CORNUCOPIA
HARBOR

CORNUCOPIA HARBOR DREDGING STUDY

Northwest Regional Planning Commission
an economic development district
302 Walnut Street Spooner, Wisconsin 54801 • 715 635-2197

CORNUCOPIA HARBOR DREDGING STUDY

DECEMBER 1986

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, AND, THE NORTHWEST REGIONAL PLANNING COMMISSION

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1.0 INTRODUCTION

1.1 Historical Perspective

The United States Army Corps of Engineers (Corps) constructed the channel entrance to the Cornucopia harbor basin during the 1920's and has provided maintenance to the channel on a regular basis. The Corps policy through the early 1970's was to maintain the breakwater which is a federal structure, and to provide maintenance dredging to the designated federal channel which serves as a turning basin. The authorized project depth for the channel is ten feet. The Corps standard practice was to remove bottom material, load it on barges and transport the dredge material to designated locations in Lake Superior for in-water disposal.

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 material could have harmful effects on the human health. In 1975 the State, in keeping with its committment to a high quality environment, requested that Corps dumping of dredge 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 that time numerous proposals have been made by the federal government to charge a sizeable portion of the cost of harbor maintenance dredging to state and local governments. It is this perceived change in federal policy that now causes concern at the state and local level with the need to find methods of dredge disposal that are both cost-effective and environmentally compatible.

1.2 Plan Intent

Because of the importance of commercial and recreational navigation in the Great Lakes to the State of Wisconsin; the planning and management of the dredging of these waters are consistent with the state's duty and the public trust. Legislation currently proposed provides a balancing of the public interest in maintaining and improving harbors with the public interest in protecting, preserving and enchancing environmental quality

In order to fully understand the balance, careful planning must be undertaken that is based upon knowledge of local conditions, proposed state and federal dredge disposal standards and the ability of governments to participate in the costs of dredging and disposal.

This planning effort offers opportunities to provide the public and local government officials with an understanding of the impacts of dredging and dredge material disposal.

This report includes an assessment of the resource base, sediment and water quality data which results in the identification of alternatives for action and the related costs of those actions.

2.0 PHYSICAL SETTING

2.1 Location

The Town of Bell is located in north central Bayfield county on the south shore of Lake Superior sixty miles east of Superior and thirty miles northwest of Ashland. The settlement of Cornucopia is a narrow strip of residential and commercial development along Siskiwit Bay in the northern portion of the Town. Cornucopia is the only population center in the Town of Bell.

Cornucopia is served by State Trunk Highway 13 and Bayfield County Trunk "C" both of which are in proximity to the harbor and provides easy access to the harbor from the Apostle Islands National Lakeshore, the Chequamegon National Forest and many inland lakes as well as neighboring communities.

2.2 Political Jurisdiction

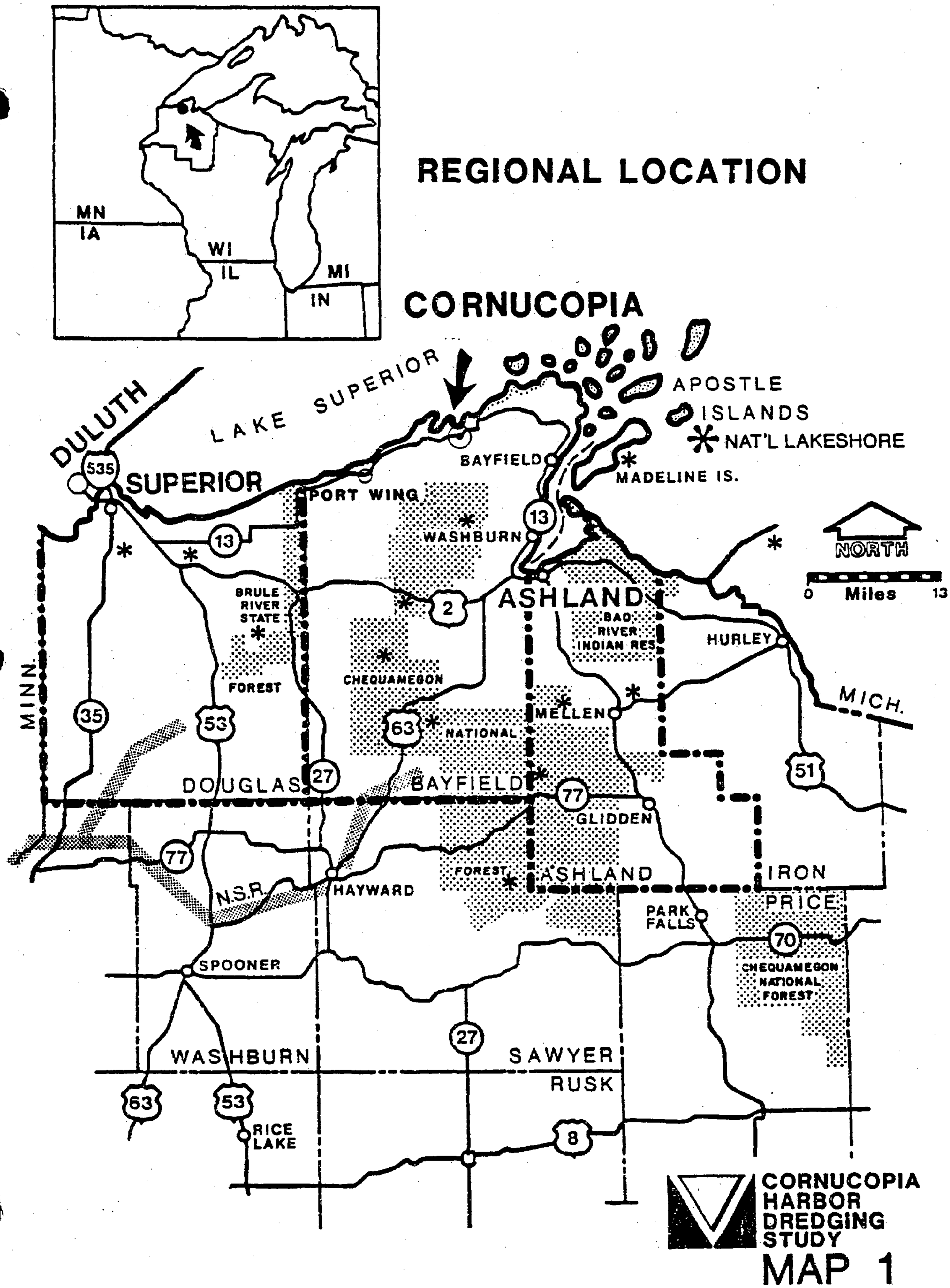
The Town of Bell exercises corporate powers through Chapter 60 of the Wisconsin Statutes. The Town Board consists of a chairman and two supervisors. Town officers include a clerk, treasurer, assessor and a constable.

The Town of Bell established a Harbor Commission in 1983 under Chapter 30 of the Statutes. The Harbor Commission is responsible for harbor planning, repairs and maintenance and has exclusive control over day-to-day operations. The activities are established by resolution of the Town Board and the Commission has no authority beyond the resolution. All planning and fiscal authority are granted to the Commmission although expenditures are subject to the approval of the Town Board.

2.3 Transportation

Access through and to the Town of Bell is primarily provided by S.T.H. 13, located close to the Lake Superior shoreline. Traffic counts, just outside Cornucopia, conducted by the Wisconsin Department of Transportation show an annualized average daily traffic (AADT) count of 610 vehicles a day. Projected AADT's for 1990 show a likely increase but is not expected to exceed the roads capacity to handle traffic.

The Bayfield to points south segment of STH 13 connects the Apostle Islands with US 2 and Ashland. STH 13 is a secondary scenic route even though it is the only east-west access route across the northern portion of Bayfield County


REGIONAL LOCATION
MN
IA
WI
IL
MI
IN
CORNUCOPIA
LAKE SUPERIOR
DULUTH
535
SUPERIOR
APOSTLE
ISLANDS
NAT'L LAKESHORE
BAYFIELD
MADELINE IS.
PORT WING
WASHBURN
13
NORTH
0 Miles 13
ASHLAND
BRULE RIVER STATE
FOREST
2
BAD RIVER INDIAN RES
HURLEY
CHEQUAMEGON
NATIONAL
MINN.
35
53
63
MELLEN
MICH.
51
DOUGLAS
27
BAYFIELD
77
GLIDDEN
77
N.S.R.
HAYWARD
FOREST
ASHLAND
IRON
PRICE
PARK FALLS
70
CHEQUAMEGON NATIONAL FOREST
SPOONER
WASHBURN
SAWYER
RUSK
27
63
53
RICE LAKE
8
CORNUCOPIA
HARBOR
DREDGING
STUDY
MAP 1

County Trunk "C", a hardsurfaced road, intersects with STH 13 in Cornucopia and connects the settlement with Washburn, twenty miles to the south. The remainder of the roads are under local jurisdiction and are gravel except for the paved streets of Cornucopia.

Cornucopia is served by a small airport west of the settlement. The grass runway is seldom used and no other improvements are at the site.

2.4 Geology and Topography

Northern Bayfield County is located in the Lake Superior Lowland geographical province. The province occupies the northern portions of Douglas, Bayfield and Ashland Counties and is bounded on the south by the Northern Highlands province, a low range of hills once the south shore of glacial Lake Duluth.

The region is characterized by a red clay-till lake plain, deeply incised by streams flowing north to Lake Superior. Pre-Cambrian sandstone of the Bayfield Group is found at depth.

Topographically the region rises from 600 feet above sea level at Lake Superior to over 1000 feet above sea level to the south and east of Cornucopia.

2.5 Climate

The climate of northern Bayfield County is classified as humid continental, which means that the region has very cold winters with rather short, moderately warm summers. Spring and fall are often short with sharp day-to-day temperature changes. All seasons have frequent weather changes as alternate high and low pressure systems move across the region.

The climate, however, is modified by the high heat and cold storage capacity of Lake Superior which tends to increase the number of frost free days along the lake and acts as a coolant in summer. As a result the Bayfield Peninsula has longer growing seasons, cooler summers and more precipitation than the balance of the county. The lake modified climate is suited for apples and other fruit trees, berries and dairying. Cornucopia is so named for the regions ability to provide large crops.

Prevailing winds are westerly from early fall through early spring and easterly the balance of the year. Average annual precipitation is 30" with an average snowfall of 73 inches. August is the wettest month with an average of 4.0 inches.

3.0 CULTURAL AND ECONOMIC CHARACTERISTICS

3.1 Town History

Cornucopia was originally platted by T.J. Stevenson, an attorney from Minneapolis, who named it for the abundance and variety of vegetables and fruits grown in the area. The settlement was first established as a small fishing and logging village. After the logging boom, commercial fishing became the primary source of income and employment for the residents. In fact, the importance of commercial fishing in Lake Superior waters led to the establishment of a federal breakwater at the mouth of the Siskiwit River in the 1920's.

Later, as a result of overfishing and predation by sea lamprey, fish stocks declined to the point where many commercial fishing operations in the area went out of business.

At this point the Town took steps to make the transition from a working harbor of refuge to a recreational boating harbor by making improvments necessary to attract tourism and bolster a sagging economy. Although the Town has received money for planning from time to time, it was not until 1986 that the town received any sort of financial aids for harbor improvements (with the exception of Corps maintenance dredging).

With the establishement of other area marinas such as Barker's Island in Superior and the complex of marinas in and about the Apostle Islands, power boating and sailing has increased. The Cornucopia harbor is in a unique position to take advantage of the expanded market. It is the first harbor west of the Apostle Islands and is a logical stopping point for boats in route from Superior to the Islands.

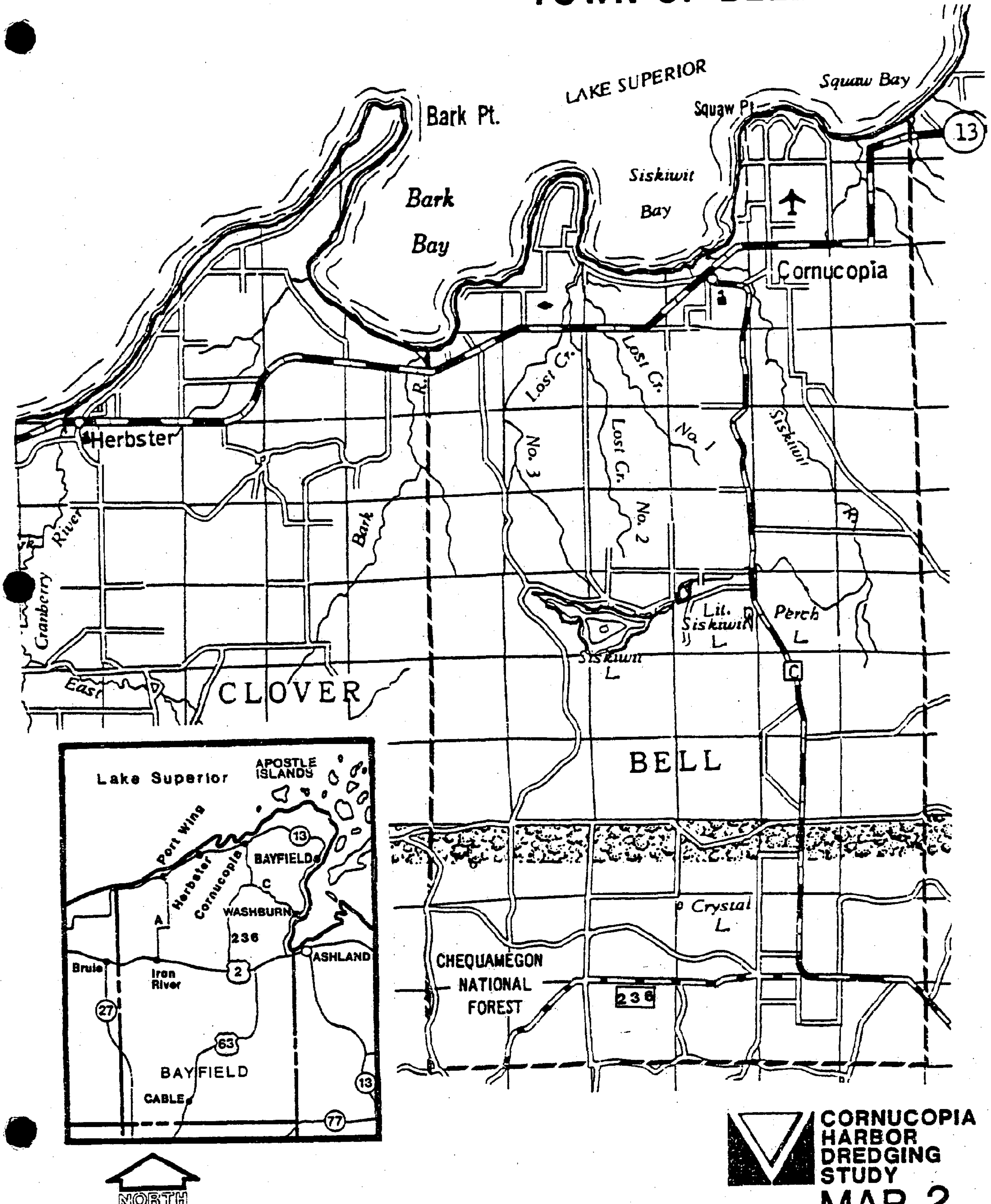
Today tourism monies generated by the marina are the single largest source of new dollars in the community. Lake Superior boater studies completed during 1984 and 1985 indicate that over $80.00 per day are spent by the average boating party. That money plus other dollars spent by the tourist support nearly 12 jobs in the community out of 77 jobs in the town reported by the 1980 census.

This being the case, any condition such as excessive sedimentation that negatively impacts the harbors ability to function and attract the recreational boater must be treated with the utmost care and minimized to the extent possible.

3.2 Town of Bell Land Use

The principal use of land in the Town of Bell is forestry with over 90% of the land area in a forest cover of mixed northern hardwoods and some pine. Between the U.S. Forest Service and the Bayfield County Forest over 70% of the land is in public ownership.

TOWN OF BELL



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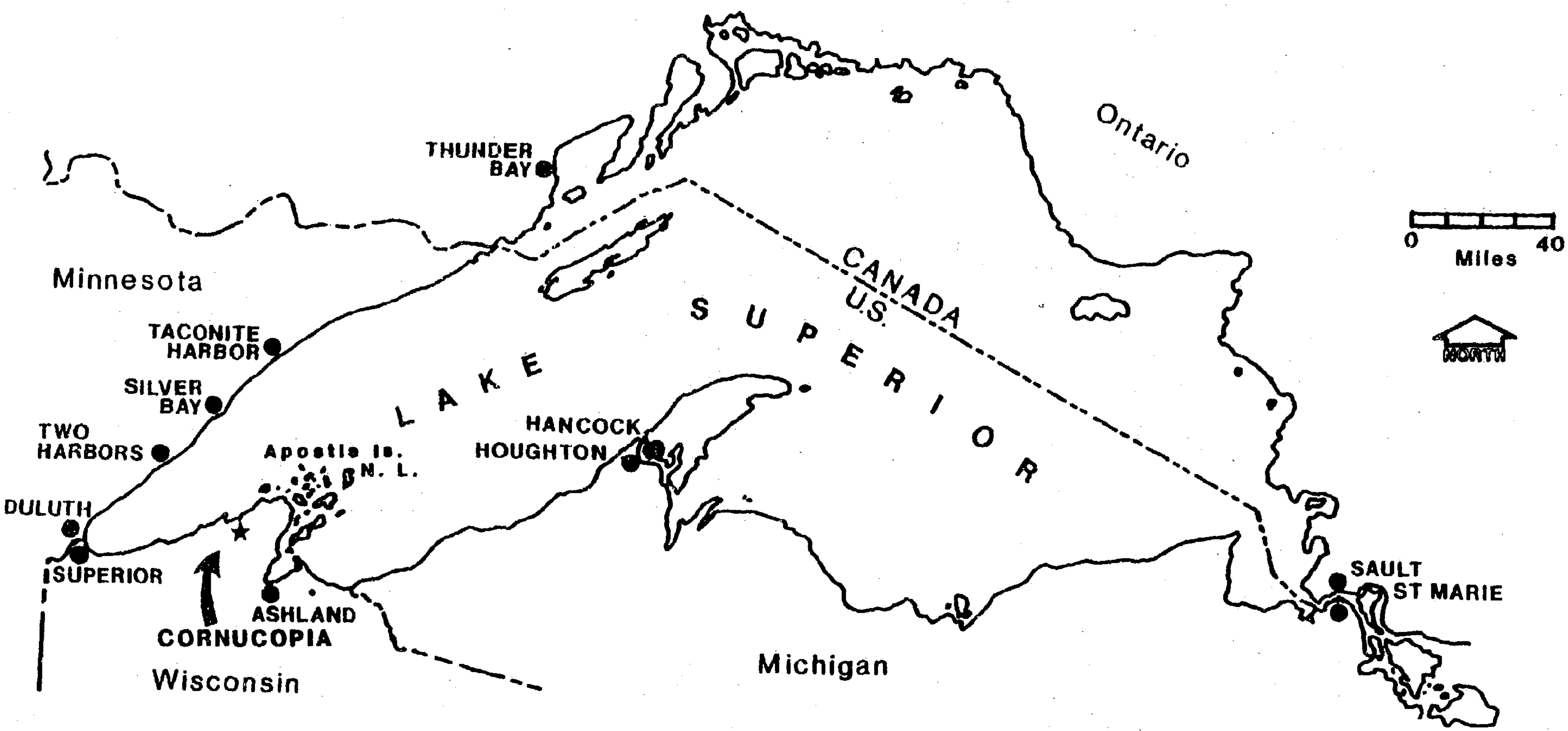
MAP 2

LAKE SUPERIOR & THE APOSTLE ISLANDS



CORNUCOPIA HARBOR DREDGING STUDY
MAP 3

Two development concentrations exist; one is the settlement of Cornucopia, containing 100 of the town's dwellings and occupying approximately one square mile on the STH 13 corridor and the other is a second home residential area on the north shore of Siskiwit Lake seven miles south of Lake Superior. Other than these two areas, development is sparse.

Dwelling counts show 122 year-around dwellings and 221 seasonal dwellings in a town of 38,300 acres.

3.3 Population

At the time of the 1980 census there were 247 persons living in the Town of Bell. The statistics show that the population declined between 1950 and 1970 to a low of 205 persons. Small area population projections made by the Northwest Regional Planning Commission suggest that the population will grow to approximately 263 by the year 2000. It must be recognized that a projection for an area of this size and population must be used with great caution since it is stongly influenced by in-out migration of a highly mobile population. It may also be stongly impacted by a relatively minor change in the economic structure of the town. One such change would be the expansion of the recreational harbor and the resultant need for additional goods and services.

3.4 Economy

The economy of northern Wisconsin has always been based on the utilization of its natural resources. The principal resources of the region, historically, have been timber, metallic ores, fish, furs and recreational opportunities. Today the region supports a good wood products industry, a weak fishing industry and an underdeveloped tourism industry. The manufacturing and service sectors of the economy have been growing in the region although not in the Town of Bell.

Early in the century, fishing, lumbering and agriculture supported small but thriving communities along Lake Superior's south shore. As each of these resources declined in importance, employment shifts from resource utilization to other sectors occured with the end result being that workers had to seek employment in communities of the region with more job opportunities.

The level of information for employment in the Town of Bell is sketchy and because of low numbers subject to dramatic shifts. No information is available for self-employed individuals. The statistics also do not account for the actual location of the employment. Some of the workers have jobs in Washburn, Bayfield and Ashland and commute on a regular basis.

The greatest opportunities for job creation exist in the service and recreation/tourism sectors of the economy provided that necessary improvments continue to be made to the harbor and that marketing of the excellent recreation/tourism opportunities improves.

4.0 SISKIWIT RIVER DRAINAGE BASIN

4.1 General Description

The Siskiwit River begins as the outlet from Siskiwit Lake and flows northeast through Little Siskiwit Lake before emptying into Siskiwit Bay at Cornucopia 9.3 miles downstream. The source elevation at Siskiwit Lake is 1061 MSL and falls at an average gradient of 48 feet per mile until it reaches the lake at 602 IGLD. The river is classified as trout water for 5.6 miles, and, 8.2 miles of the river are in public ownership.

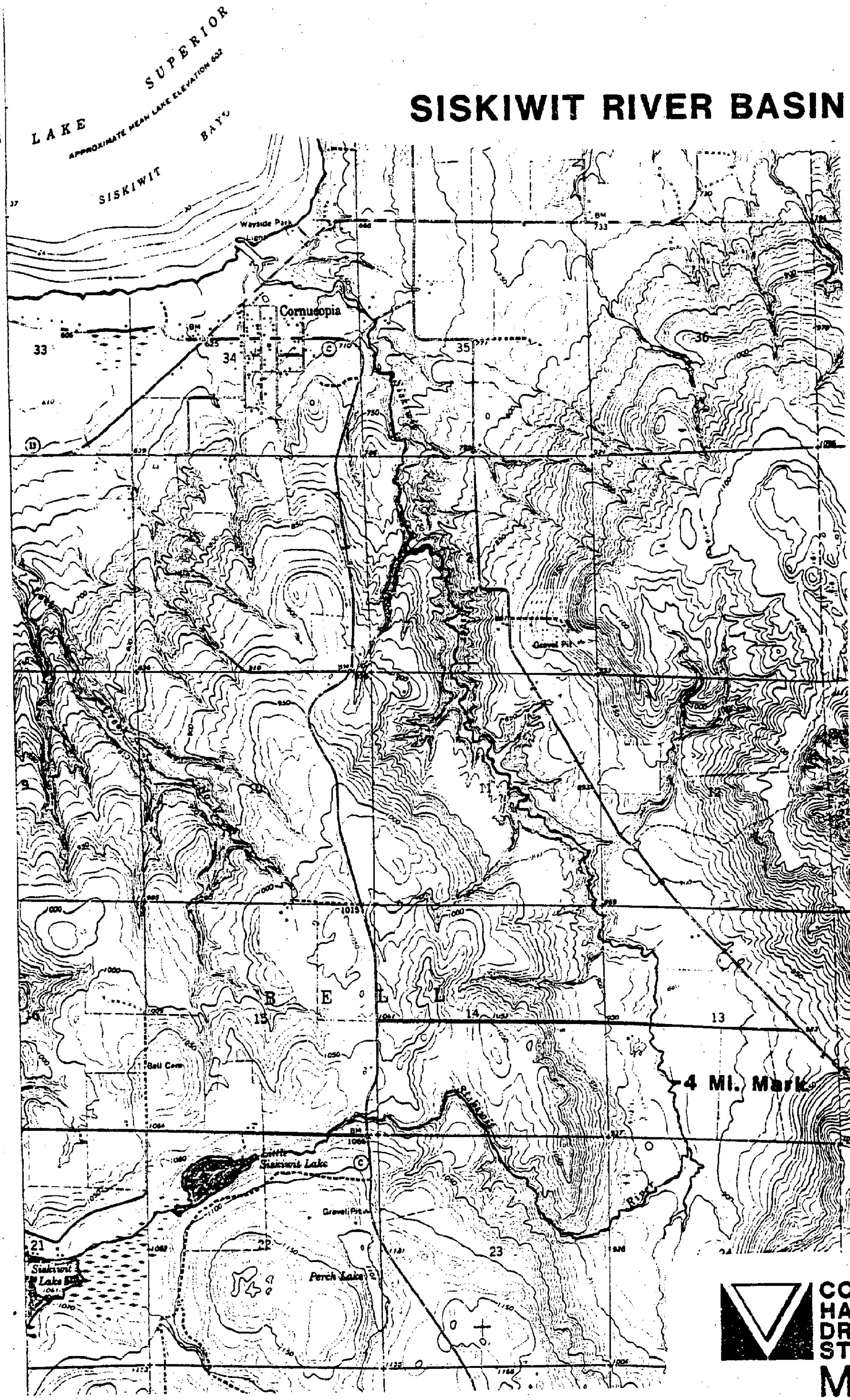
The watershed area of the river is approximately 18 square miles with an estimated population density of 2.9 persons per square mile. The direct drainage is 8.4 square miles and is composed of 2% agricultural and 98% forest use. Two hundred fifty acres of wetland are adjacent to the river.

The Siskiwit River does not have an established monitoring station, however, average discharge has been estimated at 5.1 cfs. Intermittent sampling by the University of Wisconsin, Superior indicated a pH of 7.3, dissolved oxygen concentrations of 9.1mg/l, low nitrate, phosphate and BOD5. Water color is generally red due to suspended sediment. No estimates of suspended sediment loads or bed loads are known to exist for the Siskiwit River. However, United State Geological Survey data indicated that 40 tons per square mile suspended sediment yield per year should be expected in the region.

Two areas within the basin are developed. The Siskiwit Lake shoreline has approximately 30 summer homes, a town park with a boat ramp and picnic area. The park is lightly used although the second homes are a popular weekend retreat. All the homes have on-site sewage systems which are likely contributors to Siskiwit Lake. In 1986 the Wisconsin DNR posted a fish consumption advisory on walleyes taken from the lake due to mercury. The source of the mercury has not been determined and it is unknown at this time whether the problem is transferable to all waters in the basin and Siskiwit Bay. No other non-point problems are known to exist and no studies are in progress or planned.

The settlement of Cornucopia and the harbor basin are located at the mouth of the river. Here approximatley 100 structures exist with on-site sewage systems. Several years ago at least 50% of the systems were suspected of failure. The Cornucopia Sanitary District plans to install a sewage treatment system that will eliminate this problem by 1988.

SISKIWIT RIVER BASIN



CORNUCOPIA HARBOR DREDGING STUDY
MAP 4

4.2 Basin Soils

The following major soil types are found in the basin:

Lake Beaches:	A landform rather than a distinct soil type, beaches are primarilly sand, are highly erodible and comprise about 5% of the soils in the basin.
Ontonagon-Pickford:	A fine textured soil of the lake plain consisting of clay and sand. These are highly erodible and comprise about 45% of the basin.
Superior-Ogemaw:	A coarse to medium soil of the lake plan. Primarily clay with sand. These soils are moderately erodible and cover about 35% of the basin.
Orienta:	A coarse to medium sandy loam. Ten % of the soils in the basin are of this type.
Ontonagon:	A fine textured clay soil with high erosion hazard that makes up about 5% of the basin soils.
Peat:	A very wet soil associated with the wetlands adjacent to the river.

4.3 Estimate of Sediment Volumes

As indicated previously, no estimates of sediment loads are available for the Siskiwit River system. The only data available are from two nearby streams which monitor only suspended sediment and does not include data for bed load transport. Regional suspended sediment yield estimates by the U.S.G.S. are also available, however, the estimated yield of suspended sediment does not take into account the high rate of random catastrophic stream bank loss common in the region. Given the data available, it is not possible to correlate suspended sediment with actual deposition in the harbor since an unknown amount of bed load transport is occuring and the fact that only a portion of the suspended sediment may actually be deposited in the harbor.

For the purposes of this study 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 and being deposited outside the arbitrary dredge limits.

During the period from 1950 to 1985 the Corps dredged or contracted for dredging of the Cornucopia federal channel. The following table identifies the years and the amount of material dredged. It should be noted that the Town of Bell also dredged material intermittently from other portions of the harbor (southeast basin) than the federal channel. Since no precise records exist to document the dredging activities undertaken by the town these Corps figures should be considered conservative and not reflective of the total dredging need.

Year	Amount (cy)	Year	Amount (cy)
1950	2420	1967	2750
1953	3000	1968	6900
1954	7325	1970	5275
1956	7090	1974	4120
1958	9850	1976	6260
1959	10350	1979	8075
1961	16325	1981	2881
1962	3125	1985	6564
1965	2000	TOTAL	104,310 cy

If we can make the assumption that the data are correct and that the dredging indicated took place only in the federal channel, then two dredge quantities should be determined: one, the annual average dredge quantity removed by the Corps. This figure can be determined by adding the dredge quantities for 1953 through 1985 and dividing that by 35, the total number of years represented by the data. This gives an annual average dredge quantity of 2,911 cubic yards removed by the Corps program in the federal channel; second some estimation of the amount of dredge material that could be removed from the southeast basin and adjoining riverway should be made to reflect non-federal activity

For the purpose of this study, it is assumed that deposition occurs each year over the area of the southeast basin and adjoining riverway at the same rate as in the federal channel (approximately 92,500 square feet). It is recognized that this assumption does not allow for flushing effects. The area of the channel portion of the southeast basin is 10,000 square feet, and; the channel portion of the adjoining riverway is approximately 15,000 square feet. Extension of the calculation provides an estimate of 787 cubic yards of material for the non-federal portion of the harbor complex. Adding the federal and non-federal area quantities gives a total of 3,698 cubic yards of material. To provide a margin for error, the quantity of dredge materials anticipated will be adjusted upward to 3,750 cubic yards per year even though the harbor may not be dredged each year.

5.0 HARBOR CONFIGURATION

5.1 Current Arrangement

The Cornucopia harbor lies at the mouth of the Siskiwit River approximately 600 feet east of the intersection of County Trunk "C" and STH 13 in Cornucopia. Because of the harbor's rivermouth location all sediment being discharged by the Siskiwit River must pass through the harbor.

The channel entrance is protected by an east breakwall originally constructed in 1926 and a west breakwall built in 1937. The authorized channel is fifty feet wide and its authorized depth is ten feet. the east breakwall is 938 feet long and the west breakwall is 530 feet long. During 1958, the Corps reconstructed both breakwalls with steel sheet piling and added a stone cap grouted in place. In 1963, the corps added a 180 foot extension to the end of the east breakwall to provide better protection for the channel entrance.

The harbor has three internal basins, the northeast and southeast are on the east side of the river while the southwest basin also known as the Jones Marina is on the west side of the river. The northeast and southwest basins are connected by a small turning basin, and are part of the federal project with fifty foot widths and eight foot depths authorized.. The southeast basin is the location of the Town of Bell Marina and does not have a federal channel extended into it. The southeast basin is maintained by the Town. The riverway upstream of the junction of the northeast and southwest basins is not part of the federal project and is also maintained by the Town.

As indicated earlier, the southwest basin is the location of the Jones Marina. It has slippage for 25 boats. The Town of Bell Marina in the southeast basin has slippage for 36 boats. The northeast basin moors large pleasure craft and commercial fishing boats.

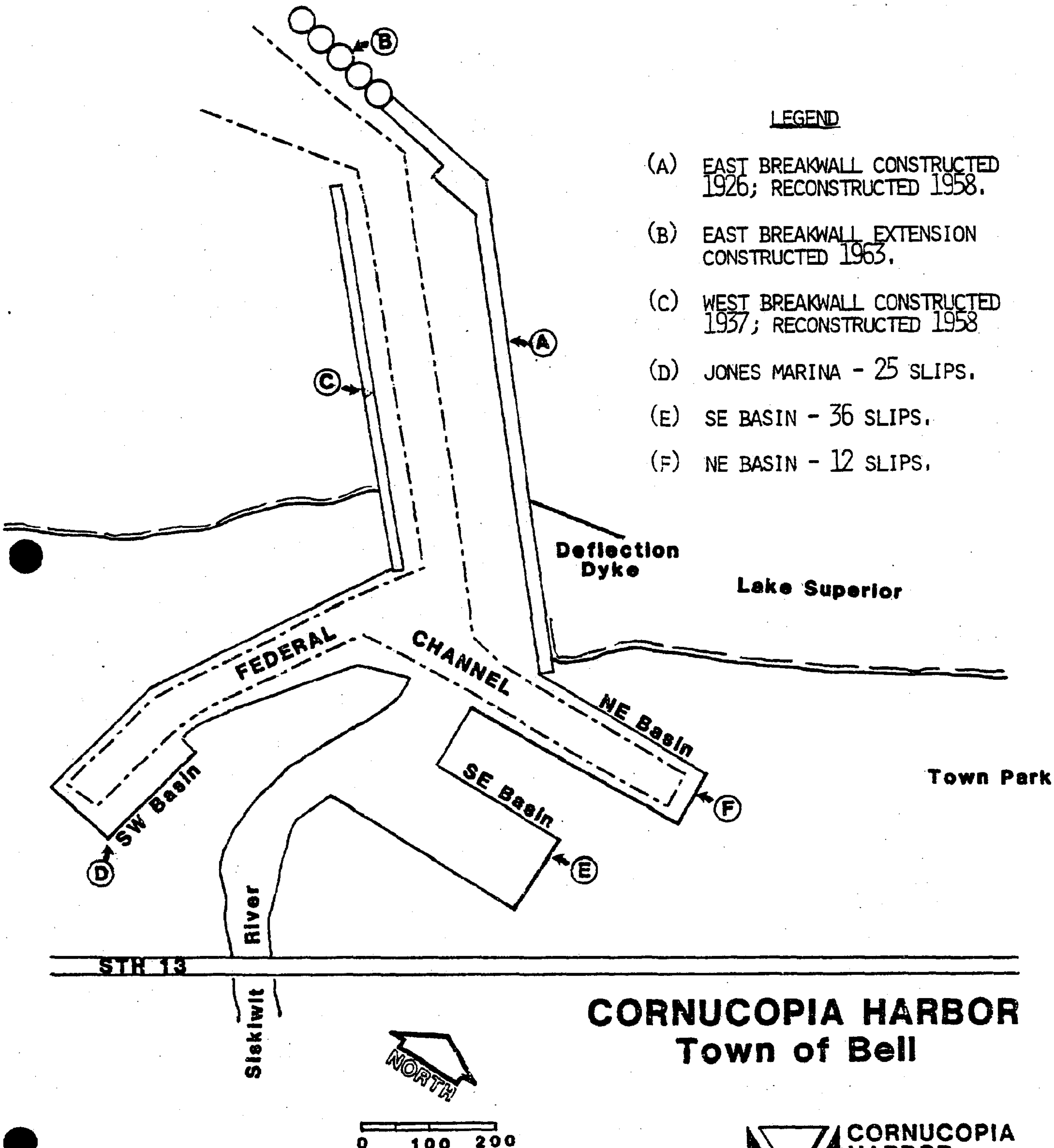
5.2 Future Improvements

During 1985, the Town of Bell received a grant from the Wisconsin Coastal Mangement Program for renovation of the south bulkhead and the reconstruction of a boat ramp. The repairs are underway and will be completed in the near future.

The long term plans of the Town include extension of the southeast basin to the east, construction of additional finger piers and rehabilitation of the north bulkhead of the southeast basin.

In order for the marinas in the harbor to continue as viable recreation/tourism facilities the harbor depth must be maintained in such a fashion as to provide access for power and sail craft with drafts in the 6 to 8 foot range.

EXISTING FACILITIES



CORNUCOPIA HARBOR
Town of Bell

CORNUCOPIA HARBOR DREDGING STUDY

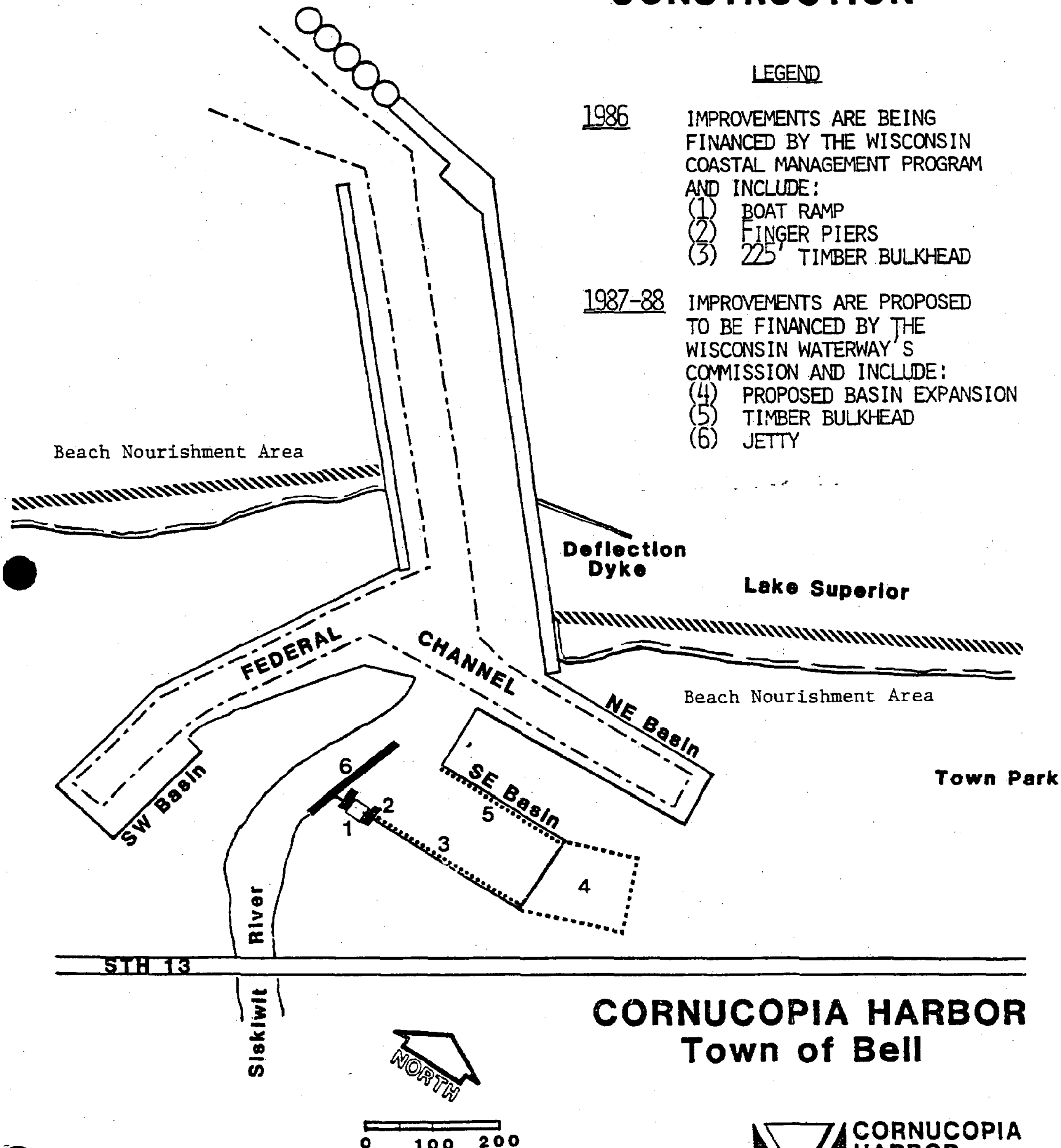
MAP 5

PROPOSED CONSTRUCTION

LEGEND

1986 IMPROVEMENTS ARE BEING FINANCED BY THE WISCONSIN COASTAL MANAGEMENT PROGRAM AND INCLUDE:
(1) BOAT RAMP
(2) FINGER PIERS
(3) 225' TIMBER BULKHEAD

1987-88 IMPROVEMENTS ARE PROPOSED TO BE FINANCED BY THE WISCONSIN WATERWAY'S COMMISSION AND INCLUDE:
(4) PROPOSED BASIN EXPANSION
(5) TIMBER BULKHEAD
(6) JETTY



CORNUCOPIA HARBOR
Town of Bell

CORNUCOPIA HARBOR DREDGING STUDY

MAP 6

6.0 CORNUCOPIA HARBOR ENVIRONMENTAL ASSESSMENT

This material is summarized from:

Wisconsin Department of Natural Resources: Cornucopia Harbor Study, Upper Great Lake Regional Commission 1977.

U.S. Army Corps of Engineers

Environmental Research Group, Inc.: 1984 Cornucopia Harbor Dredge Analysis

6.1 Terrestrial Vegetation

Band dune grass is the major vegetation type present in the harbor area. This grass is common to sand dune areas on the Lake Superior shoreline. No threatened or endangered plant species were identified in the area.

6.2 Aquatic Vegetation

The WDNR study cited above found aquatic vegetation in the harbor no different than that of other Lake Superior harbors. No endangered or threatened species were found.

6.3 Wildlife

During the investigations of 1977 river otter were observed. Other wildlife was not noted.

6.4 Fish

The WDNR assessed the fish habitat of the harbor in the summer of 1977. Assessment methods utilized were trawling and electrofishing. Nineteen species of fish were found in the survey area.

The harbor proper has no identified spawning areas although Emerald Shiners may spawn there. Lake run fish seem to be attracted to the harbor environment in the spring following ice-out. This phenomenon creates an excellent spring fishery for trout and salmon.

The Siskiwit River has a sizeable anadromous run of Rainbow Trout in the spring. Brown trout and Coho Salmon may also spawn in the river during the fall.

Cornucopia harbor is used by the WDNR as a stocking site.

6.5 Birds

During the 1977 study, the WDNR sighted 28 species of birds within the study area. All species sighted are common to the area and there are no unique nesting areas within the harbor.

6.6 Natural Area Designations

The Town of Bell contains only one site designated as a Natural Area. The site is one and one-half miles west of the harbor and consists of a lagoon, wetland bog, and interdunal bog where Lost Creek # 3 enters Siskiwit Bay. Critical plant species are present. The area is in WDNR and private ownership.

6.7 Historical and Archeological Sites

One site marker noting the "Tragedy of the Siskiwit" is present just to the east of the parking lot serving the Town of Bell Marina. Archeological sites probably exist but are not located.

6.8 Terrestrial Soils and Harbor Substrates

The terrestrial areas of the harbor are considered man made land and alluvial land. This suggests that the areas consisted of a sand spit and a low marshy area which was filled by man during harbor construction in the 1930's.

The bottom substrate reflects the water influences of the Siskiwit River. Most of the harbor consists of sand, settled clay and terrestrial organic debris. The substrate also has an abundance of sawdust probably left from past lumbering use.

6.9 Water Quality

Results of 1972-3 water quality analyses are presented in the Appendix. Water quality conditions in the harbor change rapidly depending upon the movement of water masses within the harbor. A combination of lake seiche and stream water movement results in wide variations of quality values in each of the individual harbor basins.

Dissolved oxygen levels were generally high in all samples. The pH values were slightly alkaline and consistent with other natural waters of the area.

Oils, greases and other pollutional discharges are contributed from the traffic and mooring activity of boats in the harbor's two marinas

The settlement of Cornucopia is probably contributing some amount of pollutants from failing on-site sewage systems. Cornucopia has formed a sanitary district and centralized treatment of wastes will be in place by 1988.

6.10 Sediment Analysis

Quantitative Analysis

The total volume of sediment that is anticipated to be removed on an annual average basis was calculated in Section 4 to be 3,750 cubic yards for the federal and non-federal basins and channels.

Qualitative Analysis

A. Pollutant Analysis

During 1984 chemical quality analysis of bottom sediments was performed for four stations in the Cornucpoia Harbor. The four stations depicted in the Appendix were the mouth of the breakwall system; the turning basin between the northeast and southwest basins and at the extemities of the northeast and southwest basins. The river channel upstream of the federal project area and the Town of Bell southeast basin were not sampled. For the purposes of this report it will be assumed that analysis of samples taken from those two areas would result in similar test findings.

Based upon current knowledge regarding in-water disposal of dredge materials, the WDNR is again considering the possiblity of allowing in-water disposal of clean dredge spoil. The WDNR with the assistance of a technical subcommittee has developed guidelines for evaluating disposal options for dredge spoil based upon pollutant concentrations. The Department has developed criteria for in-water disposal as follows:

1. If any pollutant, or group of pollutants, of concern is found in concentrations greater than 125 % of the criteria for that pollutant, in-water disposal will not be allowed.

2. If three or more pollutants are found in concentrations greater than 110% of the criteria for those pollutants, in-water disposal will not be allowed.

3. If one or two pollutants are found in concentrations within the range of 110% to 125% of the criteria for those same pollutants, in-water disposal will be determined on a case by case basis

The following table presents a summary of the pollutant concentrations found for each sampling station compared to the proposed maximum allowable concentrations of pollutants for in-water disposal.

Parameter	Maximum Allowable Concentrations	Detected Concentrations			
		Sites			
		1	2	3	4
ORGANICS					
PCBs	.05	ND	ND	ND	ND
Dioxin	1.0 pg/g	Not Analyzed		Not Analyzed	
Furan	1.0 pg/g	Not Analyzed		Not Analyzed	
PESTICIDES					
Aldrin	.01	ND	ND	ND	ND
Chlordane	.01	ND	ND	ND	ND
Endrin	.05	ND	ND	ND	ND
DDT	.01	ND	ND	ND	ND
Dieldrin	.01	ND	ND	ND	ND
Heptachlor	.05	ND	ND	ND	ND
Lindane	.05	Not Analyzed		Not Analyzed	
Toxaphene	.05	ND	ND	ND	ND
METALS					
Arsenic	10	1.1	ND	0.9	2.2
Barium	500	Not Analyzed		Not Analyzed	
Cadmium	1	ND	ND	ND	ND
Chromium	100	14	+	9	21
Copper	100	6	ND	4	12
Lead	50	+	+	12	+
Mercury	0.1	+	+	+	+
Nickel	100	4	ND	5	11
Selenium	1	Not Analyzed		Not Analyzed	
Zinc	100	21	7	14	38
OTHER					
Oil and Grease	1000	+	+	+	+

Notes:

Unless otherwise noted concentrations are ug/g
ND: Nondetected
+ : Positive result below test limits

4. If all pollutants are found at concentrations of 110% or less than the criteria for those same pollutants, in-water disposal may be allowed.

5. For on-the-beach disposal the particle size of the dredged material must meet the following criteria: the average percent of spoil material finer than 0.074 millimeters (mm) must not exceed the average percentage of materials finer than 0.074 mm in the existing beach by more than 15 percent. For in water disposal, particle size matching is not required.

According to the sediment analyses conducted, sediments from the stations tested did not exceed any in-water disposal pollutant criteria. However, at this point, it is not possible to determine whether or not the sediments meet all of the quality criteria for in-water disposal since analyses were not conducted for dioxin, furan, lindane, barium and selenium.

It is presumed however, that with the balance of the parameters showing very low or nondetectable concentrations, that the results of such testing will prove the sediments suitable for in-water disposal.

The Department of Natural Resources may require further testing for at least those substances not analyzed for in the 1984 study before approving the sediments for in-water disposal.

B. Particle Size Analysis

In order for dredge materials to be used for beach nourishment they must, in addition to the chemical quality criteria, also meet the particle size criteria noted as # 5 in the preceeding section: that is, for on-the-beach disposal the particle size of materials finer than 0.074mm must not be greater than 15 percentage points of the average disposal site material finer than 0.074mm. To put this in perspective, 0.074mm is often considered as the smallest diameter of a material that can be classified as very fine sand. This material will not pass through a # 200 sieve. Materials smaller than this are classified as clays and silts.

The following table indicates the particle size distribution of sediments in the Cornucopia Harbor at the time of the 1984 study.

Particle size range	Site 1	Site 2	Site 3	site 4
Greater than 2mm %	0.2	1.3	0.9	0.6
Greater than 0.43 mm %	2.2	14	7.4	8.4
Greater than 0.25mm %	9.2	78	45	19
Greater than 0.075mm %	76	99	82	68
Less than 0.075mm %	24	1.1	18	32

In this case, assuming equal volumes from each station were dredged, the average percentage of material finer than 0.075mm would be approximately 18.8%. This would mean that utilizing the criteria, the disposal site in-place material could contain no less than 3.8% fines to be considered a suitable site.

To this time no particle size distribution analysis has been performed for potential beach nourishment areas in and near the Cornucopia Harbor. Casual site observations indicate the presence of sand beaches to the east and west of the harbor entrance and there is a high probability that these beaches would be suitable areas for beach nourishment. However until testing is complete particle size matching is not assured.

Summary of Sediment Characteristices

Quantity: The anticipated volume of material to be dredged on an annualized average basis is approximately 3,750 cubic yards.

Quality: On the basis of the stations sampled and the concentrations of pollutants analyzed for and detected; the material may be considered "clean" and therefore probably suitable for in-water disposal.

Additonal testing may required for the parameters not analyzed for (dioxin, furan, lindane, barium and selenium).

Particle Size Matching: Assuming equal volumes from stations sampled, 81.2% of the dredge material will be larger than 0.074mm. 18.8% of the material will be smaller than 0.074mm

Using the 15% criteria, the particle size of an acceptable site should be not less than 3.8% site material finer than 0.074mm.

Particle size distribution analysis should be performed for beaches east and west of the harbor entrance to determine their suitability as disposal sites.

Conclusions:

1. The annualized average dredging quantity will be approximately 3,750 cubic yards.
2. The dredge material, after additonal testing for missing parameters will probably be found suitable for in-water disposal.
3. The dredge material, after testing of nearby beaches for particle size distribution match, will probably be found suitable for beach nourishment activites.

7.0 ALTERNATIVES FOR MANAGEMENT OF DREDGE MATERIALS

Many alternatives exist for the management of dredge materials including source abatement of dredge material volumes, beneficial reuse, outright disposal and a number of combinations therof. However it should be recognized that the final determinants for chosing an option are the suitability of the dredge materials for use and, if local governments must pay the entire cost, the availability of financial resources to implement the chosen alternative.

7.1 No Action

This alternative has obviously the least first cost. However the negative impact of this alternative over time in terms of the loss of jobs and income to the area, not to mention the eventual closing of the harbor, is so great that it is no alternative at all and is rejected.

7.2 Abatement of Dredge Volumes

A. Upland Treatment--Approximately 2% of the 8.4 square mile or approximately 100 acres of the direct drainage of the Siskiwit Basin is in agricultural use and potentially open to erosion. Soil loss, calculated from the Universal Soil Loss Equation, is less than 1 ton per year. It should be recognized that the USLE does not address sediment delivery to streams, but, it is a useful indicator of the nature of the soils. Treatment of critical areas may be undertaken for less than $100 per acre, however little impact on sediment deposition in the harbor will be made. Landowners should be encouraged through United States Department of Agriculture programs to practice good conservation methods on their lands.

B. Stream Bank and Channel Protection--Most if not all of the sediment reaching the Cornucopia Harbor is a result of erosion of the bank and channel of the Siskiwit River and it's tributaries at high flow levels. Protective measures such as gabions, timber cribs, and deflector wings can be utilized successfully to reduce erosion at critical sites with some improvement usually occuring to fish habitat. Considering that the river travels over nine miles through highly erodible soils, only those areas exhibiting severe problems can be treated in a cost effective manner due to the relatively high cost of protection ($330/lf, 1977 Red Clay Project).

This alternative may reduce the volume of sediment reaching the harbor but it will not negate the need for dredging

C. Floodwater and Sediment Retention--Since the majority of the erosion and sediment transport is at high flow levels, abatement of sediment volume reaching the harbor could be accomplished through the construction of floodwater and sediment retention structures. Such a structure would retard floodwater, capture bed load and allow the settlement of some suspended sediment. Construction of effective retarding structures is a project requiring significant investment in engineering, construction and maintenance. First, the structure must be located so that it can capture an optimum amount of sediment for a long period of time to be cost effective. Second, it must be located in an accessible area since yearly and long term maintenance are required for proper operation and safety. Two earth filled structures of this type were constructed in similar terrain on red clay soils during the late 1970's. The average construction cost was $240,000 (1977). Engineering was an additional $50,000. Yearly maintenance has averaged $2,000. Those structures have a design capacity of approximately 15 years and at some point in the future the sediment trapped behind the structure will have to be removed at a cost of $6.00/cy. and then transported to a disposal site.

It is not known whether a site exists on the Siskiwit River that would meet the necessary technical requirements for a structure. In addition, sediment retarding structures by their nature slow down the flow of water thus allowing the water temperature to rise and potentially making the channel above the structure unsuitable for cold water fish such as trout. In addition, fish habitat below the structure may suffer detrimental change.

Finally, an unknown amount of sediment will still reach the harbor since a retarding structure is only effective for sediment generated above it and the terrain near the harbor is generally unsuitable for this type of structure.

Summary of Abatement Alternatives

A. Upland treatment can be effective for reducing a small amount of erosion and related sediment in the harbor. The cost is low and could be accomplished through an educational effort.

B. Streambank and Channel Protection. The cost of this alternative can be very high depending upon the length of stream to be protected. This alternative could be considered further in combination with other actions taken.

C. Floodwater and Sediment Retention. At this time no engineering has been done to identify the potential effectiveness of a structure. The capital and operation/maintenance cost will be very high. Also unanswered at this time is the consequence of a structure of this type on the Siskiwit River environment.

7.3 Dredge Spoil Disposal Alternatives

These alternatives are basically of two types: in-water disposal and on-land disposal. They also represent the more traditional and straight-forward approaches to dealing the problem. Beneficial re-uses and potential cost saving techniques are identified where appropriate.

This section utilizes the following assumptions:

* Annualized average dredge requirement is 3,750cy.

* The dredge spoil is found to be "clean".

* Particle size match exists with the adjacent beaches.

* Dredging cost @ $6.00/cy.

* Mobilization costs are not included but are assumed to be 1%.

* Engineering costs are not included but are assumed to be 9%.

* Debt service costs are not included but are assumed to be 10% with 20 year amortization.

* Construction costs are from regional estimates and are not "present worth".

* Sediment analysis costs are not included but are assumed for all alternatives.

A. In-water Disposal

If the assumptions are correct, this alternative is the most straight-forward. Intuitively, this alternative would also have the least first cost. The alternative has two possible actions: 1. Dredge the material from the harbor and dump offshore in deeper water. This action, if implemented properly could benefit fish by providing a reef-type habitat. Discussion with WDNR Fish Division (Bayfield) indicates that there is not a need for this type of habitat in the Cornucopia area at this time. 2. Dredge the material from the harbor and dump in the nearshore zone. This action would benefit starved-beach areas near the Cornucopia harbor and make them less susceptable to erosion damage during high water. The costs for the two actions are essentially the same except that reef construction would require substantial engineering.

Dredge volume analysis indicates a need for removal of 3,750 cy annually. However, dredging activity should be undertaken less frequently to minimize mobilization costs charged by a dredging contractor. It is recommended that dredging take place at three year intervals or when determined to be necessary by depth soundings. For the purpose of this cost analysis it is assumed that costs are incurred on an annual basis.

Although cost estimates are not provided here, the communities of the south shore should consider the possiblity of jointly purchasing dredging equipment under a public facilities grant program and actually perform the work themselves and create several jobs in the process.

Estimated Cost

Annually dredge and dispose of 3,750cy @ $6.00/cy	$ 22,500.00
Twenty year Cost	450,000.00

B. In-water Contained Disposal

On the east breakwall there is a deflection dike extending to the southeast but not connected to the shoreline. At the present time waves flank this deflection dike and scour the area behind. It has been proposed that a timber crib or steel sheet pile extension be constructed that would connect to the shoreline. If this dike were extended, approximately 10,000cy to 13,000cy could be placed behind the dike and the land surface so created could be developed for recreation purposes and the area behind the existing deflection dike would be protected from further erosion.

Cost savings could be realized here by utilizing a land based dredge crane which can reach part of the dredge and disposal areas without moving.

Estimated Cost

Annually dredge and dispose of 3,750cy @ $6.00/cy	$ 22,500.00
First cost of containment structure	40,000.00
Twenty year Cost-Dredging	450,000.00
Construction	40,000.00
Total Twenty Year Cost	$ 490,000.00

C. On-land Disposal

There are several on-land beneficial re-uses of dredge material which will be noted here but not discussed in detail because they are generally not applicable to the Cornucopia situation.

* Dune Construction and Management-Dredge material is used to reconstruct dunes or maintain dune profiles after major storms. It can be used to enhance the quality of existing recreational areas by providing dune like habitat.

* Wetland Renovation and Construction-Nutrient rich spoil has been used to create or restore wetland areas. This generally involves placing spoil in water to raise the bottom elevation to provide water depths suitable for growing aquatic vegetation.

* Wetland Protection-Materials are used to construct barrier reefs or barrier islands to reduce erosion damage to existing wetland complexes.

In addition to the re-uses mentioned above several other uses have been discussed from time to time in the local area. These include use for road sand, soil conditioner and structural building materials. These uses are not given further consideration since they all require dewatering, multiple handling and extensive transportation systems. Suitable materials are available locally for these uses at reasonable cost.

1. On-land Beach Nourishment

This alternative is essentially the same as near shore in-water disposal except that it would take place from landward instead of from the water. There may be minor benefits in terms of better placement of the material on the beach to be treated. But, as can be seen, the costs far outweigh the minor benefits since the material has to be physically moved by two different modes of transport. Once by the dredge and once again by truck to the site of placement. The material would not require dewatering. Potential beach nourishment sites are shown on Map 6.

Estimated Cost

Annual dredge 3,750cy @ $6.00/cy	$	22,500.00
Intermediate transport and placement @ $4.00/cy		15,000.00
Total Annual Cost	$	37,500.00
Twenty Year Cost	$	750,000.00

2. On-land Disposal

On-land disposal whether contained or not, is the alternative that will be selected if dredge spoils are found to be polluted in excess of the proposed criteria. The alternative is expensive since it would require dewatering and multiple handling of the spoil material as well as the potential purchase of land suitable for spoil disposal. The Wisconsin Statutes ch 346.94 prohibits the spilling of waste or foreign matter on or along highways. Additionally, a permit must be secured from the Department of Transportation for the transport of polluted spoil material. Added cost may be incurred as well by the municipality for repairs of damage caused to bridges and highways because of heavy truck traffic. A site suitable for dredge spoil disposal has been identified and is depicted on the following map. At the anticipated dredge volumes, a forty acre site would be suitable for over 50 years of spoil storage. Site preparation costs are unknown.

Estimated Cost

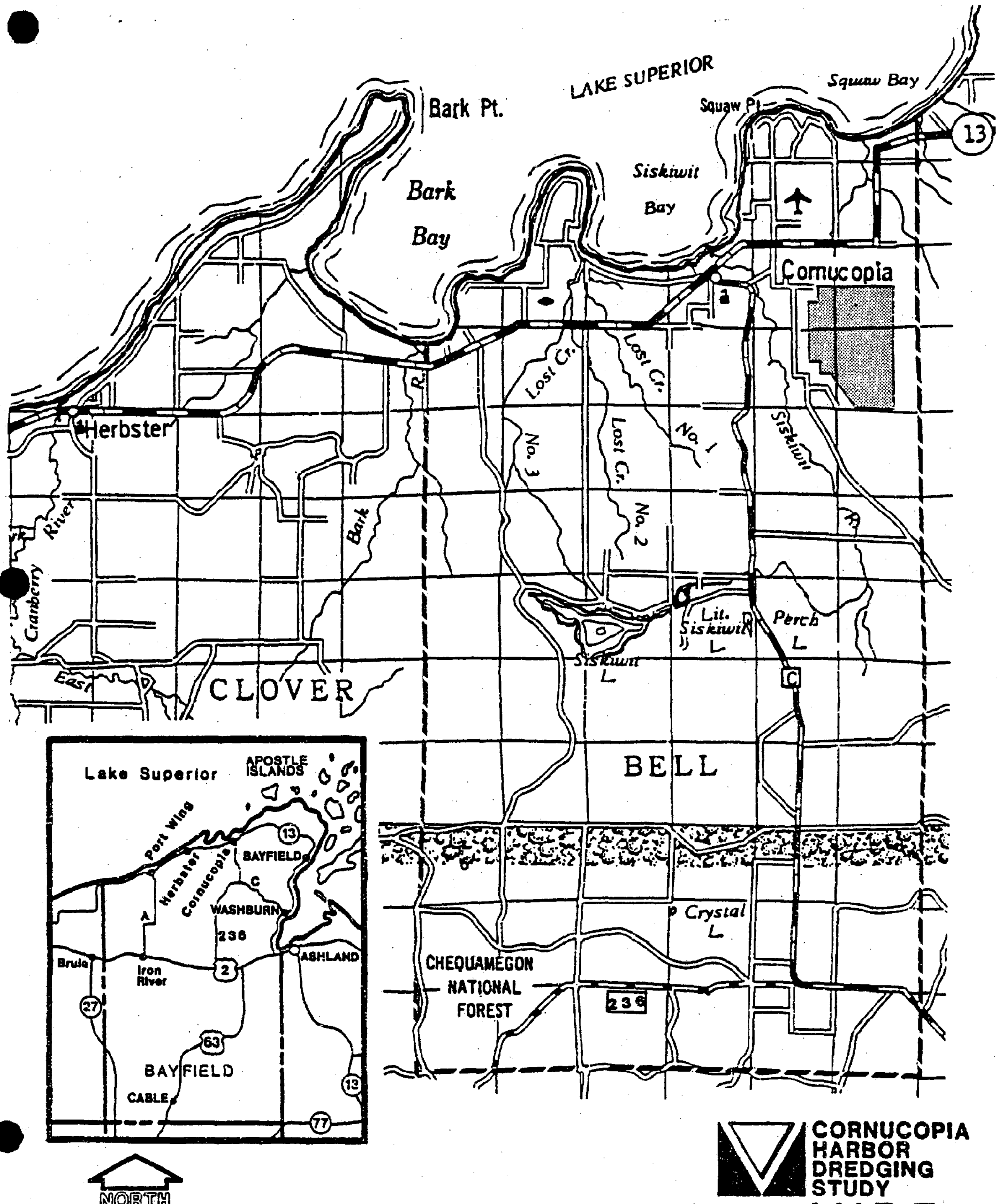
Annual dredge 3,750cy @ $6.00/cy	$	22,500.00
Dewatering and temporary stockpiling @ $4.00/cy		15,000.00
Transfer to storage site @ $4.00/cy		15,000.00
Total yearly cost	$	52,500.00
One time land purchase		5,000.00
Twenty year cost	$	1,055,000.000

7.4 Dredge Spoil Disposal Alternative Cost Summary

The costs shown below are the twenty year costs as determined in the previous section.

A. In-water disposal		
1. Disposal in deep water	$	450,000.00
2. Disposal in near shore zone	$	450,000.00
B. In-water bulkhead contained disposal	$	400,000.00
C. On-land disposal		
1. On-land beach nourishment	$	750,000.00
2. On land disposal and storage	$	1,055,000.00

POTENTIAL ON-LAND DREDGE DISPOSAL SITES



CORNUCOPIA HARBOR DREDGING STUDY

MAP 7

7.5 Recommended Alternatives

A. If the material is found to be clean as assumed, Alternative A1, A2 or B can be recommended. Alternative A1 has no apparent benefit and will not be considered further. Alternative A2 has the benefit of providing source material for beach building if placed in the near shore zone immediately lakeward of the beach. Alternative B provides the benefit of additonal protection to the harbor in the area of the deflection dike and additionally provides more land area for recreation purposes. On a cost basis Alternative A2 is the preferred alternative.

B. If the material if found to exceed the proposed criteria, which is considered unlikely, the only real alternative is C2 since it is the only alternative that will likely satisfy the regulations.

C. Ranking of Alternatives

Clean Material

1.	Alternative A2	$	450,000.00
2.	Alternative B	$	490,000.00
3.	Alternative A1	$	450,000.00
4.	Alternative C1	$	750,000.00

Polluted Material

1.	Alternative C2	$	1,055,000.00

7.6 Fiscal Impact of Least Cost Alternative

In 1980 the public debt per capita per year for the Town of Bell was $36.00 (all debt over permanent residents). The cost of the preferred alternative spread on a per capita basis will be approximately $90.00 per year (not including debt service) or three times the current debt spread. At the same time the sanitary district will be constructing centralized sewage treatment for the area. The cost of this public work, $2,200,000.00 will have a yearly debt spread of $110.00 (twenty year amortization of 25% of total cost). Both of these debts will have to be passed on to the local property tax payer who is now paying $80.00/year per capita in town taxes. The passage of this debt to the taxpayers will result in a per capita town property tax of $280.00 or 3.5 times what is now being paid for the town's portion of the property tax.

If the Town were to pass on part of the debt load to marina users the situation could be relived somewhat, but, some residents have boats in the marina and they will be reluctant to pay twice for the privelege of using the marina. In addition there is the possiblity of discouraging marina business and permenantly damaging the recreation/tourism sector by the raising of marina fees.

Unfortunately, the same situation may result if the harbor is not maintained. If a number of years go by without maintenance dredging, the harbor will become unuseable even to craft of shallow draft and subsequently destroy the economic viability of the harbor complex.

It is absolutely necessary that an assistance program be identified that can bear part of the cost of harbor maintenance for the public good. At present there are programs sponsored by several agencies which, if modified in scope and intent, could provide cost-sharing monies and thus reduce the local burden.

8.0 CONCLUSIONS

* The harbor dredging need is approximately 3,750 cubic yards on an annualized average basis.

* The dredge material can be characterized as "clean" for the pollutants analyzed for in 1984 according to the proposed pollutant criteria.

* Additonal testing for dioxin, furan, lindane, barium and selenium may be required.

* The estimated amount of dredge material less than 0.074 mm is approximately 18.2%.

* In all probability, a particle size match exists with the adjacent beaches.

* There is a need to verify the particle size match.

* Available alternatives have been identified and costed.

* The alternatives have been ranked with the result that in-water disposal in the near shore zone is considered the most cost-effective approach which also provides secondary benefits.

* Alternatives for abatement of dredge volumes exist at relatively high cost.

* The Corps of Engineers maintenance dredging program should be continued for the Cornucopia harbor.

* An cost sharing assistance program will be needed to reduce the local burden.

APPENDIX A

Table 1. Results of water quality analysis. Water samples were collected in Cornucopia Harbor by NBI in 1972 and 1973. (D.O. = Dissolved Oxygen, Turb. = Turbidity, Cond. = Conductivity, Alk. = Alkalinity, TN = Total Nitrogen, and TP = Total Phosphorus.)

Zone	Sample Number	Date	D.O. ppm	Temp. °C	pH	Turb. JTU	Cond. mhos	Alk. ppm	TN mg/l	TP mg/l
I	21	7/73	10.2	16.0	7.7	45.0	100	53.0	1.801	0.124
II	22	7/73	10.2	16.0	7.9	43.0	105	56.0	2.017	0.165
III	15	11/72	--	4.0	7.3	10.0	70	126.0	0.394	1.591
	16	11/72	--	4.0	7.5	9.0	73	88.0	0.514	1.395
V	17	11/72	--	4.0	7.5	2.7	65	114.0	0.360	2.204
	18	11/72	--	4.0	7.6	2.0	60	68.0	0.808	0.558
	19	7/73	9.6	15.0	7.8	16.0	85	56.0	3.169	0.112
	20	7/73	9.6	15.0	7.9	35.0	85	56.0	1.607	0.132

NOTE - Samples collected from Zone IV were collected by EPA and were not analyzed for the parameters presented in this table.

Table 2. Summary of water quality data obtained on samples collected in Cornucopia Harbor by NBI in 1972 and 1973. DO = Dissolved Oxygen, Turb. = Turbidity, Cond. = Conductivity, Alk. = Alaklinity, TKN = Total Kjeldahl Nitrogen, and TP = Total Phosphorus.

Zone			D.O. ppm	Temp. °C	pH	Turb. JTU	Cond. μmhos	Alk. ppm	TKN mg/1	TP mg/1
I	Mean		10.2	16.0	7.7	45.0	100	53.0	1.800	0.124
	Std. Dev.		--	--	--	--	--	--	--	--
	Range	Hi	--	--	--	--	--	--	--	--
		Lo	--	--	--	--	--	--	--	--
	No. of Obs.		1	1	1	1	1	1	1	1
II	Mean		10.2	16.0	7.9	43.0	105	56.0	2.020	0.165
	Std. Dev.		--	--	--	--	--	--	--	--
	Range	Hi	--	--	--	--	--	--	--	--
		Lo	--	--	--	--	--	--	--	--
	No. of Obs.		1	1	1	1	1	1	1	1
III	Mean		--	4.0	7.4	9.5	72	107.0	0.454	1.493
	Std. Dev.		--	0.0	.1	.5	1	10.2	0.082	0.138
	Range	Hi	--	4.0	7.5	10.0	73	126.0	0.514	1.591
		Lo	--	4.0	7.3	9.0	70	88.0	0.394	1.395
	No. of Obs.		--	2	2	2	2	2	2	2
IV	Mean		9.6	9.5	7.7	13.9	74	73.0	1.486	0.751
	Std. Dev.		0.0	6.4	0.2	15.5	13	27.6	1.235	0.989
	Range	Hi	9.6	15.0	7.9	35.0	85	114.0	3.169	2.204
		Lo	9.6	4.0	7.5	2.0	65	56.0	0.360	0.112
	No. of Obs.		2	4	4	4	4	4	4	4
TOTAL	Mean		9.9	9.8	7.6	20.3	80	77.1	1.334	0.785
	Std. Dev.		0.3	6.2	.3	17.9	16	28.9	0.993	0.827
	Range	Hi	10.2	16.0	7.9	45.0	105	126.0	3.169	2.204
		Lo	9.6	4.0	7.3	2.0	60	53.0	0.360	0.112
	No. of Obs.		4	8	8	8	8	8	8	8

APPENDIX B

Macroinvertebrates

Macroinvertebrate samples were collected using a 6" x 6" petite ponar dredge. One grab sample was collected at each station and worked through a U.S. standard 30 mesh sieve. The resultant sample was backwashed from the screen and placed in a 500 ml wide-mouth plastic container and preserved with 70% ethanol. Samples were then cooled to 4°C for transport to ERG's laboratory. For macroinvertebrate results refer to the analytical report.

Sediment Collection

The bottom type encountered at Cornucopia was unsuitable for core sampling. The material consisted primarily of hard packed sand with some detrital material. A Peterson Dredge was used at all stations for sediment collection. For each station the dredge sample was transferred into a clean stainless steel bowl, thoroughly mixed and placed into one-quart glass containers. Samples were then placed on ice and cooled for shipment back to ERG's Ann Arbor Laboratory.

The following lists the sediment types for each sampling station:

Station No. 1

This station was located near the mouth of the harbor. The depth to sediment (7.8') indicates that the shoaling in this area is approxiamtely 2.0 feet. The sample consisted almost entirely of brownish red, fine to medium coarse, hard packed sand. There was very little detritus or silts in this area. No oil was observed and the odor was earthy.

Station No. 2

This area of shoaling was pointed out by personnel from the U.S.A.C. Duluth Project Office. The actual shoal area was easily visible from the boat. The depth to sediment was 4.0 feet indicating that the depth of shoaling was approximately 3.5 to 4.0 feet.

The sample in this area consisted entirely of reddish brown, hard packed sand. There was no oil or silt observed and the sample had an earthy odor.

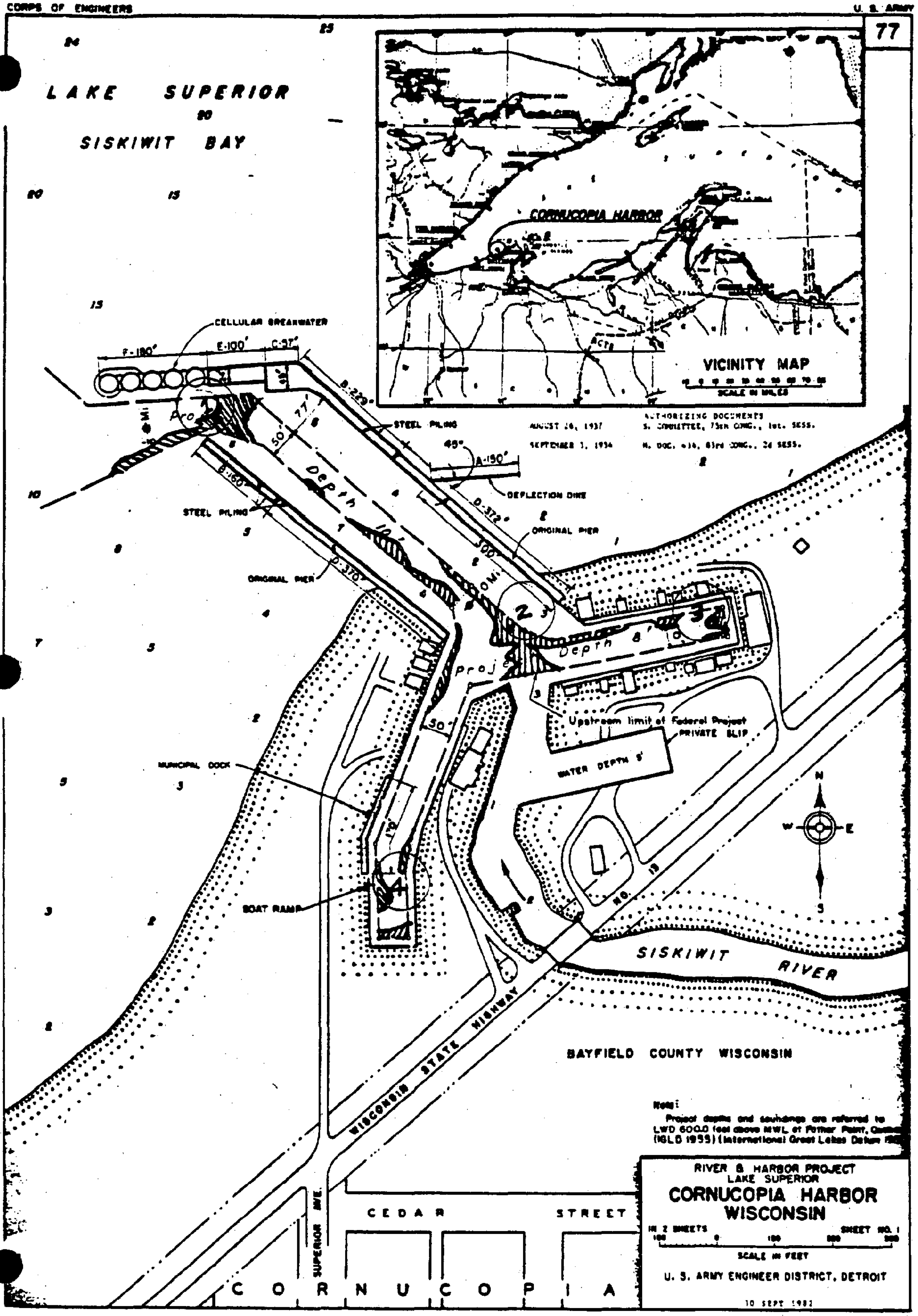
Station No. 3

This sample consisted of approximately 3" of reddish silt, over a mixture of detritus and fine reddish brown sand. The sand detritus mixture was approximately 60% sand and 40% detrital material. There was no oil and the sample had an earthy odor. Shoaling in this area was estimated to be approximately 1.0 to 2.0 feet.

Station No. 4

This sample was primarily reddish brown sand (70%) with detrital material mixed throughout. There was a light amount of fine silts on the sample's surface (1"). The odor was earthy and there was no oil.

CORPS OF ENGINEERS U. S. ARMY



ANALYTICAL REPORT
ENVIRONMENTAL RESEARCH GROUP, INC.
117 N. FIRST ST.
ANN ARBOR, MI 48104 (313) 662-3104

Project: A2406.2

Report Date: 01/07/85

Results by Sample

Prepared for:
LIMNO-TECH, INC.
15 RESEARCH DRIVE
ANN ARBOR, MI 48103
Attention: JIM SHERRILL

Client P.O.:
Report #: 80
Samples Rec'd: 10-08-84

Approved: Tom Cullen
Refer Questions to:
JOHN WILSON

**
Residual Samples Will Be Held
For Two Weeks
**

Client ID / ERG Sample Number / Matrix / Parameter	STATION 1 10/118025 SEDIMENT	STATION 2 10/118026 SEDIMENT	STATION 3 10/118027 SEDIMENT	STATION 4 10/118028 SEDIMENT	STATION 1 10/118029 ELUTRIATE	STATION 2 10/118030 ELUTRIATE
METHOXYCHLOR mg/Kg	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.50) *	ND (0.50) *
P. POLL PEST. AND PCB'S						
ALDRIN mg/Kg	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.0001) *	ND (0.0001) *
a-BHC mg/Kg	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.0001) *	ND (0.0001) *
b-BHC mg/Kg	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.0001) *	ND (0.0001) *
d-BHC mg/Kg	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.0001) *	ND (0.0001) *
g-BHC mg/Kg	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.0001) *	ND (0.0001) *
CHLORDANE mg/Kg	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.0001) *	ND (0.0001) *
4,4'-DDD mg/Kg	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.0001) *	ND (0.0001) *
4,4'-DDE mg/Kg	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.0001) *	ND (0.0001) *
4,4'-DDT mg/Kg	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.0001) *	ND (0.0001) *
DIELDRIN mg/Kg	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.0005) *	ND (0.0001) *
ENDOSULFAN I mg/Kg	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.0005) *	ND (0.0001) *
ENDOSULFAN II mg/Kg	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.0005) *	ND (0.0001) *
ENDOSULFAN SULFATE mg/Kg	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.0005) *	ND (0.0001) *
ENDRIN mg/Kg	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.50)	ND (0.0001) *
ENDRIN ALDEHYDE mg/Kg	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.050)	ND (0.0005) *	ND (0.0001) *
HEPTACHLOR mg/Kg	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.0001) *	ND (0.0001) *
HEPTACHLOR EPOXIDE mg/Kg	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.0001) *	ND (0.0001) *
TOXAPHENE mg/Kg	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.10)	ND (0.001) *	ND (0.001) *
PCB 1016 mg/Kg	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.0002) *	ND (0.0002) *
PCB 1221 mg/Kg	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.0002) *	ND (0.0002) *
PCB 1232 mg/Kg	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.0002) *	ND (0.0002) *
PCB 1242 mg/Kg	ND (0.030)	ND (0.050)	ND (0.050)	ND (0.080)	ND (0.0002) *	ND (0.0002) *
PCB 1248 mg/Kg	ND (0.030)	ND (0.050)	ND (0.050)	ND (0.080)	ND (0.0002) *	ND (0.0002) *
PCB 1254 mg/Kg	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.0002) *	ND (0.0002) *
PCB 1260 mg/Kg	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.0002) *	ND (0.0002) *
ARSENIC, TOTAL mg/Kg	1.1	ND (0.2)	0.9	2.2	ND (0.001) *	ND (0.001) *
CADMIUM, TOTAL mg/Kg	ND (0.8)	ND (0.8)	ND (0.8)	ND (0.8)	ND (0.003) *	ND (0.003) *
ORGANIC CARBON, TOTAL mg/Kg	11000	ND (500)	19000	13000	56 *	7 *
CHROMIUM, TOTAL mg/Kg	14	<2	9	21	0.02 *	0.02 *
FECAL COLIFORM BACTERIA TC/gm	7	ND (2)	53	36		
COPPER, TOTAL mg/Kg	6	<2	4	12	ND (0.005) *	ND (0.005) *
CORPS ELUTRIATE PROCEDURE mg/Kg					DONE *	DONE *
CYANIDE, TOTAL mg/Kg	ND (0.8)	ND (0.8)	ND (0.8)	<0.8	ND (0.01) *	ND (0.01) *
CHEMICAL OXYGEN DEMAND mg/Kg	33000	1900	24000	52000	320 *	22 *
IN PLACE DENSITY gm/cc3	1.6	1.9	1.7	1.4		
IRON, TOTAL mg/Kg	9200	3900	7700	14000	0.12 *	0.18 *
LEAD, TOTAL mg/Kg	<3	<3	12	<3	ND (0.01) *	ND (0.01) *
MANGANESE, TOTAL mg/Kg	110	32	93	270	0.11 *	0.007 *
MERCURY mg/Kg	<0.1	<0.1	<0.1	<0.1	ND (0.0002) *	<0.0002 *
NICKEL, TOTAL mg/Kg	4	ND (3)	5	11	ND (0.01) *	0.01 *
AMMONIA NITROGEN mg/Kg	10	1.2	16	29	0.96 *	0.41 *

 See last page for explanation of symbols

Project: A2406.2

ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.

Report Date: 07 JAN 1985

Client ID ERG Sample Number Matrix Parameter	STATION 1 10/118025 SEDIMENT	STATION 2 10/118026 SEDIMENT	STATION 3 10/118027 SEDIMENT	STATION 4 10/118028 SEDIMENT	STATION 1 10/118029 ELUTRIATE	STATION 2 10/118030 ELUTRIATE
KJELDAHL NITROGEN, TOTAL mg/Kg	1400	30	590	1000	6.3 #	0.97 #
OIL AND GREASE mg/Kg	<200	<200	<200	230	ND (1) #	2 #
PARTICLE SIZING (SPT)						
PARTICLE SIZING >2 mm %	0.2	1.3	0.9	0.6	-	-
PARTICLE SIZING >0.43 mm %	2.2	14	7.4	8.4	-	-
PARTICLE SIZING >0.25 mm %	9.2	78	49	19	-	-
PARTICLE SIZING >0.075 mm %	76	99	82	68	-	-
PARTICLE SIZING <0.075 mm %	24	1.1	18	32	-	-
PHENOLS mg/Kg	ND (0.06)	0.14	ND (0.06)	ND (0.06)	0.014 #	0.038 #
PHOSPHORUS, TOTAL mg/Kg	120	36	87	170	3.2 #	0.21 #
DISSOLVED SOLIDS, TOTAL mg/Kg	-	-	-	-	280 #	88 #
SOLIDS, PERCENT %	73	77	68	51	-	-
SUSPENDED SOLIDS mg/Kg	-	-	-	-	3600	80
VOLATILE SOLIDS %	3	<1	4	6	-	-
ZINC mg/Kg	21	7	14	38	0.000027 #	0.000028 #

 See last page for explanation of symbols

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ANALYTICAL REPORT

ENVIRONMENTAL RESEARCH GROUP, INC.

Project: [illegible]06.2

Report Date: 07 JAN 1985

Client ID ERG Sample Number Matrix Parameter	STATION 4 10/118031 ELUTRIATE	STATION A 10/118032 NATURAL WATER	STATION 3 10/118093 ELUTRIATE
METHOXYCHLOR mg/Kg	ND (0.50) *	ND (0.0005) *	ND (0.50) *
P. POLL PEST. AND PCB'S			
ALDRIN mg/Kg	ND (0.0001) *	ND (0.0001) *	ND (0.0001) *
a-BHC mg/Kg	ND (0.0001) *	ND (0.0001) *	ND (0.0001) *
b-BHC mg/Kg	ND (0.0001) *	ND (0.0001) *	ND (0.0001) *
d-BHC mg/Kg	ND (0.0001) *	ND (0.0001) *	ND (0.0001) *
g-BHC mg/Kg	ND (0.0001) *	ND (0.0001) *	ND (0.0001) *
CHLORDANE mg/Kg	ND (0.0001) *	ND (0.0001) *	ND (0.0001) *
4,4'-DDD mg/Kg	ND (0.0001) *	ND (0.0001) *	ND (0.0001) *
4,4'-DDE mg/Kg	ND (0.0001) *	ND (0.0001) *	ND (0.0001) *
4,4'-DDT mg/Kg	ND (0.0001) *	ND (0.0001) *	ND (0.0001) *
DIELDRIN mg/Kg	ND (0.0001) *	ND (0.0005) *	ND (0.0001) *
ENDOSULFAN I mg/Kg	ND (0.0001) *	ND (0.0005) *	ND (0.0001) *
ENDOSULFAN II mg/Kg	ND (0.0001) *	ND (0.0005) *	ND (0.0001) *
ENDOSULFAN SULFATE mg/Kg	ND (0.0001) *	ND (0.0005) *	ND (0.0001) *
ENDRIN mg/Kg	ND (0.0001) *	ND (0.0005) *	ND (0.0001) *
ENDRIN ALDEHYDE mg/Kg	ND (0.0001) *	ND (0.0005) *	ND (0.0001) *
HEPTACHLOR mg/Kg	ND (0.0001) *	ND (0.0001) *	ND (0.0001) *
HEPTACHLOR EPOXIDE mg/Kg	ND (0.0001) *	ND (0.0001) *	ND (0.0001) *
TOXAPHENE mg/Kg	ND (0.001) *	ND (0.001) *	ND (0.001) *
PCB 1016 mg/Kg	ND (0.0002) *	ND (0.0002) *	ND (0.0002) *
PCB 1221 mg/Kg	ND (0.0002) *	ND (0.0002) *	ND (0.0002) *
PCB 1232 mg/Kg	ND (0.0002) *	ND (0.0002) *	ND (0.0002) *
PCB 1242 mg/Kg	ND (0.0002) *	ND (0.0002) *	ND (0.0002) *
PCB 1248 mg/Kg	ND (0.0002) *	ND (0.0002) *	ND (0.0002) *
PCB 1254 mg/Kg	ND (0.0002) *	ND (0.0002) *	ND (0.0002) *
PCB 1260 mg/Kg	ND (0.0002) *	ND (0.0002) *	ND (0.0002) *
ARSENIC, TOTAL mg/Kg	ND (0.001) *	ND (0.001) *	ND (0.001) *
CADMIUM, TOTAL mg/Kg	ND (0.003) *	ND (0.003) *	0.005 *
ORGANIC CARBON, TOTAL mg/Kg	27 *	3 *	43 *
CHROMIUM, TOTAL mg/Kg	0.01 *	0.03 *	0.02 *
FECAL COLIFORM BACTERIA TC/gm	-	-	-
COPPER, TOTAL mg/Kg	ND (0.005) *	ND (0.005) *	ND (0.005) *
CORPS ELUTRIATE PROCEDURE	DONE *	-	DONE *
CYANIDE, TOTAL mg/Kg	0.31 *	ND (0.01) *	ND (0.01) *
CHEMICAL OXYGEN DEMAND mg/Kg	230 *	6 *	240 *
IN PLACE DENSITY gm/cm3	-	-	-
IRON, TOTAL mg/Kg	0.05 *	0.41 *	0.04 *
LEAD, TOTAL mg/Kg	ND (0.01) *	ND (0.01) *	ND (0.01) *
MANGANESE, TOTAL mg/Kg	0.29 *	0.013 *	0.16 *
MERCURY mg/Kg	<0.0002 *	<0.0002 *	<0.0002 *
NICKEL, TOTAL mg/Kg	<0.01 *	0.02 *	0.01 *
AMMONIA NITROGEN mg/Kg	2.7 *	0.02 *	1.6 *
KJELDAHL NITROGEN, TOTAL mg/Kg	5.9 *	0.28 *	6.6 *
OIL AND GREASE mg/Kg	3 *	<2 *	3 *
PARTICLE SIZING (5PT)			
PARTICLE SIZING >2 mm %	-	-	-
PARTICLE SIZING >0.43 mm %	-	-	-
PARTICLE SIZING >0.25 mm %	-	-	-
PARTICLE SIZING >0.075 mm %	-	-	-
PARTICLE SIZING <0.075 mm %	-	-	-
PHENOLS mg/Kg	0.027 *	0.017 *	0.020 *

See last page for explanation of symbols.

ANALYTICAL REPORT
ENVIRONMENTAL RESEARCH GROUP, INC.

Client ID ERG Sample Number Matrix Parameter	STATION 4 10/118031 ELUTRIATE	STATION A 10/118032 NATURAL WATER	STATION 3 10/118093 ELUTRIATE
PHOSPHORUS, TOTAL mg/Kg	1.8 *	0.04 *	2.4 *
DISSOLVED SOLIDS, TOTAL mg/Kg	210 *	48 *	190 *
SOLIDS, PERCENT %	-	-	-
SUSPENDED SOLIDS mg/Kg	1600	4 *	2100
VOLATILE SOLIDS %	-	-	-
ZINC mg/Kg	0.000045 *	0.010 *	0.000032 *

Project Comments:

Comments about sample 10/118025
P. POLL PEST. AND PCB'S - HIGHER DETECTION LIMIT DUE TO MATRIX INTERFERENCE.
Comments about sample 10/118026
P. POLL PEST. AND PCB'S - HIGHER DETECTION LIMIT DUE TO MATRIX INTERFERENCE.
Comments about sample 10/118027
P. POLL PEST. AND PCB'S - HIGHER DETECTION LIMIT DUE TO MATRIX INTERFERENCE.
Comments about sample 10/118028
P. POLL PEST. AND PCB'S - HIGHER DETECTION LIMIT DUE TO MATRIX INTERFERENCE.
Comments about sample 10/118029
P. POLL PEST. AND PCB'S - HIGHER DETECTION LIMIT DUE TO MATRIX INTERFERENCE.
Comments about sample 10/118032
P. POLL PEST. AND PCB'S - HIGHER DETECTION LIMIT DUE TO MATRIX INTERFERENCE.

Note - Results indicated by '*' are in mg/L instead of mg/Kg
FR = See field report for result
NA = Not applicable to test requested
ND = Nondetected, detection limit in ()
SD = Sample damaged

SR = See attached report for result
< = Positive result but at unquantifiable concentration below indicated level
- = Test not requested for this sample