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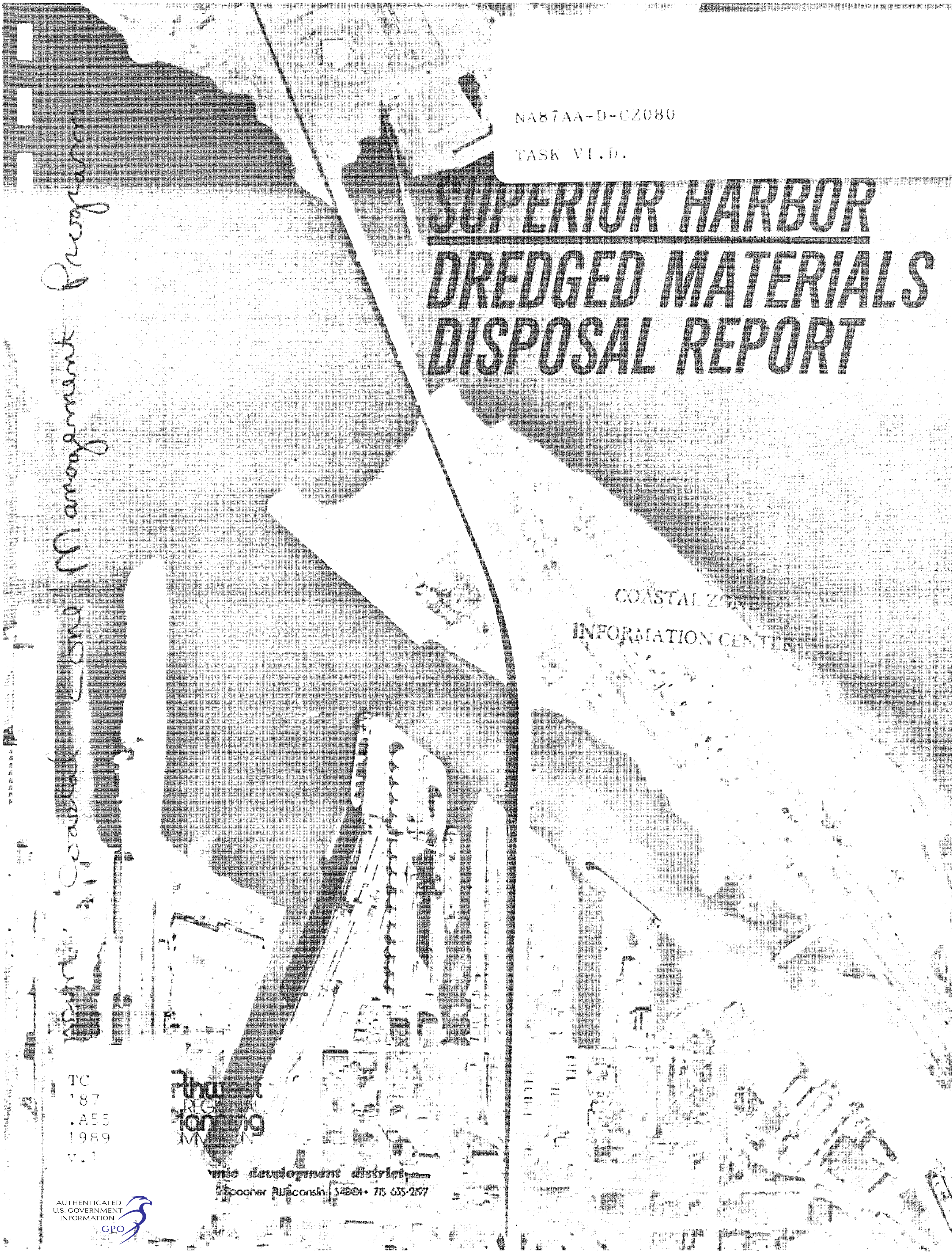
TASK VI.D.

SUPERIOR HARBOR DREDGED MATERIALS DISPOSAL REPORT



Coastal Zone Management Program

SUPERIOR HARBOR DREDGING STUDY

NOVEMBER, 1989

PREPARED BY THE NORTHWEST REGIONAL PLANNING COMMISSION

FINANCIAL ASSISTANCE PROVIDED BY: STATE OF WISCONSIN, BUREAU OF COASTAL MANAGEMENT, DEPARTMENT OF ADMINISTRATION, AND THE COASTAL ZONE MANAGEMENT IMPROVEMENT ACT OF 1980, AS AMENDED, ADMINISTERED BY THE OFFICE OF COASTAL ZONE MANAGEMENT, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION. LOCAL SHARE WAS CONTRIBUTED BY: THE NORTHWEST REGIONAL PLANNING COMMISSION; THE CITY OF SUPERIOR; AND, THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES.

SUPERIOR HARBOR DREDGING STUDY

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I. INTRODUCTION

I. INTRODUCTION

A. HISTORICAL PERSPECTIVE

The original harbor project for Superior, Wisconsin was authorized in 1867 and for Duluth, Minnesota in 1871. The ports were combined in 1896 and have been expanded and modified by more than ten River and Harbor Acts. Maintenance of the Federal Project areas have been the responsibility of the U.S. Army Corps of Engineers (USCOE) while private portions of the harbor are maintained by their owners. Maintenance of the harbor is generally confined to three types of work: 1. Maintenance and expansion of the navigation channels including dredging and the disposal of dredge materials; 2. Maintenance of aids to navigation; and, 3. maintenance and expansion of shoreland infrastructure related to recreation and commodity movement.

During the 1970's the State of Wisconsin expressed serious concerns about contamination of dredge materials and the deposition of pollutants in the Great Lakes. The State recognized that small amounts of pollutant materials could have harmful effects on the human health. In 1975 the State, in keeping with its commitment to a high quality environment, requested that all open water dumping of dredged material in the adjacent waters of the state be stopped. Based on this request and others, in-water disposal was stopped in Wisconsin Great Lakes waters.

In the early 1980's the Governor requested that the Wisconsin Coastal Management Council define dredging needs and problems of

Great Lakes harbors and to report on the impact of federal dredging policies upon the economic status of those harbors.

Since the Wisconsin Department of Natural Resources prohibition of in-water disposal, the Erie Pier Contained Disposal Facility has been receiving approximately 130,000 cubic yards of dredged materials per year from public maintenance dredge activities in the combined harbor. Since the site has only four to five years of capacity remaining, new sites must be identified that may meet the requirements of current and proposed state and federal dredge and disposal regulations. In addition, the disposal needs of private slip owners must also be recognized.

B. INTENT

While many valid research reports have already been completed on the combined harbor during the late 1970' and early 1980's, no recent attempt has been made to fill the gaps in the existing information. Nor are those existing reports responsive to the current or proposed level of permit regulations in Wisconsin.

Where possible, this report will: address various data gaps for three sites in Wisconsin that are considered to have high potential as disposal areas; identify issues or other constraints outside the conceptual or financial scope of this report for further study; where possible, provide a comparison of the potential sites and costs related to development; and, offer a legislative framework to aid in the formulation of revisions to Wis. N.R. 347 and 500 series which will, in some form, provide the regulatory basis for disposal of "clean" and "polluted" dredged materials.

II. EXISTING CONDITIONS

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A. GEOGRAPHIC SETTING

Duluth-Superior Harbor is located within the two cities and occupies roughly 32 square miles with over 100 miles of waterfront. The harbor is protected by a natural sand and gravel bar six miles in length that was formed by the deposits of the St. Louis and Nemadji Rivers as they outlet to Lake Superior. This protecting spit is penetrated by the Duluth Ship Canal and Superior Entry. The bar is known as Minnesota Point north of the Superior Entry and Wisconsin Point south of the entry. Two inner spits, Rice's and Connor's Points, divide the twin ports into inner and outer harbors. The outer harbor is comprised by Superior and Allouez Bays while the inner harbor is developed within St. Louis Bay and upstream on the St. Louis River.

The harbor is located in the estuary of the St. Louis River which originally covered an estimated 11,500 acres. Development of the harbor has resulted in dredging of approximately 4,000 acres and filling of an additional 3300 acres. (See maps in pocket.)

B. TRANSPORTATION SYSTEMS

Water

The water transportation system is contained wholly within the harbor boundaries. The system consists of channels, aids to navigation, and navigational structures. The primary water channels are owned and maintained by the public to be utilized for any appropriate transportation use in the same manner as the public highways. They are, however, perceived by the public as necessary extensions of the water commerce industry. This is reinforced by the almost total lack of water borne passenger service. Nearly all trips on the system consist of an origin or destination outside the harbor for the movement of commercial goods.

Following is a brief description of the major public and private channels:

Superior Entry - The Superior entrance to the harbor between Wisconsin and Minnesota Points is protected by two rubble mound breakwaters which form a stilling basin.

Alloues Bay Channel - The channel aids in accessing two docks.

Superior Harbor Basin - Provides an anchorage and maneuvering area. It serves the Burlington Northern ore dock areas and the mouth of the Nemadji River.

Superior Front Channel - Serves Superior's eastern waterfront.

Duluth Ship Canal - The Duluth entrance to the harbor dug in 1871; crossed by the Aerial Lift Bridge.

Duluth Harbor Basin - Provides and anchorage and maneuvering area. Serves Duluth's Railroad Street and eastern Rice's Point.

East Gate & West Gate Basins - These lie on opposite sides of the gateway between the outer and inner harbors. The John Blatnik (High) Bridge arcs overhead.

St. Louis Bay North Channel - Serves the Duluth waterfront from Rice's Point to Erie Pier.

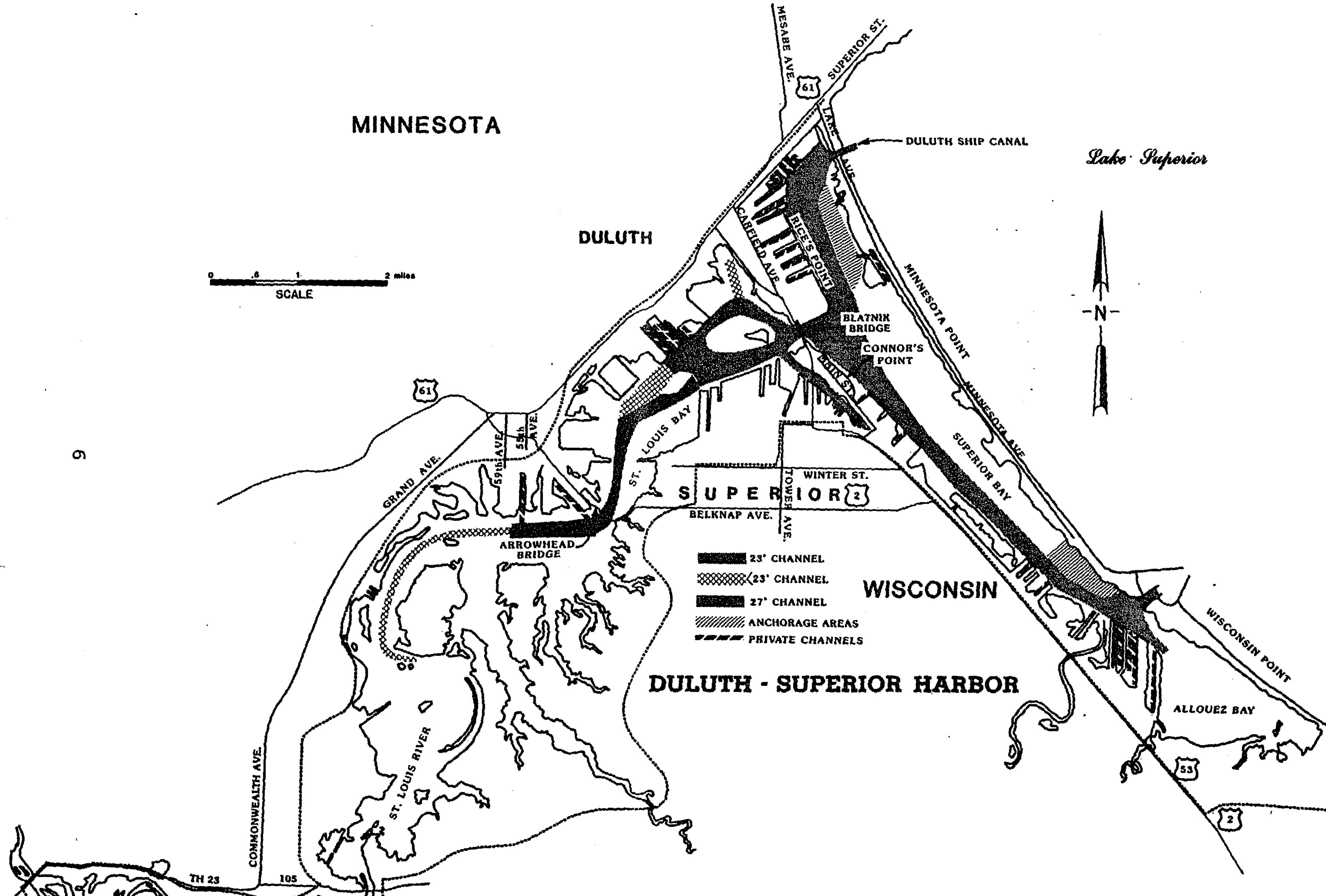
Twenty-First Avenue West Channel - Serves the 21st Ave. West slip, but is not currently maintained to project depth.

St. Louis Bay South Channel - Serves the Superior waterfront.

Cross Channel - Facilitates shipments from the DM & IR docks and provides maneuvering room.

Howards Bay - Serves both sides of Howards Bay and the Fraser Shipyards.

Upper Channel - Provides connecting a connecting link with the North and South Channels and the Minnesota Channel.


MINNESOTA
DULUTH
Lake Superior
MESABE AVE.
SUPERIOR ST.
61
LAKE AVE.
DULUTH SHIP CANAL
CANFIELD AVE.
RICE'S POINT
BLATNIK BRIDGE
CONNOR'S POINT
MINNESOTA POINT
MINNESOTA AVE.
SUPERIOR BAY
MAIN ST.
N
0 .5 1 2 miles
SCALE
GRAND AVE.
59th AVE.
55th AVE.
ST. LOUIS BAY
SUPERIOR
WINTER ST.
TOWER AVE.
BELKNAP AVE.
2
ARROWHEAD BRIDGE
23' CHANNEL
23' CHANNEL
27' CHANNEL
ANCHORAGE AREAS
PRIVATE CHANNELS
WISCONSIN
WISCONSIN POINT
ALLOUEZ BAY
DULUTH - SUPERIOR HARBOR
53
COMMONWEALTH AVE.
ST. LOUIS RIVER
TH 23
105

Minnesota Channel - Provides access to docks in West Duluth.

St. Louis River Natural Channel - Non-maintained portion of the river upstream to Fond du Lac.

Except for the St. Louis River channel, these channels and structures are publicly maintained. Branching off these primary channels are many privately maintained channels serving harbor users.

Most of the harbor is maintained at a 27 foot project depth. Current proposed modifications of the Cross Channel, Upper Channel and Minnesota Channel to greater depth and width will enable vessels to carry larger cargos at enhanced maneuvering speeds; both of which represent savings in vessel operating costs and enhanced economic benefit to the region.

Ground

The ground transportation network serving the harbor is a diverse system of railroads, highways and airports influenced by the configuration of the waterfront.

Major railroads serve the area to handle the bulk of traffic to the region. Major cargos are: grain, coal, iron ore, general freight and bulk commodities. Within the harbor area, access to rail service is generally good with most existing or potential industrial sites having ready access. The area also has railroad classification yards to facilitate cargo routing. Street and highway networks are generally good although some bottlenecks occur during the summer tourism season and the grain harvesting/shipping season which are usually local in nature and effect.

C. TOPOGRAPHY AND GEOLOGY

1. General

The appearance of the present landscape is due largely to the effects of Wisconsin glaciation and to postglacial events during which several ice sheets advanced and retreated over the area, filling valleys, gouging out lakes and forming ridges and hills. The present shoreline of Lake Superior was shaped largely during the Great Ice Age.

The north shore of Lake Superior is underlain by Keweenawan lava flows that form the Laurentian Upland, rising 500 to 1,000 feet above the lake. These flows occupy an area along the shore that extends inland for 10-20 miles. This area is bordered on the north by the Duluth Gabbro which extends from Duluth to Grand Marais.

A number of short streams drain the Superior upland; most of which cascade in falls and rapids almost directly to the lake, resulting in a scarcity of good harbors along the north shore. This is due to a north-to-south tilting of the Lake Superior basin, which is also responsible for creating "natural" harbors along the south shore of the lake as a result of the drowning of river mouths. Duluth-Superior Harbor occupies the drowned river mouth of the St. Louis River.

The City of Duluth stands at the head of Lake Superior, where a series of rock formations converge. An escarpment rises sharply above the harbor on the Duluth side and is composed of the Duluth Gabbro.

In contrast to the rocky bluffs above Duluth, which are typical of most of the north shore, low plains of lacustrine red clay dominates the shoreline around the City of Superior and extend several miles inland. These contain the watersheds of the Nemadji and Pokegama Rivers, and a number of smaller streams tributary to the harbor. Bedrock formations in this area are buried beneath a heavy mantle of glacial lake sediments.

2. St. Louis River Sub-Basin

The St. Louis River has a drainage area of 3,647 square miles. The river is used extensively for hydroelectric power generation, iron ore processing, and pulp and paper manufacturing. Average annual runoff for the area is about 9 inches with a surface water storage capacity of approximately 340,000 acre-feet.

The sub-basin can be divided in two distinct portions. Upstream from Cloquet, the river water is generally of high quality. Flow variations are seasonal and vary greatly. Low flow along the upper segments may pose problems because of the many municipalities and extensive industrial use. Below Cloquet, the river flows through the scenic gorge of Jay Cooke Park before entering St. Louis Bay. Prior to the on-line operation of the Western Lake Superior Sanitary District the lower portion of the river was in poor condition due to the stream's ability to handle waste discharges. However, recently the river has steadily been improving in water quality.

While the river flows through erodible red clay soils, much of the sediment generated is trapped by the numerous hydroelectric facilities present. Below Fond du Lac however the riverbanks are subject to catastrophic erosion during periods of unstable flow.

Streams of the upland clay soil areas in the sub-basin have sediment yields estimated by the U.S.G.S as high as 500 tons per square mile per year. In the past however, only suspended sediment has been monitored. Transport studies to identify suspended and bed load contributions generally have not been undertaken. Usage of the USGS estimated sediment yield is inappropriate for estimation of dredging quantities since it does not take into account the high rate of catastrophic stream bank erosion common to the region.

For the purposes of this report, a more reliable method of estimating future dredge quantities is to examine historical dredging activities and make assumptions about the reliability of the data. It is recognized that this approach does not address sediment entering the harbor area and being deposited outside the arbitrary dredge project limits.

3. Nemadji River Sub-basin

The Nemadji River sub-basin comprises 460 square miles in Minnesota and Wisconsin. Clayey soils make up 40% of the area. Land use consists mainly of forest lands (90%) with the balance in agriculture and urban use.

The sub-basin is essentially a level plain into which the rivers and streams have become deeply incised and meandered. The depth of the incision and meandering has caused instability of most of the length of the river's main stem and primary tributaries located in the clay zone.

In 1975, a streambank erosion inventory was conducted on the main stem and the two primary branches of the Nemadji which identified 154 major sites of channel erosion or massive bank losses over the 60 mile channel length not including the many smaller tributaries.

A major man-made source of sediment in the clay zone is roadside erosion which in most cases is caused by inappropriate maintenance and construction activities. In 1975, an inventory of all sub-basin roadside erosion sites was conducted. The result indicated a need for treatment of nearly thirty acres of roadside ditches and berms and the need for nearly twenty flow and sediment control structures.

As in the case of the St. Louis sub-basin, no major transport studies have been conducted to determine the actual contributions of the Nemadji system to the Duluth-Superior Harbor.

Again as in the case of the St. Louis sub-basin, historical dredging quantities will be used for the estimation of future dredging needs.

D. CLIMATE

The climate in the harbor area is greatly influenced by a succession of high and low pressure systems that continually cross from west to east. Lake Superior, the largest and coldest of the Great Lakes, also influences the weather especially in the spring and summer. Often the effects of the winds and the lake cause sharp temperature differences even within several miles of the lake.

Winds are primarily easterly in the summer and generally from the northwest in the other months. The average annual temperature is 39 F with January the coldest month and July the warmest month. Temperatures along the lakeshore may vary greatly during any one day. Over the period of record, temperatures have ranged from a low of -41 F to a high of 106 F.

E. FLORA AND FAUNA

This section is summarized from a number of reports and environmental impact statements prepared for a variety of projects within the harbor area.

1. Habitat

Fifteen major habitat types have been identified in or adjacent to the harbor. They are described briefly as follows:

Open Water

Mudflats. Unvegetated or sparsely vegetated areas characterized by silty, muddy substrates. The size of the area is dependant on fluctuations of water levels.

Emergent Aquatic. Nonpersistent hydrophytic vegetation that grows above the water surface. Plants fall to the surface of the substrate at the end of the growing season.

Cattail-Sedge Marsh. A wetland dominated by the two plants which remain standing until the beginning of the next growing season.

Woody Marsh. A wetland dominated by woody vegetation types: broad-leaved deciduous, needle-leaved deciduous, broad leaved evergreen, and needle-leaved evergreen species.

Sandy Beach. Unvegetated or slightly vegetated areas consisting of sloping land forms generated by waves and current which are composed predominately of unconsolidated sand, gravel, or cobbles usually continuous with the shore.

Tree Sapling. Consisting of young trees, usually birch or aspen.

Grass Meadow. Land covered with grasses and other narrow leaved plants.

Weedy Field. Land predominately covered with broad-leaved herbaceous plants.

Shrub. Land covered with low, woody vegetation generally between 1 and 3 meters high.

Hardwood-Deciduous Forest. Land covered by at least 10% tree crown coverage and dominated by aspen, birch, maple and other broad-leaved deciduous trees.

Mixed Deciduous-Coniferous Forest. Land covered by at least 10% tree crown coverage on which both coniferous and deciduous trees occur and neither predominates.

Coniferous Forest. Land covered by at least 10% tree crown coverage and dominantly forested with needle leaf species.

Residential. Land used for dwelling units.

Industrial. Land that has been developed for commercial or industrial uses.

Of these habitat types in the area, those that are more important as fish and wildlife habitat are the emergent aquatic vegetation, cattail-sedge marshes, grassy-weedy areas, upland forest, sand areas and open water areas.

Open water areas, which comprise the largest habitat type within the harbor, consist primarily of dredged shipping channels greater than 20 feet deep and shallow water areas from 0-6 feet deep. The majority of the latter areas do not have established beds of aquatic vegetation because of wave action or lack of suitable substrate.

In the reports used for this section no endangered or threatened taxa were noted.

2. Birds

The location of the harbor makes it an excellent location for nesting and a stopping place for a large bird population. This is because Lake Superior is the end of a continuous pathway from the Atlantic Ocean for the movement of ocean species; migrating birds from the north and south avoid crossing large bodies of water and are directed around Lake Superior past the harbor; and, the presence of many unique habitats. Over 236 species have been identified in the area. Excluding colonial bird nesting areas, the most heavily used areas include the Allouez Bay-Wisconsin Point area, Hearding Island, Grassy Point, Hog Island, Spirit Lake,. Mud Lake, Horseshoe Island, the Oliver Bridge and Morgan Park mudflats.

As a group, colonial nesting birds comprise the most abundant, yet sensitive breeding birds in the harbor area. The group consists of five colonial species (ringbilled gull, common tern, black tern, great blue heron, green heron) and two semi-colonial species (piping plover and yellow-headed blackbird).

Migratory waterfowl use the harbor extensively both for breeding and as feeding and resting stops during migration.

Relatively few birds spend the winter in the harbor area. Those that do include the snowy and great horned owls along with a local population of ring-necked pheasant. Some hardy waterfowl winter in warm water discharge areas.

Federally threatened or endangered birds that may reside in or pass through the harbor area include the bald eagle and the Arctic peregrine falcon.

3. Mammals

Mammals common to the harbor area include the whitetail deer and black bear. Resident small game mammals include the snowshoe hare, eastern cottontail and the gray squirrel. Furbearers are present to common with beaver, mink, otter and muskrats noted. Other rodents are common.

The only Federally threatened or endangered mammal that might occur in the harbor area is the eastern timber wolf.

4. Reptiles and Amphibians

Amphibians and reptiles are not abundant in the region with only about a dozen species noted.

5. Fish

Thirty-nine species of fish inhabit the nearshore or harbor areas of Lake Superior; among them are herring, whitefish and cisco, trout, smelt, suckers, perch, sculpin, walleye, northern pike, bass and bullhead. The game species present in significant numbers are northern pike, walleyes and yellow perch. Major forage species include bullheads, spottail shiners, emerald shiners, juvenile perch, white and longnose suckers and rainbow smelt. Water temperatures and oxygen concentrations apparently preclude the use of the harbor by salmon or trout although they have been cited as spawning in the Nemadji River system.

Gill net catches have reported showing a tendency for all food species, except burbot, to inhabit shallow areas. This tendency to concentrate in shallow water is of special significance to the problem of dredged material disposal. Disposal of sediments has created artificially shallow areas which are favorable habitat with respect to food, light conditions and temperature. Heavy metals in the sediments may subsequently promote the direct uptake of potentially toxic compounds by fish attracted to the area, as well as bottom feeding organisms which serve as fish food.

Both yellow perch and northern pike are well distributed throughout the shallow areas of the harbor and both overwinter in the harbor area. The perch utilizes living beds of emergent vegetation for spawning habitat. Northern pike typically spawn over dead grass and sedges flooded by spring high water, however with a lack of this habitat due to water levels, they appear to utilize submerged aquatic vegetation in Allouez Bay, along Grassy Point and other emergent wetlands.

Walleye appear to spend late summer, fall and winter off the Wisconsin shore of Lake Superior. Studies indicate that walleyes begin entering the harbor in late February on their spawning run up the St. Louis River to the first rapids. After spawning they may either return immediately to Lake Superior or spend time feeding on the abundance of forage fishes in Superior and Allouez Bays. By mid-July, the majority of adults have returned to Lake Superior.

Walleye fry drift down to the harbor area shortly after hatching and spend most of the summer within the harbor feeding first on zooplankton before switching to perch fry as the latter become available. Planktonic algae and zooplankton production is limited to the depth of the photic zone, normally about four to seven feet in the system. Consequently, good perch and walleye nursery habitat is comprised of an abundance of open, shallow water areas protected from strong wave action. Such areas are scattered throughout the lower harbor exclusive of slips and navigation channels.

Other Lake Superior fish species entering the harbor for spawning include rainbow smelt, emerald and spottail shiners, longnose suckers, white suckers, silver redhorse and burbot.

There are no citations of Federally endangered or threatened fish species in the harbor. Two recently introduced species (white perch and the river ruffe) are of concern to area fisheries specialists because of unknown populations and impacts.

F. LAND USE

The present day land use pattern in the harbor is a result of a 100 year process of change which continues to be dynamic; continually adjusting to local needs and the national economy. The following table summarizes the composition of current uses found in the harbor. A 1989 Harbor Land Use map is found in the pocket page.

Naturally water comprises the vast bulk of the harbor area although only a portion of the area is used for transportation. Of the land uses open space is the largest category consisting of parks and municipal forests.

Shipping is the most significant land use. The elevators, ore and coal docks, and general cargo facilities cover sizeable portions of the waterfront.

<u>EXISTING LAND USE</u>

Use	Percentage of: Total Harbor*	Developed Land	Developed Land plus Dedicated Open Space	General Description
Bulk Shipping	3.9	37.1	19.6	Shipping of coal, ore, grain, stone, petroleum
General cargo shipping	0.2	2.1	1.1	All general cargo plus miscellaneous bulk goods (scrap, paper)
Residential	1.7	16.0	8.5	All forms of residential development
Commercial	0.2	1.6	0.8	All commercial (retail, wholesale) development
Industrial (non-marine)	1.0	8.3	4.9	Industries not requiring water transportation
Industrial (marine)	0.3	4.1	1.6	Shipyards, ship repair, water dependent industries
Recreation	0.6	5.7	3.0	Marinas, beaches, parks, museums, historical sites
Dedicated Open Space	9.4	-	47.3	Municipal forests, public land dedicated to remain open
Land Transportation (including air)	2.4	22.8	12.0	Railyards, roads, airport, rail tracks
Marine Services	0.1	0.9	0.5	Pilot service, dredging service, Coast Guard, Corps of Engineers, towing service, fueling service, garbage service, etc.
Public Facilities	0.1	1.4	0.7	Sewage treatment plants
Vacant	13.4	-	-	Includes public land not dedicated for any use
Water	66.7	-	-	
	100.0	100.0	100.0	

*Total harbor area equals roughly 32 square miles

Related to shipping are several other categories of land use, which although important, cover relatively small portions of the harbor area. Services such as the Coast Guard, Corps of Engineers, private dredging operations, garbage haulers, bunkering operations and shipyards are included.

The harbor's next largest land use includes the landside transportation facilities with roads, trackage, marshalling yards and the Skyharbor Airport.

Roughly 16% is devoted to residential areas. The largest is Park Point, although significant uses are present in Allouez, Billing Park, Oliver and Fond du Lac.

Substantial segments of the harbor are used for non-water industrial operations; some of which are located on deepwater channels.

Recreation and commercial development are growing as a portion of the harbor's land use, although their current portion is relatively small.

Public facilities consist of wastewater treatment plants and water pumping stations. Also present are the Itasca CDF, Erie Pier CDF and the Mehan CDF.

III. SUPERIOR-DULUTH HARBOR DREDGE MATERIAL CHARACTERIZATION

III. SUPERIOR-DULUTH HARBOR DREDGED MATERIALS CHARACTERIZATION

A. VOLUME

In order to plan future disposal sites for dredged material, it is necessary to have an estimate of the amount of material likely to be dredged during the period. It has previously been estimated that the future maintenance volumes will be in the range of 175-215,000 cubic yards from both the public and private sectors.

The source of most harbor sediments is eroded red clay carried by the Nemadji River with additional material brought into the harbor by the St. Louis River and the other smaller streams which collectively transport a sizeable amount of material. Although some material is transported through the system into Lake Superior, most of it settles out where threshold deposition velocities are reached. The Superior Harbor Basin where the Nemadji River debouches is responsible for nearly half of the Corps' annual dredging volume.

Materials are also contributed by the harbor shoreline, reverse currents caused by seiches. Materials may be redistributed by vessel traffic.

The end result is deposition throughout the harbor that must be removed if the harbor is to operate at its designed level. Direct deposition by the Nemadji River accounts for most of the dredging need in the Superior Harbor Basin although vessel traffic may rearrange that material into specific shoals. Shoaling near the turning buoy in the Duluth Harbor Basin is probably caused by ship traffic; and both ship traffic and seiches probably contribute to shoaling in the Cross Channel.

The following tables represent a summary of COE dredging data since 1970. We have not inspected each individual record to determine exact volumes or to correlate sediment samples with NR 347 standards for each project. While this had been one of the proposed major objectives of this project, the adoption of NR 347 by the Natural Resources Board without standards for allowable concentrations of contaminants effectively negated the usefulness of the effort.

We do take the liberty to presume however, that those standards originally proposed for inclusion in NR 347 are close to those the WDNR would use for evaluating current projects.

CONTAMINANTS--MAXIMUM CONCENTRATIONS
all values in ug/g unless noted

ANALYTE	USEPA/COE 1977 CRITERIA	WNDR* ADOPTED FEB-1989	WDNR** PROPOSED 1988 NOT ADOPTED
PCB, TOTAL	LNE	X	.05
TOTAL 2,3,7,8, TCDD	LNE	X	1.0 pg/g***
TOTAL 2,3,7,6, TCDF	LNE	X	10.0 pg/g***
ALDRIN	LNE	X	.01
DIELDRIN	LNE	X	.01
CHLORDANE	LNE	X	.01
ENDRIN	LNE	X	.05
HEPTACHLOR	LNE	X	.05
LINDANE	LNE	X	.05
TOXAPHENE	LNE	X	.05
DDT	LNE	X	.01
DDE	LNE	X	.01
ARSENIC	3.0	X	10.0
BARIUM	20.0	X	500.0
CADMIUM	LNE	X	1.0
CHROMIUM	25.0	X	163.0
COPPER	25.0	X	82.0
CYANIDE	.1	X	LNE
IRON	17,000.0	X	LNE
LEAD	40.0	X	50.0
MANGANESE	300.0	X	LNE
MERCURY	LNE	X	.1
NICKEL	20.0	X	100.0
PHOSPHORUS	420.0	X	LNE
SELENIUM	LNE	X	1.0
ZINC	90.0	X	100.0
AMMONIA	75.0	X	LNE
TKN	1,000.0	X	LNE
NO2,NO3	LNE	X	LNE
COD	40,000.0	X	LNE
TOC	LNE	X	LNE
OIL AND GREASE	1,000.0	X	1,000.0
TOTAL SOLIDS	LNE	X	LNE
VOLATILE SOLIDS	5.0	X	LNE
GRAIN SIZE	LNE	X	LNE
SETTLEABILITY (RETURN FLOW)	LNE	X	LNE

LNE=LIMITS NOT ESTABLISHED--Many are decided on a case-by-case basis.

* X=Analysis Required - Limits not established.

** Numerical criteria from unadopted draft of NR 347 which are presumed to be office practice standards by which dredge disposal will be governed.

***Parts per trillion.

Maintenance Dredging 1970-1986

Year	Area	Wis. gross (c.y.)	Minn.gross (c.y.)	Poll. vs. Unpoll. *	Annual Totals
1970	Front Channel	79,000			
	North Channel		35,300	na	114,300
1971	Duluth Basin		60,200	na	60,200
1972	Duluth Basin		91,000	na	91,000
1973	Wis. Waters	161,450		na	161,450
1974	Duluth Basin		14,050	na	14,050
1975	Superior Basin	25,300		U	
	Duluth Basin		104,000	P	129,300
1976	South Channel	32,600		P	32,600
1977	Duluth Basin		39,200	P	
	Superior Basin	36,700		U	
	East Gate	87,370		P	163,270
1978	Cross Channel	36,000		P	
	West Gate	14,500		P	
	Superior Front	97,200		U	
	Ship Canal		50,000	P	197,700
1979	Duluth Basin		33,650	P	
	Cross Channel	35,450		P	
	South Channel	17,200		P	86,300
1980	Superior Basin	170,000		P	170,000
1981	Duluth Basin		19,400	P	
	Front Channel	108,900		P	128,300
1982	Duluth Basin		80,702	P	
	Cross Channel	16,521		P	97,223
1983	East Gate	17,779		P	
	Superior Basin	44,044		U	
	Howards Bay	34,380		P	
	Minnesota Channel		62,398	P	158,601
1984	S & W Channels	53,833		P	
	East Gate	71,400		P	
	Cross Channel	41,575		P	
	West Gate	7,300		P	174,108
1985	Superior Basin	147,461		U	
	Upper Channel	30,004		P	
	Minnesota Channel		16,038	P	193,503
1986	Duluth Basin		50,623	P	
	East Gate	111,563		P	
	Upper Channel		3,146	P	165,332
TOTALS		1,477,530	659,707		2,137,237

* U/P designation=COE determination.
Source: USCOE and EPA standards on following table

B. SUMMARY OF DREDGE MATERIAL VOLUME CHARACTERISTICS

Planning Assumptions from preceeding and other data.

1. Since 1970, 2,137,237 cy (gross) have been dredged from the federal project areas; an annualized average of 125,720 cy. Of this annualized average Wisconsin contributes approximately 86,900 cy (69%) and Minnesota 38,800 cy (31%).

2. Since 1975 when pollution characterization was assigned, 1,696,267 cy (gross) have been removed from the federal project areas; an annualized average of 141,353 cy.

3. Of the material dredged since 1975, 350,705 cy (gross) or 21% of total have been characterized as unpolluted by the COE (all from Wisconsin waters); an annualized average of 29,225 cy.

4. Of the material dredged since 1975, 1,345,532 cy (gross) or 79% of total have been characterized as polluted by the COE (from both Wisconsin and Minnesota waters); an annualized average of 112,128 cy.

5. The Metropolitan Interstate Committee has estimated the volume of private dredge material at 25,000 to 40,000 cubic yards per year. Their reports also indicate a need to remove a backlog of undredged shoals which amount to an additional 400,000 cubic yards. It is assumed that some of this material will be removed in the course of proposed harbor improvement projects.

6. For planning purposes, we will round up the annualized average dredge requirement for the federal channels to 130,000 cy.

7. We will also assume that 20% of the annualized volume of dredged material is "clean/unpolluted" (COE/EPA).

8. From the literature we can identify generalized source areas of "unpolluted" and "polluted" materials as shown on the black and white map found in the rear pocket.

9. Since 1968, the COE has dredged 2,674,156 cy at a total cost of $13,640,935 or an average of $5.10/cy.

10. The cost of CDF disposed materials at Erie Pier exceeds beach nourishment at Wisconsin Point by $2.50/cy.

11. Costs at other Lake Superior dredging sites have been reported at: Black River Harbor, Michigan ($6.00/cy); Ontonagon, Michigan ($3.00/cy); and Saxon Harbor, Wisconsin ($9.50/cy). The cost for Saxon Harbor is elevated due to Wisconsin Standards.

IV. ENVIRONMENTAL ANALYSIS OF SELECTED ALTERNATE DISPOSAL SITES

IV. ENVIRONMENTAL ANALYSIS OF SELECTED ALTERNATE DISPOSAL SITES

A. INTRODUCTION

Over the last decade, a number of alternate sites in Wisconsin have been identified as having potential for dredge disposal under a variety of methods and conditions. The two most commonly mentioned in the literature are the creation of a Contained Disposal Facility (CDF) at Bunge Slip in conjunction with the previously permitted Itasca upland site for "polluted" materials; and, for "clean" materials, in-water contained disposal at the Cross Channel "deep hole".

In the selection and further analysis of these sites we have recognized the guidance of the Land Use and Management Plan for the Duluth-Superior Harbor (1978) and as amended which provides the following policies for dredging and dredged material disposal:

Dredging

1. Recycling and reuse of maintenance dredge materials is generally preferred to other disposal methods or to the mining of harbor sediments for upland uses.

2. Dredging shall be conducted to ensure that:

a. Access to port and marina facilities is preserved and improved to accommodate authorized channel depths;

b. Efficient and safe navigation is permitted;

c. Adverse short-term effects such as pollutant release, dissolved oxygen depletion and disturbance of important localized biological communities are evaluated and addressed;

d. Adverse long-term effects such as loss of fish habitat, shoreline vegetation, wetlands, destabilization of bottom sediments, and biologically harmful changes in circulation patterns are evaluated and addressed;

e. Channelization not necessary for efficient and economic navigation in the harbor is to be avoided.

3. The cost of dredging shall be addressed in evaluating methods related to disposal in upland sites.

Dredged Material Disposal

1. Polluted dredged material may be deposited in the harbor in a contained disposal site if the disposal site is designed to prevent the release of pollutants from disposed materials at levels in violation of applicable standards.

2. Dredged material disposal activities within wetlands and productive shallow water areas are generally discouraged. They may be allowed if the project:

   a. Cannot feasibly be constructed elsewhere, is a water dependant or water related project in a designated development area, or is part of a dredged material disposal plan; and

   b. Has a site designed to minimize unfavorable impacts on fish and wildlife habitat, wetlands, and circulation of harbor water; and

   c. Compensatory action is taken elsewhere in the harbor to create or restore habitat with a biological potential similar to that destroyed; and

   d. Has a justifiable need for the resulting land;

   e. Benefits or does not change water quality conditions in the harbor or Lake Superior.

3. Deposition of dredged material for port improvement, expansion and modernization is to be encouraged only in development areas designated in the approved harbor plan.

4. Disposal into Lake Superior may be allowed if the material is suitable by chemical, physical and other appropriate standards and is to be used for beneficial beach nourishment.

5. Disposal sites must meet the following criteria:

   a. Be available to all public and private dredging operations within the harbor (does not apply to private sites);

   b. Appropriate access is available to serve disposal and the eventual uses of the disposal site;

   c. The disposal site and programmed uses are compatible with the approved harbor plan.

6. Except where the use of the property requires otherwise, the shoreline resulting from disposal is to be given a "natural" appearance.

7. Disposal of dredged materials on environmentally acceptable upland sites is generally encouraged provided that it is put to a beneficial use and does not pre-empt a more valuable use of the property.

8. Priority will be given to maintenance dredged material disposal in filling designated disposal sites.

9. The four existing man-made deep holes in the harbor are considered potential disposal sites for maintenance dredged material.

a. The use of deep-holes as disposal sites is contingent upon state laws and the performance of a pilot deep-hole disposal project in the harbor.

b. Any use of deep-holes as disposal sites for maintenance dredged material will be done in accordance with the findings and recommendations of the pilot project and the prior report titled An Evaluation of Man-Made Deep-Holes of the Duluth-Superior Harbor as Potential Disposal Sites for Maintenance Dredge Material.

10. Recycling of dredged material for upland uses is encouraged. The washing of polluted or partially polluted material shall be encouraged whenever economically feasible provided that the material meets applicable standards for reuse, in order to lengthen the life of contained disposal facilities.

11. Dredged material may be used for the creation and enhancement of islands and shoal areas provided the material is unpolluted, designed to be stable within the harbor system, does not interfere with navigation and serves to benefit natural resources such as fisheries or wildlife habitat.

B. SCOPE OF CURRENT WORK

Regulatory agencies reviewing documents related to the use of Bunge Slip and the Cross Channel Hole as disposal areas have general pointed to the need for several concerns to be addressed prior to the consideration of such areas for disposal. The following are a list of most often mentioned concerns with a response to be offered by this report:

1. Lack of information related to the two area's use as unique fisheries habitats;

   Following as Section 5 is a fisheries assessment completed by the University of Wisconsin-Superior's Center for Lake Superior Environmental Studies. The report covers a year of netting and trawling as well as temperature and dissolved oxygen profiles for both sites. The assessment was carried out in accordance with a guidance memorandum prepared by the Wisconsin DNR (7/26/88).

2. Lack of information dealing with the physical and chemical character of the bottom sediments at both sites.

   Following as Section 6 are the results of physical and chemical analysis of sediment samples taken from both sites. The analytes tested for are in accordance with NR 347 (as adopted).

3. Lack of information on the plant communities and wildlife habitat of the Bunge Dock and Slip.

Following as Section VII is a report prepared by a qualified consultant.

4. Lack of information on the effects upon the water column and bottom sediments by various disposal techniques.

This work is beyond the scope of this report.

5. In water disposal is currently prohibited in Wisconsin.

In a later section, this report offers a alternative legal framework for dredged materials disposal which addresses the issue of not only in-water disposal but also CDF's.

C. CHARACTERIZATION OF SELECTED SITES

1. Cross Channel Hole

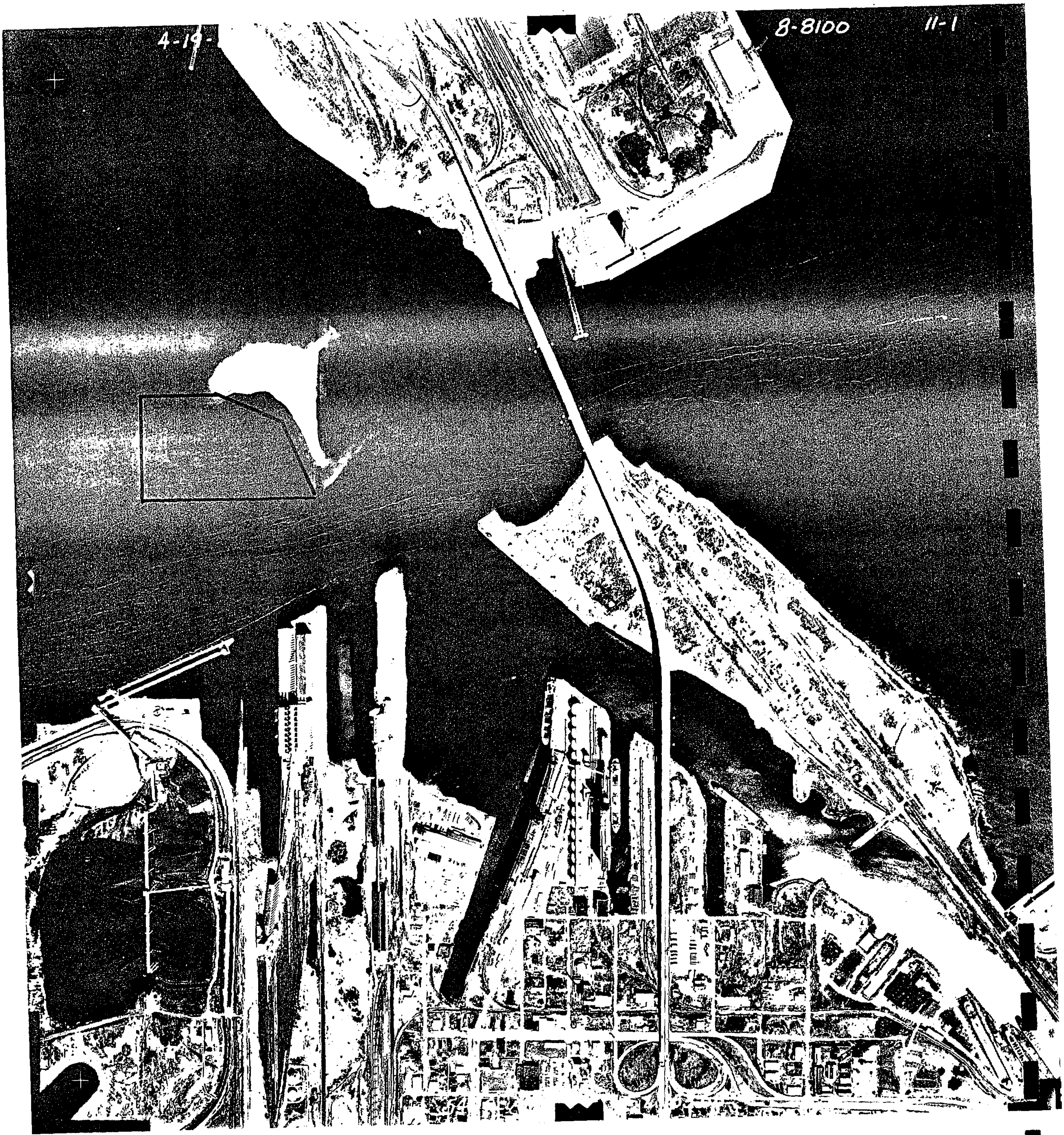
The site is a hole resulting from sand mining for construction purposes. It is an irregular depression that ranges from 5-39 feet below water surface. Surface area is approximately 20 acres with an estimated volume of 970,000 cubic yards. For a more complete description see An Evaluation of Man-Made Deep-holes of the Duluth Superior Harbor As Potential Disposal Sites for Maintenance Dredged Material. October 1983. Metropolitan Interstate Committee. See also air photo and digitized site map following.

2. Bunge Slip and Dock

Located in Superior's east end, the site was formerly utilized for water-related transportation purposes. Once served by both rail and road, only the roadway currently exists. The dock surface area is approximately 23 acres with a total length of nearly 4200 feet. The perimeter consists of rip-rap on the east and a combination of rip-rap and concrete berthing wall on the west. The slip area is approximately 3600 feet long with a surface area of 37 acres. Wetlands occupy approximately 8.5 acres of the slip. Theoretical volume of the slip is 1,100,000 cubic yards. See air photo and digitized site map following.

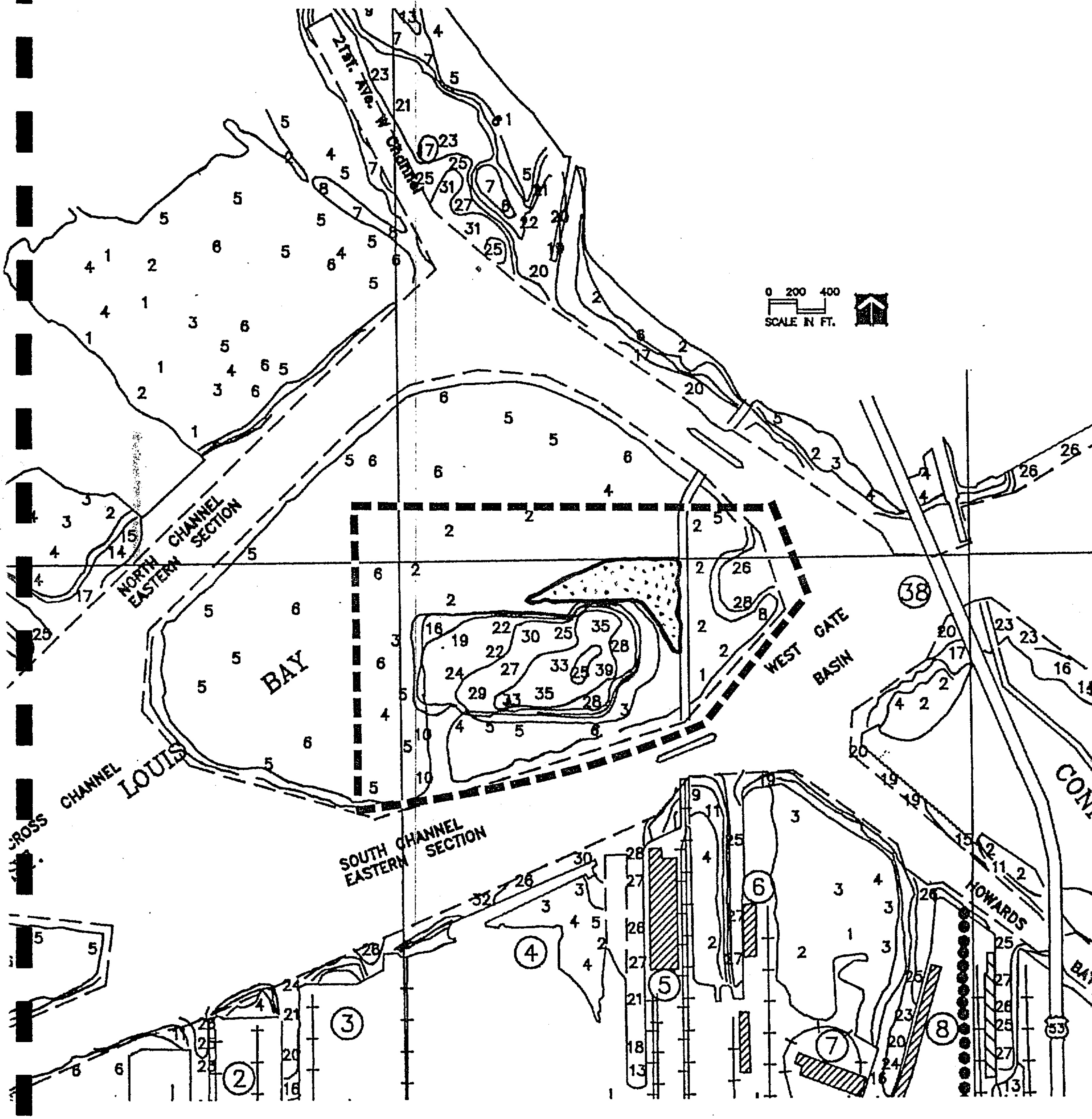
3. Itasca Upland Site

The Itasca site is property owned by Douglas County and leased to the City of Superior. It is an upland site permitted most recently for disposal of dredged materials generated during the construction of the Barker's Island Marina. The site has existing dikes, most of which will require repair and maintenance. The site is 32 acres in size and has capacity remaining of nearly 520,000 cubic yards, which could be increased if suitable reuse materials could be found for excavation. The capacity could also be increased by redesign of the diking system. For the site to be used for future disposal, new accommodations for treatment of return flows would be necessary. See air photo and digitized map following.



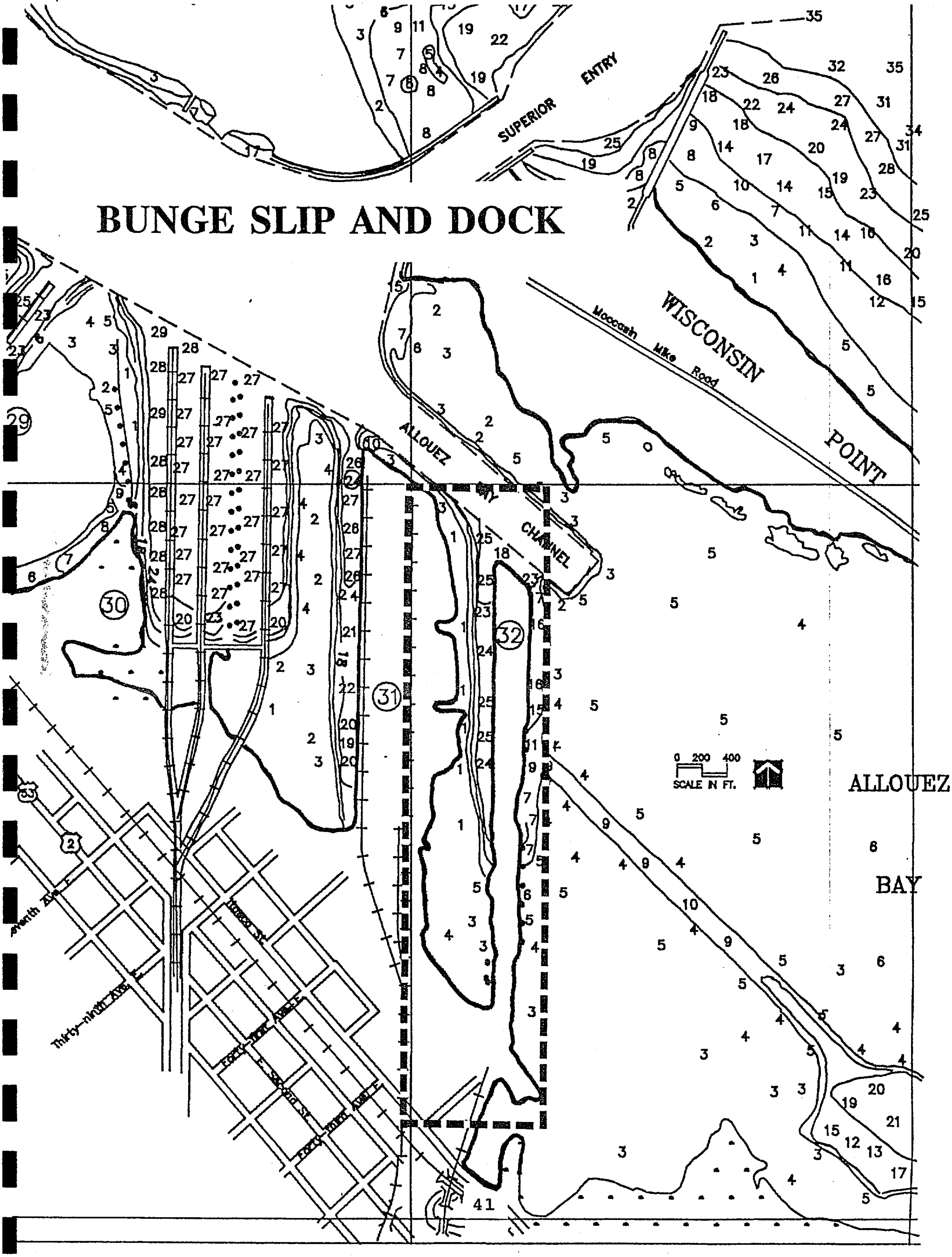
CROSS CHANNEL DEEP HOLE
Scale 1" : 800'

CROSS CHANNEL DEEP HOLE



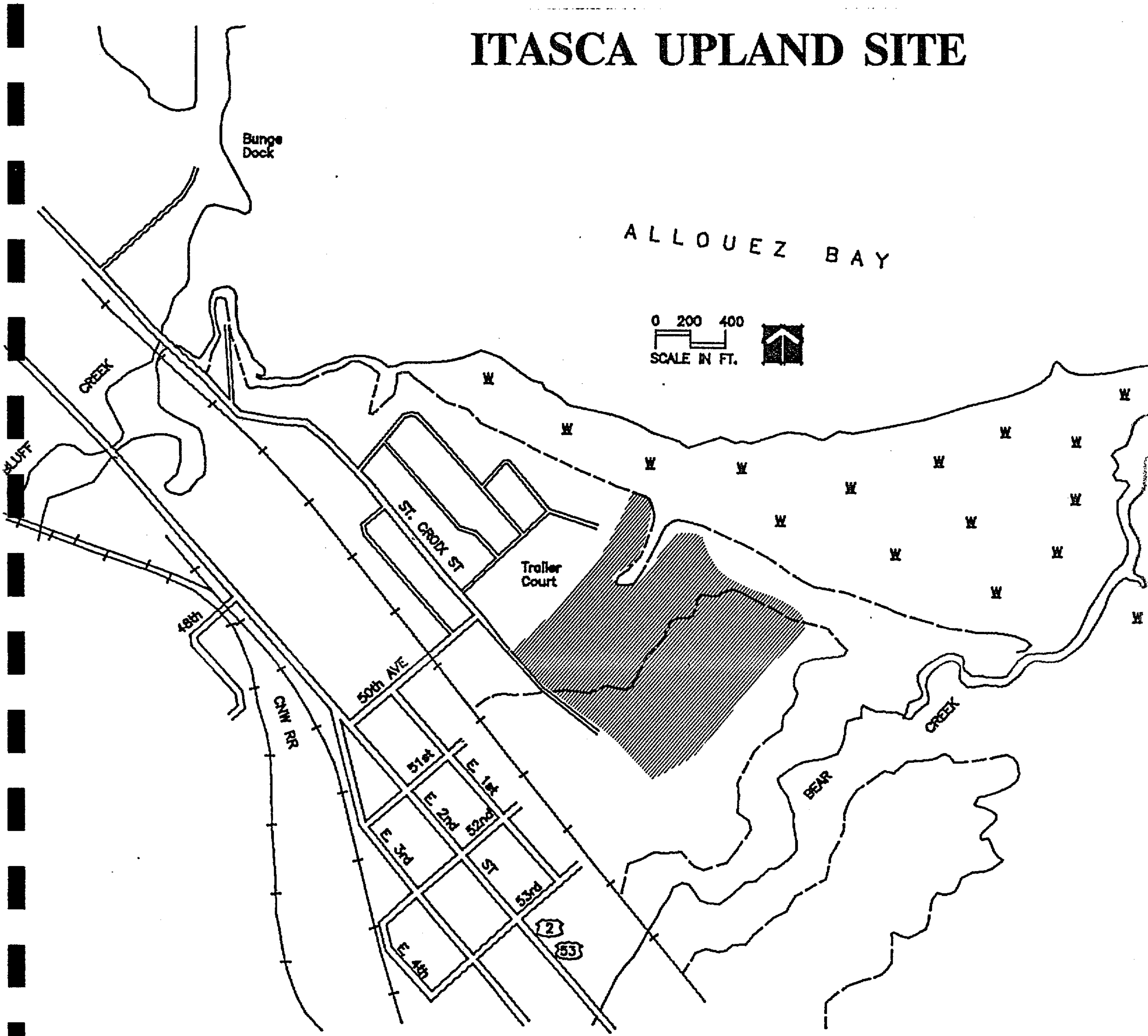
BUNGE SLIP AND DOCK
Scale 1" : 800'

BUNGE SLIP AND DOCK



ITASCA UPLAND SITE
Scale 1" : 800'

ITASCA UPLAND SITE



V. CROSS CHANNEL AND BUNGE SLIP

FISH ASSESSMENT

V. CROSS CHANNEL AND BUNGE SLIP FISH ASSESSMENT

This section of the project report is represented by the final report of the University of Wisconsin-Superior Center for Lake Superior Environmental Studies which follows. The data sheets for the study are found in the Technical Appendix to the project report.

CROSS CHANNEL HOLE

AND

BUNGE SLIP

FISH ASSESSMENT

A final report to the

Northwest Regional Planning Commission

by

Mary D. Balcer

University of Wisconsin-Superior

Center for Lake Superior Environmental Studies

October, 1989

INTRODUCTION

The Northwest Regional Planning Commission, the City of Superior and the Wisconsin Department of Natural Resources are, with financial assistance from the Wisconsin Coastal Management Program, preparing a plan for long term disposal of materials dredged from the Superior harbor. Two of the potential disposal sites, Interstate hole and Bunge slip, are located within the Duluth-Superior harbor. An environmental assessment of the effects of dredge spoil deposition must be completed before these sites can be utilized as disposal areas. The University of Wisconsin - Superior's Center for Lake Superior Environmental Studies was contracted to perform an assessment of the fish populations at the two proposed disposal sites. This assessment included an examination of the utilization of the sites by both resident and transient fish populations in the harbor system.

SITE DESCRIPTIONS

The first site, Interstate or Cross Channel Hole, is located southwest of Interstate Island in St. Louis Bay (Figures 1 and 2). The hole was formed when bottom materials were excavated several years ago for use in highway and bridge construction. This site contains a large area (approximately 94,000 m^2) with water depths of 7 to 10 m. The hole has a relatively smooth bottom and is surrounded by steep banks that rapidly rise to within 1 to 2 m of

Figure 1. Location of sampling sites.

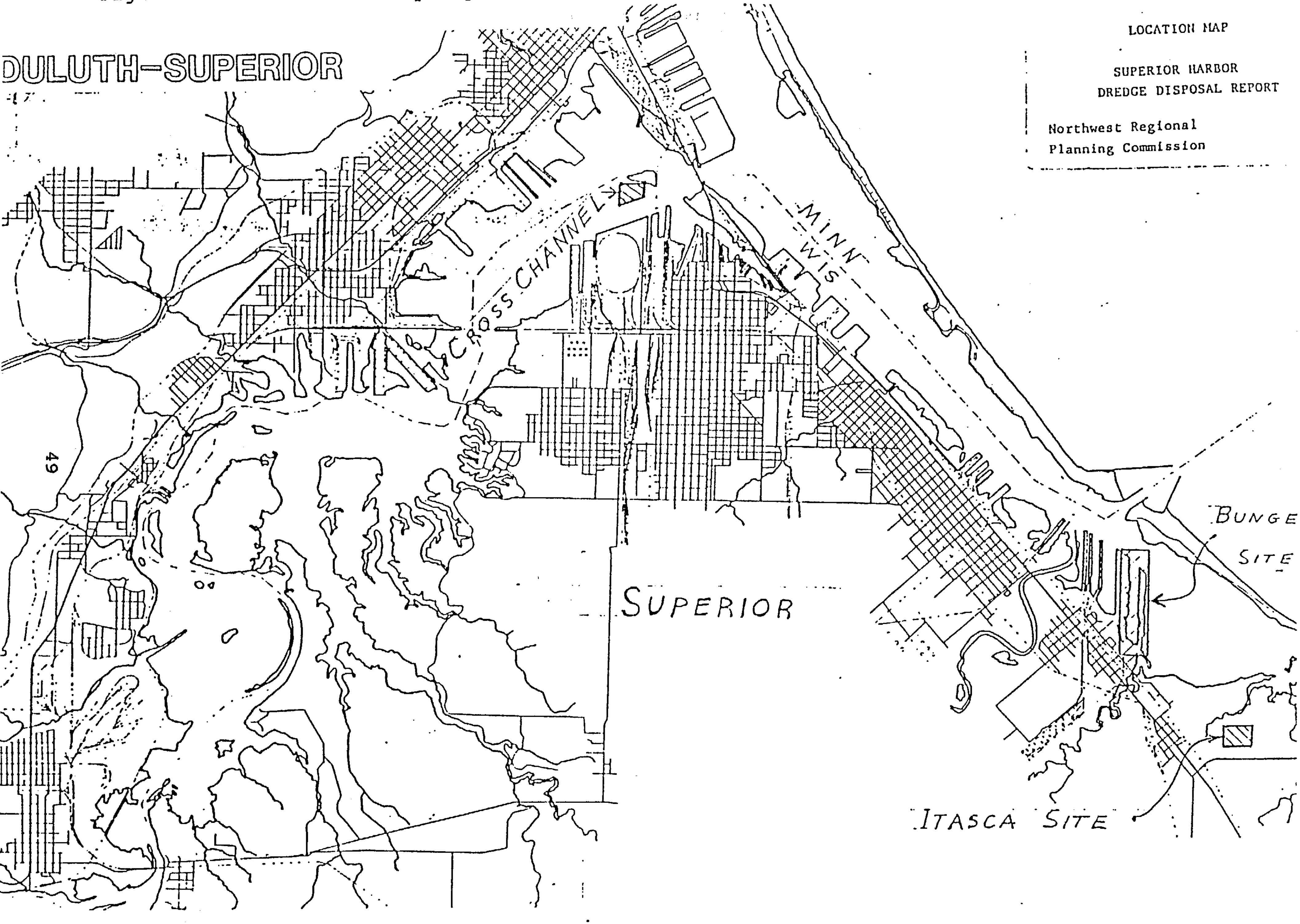
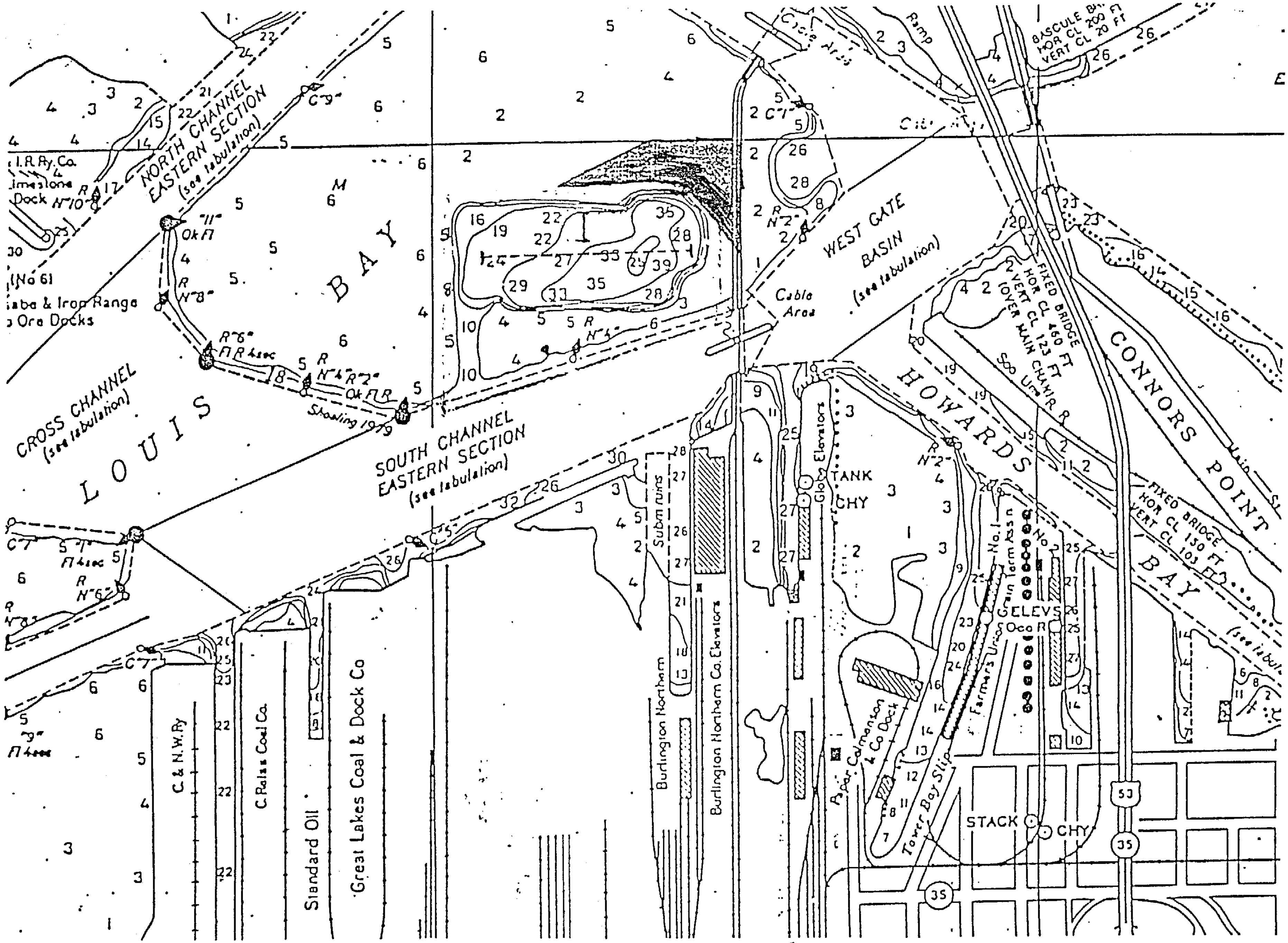


Figure 2. Bathymetric map of Interstate hole showing the location of the trawl transect (- - - -) and the gill net set (____). Depth contours are at 5 foot intervals.



the surface. The western portion of Interstate Hole has more gradually sloping banks than the eastern portion and is connected to the South Channel of St. Louis Bay by a narrow 3-4 m deep dredged channel.

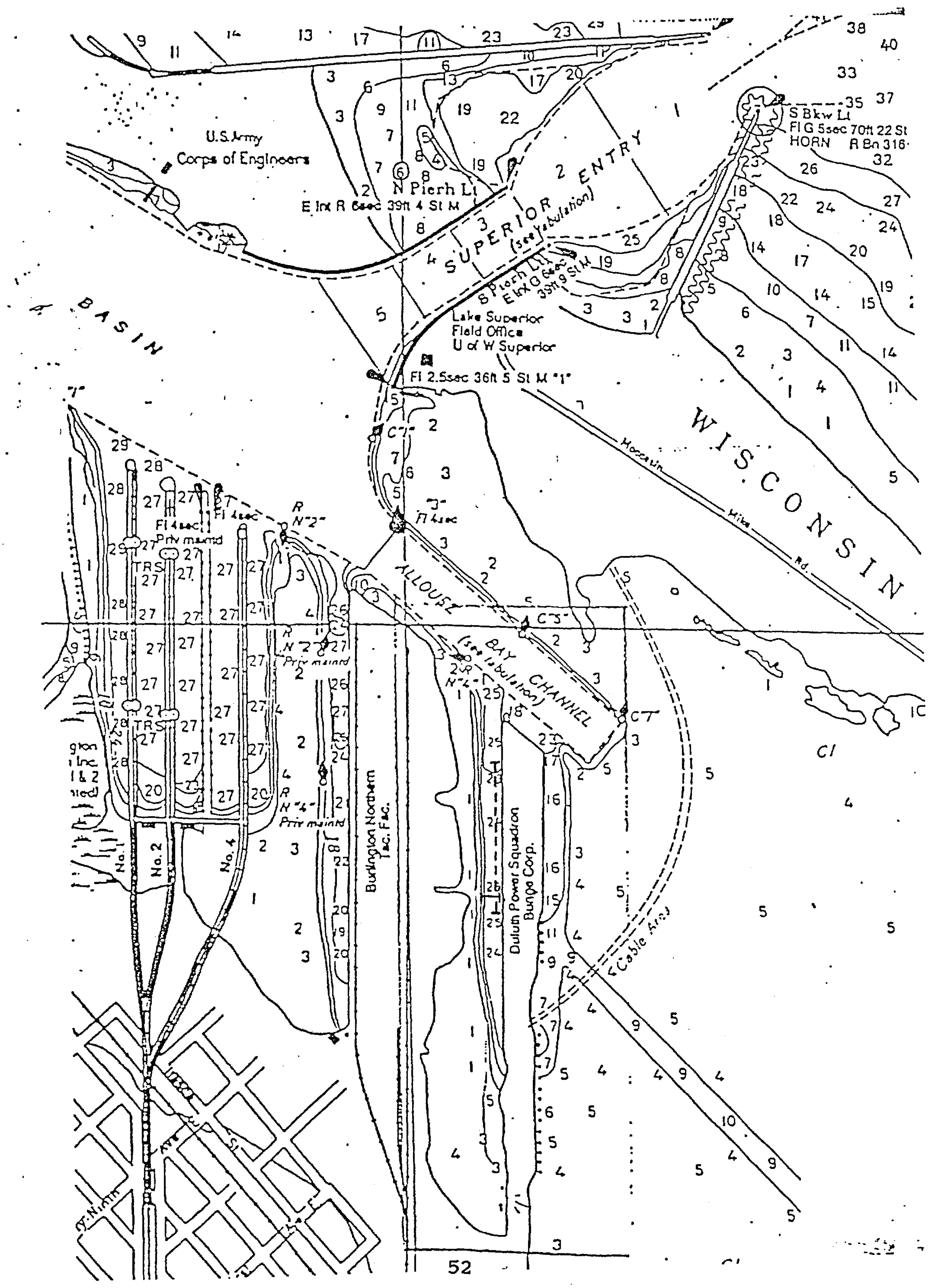
The second site, Bunge Slip, is located along Superior's eastern waterfront (Figures 1 and 3). This site consists of a narrow channel (45 m wide x 825 m long) dredged to depths of 7-8 m. The channel has an uneven bottom with scattered piles of debris and mounds of clay. An area of shallow water (1-2 m deep) with aquatic vegetation lies along the western edge of the slip.

METHODS

Fish populations at the two sites were assessed by trawling and gill netting. The gill net that was used was comprised of seven separate panels of variable size nylon mesh. Each panel was 25 feet long by 6 feet high and was equipped with a weighted foot line and a buoyant head line. The mesh sizes of the panels ranged from 1 to 4 inches stretch measure. The panels were sewed together in the following randomly determined pattern, 3.5, 4, 1, 2.5, 1.5, 2, and 3 inch stretch mesh.

Gill nets were set perpendicular to shore at each site (Figures 2-3) and were allowed to fish for 24 hours. Collections were made at approximately two week intervals between November 15, 1988 and September 15, 1989. The fish caught in each panel were identified, measured, and recorded separately.

Figure 3. Bathymetric map of Bunge slip showing the location of the trawl transect (- - - -) and the gill net set (____). Depth contours are at 5 foot intervals.



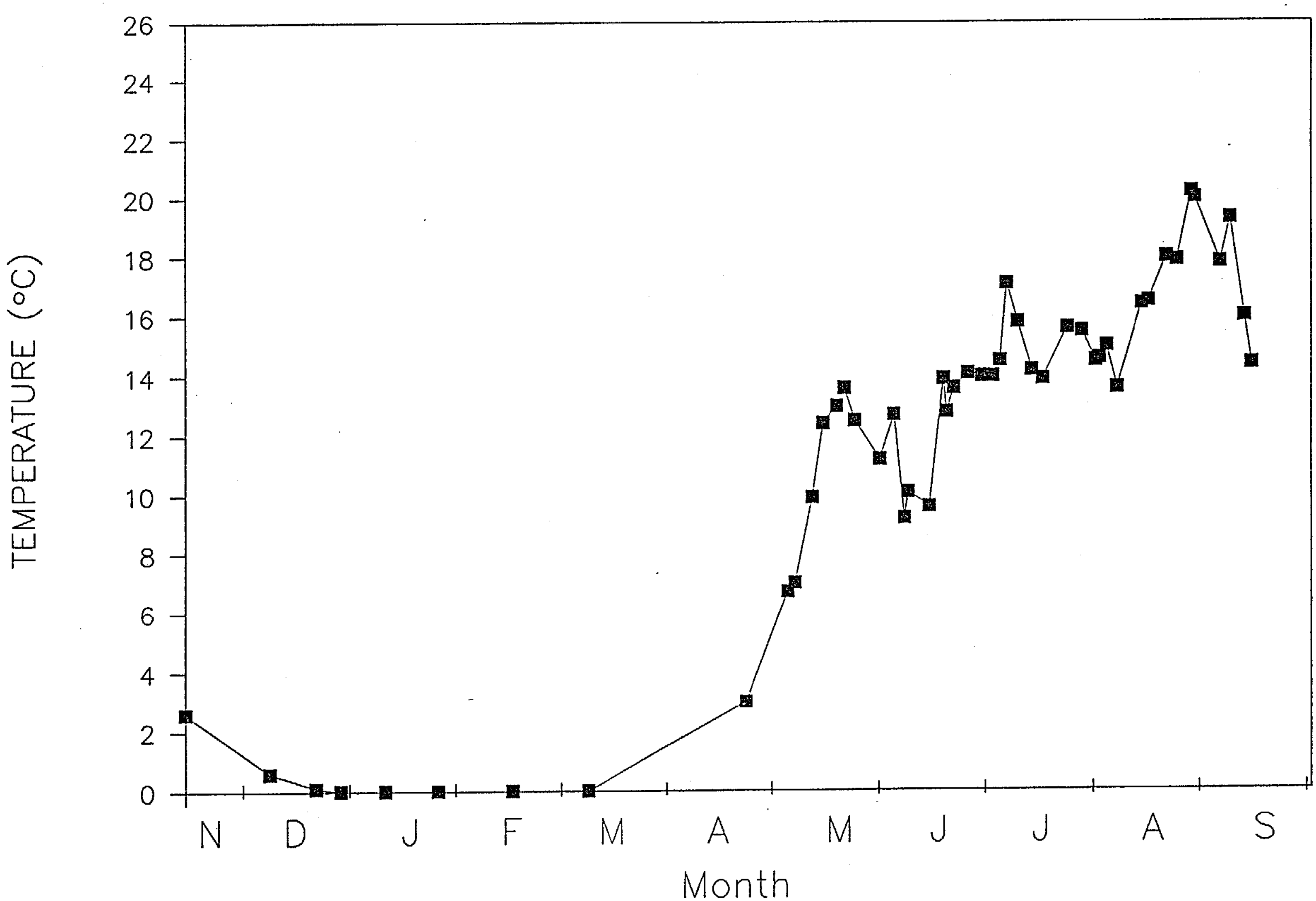
Fish were also captured by use of trawls during the open water season, May 6, 1989 through September 12, 1989. Two replicate five minute bottom trawls were made down the long axis of each site (Figures 2-3) twice a week. The trawl consisted of a 16 foot headrope, 19 foot footrope, 1.5 inch stretch mesh nylon net body, 1.25 inch stretch mesh cod end and 0.5 inch stretch mesh inner liner. Trawling speeds ranged from 1 to 1.8 mph. Data on species composition and length-frequency distributions were recorded separately for each trawl. Data from the two 5-minute trawls at each site were combined in order to calculate abundance based on a standard 10 minutes of trawling.

Water quality profiles were made for each gill net set and trawl sequence. Temperature and dissolved oxygen content were measured at 1 m intervals from the surface to the bottom at each site by use of a Yellow Springs Instrument Company Model 54a Oxygen meter. Measurements from all depths were averaged for ease in data interpretation.

RESULTS

The temperature profiles at Bunge slip displayed the normal pattern of seasonal changes expected of northern lakes (Figure 4, Appendix I). Fall turnover had occurred prior to November 15, 1988 and water temperatures had cooled to 2.5 °C. Ice cover became established by late November. Ice depth increased steadily through the winter months with a maximum of 68 cm occurring on February 16,

Figure 4. Average water temperatures at Bunge slip Between November 15, 1988 and September 14, 1989.



1989. By mid-March ice depth had decreased to 64 cm and pools of melt water occurred on top of the ice mass. The thermistor unit on the YSI meter was adversely affected by frigid air temperatures during the winter months and often gave below zero readings. Use of a glass thermometer revealed that actual water temperature one foot below the ice ranged from 0 to 4 °C during the winter.

Bunge slip opened partially in late April and sampling resumed amid the floating ice masses. Water temperatures were a uniform 3 °C at this time. Rapid warming of the upper water layers occurred in early May with surface temperatures approaching 16 °C. The bottom of the water column remained 3 to 6 °C cooler than the surface. This weak stratification pattern persisted throughout the summer. A slight drop in average water temperatures occurred in early June. Mean temperatures then increased to a peak of 20 °C in late August. Temperatures began to decline thereafter. Fall turnover had not yet occurred by the last sampling date (September 14, 1989) when temperatures ranged from 15.2 °C at the top to 13.3 near the bottom.

Dissolved oxygen concentrations at Bunge slip were generally greater than 8 ppm (Figure 5, Appendix I). Because cold water is capable of holding more oxygen than warm water, the oxygen concentrations tended to decline during the summer months as temperatures increased. Dissolved oxygen concentrations were generally between 80 and 90% of the saturation level for oxygen in water. A low value of 5.9 ppm oxygen was recorded near the bottom on January 26, 1989. This concentration was 48% of saturation.

Figure 5. Mean oxygen concentrations at Bunge slip between November 15, 1988 and September 14, 1989.

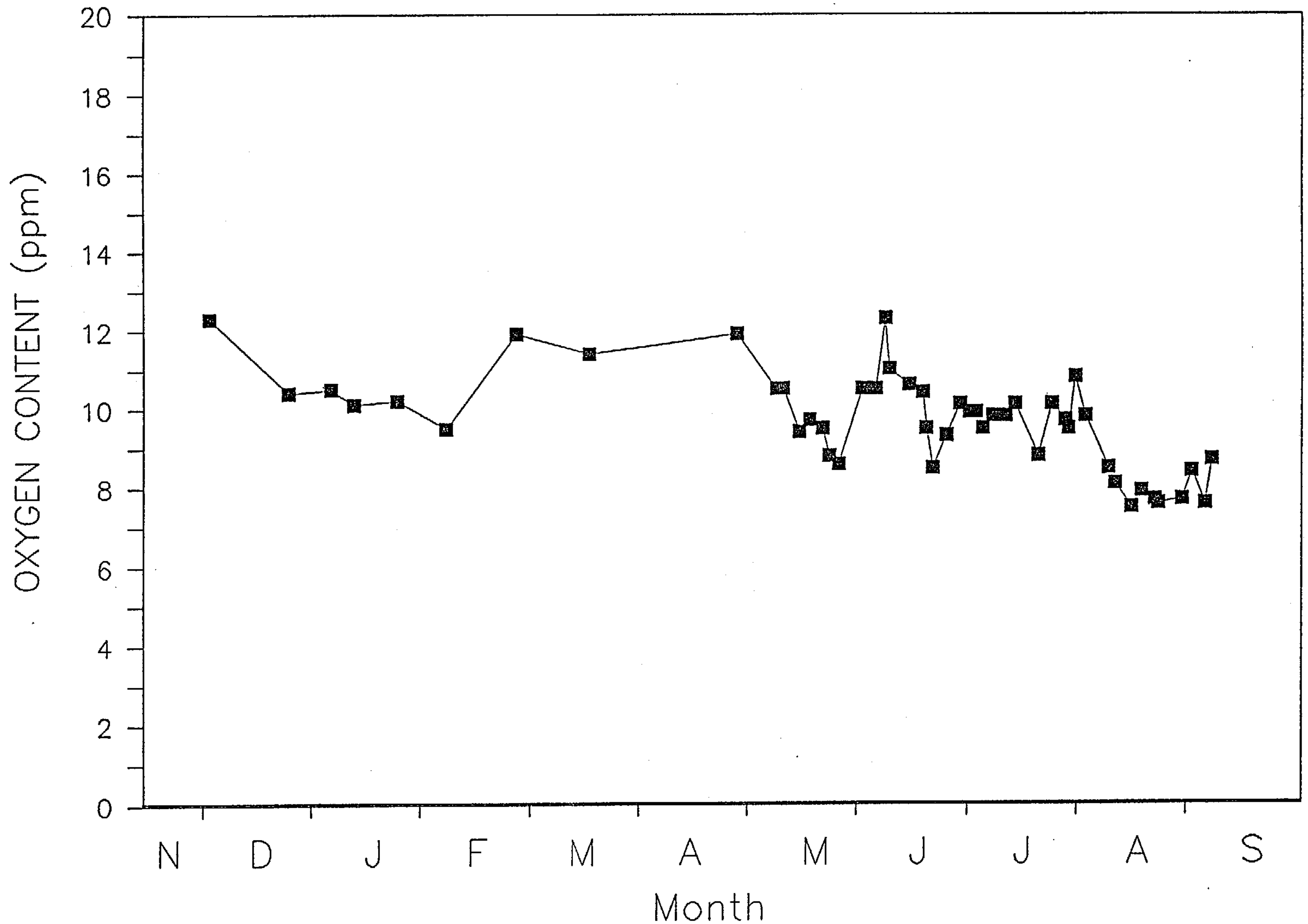
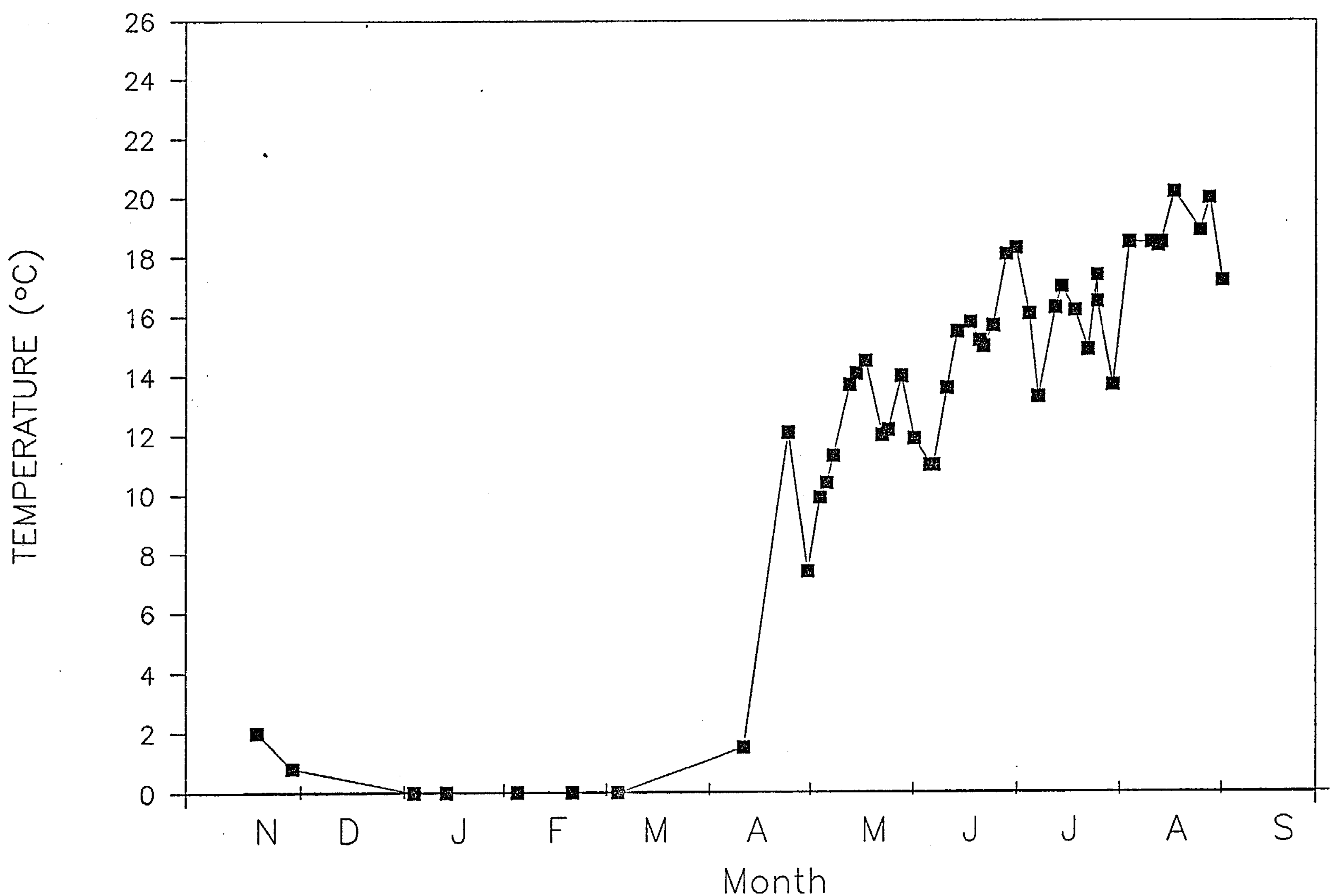


Figure 6. Average water temperatures at Interstate hole between November 17, 1988 and September 12, 1989.



Seasonal changes in water temperatures at Interstate hole (Figure 6) parallelled those at Bunge slip (Figure 4). Ice began to form at Interstate hole in mid-November and reached a maximum thickness of 60 cm by early March (Appendix II). The sampling area began to open up in April, however, large ice masses persisted through the month and interfered with sampling on April 17, 1989.

The water column at Interstate hole did not stratify during the summer months. Surface temperatures generally were within 1 - 2 °C of the bottom temperatures. Surface temperatures were approximately 20 °C from late August through early September. Water temperatures then began to drop slowly, reaching 17 °C by September 12, the last sampling date.

The average concentration of dissolved oxygen at Interstate hole ranged from 12.9 ppm in November to 7.5 ppm in August (Figure 7, Appendix II). The percent saturation varied from a low of 65% at the bottom on May 7 to a high of over 100% at the surface in late summer. Average saturation values ranged from 85 to 95%.

Twenty-one species of fish were captured in the gill nets set at Bunge slip (Table 1). The daily catch per 24 hour net set ranged from 10 to 87 fish (Appendix III). The trout-perch, Percopsis omiscomaycus, was the most common species collected between November 1988 and March 1989. Trout-perch abundance averaged 18 fish/net set, or 71 % of the catch, during this time period. Rainbow smelt, Osmerus mordax, were captured in low numbers during their spawning run in April. Other forage species that were found occasionally in the slip included spottail shiners

Figure 7. Mean oxygen concentrations at Interstate hole between November 17, 1988 and September 12, 1989.

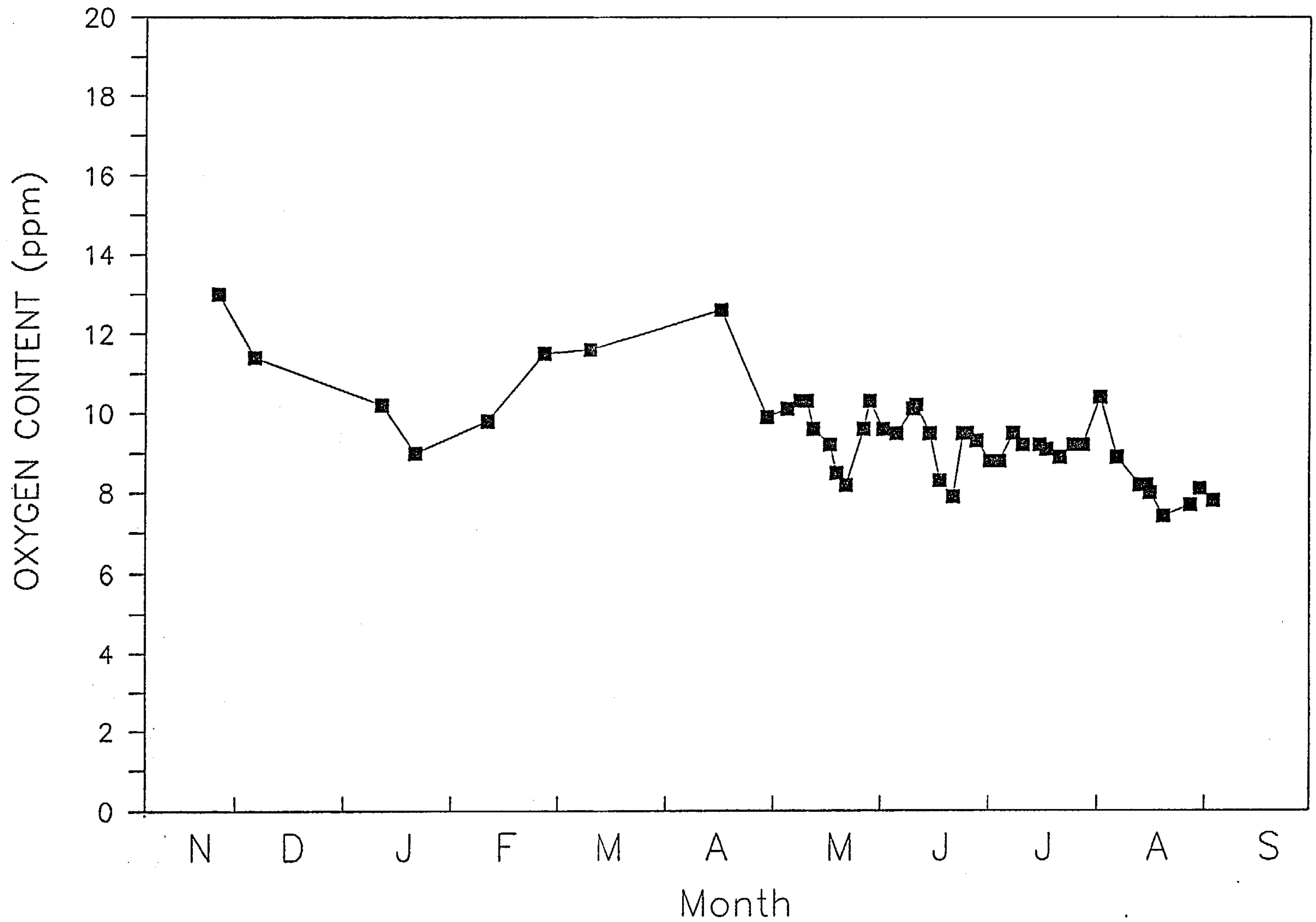


Table 1. Abundance and species distribution of fish captured in 24 hr gill net sets at Bunge slip.

DATE	TP	SS	ES	SM	LC	LH	BH	YB	WS	RS	LNS	RF	WP	RB	WB	BC	YP	WL	NP	ST	BB	LT	TOTAL
11/15/88	48	1	0	0	0	0	21	0	7	0	0	0	0	2	0	0	8	0	0	0	0	0	87
12/09/88	9	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	13
12/22/88	8	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	10
12/29/88	16	0	0	0	0	0	0	0	3	0	0	1	0	0	0	0	0	0	1	0	0	0	21
01/11/89	24	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	2	0	1	0	29
01/26/89	12	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	1	0	1	0	1	0	24
02/16/89	16	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	19
03/10/89	15	0	0	3	0	0	0	0	2	0	0	1	0	0	0	0	0	0	1	0	0	0	22
04/24/89	40	9	0	16	1	0	0	0	0	0	2	2	0	0	0	0	6	0	0	0	0	0	76
05/08/89	6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	2	0	0	1	0	11
05/23/89	9	0	1	0	0	0	0	0	9	0	1	1	0	0	0	0	6	0	0	0	0	0	27
06/08/89	9	0	0	0	0	0	3	0	1	0	0	0	0	0	0	0	6	0	0	0	1	0	20
06/21/89	1	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	4	0	0	0	1	0	11
07/05/89	0	0	0	0	0	1	0	0	0	12	0	0	0	0	0	0	1	1	0	1	0	0	16
07/17/89	1	0	0	0	0	0	1	0	6	3	0	1	0	0	0	0	17	0	0	0	0	0	29
08/02/89	0	0	0	0	0	0	6	0	1	0	0	0	0	0	0	0	14	1	0	0	0	0	22
08/16/89	0	0	0	1	0	0	6	0	1	3	0	1	0	0	0	0	12	2	0	0	0	0	26
08/29/89	2	2	0	0	0	0	10	0	2	0	0	2	2	0	0	0	19	0	1	0	0	0	40
09/14/89	2	0	0	0	0	0	23	0	7	5	1	2	0	0	10	1	20	0	1	0	0	1	73
*** Total ***	218	12	1	20	1	1	71	0	59	23	4	12	3	2	10	1	115	7	8	1	6	1	576

TP=trout-perch, SS=spottail shiner, ES=emerald shiner, SM=smelt, LC=lake chub, LH=lake herring, BH=black bullhead, YB=yellow bullhead, WS=white sucker, RS=redhorse sucker, LNS=longnose sucker, RF=ruffe, WP=white perch, RB=rock bass, WB=white bass, BC=black crappie, YP=yellow perch, WL=walleye, NP=northern pike, ST=sturgeon, BB=burbot, LT=lake trout

(Notropis hudsonius), emerald shiners (Notropis atherinoides), the lake chub (Couesious plumbeus), and the lake herring (Coregonus artedii).

White suckers (Catostomus commersoni) were the most common non-game species captured by gill nets in Bunge slip. Suckers were present throughout the year and averaged three fish per lift. Black bullheads (Ictalurus melas) were collected most frequently in late summer. Between August and November an average of 13 bullheads were retrieved from each gill net set. Redhorse suckers (Moxostoma sp.) were also common in late summer, averaging four fish per net lift. Longnose suckers (Catostomus), white perch (Morone americana), rock bass (Ambloplites rupestris), white bass (Morone chrysops), and black crappie (Pomoxis nigromaculatus) were present in Bunge slip in lower numbers.

The yellow perch (Perca flavescens) averaged two fish/net lift from winter through early summer. This species became quite common from mid-July through September when mean abundance reached 13 fish/lift or 49% of the total catch. Other piscivorous game fish present in low numbers in Bunge slip included the walleye (Stizostedion vitreum), the northern pike (Esox lucius), and the burbot (Lota lota). A sturgeon (Acipenser fulvescens) and a lake trout (Salvelinus namaycush namaycush) were also collected from gill nets set at this site.

Species diversity (13 species) and average daily gill net catch (1 to 19 fish) were generally lower at the Interstate hole site than in Bunge slip (Table 2, Appendix IV). An exception

Table 2. Abundance and species distribution of fish captured in 24 hr gill net sets at Interstate hole. The May 1 set was 48 hours long.

DATE	TP	SS	SM	BH	YB	WS	RS	LNS	RF	YP	WL	NP	BB	TOTAL
11/17/88	1	1	0	0	0	0	0	0	1	1	1	0	0	5
11/28/88	2	1	0	0	0	0	0	0	0	0	0	0	2	5
01/05/89	1	0	0	0	0	0	0	0	0	0	0	0	0	1
01/15/89	0	0	0	0	0	0	0	0	1	0	1	0	0	2
02/06/89	2	0	0	0	0	0	0	0	0	0	0	0	0	2
02/23/89	0	0	1	0	0	0	0	0	0	0	0	0	0	1
03/09/89	0	0	1	0	0	0	0	0	0	0	0	0	0	1
04/17/89	0	0	56	0	0	1	0	0	1	0	2	0	3	63
05/01/89	2	0	456	0	0	4	0	0	1	0	0	0	0	463
05/15/89	6	0	23	0	0	2	0	4	0	1	0	0	0	36
05/30/89	1	0	0	0	0	10	0	0	0	2	1	0	0	14
06/15/89	3	0	0	0	0	4	0	0	1	1	1	0	0	10
06/30/89	1	0	0	1	0	4	4	0	0	8	1	0	0	19
07/12/89	0	0	0	1	0	2	2	0	0	7	1	0	0	13
07/25/89	0	0	0	0	0	1	2	0	4	1	1	0	0	9
08/09/89	0	0	0	0	0	6	2	0	2	2	5	0	0	17
08/22/89	1	0	0	0	2	3	0	0	2	2	3	0	0	13
09/06/89	0	0	0	1	0	3	1	0	0	5	1	2	0	13
*** Total ***	20	2	537	3	2	40	11	4	13	30	18	2	5	687

TP=trout-perch, SS=spottail shiner, SM=smelt, BH=black bullhead, YB=yellow bullhead, WS=white sucker, RS=redhorse sucker, LNS=longnose sucker, RF=ruffe, YP=yellow perch, WL=walleye, NP=northern pike, BB=burbot occurred during late April and early May when rainbow smelt moved into the area during their spawning run. More than 450 smelt were captured in a 48 hr period in early May. (The prolonged sampling period was due to adverse ice and wind conditions which prevented us from retrieving the gill net at Interstate hole.)

Trout-perch was the only other forage species consistently found at Interstate hole. Its abundance averaged only one fish/net lift.

White and redhorse suckers appeared in moderate numbers (1 to 10/net lift) between May and September. Ruffe (Gymnocephalus cernuus) were captured in low numbers throughout the year.

Yellow perch and walleye were the primary predators at Interstate hole from May through November with average catches of 2.6 and 1.4 fish/net lift respectively during this time period. Only one walleye was captured during the winter months.

An examination of the species composition of the average monthly gill net catch (Figure 8) reveals that forage species comprise the majority of the fish population at Bunge Slip from November through June. During the summer, predatory game species (such as yellow perch) and nongame species (suckers and bullheads) become more abundant while the forage density declined.

Total fish abundance was lower at Interstate hole than at Bunge slip except during the smelt run. Forage species were generally not found in gill net catches from Interstate hole.

The various mesh sizes in the gill net panels have different capture efficiencies for different species of fish (Table 3).

Figure 8. Average monthly catch of game (■), nongame (▨) and forage species (☒) in 24 hr gill net sets at Bunge Slip and Interstate hole

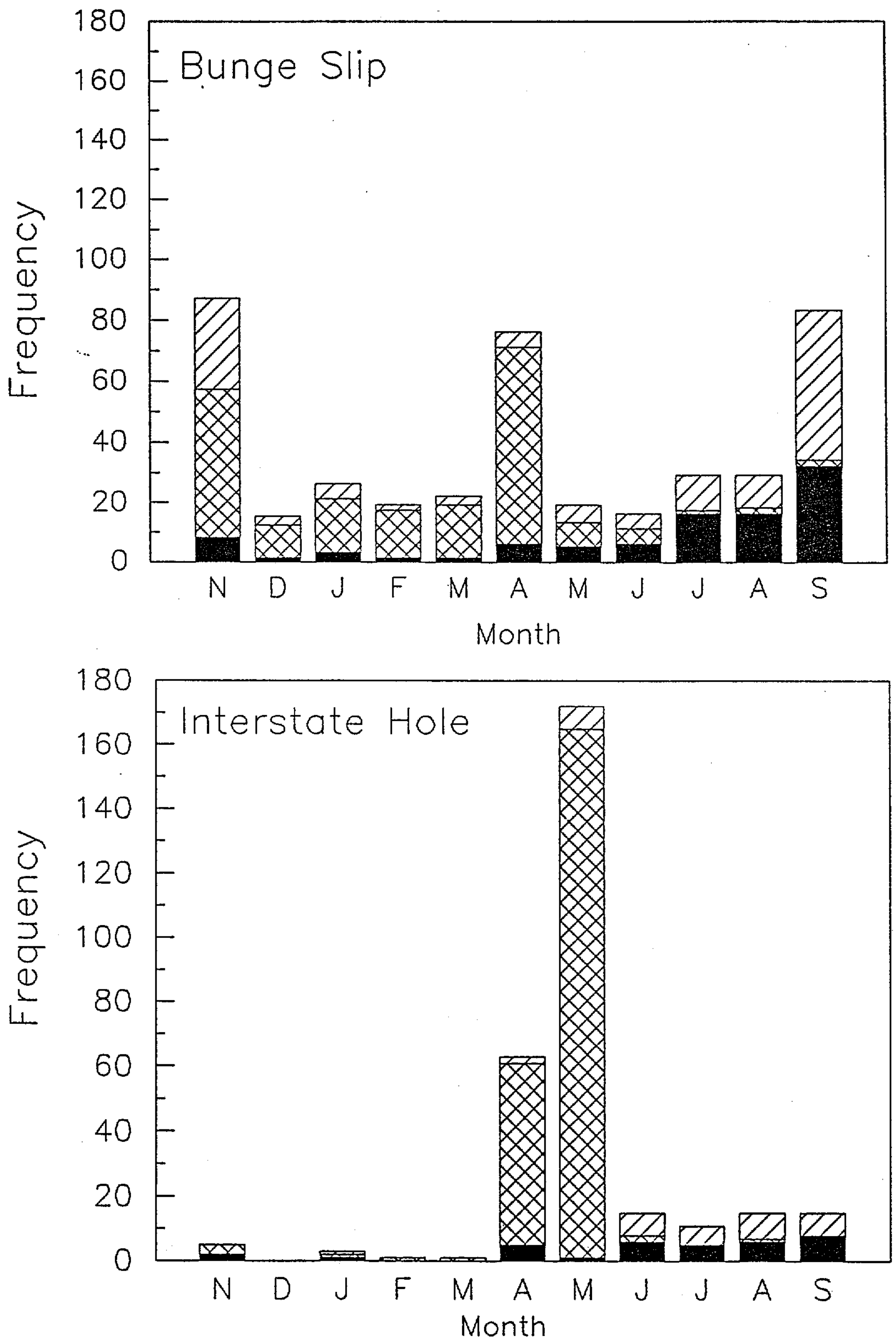


Table 3. Number of fish caught by various sizes of gill net mesh.

	Stretch Mesh Size (Inches)						
Species	1	1.5	2	2.5	3	3.5	4
Troutperch	237	1					
Spottail S.	14	1					
Smelt	513	34					
Ruffe	4	19	4				
Yellow Perch	6	45	34	42	10	7	
Bullheads	1	3	25	8	18	16	5
White Sucker	1	3	11	17	13	25	23
Walleye		4	7	6	5	1	1
Redhorse S.			1	1	11	9	10
Longnose S.		1	3		2	1	2
Northern P.				1	4	1	2
Burbot				2		4	5

Trout-perch, shiners, and smelt were found primarily in the 1 inch stretch mesh. The 1.5 inch mesh was most efficient at capturing ruffe. Several year classes of yellow perch, bullheads, suckers and walleye are present in the Duluth-Superior harbor. Some members of these species were captured in almost all of the gill net panels. The larger mesh sizes (2.5 - 4 inches) were useful in catching the redhorse suckers, northern pike, and burbot.

Eighteen species of fish were captured by bottom trawls at the Bunge slip site between May and September 1989 (Table 4, Appendix V). Total catch per standard 10 minute trawl ranged from 11 to 250 fish. Sixty percent of the catch was comprised of trout-perch which had a mean abundance of 48 fish/standard trawl. Other forage species that were consistently present in moderate numbers included rainbow smelt, spottail shiners, and emerald shiners. In May large schools of emerald shiners were encountered with numbers exceeding 200 fish/standard trawl.

Black bullheads were present in Bunge slip in moderate numbers (mean=8/standard trawl) throughout the summer. Density was highest in August when 97 fish were captured in 10 minutes of trawling. From late June through August sculpins were found in the slip. Ruffe were also captured periodically during this time period. The highest densities of ruffe (7/standard trawl) occurred in September. Other non-game species that were occasionally captured in the bottom trawl at this site included carp (Cyprinus carpio), lake chubs, yellow bullhead (Ictalurus natalis), white and redhorse suckers, channel catfish (Ictalurus punctatus), white bass, and

Table 4. Abundance and species distribution of fish captured during 10 minutes of bottom trawling at Bunge slip.

DATE	TP	SS	ES	CP	SM	LC	BH	YB	WS	RS	CC	RF	WB	WP	SC	YP	WL	BB	TOTAL
05/06/89	54	20	11	2	0	0	9	0	5	0	0	0	0	1	0	8	1	0	113
05/11/89	18	5	8	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	33
05/13/89	18	3	209	1	0	0	0	3	1	0	0	0	0	0	0	1	0	0	236
05/16/89	2	5	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	11
05/20/89	30	2	18	0	1	0	6	0	0	0	0	0	0	0	0	0	0	0	57
05/22/89	95	1	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	100
05/25/89	82	19	53	0	2	0	3	0	1	0	2	0	0	0	0	2	0	0	162
06/01/89	100	9	3	0	2	0	2	0	1	0	0	1	0	0	0	1	0	0	120
06/05/89	71	2	1	0	1	0	2	0	1	0	0	0	0	0	0	0	0	0	79
06/09/89	24	6	2	0	2	0	7	1	1	0	0	0	0	0	0	0	0	0	43
06/15/89	30	2	7	0	2	0	13	1	0	0	0	0	0	0	0	1	0	0	56
06/19/89	33	0	0	0	2	1	2	0	0	0	0	0	0	0	1	0	0	0	39
06/22/89	36	0	2	0	4	0	0	0	0	0	0	0	0	0	0	0	0	2	44
06/26/89	23	0	1	0	2	1	28	0	0	0	0	0	0	0	4	0	0	0	59
06/30/89	98	0	1	0	3	0	3	0	1	0	0	0	0	0	3	0	0	0	109
07/03/89	45	1	3	0	7	0	2	0	0	0	0	0	0	0	3	1	0	1	63
07/07/89	120	1	19	0	3	0	1	0	0	0	0	0	0	0	4	1	0	0	149
07/10/89	21	0	1	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	29
07/14/89	43	0	7	0	1	0	0	0	0	1	0	2	0	0	15	1	0	1	71
07/17/89	41	0	5	0	0	0	3	0	0	0	0	0	0	0	4	2	0	0	55
07/21/89	18	0	0	0	3	0	1	0	0	0	0	0	0	0	1	0	1	0	24
07/24/89	6	0	1	0	1	0	0	0	0	0	0	2	0	0	2	0	0	0	12
07/28/89	33	0	4	0	0	0	3	0	0	1	0	3	0	0	2	1	2	0	49
08/01/89	32	0	3	0	1	0	97	0	1	0	0	0	0	0	1	1	0	0	137
08/04/89	47	0	2	0	8	0	7	0	0	0	1	0	0	0	0	0	0	0	65
08/07/89	161	0	6	0	10	0	66	0	0	1	2	1	0	0	0	1	0	0	250
08/14/89	35	1	17	0	0	0	0	0	1	1	2	0	0	0	1	0	0	0	58
08/21/89	27	0	21	0	9	0	0	0	0	0	1	2	0	0	1	0	0	0	61
08/24/89	13	0	4	0	27	0	0	0	0	0	0	1	0	0	1	0	0	0	46
08/28/89	58	1	0	0	4	0	1	0	0	0	0	6	0	0	3	2	0	0	75
09/01/89	90	7	9	1	4	0	1	0	1	0	1	6	1	0	0	3	0	0	125
09/05/89	43	9	1	0	0	0	4	1	1	0	1	7	0	0	0	7	0	0	74
09/08/89	46	2	0	0	1	0	8	0	1	0	0	6	0	0	0	3	0	1	71
09/12/89	39	8	4	0	11	0	0	0	0	0	2	0	0	0	0	1	0	1	67
*** Total ***	1632	104	424	4	118	2	272	6	16	4	14	39	1	1	46	39	4	6	2742

CP=carp, CC=channel catfish, SC=sculpin, see table 1 for additional abbreviations.

white perch.

The bottom trawl did not capture large numbers of game fish at Bunge slip. Yellow perch were generally present in low numbers (mean = 1 / standard trawl). Walleye and burbot were occasionally captured at this site.

Sixteen species of fish were found at the Interstate hole site (Table 5, Appendix VI). Catch per standard 10 minute trawl ranged from 18 to 264 fish. Trout-perch were again the dominant species, comprising 74% of the catch. Mean abundance of trout-perch was 54 fish/standard trawl. Spottail shiners, emerald shiners, and rainbow smelt were captured in low numbers throughout the open water season as were johnny darters (Etheostoma nigrum).

Black bullheads were not as abundant at Interstate hole as they were at Bunge slip (mean abundance <1 fish/trawl). Ruffe, however, were more common at this site, especially in midsummer when a maximum of 22 fish were captured in 10 minutes of trawling.

Bottom trawling at Interstate hole did not result in the capture of many predatory fish species. A total of 22 walleye and 15 yellow perch were caught during 34 trawl series.

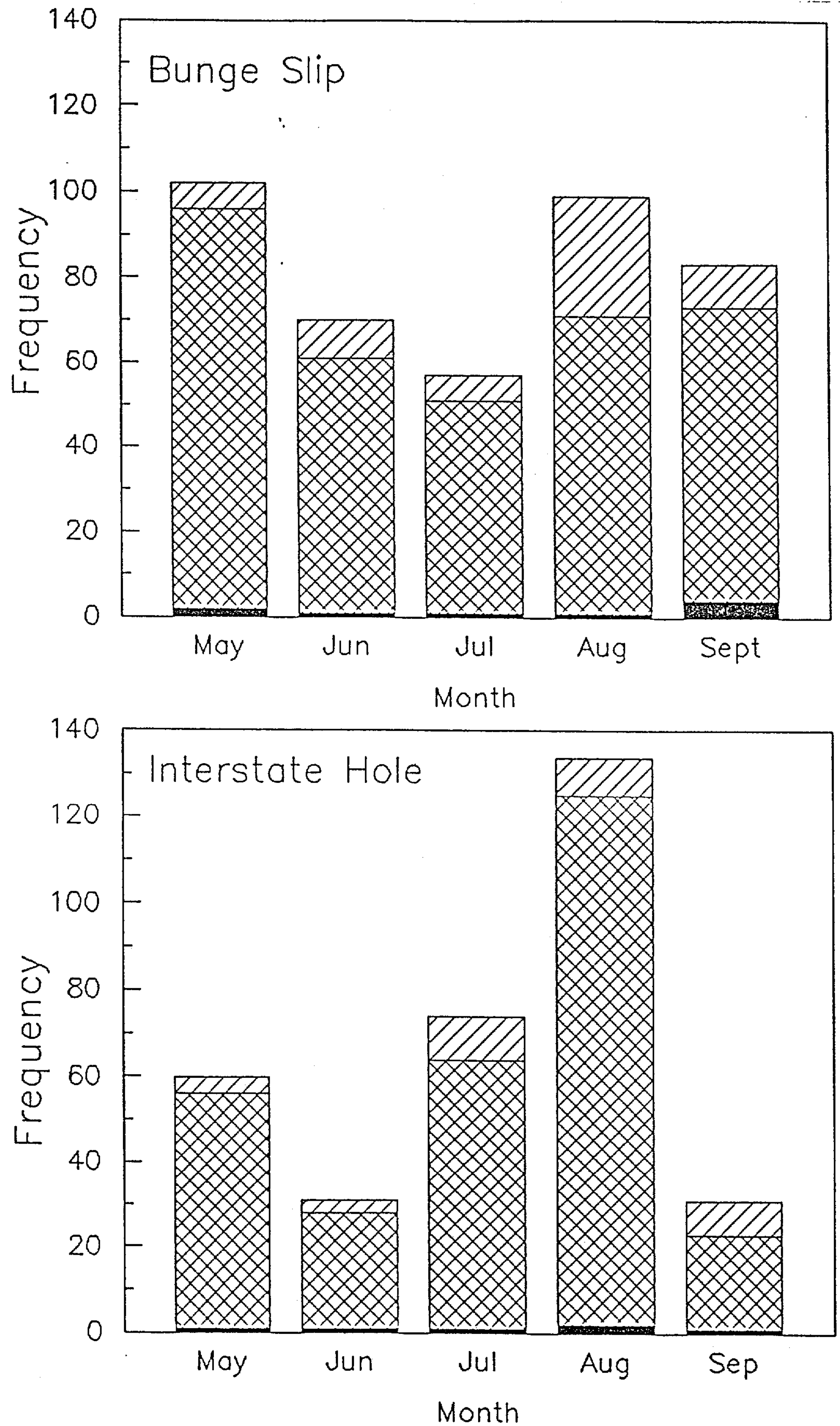
The majority of the fish captured during the summer by bottom trawling at both Bunge slip and Interstate hole were forage species (Figure 9). This is in sharp contrast to the data from gill net catches made during the same time period (Figure 8) which showed fairly low numbers of forage species during the summer months. This may have been due to the inability of the gill net to capture the small forage fish that were recruited during the summer.

Table 5. Abundance and species distribution of fish captured during 10 minutes of bottom trawling at Interstate hole.

DATE	TP	SS	ES	JD	CP	SM	LC	BH	YB	WS	RS	LNS	CC	RF	WP	SC	YP	WL	BB	TOTAL
05/07/89	113	33	0	2	0	18	0	0	1	3	0	0	0	2	0	0	2	0	0	174
05/11/89	24	3	0	3	0	25	0	0	2	3	0	1	1	0	0	0	0	0	0	62
05/13/89	15	4	0	2	0	19	0	0	0	2	0	0	0	1	0	0	0	0	0	43
05/16/89	14	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	2	0	0	19
05/20/89	18	3	30	1	1	1	0	0	0	2	0	0	1	0	0	0	0	0	0	58
05/22/89	14	4	3	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	24
05/25/89	28	3	1	1	0	0	0	0	4	2	0	0	0	0	0	0	0	0	0	39
06/01/89	40	1	0	1	0	1	0	0	2	2	0	0	0	0	0	0	3	0	0	50
06/05/89	10	0	0	1	0	0	0	0	5	0	0	0	0	0	0	0	1	0	0	17
06/09/89	21	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	24
06/15/89	30	2	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	37
06/19/89	20	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	24
06/22/89	14	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
06/26/89	35	2	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	40
06/30/89	25	1	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	3	0	34
07/03/89	34	3	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	39
07/07/89	119	0	1	0	0	4	0	0	0	0	0	0	0	5	0	0	0	1	0	130
07/10/89	80	1	2	0	0	0	0	0	0	0	0	0	0	13	0	0	0	2	0	98
07/14/89	50	0	0	0	0	1	0	0	0	0	0	0	0	22	0	0	0	0	0	73
07/17/89	27	0	1	0	0	1	0	0	0	0	0	0	0	7	0	0	0	2	0	38
07/21/89	32	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	4	0	43
07/24/89	66	1	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	74
07/28/89	83	0	0	0	0	0	0	0	0	0	0	0	2	14	0	0	0	0	0	99
08/01/89	244	1	0	3	0	0	0	1	0	0	0	0	2	17	0	1	0	0	0	264
08/04/89	304	1	0	0	0	0	0	2	0	0	0	0	0	11	0	0	1	0	0	319
08/07/89	7	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	10
08/14/89	93	0	0	2	0	0	0	0	0	1	0	0	2	13	0	1	1	7	0	120
08/21/89	36	0	3	0	0	3	0	2	0	1	0	0	0	2	0	0	0	2	0	51
08/24/89	95	1	0	3	0	0	0	1	0	0	0	0	0	3	0	0	1	0	0	104
08/28/89	56	0	9	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	68
09/01/89	16	1	0	0	0	0	0	0	2	0	0	0	1	1	0	0	1	0	0	22
09/05/89	34	1	0	2	0	0	0	0	1	0	0	0	0	5	0	0	0	0	0	43
09/08/89	9	0	0	1	0	4	0	1	0	0	0	0	0	3	0	0	0	0	0	18
09/12/89	15	1	0	0	0	3	0	0	0	0	0	0	3	16	0	0	1	0	0	39
*** Total ***	1821	68	57	26	1	83	0	8	20	19	0	1	12	161	1	2	15	22	0	2316

JD=johnny darter, CP=carp, CC=channel catfish, SC=sculpin, see table 1 for additional abbreviations.

Figure 9. Average monthly catch of game (▩), nongame (▨), and forage species (⊠) in 10 minute bottom trawls at Bunge slip and Interstate hole.



Trout-perch with total lengths of 80 to 120 mm were captured in gill nets during the winter months (Figure 10). Length frequency histograms for May which included gill net and bottom trawl data (Figure 11) confirmed the presence of this size class of fish at both sampling sites. The spring histograms also indicated that a second size class of fish (40-70 mm long) was present in the harbor area. This size class, which had probably been present during the winter, was not being caught by the gill nets.

Trawling revealed that a new year class became susceptible to capture in June when they reached lengths of 20 to 30 mm. Growth of this group of fish was evident during the summer months with modal length reaching 30 to 40 mm by August (Figure 12).

These length frequency histograms suggests that three year classes of trout-perch are present in the Duluth-Superior harbor. During their first year of life, the fish achieve lengths of 40-50 mm. They reach 70-80 mm during year two, and 90-110 mm by year three. Bottom trawls captured all three of these groups while the gill nets captured primarily three year olds.

Length frequency histograms were also made for other species of fish that were commonly collected at the two sites. Data from trawls and gill net lifts were combined in order to obtain adequate sample sizes. Adult rainbow smelt, 80-180 mm long, utilized Interstate hole during the spring spawning run (Figure 13). Although Bunge slip did not have many large smelt present in the spring, it did serve as a nursery for small numbers of young smelt

Figure 10. Length distributions of trout-perch captured between November 15, 1988 and April 30, 1989 at Bunge slip and Interstate hole.

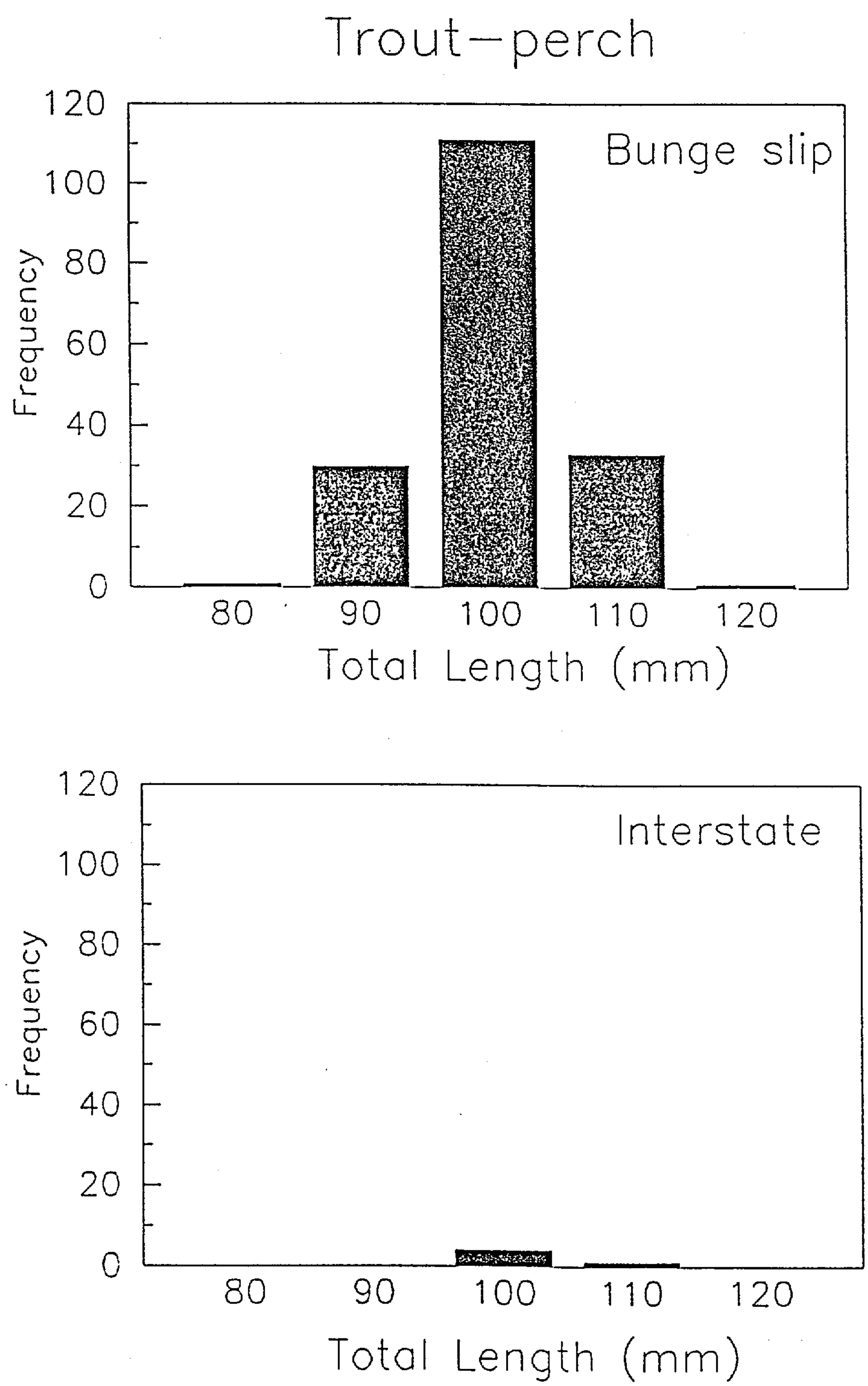


Figure 11. Length distributions of trout-perch captured during May and June, 1989 at Bunge slip and Interstate hole.

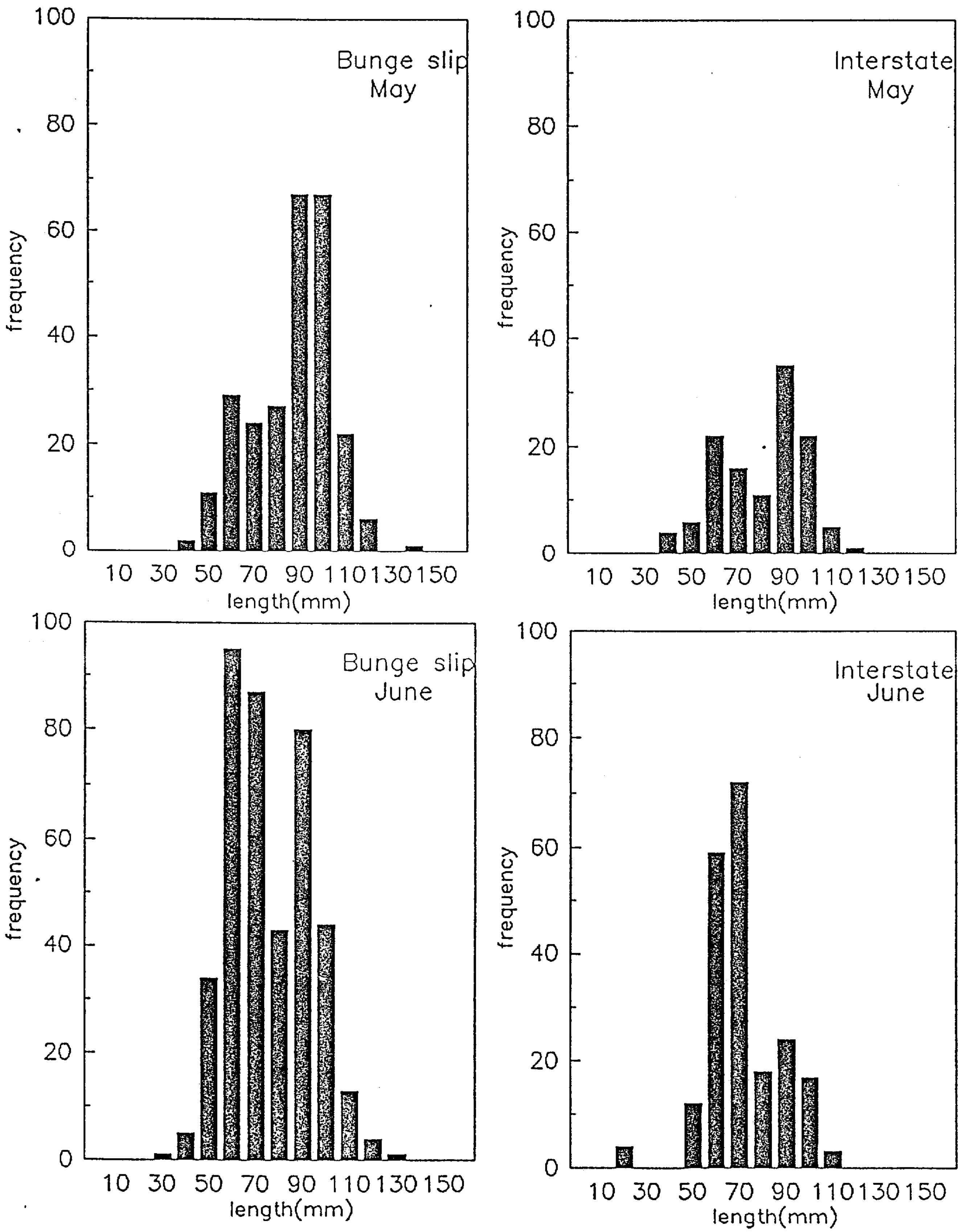


Figure 12. Length distributions of trout-perch captured during July and August, 1989 at Bunge slip and Interstate hole.

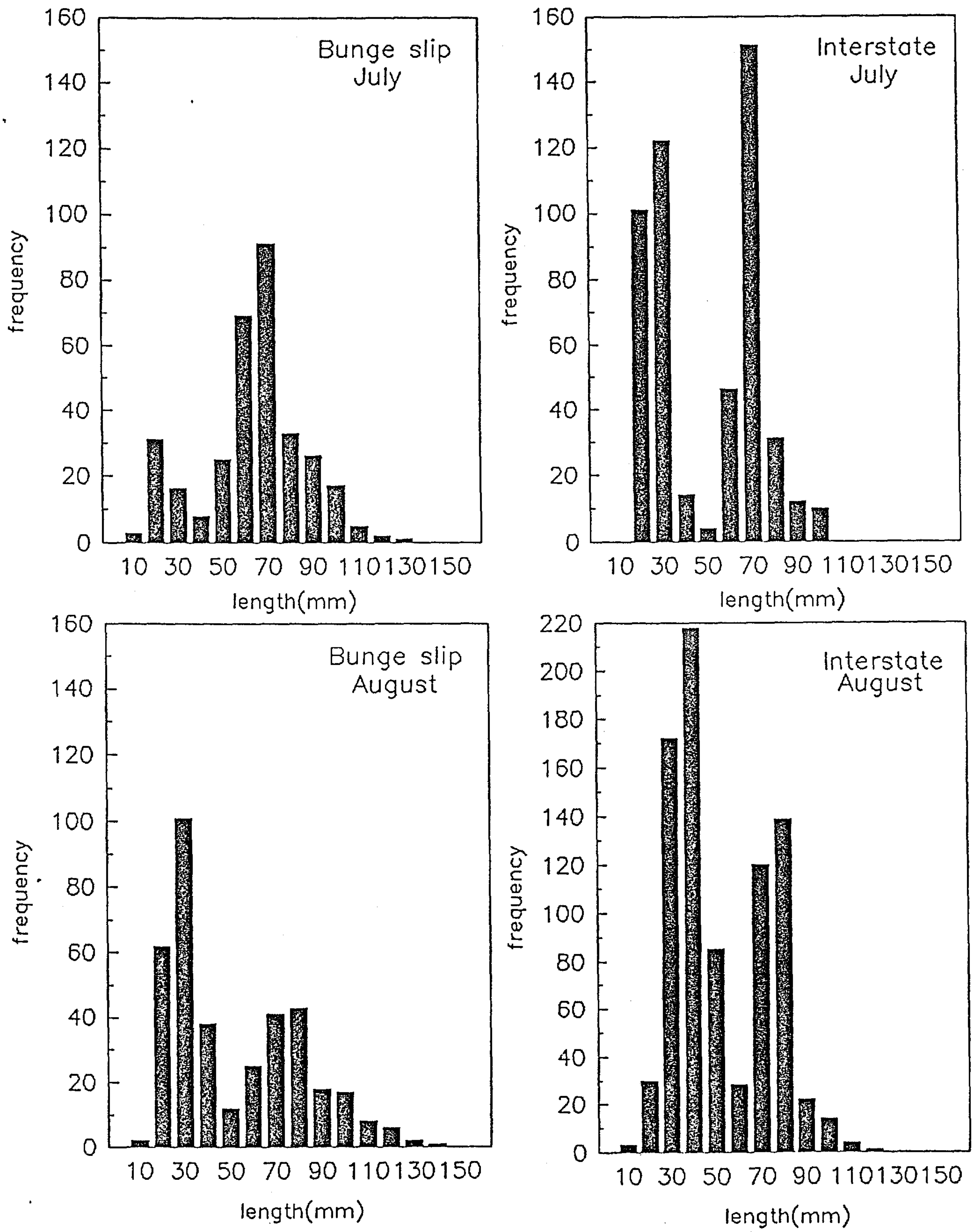
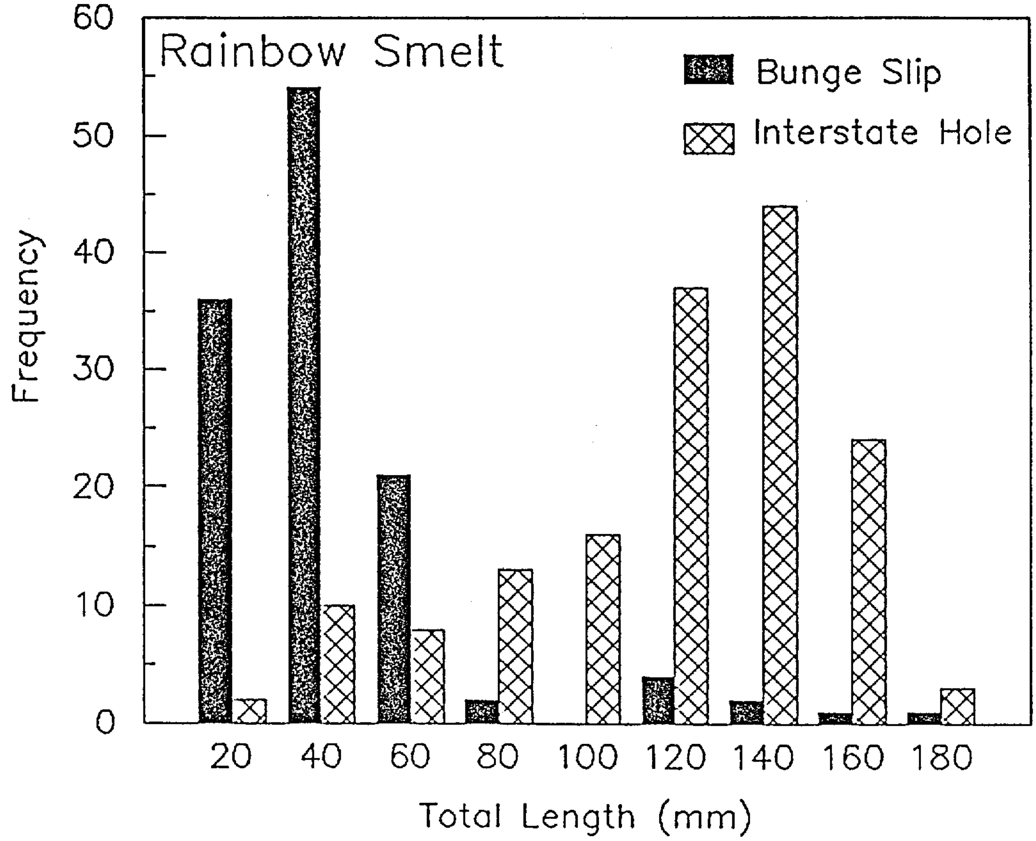
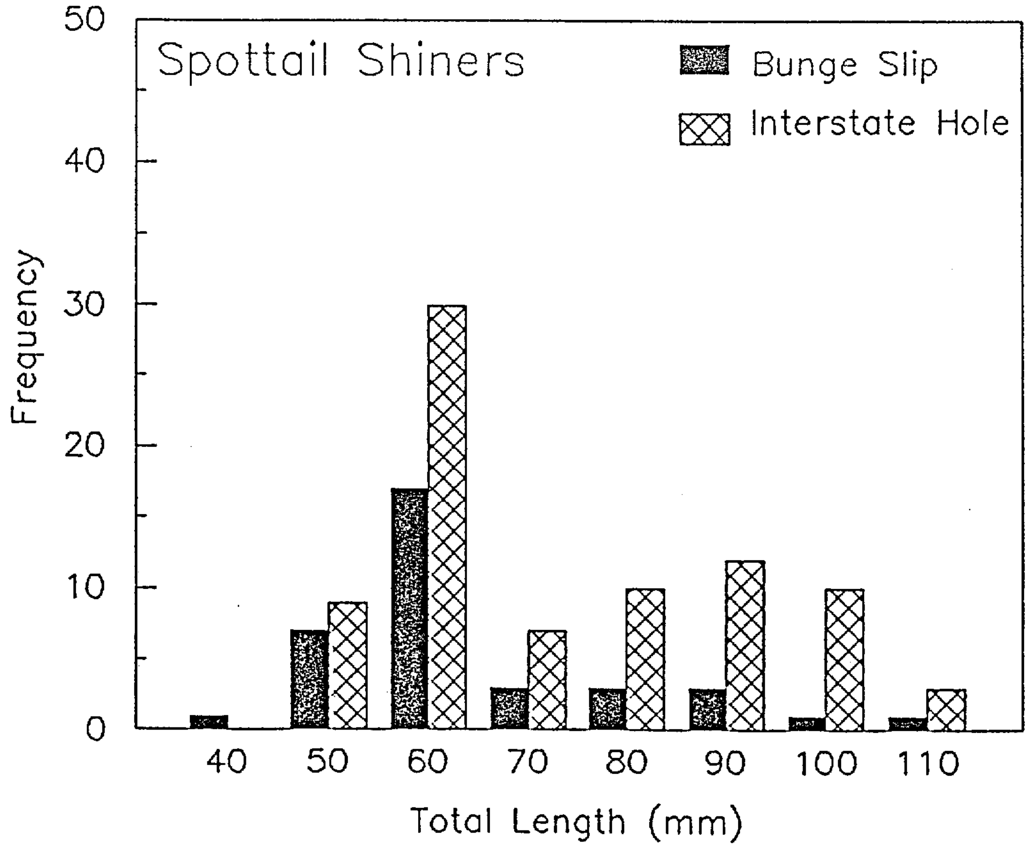


Figure 13. Length distributions of rainbow smelt and spottail shiners at Bunge slip and Interstate hole between November 1988 and September 1989.





during the summer months (Figure 13, Table 4).

The length-frequency histograms for spottail shiners (Figure 13) and emerald shiners (Figure 14) at Bunge slip are similar to those from Interstate hole with modal length of these forage species ranging from 60 to 80 mm.

Several year classes of white suckers were present at both of the sampling sites (Figure 15). Total lengths of captured fish ranged from 25 to 450 mm. Large fish (>200 mm) were generally more abundant than small fish in the samples.

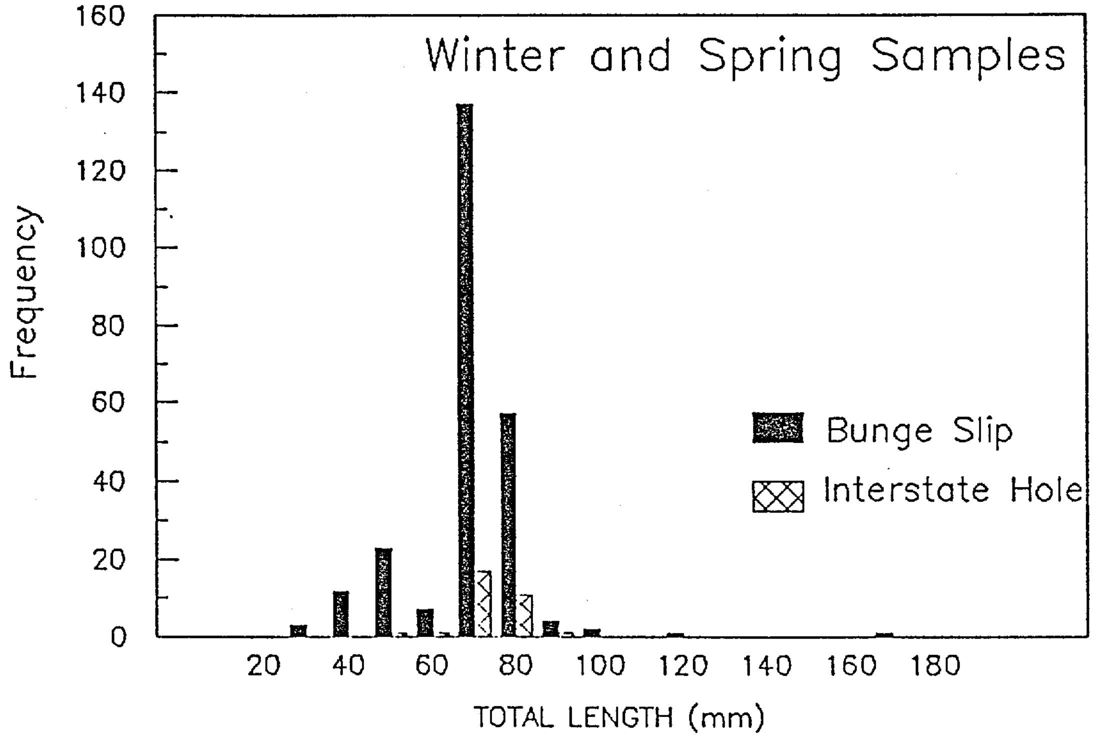
At Bunge slip bullheads were common and exhibited a modal length of 120 mm. Total lengths ranged from 20 to 280 mm (Figure 16). Although fewer bullheads were captured at Interstate hole, they had a similar length range.

DISCUSSION

Seasonal temperature profiles from Bunge slip and Interstate hole are similar to those obtained at other sites in the Duluth-Superior harbor and nearshore waters of western Lake Superior (Balcer 1981, 1988). Water temperatures were uniformly cool during the winter (0-4°C). The water column remained well mixed during the spring and summer and thermal stratification did not develop as the waters warmed. Maximum surface and bottom temperatures reached 21 and 19.5 °C, respectively.

The temperature ranges observed at the two sampling sites (4-21°C) are not restrictive for the species of fish that normally

Figure 14. Length distributions of emerald shiners captured at Bunge slip and Interstate hole during the winter and spring (November-May) and summer and fall (June-Sept).



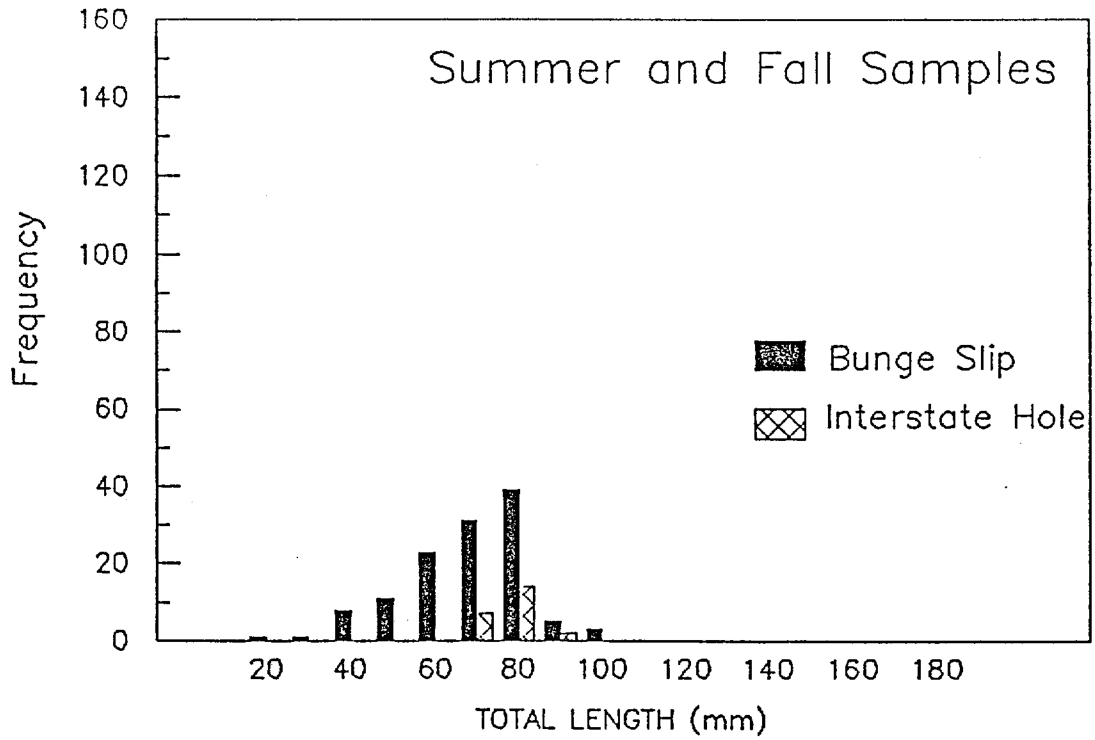


Figure 15. Length distributions of white suckers captured at Bunge slip and Interstate hole between November 1988 and September 1989.

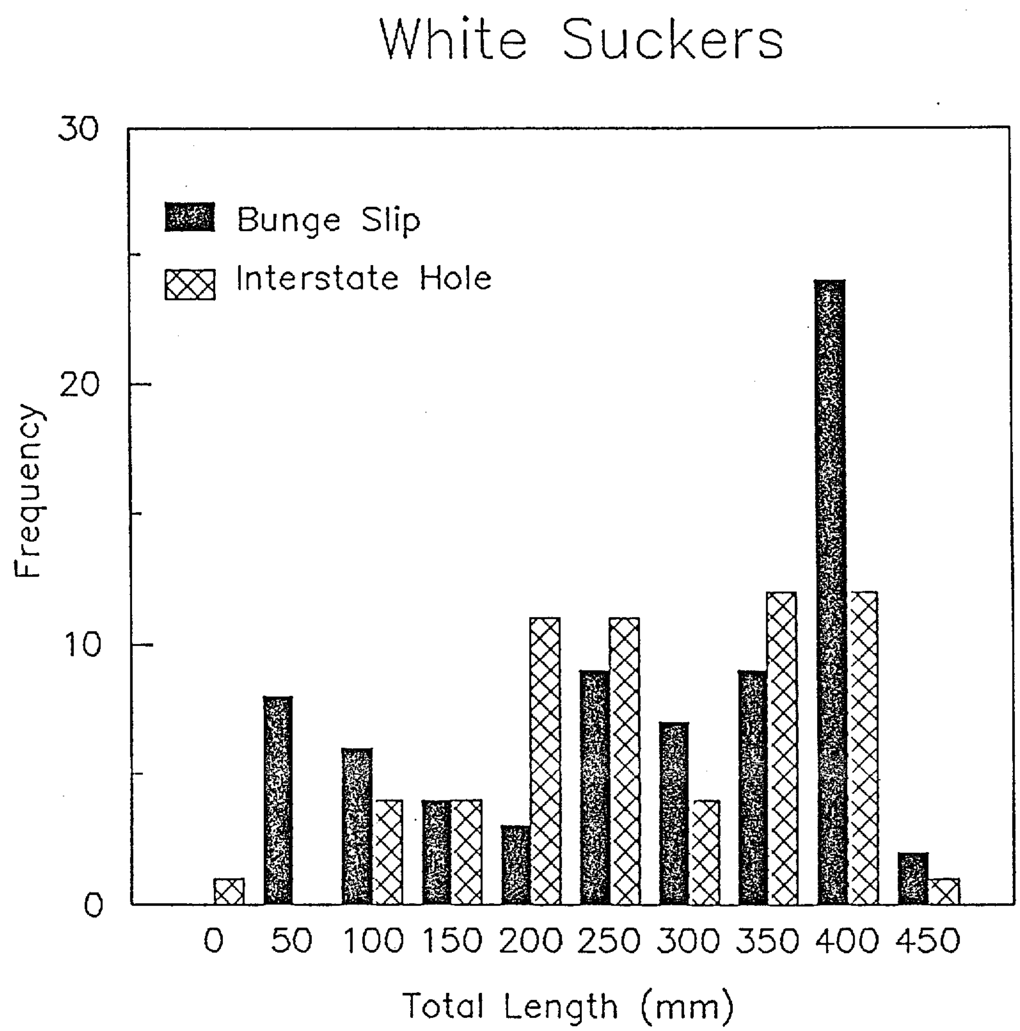
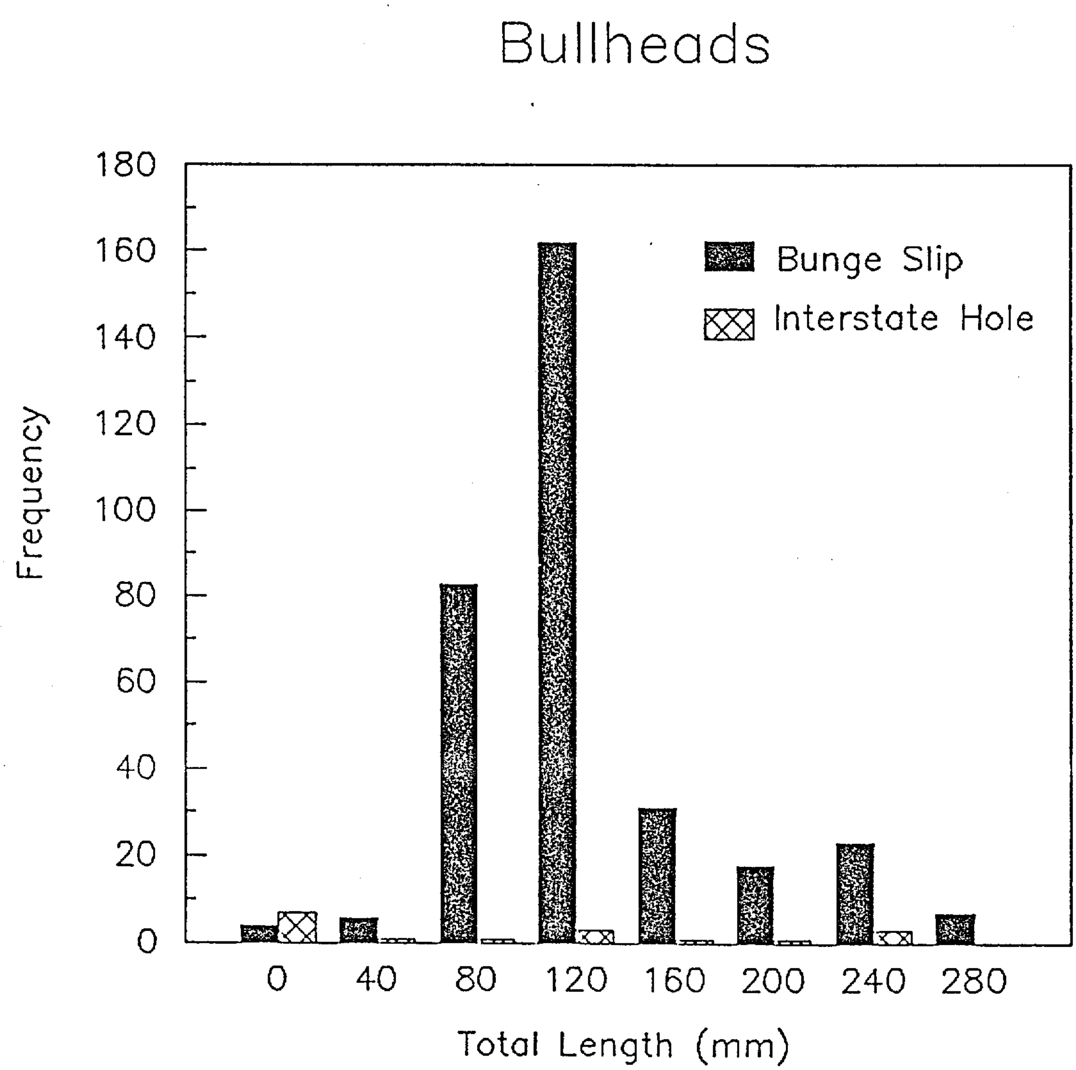


Figure 16. Length distribution of bullheads (black and yellow) captured at Bunge slip and Interstate hole between November 1988 and September 1989.



inhabit the harbor region. Becker (1983) and Scott and Crossman (1973) report that trout-perch spawn at 15.6-20°C while black bullheads prefer 21°C. Yellow perch were found inhabiting waters with temperatures of 19.7-21°C during the summer months. Studies showed that walleye were most active at temperatures between 12.8 and 23.3°C and white suckers preferred 11.8-20.6°C.

Because the water columns at the two study sites remain well mixed as they warm during the summer months, the lower water layers fail to provide refuges for cool water species such as the burbot.

During the 1970's low levels of dissolved oxygen were often found in the Duluth-Superior harbor. Devore (1978) reported concentrations of 0.3 to 2.1 ppm oxygen in February of 1977 which resulted in fish kills. Water quality has improved considerably in the past decade with oxygen levels remaining above 85% saturation during most of the year. Although the lower meter of water at Bunge slip contained only 5.9 ppm oxygen (48% saturation), the remainder of the water column had at least 9.3 ppm oxygen, quantities sufficient to support the fish populations of the region.

Catch data indicates that gill nets with meshes greater than 1 inch stretch measure generally do not adequately sample the small forage species (trout-perch and shiners). Larger species (walleye, northern pike and burbot) appeared to avoid the 16 foot bottom trawl when it was towed at speeds under 2 mph. Both types of gear captured a wide size range of bullheads, ruffe, and suckers.

The fish population of Bunge slip was quite similar to that of Interstate hole. Trout-perch, suckers, yellow perch, walleye, and ruffe were found throughout the year at both sites. Adult smelt were present in large numbers at Interstate hole during the spring spawning season. Although fewer adult smelt were found at Bunge slip in the spring, this site served as a nursery for small numbers of young smelt throughout the summer. Bunge slip had a larger resident population of bullheads and emerald shiners than Interstate hole.

Data from this study were compared to results from previous studies conducted by UW-S, the Wisconsin Department of Natural Resources, and the U.S. Fish and Wildlife Service (Devore 1978). During the summer months (June-September) of 1973 through 1978 the three agencies set gill nets at several sites in the Duluth-Superior harbor. These sites included shallow, nearshore waters. The standard nets employed consisted of 50 foot panels of 1, 1.5, 2, 3, and 4 inch stretch mesh. Twenty-four hour net sets were standard. Abundance of the non-forage species was reported as catch per meter of gill net set. For comparison purposes, data from our study and from the previous studies were converted to catch per 100 feet of gill net set (Table 6). Species composition was also expressed as a percent of the total catch excluding forage species.

The species composition at the two deep water sites examined in 1989 was comparable to that found at the sites examined between 1973 and 1978. Yellow perch and white suckers were the most common non-forage species. Total catch (number/100 feet) was a bit lower

Table 6. Comparison of catch per unit effort (CPUE = number per 100 feet of gill net) for major non-forage species collected at Bunge slip and Interstate hole in the summer of 1989 and at other sites in the Duluth-Superior harbor sampled during the summers of 1973 through 1978.

	Bunge Slip		Interstate hole		Harbor sites	
Species	CPUE	% catch	CPUE	% catch	CPUE	% catch
Yellow perch	6.6	43	2.1	29	10.4	35
Suckers	3.4	22	2.7	38	7.1	24
Bullheads	3.5	23	0.4	6	7.8	26
Walleye	0.3	2	1.0	15	1.5	5
Northern Pike	0.1	1	0.2	2	2.4	8
Total	13.9		6.4		29.3	

at Bunge slip and Interstate hole than at the other sampling sites which contained shallower water.

The U.S. Fish and Wildlife Service provided data from a series of bottom trawls that were made in dredged channels of the Duluth-Superior harbor between June and August of 1989 (J. Selgeby, USFWS-Ashland, WI., personal communication). The trawl used by the Fish and Wildlife Service was similar to the one used in this study and was towed at an average speed of 1.9 mph. All trawl data was converted to catch per 5 minutes of trawling in order to allow comparisons of the results (Table 7). Both forage and non-forage species were captured by the trawl. Net avoidance by larger fish may have led to the predominance of forage species in the catch. Forage fish made up between 76 and 88% of the catch in all sample areas. Species composition at Bunge slip and Interstate hole, as determined by bottom trawling, was very similar to that observed in other deep-water dredged channels in the harbor. The higher catch rate observed at the Fish and Wildlife Service sites may have been due to their slightly faster average trawling speed.

Table 7. Comparison of average catch per unit effort (CPUE = number per 5 minute trawl) for Bunge slip, Interstate hole, and dredged channels in the Duluth-Superior harbor between June 12 and August 14, 1989.

Species	Bunge Slip (n=17)		Interstate hole (n=17)		Dredged channels (n=50)	
	CPUE	% catch	CPUE	% catch	CPUE	% catch
Trout-perch	24.9	66.4	34.8	85.3	36.4	68.0
Emerald shiner	1.8	4.8	0.3	0.7	3.5	6.5
Spottail shiner	0.2	0.5	0.4	1.0	1.9	3.6
Johnny darter	-	-	0.2	0.5	0.5	0.9
Rainbow smelt	1.6	4.3	0.3	0.7	2.0	3.7
Total forage species	28.5	76.0	36.0	88.2	44.3	82.8
Bullheads	6.7	17.9	0.1	0.2	1.4	2.6
Ruffe	0.3	0.8	3.6	8.8	4.2	7.9
White sucker	0.1	0.3	0.1	0.2	0.9	1.6
Channel catfish	0.2	0.5	0.2	0.5	1.3	2.4
Sculpin	1.2	3.2	0.1	0.2	0.1	0.2
Total non-game species	8.5	22.7	4.1	10.0	8.0	14.9
Yellow perch	0.3	0.8	0.1	0.2	0.5	0.9
Walleye	0.1	0.1	0.6	1.5	0.6	1.1
Burbot	0.1	0.3	-	-	0.1	0.2
Total game species	0.5	1.3	0.7	1.7	1.2	2.2
Total Catch	37.5		40.8		53.5	

SUMMARY

1. Water quality at Bunge slip and Interstate hole is quite good, with adequate levels of dissolved oxygen present at all depths. The water columns remain well mixed during the summer months with water temperatures approaching 20°C. Although this temperature range is suitable for most harbor species, no refuge exists near the bottom for cold water species.

2. Numerically, forage species (trout-perch in particular) dominate the fish populations at both Bunge slip and Interstate hole. Suckers, ruffe, yellow perch, and walleye are present at both sites in low numbers throughout the year. Moderate numbers of adult rainbow smelt pass through Interstate hole during the spring spawning season. Young smelt use Bunge slip as a nursery through the summer. Bunge slip contains a larger resident population of bullheads than Interstate hole.

3. Comparisons of trawl data from Bunge slip and Interstate hole with data from other studies reveal that summer abundance and species composition of the populations at the two study areas are similar to each other and to those found in deep-water dredged channels in the Duluth-Superior harbor. Abundance of non-forage species captured in gill nets at shallower sites in the harbor during the summers of 1973-1978 was higher than in the two deep-water sites under investigation in 1989.

REFERENCES

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Becker, G.C. 1983. Fishes of Wisconsin. University of Wisconsin Press. Madison, WI.

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Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada. Bulletin 184. Fisheries Research Board of Canada.

VI. CROSS CHANNEL AND BUNGE SLIP SEDIMENT ANALYSIS

VI. CROSS CHANNEL AND BUNGE SLIP SEDIMENT ANALYSIS

This section of the report is represented by the final report of Twin City Testing Corporation. The report is found here in it's entirety.

GEOTECHNICAL & CHEMICAL ANALYSIS

POTENTIAL DREDGE DISPOSAL SITES

BUNGE PIER LOCATION

SUPERIOR, WISCONSIN

8400 89-204

1.0 INTRODUCTION

1.1 Project Information

This potential dredge disposal site exists in the slip area on the west side of Bunge Pier in Superior, Wisconsin. The need for this analysis is to determine if any contaminants exist at the site that may be stirred up if dredge materials are dumped there.

In accordance with your acceptance of our January 25, 1989 proposal for the project, we have performed a geotechnical and chemical analysis program.

1.2 Scope of Services

As noted in our January 25, 1989 proposal, our work scope for this project is limited to the following:

1. Sample the soils in four locations along the Bunge Pier by driving a split barrel sampler into the lake bottom.

2. Perform a limited number of laboratory tests on selected samples directed towards obtaining pertinent engineering characteristics with emphasis on grain size distribution and material classification.

3. Send selected samples to our St Paul laboratory for chemical analysis which was designed to look for potential contamination such as PCB´s and metals.

4. Submit a factual report including logs of the test borings, a sketch illustrating the boring locations and surface elevations along with the results of our laboratory testing.

1.3 Purpose

The purpose of this report is to present the findings of our field and laboratory programs.

2.0 EXPLORATION PROGRAM RESULTS

2.1 Exploration Scope

The four samples for the project were taken on February 16, 1989. They were taken at locations selected by us, as illustrated on the sketches included in the Appendix.

The samples were taken over the ice and the water depths and soil conditions at the hole locations are as follows:

Boring 89-01

0 - 2 1/2′	Ice
2 1/2 - 23′	Water
23 - 24 1/2′	Silt, brown, organic*
24 1/2 - 25′	Silty Sand, brown, w/organics

* Non-plastic

Boring 89-02

0 - 2 1/2′	Ice
2 1/2 - 23′	Water
23 - 24 1/2′	Silt, brown, organic
24 1/2 - 25′	Silt w/sand, brown, w/organics

Boring 89-03

0 - 2′	Ice
2 - 4 1/2′	Water
4 1/2 - 6 1/2′	Lean Clay, brown, organic*

* LL-29, PL-20, PI-9

Boring 89-04

0 - 2′	Ice
2 - 4 1/2′	Water
4 1/2 - 5.7′	Lean Clay, brown, organic
5.7 - 6 1/2′	Sand, brown, fine to medium grained

2.2 Laboratory Test Program

The laboratory testing program for the project consisted of performing four hydrometer tests and two atterberg limits tests in our Duluth lab to determine the particle size distribution of the soils. In addition, chemical tests for detection of contaminants such as PCB′s, metals and dioxins were performed on two samples by our St Paul lab. The results of all tests are included in the appendices. Appendix B includes a copy of our St Paul laboratory′s report.

2.3 Data Review

The results of all tests are included in the appendices. The results of the classification tests indicate that the soils encountered on the lake bottom consist of sandy silts or silt materials. The results of the chemical tests are shown in the TCT St Paul report. The tests results for dioxins, PCB´b, metals and other miscellaneous substances are included in tables 5, 6, 7 and 8, respectively. We understand you will be reviewing the concentration levels of these substances.

3.0 FIELD EXPLORATION PROCEDURES

3.1 Soil Sampling

Soil Sampling was performed by driving a split barrel sampler into the lake bottom and extracting by hand.

3.2 Soil Classification

As the samples were obtained in the field, they were visually and manually classified by the crew chief in accordance with ASTM:D-2487-85 and D2488. Representative portions of the samples were then returned to the laboratory for further examination and for verification of the field classification.

This report was prepared by: Kris Lyytinen
Kris Lyytinen, EIT
Geotechnical Engineer

Under the direct supervision of: Thomas G. Krzewinski
Thomas G Krzewinski, PE
Regional Geotechnical Engineer

Proofread by: [signature]

Job No. 8400 89-204

Boring No. 89-1 Sample No. ______ Depth: 23 - 25'

Classification (ASTM:D2487-66T, D2488-66T) SM

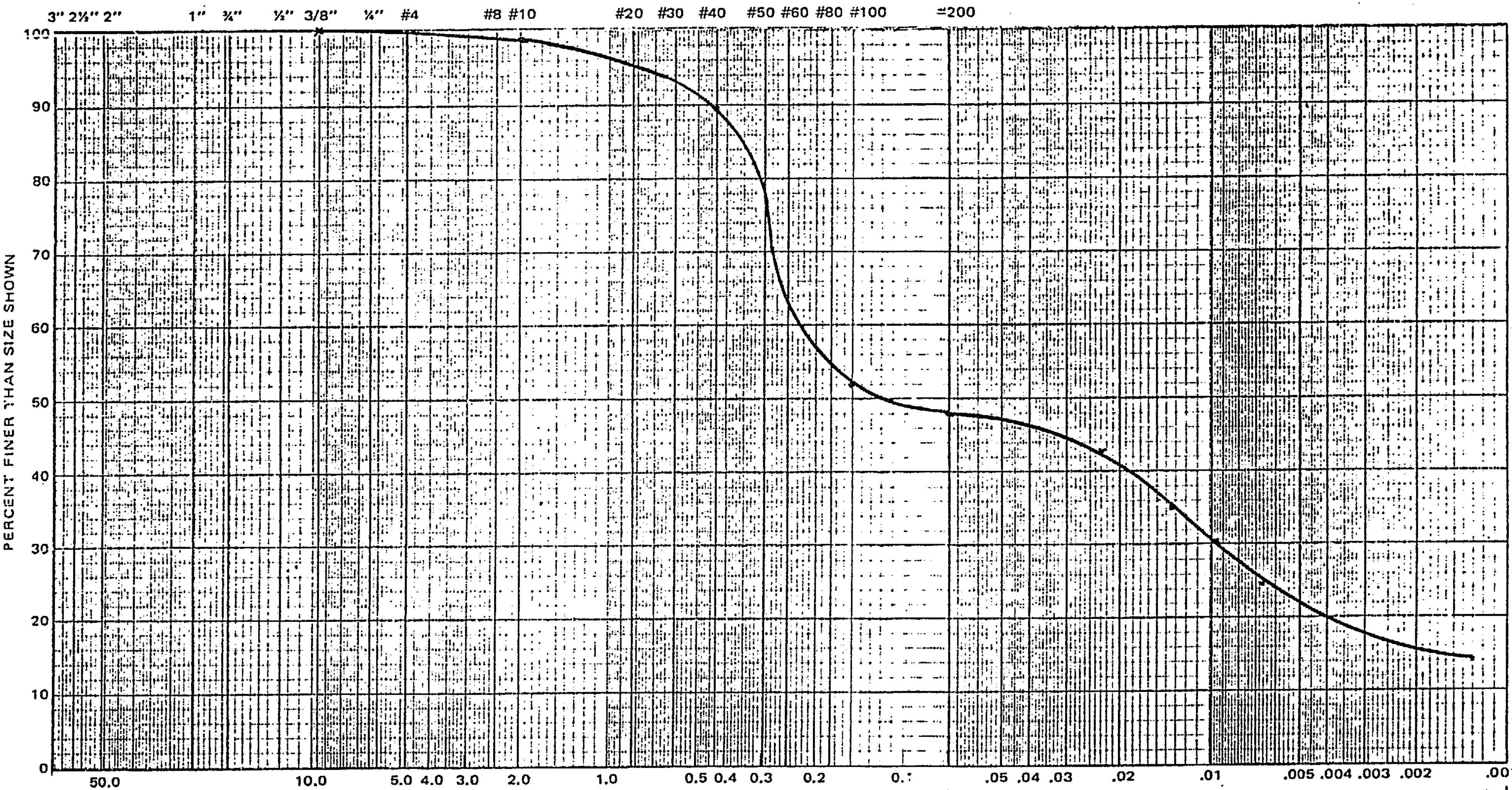
Description SILTY SAND, brown, w/organics

lakehead testing laboratory, inc.
226 NORTH CENTRAL AVENUE
P.O. BOX 7168
DULUTH, MN 55807
PHONE 218 628-2295

Project: POTENTIAL DREDGE DISPOSAL SITE
BUNGE SLIP - SUPERIOR, WISCONSIN

Reported To: Northwest Regional Planning Commission

GRAIN SIZE DISTRIBUTION CURVE



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

Job No. 8400 89-204

Boring No. 89-02 Sample No. ______ Depth: 23 - 25'

Classification (ASTM:D2487-66T, D2488-66T) ML

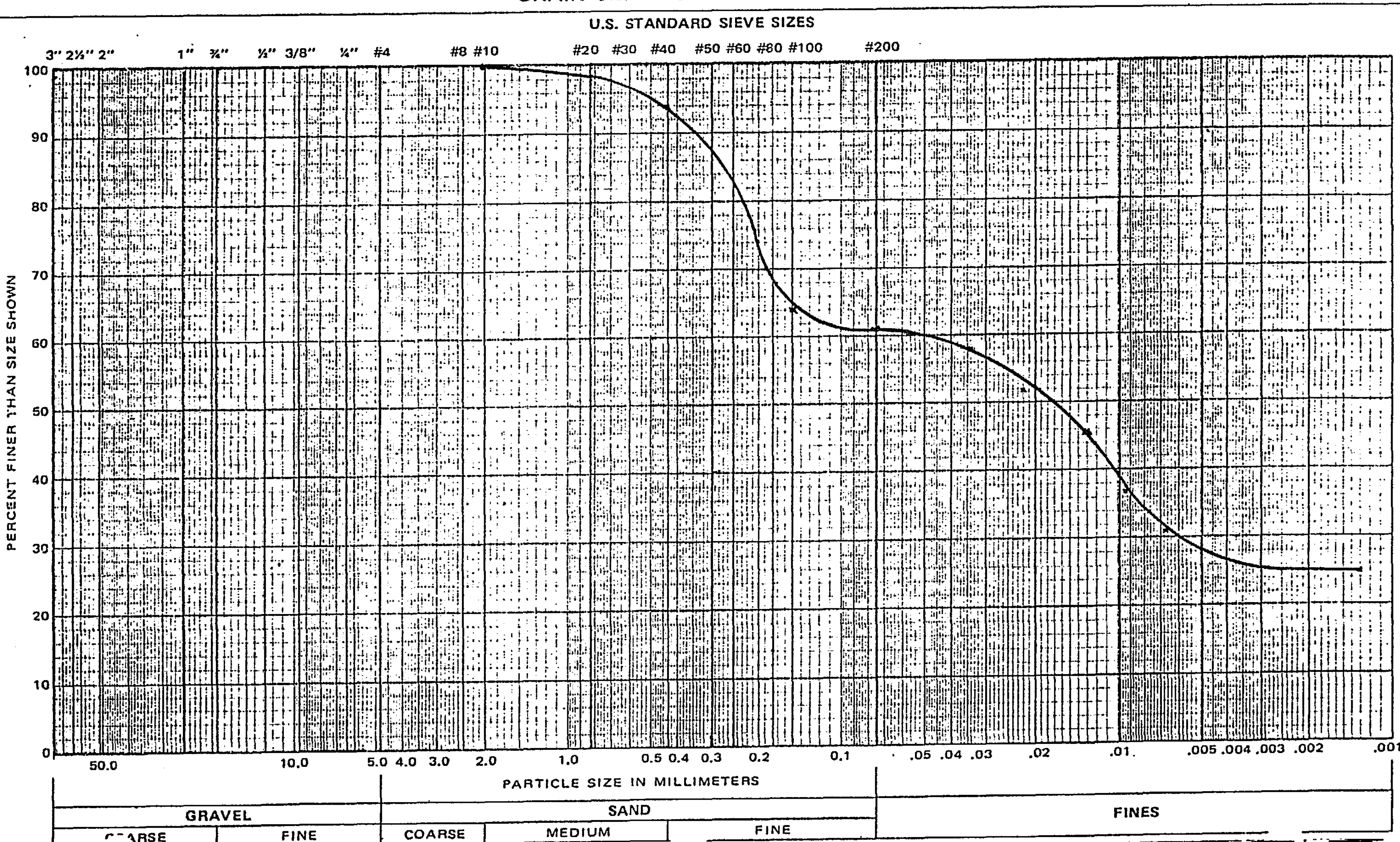
Description SILT, w/sand, w/organics

lakehead testing laboratory, inc.
226 NORTH CENTRAL AVENUE
P O BOX 7168
DULUTH, MN. 55807
PHONE 218/628-2295

Project: POTENTIAL DREDGE DISPOSAL SITE
BUNGE SLIP - SUPERIOR, WISCONSIN

Reported To: Northwest Regional Planning Commission

GRAIN SIZE DISTRIBUTION CURVE



Job No. 8400 89-204

Boring No. 89-03 Sample No. ______ Depth: $4\frac{1}{2}$ - $6\frac{1}{2}$'

Classification (ASTM:D2487-66T, D2488-66T) ML

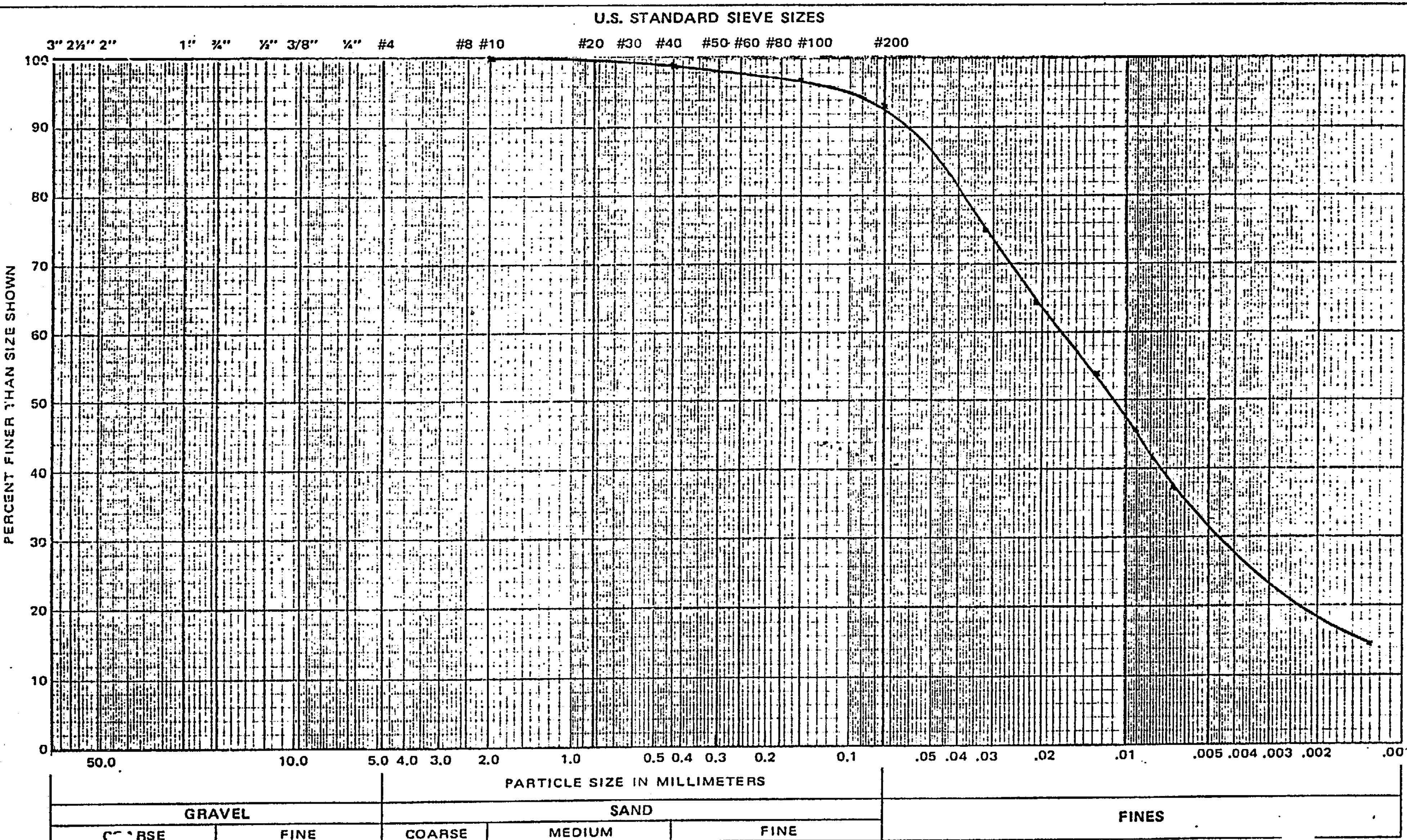
Description SILT, brown, w/organics

lakehead testing laboratory, inc.
226 NORTH CENTRAL AVENUE
P O BOX 7168
DULUTH, MN. 55807
PHONE 218/628-2295

Project: POTENTIAL DREDGE DISPOSAL SITE
BUNGE SLIP - SUPERIOR, WISCONSIN

Reported To: NOrthwest Regional Planning Commission

GRAIN SIZE DISTRIBUTION CURVE



Job No. 8400 89-204

Boring No. 89-05 Sample No. ______ Depth: 4½ - 6½'

Classification (ASTM:D2487-66T, D2488-66T) ML

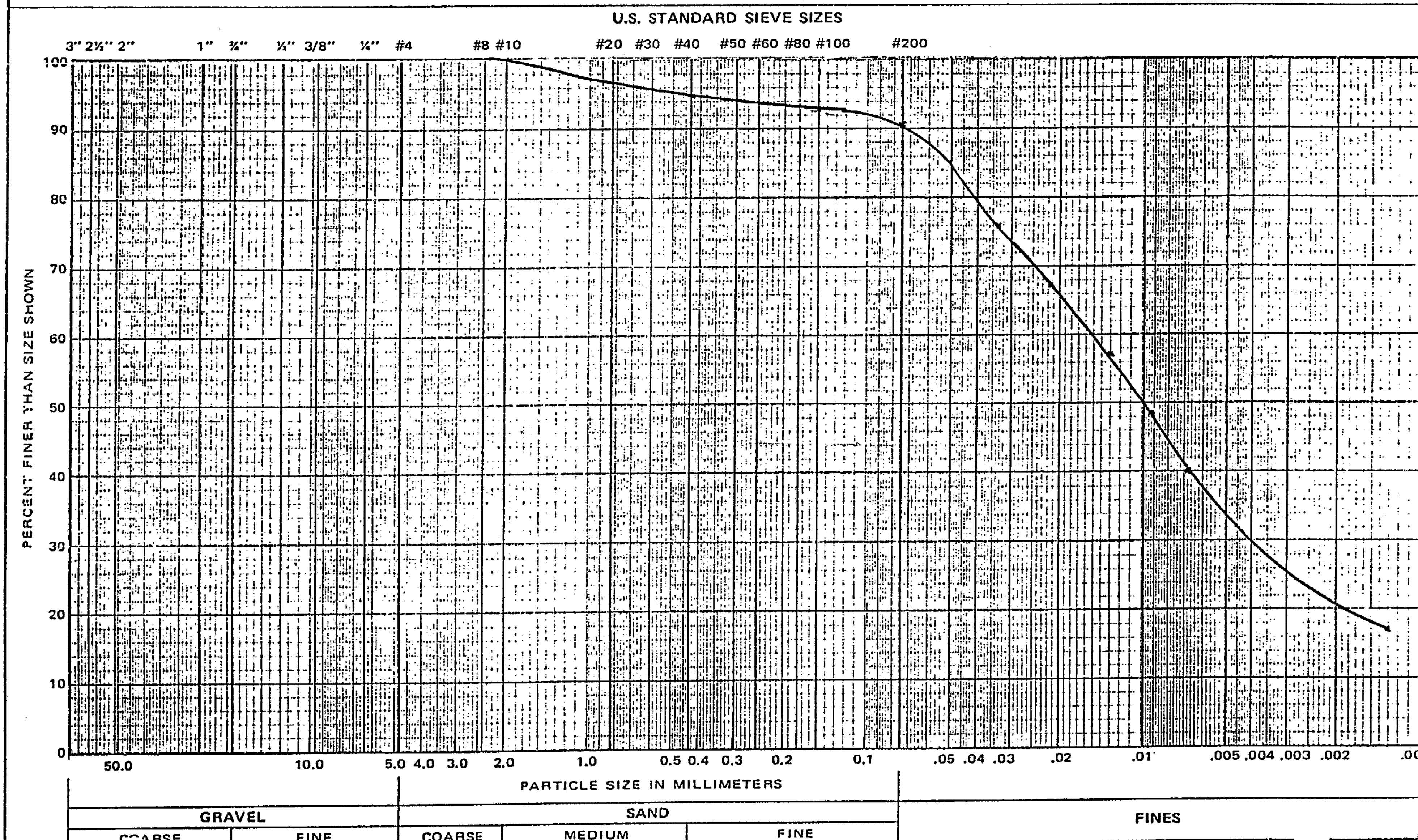
Description SILT, brown; w/organics

lakehead testing laboratory, inc.
226 NORTH CENTRAL AVENUE
P O BOX 7168
DULUTH, MN. 55807
PHONE 218-628-2295

Project: POTENTIAL DREDGE DISPOSAL SITE
BUNGE SLIP - SUPERIOR, WISCONSIN

Reported To: Northwest Regional Planning Commission

GRAIN SIZE DISTRIBUTION CURVE



GENERAL NOTES

DRILLING AND SAMPLING SYMBOLS

SYMBOL	DEFINITION
HSA	3 1/4" I.D. Hollow Stem Auger
_FA	4", 6" or 10" Diameter Flight Auger
_HA	2", 4" or 6" Hand Auger
_DC	2 1/2", 4", 5" or 6" Steel Drive Casing
_RC	Size A, B, or N Rotary Casing
PD	Pipe Drill or Cleanout Tube
CS	Continuous Split Barrel Sampling
DM	Drilling Mud
JW	Jetting Water
SB	2" O.D. Split Barrel Sample
_L	2 1/2" or 3 1/2" O.D. SB Liner Sample
_T	2" or 3" Thin Walled Tube Sample
3TP	3" Thin Walled Tube (Pitcher Sampler)
_TO	2" or 3" Thin Walled Tube (Osterberg Sampler)
W	Wash Sample
B	Bag Sample
P	Test Pit Sample
_Q	BQ, NQ, or PQ Wireline System
_X	AX, BX, or NX Double Tube Barrel
CR	Core Recovery - Percent
NSR	No Sample Recovered, classification based on action of drilling equipment and/or material noted in drilling fluid or on sampling bit.
NMR	No Measurement Recorded, primarily due to presence of drilling or coring fluid.
▼	Water Level Symbol

TEST SYMBOLS

SYMBOL	DEFINITION
W	Water Content - % of Dry Wt. - ASTM D 2216
D	Dry Density - Pounds Per Cubic Foot
LL, PL	Liquid and Plastic Limit - ASTM D 4318

Additional Insertions in Last Column

SYMBOL	DEFINITION
Qu	Unconfined Comp. Strength-psf - ASTM D 2166
Pq	Penetrometer Reading - Tons/Square Foot
Ts	Torvane Reading - Tons/Square Foot
G	Specific Gravity - ASTM D 854
SL	Shrinkage Limits - ASTM D 427
OC	Organic Content - Combustion Method
SP	Swell Pressure - Tons/Square Foot
PS	Percent Swell
FS	Free Swell - Percent
pH	Hydrogen Ion Content, Meter Method
SC	Sulfate Content - Parts/Million, same as mg/L
CC	Chloride Content - Parts/Million, same as mg/L
C*	One Dimensional Consolidation - ASTM D 2435
Qc*	Triaxial Compression
D.S.*	Direct Shear - ASTM D 3080
K*	Coefficient of Permeability - cm/sec
D*	Dispersion Test
DH*	Double Hydrometer - ASTM D 4221
MA*	Particle Size Analysis - ASTM D 422
R	Laboratory Resistivity, in ohm - cm - ASTM G 57
E*	Pressuremeter Deformation Modulus - TSF
PM*	Pressuremeter Test
VS*	Field Vane Shear - ASTM D 2573
IR*	Infiltrometer Test - ASTM D 3385
RQD	Rock Quality Designation - Percent

* See attached data sheet or graph

WATER LEVEL

Water levels shown on the boring logs are the levels measured in the borings at the time and under the conditions indicated. In sand, the indicated levels may be considered reliable ground water levels. In clay soil, it may not be possible to determine the ground water level within the normal time required for test borings, except where lenses or layers of more pervious waterbearing soil are present. Even then, an extended period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol for cohesive or mixed texture soils may not indicate the true level of the ground water table. Perched water refers to water above an impervious layer, thus impeded in reaching the water table. The available water level information is given at the bottom of the log sheet.

DESCRIPTIVE TERMINOLOGY

DENSITY TERM	"N" VALUE	CONSISTENCY TERM
Very Loose	0-4	Soft
Loose	5-8	Medium
Medium Dense	9-15	Rather Stiff
Dense	16-30	Stiff
Very Dense	Over 30	Very Stiff

Standard "N" Penetration: Blows Per Foot of a 140 Pound Hammer Falling 30 inches on a 2 inch OD Split Barrel Sampler

Lamination	Up to 1/2" thick stratum
Layer	1/2" to 6" thick stratum
Lens	1/2" to 6" discontinous stratum, pocket
Varved	Alternating laminations of clay, silt and/or fine grained sand, or colors thereof
Dry	Powdery, no noticeable water
Moist	Below saturation
Wet	Saturated, above liquid limit
Waterbearing	Pervious soil below water

RELATIVE GRAVEL PROPORTIONS

CONDITION	TERM	RANGE
Coarse Grained Soils	A little gravel	2 - 14%
	With gravel	15 - 49%
Fine Grained Soils		
15-29% + No. 200	A little gravel	2 - 7%
15-29% + No. 200	With gravel	8 - 29%
30% + No. 200	A little gravel	2 - 14%
30% + No. 200	With gravel	15 - 24%
30% + No. 200	Gravelly	16 - 49%

RELATIVE SIZES

Boulder	Over 12"
Cobble	3" - 12"
Gravel	
Coarse	3/4" - 3"
Fine	#4 - 3/4"
Sand	
Coarse	#4 - #10
Medium	#10 - #40
Fine	#40 - #200
Silt & Clay	– #200, Based on Plasticity

SE-4 (84-C)

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES
ASTM Designation: D 2487 - 85
(Based on Unified Soil Classification System)

SOIL ENGINEERING

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic clay[K,L,M,N] Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic clay[K,L,M,P] Organic silt[K,L,M,Q]
Highly organic soils Fibric Peat > 67% Fibers		Primarily organic matter, dark in color, and organic odor Hemic Peat 33%-67% Fibers		PT	Peat Sapric Peat < 33% Fibers

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥30% plus no. 200, predominantly sand, add "sandy" to to group name.

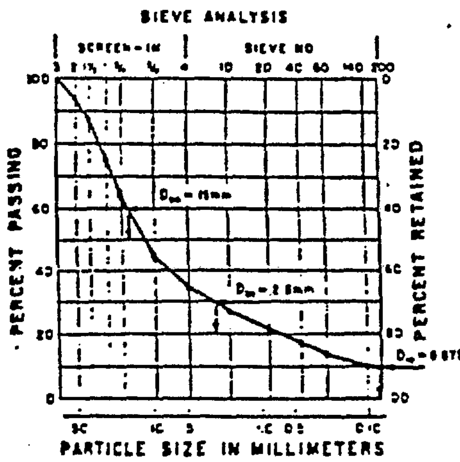
[M] If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

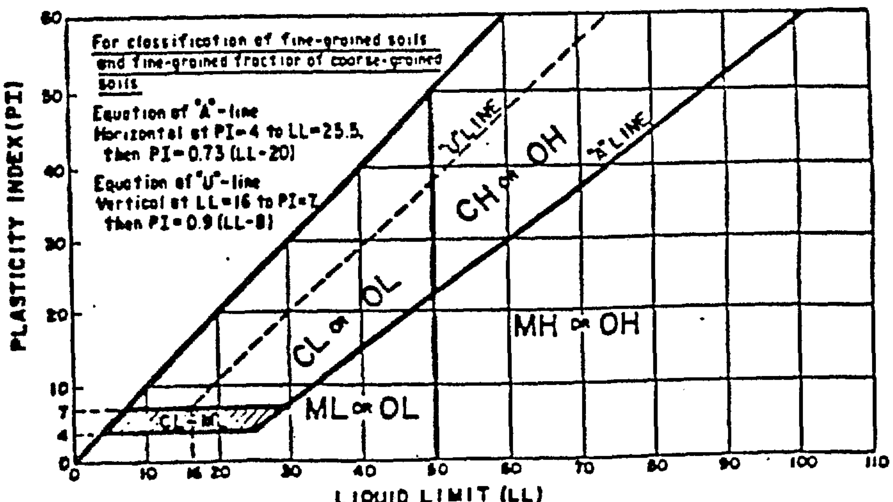
[O] PI < 4 or plots below "A" line.

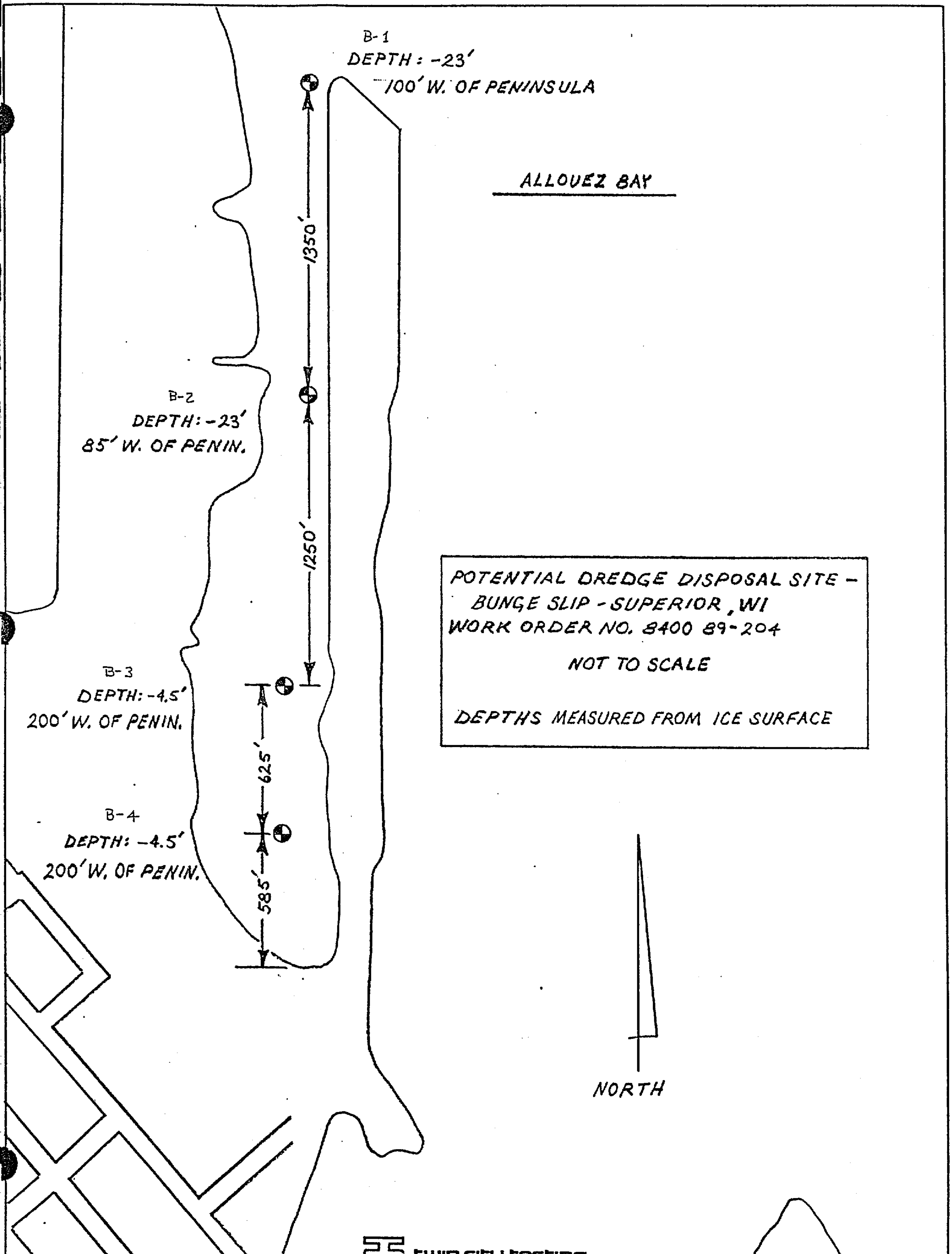
[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



$C_u = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200 \qquad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$





twin city testing

GEOTECHNICAL & CHEMICAL ANALYSIS

POTENTIAL DREDGE DISPOSAL SITES

CROSS CHANNEL HOLE - ST LOUIS BAY

SUPERIOR, WISCONSIN

8400 89-204

1.0 INTRODUCTION

1.1 Project Information

The potential dredge disposal site lies in the center of St Louis Bay on the Wisconsin side. The need for this analysis is to determine if any contaminants exist on the lake bottom at this location that may be stirred up if dredge materials are disposed of there.

In accordance with your acceptance of our January 25, 1989 proposal for the project, we have performed a geotechnical and chemical analysis program.

1.2 Scope of Services

As noted in our January 25, 1989 proposal, our work scope for this project is limited to the following:

1. Sample the soils in five locations in cross channel hole by driving a split barrel sampler into the lake bottom.

2. Perform a limited number of laboratory tests on selected samples directed towards obtaining pertinent engineering characteristics with emphasis on grain size distribution and material classification.

3. Send selected samples to our St Paul laboratory for chemical analysis which was designed to look for potential contamination such as PCB´s, dioxins, metals, etc.

4. Submit a factual report including logs of the test borings, a sketch illustrating the boring locations and surface elevations along with the results of the laboratory testing.

1.3 Purpose

The purpose of this report is to present the findings of our field and laboratory program.

2.0 EXPLORATION PROGRAM RESULTS

2.1 Exploration Scope

The five samples for the project were taken on February 20, 1989. They were taken at locations selected by us, as illustrated on the sketches included in the Appendix.

The samples were taken over the ice and the water depths and soil conditions at the hole locations are as follows:

Boring 89-01

0 - 2 1/2´	Ice
2 1/2 - 31 1/2´	Water
31 1/2 - 32 1/2´	Sandy Silt, greyish brown, organic
32 1/2 - 33 1/2´	Silty Sand, brown, fine grained, w/organics

Boring 89-02

0 - 2 1/2´	Ice
2 1/2 - 33 1/2´	Water
33 1/2 - 34 1/2´	Sandy Silt, greyish brown, organic*
34 1/2 - 35 1/2´	Silty Sand, greyish brown, fine grained, w/organics

* Non-plastic

Boring 89-03

0 - 2 1/2´	Ice
2 1/2 - 31´	Water
31 - 32´	Sandy Silt, greyish brown, organic
32 - 33´	Silty Sand, greyish brown, organic

Boring 89-04

0 - 2 1/2´	Ice
2 1/2 - 21´	Water
21 - 22 1/2´	Silt, greyish brown, organic*
22 1/2 - 23´	Peat with sand, grey to greyish brown

* Non-plastic

Boring 89-05

0 - 2´	Ice
2 - 9 1/2´	Water
9 1/2 - 10 1/2´	Silt with sand, greyish brown, organic
10 1/2 - 11 1/2´	Peat, with wood, greyish brown

2.2 Laboratory Test Program

The laboratory testing program for the project consisted of performing three hydrometer, two atterberg limit tests and two mechanical analyses in our Duluth lab to determine the particle size distribution of the soils. In addition, chemical tests for detection of contaminants such as PCB´s, metals and dioxins were performed on two samples by our St Paul lab. The results of all tests are included in the appendices. Appendix B includes a copy of our St Paul laboratory´s report.

2.3 Data Review

The results of all tests are included in the appendices. The results of the classification tests indicate that the soils encountered on the lake bottom consist of sandy silts or silt materials. The results of the chemical tests are shown in the TCT St Paul report. The tests results for dioxins, PCB´b, metals and other miscellaneous substances are included in tables 5, 6, 7 and 8, respectively. We understand you will be reviewing the concentration levels of these substances.

3.0 FIELD EXPLORATION PROCEDURES

3.1 Soil Sampling

Soil Sampling was performed by driving a split barrel sampler into the lake bottom and extracting by hand.

3.2 Soil Classification

As the samples were obtained in the field, they were visually and manually classified by the crew chief in accordance with ASTM:D-2487-85 and D2488. Representative portions of the samples were then returned to the laboratory for further examination and for verification of the field classification.

This report was prepared by: Kris Lyytinen (signature)
Kris Lyytinen, EIT
Geotechnical Engineer

Under the direct supervision of: (signature)
Thomas G Krzewinski, PE
Regional Geotechnical Engineer

Proofread by: (signature)

3-4-91

Job No. 8400 89-204

Boring No. 89-01 Sample No. ______ Depth: 31½ - 33½'

Classification (ASTM:D2487-66T, D2488-66T) ML

Description SANDY SILT, greyish brown

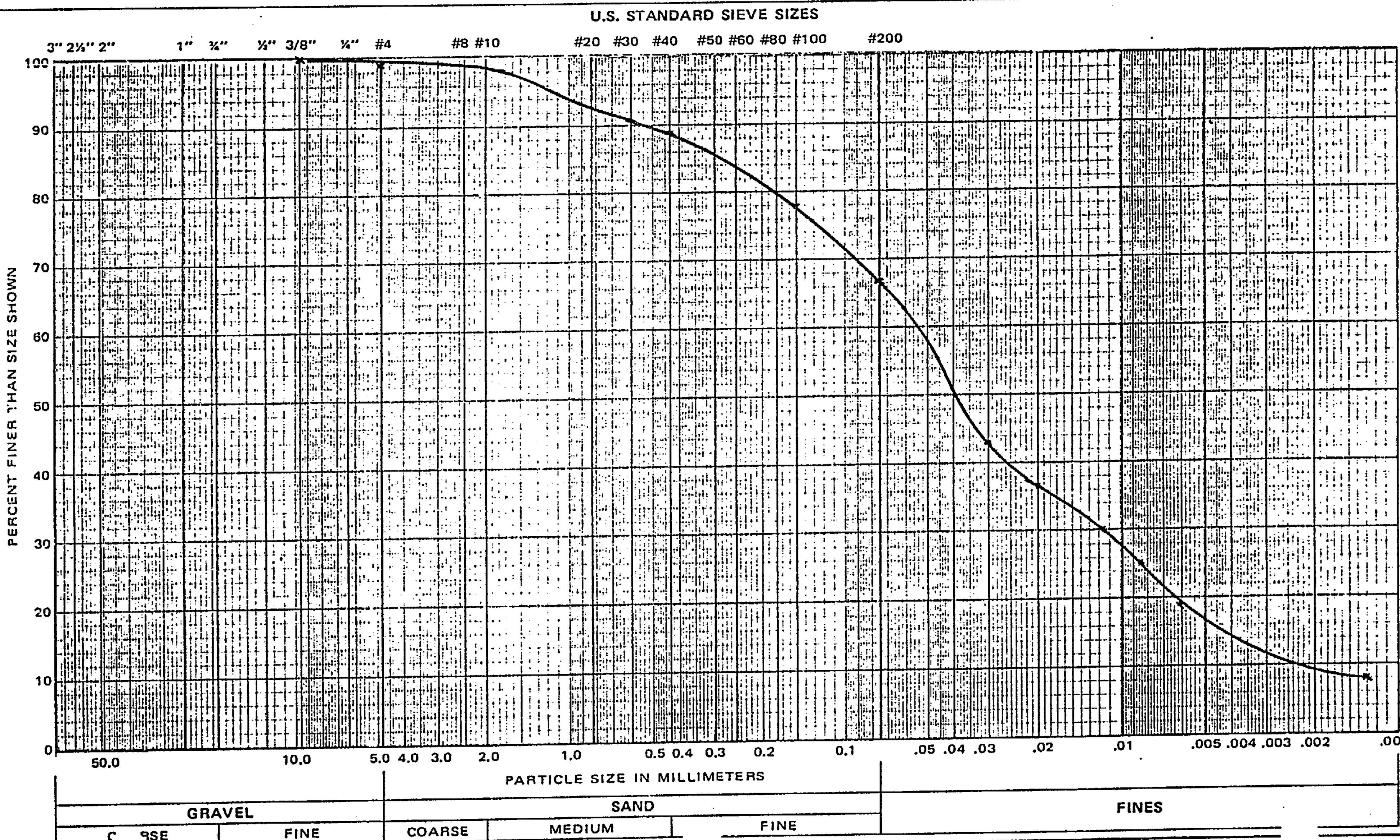
lakehead testing laboratory, inc.

226 NORTH CENTRAL AVENUE
P O BOX 7168
DULUTH, MN. 55807
PHONE 218/628-2295

Project: POTENTIAL DREDGE DISPOSAL SITES
CROSS CHANNEL HOLE - ST LOUIS BAY

Reported To: Northwest Regional Planning Commission

GRAIN SIZE DISTRIBUTION CURVE



lakehead testing
laboratory, inc.
226 NORTH CENTRAL AVENUE
P O BOX 7168
DULUTH, MN. 55807
PHONE 218-628-2295

Job No. 8400 89-204

Boring No. 89-03 Sample No. ______ Depth: 31 - 33'

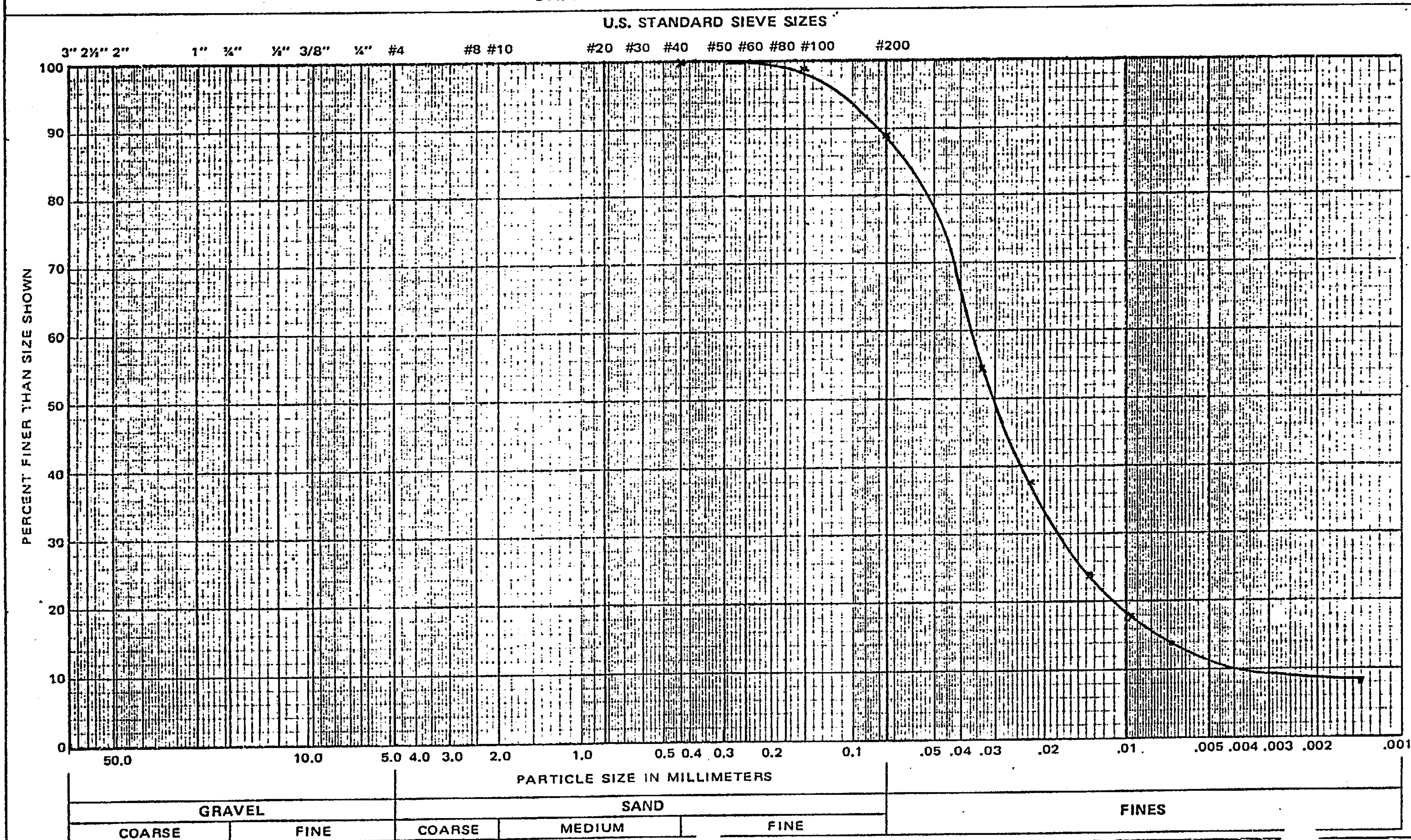
Classification (ASTM:D2487-66T, D2488-66T) ML

Description SILT

Project: POTENTIAL DREDGE DISPOSAL SITE
CROSS CHANNEL HOLE ST LOUIS BAY

Reported To: Northwest Regional Planning Commission

GRAIN SIZE DISTRIBUTION CURVE



87-03

Job No. 8400 89-204

Boring No. 89-03 Sample No. ______ Depth: 31 - 33'

Classification (ASTM:D2487-66T, D2488-66T) ML

Description SILT

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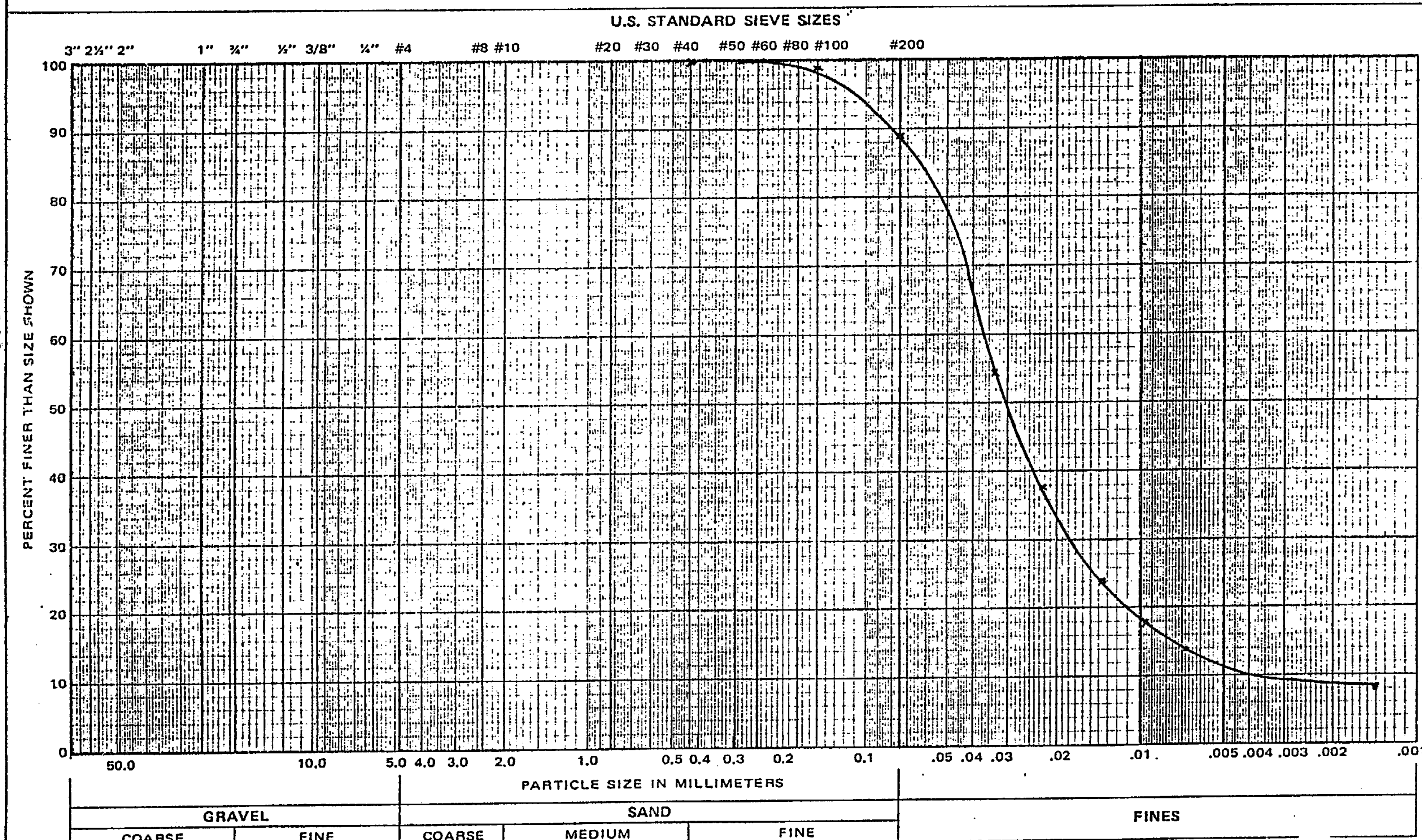
Project: POTENTIAL DREDGE DISPOSAL SITE
CROSS CHANNEL HOLE ST LOUIS BAY

Reported To: Northwest Regional Planning Commission

GRAIN SIZE DISTRIBUTION CURVE



Job No. 8400 89-204

Boring No. 89-05 Sample No. ______ Depth: 9½ - 11'

Classification (ASTM:D2487-66T, D2488-66T) ML

Description SILT

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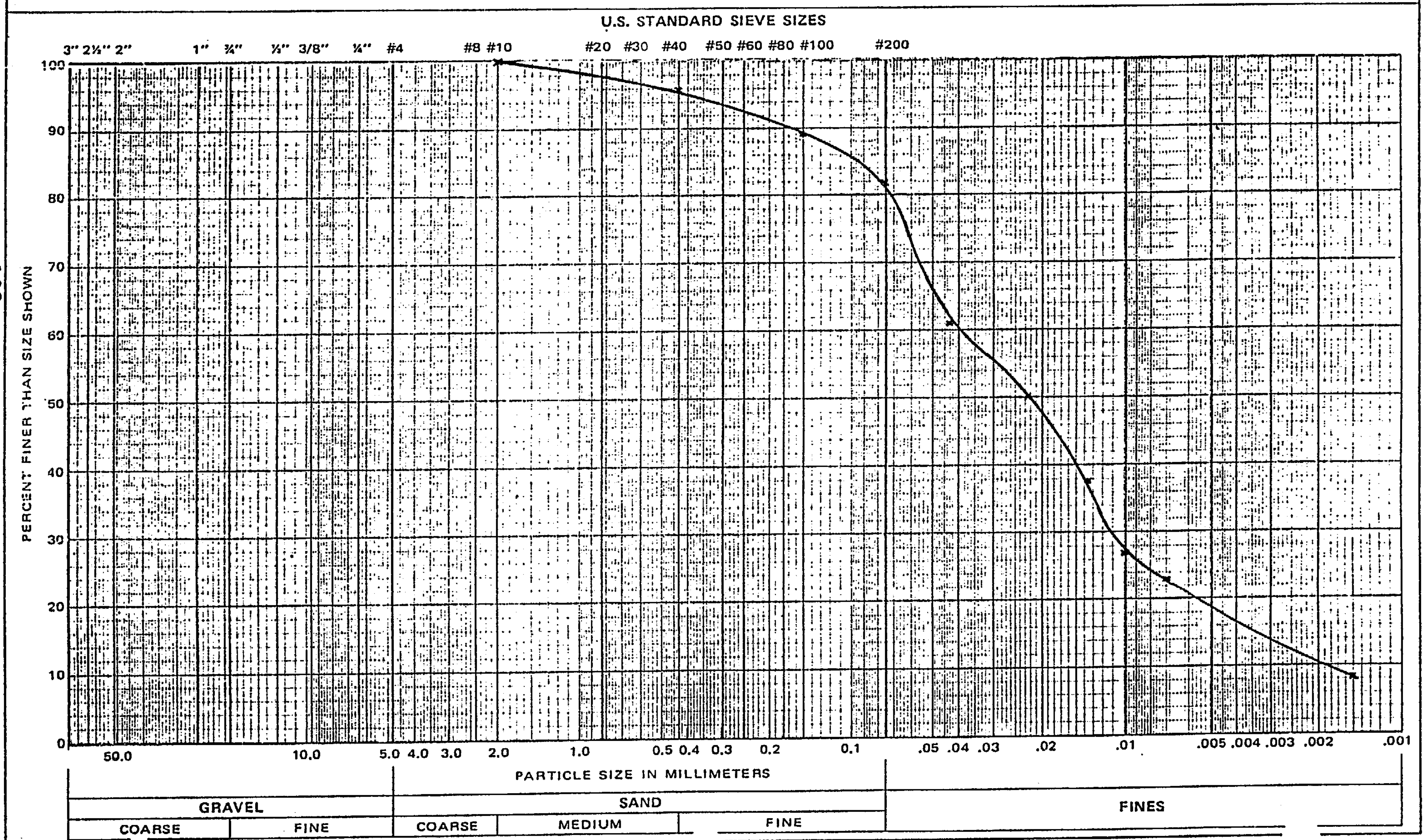
Project: POTENTIAL DREDGE DISPOSAL SITE
CRESS CHANNEL HOLE - ST LOUIS BAY

Reported To: Northwest Regional Planning Commission

GRAIN SIZE DISTRIBUTION CURVE



SIEVE ANALYSIS TESTS

PROJECT POTENTIAL DREDGE DISPOSAL SITE
CROSS CHANNEL HOLE - ST LOUIS BAY

DATE 2/22/89

REPORTED TO Northwest Regional Planning Commission

JOB NO. 8400 89-204

BORING NO.	89-02	89-04		
SAMPLE NO.				
DEPTH (ft)	33½ - 35½'	21 - 23'		
TYPE OF SAMPLE				
CLASSIFICATION (ASTM: D 2487) Symbol	ML	ML		
Description	SANDY SILT	SILT		
MECHANICAL ANALYSIS: Dry Weight of Total Sample (grams)	97.6	75.1		
Based on Total Sample Gravel - % (On# 4)	0	0		
Based on - Total Sample Sand - % (#4 – #10)	0.1	0.1		
(#10 – #40)	5.1	0.4		
(#40 – #100)	14.1	1.0		
(#100 – #200)	29.7	7.4		
Fines - % (#200 Down)	51.0	91.2		

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GENERAL NOTES

DRILLING AND SAMPLING SYMBOLS

SYMBOL	DEFINITION
HSA	3 1/4" I.D. Hollow Stem Auger
_FA	4", 6" or 10" Diameter Flight Auger
_HA	2", 4" or 6" Hand Auger
_DC	2 1/2", 4", 5" or 6" Steel Drive Casing
_RC	Size A, B, or N Rotary Casing
PD	Pipe Drill or Cleanout Tube
CS	Continuous Split Barrel Sampling
DM	Drilling Mud
JW	Jetting Water
SB	2" O.D. Split Barrel Sample
_L	2 1/2" or 3 1/2" O.D. SB Liner Sample
_T	2" or 3" Thin Walled Tube Sample
3TP	3" Thin Walled Tube (Pitcher Sampler)
_TO	2" or 3" Thin Walled Tube (Osterberg Sampler)
W	Wash Sample
B	Bag Sample
P	Test Pit Sample
_Q	BQ, NQ, or PQ Wireline System
_X	AX, BX, or NX Double Tube Barrel
CR	Core Recovery - Percent
NSR	No Sample Recovered, classification based on action of drilling equipment and/or material noted in drilling fluid or on sampling bit.
NMR	No Measurement Recorded, primarily due to presence of drilling or coring fluid.
▼	Water Level Symbol

TEST SYMBOLS

SYMBOL	DEFINITION
W	Water Content - % of Dry Wt. - ASTM D 2216
D	Dry Density - Pounds Per Cubic Foot
LL, PL	Liquid and Plastic Limit - ASTM D 4318

Additional Insertions in Last Column

Qu	Unconfined Comp. Strength-psf - ASTM D 2166
Pq	Penetrometer Reading - Tons/Square Foot
Ts	Torvane Reading - Tons/Square Foot
G	Specific Gravity - ASTM D 854
SL	Shrinkage Limits - ASTM D 427
OC	Organic Content - Combustion Method
SP	Swell Pressure - Tons/Square Foot
PS	Percent Swell
FS	Free Swell - Percent
pH	Hydrogen Ion Content, Meter Method
SC	Sulfate Content - Parts/Million, same as mg/L
CC	Chloride Content - Parts/Million, same as mg/L
C*	One Dimensional Consolidation - ASTM D 2435
Qc*	Triaxial Compression
D.S.*	Direct Shear - ASTM D 3080
K*	Coefficient of Permeability - cm/sec
D*	Dispersion Test
DH*	Double Hydrometer - ASTM D 4221
MA*	Particle Size Analysis - ASTM D 422
R	Laboratory Resistivity, in ohm - cm - ASTM G 57
E*	Pressuremeter Deformation Modulus - TSF
PM*	Pressuremeter Test
VS*	Field Vane Shear - ASTM D 2573
IR*	Infiltrometer Test - ASTM D 3385
RQD	Rock Quality Designation - Percent

* See attached data sheet or graph

WATER LEVEL

Water levels shown on the boring logs are the levels measured in the borings at the time and under the conditions indicated. In sand, the indicated levels may be considered reliable ground water levels. In clay soil, it may not be possible to determine the ground water level within the normal time required for test borings, except where lenses or layers of more pervious waterbearing soil are present. Even then, an extended period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol for cohesive or mixed texture soils may not indicate the true level of the ground water table. Perched water refers to water above an impervious layer, thus impeded in reaching the water table. The available water level information is given at the bottom of the log sheet.

DESCRIPTIVE TERMINOLOGY

DENSITY TERM	"N" VALUE	CONSISTENCY TERM
Very Loose	0-4	Soft
Loose	5-8	Medium
Medium Dense	9-15	Rather Stiff
Dense	16-30	Stiff
Very Dense	Over 30	Very Stiff

Standard "N" Penetration: Blows Per Foot of a 140 Pound Hammer Falling 30 inches on a 2 inch OD Split Barrel Sampler

Lamination	Up to 1/2" thick stratum
Layer	1/2" to 6" thick stratum
Lens	1/2" to 6" discontinous stratum, pocket
Varved	Alternating laminations of clay, silt and /or fine grained sand, or colors thereof
Dry	Powdery, no noticeable water
Moist	Below saturation
Wet	Saturated, above liquid limit
Waterbearing	Pervious soil below water

RELATIVE GRAVEL PROPORTIONS

CONDITION	TERM	RANGE
Coarse Grained Soils	A little gravel	2 - 14%
	With gravel	15 - 49%
Fine Grained Soils		
15-29% + No. 200	A little gravel	2 - 7%
15-29% + No. 200	With gravel	8 - 29%
30% + No. 200	A little gravel	2 - 14%
30% + No. 200	With gravel	15 - 24%
30% + No. 200	Gravelly	16 - 49%

RELATIVE SIZES

Boulder	Over 12"
Cobble	3" - 12"
Gravel	
Coarse	3/4" - 3"
Fine	#4 - 3/4"
Sand	
Coarse	#4 - #10
Medium	#10 - #40
Fine	#40 - #200
Silt & Clay	- #200, Based on Plasticity

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES
ASTM Designation: D 2487 - 85
(Based on Unified Soil Classification System)

SOIL ENGINEERING

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic clay[K,L,M,N]; Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic clay[K,L,M,P]
					Organic silt[K,L,M,Q]
Highly organic soils		Primarily organic matter, dark in color, and organic odor		PT	Peat
Fibric Peat > 67% Fibers		Hemic Peat 33%-67% Fibers			Sapric Peat < 33% Fibers

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains $\geq$ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains $\geq$ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains $\geq$ 30% plus no. 200, predominantly sand, add "sandy" to to group name.

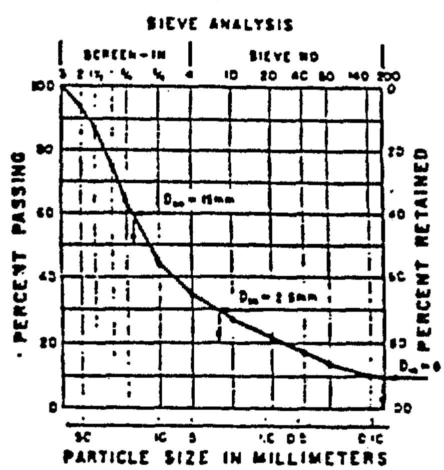
[M] If soil contains $\geq$ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI $\geq$ 4 and plots on or above "A" line.

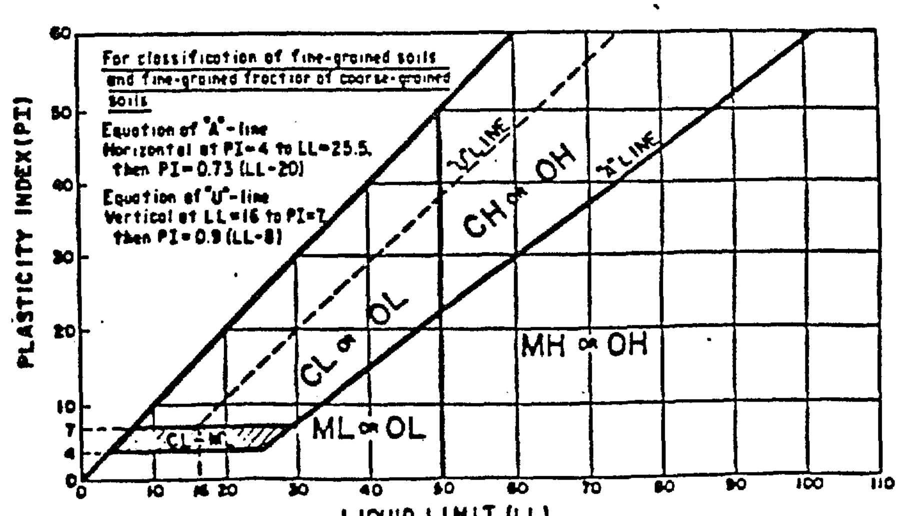
[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



$C_u = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$



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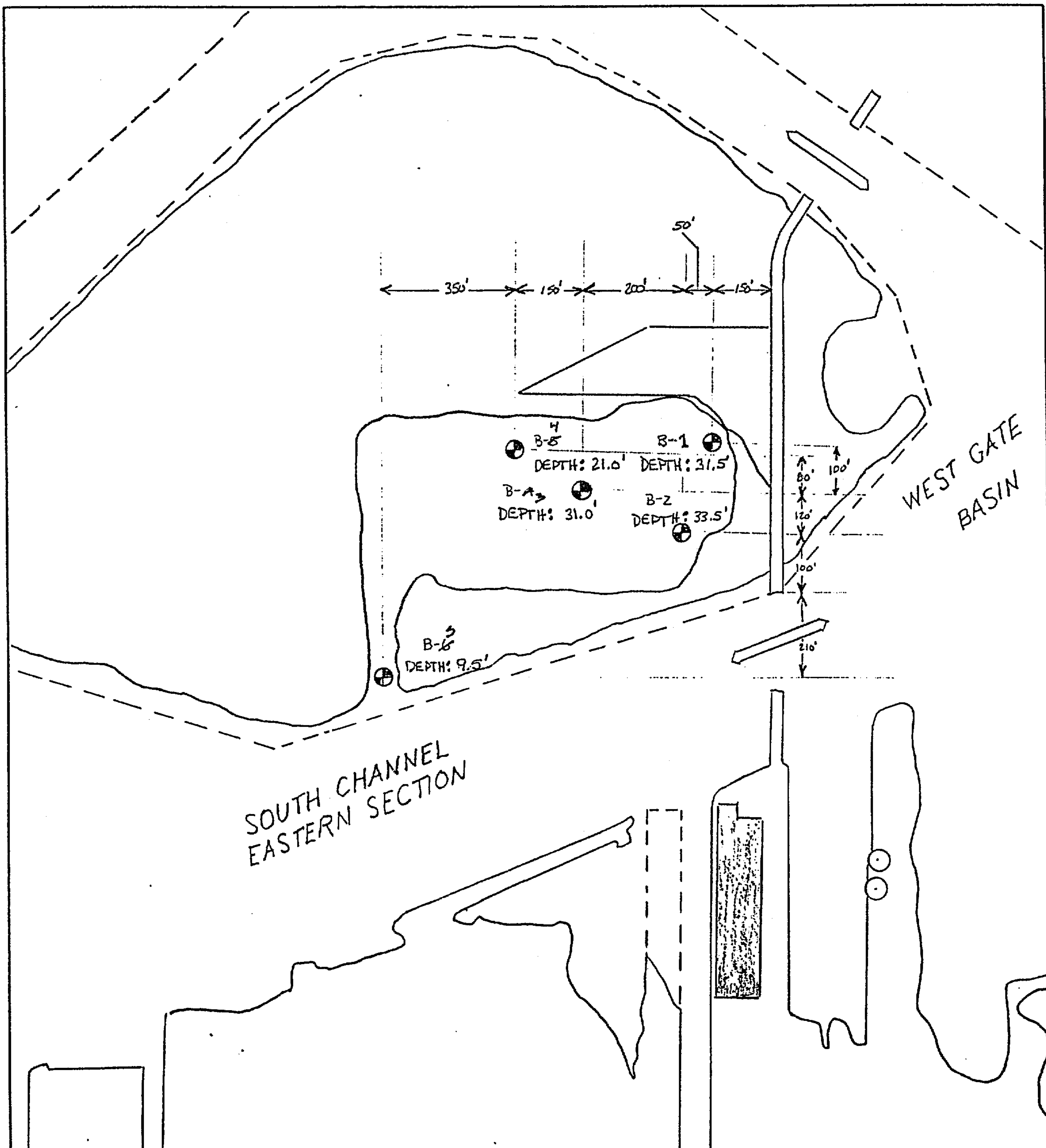

POTENTIAL DREDGE DISPOSAL SITE -

CROSS CHANNEL HOLE - SUPERIOR, WISCONSIN

WORK ORDER NO. 8400 89-204

NOT TO SCALE

DEPTHS MEASURED FROM ICE SURFACE

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ST. PAUL, MN 55114
PHONE 612/645-3601

REPORT OF: CHEMICAL ANALYSES

PROJECT: BUNGE PIER SOIL ANALYSIS DATE: April 3, 1989

ISSUED TO: Lakehead Testing Laboratory INVOICE NO.: 4410 89-2762
Attn: Ms. Susan Schultz
226 N. Central Avenue
P.O. Box 7168
Duluth, MN 55807

INTRODUCTION

This report presents the results of analyses performed on four soil samples submitted by Ms. Susan Schultz of Lakehead Testing Laboratory. The scope of the project was to analyze the samples for the presence of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF), and the parameters identified in the Methodology section of this report.

SAMPLE IDENTIFICATION

Client ID	Sample Type	TCT ID
B1, Alloweez Bay	Soil	112450
B3, Alloweez Bay	Soil	112452
B3, St. Louis Bay	Soil	113053
B1, St. Louis Bay	Soil	113052

METHODOLOGY

High Resolution 2,3,7,8-TCDD Analyses:

Extraction: The samples were spiked with 2 nanograms (ng) each of C-13 labeled 2,3,7,8-TCDD and 2,3,7,8-TCDF as internal standards and then extracted as described in EPA Method 8290. The extracts were quantitatively transferred to Kuderna Danish concentrators, concentrated, and solvent exchanged to hexane. The hexane extracts were then processed through the analyte enrichment procedures described below.

Analyte Enrichment: The extraction procedure often removes a variety of compounds, in addition to 2,3,7,8-TCDD and 2,3,7,8-TCDF, from the sample matrix. Some of these compounds, for example polychlorinated biphenyls, can directly interfere with the analyses. Other compounds can overload the capillary column, causing a degradation in chromatographic resolution or sensitivity. The analyte enrichment steps are used to remove interferences from the extracts.

The extracts were quantitatively transferred to liquid chromatography columns containing alternating layers of silica gel, 44% concentrated sulfuric acid on silica gel, and 33% 1 M sodium hydroxide on silica gel. The columns were eluted with 60 ml of hexane and the entire eluates were collected and concentrated, under a gentle stream of dry nitrogen, to a volume of 1 ml.

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REPORT OF: CHEMICAL ANALYSES

DATE: April 3, 1989

INVOICE NO.: 4410 89-2762

METHODOLOGY (Continued)

The extracts were then fractionated on liquid chromatography columns containing 4 g of activated alumina. The analytes were eluted with 15 ml of hexane followed by 20 ml of 2% methylene chloride/hexane and 35 ml of 60% methylene chloride in hexane. The 60% methylene chloride/hexane fractions were concentrated to 1 ml under a stream of dry nitrogen and applied to the tops of columns containing carbon on silica gel. The columns were eluted with cyclohexane/methylene chloride (50:50 V/V) and cyclohexane/methanol/benzene (75:20:5 V/V) in the forward direction, and then with toluene in the reverse direction. The toluene fractions were collected, spiked with a recovery standard (976 pg of 1,2,3,4-TCDD-C13), and concentrated to a final volume of 10 ul.

HRGC/HRMS Analyses:

The sample extracts were analyzed for the presence of 2,3,7,8-TCDD and 2,3,7,8-TCDF using combined capillary column gas chromatography/high resolution mass spectrometry (HRGC/HRMS). The column, a 60 M DB-5 coated fused silica capillary, was interfaced directly into the ion source of a VG Model 7070E high resolution mass spectrometer. This provided the highest possible sensitivity while minimizing degradation to the chromatographic resolution.

The mass spectrometer was operated in the electron impact ionization mode at a mass resolution of 10000-11000 ($M/\Delta M$, 10 percent valley definition). Operating parameters for the HRGC/HRMS analyses are summarized in Table 1.

The data were acquired by selected-ion-recording (SIR), monitoring a group of ion masses as described in EPA method 8290. Two ion masses were monitored for the native TCDD/TCDF and the 13C labelled TCDD/TCDF classes. Two ion masses were monitored so that the ratio between the low and high ion masses could be compared to the expected theoretical value (0.77). The actual ion masses monitored are listed below:

	Native TCDD	C13 labeled TCDD	Native TCDF	C13 labeled TCDF
Ion Masses	319.8965	331.9367	303.9016	315.9418
	321.8936	333.9338	305.8987	317.9389

The group of ion masses also contained a lock mass. The lock mass was used by the data system to automatically correct the mass focus of the instrument. Most modern mass spectrometers are stable on a short term basis (1 - 10 minutes), however, they can drift from the center of the

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mass peak during the course of a 30 - 60 minute analysis. The data system determined the centroid of the lock mass during each data acquisition cycle and corrected the mass focus of the analyte and internal standard ion masses to assure that the centers of the mass peaks were being monitored.

The criteria used to judge positive responses for the TCDD/TCDF isomers included:

- Simultaneous response at both ion masses of the 2,3,7,8-TCDD or 2,3,7,8-TCDF,

- Signal to noise ratio equal to or greater than 2.5:1.0 for both ion masses,

- Chlorine isotope ratio within 15 percent of the theoretical value, and

- Chromatographic retention times within 2-3 seconds of the authentic standards.

Quantification and Calculations:

The TCDD and TCDF were quantified by comparison of their responses to the responses of the labeled internal standards. Relative response factors were calculated from analyses of standard mixtures containing 2,3,7,8-TCDD and 2,3,7,8-TCDF at seven concentration levels, and the internal standards at one concentration level, as shown in Table 2. The TCDD/TCDF response factors were calculated by comparing the sum of the responses from the two ion masses monitored for the native compounds to the sum of the responses from the two ion masses of the corresponding isotopically labeled internal standard. Table 3 shows the response factor at each of the calibration levels as well as the average response factor and the relative percent deviation. The chlorine isotope ratios are shown in Table 4. The formula for the response factor calculation is:

$$Rf = \frac{An \times Qis}{Ais \times Qn}$$

where:

Rf = Response factor
An = Sum of integrated areas for native 2,3,7,8-TCDD/TCDF
Qis = Quantity of labeled internal standard
Ais = Sum of integrated areas for labeled internal standard
Qn = Quantity of native isomer

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REPORT OF: CHEMICAL ANALYSES

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The levels of 2,3,7,8-TCDD and 2,3,7,8-TCDF in the samples were quantified using the following equation:

$$C = \frac{An \times Qis}{Ais \times W \times Rf}$$

where:

C = Concentration of 2,3,7,8-TCDD or 2,3,7,8-TCDF
An = Sum of integrated area for 2,3,7,8-TCDD or 2,3,7,8-TCDF
Qis = Amount of labeled internal standard added to the sample
Ais = Sum of integrated areas for the labeled internal standard
W = Sample weight, volume or area
Rf = Response factor

A limit of detection (LOD), based on producing a signal that is 2.5 times the noise level, was calculated when 2,3,7,8-TCDD or 2,3,7,8-TCDF were not detected. The noise heights used to calculate the detection limit were measured at the retention time of the specific isomer. The formula used for calculating the LOD is:

$$LOD = \frac{Hn \times Qis \times 2.5}{His \times W \times Rf}$$

where:

LOD = Single isomer limit of detection
Hn = Height of noise at native isomer retention time
Qis = Quantity of labeled internal standard
His = Sum of peak heights for labeled internal standard
W = Sample weight, volume or area
Rf = Response factor

The recovery of the C13-labeled 2,3,7,8-TCDD or 2,3,7,8-TCDF internal standard, relative to 1,2,3,4-TCDD-C13, was calculated using the following equation:

$$\%R = \frac{Ais \times Wrs \times 100\%}{Rfr \times Ars \times Wis}$$

where:

%R = Percent recovery of C13 internal standard
Ais = Sum of integrated areas of internal standard
Wrs = ng of recovery standard
Ars = Sum of integrated areas of recovery standard
Rfr = Response factor of C13 internal standard relative to the recovery standard
Wis = ng of the C13 internal standard added to the sample prior to extraction

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Percent Solids:

A portion of the sample was weighed, heated on a steam bath, and placed in an oven at 105°C until a constant weight was reached.

Metals:

Specified metals were determined based on EPA Test Methods for Evaluating Solid Wastes, SW-846. Individual methodologies used are listed in Table 7.

Total hydrocarbons as oil and grease:

The sample was analyzed with methods based on EPA Methods for the Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983, Method 413.1.

PCB/pesticides:

A portion of each sample was weighed and extracted with methylene chloride. The extracts were dehydrated with anhydrous sodium sulfate, solvent switched to hexane, and concentrated to less than five milliliters in a Kuderna-Danish Concentrator on a steam bath. The concentrates were then analyzed using a Hewlett-Packard Model HP5890A Gas Chromatograph equipped with an electron capture detector. Compounds were identified by column retention time and quantified by peak area comparisons to those of known standards using a VG Laboratory Data System.

Total Organic Carbon, % Organic Matter:

The samples were analyzed based on the Walkley Black Method listed in the American Society of Agronomy, Methods of Soil Analysis, C A Black, editor, 1965, pp 1372-1376.

Total Kjeldahl Nitrogen:

Total nitrogen was determined based on Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, March 1983, Method 351.3.

Ammonia Nitrogen:

Ammonia Nitrogen was analyzed for based on Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, March 1983, Method 350.2.

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Total Phosphorus:

The samples were analyzed using Method 365.2 of Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, March 1983.

Nitrate and Nitrite as Nitrogen:

Nitrate and Nitrite as Nitrogen were determined based on Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, March 1983, Method 300.0.

RESULTS

Table 5 - High Resolution TCDD/TCDF Analyses Results
Table 6 - Pesticides/PCBs
Table 7 - Metals
Table 8 - Chemical Analyses

REMARKS

The sample extracts will be retained for a period of 30 days from the date of this report. The raw mass spectral data will be archived on magnetic tape for a period of one year.

TWIN CITY TESTING CORPORATION

Nancy Soutor
Project Coordinator

David Pauly
Mass Spectrometrist

Approved by:

Fred L. DeRoos, Ph.D.
Manager, Organic Chemistry Department

/mm

TABLE 1
Lakehead Testing Laboratory
HRGC/HRMS Operating Parameters

Mass Resolution	10,000-11,000 (M/ΔM, 10% valley)
Instrument	VG 7070E
Electron Energy	70 electron volts
Accelerating Voltage	6,000 volts
Source Temperature	275°C
Preamplifier Gain	10^{-7} amp/volt
Electron Multiplier Gain	~10^5
Chromatographic Column	60 M DB-5
Transfer Line Temperature	290°C
Injection Mode	Splitless
Carrier Gas	Helium
Carrier Flow Velocity	~30 cm/sec
Injection Volume	2.0 uL

Laboratory No. 4410 89-2762

TABLE 2
Lakehead Testing Laboratory
High Resolution TCDD/TCDF Calibration Solutions

Solution #	TCT #	Concentration (pg/ul) 2,3,7,8-TCDD	2,3,7,8-TCDF	2,3,7,8-TCDD $^{13}C_{12}$	2,3,7,8-TCDF $^{13}C_{12}$	1,2,3,4-TCDD $^{13}C_{12}$
1	A96	2.5	2.5	50	50	50
2	A95	5.0	5.0	50	50	50
3	A94	10	10	50	50	50
4	A93	25	25	50	50	50
5	A92	50	50	50	50	50
6	A91	100	100	50	50	50
7	A90	200	200	50	50	50

Laboratory No 4410 89-2762

TABLE 3
Lakehead Testing Laboratory
High Resolution Initial Calibration (10/06/88)
Summary of Response Factors

Solution #	TCT #	2,3,7,8-TCDF[1]	2,3,7,8-TCDD[2]	2,3,7,8-TCDF$^{13}C_{12}$[3]	2,3,7,8-TCDD$^{13}C_{12}$[3]
1	A96	1.0470	1.0127	2.1976	1.2065
2	A95	1.0401	0.9095	2.2532	1.1920
3	A94	1.1016	0.9102	1.9898	1.1138
4	A93	1.1070	0.9308	1.0385	1.1258
5	A92	1.0523	0.9150	2.0910	1.2206
6	A91	1.1107	0.9373	2.2707	1.2135
7	A90	1.0991	0.9283	2.2263	1.3305
Average		1.0797	0.9310	2.1525	1.2004
Standard Deviation		2.70%	3.77%	4.80%	5.51%

[1] Response factor vs 2,3,7,8-TCDF$^{13}C_{12}$

[2] Response factor vs 2,3,7,8-TCDD$^{13}C_{12}$

[3] Response factor vs 1,2,3,4-TCDD$^{13}C_{12}$

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TABLE 4
Lakehead Testing Laboratory
HRGC/HRMS Analyses (10/06/88)
Chlorine Isotope Ratios

Solution #	TCT #	2,3,7,8-TCDF	2,3,7,8-TCDD	1,2,3,4-TCDD $^{13}C_{12}$	2,3,7,8-TCDF $^{13}C_{12}$	2,3,7,8-TCDD $^{13}C_{12}$
1	A96	0.89	0.77	0.76	0.81	0.81
2	A95	0.84	0.85	0.83	0.82	0.85
3	A94	0.80	0.89	0.81	0.84	0.78
4	A93	0.76	0.73	0.78	0.79	0.82
5	A92	0.79	0.78	0.78	0.77	0.80
6	A91	0.78	0.83	0.83	0.82	0.81
7	A90	0.78	0.78	0.79	0.77	0.79

All ratios must fall within the range of 0.65 - 0.89 for TCDD/TCDF isomers.

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TABLE 5
Lakehead Testing Laboratory
High Resolution TCDD/TCDF Analyses Results

	Method Blank (pg/g)	TCT #112450 B-1, Alloweez Bay (pg/g)	TCT #113053 B-3, St. Louis Bay (pg/g)
2,3,7,8-TCDF[a]	ND	2.6	0.67
DL	0.44	--	--
Percent Recovery 2,3,7,8-TCDF-$^{13}C_{12}$	77%	96%	100%
2,3,7,8-TCDD	ND	ND	ND
DL	0.58	2.6[b]	0.65
Percent Recovery 2,3,7,8-TCDD-$^{13}C_{12}$	78%	94%	102%

Quantities/Detection Limits of TCDD/TCDF are expressed in picograms-per-gram (pg/g).

DL - The Detection Limit is calculated as described in EPA Method 8290.

ND - Not Detected

[a]Maximum amount present.

[b]The elevated detection limit for this isomer is due to the smaller quantity of soil extracted for the analysis. Approximately 10 g of soil were extracted for the Method Blank and Sample B-3 (TCT #113053), whereas approximately 2.5 g of soil were extracted for Sample B-1 (TCT #112450).

TABLE 6
Lakehead Testing Laboratory
Pesticide/PCB Results

Parameter	Lab Blank (ug/kg)	St. Louis Bay Boring 3 TCT #113053 (ug/kg)	Alloweez Bay Boring 1 TCT #112450 (ug/kg)	MDL (ug/kg)
Aldrin	ND	ND	ND	1.0
A-BHC	ND	ND	ND	8.0
B-BHC	ND	ND	ND	4.0
D-BHC	ND	BDL	ND	8.0
Chlordane	ND	ND	ND	10.0
4,4'DDD	ND	ND	ND	3.0
4,4'DDE	ND	ND	ND	3.0
4,4'DDT	ND	ND	ND	3.0
Dieldrin	ND	ND	ND	3.0
Endosulfan I	ND	ND	ND	10.0
Endosulfan II	ND	ND	ND	10.0
Endosulfan sulfate	ND	ND	ND	10.0
Endrin	ND	ND	ND	10.0
Endrin Aldehyde	ND	ND	ND	2.0
Heptachlor	ND	ND	ND	0.8
Heptachlor eposide	ND	ND	ND	3.0
Lindane (G-BHC)	ND	ND	ND	1.0
Toxaphene	ND	ND	ND	10.0
PCB 1016	ND	ND	ND	20.0
PCB 1221	ND	ND	ND	20.0
PCB 1232	ND	ND	ND	20.0
PCB 1242	ND	ND	ND	20.0
PCB 1248	ND	ND	ND	20.0
PCB 1254	ND	ND	ND	20.0
PCB 1260	ND	ND	ND	20.0

ug/kg - micrograms per kilogram which is equal to parts-per-billion (ppb)
MDL - Method Detection Limit
ND - Not Detected, none present above method detection limit
BDL - Parameter detected, but below quantifiable limits

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TABLE 7
Lakehead Testing Laboratory

Parameter (mg/kg)	Alloweez Bay B-1	Alloweez Bay B-3	St. Louis Bay Sample Boring 1	St. Louis Bay Sample Boring 3	Analysis Date	Method Number	MDL
Arsenic	3	2	ND	ND	2-28-89	7060	1
Barium	150	97	130	78	3-10-89	7080	1
Cadmium	1.4	1.2	1.3	1.5	2-24-89	7130	0.5
Total Chromium	33	24	37	26	2-24-89	7190	0.5
Copper	86	44	130	43	2-24-89	7210	0.5
Iron	30,000	17,000	28,000	22,000	2-24-89	7380	2
Lead	33	16	32	19	2-24-89	7420	5
Manganese	750	320	840	500	2-24-89	7450	0.5
Mercury	0.10	0.03	0.16	0.05	3-10-89	7471	0.03
Nickel	38	26	35	25	2-24-89	7520	0.5
Zinc	130	49	170	72	2-24-89	7950	0.5
Total Cyanide	ND	ND	ND	ND	2-28-89	9010	0.10

LDL = Lower detectable limit
ND = Not detected; not present above lower detectable limit

All values are listed in mg/kg. mg/kg is equal to parts-per-million.

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twin city testing corporation

TABLE 8
Lakehead Testing Laboratory

Parameter (mg/kg)*	Alloweez B-1	St. Louis Bay Sample Boring 3	Analysis Date	MDL
Kjeldahl Nitrogen	920	560	3-22-89	0.5
Ammonia (as N)	42	23	3-22-89	0.2
Nitrite (as N)	ND	ND	3-20-89	0.3
Nitrate (as N)	36.8	9.7	3-20-89	0.3
Total Phosphorus (as P)	366	394	3-07-89	0.1
Solids, %	45.7	59.5	3-14-89	0.1
Total Organic Carbon %	3.06	2.91	3-29-89	0.2
Oil and Grease	51.8	27.2	3-01-89	1.0
Moisture	54.4	40.5	3-14-89	0.1

LDL = Lower detectable limit

ND = Not detected; not present above lower detectable limit

*All values with the exception of those listed as percents are in mg/kg. mg/kg is equal to parts-per-million.

Laboratory No. 4410 89-2762

VII. BUNGE DOCK AND SLIP PLANT COMMUNITIES AND WILDLIFE HABITAT

VII. BUNGE DOCK AND SLIP PLANT COMMUNITIES AND WILDLIFE HABITAT

This section of the report is represented by the final report of Mr. Don Reed, consulting biologist. The report is presented here in it's entirety.

SURVEY OF PLANT COMMUNITIES AND WILDLIFE HABITAT;
BUNGE DOCK AND SLIP

On July 22, 1989, a field inspection was conducted of the plant communities and wildlife habitat associated with the Bunge Dock and Slip, located in portions of the Southwest, Southeast, Northeast, and Northwest one-quarters of U.S. Public Land Survey Sections 28, 29, 32, and 33, respectively, Township 49 North, Range 13 West, City of Superior, Douglas County, Wisconsin. The results of the field inspection are attached hereto as Exhibit A and, along with a review of information available from the Wisconsin Department of Natural Resources (WDNR), may be summarized as follows:

1. Four plant community areas were identified on the subject property. The location and areal extent of the four plant community areas are shown on the enlarged copy of an aerial photograph attached hereto as Exhibit B.
2. Plant community area No. 8-1 is an approximately 2.5-acre disturbed old field. Disturbances to this plant community area include filling and dumping.
3. Plant community area No. 8-2 is an approximately 1.5-acre disturbed old field with invading shrubs adjacent to the shoreline. Disturbances to this plant community area include filling and dumping.
4. Plant community area No. 8-3 is an approximately 7.0-acre wetland complex consisting of deep and shallow marsh, shrub carr, and second growth lowland hardwoods. These four wetland types correspond to the Aquatic bed, Rooted floating, Standing water, Lake (A3L); Emergent/wet meadow, Narrow-leaved persistent, Standing water,

Palustrine (E2H); Scrub/shrub, Broad-leaved deciduous, Wet soil, Palustrine (S3K); and Forested, Broad-leave deciduous, Wet soil, Palustrine (T3K) wetland cover type classes identified on the Wisconsin Wetland Inventory Maps.

5. Plant community area No. 8-4 is an approximately 3.0-acre second growth stand of Balsam poplar (Populus balsamifera) upland woods grading down to shrub carr and shallow marsh type wetlands along the shoreline. The latter two wetland types correspond to the E2H and S3K wetland cover-type classes. Disturbances to the upland woods include past filling and dumping, trails, and erosion of the slope.

6. The wetland types present in plant community area Nos. 8-3 and 8-4 have been created largely as a result of the dock construction. Disturbance to these wetlands include filling and dumping, and erosion.

7. Discussions on July 31, 1989 with Mr. Dennis M. Pratt, Western Lake Superior Fish Manager of the WDNR staff, indicate that various fish species do use the emergent and floating vegetation (deep and shallow marsh) areas of the Slip. Deeper areas of the Slip may be used by fish in the winter. However, the shallow areas freeze. Mr. Pratt noted that a deep hole fishery investigation of the Slip is presently underway.

8. Discussions on August 24, 1989, with Mr. Fred Strand, Wildlife Manager of the WDNR staff, indicate that, while Allouez Bay supports a high value (Class I) wildlife area for waterfowl, the Bunge Dock and Slip is not of particularly high value, nor does it provide unique

habitat. The subject plant community area wetlands are fairly common in the western Lake Superior region. Mr. Strand agreed that the wildlife classification for the Bunge Dock and Slip wetland should be about a Class III, or low value wildlife habitat, on a Region-wide basis, for waterfowl, gulls and terns, swallows, and aquatic fur bearers, with some shorebird use.

9. No Federal- or State-designated rare, threatened, or endangered species were observed during the field inspection. In addition, a review of the WDNR, Bureau of Endangered Resources' files by Mr. Thomas A. Meyer, of the Bureau staff, on July 28, 1989 indicate that no records of any rare, threatened, or endangered species have been reported from the Bunge Dock and Slip site.

Based on the aforementioned findings, plant community areas 8-1, 8-2, and the Balsam poplar woods of 8-4 are upland habitats, while plant community area Nos. 8-3 and the shrub carr and shallow marsh portion of 8-4 are wetlands. In addition, it is my opinion that the Bunge Dock and Slip does not contain plant communities nor wildlife habitat of a Regional or Statewide significance.

EXHIBIT B

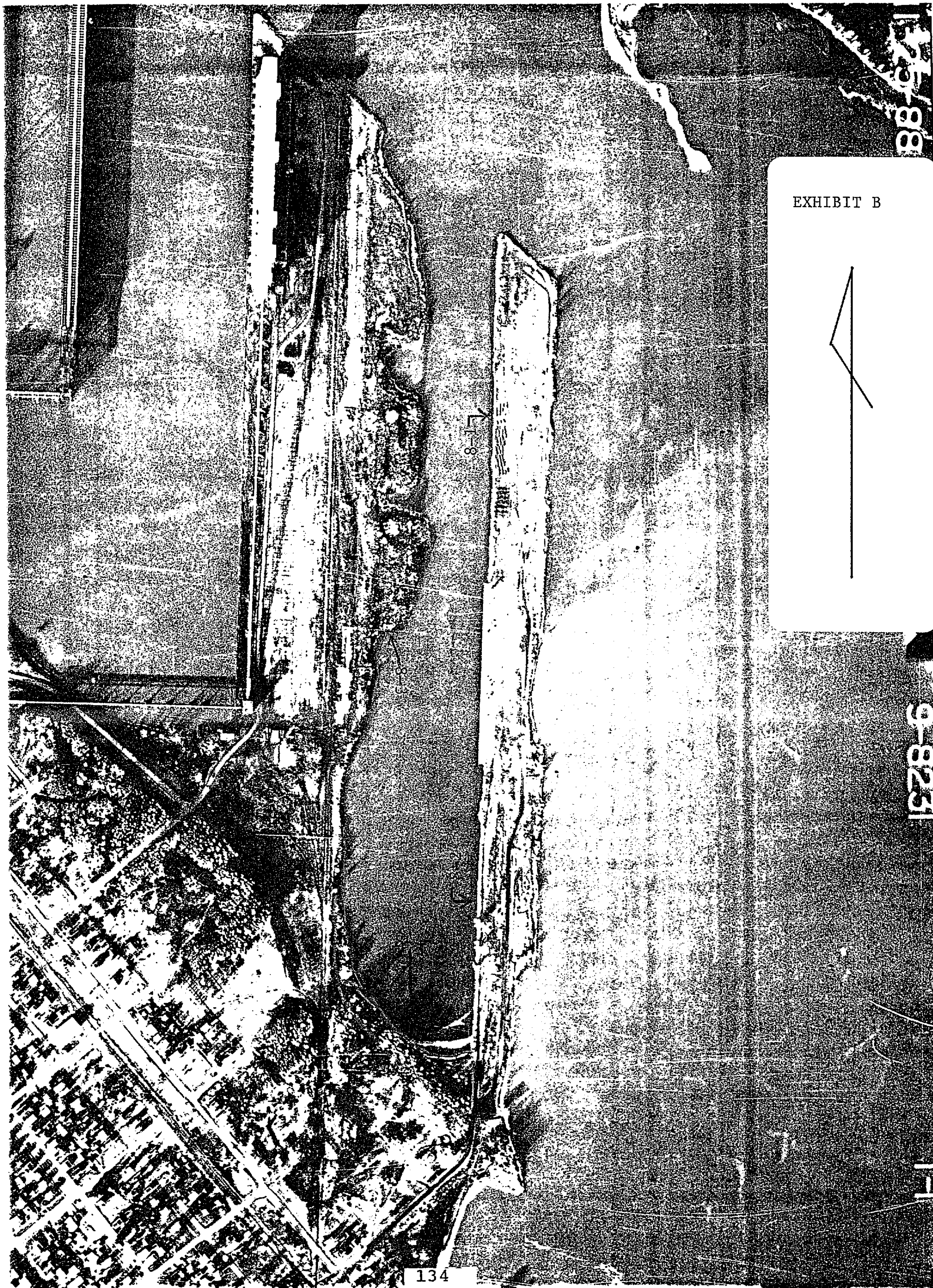


EXHIBIT A

PRELIMINARY VEGETATION SURVEY
BUNGE DOCK AND SLIP

DATE July 22, 1989

OBSERVER: Donald M. Reed, Consulting Biologist

LOCATION: City of Superior in parts of the Southwest, Southeast, Northeast, and Northwest one-quarters of U.S. Public Land Survey Sections 28, 29, 32, and 33, respectively, Township 49 North, Range 13 West, Douglas County, Wisconsin.

SPECIES LIST:

Plant Community Area No. 8-1

EQUISETACEAE
Equisetum sp. --- Horsetail

GRAMINEAE
Poa pratensis --- Kentucky bluegrass
Agropyron repens 1 --- Quack grass
Phleum pratense 1 --- Timothy

SALICACEAE
Salix nigra 2 --- Black willow
Salix interior --- Sand-bar willow
Salix spp. --- Willows

BETULACEAE
Alnus rugosa --- Tag alder

POLYGONACEAE
Polygonum persicaria 1 --- Lady's thumb

CARYOPHYLLACEAE
Saponaria officinalis 1 --- Bouncing bet

CRUCIFERAE
Berteroa incana 1 --- Hoary alyssum

FABACEAE
Trifolium pratense 1 --- Red clover
Trifolium repens 1 --- White clover
Trifolium hybridum 1 --- Alsike clover
Melilotus alba 1 --- White sweet clover
Melilotus officinalis 1 --- Yellow sweet clover

BALSAMINACEAE
Impatiens biflora --- Jewelweed

ONAGRACEAE
Oenothera biennis --- Evening primrose

CORNACEAE

Cornus stolonifera --- Red osier dogwood

OLEACEAE
Fraxinus pennsylvanica 2 --- Green ash

CONVOLVULACEAE
Convolvulus arvensis 1 --- Field bindweed

COMPOSITAE
Matricaria maritima 1 --- Scentless chamomile
Tanacetum vulgare 1 --- Tansy
Artemisia ludoviciana ? --- White sage
Aster sp. --- Aster
Cirsium arvense 1 --- Canada thistle
Hieracium canadense --- Canada hawkweed
Taraxacum officinale 1 --- Common dandelion
Lactuca serriola 1 --- Prickly wild lettuce

Total number of plant species: 29
Number of alien, or non-native, plant species: 16 (55 percent)

This approximently 2.5-acre plant community area is a disturbed old field. Disturbances to the site include past filling and dumping. No federal- or state-designated rare, threatened, or endangered species were observed during the field inspection.

1 Alien, or non-native, plant species.

2 Sapling tree

plant Community Area No. 8-2

EQUISETACEAE
Equisetum sp. --- Horsetail

NAJADACEAE
Potamogeton sp. --- Pondweed

GRAMINEAE
Bromus inermis 1 --- Smooth brome grass
Poa pratensis --- Kentucky bluegrass
Agropyron repens 1 --- Quack grass
Phleum pratense 1 --- Timothy

CYPERACEAE
Scirpus atrovirens --- Green bulrush
Carex sp. --- Sedge

SALICACEAE
Populus balsamifera --- Balsam poplar
Salix nigra --- Black willow
Salix interior --- Sand-bar willow
Salix spp. --- Willows

BETULACEAE
Alnus rugosa --- Tag alder

POLYGONACEAE
Polygonum persicaria 1 --- Lady's thumb

CARYOPHYLLACEAE
Saponaria officinalis 1 --- Bouncing bet

CRUCIFERAE
Berteroa incana 1 --- Hoary alyssum

FABACEAE
Trifolium pratense 1 --- Red clover
Trifolium repens 1 --- White clover
Trifolium hybridum 1 --- Alsike clover
Melilotus alba 1 --- White sweet clover
Melilotus officinalis 1 --- Yellow sweet clover

ANACARDIACEAE
Rhus typhina --- Staghorn sumac

ACERACEAE
Acer saccharinum --- Silver maple
Acer negundo --- Boxelder

BALSAMINACEAE
Impatiens biflora --- Jewelweed

VITACEAE
Parthenocissus quinquefolia --- Virginia creeper

ONAGRACEAE
Oenothera biennis --- Evening primrose

CORNACEAE
Cornus stolonifera --- Red osier dogwood

OLEACEAE
Fraxinus pennsylvanica 2 --- Green ash

CONVOLVULACEAE
Convolvulus arvensis 1 --- Field bindweed

COMPOSITAE
Matricaria maritima 1 --- Scentless chamomile
Tanacetum vulgare 1 --- Tansy
Artemisia ludoviciana ? --- White sage
Aster sp. --- Aster
Cirsium arvense 1 --- Canada thistle
Centaurea maculosa 1 --- Spotted knapweed
Hieracium canadense --- Canada hawkweed
Taraxacum officinale 1 --- Common dandelion
Lactuca serriola 1 --- Prickly wild lettuce

Total number of plant species: 39
Number of alien, or non-native, plant species: 18 (46 percent)

This approximately 1.5-acre plant community area is a disturbed old field with invading shrubs adjacent to the shoreline. Disturbances to the site include past filling and dumping. No federal- or state-designated rare, threatened, or endangered species were observed during the field inspection.

1 Alien, or non-native, plant species.

2 Sapling tree.

Plant Community Area No. 8-3

TYPHACEAE
Typha latifolia --- Broad-leaved cat-tail

SPARGANIACEAE
Sparganium eurycarpum --- Common bur-reed

NAJADACEAE
Potamogeton sp. --- Pondweed

ALISMATACEAE
Sagittaria latifolia --- Common arrowhead

GRAMINEAE
Calamagrositis canadensis --- Canada bluejoint grass

CYPERACEAE
Scirpus validus --- Soft-stemmed bulrush
Carex aquatilis --- Aquatic sedge
Carex spp. --- Sedges

SALICACEAE
Populus tremuloides --- Quaking aspen
Populus balsamifera --- Balsam poplar

BETULACEAE
Alnus rugosa --- Tag alder

NYMPHAEACEAE
Nuphar variegatum --- Yellow water lily

Total number of plant species: 12
Number of alien, or non-native, plant species: 0 (0 percent)

This approximently 7.0-acre plant community area consists of deep and shallow marsh, shrub carr, and second growth lowland hardwoods. Disturbances to the site include past filling and dumping. No federal- or state-designated rare, threatened, or endangered species were observed during the field inspection.

Plant Community Area No 8-4

EQUISETACEAE
Equisetum sp. --- Horsetail

TYPHACEAE
Typha latifolia --- Broad-leaved cat-tail

SPARGANIACEAE
Sparganium eurycarpum --- Common bur-reed

ALISMATACEAE
Sagittaria latifolia --- Common arrowhead

GRAMINEAE
Bromus inermis 1 --- Smooth brome grass
Agropyron repens 1 --- Quack grass
Calamagrositis canadensis --- Canada bluejoint grass
Phleum pratense 1 --- Timothy

CYPERACEAE
Carex sp. --- Sedge

SALICACEAE
Populus tremuloides --- Quaking aspen
Populus balsamifera 2 --- Balsam poplar
Salix interior --- Sand-bar willow
Salix bebbiana --- Beaked willow
Salix spp. --- Willows

BETULACEAE
Betula papyrifera --- Paper birch
Alnus rugosa --- Tag alder

POLYGONACEAE
Rumex crispus 1 --- Curly dock
Polygonum persicaria 1 --- Lady's thumb

NYMPHAEACEAE
Nuphar variegatum --- Yellow water lily

ROSACEAE
Rubus strigosus --- Red raspberry

FABACEAE
Trifolium pratense 1 --- Red clover
Trifolium hybridum 1 --- Alsike clover
Melilotus alba 1 --- White sweet clover
Melilotus officinalis 1 --- Yellow sweet clover

ACERACEAE
Acer negundo --- Boxelder

BALSAMINACEAE
<u>Impatiens</u> <u>biflora</u> --- Jewelweed

ONAGRACEAE
<u>Epilobium</u> <u>angustifolium</u> --- Fireweed

CORNACEAE
<u>Cornus</u> <u>stolonifera</u> --- Red osier dogwood

SOLANACEAE
<u>Solanum</u> <u>dulcamara</u> 1 --- Deadly nightshade

VALERIANACEAE
<u>Valeriana</u> <u>officinalis</u> 1 --- Garden heliotrope

COMPOSITAE
<u>Achillea</u> <u>millefolium</u> 1 --- Yarrow
<u>Matricaria</u> <u>maritima</u> 1 --- Scentless chamomile
<u>Tanacetum</u> <u>vulgare</u> 1 --- Tansy
<u>Cirsium</u> <u>arvense</u> 1 --- Canada thistle

Total number of plant species: 34
Number of alien, or non-native, plant species: 15 (44 percent)

This approximently 3.0-acre plant community area consists of a second growth Balsam poplar woods with shrub carr and shallow marsh species along the shoreline. Disturbances to this site include past filling and dumping, trails, and erosion. No federal- or state-designated rare, threatened, or endangered species were observed during the field inspection.

1 Alien, or non-native, plant species.

2 Dominant plant species.

VIII. REGULATORY STRUCTURE

VIII. REGULATORY STRUCTURE

A. CURRENT

NR. 347 governing dredging and disposal activities related to sediment sampling, monitoring and disposal criteria has been in effect since March 1, 1989. This administrative rule appears to allow only beach nourishment and upland disposal sites and treats dredge materials as solid waste through its reference to earlier statutes. Noticeable, because of its absence, is reference to standards which are statistically significant, environmentally meaningful and cost effective from a socioeconomic standpoint. The rule is also unnecessarily stringent in its lack of consideration of other disposal options that may meet the test of good rule-making.

The portion of the NR. 500 Series which will set standards for disposal is currently under review. However, in its proposed form which calls for treatment of dredge materials as solid waste; and subject to highly stringent regulation, will force undue economic impacts on local units of government who, for the most part, have no control over sediments entering their dredging project areas.

Good rule-making comprises a complete process of dredged material assessment and incorporates a range of scientific and administrative factors. Beyond the decision to base dredged material evaluation on avoiding unacceptable adverse biological effects, an effective process should also be:

* Accountable - Any required tests as part of the permitting process must be justifiable to the individual permittee and to the public.

* Adaptable - The requirement must be flexible enough to allow for project and site-specific concerns and be adaptable to projects of any size.

* Consistent - Within local areas there will be multiple projects of various sizes, kinds, scope, and chemical concentrations. Nevertheless, the permitting process must be applied consistently.

* Cost-effective - The most cost-effective means of achieving the required technical adequacy must be applied.

* Objective - The requirements must be clearly stated and logical. Even if the criteria are subjective, they must be able to be applied in an objective manner.

* Revisable - Because scientific uncertainties exist, the process must be able to be updated to incorporate best current information and judgment.

* Understandable - The requirements must not be unnecessarily cumbersome or convoluted.

* Technically adequate - Characterization of the dredged material must be adequate to make appropriate decisions concerning dredging and disposal.

* Time efficient - Because major dredged disposal projects are a continual necessity, evaluation procedures must not result in unnecessary delays.

* Verifiable - To be enforceable, the implementation of the requirements must be verifiable through monitoring.

B. PROPOSED FRAMEWORK FOR LEGISLATION

1. Background

FRAMEWORK FOR LEGISLATION--WISCONSIN
DREDGED MATERIAL DISPOSAL MANAGEMENT PROGRAM

Proposed Chapter 30.22

The navigable waterways of Wisconsin have and will continue playing a vital role in Wisconsin's development through the years. Because of the unique importance to the State of commercial navigation in the Great Lakes and riverways, it is in the public interest to maintain navigation of these waters for economic benefit of the State. It is also in the public interest and to protect, preserve and enhance the ecological value of water quality.

It is the purpose of this proposed legislation to provide for the predictable regulation of the disposal of dredged materials.

2. Definitions and Abbreviations -- (See Appendix to this section)

3. Management Strategy

The diversity of disposal alternatives and techniques for the management of contaminated and uncontaminated dredged material requires the development of an overall, long-term management strategy for disposal. The selection of an appropriate technique is dependent on the nature of the dredged material, the nature and level of contamination, the dredging alternatives, the project size, and site specific physical and chemical conditions, all of which have potential for environmental impacts.

Technical feasibility, economics, and other socio-economic factors must be considered in the decision-making process. The management strategy presented here mainly considers the nature and degree of contamination, potential environmental impact and related technical factors.

The main thrust of the management strategy is to have adequate and reasonable information to make valid decisions on; and to provide the elimination and control of unacceptable environmental impacts in a cost effective manner.

Technical Management Strategy -- Dredged material. Disposal management strategy must be broad enough to handle a wide range of dredged material characteristics, dredging techniques, transportation methods, and disposal alternatives. The long-term management strategy must consider the nature of the sediment to be dredged, potential environmental impacts of dredged material disposal, nature and degree of contamination, dredging equipment, project size, site-specific conditions, technical feasibility, economics and other socioeconomic factors.

Two major features of the technical management strategy are:

a. determination of the characteristics of candidate dredged disposal material

b. determination the appropriate disposal technique for that material

Steps to implement these two features are as follows:

a. conduct an initial evaluation to assess contamination potential

b. select a potential disposal alternative

c. identify problems associated with an alternative

d. apply appropriate testing protocol

e. assess the need for disposal restrictions

f. select the disposal site classification,

g. select the implementation plan

h. identify available control options

i. evaluate design considerations

j. evaluate final design and appropriate control measures

4. Classification of Dredged Material

Type A. Clean sediments--no contaminants. This material can be disposed in any Class disposal site.

Type B. Unpolluted material--but w/high percentage silts and clays (over 70%). Type B material can be disposed of in Class II, III, IV, V, VI, VII, but normally in Class II, III, or V.

Type C. Moderately polluted material with local metals, but not higher than background levels. No heavy metals. Type C material would normally be disposed of in a Class II or III disposal site.

Type D. Moderately polluted material with less than 5 contaminants in excess of standard but less than 1 standard deviation of all samples from project area. Type D material would normally be disposal of in a Class III, IV or VI disposal site.

Type E. Heavily polluted material with more than 5 contaminants in excess of standard but less than 1 standard deviation of all samples from project area. Type E material would be disposed of in a Class VI or VII disposal site.

Type F. Hazardous waste material means a material which "because of its quantity, concentration, or physical, chemical, or infectious characteristics may

a. cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or

b. pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed."

Type F material shall be disposed of in a Class VIII disposal site.

Type G. PCB's in excess of (standard not established)
Dioxide in excess of (standard not established)
Furan in excess of (standard not established)

Type G material would be disposed of in a Class VII or Class VIII site.

5. Class of Dredged Material Disposal Sites

I. Open Water Disposal--no confinement

a. nearshore beach nourishment

II. Open water Disposal--with confinement
a. island creation
b. mined holes, abandoned Federal channels, abandoned private channels and slips.
c. confined beach nourishment

III. Near-shore Disposal -- CDF-diked w/solids containment

IV. Near-shore Disposal -- CDF-solids and liquid containment

V. Upland Disposal -- land spreading

VI. Upland Disposal -- moderate environmental Controls

VII. Upland-Secured Disposal -- restrictive environmental controls .Meets technical contruction standards for hazardous sites per NR-504

VIII. Reuse -- Unrestricted

IX. Reuse -- Restricted

6. Candidate Dredged Material Testing/see Testing sequence flowchart, Appendix 2.

   a. Tier I - assesses existing sediment information
   b. Tier II - conduct chemical testing, if necessary
   c. Tier III - conduct biological testing, if necessary

7. Permits, Approvals and Reviews Required

a. Applicability

The provisions of this chapter apply to the removal and disposal of material from the beds of waterways except where exempted by statute.

b. The following are the permit, approval and review requirements for dredging projects: (See text in Appendix 3.)

8. Post Construction Monitoring Requirements

a. (reserved)
b. (reserved)

9. Public Input Process and hearing requirements

a. (reserved)

10. Financial Assistance

There is a presumption that the dredger, C.O.E. and/or local sponsors will be responsible for disposal costs as prescribed by Federal standards and guidelines. Should costs exceed those dictated by Federal standards and guidelines due to additional requirements of State statutes, rule-making, or the State staff interpretation of statutes, rules, or guidelines, the Department of

Natural Resources will be responsible for 100% of the increase due to State requirements. The source of the funds shall be provided through General State Revenues. These costs shall include, but are not limited to, additional engineering, legal, right-of-way acquisition, feasibility studies, transportation, monitoring, testing, construction, construction administration, operation, post-construction monitoring, and closure requirements.

11. Penalties

a. (reserved)

APPENDIX A

WISCONSIN DREDGED DISPOSAL MANAGEMENT PROGRAM

Definitions

Amphipods. Small shrimp-like crustaceans (for example, sand fleas). Many live on the bottom, feed on alae and detritus, and serve as food for many marine species. Amphipods are used in laboratory bioassays to test the toxicity of sediments.

Apparent Effects Threshold. The sediment concentration of a contaminant above which statistically significant biological effects would always be expected.

Area Ranking. The designation or type of a dredging area relative to its potential for having sediment chemicals of concern. Rankings range from "low" potential to "high" potential, and area used to determine the intensity of dredged material evaluation and testing that might be required.

Baseline Study. A study designed to document existing environmental conditions at a given site. The results of a baseline study may be used to document temporal changes at a site or document background conditions for comparison with another site.

Bathymetry. Shape of the bottom of a water body expressed as the spatial pattern of water depths. Bathymetric maps are essentially topographic maps of the bottom of a body of water.

Benthic Organisms. Organisms that live in or on the bottom of a body of water.

Bioaccumulation. The accumulation of chemical compounds in the tissues of an organism. For example, certain chemicals in food eaten by a fish tend to accumulate in its liver and other tissues.

Bioassay. A laboratory test used to evaluate the toxicity of a material (commonly sediments or wastewater) by measuring behavioral, physiological, or lethal responses of organisms.

Biota. The animals and plants that live in a particular area of habitat.

Bottom-Dump Barge. A barge that disposes of dredged material by opening along a center seam or through doors in the bottom of the barge.

Bottomfish. Fish that live on or near the bottom of a body of water.

Bulk Chemical Analyses. Chemical analyses performed on an entire sediment sample, without separating water from the solid material in a sample.

Capping. See confined aquatic disposal.

Candidate Dredged Material. Sediments proposed for dredging.

Carcinogenic. Capable of causing cancer.

Clamshell Dredging. Scooping of the bottom sediments using a mechanical clamshell bucket of varying size. Commonly used in calm water over a wide variety of grain sizes and calm water, the sediment is dumped onto a separate barge and towed to a disposal site when disposing in open water.

Code of Federal Regulations. The compilation of Federal regulations adopted by Federal agencies through a rule-making process.

Compositing. Mixing portion of different samples to produce a composite sample for chemical and/or biological testing.

Confined Disposal. A disposal method that isolates the dredged material from the environment. Confined disposal may be in aquatic, nearshore, or upland environments.

Confined Aquatic Disposal (CAD). Confined disposal in a water environment. Usually accomplished by placing a layer of sediment over material that has been placed on the bottom of a water body (i.e., capping).

Contaminant. A chemical or biological substance in a form or in a quantity that can harm aquatic organisms, consumers of aquatic organisms, or users of the aquatic environment.

Contaminated Sediment.
Technical Definition: A sediment that contains measurable levels of contaminants.

Management or Common Definition: A sediment that contains sufficient concentration(s) relative to accepted Federal standards of chemicals to produce unacceptable adverse environmental effects and thus require restriction(s) for dredging and/or disposal of dredged material.

Conventional Nearshore Disposal. Disposal at a site where dredged material is placed behind a dike in water along the shoreline, with the final elevation of the fill being above water. "Conventional" disposal additionally means that special contaminant controls or restrictions are not needed.

Conventional Upland Disposal. Disposal at a site created on land (away from shore area) in which the dredged material eventually dries. Upland sites are usually diked to confine solids and to allow surface water from the disposal operation to be released. "Conventional: disposal additionally means that special contaminant controls or restrictions are not needed.

Depositional Analysis. A scientific inspection of the bottom sediments that identifies where and what type of sediments tend to accumulate.

Depositional Area. An underwater region where sediments tend to accumulate.

Disposal. See confined disposal, conventional nearshore disposal, conventional upland disposal, and unconfined, open-water disposal.

Disposal Site. The bottom area that receives discharged dredged material; encompassing, and larger than, the target area and the disposal zone.

Disposal Zone. The area that is within the disposal site that designates where surface release of dredged material will occur. It encompasses the smaller target area. (See also "target area" and "disposal site".)

Dredged Material. Sediments excavated from the bottom of a waterway or water body.

Dredger. Private developer or public entity (e.g., Federal or State agency, port or local government) responsible for funding and undertaking dredging projects. This is not necessarily the dredging contractor who physically removes and disposes of dredged material (see below).

Dredging. Any physical digging into the bottom of a water body. Dredging can be done with mechanical or hydraulic machines.

Dredging Contractor. Private or public (e.g., Corps of Engineers) contractor or operator who physically removes and disposes of dredged material for the dredger (see above).

Ecosystem. A group of completely interrelated living organisms that interact with one another and with their physically environment.

Effluent. Effluent is the water flowing out of a contained disposal facility. To distinguish from "runoff" (see below) due to rainfall, effluent usually refers to water discharged during the disposal operation.

Elutriate. The liquid portion from mixing water and dredged material. The elutriate can be used for chemical and biological testing to access potential water column effects of dredged material disposal.

Entrainment. The addition of material to dredged material during disposal, as it descends through the water column.

Environmental Impact Statement. A document that discusses the likely significant environmental impacts of a proposed project, ways to lessen the impacts, and alternatives to the proposed project. EIS's are required by the National and State Environmental Policy Acts.

Erosion. Wearing away of rock or soil via gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical or chemical forces.

Estuary. A constricted coastal water body where lake water is mixed with other inflowing water sources.

Ground Water. Underground water body, also called an aquifer. Aquifers are created by rain which soaks into the ground and flows down until it collects at a point where the ground is not permeable.

<u>Habitat.</u> The specific area or environment in which a particular type of plant or animal lives. An organism's habitat provides all of the basic requirements for life.

<u>Hazardous Waste.</u> Any solid, liquid, or gaseous substance which, because of its source or measurable characteristics, is classified under Federal law as hazardous, and is subject to special handling, shipping, storage, and disposal requirements.

<u>Hopper Dredge.</u> A hydraulic suction dredge that is used to pick up coarser grain sediments (such as sand), particularly in less protected areas with sea swell. Dredged materials are deposited in a large holding tank or "hopper" on the same vessel, and then transported to a disposal site.

<u>Hydraulic Dredging.</u> Dredging accomplished by the erosive force of a water suction and slurry process, requiring a pump to move the water-suspended sediments. Pipeline and hopper dredges are hydraulic dredges.

<u>Hydraulically Dredged Material.</u> Material, usually sand or coarser grain, that is brought up by a pipeline or hoper dredge. This material usually includes slurry water.

<u>Hydrocarbon.</u> An organic compound composed of carbon and hydrogen. Petroleum and its derived compounds are hydrocarbons.

<u>Infauna.</u> Animals living in the sediment.

Leachate. Water or other liquid that may have dissolved (leached) soluble materials, such as organic salts and mineral salts, derived from a solid material. Rainwater that percolates through a sanitary landfill and picks up contaminants is called the leachate from the landfill.

Local Sponsor. A public entity (e.g., port district) that sponsors Federal navigation projects. The sponsor seeks to acquire or hold permits and approvals for disposal of dredged material at a disposal site.

Loran C. An electronic system to facilitate navigation positioning and course plotting/tracking.

Mechanical Dredging. Dredging by digging or scraping to collect dredged materials. A clamshell dredge is a mechanical dredge. (See "hydraulic dredging.")

Metals. Metals are naturally occurring elements. Certain metals, such as mercury, lead, nickel, zinc, and cadmium, can be of environmental concern when they are released to the environment in unnatural amounts by man's activities or through physical processes such as erosion.

Microlayer, Surface Microlayer. The extremely thin top layer of water that can contain high concentrations of natural and other organic substances. Contaminants such as oil and grease, many lipophilic (fat or oil associated) toxicants, and pathogens may be present at much higher concentrations in the microlayer than they are in the water column. Also the microlayer is biologically important as a rearing area for marine organisms.

Microtox. A laboratory test using luminescent bacteria and measuring light production, used to assess toxicity of sediment extracts.

Molt. A complex series of events that results in the periodic shedding of the skeleton, or carapace by crustaceans (all arthropods for that matter). Molting is the only time that many crustaceans can grow and mate (particularly crabs).

Monitor. To systematically and repeatedly measure something in order to detect changes or trends.

Nutrients. Essential chemicals needed by plants or animals for growth. Excessive amounts of nutrients can lead to accelerated growth of algae and subsequent degradation of water quality due to oxygen depletion. Some nutrients can be toxic at high concentrations.

Overdepth Material. Dredged material removed from below the dredging depth needed for safe navigation. Though overdepth is incidentally removed due to dredging equipment precision, its excavation is usually planned as part of the dredging project to ensure proper final water depths. Common overdepth is 2 feet below the needed dredging line.

Oxygen Demanding Materials. Materials such as food waste and dead plant or animal tissue that use up dissolved oxygen in the water when they are degraded through chemical or biological processes. Chemical and biological oxygen demand (COD and BOD, respectively) are different measures of how much oxygen demand a substance has.

Parameter. A quantifiable or measurable characteristic of something. For example, height, weight, sex, and hair color are all parameters that can be determined for humans. Water quality parameters include temperature, pH, salinity, dissolved oxygen concentration, and many others.

Pathogen. A disease-causing agent, especially a virus, bacteria, or fungi. Pathogens can be present in municipal, industrial, and nonpoint source discharge.

Permit. A written warrant or license, granted by an authority, allowing a particular activity to take place. Permits required for dredging and disposal of dredged material include the U.S. Army Corps of Engineers Section 404 permit, the Wisconsin Department of Natural Resources permit.

Persistent. Compounds that are not readily degraded by natural physical, chemical, or biological processes.

Pesticide. A general term used to describe any substance, usually chemical, used to destroy or control organisms (pests). Pesticides include herbicides, insecticides, algicides, and fungicides. Many of these substances are manufactured and are not naturally found in the environment. Others, such as pyrethrum, are natural toxins which are extracted from plans and animals.

pH. The degree of alkalinity or acidity of a solution. Water has a pH of 7.0. A pH of less than 7.0 indicates an acidic solution, and a pH greater than 7.0 includes a basic solution. The pH of water influences many of the types of chemical reactions that occur in it.

Pipeline Dredge. A hydraulic dredge that transports slurried dredged material by pumping it via a pipe. (See "hydraulic dredge".)

Point Source. Locations where pollution comes out of a pipe or single discharge.

Polychlorinated Biphenyls. A group of manmade organic chemicals, including about 70 different but closely related compounds made up of carbon, hydrogen, and chlorine. If released to the environment, they persist for long period of time and can concentrate in food chains. PCB's are not water soluble and are suspected to cause cancer in humans. PCB's are an example of an organic toxicant.

Polycyclic (Polynuclear) Aromatic Hydrocarbon. A class of complex organic compounds, some of which are persistent and cancer-causing. These compounds are formed from the combustion of organic material and are ubiquitous in the environment. PAH's are commonly formed by forest fires and by the combustion of fossil fuels. PAH's often reach the environment through atmospheric fall-out, highway runoff, and oil discharge.

Priority Pollutants. Substances listed by EPA under the Clean Water Act as toxic and having priority for regulatory controls. The list includes toxic metals, inorganic contaminants such as cyanide and arsenic, and a broad range of both natural and artificial organic compounds.

Range Markers. Pairs of markers which, when aligned, provide a known bearing to a boat operator. Two pairs of range markers can be used to fix position at a point.

Regulatory Agencies. Federal and State agencies that regulate dredging and dredged material disposal in Wisconsin, along with pertinent laws/permits, include:

U.S. Army Corps of Engineers

- River and Harbor Act of 1899 (Section 10 permits)
- Clean Water Act (Section 404 permits)

U.S. Environmental Protection Agency

- Clean Water Act (Section 404 permits)

Wisconsin Dept. of Natural Resources

- Chapter 30 permits

The Resource Conservation and Recovery Act. The Federal law that regulates solid and hazardous waste.

Respiration. The metabolic processes by which an organism takes in and uses oxygen and releases carbon dioxide and other waste products.

Runoff. Runoff is the liquid fraction of dredged materials or the flow/seepage caused by precipitation landing on and filtering through upland or nearshore dredged material disposal sites.

Salmonid. A fish of the family Salmoniidae. Fish in this family include salmon and trout.

Sediment. Material suspended in or settling to the bottom of a liquid, such as the sand and mud that make up much of the shorelines and bottom of waterways. Sediment input comes from natural sources, such as erosion of soils and weathering of rock, or anthropogenic sources, such as forest or agricultural practices or construction activities. Certain contaminants tend to collect on and adhere to sediment particles.

Site Condition. The degree of adverse biological effects that might occur at a disposal site due to the presence of sediment chemicals of concern; the dividing line between "acceptable" (does not exceed the condition) and "unacceptable" (exceeds the site condition) adverse effects at the disposal site. Other phrases used to describe site condition include "biological effects condition for site management" and "site management condition."

Spot Checking. Inspections on a random basis to verify compliance with permit requirements.

Statistically Significant. A quantitative determination of the statistical degree to which two measurements of the same parameter can be shown to be different, given the variability of the measurements. (Chi-squared.)

Suspended Solids. Organic or inorganic particles that are suspended in water. The term includes and, mud, and clay particles as well as other solids suspended in the water column.

Toxic. Poisonous, carcinogenic, or otherwise directly harmful to life.

Toxic Substances and Toxicants. Chemical substances, such as pesticides, plastics, detergents, chlorine, and industrial waste that are poisonous, carcinogenic, or otherwise harmful to life if found in sufficient concentrations.

Treatment. Chemical, biological, or mechanical procedures applied to an industrial or municipal discharge or to other sources of contamination to remove, reduce, or neutralize contaminants.

Turbidity. A measure of the amount of material suspended in the water. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. Very high levels of turbidity can be harmful to aquatic life. Turbidity may be natural or manmade.

Unconfined, Open-Water Disposal. Discharge of dredged material into an aquatic environment, usually by discharge at the surface, without restrictions or confinement of the material once it is released.

Variable Range Radar. Radar equipped with markers which allow measurement of bearings and distances to known targets.

Volatile Solids. The material in a sediment sample that evaporates at a given high temperature.

Wetlands. Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adopted for life in saturated soil conditions. Wetlands include, but are not limited to, swamps, marshes, bogs, and similar areas.

Wisconsin Environmental Policy Act. A State law intended to minimize environmental damage. WEPA requires that State agencies and local governments consider environmental factors when making decisions on activities, such as development proposals.

Zoning. To designate, by ordinances, areas of land reserved and regulated for specific land uses.

Abbreviations

AET. Apparent Effects Threshold.

CFR. Code of Federal Regulations.

Corps. U.S. Army Corps of Engineers.

CWA. The Federal Clean Water Act, previously known as the Federal Water Pollution Control Act.

DEIS. Draft Environmental Impact Statement.

DNR. Wisconsin Department of Natural Resources.

EIS. Environmental Impact Statement.

EPA. Environmental Protection Agency.

FVP. Field Verification Program.

ML. Maximum Level.

NEPA. National Environmental Policy Act.

PAH. Polycyclic (Polynuclear) Aromatic Hydrocarbon.

PCB's. Polychlorinated Biphenyls.

PMP. Proposed Management Plan.

RCRA. The Resource Conservation and Recovery Act.

WEPA. Wisconsin Environmental Policy Act.

SL. Screening Level.

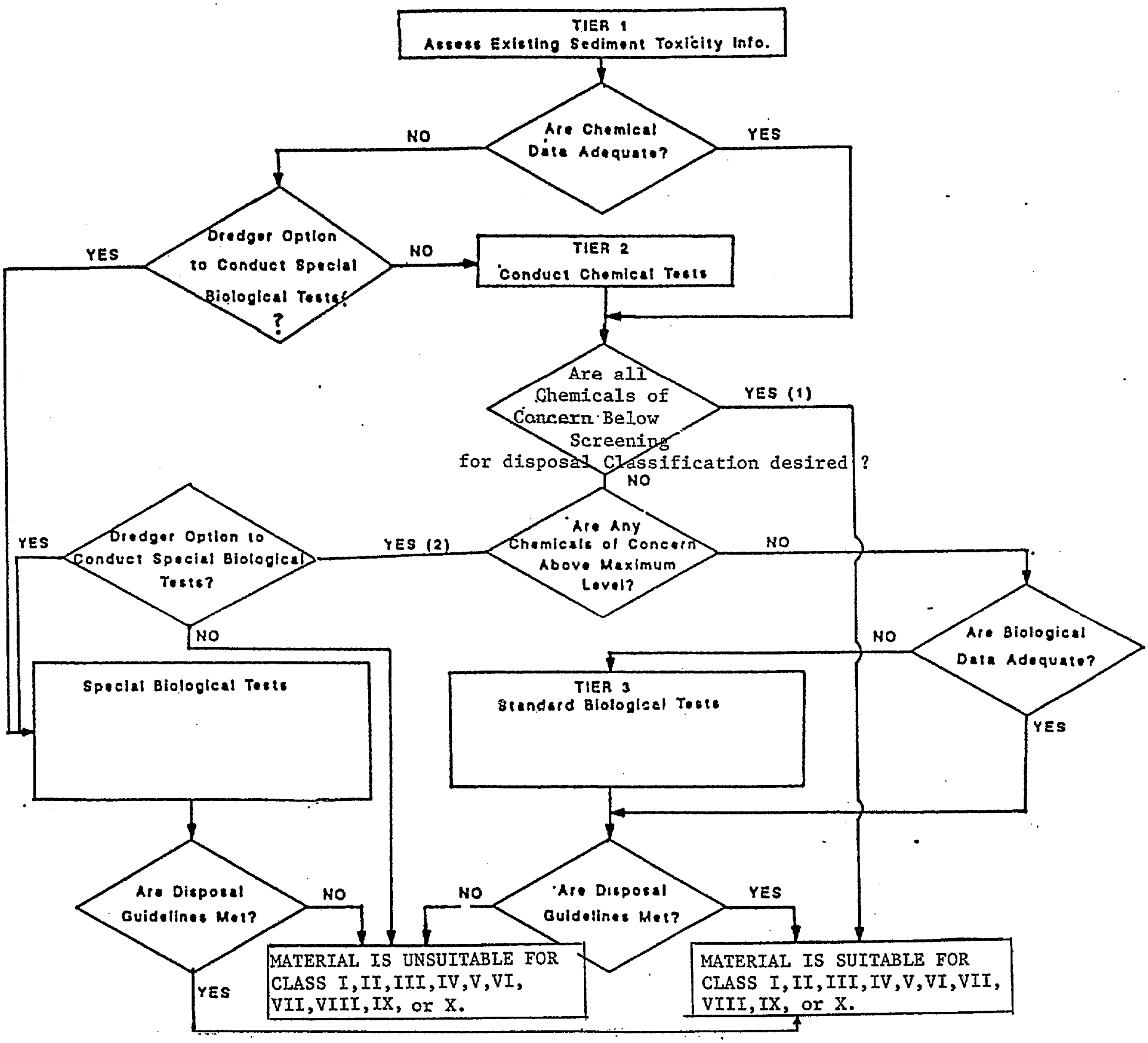
__WES.__ Waterways Experiment Station.

__401.__ Section 401 of the Clean Water Act.

__404.__ Section 404 of the Clean Water Act.

APPENDIX 2

WISCONSIN DREDGED MATERIAL DISPOSAL MANAGEMENT PROGRAM
Testing Sequence Flow Chart



IX. SELECTED DISPOSAL TECHNIQUES

IX. SELECTED DISPOSAL TECHNIQUES

A. BEACH NOURISHMENT (CLASS I a, II c)

Shoreline features in many areas have been eroded due to increased wave action caused by higher lake levels. As these landforms are lost, wetlands and marshes, agricultural land and residential properties are left vulnerable to seasonal and storm-related high water and wave action. These landforms could be re-established or protected by barriers partially constructed with dredged material.

An option is to construct a perimeter barrier around the area to be protected and reclaimed. This barrier could be constructed of various materials but would likely be armored or otherwise stabilized on the lake side. The back side could be constructed in a less stable fashion using silt fence or other means to keep the dredged material in place.

Another option would be to design shoreline protection using a sacrificial beach which would be renourished each year by dredging. An alternative would be to construct a nearshore structure with fill capacity.

A third option would involve reconstruction of barrier beaches if relatively clean sediments are available. Many marsh areas are threatened due to barrier beaches being breached by wave action and eventually submerged. The intense flooding and wave action in the marshlands could alter the area landforms and ecosystems. Placing dredged materials where the beaches used to be would provide replacement of eroded material and protection of fragile wetlands.

Because of the shallow nature of the areas involved in all of these options, pumping would probably be required. However, it is important to weight the costs of these projects against the potential benefits that could be derived, i.e., flood protection, habitat enhancement and restoration of valuable shoreline. In addition, the creation of barriers, beaches or reconstructing eroded landforms will not result in a land cost as would occur in the acquisition of property for upland operations. Therefore, only the cost of dredged material transport to a shoreline reconstruction site is considered here.

The basic costs of pipeline transportation (power, maintenance) are on the order of $0.50/cy/mi. An additional cost is the pumping, mooring station which is estimated to be about $500,000 and have a 20-year life. Pipe is estimated at $185,000/mile (IJC-1988).

Those facilities protected by stable or armored dikes will weather the rigors of wind and water for many years without much maintenance. They present a finite amount of disposal space, not unlike a CDF. On the other hand, placing material with temporary or no confinement depends on lake levels, storms, and the establishment of vegetative cover for long-term stability. Erosion from year to year is quite likely, meaning that yearly renewal of eroded areas would be required in order to provide structural stability and inshore protection

For this report we will assume that the "clean" material (± 30,000 cy/yr) would be eligible for this type of disposal.

B. CONTAINED AQUATIC DISPOSAL AT CROSS CHANNEL DEEP HOLE (CLASS II b)

Contaminants found in river or harbor sediments may be effectively isolated by subaquatic burying. This option involves the capping (covering) of contaminated sediments with cleaner, less contaminated sediments. Although it is technically feasible to cap highly contaminated sediments in-place, at their original location, conflicting uses such as navigation and the cost of relocating that use may dictate that contaminated sediments be moved from their original site of deposition. Contaminated sediments can be collected from various and disparate sites, placed in a smaller area, and subsequently capped (or buried) in order to achieve isolation. Dredging and dredged material disposal techniques are used to accomplish these tasks. The term Contained Aquatic Disposal (CAD) has been coined in U.S. Army Crops of Engineers publications to describe this option.

It is also technically feasible to cap contaminated sediments in place at their original location. The following discussion may be applied in either case, in regard to the material to be capped, the capping material and the placement of the capping material.

When relocating contaminated sediments, it is normally considered desirable to minimize the physical size of the placement through precise deposition. Deposition is controlled through careful selection and operation of the dredging equipment. Precise placement of the dredged materials is complicated, however, by the quantities of materials involved, their density (percent solids), and the difficulty of positioning equipment. Deposition is further complicated by the lack of direct visual contact with the bottom. Precise placement of materials can be accomplished with careful control of a variety of operational factors, including good navigational control of the depositing ship or barge and the maintenance of a relatively consolidated material mass through mechanical dredging or the fitting of low velocity diffusers on the discharge ends of hydraulic pipelines. The most effective means of controlling subaquatic placement can be achieved by the preliminary preparation of the disposal site through excavation of an underwater "hole," into which the contaminated materials are placed and subsequently covered; not considered necessary in this case because of the Cross Channel hole's existence.

The sediments which are to be capped should be relatively dense and consolidated in order to support the weight of the capping material. If the materials which are to serve as a cap are denser than the materials to be covered, the capping materials are liable to sink through the contaminated sediments, leaving them uncovered. Gunnison et. al. (1987) reported that "attempts to cap sediments having densities (percent solids) below 40% are presently interpreted to mean that clamshell dredging, rather than hydraulic dredging, gives the better substrate of contaminated dredged material for a capping operation. However, this recommendation does not necessarily mean that all clamshell-dredged contaminated sediments are suitable for capping. On occasion, some modifications may be required to increase the density of the contaminated dredged material, decrease the density of the cap material, or otherwise prevent the capping material from sinking into the underlying contaminated dredged sediment."

Although either mechanical or hydraulic methods may be used to place contaminated sediments into the underwater hole, each case should be evaluated based on sediment and capped material characteristics and disposal site considerations, to determine the most appropriate type of equipment to use. While mechanical dredging and placement can result in the deposition of a highly consolidated mass of materials, there is a certain amount of sediment resuspension into the overlying water column (albeit transiet) as the materials fall through the water column. Direct placement of the contaminated materials, at a specifically defined disposal site, can also be accomplished through pipelines which are outfitted with diffuser discharge heads to provide for minimum discharge velocities and, therefore, rapid settling of the discharged solids and their associated contaminants.

This is the preferred method.

The cover must provide a physical barrier to isolate the contaminated sediments from contact with the biota in the overlying aquatic environment. Thus, it must be of sufficient thickness to prevent chemical diffusion and mechanical breaching of the cover. Mechanical breaching can be caused by wave scour and the burrowing of aquatic organisms such as clams and worms. Gunnison et al. (1987) have described how laboratory testing of three parameters in bench type tests can be used to determine the minimum cap thickness necessary to provide for chemical isolation of contaminated sediments. Depletion of dissolved oxygen, the release of ammonium-nitrogen and occasionally the release of orthophosphate-phosphorus were found to be effective predictors to determine the minimum thickness of capping materials needed to provide chemical isolation of contaminated sediments.

In most cases, organic contaminants found in sediments are much less mobile than ammonium or dissolved oxygen. Thus, a cap thickness that is effective these inorganic constituents will also be effective for organic contaminants, which are normally strongly bound to the fine grained particles and the oils and greases common to highly contaminated sediments. Organic contaminants which are more strongly bound to the sediments than these inorganic indicators include polynuclear aromatic hydrocarbons (PAHs), petroleum hydrocarbons, and polychlorinated biphenyls (PCBs). In tests on a limited number of sediment samples at the U.S. Army Corps of

Engineers' Waterways Experiment Station, the ability to successfully cap contaminated sediments was found to be dependent on the relative densities of the contaminated sediments and the materials to be used as their caps. Fine grained sediments have been found to be a more effective capping material than coarse grained, sandy material.

Minimum cap thickness needed to prevent physical disturbance to buried contaminated sediments should normally be a function of the maximum burrowing depth by benthic organisms found in the region and erosive forces due to currents and turbulence. The depth of biological penetration can be determined through benthic community investigations or from the first hand knowledge of aquatic biologists regarding the habits of the local benthic communities. Erosive forces are a function of wave height and water depth, and the currents generated can be measured with current meters.

Gunnison et al. (1987) described the minimum cap thickness needed to achieve total isolation of the underlying contaminants as being equal to the sum of the individual cap thicknesses which would each be needed to achieve both physical and chemical isolation. It is necessary to sum these two values in order to preclude burrowing organisms from penetrating the zone of chemical diffusion in the cap.

In order to successfully over and contain contaminated sediments, many operational factors must be coordinated.

These factors, as listed by Truitt (1987a), are identified in the following Table.

CONSIDERATIONS FOR PLANNING CAPPING OPERATIONS

DECISION NUMBER	DESCRIPTION	IMPACTED BY DECISION NO.
1	Dredge equipment selection	
2	Selection of disposal and capping site	
3	Placement method for contaminated material	1,2
4	Method for transporting contaminated material to disposal site	1,2,3
5	Selection of capping material	1,2,3,4
6	Placement method for cap	1,2,3,4,5
7	Dredge plant for obtaining cap material	1,2,3,4,5,6
8	Method for transporting cap material to disposal site	1,2,3,4,5,6,7
9	Method for navigation and positioning at site	2,4,8
10	Method for monitoring site	2,9

Subaqueous capping has been conducted using mechanical dredging techniques in Long Island Sound and the New York Bight, New York, and the Duwamish Waterway in the State of Washington. These cases have shown that capping is technically feasible and that the caps are stable under normal tidal, wave and biological conditions. Although disposal site preparation by predisposal excavation has not been demonstrated in either the United States or Canada as of September 1987, a pilot demonstration of the technique using hydraulic equipment is currently being proposed to state authorities by the U.S. EPA and the U.S. Army Corps of Engineers as a remedial action for a Superfund clean up site in New Bedford Harbor, Massachusetts. It seems logical that predisposal excavation would enhance the isolation of contaminated materials by reducing the surface area of the contaminated materials with respect to their exposure to the water column.

Laboratory and field verification studies have demonstrated that capping of contaminated sediments can be effective in short, medium and long time frames for preventing the movement of contaminants into the water column and biota (Brannon et al. 1986).

Close short-term monitoring, hydrographic survey, is required to assure that the contaminated sediments are placed in the proper location and that the subsequent capping completely covers the contaminated sediments to the minimum capping thickness required. Long-term monitoring, hydrographic survey, is required to assure that the capping material remains in place. Additional post-remediation monitoring is needed to assure that contaminated sediments have been effectively isolated from the water column.

This option is the preferred short range, low cost alternative. The option would include deposition of "polluted" materials with a cap of "clean" material for each dredging cycle. The option would provide approximately 7.5 years of storage at historical dredging volumes with additional benefits as follows:

* Provide low cost disposal for a period during which dredging and disposal standards and methods may be formalized through the regulatory process.
* Provide additional time for the design and permitting of new long-term disposal alternatives.

* Create new shallow water and upland habitat within the harbor.

C. IN WATER/NEARSHORE CONFINED DISPOSAL AT BUNGE SLIP (CLASS III)

At present, almost all contaminated dredged material is disposed of either at suitable upland sites or in engineered confined disposal facilities. Isolation of the material is achieved through placement in an area that has been specifically prepared and dedicated as a long-term storage or disposal site. The dedicated storage location is normally prepared by construction of perimeter dikes to withhold the contaminated materials.

Contaminated sediments are first collected and removed from their original site of deposition by dredging (Appendix I provides a discussion on the selection of dredging equipment). These contaminated sediments are then transported and deposited in the confined disposal facility. The specific design of the CDF, the specific type of dredging equipment to be used, the method of transportation, and the operation of the CDF must be tailored to site specific circumstances in order to insure that contaminants of concern are captured, deposited into and retained by the CDF at minimum cost. The design and construction methodology for a CDF depends on many factors such as physical characteristics of the dredged material, type and level of contaminants present in the sediment, dredging method, design life of the facility and site-specific considerations such as its location, wave climate and availability of construction material. a more detailed discussion of factors to be considered for disposal of dredged material and their interaction is included in the Corps of Engineers' CDF Design Memorandum. A typical CDF consists of a diked enclosure with one large cell for disposal of material, and adjoining cells for retention and decantation of turbid supernatant water. In a mechanical dredging project, the material is usually double handled into the facility in a considerable dewatered state, thus the provision of a decant cell is not required.

Some CDFs have been constructed adjacent to existing breakwaters, incorporating the breakwater as a portion of the containment structure. Some have been built adjacent to the existing shore to take advantage of the shoreline to form a portion of the containment boundaries. Others, located offshore and entirely in the lake and without being attached to any other structure, have formed new, man-made islands. Upon completion of filling operations, the deposited contaminated sediments are covered with a layer of clean fill material. The extent and thickness of clean fill is dependent on the type and level of contaminants present in the sediments. Ultimately, a top vegetative cover is provided for stabilization and to minimize erosion.

Advantages of sites located in the water include maintenance of a saturated soil condition in the lower levels, a relatively neutral hydraulic gradient relative to groundwater, greatly reduced land costs, the ability to locate disposal sites near sources of contaminated sediments (thereby minimizing transportation costs), and public concern is frequently minimized as the sites are not adjacent to or near private residential property.

Against the overall landscape, CDFs are fairly large, relatively isolated areas with a variety of physical characteristics attractive to various species of fish and wildlife. As accumulating sediments rise above the level of the interior pond water, the sites will become colonized by a wide variety of opportunistic plant and animal species. Over 145 species of birds have been found on Great Lakes CDFs; gulls, terns, herons, egrets, shorebirds and waterfowl are common. Because these sites are relatively isolated and undisturbed by human presence, CDFs are typically colonized as nesting sites. Nesting colonies of gulls, terns and black-crowned night herons have established themselves in the Saginaw and Pointe Mouille CDFs among others. The shallow water and mud flat areas of CDFs can cause waterfowl botulism problems. Labour-intensive responses to discourage waterfowl use has been found to be effective in response to these problems. Fish populations, trapped through original construction and introduced with waters from dredging, are typically present in the interior pond water. These fish have been found to accumulate significant concentrations of organic contaminants found in the sediments.

The first CDF to come into use in the Great Lakes was the Grassy Island site for containment of contaminated sediments from the Rouge River, Michigan navigation project in 1960. Use of CDF sites has increased significantly in the Great Lakes since 1970; most sites were constructed between 1972 and 1979. Considerable experience has been gained and improvements made in the design, construction, operation and maintenance of such facilities over this period. Significant improvements also have been made to ensure structural integrity of containment dikes so that minimal loss of contaminants occurs from the CDFs. Monitoring work has shown that CDFs, if properly designed and operated, have succeeded in isolating and preventing polluted sediments from re-entering the lakes. In short, technical and environmental feasibility of CDFs have been well established from experience gained over the years. There are, at present, five long-term sites in Canada and 30 long-term sites in the United States portion of the Great Lakes. The cost of building and operating CDFs are dependent on their size, mode of operation and a host of site-specific factors. The cost of CDFs built in Canadian portions of the Great Lakes have ranged anywhere from $2.30 to $7.65/yd of capacity, which would be comparable to any other mode of disposal. In some instances, the cost of CDFs were more than offset by the value of land created in the process. Costs of construction for the United States sites range from $.38 to $11.47/yd capacity. The most typical unit costs range from \$.76 to \$3.86/yd; nearly 60% of the facilities have construction costs within this range. However, in a significant portion of the facilities (about 23%), construction costs exceeded \$7.65/yd. Costs for siting, engineering, land acquisition, dredging, transportation of contaminated sediments to the site and long-term maintenance need to be added in order to determine the final unit costs for disposal with this alternative (IJC-1988). a recent sanitary landfill project for the City of Superior was projected at \$3.50/cy of capacity. The new cell was designed to NR 500 series whose standards are assumed to be similar to a CDF. (low bid proposal 6/22/89).

The Corps has also developed a cost of \$2.33/cy of capacity for its upland disposal facility for the Duluth-Superior Harbor Channel Extension Project. It should be noted that the lower cost of the Corps facility is related to the difference in disposal standards between the Corps and WDNR.

D. UPLAND CONFINED DISPOSAL AT ITASCA (CLASS VI)

The landfilling of contaminated sediments has three stages:

1. dredging or other removal process
2. transportation to a landfill; and
3. disposal in the landfill

The dredging requirements of contaminated sediments destined for landfilling need not be different from those that may be associated with other sediment management programs. However, sediments to be landfilled may have significant dewatering requirements in order to reduce the quantity of material to be landfilled or, in some cases, to permit the sediments to be classified as a "solid" for landfilling purposes. As described below, the landfilling of material classified for these purposes as "liquid" is not allowed in the United States.

- Transportation of sediments to a landfill requires compliance with applicable state and federal regulations. Landfilling must only occur in appropriately licensed facilities. The specific transportation and disposal requirements for contaminated sediments will vary according to the characteristics of the waste as determined for waste management purposes in a particular jurisdiction.

- Landfilling of wastes is an established practice in many jurisdictions and is continually being improved through new standards and procedures. Although there are no technical or regulatory provisions prohibiting the disposal of contaminated sediments in landfills, there are three major reasons why the routine landfilling of contaminated sediments may be either impractical or undesirable from a public policy perspective:

- Cost. In many cases the landfilling of sediments is likely to be an expensive option. some of the cost factors include: tipping fees at both nonhazardous and hazardous landfill sites (these have risen rapidly in recent years) and transportation costs which may exceed disposal costs. Consequently, the landfilling of contaminated sediments is likely to be most cost-effective where small amounts of sediment can be disposed of at a landfill site within close proximity.

- Landfill Capacity. Landfills are any integral component of waste management programs throughout the Great Lakes Basin. However, existing landfill capacity is limited and new landfills can only be sited with considerable cost and difficulty. All levels of government in the United States are working to conserve current landfill capacity by introducing alternate options (e.g. recycling) for many types of solid waste. Therefore, while there may be contaminated sediments for which landfilling is a viable management option, landfilling of these sediments on a routine basis would be counter to these efforts if other acceptable management options were available.

- Selective Use. In some cases it may be possible to use contaminated sediments in a selective fashion. There are a range of uses for contaminated sediments. Instead of occupying a large volume of a landfill site, the disposal of this material can be phased over time, e.g. in a landfilling context, it may be possible to use sediments as daily cover material in place of topsoil that may otherwise be required.

The principal legislation governing waste management in the United States is the Resource Conservation and Recovery Act (RCRA). This legislation sets out the waste management procedures and standards that must be met on a national basis. However, individual states may implement waste management programs that complement the RCRA program or which replace it if the U.S. Environmental Protection Agency (EPA) deems that the state program is at least equivalent to the federal program. The landfilling of sediments in the states is therefore subject to the minimum requirements of the federal legislation.

RCRA provides for the classification of hazardous waste, the definition of solid and liquid waste and requirements for the permitting of hazardous and non hazardous waste landfills. Sediments may be classified as "hazardous" according to their leachate characteristics as defined by the Extraction Procedure (EP) Toxicity Test. Sediments classified as nonhazardous waste may be disposed of in landfills approved under Subtitle D of RCRA;

sediments classified as hazardous must be disposed of in landfills approved under Subtitle C of RCRA. Hazardous wastes must be registered with the U.s. EPA prior to transportation or disposal. Manifesting of these wastes is also required and transportation must be undertaken by an approved hauler.

Liquid wastes, as defined by the Paint Filter Liquid Test specified in RCRA, may not be landfilled in the United States. Contaminated sediments classified as liquid waste by this test must be solidified by dewatering, or some other means, if they are to be landfilled.

In Wisconsin, sediments may contain contaminants of concern for which hazardous waste classification criteria have not been developed. Where landfilling of these sediments is proposed, regulatory authorities may require testing to establish the nature and extent of these contaminants. Landfilling of these sediments may only be permitted in hazardous waste disposal facilities.
We recommend that this option be considered as a last resort and that only "polluted" materials be placed in an upland CDF.

E. BENEFICIAL RE-USE

Papers and reports have identified a variety of beneficial re-uses of dredge materials including soil, enhancement, recreational topography modifications, construction and others. It is assumed that beneficial re-use will be maximized in any alternative utilizing contained disposal.

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X. SELECTED DISPOSAL SCENARIO

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A. PLANNING ASSUMPTIONS

1. Since 1970, 2,137,237 cy (gross) have been dredged from the federal project areas; an annualized average of 125,720 cy. Of this annualized average Wisconsin contributes approximately 86,900 cy (69%) and Minnesota 38,800 cy (31%).

2. Since 1975 when pollution characterization was assigned, 1,696,267 cy (gross) have been removed from the federal project areas; an annualized average of 141,353 cy.

3. Of the material dredged since 1975, 350,705 cy (gross) or 21% of total have been characterized as unpolluted by the COE (all from Wisconsin waters); an annualized average of 29,225 cy.

4. Of the material dredged since 1975, 1,345,532 cy (gross) or 79% of total have been characterized as polluted by the COE (from both Wisconsin and Minnesota waters); an annualized average of 112,128 cy.

5. The Metropolitan Interstate Committee has estimated the volume of private dredge material at 25,000 to 40,000 cubic yards per year. Their reports also indicate a need to remove a backlog of undredged

shoals which amount to an additional 400,000 cubic yards. It is assumed that some of this material will be removed in the course of proposed harbor improvement projects.

6. For planning purposes, we will round up the annualized average dredge requirement for the federal channels to 130,000 cy.

7. We will also assume that 20% of the annualized volume of dredged material is "clean/unpolluted" (COE/.EPA).

8. From the literature we can identify generalized source areas of "unpolluted" and "polluted" materials as shown on the black and white map found in the rear pocket.

9. Since 1968, the COE has dredged 2,674,156 cy at a total cost of $13,640,935 or an average of $5.10/cy.

10. The cost of CDF disposed materials at Erie Pier exceeds beach nourishment at Wisconsin Point by $2.50/cy.

11. Costs at other Lake Superior dredging sites have been reported at: Black River Harbor, Michigan ($6.00/cy); Ontonagon, Michigan ($3.00/cy); and Saxon Harbor, Wisconsin ($9.50/cy). The cost for Saxon Harbor is elevated due to Wisconsin Standards.

12. Transport cost of 0.25 $/cy/mi are applicable in the area.

13. The Cross Channel Deep Hole has an estimated capacity of 970,000 cubic yards. An additional 190,000 cy of storage is available if island creation is considered.

14. The total capacity of other deep holes in the harbor is approximately 1,452,000 cubic yards.

15. The Bunge Slip has an estimated capacity of 1,100,000 cubic yards.

16. The water column of Bunge Slip exhibited weak stratification while Cross Channel Deep Hole exhibited no stratification.

17. Dissolved oxygen concentrations at Bunge Slip were generally between 80 and 90% of saturation. Cross Channel Deep Hole saturations were generally between 85 and 95%.

18. Fish species composition at Bunge Slip and Cross Channel Deep Hole were found to be similar to that observed in other deep-water dredged channels in the harbor; was comparable to 1973 and 1978 data.

19. Fish populations of both sites were similar.

20. Sediment analysis of samples from Cross Channel Deep Hole and the Bunge Slip found no PCB/s, no pesticides, no dioxin. Furan was detected at levels below 3 pg/g (3 parts per trillion dl of 0.44 pg/g).

21. Analytes found in excess of unadopted NR.347 standards are cadmium (1.2-1.5 mg/kg); copper (86 & 130 mg/kg); mercury (.1 & .16 mg/kg); and zinc (130 & 170 mg/kg).

22. Wetlands and wildlife at both Bunge Dock/Slip and Itasca were characterized as being of low quality. The Bunge Dock and Slip area contains approximately 8.5 acres of wetlands. The existing wetlands of the Itasca site were induced by upland disposal activities during the Barker's Island Project.

23. Purchase of new CDF disposal capacity at local sites is expected to be between $2.30-3.50/cy based on recent construction estimates for related projects. This does not include O & M, land purchase, design, monitoring, long term care, closure and other "soft" costs. Over a ten year period the cost would be in the range of $3,029,000-4,550,000 for a new upland CDF.

24. The technology exists to place materials in a subaqueous setting with a minimum of entrainment and bottom disturbance utilizing a down-tube with a velocity diffuser.

B. DESCRIPTION OF PROPOSED ALTERNATIVE

1. Scenario for Short and Medium Term Disposal (Pilot Project With Positive Findings)

Upon approval of a Confined Aquatic Disposal Pilot Project, "polluted" materials would be mechanically dredged, transported to the "deep hole" and placed within the confines of the hole utilizing a down-tube and velocity diffuser to minimize entrainment and bottom disturbance. "Clean" materials would then be dredged and placed in the same fashion providing a cap which would act as a screen to prohibit migration of contaminants. The literature sources suggest about two feet of cap although this should be substantiated through local research. This activity could continue until the useable capacity of the "deep hole" has been reached; an estimated 7.5 years. At the time that capacity is reached, several options for finishing the area are available.

a. A final cap at ± 6' below water surface level could be left composed of grain size material that would enhance its use by benthic organisms or aquatic vegetation. This would have the benefit of creating new shallow water habitat.

b. "Clean" material could be placed to elevation above surface water level and finished in such a fashion as to provide upland habitat as a continuation of the Interstate Island nesting area.

In either case or a combination of a. and b., approximately 20 acres of new habitat could be created that could be "mitigation banked" against potential future wetland losses that may occur at Bunge Slip (8.5 A.).

If the pilot project was considered a success and, if the State of Minnesota accepted the findings, the same process could be extended to the remaining "deep holes" in the harbor which can contain an estimated 1,452,000 cubic yards; an additional 11.1 years of dredged material storage (total of 18.6 years), and significant gains in shallow water and/or upland habitat.

The only new capital cost associated with this proposal is the acquisition of the machinery and equipment necessary for the down-tube pumping and velocity diffusion estimated at less than $750,000.

2. Scenario for Medium Term Disposal (Pilot Project With Negative Findings)

"Clean" material would be utilized for beach nourishment at either confined or unconfined sites. "Polluted" material would be transported to Bunge

Slip for solids and/or liquids containment using conventional technology. Beneficial reuse of larger grain size materials will be maximized. Bunge Slip has the capacity for approximately 8.5 years of storage (with no reuse). Since reuse varies with the market, no estimation of additional storage due to reuse is possible.

The potential benefits accruing to this scenario are the creation of new waterfront land; the unquantified reuse of suitable materials; and, the removal of dredged materials from the harbor system.

Negative attributes include: the high cost of the property; first capital construction and machinery/equipment costs for containment and reuse which will be in excess of $1,500,000; operations and maintenance cost; and disruption to nearby residential areas by truck traffic and day-to-day operations. This phase will also accrue the loss of 8.5 acres of low quality wetland and a useable slip and dock which may be needed in the future.

3. Scenario For Long Term Disposal

It is assumed that the traditional methods of dredging and disposal such as beach nourishment and CDF's will be available to the City of Superior. In this light, the Itasca Upland Site can be made available as a rejuvenated CDF. The site will require extensive reconstruction of the diking system, new road service and return flow controls. In addition, new pumping facilities will be required near the lakeshore along with a maintained channel of the off loading of dredged materials. These two latter activities will cause disruption of valuable shallow water habitat and the wetlands in Allouez Bay. Some disturbance to nearby residential areas may also occur depending upon reuse activities.

Numerous new technologies are being researched that may provide reasonable cost-effective and environmentally compatible alternatives. They are not described here in detail, but include: in-situ chemical and biological treatment for isolation and solidifcation of sediment and/or pollutants; and, decontamination of materials after dredging.

4. Impacts of Proposed Short and Medium Term Proposal

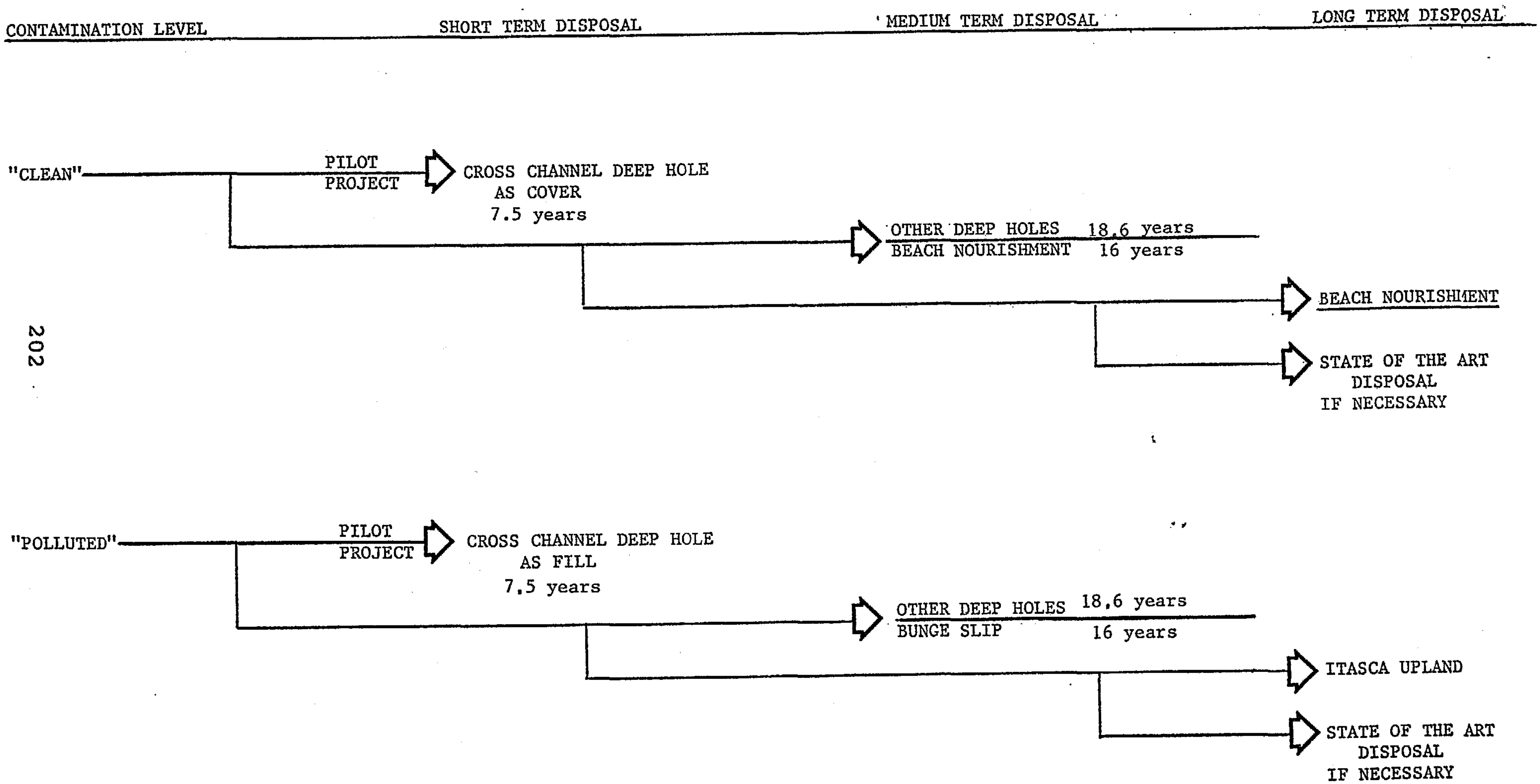
* Pilot Project provides contained disposal at minimal new capital cost for approximately 7.5 years; and up to 18+ years if transferable to other "deep holes."

* Minimal environmental impacts will occur in the immediate vicinity of the "deep hole."

* No new land disruption will take place.

* New shallow water and/or upland habitat will be created.

PROPOSED DISPOSAL SCENARIO



* The term of the Project will allow for enough research to be completed that will lead to establishment of cost-effective, environmentally compatible and reasonable standards for disposal that are unified across the responsible regulatory agencies for the Duluth-Superior Harbor.

* The term of the Project, and the concurrent creation of acceptable standards will allow for enough time to adequately plan, design and identify financing for a new facility if needed.

* Negative impacts to Superior's harbor socioeconomic structure will be minimized.

* The State of Wisconsin has an opportunity to take a leadership role in the development of disposal technology.

XI. ACTION REQUIRED

XI. ACTION REQUIRED

WE RECOMMEND THAT THE STATE OF WISCONSIN IN COOPERATION WITH THE CITY OF SUPERIOR AND THE CORPS OF ENGINEERS PROCEED IMMEDIATELY WITH:

* IDENTIFICATION OF A SCOPE OF WORK AND PLAN FOR A DEMONSTRATION PROJECT AS SUGGESTED

* SECURING AUTHORIZATION AND FINANCING FOR THE PILOT PROJECT.

* IMPLEMENTATION OF THE PILOT PROJECT.

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For WCMP Staff Use

Wisconsin Coastal Management Program
PROGRESS REPORT

WCMP Project Number:	
Date Received:	

Project Title: SUPERIOR HARBOR DREDGED MATERIAL DISPOSAL REPORT

Purchase Order Number: ADI-00223

Project Start Date: 7/20/89 **Completion Date:** 9/30/89

Report Period From: 9/30/89 **To:** FINAL

Signature of Project Manager: [signature]

1. **Thoroughly discuss progress made during this reporting period, citing specific tasks listed in contract scope of services.**

SCOPE OF SERVICES

Items listed below conform to the detailed scope and budget submitted 11/88 in accordance with the Proposed Scope of Services and as amended by Contract # 89033-891.3.

1. Literature Search--Item Complete

2. Field Study Design--Item Complete

3. Field Studies

   Aquatic--Item Complete
   Sediment--Item Complete
   Habitat--Item Complete
   Air Photo--Item Complete
   Digitization--Item Complete

4. Data Assembly--Item Complete

5. Data Evaluation--Item Complete

6. Draft and Final Report--Item Complete

SUPPLEMENTAL--see supplemental notes to previous reports.

over

Send to: Wisconsin Coastal Management Program
Department of Administration
P.O. Box 7868
Madison, WI 53707

Signature of person authorized to receive fund[s]: [signature]