, and may be severely eroded. The addition of dredged material to these areas may alter the characteristics of the soil in such a way that water and nutrients become more available for plant growth and, in some cases, soil drainage characteristics may be improved.

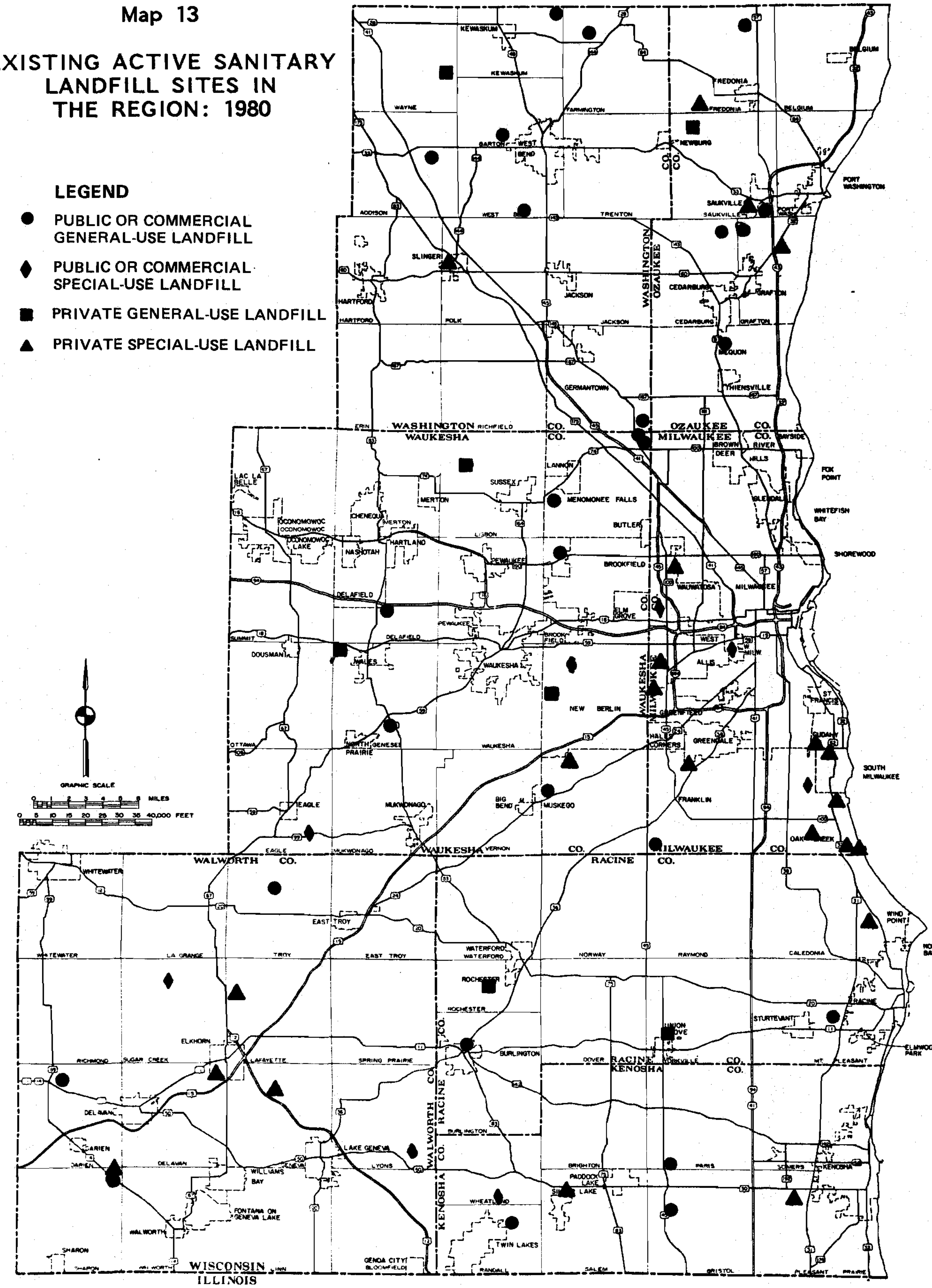
The use of specific site-selection criteria is necessary to ensure that appropriate areas are chosen for use of dredged materials to enhance the quality and productivity of agricultural land. As with other forms of dredged material disposal, it is generally required that the physical and chemical characteristics of the dredged material and the soil characteristics of the agricultural land disposal site be singly and jointly evaluated. The high levels of some pollutants in the dredged material--as reported in Chapter II--may preclude the use of these materials on agricultural lands. However, the the pollutant levels of the dredged material may change over time, and it may eventually be possible to segregate dredged materials as dredging proceeds, and to transfer a less polluted fraction of the material for one use, while other fractions of the material are disposed of by other methods.

Map 13

EXISTING ACTIVE SANITARY LANDFILL SITES IN THE REGION: 1980

LEGEND

- ● PUBLIC OR COMMERCIAL GENERAL-USE LANDFILL
- ♦ PUBLIC OR COMMERCIAL SPECIAL-USE LANDFILL
- ■ PRIVATE GENERAL-USE LANDFILL
- ▲ PRIVATE SPECIAL-USE LANDFILL



Source: Wisconsin Department of Natural Resources and SEWRPC.

Chemical analysis of the dredged material and the soil at a proposed agricultural site will determine the amount of dredged material required at the site to increase fertility and/or improve drainage. Even though this type of site-specific analysis is needed to match the character of the dredged material to the specific location for land application, some insight can be gained into the practicality of this method of disposal by a more general review of potential disposal sites.

For analysis purposes, it was assumed that four inches of dredged material would be applied to agricultural land and blended with the top 12 inches of the existing soil. This would result in the use of about 1,500 acres of land if all of the 750,000 cubic yards of dredged material anticipated during the study period were applied to agricultural land.

Other Criteria and Land Application Area Siting Considerations

Many of the criteria discussed above for potential landfill site location are applicable to land spreading sites. These include criteria which would categorize the following areas as having no potential for land application sites:

- Primary environmental corridors;
- Environmentally significant areas;
- 100-year recurrence interval floodlands;
- Areas designated by the regional wastewater sludge management plan for land application of sewage sludge from specific sewage treatment plants located outside Milwaukee County; and
- Urban areas.

Further criteria have been established for the application of wastewater sludge to agricultural lands. Such criteria, as presented in Wisconsin Department of Natural Resources Technical Bulletin No. 88[1] (revision of 1981), may also be applicable to the use of nonpolluted or moderately polluted dredged material to amend soils of agricultural lands. Further, site-specific analyses and dredged material testing, in addition to those discussed below, would be required under this alternative. Such analyses are also discussed in Technical Bulletin No. 88. Detailed analyses of the dredged material is needed because certain crops are sensitive to the quality characteristics of sludges and because certain crops will be consumed by animals and human beings. The nutrient and metal content of the dredged materials will affect the amount of material which can be applied and the type of crops which can be grown. Soil properties and crop types are significant factors to be considered in the evaluation of potential sites for land application of dredged material.

The existing transportation system is a consideration which will have a direct impact on the selection of a land application site. Transportation system criteria established for the first phase or general area phase siting study include designating a maximum haul distance of 35 miles for sites categorized as having a high potential for land application.

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[1]D. R. Keeney, K. W. Lee, and L. M. Walsh, Guidelines for the Application of Wastewater Sludge to Agricultural Land in Wisconsin, Wisconsin Department of Natural Resources Technical Bulletin No. 88, 1975 (Revised 1981).

Methodology for General Agricultural Site Selection Process

Several studies have been conducted in the Southeastern Wisconsin Region which are directly related to land application siting. A brief discussion of those studies follows.

Milwaukee Metropolitan Sewerage District Site-Specific Analysis: This study was noted previously under the discussion of landfill siting. As part of the Milwaukee pollution abatement program facility planning studies, an analysis of sites available for landfill and for land application was conducted. One of the first steps in that study was the delineation of areas in southeastern Wisconsin which had no potential for landfill or land application sites. The screening of areas with low potential for landfill or land application sites was based on excluding from the potential areas all of the following:

- Primary environmental corridors;
- Wetlands;
- 100-year recurrence interval floodlands;
- Recreational areas;
- Wastewater sludge land application areas specifically recommended by SEWRPC to be used by sewage treatment plants located outside Milwaukee County; and
- Urban areas.

The mapping results of that categorization are available in MMSD and SEWRPC files. Areas selected by the Milwaukee Metropolitan Sewerage District in the site-specific analysis for land application of sludge would be considered to have no potential for the application of dredged material unless the mix of sludge and dredged material proves beneficial.

Regional Wastewater Sludge Management Plan: In 1978 SEWRPC prepared a regional sludge management plan which evaluated alternative sludge disposal and utilization methods, including land application of sludge solids. That study concluded that there were about 358,000 acres of agricultural land in southeastern Wisconsin suitable for land application of wastewater treatment plant sludges. It was estimated that 73,000 to 110,000 acres would be needed for land application of sludges, depending upon the level of contaminant reduction practices applied by the sludge generators.

County Farmland Preservation Plans: Kenosha, Racine, Walworth, and Washington Counties have completed plans which serve as the basis for the preservation of farmland through the application of exclusive agricultural zoning within those counties. As a result of such zoning, farmers may become eligible to participate in the Wisconsin Farmland Preservation Program, as authorized under the Wisconsin Farmland Preservation Act of 1977.

The existing open land in the Region is shown on Map 5. The amount of agricultural land in the Region as of 1980 is about one million acres. A two-step process was used to categorize the open or agricultural land of the Region with regard to its suitability for land application of dredged material to enhance the fertility or drainage characteristics of the soil. As previously discussed, certain areas were considered unsuitable for land application because of existing land uses or special conditions. These areas include urban areas, wetlands, 100-year recurrence interval floodlands, environmental corridors, and areas specifically identified in the regional sludge management plan as sites for the application of sludge from sewage treatment plants located outside Milwaukee County. As shown on Map 14, this analysis resulted in the identification of about 1,876 square miles, or 70 percent of the area of the Region, as having no potential for land application of dredged material. The second step in the process of identifying those areas with the best potential for land application of dredged material was the consideration of the characteristics of the dredged material and of the in-place soils.

As discussed in Chapter IV, the dredged materials from the Milwaukee Harbor contain about equal amounts of sand, silt, and clay and are low in nutrients when compared with commercial fertilizers. Consequently, the dredged material would have greater application as a soil conditioner to improve drainage, texture, and permeability than as a fertilizer. With these considerations in mind, the characteristics of the soil covering the 813 square miles, or 30 percent of the area of the Region, remaining after the first screening were reviewed. Based upon very broad suitability associations, the soils in this area were then classified as having a high, moderate, or low potential for disposal of dredged material on agricultural land. The suitability classifications are shown on Map 14. Areas remaining after the first screening which have soils that are generally poorly drained, have a high water table, and are interspersed with peat and muck are not well suited for some agricultural uses, and cover about 102 square miles, or 4 percent of the Region. Such areas were determined to have a high potential for land application of dredged materials since the drainage characteristics of these soils could potentially be improved by the addition of dredged materials. It should be noted that many of the areas containing these types of soils are characteristic of wetlands and floodlands, and consequently were eliminated from further consideration during the first stage of the screening process. Areas remaining after the first screening which have soils that are generally well drained and are productive as cropland are considered well suited for agricultural use. These areas cover about 65 square miles, or 24 percent of the Region, and were determined to have a moderate potential for land application of dredged materials. Steeply sloped areas which have bedrock close to the surface and thin, moderately fertile soils are generally not well suited for many agricultural uses. Such areas remaining after the first screening cover about 60 square miles, or 2 percent of the Region, and were determined to generally have a low potential for land application of dredged materials. It was determined that approximately 440 square miles, or 54 percent of the previously described areas with high, moderate, or low potential for land application of dredged materials, are located within 35 road miles of the Milwaukee Harbor.

It should be noted that while this analysis is based upon generalized regional data, the actual selection of an area suitable for land application of dredged material requires more detailed, site-specific analyses. Localized conditions may result in the identification of small areas within each category which have characteristics which make a site more or less suitable for land application of the dredged material than indicated in the above analysis.

USE OF DREDGED MATERIAL AS FILL

Historically, the use of dredged material to supplement or replace conventional fill materials used during general construction activities, establish or enhance park and recreation areas, or develop wildlife habitat was dictated by the proximity of the dredging work to these sites. However, the lack of applicable land areas near dredging activities and increased environmental concerns about dredge material disposal have dictated that a broader range of upland disposal sites be considered, and that criteria for selection of such sites be developed. The U. S. Army Corps of Engineers has conducted a dredged material research program to develop economically feasible dredging and disposal alternatives, including consideration of dredged material as a manageable, usable resource. As part of that study, procedures for site selection and for the evaluation of various uses as a fill material were developed.

An analysis of the physical and chemical characteristics of the dredged material to be used to supplement or replace conventional fill material is a necessary first step in determining whether the material is conducive to such use. The soil composition and structural characteristics of the dredged material will determine to a large extent its potential use. These characteristics include the general makeup of the material by soil type components such as sand, silt, clay, gravel, and organic material. Further, other physical soil characteristics associated with drainage, moisture content, compactability, and stability of the soil aggregates would also need to be determined. The time required to dewater the material and the density of the material will also have to be evaluated before it can be used. In most cases, material will need to be partially dried before it can be utilized. In addition, environmental considerations dictate that the chemical characteristics of the dredged material be analyzed. As previously discussed, dredged materials from the Milwaukee Harbor contain varying concentrations of pollutants which would restrict their potential for productive uses.

The criteria that are utilized to predetermine the suitability of a site for the disposal of dredged material are important to ultimate site selection and to an understanding of the major planning considerations that affect the productive use of dredged material. General engineering criteria associated with construction work, such as the structural foundation and integrity of the underlying soil layers, will need to be assessed. Further, the depth to the water table, slope, and surface drainage characteristics at the site will need to be determined. Future use of the area will also be an important criterion in determining site selection, since light industry, open space, and/or recreation areas have less stringent fill requirements. Institutional constraints and environmental regulations would also need to be considered during site selection.

In order for use of the dredged material to be economically feasible, it is likely that the usable fraction, or sand and gravel portion, of the material will need to be separated from the unusable, organic components. This could probably best be accomplished as the dredging proceeds, with the material which is best suited for future use being segregated and transported to the site where it will be utilized, and the remaining portions disposed of in suitable landfills.

Because of the varied types of use, and varied locations for use, of fill material, specific, site selection criteria have not been presented. These would have to be developed on a site-specific basis.

MAP 14

GENERAL SITING ANALYSIS RESULTS FOR USE OF DREDGED MATERIAL ON AGRICULTURAL LAND

LEGEND

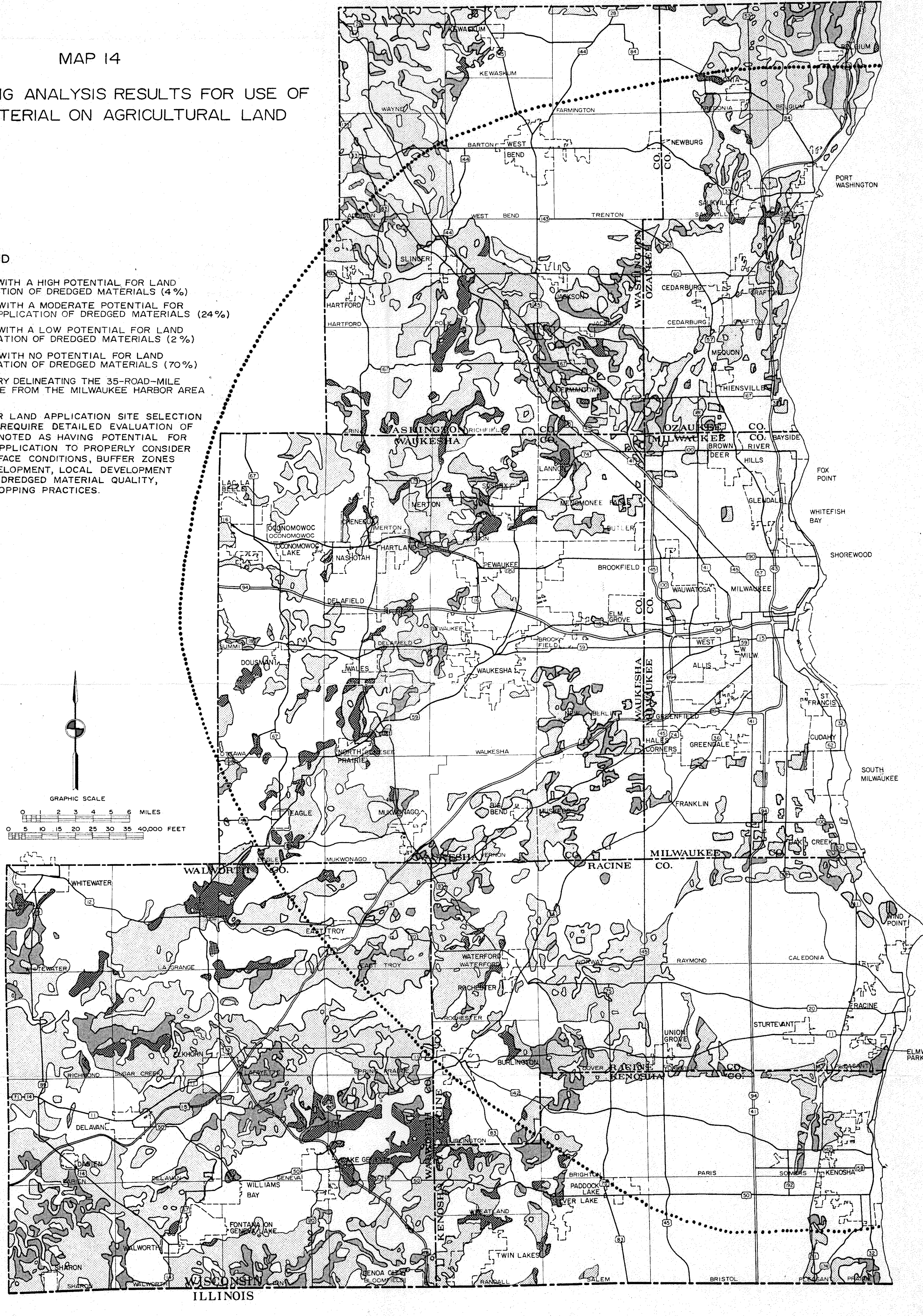
- AREAS WITH A HIGH POTENTIAL FOR LAND APPLICATION OF DREDGED MATERIALS (4%)
- AREAS WITH A MODERATE POTENTIAL FOR LAND APPLICATION OF DREDGED MATERIALS (24%)
- AREAS WITH A LOW POTENTIAL FOR LAND APPLICATION OF DREDGED MATERIALS (2%)
- AREAS WITH NO POTENTIAL FOR LAND APPLICATION OF DREDGED MATERIALS (70%)
- BOUNDARY DELINEATING THE 35-ROAD-MILE DISTANCE FROM THE MILWAUKEE HARBOR AREA

NOTE: FURTHER LAND APPLICATION SITE SELECTION WOULD REQUIRE DETAILED EVALUATION OF AREAS NOTED AS HAVING POTENTIAL FOR LAND APPLICATION TO PROPERLY CONSIDER SUBSURFACE CONDITIONS, BUFFER ZONES TO DEVELOPMENT, LOCAL DEVELOPMENT PLANS, DREDGED MATERIAL QUALITY, AND CROPPING PRACTICES.

GRAPHIC SCALE

0 1 2 3 4 5 6 MILES

0 5 10 15 20 25 30 35 40,000 FEET



Source: *MILWAUKEE METROPOLITAN SEWERAGE DISTRICT and SEWRPC*

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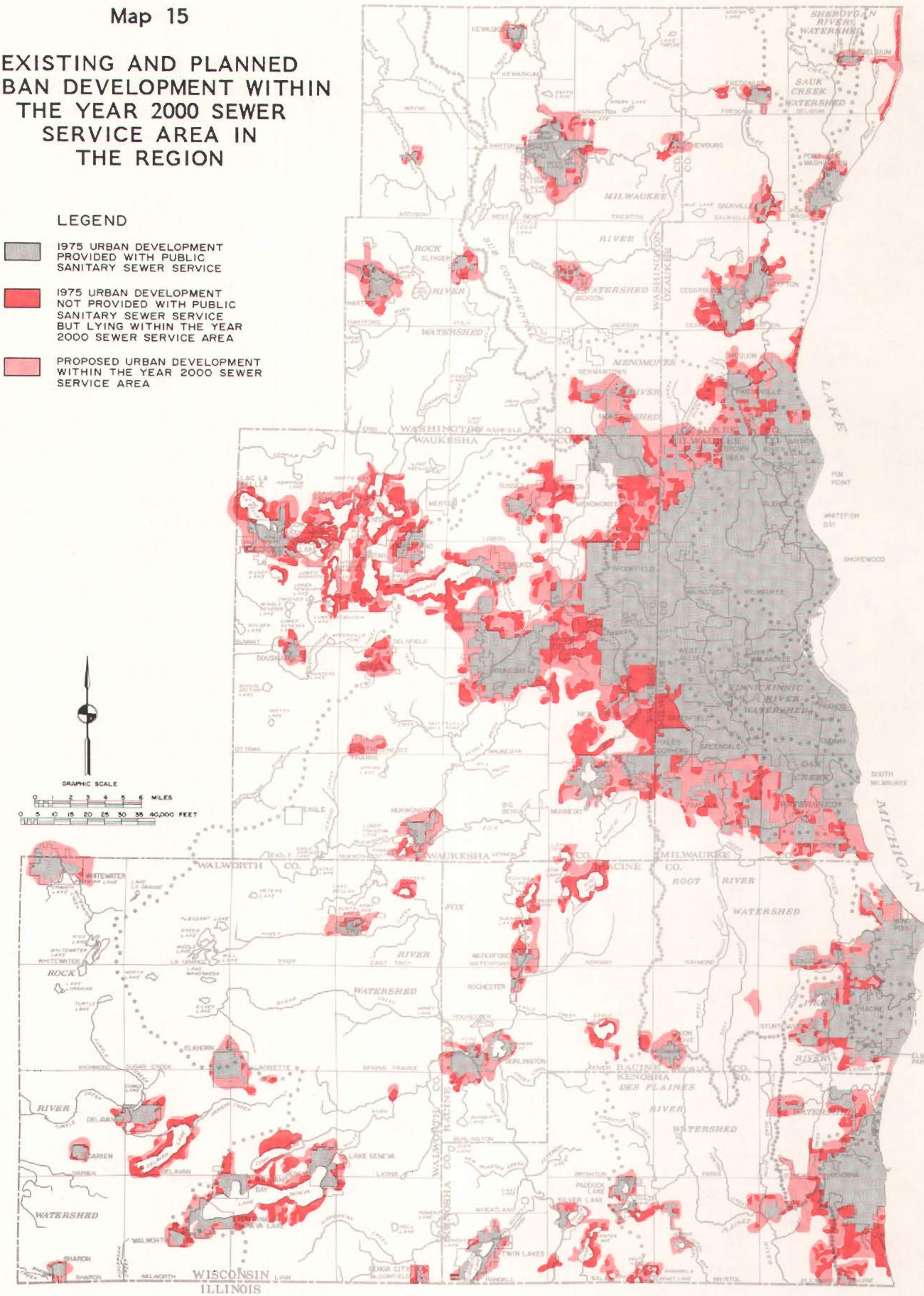
The selection of potential areas in southeastern Wisconsin for the productive use of dredged material from the Milwaukee Harbor is dependent on the need for supplemental fill material and the previously discussed restrictions on the use of the material. Thus, no general area phase analysis is included herein. However, potential areas of use include areas of proposed new urban development located within a haul distance of 20 miles of the Milwaukee Harbor, as shown on Map 15.

Map 15

EXISTING AND PLANNED URBAN DEVELOPMENT WITHIN THE YEAR 2000 SEWER SERVICE AREA IN THE REGION



Source: SEWRPC.

Chapter V

DESCRIPTION OF UPLAND DISPOSAL ALTERNATIVES

In the preceding chapter of this report, four alternative upland disposal techniques were identified and their potential feasibility for application in the Southeastern Wisconsin Region evaluated. The four alternative techniques are: 1) disposal of dredged material in a single use, specially designed, new landfill or lagoon; 2) disposal in a general refuse sanitary landfill; 3) surface application as a soil conditioner to agricultural or silvicultural lands; and 4) the use of dredged materials for fill. Each of these four alternatives was deemed to have sufficient potential for application in the Region to warrant further evaluation.

In addition to ascertaining the potential feasibility of a given alternative, it is necessary to establish the economic practicality of the alternative. Accordingly, this chapter addresses the economic factors associated with each of the four disposal alternatives. Specifically, the costs of storage, dewatering, transport, and reuse and/or disposal of the dredged materials are considered. The costs of land acquisition, engineering design, construction, and operation and maintenance are evaluated for each alternative, as applicable. An analysis of the economic factors attendant to each alternative may be expected to provide the basis for comparing the practicality of the various potential upland disposal techniques. It must be recognized in this respect, however, that management decisions relating to the use or disposal of dredged material should not be based upon economic considerations alone, but, as discussed later in this chapter, upon other considerations as well.

The analyses contained herein of the economic factors involved in the various upland disposal alternatives for dredged materials are in sufficient detail for use in comparing the alternatives, and for use in comparing the upland disposal alternatives presented herein to other dredged material disposal options, such as near-shore or coastal containment. More detailed, site-specific engineering studies will be needed prior to implementation of any alternative.

Each of the alternatives considered was designed for the reuse or disposal of approximately 50,000 cubic yards of in situ dredged material per year over a 15-year period from 1986 through the year 2000, or for the disposal of a total of 750,000 cubic yards over the design period. The first four alternatives considered assume that all of this volume of material will be reused or disposed of utilizing one method. Following the description and analysis of the four individual alternatives, a fifth alternative is discussed which envisions multiple methods of reuse and disposal of the dredged materials.

Design of the alternatives was based upon the following assumptions--developed on the basis of the inventory findings--about the characteristics of the dredged materials:

- Solids content--variable from 15 to 75 percent by weight, with an average of 40 percent.
- Texture--variable, with an average textural composition of 25 percent sand, 65 percent silt, and 10 percent clay, by weight.

- Total nitrogen content--0.2 percent by weight.
- Total phosphorus content--0.3 percent by weight.
- Concentrations of other pollutants--variable, as noted in the discussion of each alternative.

The principal features and costs of the five alternatives are summarized in Table 10, and each alternative is described below. The unit cost data utilized in the development of these alternative cost estimates are provided in Appendix A. A more detailed breakdown of the costs of each alternative is recorded in the SEWRPC files as Memorandum No. DSA-2. All costs are expressed in constant 1981 dollars.

ALTERNATIVE 1A: DISPOSAL OF DREDGED MATERIAL IN A LANDFILL DESIGNED EXCLUSIVELY FOR DREDGED MATERIAL DISPOSAL

The first alternative considered envisions the construction of a landfill located at an upland site and specifically designed for the controlled disposal of dredged material from the Milwaukee Harbor. The alternative includes a storage and dewatering system and a transportation system. This alternative also envisions that a proportion of the dredged material in the harbor will be considered to be moderately polluted and the remaining proportion to be heavily polluted.

The alternative consists of three principal components: 1) a storage and partial dewatering system, 2) a transportation system utilizing trucks, and 3) a landfill specifically designed for dredged material disposal.

The storage and dewatering facility has been included in the alternative based upon the assumption that substantial portions of the dredged materials will have a water content high enough to warrant partial dewatering prior to hauling. For cost-estimating purposes, it was assumed that this storage and dewatering system would be located at the existing diked disposal area at the south end of the outer harbor. The alternative envisions utilizing, with appropriate modifications, the outlet sand filter which is presently used to remove pollutants from the water drained from the deposited dredged material.

Assuming that a 30-day storage time will be required and that about 50 percent of the dredged material will need to be stored and partially dewatered, about five acres of storage area would be needed for placement of the dredged material at an average depth of about two feet, including area for roadway and loading facilities. This storage site would be designed for dewatering by evaporation and drainage--with the drained water passing through the sand filtration system. It is estimated that 2 million gallons of water would be drained from the dredged materials per year. The storage facility would also provide flexibility in scheduling and timing of dredging and transport activities. The storage facility is assumed to receive dredged material over about a six-month dredging period each year. The subsequent transportation and landfill operation is envisioned to operate for about seven months each year. Because of the reduction in the water content of the dredged materials at the storage site, the total volume of dredged material to be transported may be expected to be reduced by about 25 percent. Thus, the volume of dredged material to be transported for landfilling is estimated at 37,500 cubic yards per year, including both the dewatered fraction and the fraction handled without dewatering.

Table 10

PRINCIPAL FEATURES AND COSTS OF MANAGEMENT ALTERNATIVES FOR UPLAND DISPOSAL AND REUSE OF DREDGED MATERIALS FOR THE MILWAUKEE HARBOR

Alternative			Cost Estimates				Economic Analysis Estimates					
							Present Worth			Equivalent Annual Cost		
Number	Name	Principal Components	Capital	1986-2000 Annual Operation and Maintenance	Total Average Annual Cost	Unit Cost (dollars per cubic yard)	Capital	Operation and Maintenance	Total	Capital	Operation and Maintenance	Total
1A	Disposal of Dredged Material in a Landfill Designed Exclusively for Dredged Material	• Storage and dewatering system • Transportation system • Landfill disposal system	$3,952,000	$202,600	$466,100	$9.30	$1,413,000	$ 957,000	$2,370,000	$166,000	$112,000	$278,000
1B	Disposal of Dredged Material in a Lagoon Designed Exclusively for Dredged Material	• Transportation system • Lagoon disposal system • Wastewater treatment of supernatant	3,473,000	240,100	471,600	9.40	1,258,000	1,134,000	2,392,000	148,000	133,000	281,000
2	Disposal of Dredged Material in an Existing Landfill	• Transportation system • Storage and partial dewatering system • Existing solid waste landfill	454,000	646,400	391,200	7.80	282,000	1,704,000	1,986,000	33,000	200,000	233,000
3	Application of Dredged Material as a Soil Conditioner	• Material quality control system • Transportation system • Remote storage facility • Land application system	771,000	429,000	480,400	9.60	440,000	2,026,000	2,466,000	52,000	238,000	290,000
4	Use of Dredged Material as a Fill	• Storage, partial dewatering, and segregation system • Transportation system • Filling operation	378,000	186,100	211,300	4.20	235,000	879,000	1,114,000	28,000	103,000	131,000
5	Disposal and Use of Dredged Materials by Multiple Methods	• Storage and partial dewatering system • Transportation system • Landfilling disposal system • Remote storage system for land application • Productive landfill, land application, and filling uses	1,311,000	298,000	385,000	7.70	423,000	1,407,000	1,830,000	50,000	165,000	215,000

Source: SEWRPC.

Following dewatering and storage for about 30 days, the material would be loaded for transport to the landfill site. The dredged material would be hauled to the disposal site by open dump trucks with a 30-cubic-yard capacity. For estimating purposes, the disposal site has been assumed to be located about 30 road miles from the dewatering and storage area. The data presented in Chapter IV indicate that a number of sites with a high potential for landfill application should be available within this 30-mile haul distance. The transportation costs include the cost of purchase, operation, and maintenance of four 30-cubic-yard dump trucks, each truck making about three round trips per day in a five-day-per-week, one-shift-per-day, operation during the six-month dredging period each year.

Alternative 1A envisions that the dredged materials would be disposed of in a landfill located in an area having a high potential for landfill application and having natural clay soils present in amounts adequate to negate any need to transport material for use in construction of the landfill. A 60-acre site would be adequate for the landfill operation, including a 300-foot buffer strip around the landfill itself.

Schematic representations of potential types of landfills which could be used are shown in Figure 2 in Chapter III. The plan of operation would be to construct modules, each with a capacity for one year's dredged material. For estimating purposes, it was assumed that the landfill would be constructed with a clay liner using suitable materials located on the site, properly compacted to specified densities. It is expected that selective placement of dredged material will negate the need to import cover material daily, and that the dredged material itself, or a mixture of dredged material and onsite soils, would instead be utilized. The project would include suitable landfill leachate and gas monitoring and control systems, as well as a groundwater monitoring system.

The site would be constructed in a total of 15 modules. The final layer of dredged materials would be covered with about two feet of impermeable soil, such as clay, properly graded to prevent erosion. Site restoration would be planned so as to enhance and support adjoining land uses. Topsoil would then be emplaced and planted with vegetation. After site closure, the long-term site responsibility required by the Wisconsin Department of Natural Resources (DNR) would be maintained for a period of 10 years, during which monitoring and inspection would be continued to ensure that no adverse environmental problems develop.

The estimated capital cost of Alternative 1A is $3,952,000, with an average annual operation and maintenance cost of $202,600. Using an annual interest rate of 10 percent, an amortization period of 15 years, and an analysis period of 20 years, the equivalent annual cost of construction and operation of this alternative is $278,000.

ALTERNATIVE 1B: DISPOSAL OF DREDGED MATERIAL IN A LAGOON DESIGNED EXCLUSIVELY FOR DREDGED MATERIAL DISPOSAL

Alternative 1B is similar to Alternative 1A except that the disposal structure would be a lagoon, rather than a landfill; and the storage and partial dewatering facilities included in Alternative 1A would not be included in Alternative 1B. Rather, the dredged materials would be hauled to the lagoon site without any dewatering. Dewatering would take place in the lagoon itself by evaporation. Thus, the alternative consists of three principal components:

1) a transportation system utilizing trucks, 2) a lagoon specially designed for dredged material disposal and for supernatant withdrawal, and 3) provision for wastewater treatment of the supernatant.

The dredged material would be transported in 30-cubic-yard capacity open dump trucks, loaded, however, on the average to 25 cubic yards, depending on moisture content. The trucks would be designed to prevent leakage of liquids. In order to estimate transportation costs, the lagoon site was assumed to be located about 30 road miles from the harbor area. The data presented in Chapter IV indicate that a number of sites with a high potential for lagoon application should be available within this 30-mile haul distance. The transportation costs include the cost of purchase, operation, and maintenance of five 30-cubic-yard dump trucks, each truck making about three round trips per day in a five-day-per-week, one-shift-per-day, operation during the six-month dredging period each year.

Alternative 1B envisions that the dredged material would be disposed of in a lagoon located in an area having soils suitable for the construction of a clay-lined lagoon, thus avoiding the need to import soils for construction. A 60-acre site would be required, including provision for a 300-foot buffer strip around the landfill itself. A supernatant withdrawal system would be provided, with the liquor--estimated to total about 10,000 gallons per day--being loaded into a tank truck for conveyance and discharge into the sewerage system of the Milwaukee Metropolitan Sewerage District. The material would be discharged into the sewerage system during periods of low sewage flow. A schematic representation of the lagoon is shown in Figure 3 in Chapter III.

Under this alternative, 15 lagoon cells would be constructed, two at a time. Each cell would have sufficient capacity to receive the material dredged during a one-year period--50,000 cubic yards. The surface of each lagoon would subside as dewatering occurs. The lagoon would be filled to final grade, covered, and planted with suitable vegetation for site restoration and reuse. Final site uses after filling would generally be limited to recreational, agricultural, or other open space uses, but could include, with proper foundation design, industrial and commercial uses as well. After site closure, DNR-required long-term site responsibility would be maintained for a period of 10 years, during which monitoring and inspection would be continued to ensure that no adverse environmental impacts develop.

The estimated capital cost of Alternative 1B is $3,473,000, with an average annual operation and maintenance cost of $240,000. Using an annual interest rate of 10 percent, an amortization period of 15 years, and an analysis period of 20 years, the equivalent annual cost of construction and operation of this alternative is $281,000.

ALTERNATIVE 2: DISPOSAL OF DREDGED MATERIAL IN AN EXISTING LANDFILL ALONG WITH OTHER SOLID WASTES

The second alternative considered envisions the transport of all dredged materials to an existing sanitary landfill for disposal along with other solid wastes. This alternative consists of the use of an existing, suitably licensed, sanitary landfill for disposal of the dredged materials. This alternative envisions the quality of the dredged material to be such that about 50 percent of the materials could be used beneficially in the landfill, while the other 50 percent would be landfilled along with other solid wastes. It is assumed that the dredged material quality would be acceptable at two major commercial landfills which are located within a 25-mile, over-the-road haul distance from the harbor area--one in the City of Franklin in Milwaukee County and one in the Village of Germantown in Washington County.

The alternative consists of three principal components: 1) a storage and partial dewatering system, 2) a transportation system, and 3) a landfilling system at existing solid waste landfills.

The storage and partial dewatering system called for under this alternative would be located in the harbor area and would be essentially the same as the system described under Alternative 1A. For purposes of cost estimation, it is assumed that about 50 percent, or 25,000 cubic yards per year, of the materials dredged would have a water content sufficiently high to warrant partial dewatering at a facility located on the existing diked disposal area. A storage period of 30 days is assumed, after which the materials would be transported to one of the two landfills cited above. The locations of these two landfills and of the harbor area are shown on Map 13. These landfills have a remaining licensed and approved capacity of about 7 million and 40 million cubic yards, respectively, as of 1980. During 1980, the landfill in Franklin received about 3,000 cubic yards of refuse per day, while the landfill in Germantown received about 7,500 cubic yards of refuse per day. It is possible that the amount of dredged material allowed to be disposed of would be limited to a percentage of the other refuse in order to minimize leachate production. This percentage would be determined by site-specific studies.

The storage facility design assumes that dredging would take place over a six-month period each year. The subsequent transportation and landfill operations are envisioned to operate over a seven-month period. Following storage and dewatering of about 50 percent of the dredged material, the total volume of the dredged material to be transported would be about 37,500 cubic yards per year, including both the dewatered fraction and the fraction handled without dewatering.

The dredged material would be transported by open dump trucks of 30-cubic-yard capacity. The transportation costs assume the purchase, operation, and maintenance of four 30-cubic-yard trucks, with each truck making three round trips per day in a five-day-per-week, one-shift-per-day, operation during the six-month dredging period each year.

Alternative 2 envisions that about 50 percent of the dredged materials, or about 18,500 cubic yards per year, could be utilized beneficially in the landfill operation as material for daily cover, in the construction of gas vents, or as backfill in the construction of leachate collection underdrains. It is assumed that the material which could be utilized beneficially in the landfill operation will be accepted at the landfill at no cost. The remaining 18,500 cubic yards would be landfilled along with other solid wastes received at the landfill. The cost for disposal of this portion of the dredged materials would be about $10 per cubic yard, based upon the 1981 costs charged by the landfill operators.

The estimated capital cost of Alternative 2 is $454,000, with an average annual operation and maintenance cost of $646,000. Using an annual interest rate of 10 percent, an amortization period of 15 years, and an analysis period of 20 years, the equivalent annual cost of construction and operation of this alternative is $233,000.

ALTERNATIVE 3: APPLICATION OF DREDGED MATERIAL AS A SOIL CONDITIONER

The third alternative considered envisions the use of dredged material to amend soils on agricultural or silvicultural lands, where productivity can be improved by the use of soil conditioners. Under this alternative, it was assumed that the pollutant content of the dredged material would be low enough to permit reuse of the material as a soil conditioner. This assumption can be verified only by extensive sampling of the harbor sediments.

The alternative consists of four principal components: 1) a material quality control system, 2) a transportation system utilizing trucks, 3) a storage area remote from the harbor and near the agricultural lands where the material is to be used, and 4) a land application system. Under this alternative, the storage area would be located near the point of use in order to conveniently provide adequate supplies of dredged materials during the periods when solids can be worked into the soil, and to provide for storage during the summer months when crops are growing in the fields.

The first component of this alternative is a dredged material sampling and quality control system, which would include: extensive in-place sampling and classification of dredged materials; sampling and analysis of the dredged materials in the storage facility; agricultural and silvicultural land soil sampling; a procedure to determine desirable amounts of materials to be applied; and a procedure for inventory control to assure timely delivery of the proper amounts of the specific materials to the proper land areas.

The dredged material would be transported in 30-cubic-yard trucks, loaded, however, on the average to only 25 cubic yards. The trucks would be designed to prevent leakage of liquids. In order to estimate transportation costs, the storage site was assumed to be located an average of 35 road miles from the harbor area. The data presented in Chapter IV indicate that a number of sites are available in agricultural areas of the Region within this 35-mile distance. The transportation costs include the cost of purchase, operation, and maintenance of six 30-cubic-yard dump trucks, each making about three round trips per day to the storage site in a five-day-per-week, one-shift-per-day, operation during the six-month dredging period each year.

The dredged material would be stored at a storage site having an area of about 20 acres. The site would be designed for secure storage of the dredged materials, including provisions for the prevention of runoff. The storage area would include a system to segregate dredged material according to type and quality to afford the most practical distribution and application. During the spring and fall, the material would be removed from the storage site by trucks and applied to the land prior to conventional cultivation. The same trucks used to haul the dredged material to the storage site would be used to haul the material from the storage site to the fields.

Assuming an average of four inches of dredged material to be placed on and disced into the in-place soils, about 100 acres of agricultural or silvicultural land would be needed for application of the dredged materials each year. Before the dredged materials are applied, detailed analyses of the soils and of the dredged materials would be conducted to optimize the use of the material as a soil conditioner.

The estimated capital cost of Alternative 3 is $771,000, with an average annual operation and maintenance cost of $429,000. Using an annual interest rate of 10 percent, an amortization period of 15 years, and an analysis period of 20 years, the equivalent annual cost of construction and operation of this alternative is $290,000.

ALTERNATIVE 4: USE OF THE DREDGED MATERIAL AS FILL

The fourth alternative considered envisions the use of the dredged materials as fill. This alternative assumes that the dredged material will be of such quality and have such characteristics as to be acceptable for use as a fill material. However, it is recognized that, by its nature, some portion of the material may not have properties suitable for use in supporting anything except open space uses. Thus, under this alternative it was assumed that about 30 percent of the dredged material, or 15,000 cubic yards per year, would be well suited for fill uses and could be segregated on the basis of sediment sampling, and that such material would have a value of $0.50 per cubic yard. The remaining 70 percent of the material would also be used as a fill but, because of its quality and characteristics, would be used only in limited situations--such as fill for the development of parkland--and would therefore have no monetary value.

The alternative consists of three principal components: 1) a storage, partial dewatering, and material segregation system, 2) a transportation system, and 3) a filling operation.

A storage and partial dewatering system was included under this alternative on the assumption that at least portions of the dredged materials will have a water content high enough to warrant partial dewatering prior to use as fill material. This storage and dewatering system is essentially the same as that described for Alternatives 1A and 3. In addition, materials would be segregated and stockpiled based upon their quality and characteristics. About 50 percent of the dredged material would need to be dewatered. After dewatering, about 37,500 cubic yards of dredged material would remain for disposal or reuse, including both the dewatered fraction and the fraction handled without dewatering.

Alternative 4 is based upon the further assumption that about 30 percent of the dredged material, or about 11,250 cubic yards per year, would be well suited for fill and, therefore, would be transported by the end users at no cost to the dredging operation. In addition, those end users are assumed to be willing to pay $0.50 per cubic yard for the material. The remaining dredged material was assumed to be only marginally suited for fill. This material would be used for fill in areas to be used for recreation or other open space uses. It was assumed that this material would have to be transported to the site by the dredging party, and would be accepted for fill at no cost to either the dredging party or the fill user.

The dredged material would be transported to the disposal site by 30-cubic-yard dump trucks. For estimating purposes, these sites were assumed to be located within 20 road miles of the storage area. The data provided in Chapter IV identified this distance as the average expected haul distance, even though the locations of the individual sites receiving the dredged material may be scattered throughout the urbanizing area of the Region.

The transportation costs include the cost of purchase, operation, and maintenance of three 30-cubic-yard trucks, each making about three round trips per day in a five-day-per-week, one-shift-per-day, operation during the six-month dredging period each year.

The estimated capital cost of Alternative 4 is $378,000, with an average annual operation and maintenance cost of $186,000. Using an annual interest rate of 10 percent, an amortization period of 15 years, and an analysis period of 20 years, the equivalent annual cost of construction and operation of this alternative is $131,000.

ALTERNATIVE 5: DISPOSAL AND REUSE OF DREDGED MATERIAL BY MULTIPLE METHODS

Following review of the individual alternatives described above, it was concluded that there was another viable alternative for the reuse or disposal of dredged materials. This alternative would involve the use of a combination of several different methods, each of which would be best suited for the various components of the dredged material. This conceptual alternative would involve the following methods of reuse or disposal.

- Placement in a landfill designed specifically for polluted dredged materials of that portion of the materials deemed unsuited for other, more beneficial uses. This alternative assumes that about 25 percent of the volume of the dredged material remaining after partial dewatering of portions of the material, or 9,400 cubic yards per year of the dredged material, could and would be disposed of by this method.

- Productive uses as a cover material in a sanitary landfill designed principally to receive other solid waste. The alternative also assumes that 25 percent, or 9,400 cubic yards per year, of the dredged material could and would be utilized in this manner.

- Land application as a soil conditioner. The alternative envisions that 25 percent, or 9,400 cubic yards per year, of the dredged material could and would be utilized in this manner.

- Use as a fill material. The alternative envisions that 25 percent, or 9,400 cubic yards per year, of the dredged material could and would be utilized in this manner.

Alternative 5 consists of five components, including: 1) a storage, dewatering, and stockpiling system, 2) a transportation system, 3) a landfilling system, 4) a land application storage system, and 5) the productive landfill, land application, and filling end uses.

The storage, dewatering, and stockpiling system would be similar to that described under Alternative 4. Materials would be segregated into four different stockpiles, based upon the four reuse or disposal options noted above. The segregation would be partially accomplished by detailed bottom sediment sampling and the coordination of subsequent dredging to initially segregate materials by pertinent characteristics. Storage site material sampling and handling procedures would also be directed toward segregation of material. The transportation system would be similar to the systems described for Alternatives 1A, 2, and 4. Alternative 5 would include a provision for the transportation of the selected and stockpiled fill material by the user at no cost to the dredging party.

The special landfill site would require 20 acres for the 9,400 cubic yards to be received per year over the 15-year period. The system would be similar to that described under Alternative 1A, but substantially smaller.

The systems related to land application would be similar to those described for Alternative 3; however, the storage site would be only about three acres in area, and the land requirement would be only about 25 acres per year.

The estimated capital cost of Alternative 5 is $1,311,000, with an average annual operation and maintenance cost of $298,000. Using an annual interest rate of 10 percent, an amortization period of 15 years, and an analysis period of 20 years, the equivalent annual cost of construction and operation of this alternative is $215,000.

Chapter VI of this report compares the five alternatives described above to each other and to other means of dredged material disposal, such as open lake disposal and coastal methods of disposal.

Chapter VI

COMPARISON OF ALTERNATIVES AND CONCLUSIONS

The preceding chapter of this report described and presented economic data for five alternative upland area methods of disposal or reuse of dredged material from the Milwaukee Harbor. The information presented is intended to provide a basis for the comparison of the alternatives to each other and to other dredged material disposal options, such as in near-shore or coastal confinement facilities. The following sections include a discussion of the advantages and disadvantages of each upland area alternative considered, and present a comparison of those alternatives to each other as well as to other disposal alternatives. Table 11 summarizes the cost and the major advantages and disadvantages of each alternative.

ALTERNATIVE 1A: DISPOSAL OF DREDGED MATERIAL IN A LANDFILL DESIGNED EXCLUSIVELY FOR DREDGED MATERIAL DISPOSAL

As described in the preceding chapter of this report, this alternative requires the construction of a landfill specifically designed for the disposal of dredged materials from the Milwaukee Harbor. The alternative consists of three main components: a storage and partial dewatering system, a transportation system utilizing trucks, and a landfill designed specifically for dredged material disposal. It is estimated that a 60-acre site would be required for disposal of about 37,500 cubic yards of partially dewatered dredged material per year--equivalent to 50,000 cubic yards in-place--over a 15-year period. The cost of disposal utilizing this method was estimated to be $9.30 per cubic yard.

The major advantage of landfilling is that it provides a flexible and environmentally safe method of disposal which can be operated at all times of the year when dredging occurs. The landfill can be specifically designed to accommodate the material to be disposed of.

If implemented, Alternative 1A would ensure that there would be an adequate facility available for the disposal of dredged material, designed to receive material of varying characteristics--including pollutants. As previously discussed, the chemical analyses of samples from existing bottom sediments in the Milwaukee Harbor indicate that the sediments are moderately to heavily polluted and, consequently, may require specially designed disposal facilities to preclude the creation of environmental problems and to comply with existing solid waste disposal regulations. Thus, unless the quality of the dredged material improves over time, there will be a need for some type of secure, environmentally sound disposal system. A properly designed landfill could provide such a disposal system.

Under Alternative 1A there would be no need to segregate the material into reusable and unusable fractions during the dredging operation. Such segregation of materials would be required under Alternatives 3, 4, and 5.

The major disadvantage of Alternative 1A would be the potential problem entailed in obtaining local public support for the location of a specific landfill site for the dredged material. Public concern, particularly relating to the potential for groundwater pollution, could pose a difficult problem in

Table 11

COMPARISON OF PRINCIPAL FEATURES AND COSTS OF UPLAND DISPOSAL AND REUSE OF DREDGED MATERIALS FOR THE MILWAUKEE HARBOR

Alternative			Unit Cost (dollars per cubic yard)	Key Considerations		
Number	Name	Principal Components		Land Requirements	Advantages	Disadvantages
1A	Disposal of Dredged Material in a Landfill Designed Exclusively for Dredged Material	• Storage and dewatering system • Transportation system • Landfill disposal system	$9.30	Landfill-60 acres Storage and dewatering-5 acres	High flexibility; reduced harbor sediment sampling; no material segregation required; potential for reuse of storage and landfill areas following rehabilitation	Social and environmental constraints in finding suitable site; partial dewatering and storage required; relatively high cost; no beneficial reuse of materials
1B	Disposal of Dredged Material in a Lagoon Designed Exclusively for Dredged Material	• Transportation system • Lagoon disposal system • Wastewater treatment of supernatant	9.40	Lagoon-60 acres	High flexibility; potential reuse of lagoon; reduced harbor sediment sampling; no material segregation required; partial storage and dewatering not required	Social and environmental constraints to finding suitable site; relatively high cost; no beneficial reuse of material
2	Disposal of Dredged Material in an Existing Landfill	• Transportation system • Storage and partial dewatering system • Existing solid waste landfill	7.80	Portion of existing landfill loading: Germantown-10 percent Franklin-20 percent Storage and dewatering-5 acres	Relatively high flexibility; reduced harbor sediment sampling; beneficial use of some of the material; potential for reuse of storage and dewatering areas and landfill areas following rehabilitation; relatively low cost	Reduced capacity of existing landfill; partial dewatering and storage of material required; limited amount of material segregation required
3	Application of Dredged Material as a Soil Conditioner	• Material quality control system • Transportation system • Remote storage facility • Land application system	9.60	Agricultural land required-100 acres Agricultural storage area-20 acres	Beneficial reuse of material; potential for improved soil fertility and drainage	Social and environmental constraints in finding suitable areas; sophisticated bottom sediment sampling and material quality controls; storage and partial dewatering required; potential buildup of chemical pollutants in soils on treated areas
4	Use of Dredged Material as a Fill	• Storage, partial dewatering, and segregation system • Transportation system • Filling operation	4.20	Disposal areas Storage and dewatering-5 acres	Beneficial reuse of material; relatively flexible; relatively low cost	Sophisticated bottom sediment sampling and material quality controls required; difficulty in locating suitable sites; storage and partial dewatering required
5	Disposal and Use of Dredged Materials by Multiple Methods	• Storage and partial dewatering system • Transportation system • Landfilling disposal system • Remote storage system for land application • Productive landfill, land application, and filling uses	7.70	Storage and dewatering-5 acres Other storage-10 acres	High flexibility; beneficial reuse of material; potential for enhancement of agricultural and silvicultural lands; relatively low cost	Highly sophisticated bottom sediment sampling, quality controls, and material distribution systems required; difficulty in locating suitable sites; storage and partial dewatering required

Source: SEWRPC.

the implementation of this alternative. In addition, significant engineering and legal efforts would be entailed in obtaining approval of a site for the construction of a landfill for dredged materials, particularly if the materials are heavily polluted.

Another factor to be considered in the comparison of alternatives is the commitment of the land required. Under Alternative 1A, about five acres of land would be needed for storage and dewatering at the harbor area, and about 60 acres of land would be needed for disposal. While the use of this land would be impaired during the landfill operation, the site could be put to a variety of other uses following completion of the landfilling. The storage site located in the harbor area could also be restored to other uses following the period of use for storage and dewatering.

ALTERNATIVE 1B: DISPOSAL OF DREDGED MATERIAL IN A LAGOON DESIGNED EXCLUSIVELY FOR DREDGED MATERIAL DISPOSAL

As discussed in the preceding chapter of this report, Alternative 1B is similar to Alternative 1A, except that the disposal mechanism is a lagoon instead of a landfill, and consequently, the storage and partial dewatering facilities required under Alternative 1A are not required under Alternative 1B. Thus, the alternative consists of a transportation system utilizing trucks, a lagoon specially designed for dredged material disposal and supernatant withdrawal, and the provision of a system for wastewater treatment of the supernatant. It is estimated that a 60-acre site would be required for disposal of about 50,000 cubic yards of dredged material per year over a 15-year period. The cost of disposal utilizing this method is estimated to be $9.40 per cubic yard.

As with Alternative 1A, the major advantage of this alternative is that it provides a flexible and environmentally safe method of disposal which can be operated at all times of the year when dredging occurs. The lagoon can be specially designed to accommodate the material to be disposed of.

Alternative 1B, if implemented, would also ensure that there would be an adequate facility available for the disposal of dredged material, designed to receive material of varying characteristics--including pollutants. As previously discussed, the chemical analyses of samples from existing bottom sediments in the Milwaukee Harbor indicate that the sediments are moderately to heavily polluted and, consequently, may require specially designed disposal facilities to preclude the creation of environmental problems and to comply with existing solid waste disposal regulations. Thus, unless the quality of the dredged material improves over time, there will be a need for some type of secure, environmentally sound disposal system. A properly designed lagoon system could afford such a method of disposal.

Under this alternative there would also be no need to segregate the material into reusable and unusable fractions during the dredging operation. Such segregation of materials would be required under Alternatives 3, 4, and 5.

As with Alternative 1A, the major disadvantage of Alternative 1B is the potential problem entailed in obtaining local public support for the location of a specific lagoon site. Public concern, particularly relating to the potential for groundwater pollution, could pose a difficult problem in the implementation of this alternative. In addition, significant engineering and legal efforts would be entailed in obtaining approval of a site for the construction of the lagoon for dredged materials, particularly if the materials are heavily polluted.

Another factor to be considered in the comparison of alternatives is the commitment of the land required. Under Alternative 1B, about 60 acres of land would be needed for construction of the lagoon. While the use of this land would be impaired during the dredged material disposal operation, the site could be put to a variety of uses following completion of the disposal operation.

ALTERNATIVE 2: DISPOSAL OF DREDGED MATERIAL IN AN EXISTING LANDFILL ALONG WITH OTHER SOLID WASTES

As discussed in the preceding chapter of this report, Alternative 2 calls for the transport of all dredged materials to an existing sanitary landfill for disposal along with other solid wastes. This alternative consists of three main components: a storage and partial dewatering system, a transportation system utilizing trucks, and a landfilling system at existing commercial sanitary landfills. It was determined that a portion of one of two major existing commercial landfills would be required for disposal of about 37,500 cubic yards of dredged material per year over a 15-year period. The cost of disposal utilizing this method was estimated to be $7.80 per cubic yard.

As with Alternatives 1A and 1B, the major advantage to the use of an existing sanitary landfill is that it would present a flexible and environmentally safe method of disposal which can be operated at all times of the year when dredging occurs.

Alternative 2, if implemented through a firm, long-term contract with the landfill operator, would also ensure that there would be an adequate facility available for the disposal of dredged material of varying characteristics, including pollutants. As previously discussed, the chemical analyses of samples from the existing bottom sediments in the Milwaukee Harbor indicate that the sediments are moderately to heavily polluted and, consequently, may require special disposal facilities with design criteria similar to those used for construction of sanitary landfills to avoid the creation of environmental problems and to comply with existing regulations for the disposal of such materials. Thus, unless the quality of the dredged material improves over time, there will be a need for some type of secure, environmentally sound disposal system. A properly designed sanitary landfill could afford such a method of disposal.

Under this alternative there would be no need to segregate the material into reusable and unusable fractions during the dredging operation. Such segregation of materials would be required under Alternatives 3, 4, and 5.

Under Alternative 2, 50,000 cubic yards per year of dredged material would be disposed of at an existing landfill. This quantity would constitute approximately 6 percent of the annual load to the Franklin landfill, or approximately 3 percent of the annual load to the Germantown landfill. This alternative does not have a direct land requirement for dredged material disposal; however, the need for new or expanded commercial landfill sites would be accelerated. The use of the land would be impaired during the landfill operation, and, even following completion of the landfilling, the site could probably serve only open space uses. The storage site located in the harbor area could be restored to other uses following the period of use for storage and dewatering.

ALTERNATIVE 3: APPLICATION OF DREDGED MATERIAL AS A SOIL CONDITIONER

As discussed in the preceding chapter of this report, Alternative 3 provides for the use of the dredged material to amend marginal agricultural or silvicultural land where productivity can be improved through the use of soil-conditioning measures. For the purposes of this alternative assessment, it was assumed that the dredged material will contain pollutant levels low enough to permit safe use as a soil conditioner. This alternative consists of four main components: a material quality control system, a transportation system utilizing trucks, a storage area near the land where the material is to be used, and a land application system. It was estimated that 100 acres of agricultural or silvicultural land per year would be required for disposal of about 50,000 cubic yards of dredged material per year over a 15-year period. In addition, a storage site of about 20 acres in size would be needed near the land to be amended. The cost of disposal utilizing this method was estimated to be $9.60 per cubic yard.

The major advantage to the reuse of the dredged material to amend soil is the increased fertility and improved drainage it would provide.

The major disadvantage of Alternative 3 is that public concern, particularly relating to the potential for groundwater pollution, could present a problem in locating a suitable agricultural area for the disposal of the dredged material. Consequently, a sophisticated, material quality control system, including intensive sampling of bottom materials and a sophisticated segregation process, would need to be developed and utilized under this alternative. In addition, detailed, site selection criteria would need to be developed and applied in order to assure that use of the material as a soil amendment would not create any environmental problems.

Under Alternative 3, about 20 acres of land would need to be committed for storage and dewatering near the area to be amended, and about 100 acres of agricultural or silvicultural land per year requiring amendment would be needed. The potential buildup of certain chemical pollutants, including heavy metals, on lands amended with the dredged materials could preclude the future use of the amended soil for the production of some agricultural products.

ALTERNATIVE 4: USE OF THE DREDGED MATERIAL AS FILL

As discussed in the preceding chapter of this report, Alternative 4 consists of the use of dredged materials to replace or supplement conventional fill materials. The alternative assumes that the quality of the dredged material will render it suitable for such use. The alternative consists of three main components: a storage and partial dewatering system, a transportation system utilizing trucks, and a filling operation. It was estimated that 15,000 cubic yards of dredged material per year could be segregated for use as fill, and could be marketed as fill. The remaining 35,000 cubic yards would be only marginally suited for use as fill, and would not be readily marketable for this purpose. Thus, these 35,000 cubic yards would have to be provided at no cost. The net cost of disposal utilizing this method, and deducting the monies received for the marketable fraction, was estimated to be $4.20 per cubic yard.

A major advantage of this type of disposal is that the cost per cubic yard is lower than that of all the other alternatives. In addition, this alternative would substitute dredged material for conventional, more expensive sources of fill, while at the same time providing for a convenient and inexpensive means of disposal.

The major disadvantage of Alternative 4 is the need to do extensive sampling of bottom materials prior to dredging and to segregate the material during the dredging operation. Although no land would have to be committed specifically to disposal under this alternative, construction sites requiring fill would need to be found within about 20 road miles from the harbor. The sites would have to have subsoil and groundwater characteristics that would preclude the creation of any environmental problems from the use of the dredged material as fill.

ALTERNATIVE 5: DISPOSAL AND REUSE OF DREDGED MATERIAL BY MULTIPLE METHODS

As discussed in the preceding chapter of this report, it was concluded following review of the four alternatives originally considered that there was another viable and probably more practical alternative for reuse and disposal of dredged materials. This additional alternative would provide for the reuse and disposal of dredged material using a combination of methods, including placement of the material in a specially designed landfill, use of the material as a cover material at an existing commercial landfill, use of the material as a soil amendment, and use of the material as a fill material. This alternative consists of five main components: a storage and partial dewatering system, a transportation system utilizing trucks, a landfilling disposal system, a land application storage system, and the landfill, land application, and filling disposal systems. It was estimated that 25 percent of the material would need to be disposed of in a specially designed landfill because of high pollutant content; 25 percent could be utilized as cover material at existing commercial landfills; 25 percent could be used as a soil amendment on agricultural or silvicultural areas; and the remaining 25 percent could be used for fill material. The cost of disposal utilizing this method was estimated to be $7.70 per cubic yard.

The major advantage of this alternative is that it would provide a highly flexible as well as environmentally safe method of disposal for the wide variety of materials that may be encountered in dredging the Milwaukee Harbor. In addition, one or more of these disposal methods could be utilized at all times of the year when dredging occurs.

As previously discussed, the chemical analyses of samples from existing bottom sediments in the Milwaukee Harbor indicate that the sediments are moderately to heavily polluted and, consequently, a substantial fraction of the material may require specially designed disposal facilities to preclude environmental degradation. Conversely, material with moderate pollutant levels could be reused for one or more of the previously discussed disposal methods. Thus, unless the quality of the dredged material improves over time, there will be a need for some type of secure, environmentally sound disposal system. A properly designed landfill could afford such a method of disposal under this combination alternative.

The major disadvantage under this alternative is the need for comprehensive sampling of the bottom sediments prior to dredging, and subsequent segregation of the materials during dredging to ensure that the reusable and unusable fractions of the material are identified and separated for disposal. In addition, a sophisticated coordination system for dissemination of the dredged material would need to be developed to ensure the most cost-effective means for reuse and disposal.

Another disadvantage of Alternative 5 is the need to address the concern and opposition of public and elected officials in locating a specific landfill site for the dredged material and to find other areas where reuse of the material would be possible. This public concern, particularly relating to the potential for groundwater pollution, may need to be addressed through public education and the involvement of elected officials. In addition, significant engineering and legal efforts may be entailed in the acquisition and approval of a landfill site for dredged materials, particularly if the materials are heavily polluted.

Under Alternative 5, about three acres of land at the harbor area would be needed for storage and dewatering. In addition, about 20 acres of land would be needed for construction of the specially designed landfill, and 25 acres per year of suitable agricultural or silvicultural land in need of soil conditioning would be needed.

While the use of some of these areas would be impaired by the dredged material disposal, the areas would be able to be reused following cessation of dredging activities. The storage site located in the harbor area could also be restored to other uses following the period of use for storage and dewatering.

COMPARISON OF UPLAND DISPOSAL ALTERNATIVES TO OTHER METHODS OF DREDGED MATERIAL DISPOSAL

Throughout this report, the primary emphasis has been on the development of alternatives for upland disposal of dredged material from the Milwaukee Harbor. However, other methods for the disposal of dredged material have been utilized in the past, including placement in near-shore or coastal containment facilities built specifically for disposal of these materials, use of dredged material for shoreline protection, and open water disposal. Presently, the economic and environmental aspects of these alternatives are being further evaluated in studies being conducted by the University of Wisconsin Sea Grant Institute, the Wisconsin Department of Natural Resources, and the U. S. Army Corps of Engineers. The findings of one or more of these studies may lead the Harbor Commission to evaluate the feasibility of using upland disposal facilities with one or more of the aforementioned near-shore or open water disposal methods. The relatively low cost of less than $3.00 per cubic yard of these disposal techniques as compared with a range of between $4.20 and $9.60 per cubic yard for upland disposal methods--with a practical integrated mix of multiple methods of dredged material disposal estimated to cost $7.70 per cubic yard--and the established technical feasibility of these methods necessitate their consideration as methods of disposal. As of 1981, the cost of the dredging, transport, and disposal of material from the Milwaukee Harbor is estimated at $9.00 per cubic yard. The upland disposal alternatives presented in this report would increase the cost of dredging and disposal by about 50 percent to about $14.00 per cubic yard utilizing an integrated mix of upland disposal methods. However, the lowest cost alternative discussed in the report--that is, the beneficial use of dredged material in construction activity--may represent a technically feasible, cost-effective means of disposal of a significant amount of the dredged material.

CONCLUSIONS

The evaluation and comparison of five alternative methods for the upland disposal of approximately 50,000 cubic yards per year of dredged material from the Milwaukee Harbor indicated that the cost of such disposal may be expected to range from $4.20 for Alternative 4 to $9.60 for Alternative 3. In addition, the evaluation indicated that the inherent heterogeneity in the physical and chemical composition of the bottom sediments to be dredged may require use of a combination of upland disposal techniques, rather than the adoption of one technique. The use of several dredged material disposal methods will require varying amounts of time and effort to overcome or minimize the disadvantages attendant to each of the alternatives presented in Table 11.

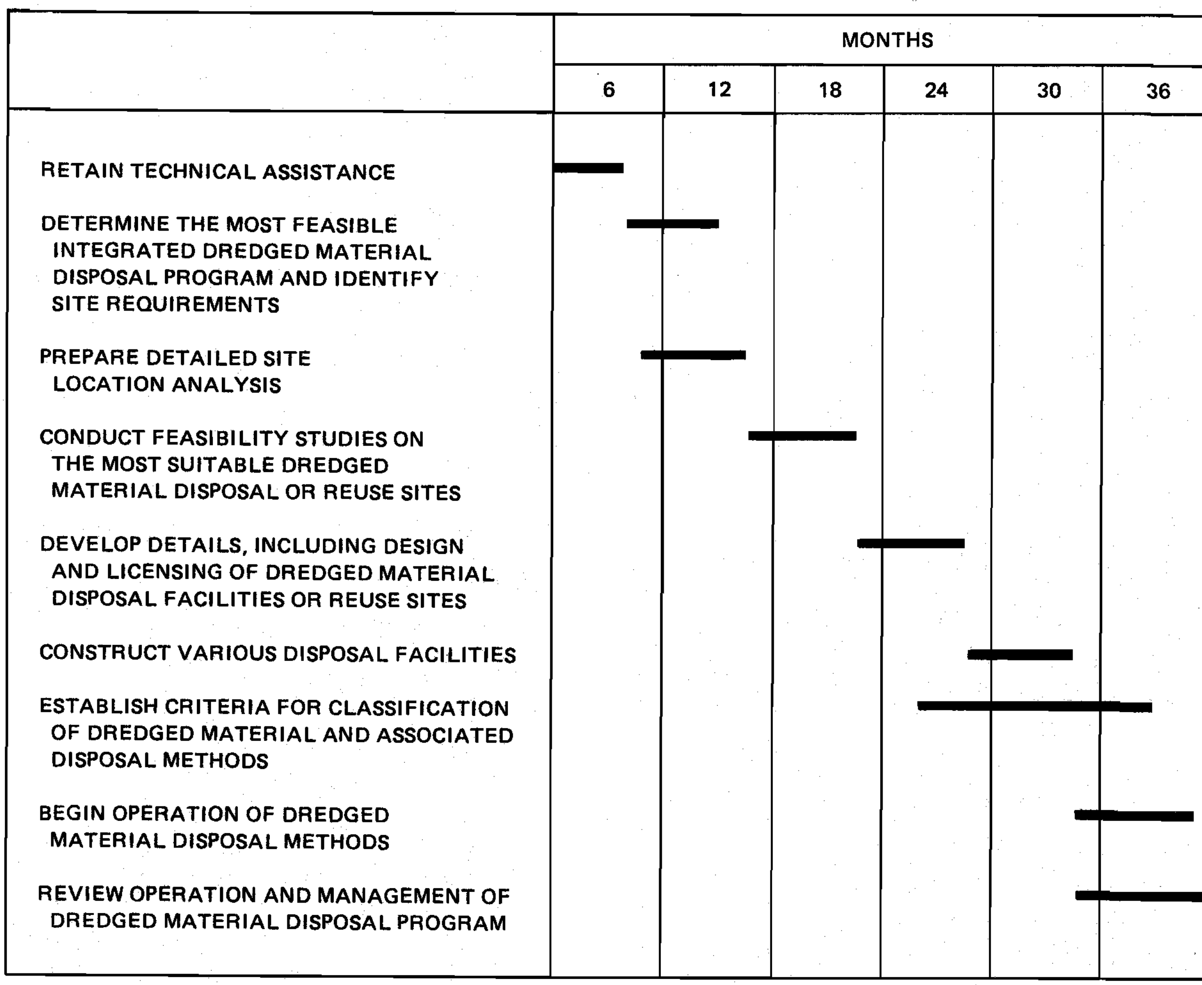
As mentioned above, the foregoing comparisons of the alternatives seem to indicate that a combination of alternative dredged material disposal methods should be considered. The various work efforts associated with the establishment and operation of an integrated dredged material disposal program would be initiated by completion of a first order feasibility study, which this report represents. The implementation of an integrated dredged material disposal program, similar to the one described under Alternative 5, would then require substantial efforts, including, but not limited to, the completion of further site-specific studies to select areas suitable for the construction of a new landfill, and the location of existing commercial landfills with the capacity and willingness to accept some dredged material, of construction sites requiring additional fill, and of agricultural and silvicultural lands suitable for treatment with dredged material.

The implementation steps and time periods required to initiate a dredged material disposal program described in Alternative 5 are presented in Figure 4. Adoption of a variation in the methods or relative amounts of material disposed of by each method set forth in Alternative 5 would likely require a similar set of steps for implementation.

In addition to conducting detailed, site-specific evaluations to determine the feasibility of using the upland dredged material disposal techniques discussed herein, it would be desirable for the Harbor Commission to further evaluate the potential for incorporation of near-shore or open water disposal methods into their future maintenance dredging programs. As previously discussed, the environmental impacts of near-shore and open water disposal methods are presently being evaluated by other agencies concerned with the disposal of dredged material. Completion of these studies and publication of the results may prompt the Harbor Commission to include one or more of these additional disposal methods in their dredged material disposal plans.

Figure 4

SUMMARY IMPLEMENTATION SCHEDULE FOR ADOPTION OF AN INTEGRATED UPLAND DREDGED MATERIAL DISPOSAL SYSTEM



Source: SEWRPC.

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Chapter VII

SUMMARY

The objective of this study, undertaken at the request of the Port of Milwaukee, was to evaluate alternative upland disposal techniques for the disposition of dredged materials from the Milwaukee Harbor area. Disposal of dredged materials in upland sites provides an alternative to the historically more prevalent methods of disposing of such materials in the open waters of Lake Michigan and in near-shore containment structures.

Maintenance dredging activities in the Milwaukee Harbor are shared by the U. S. Army Corps of Engineers--which has responsibility for the maintenance of federal project waters--and the Port of Milwaukee--which has responsibility for the maintenance of all municipal mooring slips and docking facilities. The standard depth to which Milwaukee Harbor facilities are to be maintained is 27 feet below International Great Lakes Datum (IGLD) in order to accommodate the draft of fully loaded lake- and sea-going commercial vessels.

In 1970, the Wisconsin Department of Natural Resources banned the disposal of dredged materials in the open waters of Lake Michigan because of the potential damage to the aquatic environment as a result of pollutants in the bottom sediments. With this prohibition on open water disposal, the U. S. Army Corps of Engineers constructed a confined disposal facility at the southern end of the Milwaukee Harbor which was intended to provide an interim solution to the problem of disposing of polluted dredged materials. This facility, which was completed during 1975, was designed to have a useful life of about 10 years in the anticipation that in that period of time, a long-term solution to the sediment disposal problem would be found.

Since the present confined disposal facility will serve for only a limited period of time, alternative solutions to the problem of how to dispose of dredged materials from the Milwaukee Harbor area must be identified. The upland disposal of dredged materials offers one such potential solution. This report has described and evaluated alternative methods for the upland disposal of dredged materials, and has set forth a recommended plan for upland disposal.

ALTERNATIVES CONSIDERED

There are four potentially feasible alternatives for the upland disposal of dredged materials from the Milwaukee Harbor:

1. Disposal in a new landfill or lagoon specifically designed and used for dredged materials.

2. Disposal in an existing or new general refuse sanitary landfill jointly with other wastes.

3. Surface application on agricultural land as a soil conditioner.

4. Use as a fill material for highway, railway, airport, industrial, and commercial construction, and for the development of recreational areas.

These four alternative upland disposal techniques were evaluated in terms of the costs entailed and in terms of the advantages and disadvantages attendant to each method.

New Landfill or Lagoon Site Alternative

The feasibility of siting a new landfill or lagoon for the exclusive disposal of dredged materials was evaluated under the assumptions that the total amount of material to be deposited would be 750,000 cubic yards, equivalent to 50,000 cubic yards per year over the 15-year period 1986 to 2000; that the average depth of the fill would be 30 feet exclusive of the final cover; and that the ratio of dredged material to other covering soils or material would be five to one. Under these assumptions, a site of approximately 60 acres would be needed to meet the expected demand for the disposal of dredged materials, including buffer areas. Of this 60 acres, about 25 acres would be used for the disposal operation proper.

The criteria applicable to this alternative disposal method included geology--specifically, depth to bedrock and bedrock type; groundwater impacts, such as depth to groundwater and well locations; surface water impacts; existing land use; 100-year recurrence interval floodlands; areas identified in the regional sludge management plan as sites for the application of sewage sludge; and impacts on environmentally significant areas. Of the total area of the Region, about 779 square miles, or 29 percent, was found to be included within areas designated as having potential for the location of a new landfill site as defined by the associated criteria. In view of the relatively large amount of land included in the areas designated as having potential for the location of a landfill or lagoon facility, as compared with the relatively small site needed, this alternative was deemed feasible for further consideration in more specific analyses.

Existing Landfill Site Alternative

The potential uses of dredged materials in existing landfills include use as a cover material, use in the construction of gas barriers and vents, use in the construction of impervious linings, use as leachate collection conduit linings, and use as leachate collection underdrains. Another possibility is the placement of dredged materials in an existing landfill along with other solid wastes without consideration of its beneficial uses. The criteria used to evaluate the suitability of existing landfills for the disposal of dredged materials were the same as those used for the special-purpose landfills.

There are two large commercial landfills located within or adjacent to Milwaukee County: the Metro Disposal Service in the City of Franklin, Milwaukee County, and the Waste Management landfill in the Village of Germantown, Washington County. The disposal of dredged materials at one or both of these sites, or at other similar landfill sites, was deemed feasible for further consideration in more specific analyses.

Land Application Site Alternative

Dredged materials from the Milwaukee Harbor may be used to amend marginal agricultural and silvicultural land where productivity can be improved through the use of soil-conditioning measures. The addition of dredged materials to these areas may alter the characteristics of the soil in such a way that water and nutrients become more readily available for plant growth, and, in some cases, soil drainage characteristics may be improved.

For analysis purposes, it was assumed that four inches of dredged material would be applied and blended with the top 12 inches of the existing agricultural soils. This would require the use of about 1,500 acres, or less than 0.2 percent of the total agricultural land in the Region, if all of the 750,000 cubic yards of dredged materials were applied to agricultural land over the 15-year design period, or about 100 acres per year. The criteria applicable to this alternative disposal method included geology--specifically, depth to bedrock and bedrock type; groundwater impacts, such as depth to groundwater and well locations; surface water impacts; existing land use; 100-year recurrence interval floodlands; areas identified in the regional sludge management plan as sites for the application of sewage sludge; and impacts on environmentally significant areas. Of the total area of the Region, about 813 square miles, or 30 percent, was found to be included within areas designated as having potential for the location of a new landfill site as defined by the associated criteria. In view of the relatively large amount of land included in the areas designated as having potential for the location of a landfill or lagoon facility, as compared with the relatively small site needed, this alternative was deemed feasible for further consideration in more specific analyses. Since the amount of agricultural land in the Region is relatively large, and the amount of dredged material to be spread is relatively small, this alternative was deemed feasible for further consideration in more specific analyses.

Fill Material Use Alternative

Dredged materials have successfully been used as fill material for general construction activities, the enhancement of park and recreational areas, and wildlife habitat development. The composition and structural characteristics of the dredged material determine to a large extent its potential use as a fill material. In order for the use of the dredged material to be economically feasible, the usable fraction, or the chiefly sand and gravel portion of the dredged material, must, at least for many applications, be separated from the unusable fraction, such as the organic compounds. The selection of potential areas in southeastern Wisconsin for the productive use of dredged materials is dependent on the need for supplemental fill material. This need can only be determined on a project-by-project basis.

EVALUATION OF ALTERNATIVES

Each of the four alternatives considered was evaluated for its practicality of implementation in southeastern Wisconsin. In addition, a fifth alternative, which envisions the combined use of several alternative methods of reuse and disposal of the dredged materials, was evaluated. The evaluation of the alternatives was based upon the following assumptions--developed on the basis of the inventory findings--about the characteristics of the dredged materials:

- Solids content--variable from 15 to 75 percent by weight, with an average of 40 percent.

- Texture--variable, with an average textural composition of 25 percent sand, 65 percent silt, and 10 percent clay, on a dry weight basis.

- Total nitrogen content--0.2 percent by weight.
- Total phosphorus content--0.3 percent by weight.
- Concentration of other pollutants--variable as previously noted.

Special-Purpose Landfill or Lagoon Disposal

The alternative calling for the disposal of dredged material in a landfill consists of three principal components: 1) a storage and partial dewatering system, 2) a transportation system utilizing trucks, and 3) a landfill specifically designed for dredged material disposal. A storage and dewatering system would be required on the assumption that a substantial portion of the dredged materials will have a water content high enough to warrant partial dewatering prior to hauling. Such a dewatering system could be located at the existing diked disposal area at the south end of the harbor, and would require about five acres of storage area of the 44-acre site.

Following storage and dewatering for about 30 days, the material would be loaded on open dump trucks of about 30-cubic-yard capacity and transported to the disposal area, assumed to be within a 30-mile radius of the storage and dewatering area. Transportation requirements include the purchase, operation, and maintenance of four, 30-cubic-yard dump trucks, each truck making three round trips per day in a five-day-per-week, one-shift-per-day, operation during the six-month period of dredging.

The landfill site would encompass a total site area of about 60 acres, including a 300-foot buffer strip around the perimeter of the landfill itself. The plan of operation would be to construct modules, each having a capacity for one year's dredged materials. The landfill itself would be constructed with a clay liner using suitable materials located on the site. Site restoration would be so planned as to support and enhance adjoining land uses.

The estimated capital cost of this alternative is $3,952,000, with an annual average operating and maintenance cost of $202,600. The total cost of construction and operation of this alternative is estimated at $9.30 per cubic yard of material dredged. All costs are expressed in constant 1981 dollars.

The disposal of dredged materials in a specially designed lagoon is similar to disposal in a landfill with the exception that storage and dewatering facilities are not required. Thus, this alternative would consist of three principal components: 1) a transportation system utilizing trucks, 2) a lagoon specifically designed for dredged material disposal and for supernatant withdrawal, and 3) provisions for the wastewater treatment of the supernatant.

Under this alternative, a 60-acre site located in an area having soil suitable for the construction of a clay-lined lagoon would be developed with 15 lagoon cells, each having sufficient capacity to receive the material dredged during a one-year period. The surface of each lagoon cell would subside as evaporative dewatering occurs. The lagoon would be filled to final grade, covered, and planted with suitable vegetation for site restoration and reuse.

The estimated capital cost of the development of a lagoon disposal site is $3,473,000, with an average annual operating and maintenance cost of $240,000. The total cost of construction and operation of this alternative is estimated at $9.40 per cubic yard of material dredged.

Disposal in Existing Landfills

This alternative calls for the transport of dredged materials to an existing, suitably licensed, sanitary landfill for disposal along with other solid wastes. It is assumed under this alternative that 50 percent of the dredged material could be used benefically in the landfill, while the other 50 percent would be landfilled along with other solid wastes. This alternative consists of three principal components: 1) a storage and partial dewatering system, 2) a transportation system, and 3) a landfilling system at existing solid waste landfills. The storage and dewatering system and the transportation system envisioned under this alternative would be the same, and have the same cost, as the comparable systems previously described for special-purpose landfills.

Under this alternative, it is envisioned that 50 percent of the dredged material would be used at the existing landfill for daily cover, in the construction of gas vents, or as backfill in the construction of leachate collection underdrains. It is further assumed that this material would be accepted at the landfill at no cost.

The estimated capital cost of this alternative is $454,000, with an annual average operating and maintenance cost of $646,000. The total annual cost of construction and operation of this alternative is estimated at $7.80 per cubic yard of material dredged.

Disposal on Agricultural Lands

Under this alternative, the dredged materials would be used to amend soils on agricultural lands where productivity can be improved by the use of soil conditioners. This alternative consists of four principal components: 1) a material quality control system, 2) a transportation system utilizing trucks, 3) a storage area near the agricultural land where the material is to be applied, and 4) a land application system.

The dredged material quality control system would include extensive in-place sampling of the materials to establish pollutant content; sampling and analysis of the materials in the storage facility; agricultural land soil sampling; a procedure to determine desirable amounts of materials to be applied; and a procedure for inventory control to assure timely delivery of the proper amounts of the specific materials to the proper land areas. Six, 30-cubic-yard trucks would be required to transport the dredged materials to the storage area, each making about three round trips per day on a five-day-per-week, one-shift-per-day, operation during the six-month period of dredging.

The dredged material would be stored at a site having an area of about 20 acres and designed for the secure storage of the dredged materials, including provisions for the prevention of runoff. The storage area would also include a system to segregate dredged material according to type and quality. Assuming an average of four inches of dredged material to be placed on and disced into the in-place soils, about 100 acres of agricultural lands would be needed for application of dredged materials each year.

The estimated capital cost of this alternative is $771,000, with an average annual operating and maintenance cost of $429,000. The total cost of construction and operation of this alternative is estimated at $9.60 per cubic yard of material dredged.

Disposal as a Fill Material

This alternative envisions the use of dredged materials as fill in construction projects, assuming that the quality and characteristics of the dredged materials are acceptable for such purposes. Under this alternative, it is assumed that about 30 percent of the dredged material will be well suited for fill uses, and that such material will have a value of $0.50 per cubic yard. The remaining 70 percent of the material is assumed to have limited application as a fill material and therefore to have no monetary value.

This alternative has three principal components: 1) a storage, partial dewatering, and material segregation system, 2) a transportation system utilizing trucks, and 3) a filling operation. After partial dewatering and material segregation in the storage area, the beneficial dredged materials would be transported to the filling operation using three, 30-cubic-yard trucks.

The estimated capital cost of this alterative is $378,000, with an average annual operating and maintenance cost of $186,000. The total cost of construction and operation of this alternative is estimated at $4.20 per cubic yard of material dredged.

Disposal by Multiple Methods

This alternative assumes that the disposal or reuse of dredged materials will involve the use of a combination of several different methods depending on the means best suited for the various components of the dredged material. This alternative would involve the following methods of reuse or disposal:

- About 25 percent of the volume of dredged materials remaining after partial dewatering would be disposed of in a landfill designed specifically for polluted dredged materials.

- About 25 percent of the dredged materials would be used as a daily cover material in a sanitary landfill designed principally to receive other solid wastes.

- About 25 percent of the dredged material would be spread on agricultural lands as a soil conditioner.

- About 25 percent of the dredged material would be used as fill material for construction projects.

This alternative consists of five principal components: 1) a storage, dewatering, and stockpiling system, 2) a transportation system utilizing trucks, 3) a landfilling system, 4) a land application storage system, and 5) the productive landfill, land application, and filling end uses.

The estimated capital cost of this alternative is $1,311,000, with an average annual operating and maintenance cost of $298,000. The cost of construction and operation of this alternative is estimated at $7.70 per cubic yard of material dredged.

CONCLUSIONS

The evaluation and comparison of the alternative methods for the upland disposal of approximately 50,000 cubic yards per year of dredged material from the Milwaukee Harbor indicated that the cost for such disposal may be expected to range from $4.20 per cubic yard for using the material as fill to more than $9.00 per cubic yard for the landfill, lagooning, or land application alternatives. Moreover, this evaluation indicated that, because of the wide variation in the physical and chemical composition of the bottom sediments, the use of a combination of upland disposal methods may be necessary, rather than the adoption of a single disposal method.

It should be noted that, whereas this study has focused on the development of alternative upland disposal methods for dredged material from the Milwaukee Harbor, other methods for the disposal of such materials have been utilized in the past, including the placement of dredged materials in near-shore or coastal containment facilities, the use of dredged materials for shoreline protection, and open water disposal of dredged materials. The economic and environmental aspects of these additional disposal methods are being further evaluated by other federal, state, and local agencies. The findings of one or more of these studies may prompt the Harbor Commission to evaluate the feasibility of combining the future use of upland disposal facilities with one or more of the aforementioned near-shore or open water disposal methods.

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APPENDICES

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Appendix A

UNIT COSTS UTILIZED IN THE DEVELOPMENT OF ESTIMATES FOR DISPOSAL ALTERNATIVES AND ECONOMIC ANALYSES[a]

Item	Cost
Site Acquisition and Preparation	
Land	$5,000 per acre
Clearing and Grubbing	$1,200 per acre
Topsoil Excavation	$0.90 per cubic yard
Excavation, Placement, and Grading	$1.70 per cubic yard
Liner Compaction	$1.00 per square yard
Leachate Collection Pipes	$7.00 per lineal foot
Leachate Storage Tank	$10,000 per tank
Fencing for Site Protection	$2.00 per foot
Roadway Costs	$10.00 per foot
Seeding and Finish Work	$1,500 per acre
Replace Topsoil	$1.50 per cubic yard
Equipment	
Scraper	$200,000
Dozer	$100,000
Crane	$100,000
Truck (30 yard)	$76,000
Equipment Operation and Maintenance	
One Equipment Operator (includes benefits)	$30,000
Equipment Maintenance	
Scraper	$4,000 per year
Dozer	$4,700 per year
Crane	$5,000 per year
Truck	$4,300 per year
Fuel	$1.10 per gallon
Insurance	
Scraper	$1,200 per year
Dozer	$2,100 per year
Crane	$4,000 per year
Truck	$1,200 per year

[a]Engineering News Record Cost Index 3300, June 1980.

Source: SEWRPC.