REMEDIAL ACTION PLAN UPDATE
MANISTIQUE RIVER AND HARBOR
AREA OF CONCERN
MANISTIQUE, MICHIGAN

PREPARED FOR:

GREAT LAKES COMMISSION
AND
MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

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PROJECT NO. W023452

SEPTEMEBER 2002

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LIST OF ACRONYMS

AOC	Area of Concern
cfs	cubic feet per second
City	City of Manistique
CSO	combined sewer overflow
CEM	Coastal Environmental Management
FDA	Federal Drug Administration
FDA	Food and Drug Administration
GAO	General Accounting Office
GLWQA	Great Lakes Water Quality Agreement
IJC	International Joint Commission
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
MDPH	Michigan Department of Public Health
MDCH	Michigan Department of Community Health
NPDES	National Pollutant Discharge Elimination System
PAC	Public Advisory Council
PCB	polychlorinated biphenyl
ppm	parts per million
RAP	Remedial Action Plan
SPAC	Statewide Public Advisory Council
TerraFirma	TerraFirma Environmental, Inc.
Triad	Triad Engineering Incorporated
TSCA	Toxic Substances Control Act
U.S.	United States
USEPA	United States Environmental Protection Agency
WWTP	wastewater treatment plant

PREFACE

Preparation of this Remedial Action Plan (RAP) Update for the Manistique River and Harbor Area of Concern (AOC) was completed by Triad Engineering Incorporated (Triad) and TerraFirma Environmental, Inc. (TerraFirma). Funding for the Update was provided from United States Environmental Protection Agency (USEPA) Coastal Environmental Management (CEM) funds through grant money distributed by the Great Lakes Commission in cooperation with the Water Division of the Michigan Department of Environmental Quality (MDEQ). Matching and/or in-kind funds were provided by Triad and TerraFirma, as well as the Manistique River and Harbor Public Advisory Council (PAC).

This document is an update of remedial activities that have been completed or are currently in progress since the RAP Update prepared in 1997 (MDNR, 1997). It lists current beneficial use impairments, remedial activities completed or in progress, general and site specific delisting criteria and recommendations for future work that will be necessary to restore the AOC ecosystem and to complete the delisting process. The intended audiences are the local community in Manistique and the federal, state, and local government agencies that are working to restore the beneficial uses of the Manistique River and Harbor.

A limited chronology of the activities completed in the AOC to date is located in Section 5.0. There is much greater detail on the history of the Manistique River and Harbor AOC in both the 1987 RAP and 1997 RAP Update (MDNR, 1987, 1997). The 1994 Engineering Evaluation/Cost Analysis (USEPA 1994 and Blasland, Bouck and Lee, 1994) completed for the site has all the data for initial polychlorinated biphenyls (PCB) sampling results, except for the 1995 USEPA sampling results, which can be reviewed in the Administrative Record.

RAP and RAP Updates are approved by members of the PAC and the RAP Technical Team. Stakeholder groups are represented by PAC members in the approval process. The Michigan Department of Natural Resources (MDNR) and the MDEQ Water Division coordinate the RAP Technical Team members and approves the plan for the divisions that each represents. The approved RAPs and RAP Updates are forwarded to the MDEQ Office of the Great Lakes, which in turn forwards it to the International Joint Commission (IJC) of the U.S. and Canada for an external review.

Remedial actions approved by the PAC and RAP Technical Team are implemented as funding and time resources are available.

All local, state and federal documents related to remedial actions completed in the Manistique River and Harbor can be viewed and/or obtained at either the Manistique Public Library or from the appropriate contacts listed in Section 9.0. A summary of the Administrative Record has been provided in scanned formats by the PAC on a compact disc (CD) and can also be accessed at the Manistique Public Library. To obtain a copy of the CD contact Ms. Sharon Baker, RAP Contact, MDEQ Water Division.

EXECUTIVE SUMMARY

The Manistique River flows through Schoolcraft County in Michigan's central Upper Peninsula and discharges into Lake Michigan at Manistique. The Area of Concern (AOC) extends from the dam in the City of Manistique (City) to the mouth of the Harbor at Lake Michigan, a distance of approximately 1.7 miles.

The initial Remedial Action Plan (RAP) for the Manistique River and Harbor was written by the Michigan Department of Natural Resources (MDNR) in 1987. This RAP described known problems and identified actions and studies needed to further define and restore those problems. However, the RAP was written before the 1987 amendments to the Great Lakes Water Quality Agreement (GLWQA), which outlined new guidelines for completing AOC RAPs. The guidelines included identifying which, if any, of 14 potential beneficial use impairments existed within the AOC.

The 1997 RAP Update reflected the requirements set forth in the 1987 amendments to the GLWQA, and included activities completed from 1987 to 1996 pertinent to the health and viability of the AOC. Recommendations for future actions required to restore the beneficial uses were also included. The PAC and the RAP Technical Team used the beneficial use impairment guidance in Annex 2 of the 1987 amendments to the GLWQA to assess the ecosystem in the AOC. Five beneficial use impairments were identified. The impairments included:

- Restriction on fish and wildlife consumption
- Degradation of benthos
- Loss of fish habitat
- Restrictions on dredging activities
- Potential restrictions on body contact (beach closings)

These beneficial use impairments resulted from what the PAC and the RAP Technical Team identified at that time as three basic problems in the AOC. These problems consisted of:

- Polychlorinated biphenyl (PCB) impacted sediment
- Effects of the dam and paper mill flume on fisheries management goals
- Combined sewer overflows (CSOs) that discharged directly to the River or Harbor

The PAC and RAP Technical Team concluded that by addressing the three problems referenced above the 5 beneficial uses in the AOC ecosystem would be restored. However, during technical discussions between the PAC, MDEQ Water Division and Triad/TerraFirma regarding this RAP Update, it became evident that the effects of the dam /and paper mill flume on fisheries management goals did not reflect issues concerning the AOC. Consequently, fisheries management goals were eliminated from the list of problems and will not be addressed in this RAP Update. If there are questions regarding the fisheries

management plan, which is currently being drafted, please contact Steve Scott, Fisheries Division, MDNR at 920-293-5131.

Remedial actions recommended in the 1997 RAP Update included:

- Remediation of PCB impacted sediments. This was completed in 2001 by the USEPA Region 5 Superfund program and the potentially responsible parties.

- Completion of the CSO elimination plan.

- Increase flow in the River channel that parallels the flume from a minimum of 50 cubic feet per second (cfs) to 250 cfs. The increased flow would flood the gravelly areas and rocky ledges, which are excellent fish spawning and benthos habitats.

- Construction of a fish and sea lamprey trap and fish lock system below the dam for fisheries management purposes.

- Establishment of a permanent group of citizens and government agency personnel to guide pollution prevention and resource conservation in the AOC for long-term protection of the Manistique River and Harbor ecosystem.

As previously discussed, based on recent decisions between the PAC, MDEQ Water Division, and Triad/Terra Firma regarding this RAP Update, the latter three recommendations set forth in the 1997 RAP Update do not pertain to identified issues relating to the AOC. As such, the latter three recommendations are not addressed in this Update.

The following key remedial actions were under way prior to and subsequent to the 1997 RAP Update:

- Extensive discussions in 1994 and 1995 led to a decision for remediation of PCB impacted sediment in the Manistique River and Harbor. Consequently, part of the site was to be dredged by USEPA with diver-assisted hydraulic dredging. Disposal of the material was in a special landfill located out of state. A portion of the site was to be temporarily capped by the USEPA/potentially responsible parties with an engineered cap consisting of a layer of geo-textile, a 20-inch layer of carbon-enriched sand, and a 14-inch layer of stone armor.

- Plans for modifications to the dam and flume were reported in 1997 as being in place, although no plans or provisions for fisheries management concerns were noted in the Administrative Record. The City and the MDEQ were working together on upgrades to the City sewer system and as of the 1997

RAP Update had approved a plan to eliminate the last CSO pipe, which is currently scheduled for sewer separation before the year 2020.

- The 1997 RAP Update outlined a relatively aggressive timeline for all of the proposed activities, including that of monitoring and delisting, with the anticipation that these would be completed by 1998, and that the River and Harbor would then be delisted. In actuality, dredging operations were completed and sediment assessment sampling was initiated in 2000.

- USEPA-led remedial and dredging activities continued from 1995 to 2000. Final dredging was conducted by divers under the auspices of the USEPA Emergency Response Branch with hydraulic techniques to ensure minimized resuspension during dredging, and a "clean" substrate when completed. It is estimated that 141,000 cu yds of PCB and heavy metal impacted sediment were removed from the River and Harbor from 1995 to 2000.

- Sediment assessment sampling was completed across the AOC dredged areas in 2001. Sediment sample results indicated that average PCB concentrations in samples collected in the dredged areas of the AOC were below 10 parts per million (ppm) throughout the Harbor (7.06 ppm at 95% confidence intervals; Appendix A).

Cost estimates for the Manistique River and Harbor sediment remediation project ranged from $5 million to $7 million at the start of the project in 1995 to approximately $50 million in 2000.

Our conversations with the community prior to the writing of this Update reveal that they felt that many decisions related to the remedial activities in their harbor were made without a "weighted mix" comparative analysis of their thoughts and comments. This seemed particularly true in the case of whether to cap or dredge the majority of the system, and the projected costs and difficulties associated with the dredging efforts. A survey was sent out to the community in March 2002. The results of the survey indicate that many people did not feel the actions taken by the USEPA in the River and Harbor were warranted (Appendix B).

Delisting of the AOC begins when criteria specific to the five impairments are met as outlined in the 2001 *International Joint Commission/Great Lakes Commission (IJC/GLC) Delisting Criteria Workshop*, and discussed in Section 3.0 of this report. At this time, none of the impairments have been requested for delisting, as monitoring or summary data on each impairment is not yet available. A summary of the technical details of the remedial activities is currently under final review by the USEPA and should be available late 2002 or early 2003.

Recommendations of this Update include facilitating close coordination between the PAC and the MDEQ Water Division to prepare recommendations for submittal to USEPA Region 5 to establish final delisting criteria, establishment of a timeline for the continued remedial,

if appropriate, and monitoring efforts, and provide a mechanism for the PAC to focus on funding sources.

Section 1.0
INTRODUCTION

1.1 REVIEW OF THE AREA OF CONCERN PROGRAM

1.1.1 The Great Lakes Area of Concern Program

The Area of Concern (AOC) program is part of the Great Lakes Water Quality Agreement (GLWQA; Annex 2 of the 1987 Protocol) established between the United States (U.S.) and Canada. The AOCs are defined as "geographic areas that fail to meet the general or specific objectives of the agreement where such failure has caused or is likely to cause impairment of beneficial use of the area's ability to support aquatic life." The GLWQA mandates that the U.S. and Canada in cooperation with state and provincial governments develop and implement Remedial Action Plans (RAPs) to address the restoration and protection of an ecosystem for each AOC using beneficial use impairments as a guide.

1.1.2 Michigan's Area of Concern Program

Of the 42 current Great Lakes AOCs, 14 are located in Michigan. The Michigan AOC program is administered by the MDEQ Water Division in collaboration with other state and federal agencies, and stakeholders in the AOC communities.

In 1991, a Statewide Public Advisory Council (SPAC) was formed to facilitate public participation in the AOC programs, to increase public awareness of and participation in the RAPs being developed within the local AOCs, and to generate local support for implementation of restoration and protection activities taking place within the AOCs. The SPAC is comprised of citizen representatives from each of the 14 AOCs.

At the April 1996 quarterly meeting, a long-term strategic plan for the SPAC was approved. Three goals were set forth in their mission statement. Those goals included:

- RAP Process – The public and RAP participants advance the RAP process to ensure the restoration and protection of Michigan's AOCs.
- RAP Funding – The AOC program is adequately funded to ensure timely and effective cleanup of Michigan's AOCs.
- Public Involvement – The public is knowledgeable of the AOC Program and actively participates in the cleanup of the Michigan's AOCs.

A more detailed summary of the SPAC's mission statement and goals can be accessed at http://www.glc.org/spac/strategy.pdf.

1.1.3 Manistique River and Harbor Area of Concern

The Manistique River and Harbor RAP was initially written by the Michigan Department of Natural Resources (MDNR) in 1987. This RAP described known problems and identified actions and studies needed to further define and restore those problems. However, the RAP was written before the 1987 amendment to the GLWQA, which outlined new guidelines for completing the AOC RAPs. These guidelines included identifying which, if any, of 14 potential beneficial use impairments exist within an AOC. The Manistique River and Harbor 1997 RAP Update specifically outlined five areas of beneficial use impairments. The beneficial use impairments identified included:

Restrictions on Fish and Wildlife Consumption – Polychlorinated biphenyl (PCB) and heavy metal impacts of the sediments within the AOC were first identified in the mid-1970's. PCBs, a synthetic class of chlorinated hydrocarbons that are very persistent, bio-accumulate, and are suspected of being toxic to many aquatic animals at low levels or with chronic exposures, may cause birth defects or cancer in some organisms. PCBs were produced for use in a variety of industries from the late 1930s until they were eventually banned from production by the USEPA in 1977.

Carp tissue collected from the Manistique River within the AOC had concentrations of PCBs that exceeded the action level of the Food and Drug Administration (FDA) and Michigan Department of Public Health (MDPH) of 2 parts per million (ppm). A fish-consumption advisory is still in effect for carp caught below the dam in the Manistique River and Harbor, advising anglers not to eat these fish due to elevated levels of PCBs in the tissue.

Degradation of Benthos – Impacts to the biota were first noted in the mid-1950's. These impacts were attributed primarily to deposits of wood fibers and waste from sawmill and paper mill operations, and discharges from combined sewer overflows (CSOs) from the City wastewater treatment plant (WWTP). Later studies also identified chemical wastes as contributing to the degradation.

Loss of Fish and Wildlife Habitat – In an effort to provide suitable habitat to support the restoration and maintenance of a coldwater fishery in the AOC and to maintain sea lamprey and salmon passage control at the dam, modifications to the dam and paper mill flume (flume) were proposed in the 1997 RAP Update.

Restrictions on Dredging Activities – Heavy metals, lead, zinc, cadmium, chromium, copper and PCB's, were found in the sediments at concentrations that categorized the sediments as "heavily polluted" according to the dredge spoil disposal guidelines (MDNR, 1987, 1997).

Potential Restrictions on Body Contact – This impairment relates to the direct discharge of storm water and untreated sanitary waste to the Manistique Harbor from the City's WWTP during extreme wet weather events. Potentially high

bacterial counts in the water of the Harbor could occur following an overflow event. Consequently, since the 1987 RAP was written, the City has completed two sewer separation projects, closing two of the three CSO pipes that historically discharged to the River and/or Harbor. A third CSO that currently discharges directly to the Manistique Harbor is scheduled for sewer separation before the year 2020.

1.1.4 History of Improvements

Numerous types of industry have been located within the Manistique River and Harbor AOC in the past, especially sawmills (MDNR, 1987, 1997). At the time of the 1997 RAP Update, there were only two active point source dischargers; Manistique Papers, Inc. and the Manistique WWTP.

Over the past 25 years a number of actions have taken place that have resulted in improvements in the known impairments within the AOC. In 1977, the Manistique WWTP upgraded to secondary (biological) treatment. Manistique Papers, Inc. also upgraded its wastewater treatment facilities to provide secondary treatment of process wastewater from its paper making operations. These improvements greatly reduced oxygen demanding loads to the Manistique River, as well as, reducing or eliminating the discharge of toxicants (metals and organic) and materials such as wood fibers and paper to the River or Harbor. In 1986, at the request of the Michigan Department of Natural Resources (MDNR), Manistique Papers, Inc. placed an erosion barrier along the west bank of the main river channel upstream from the U.S. 2 highway bridge to control erosion of PCB-impacted soil located there (MDNR, 1987). The last sentence contains a correction to the 1987 RAP, which indicated that an erosion barrier had been placed on the east bank of the main river. Since the 1987 RAP was written, the City has also completed two sewer separation projects, closing two of the three CSO pipes that discharged to the River and/or Harbor.

The PAC for the Manistique River and Harbor AOC was established in 1993 and consisted of members representing a variety of interests in the community. The RAP Technical Team is made up of staff from state and federal agencies that have an interest in management of the ecosystem of the AOC. PAC and RAP Technical Team contact information is located in Section 9.0 of this Update. These groups produced the 1997 RAP Update, and gave guidance for the production of the 2002 RAP Update.

Beginning in 1993, USEPA identified several potentially responsible parties for the PCB contamination. Two of these, Manistique Papers, Inc. and Edison Sault Electric, worked with consultants and USEPA to complete extensive sampling in the River and Harbor for PCBs. They produced ecological and human health risk assessments, and an Engineering Evaluation/Cost Analysis for the site in 1994. The risk assessment and the Engineering Evaluation/Cost Analysis are available from USEPA Region 5, and are located in the Manistique Public Library, as well as on the Administrative Record CD, which was produced by the PAC.

In June and December 1993, April 1994 and May, June and July 1995, sediment samples were collected from the navigation channel, along with other Harbor and upstream

locations. Sample cores were generally advanced to bedrock. It was estimated that there were about 104,000 cu yds (cu yds) of material in the Harbor impacted by levels of PCBs exceeding 10 ppm, covering 22 acres. There were estimated to be approximately 8 tons of PCBs in the River and Harbor sediments (USEPA, 1994).

In 1993, a temporary weighted plastic cover was placed over sediment containing PCBs just downstream from the City marina (Figure 2).

Discussions between the community, the potentially responsible parties, and USEPA throughout 1994 and most of 1995 led to a final determination by USEPA regarding remediation for the PCB impacted sediments. USEPA determined that it would dredge an area mostly north of the U.S. 2 highway bridge on the west side of the River by hydraulic dredging, including diver-assisted dredging. Dewatered PCB-impacted sediments with concentrations greater than 50 ppm would be disposed of at a Toxic Substances Control Act (TSCA) PCB disposal facility, sediments with PCB concentrations of less than 50 ppm would be disposed of at an in-state sanitary landfill. Treated water from dredging was returned to the river after analysis indicated that state and federal water quality standards were met.

There is much greater detail on the history of the Manistique River and Harbor AOC in both the 1987 RAP and 1997 RAP Update (MDNR, 1987, 1997). The 1994 Engineering Evaluation/Cost Analysis (Blasland, Bouck and Lee, 1994) completed for the site has all the data for initial PCB sampling results, except for the 1995 sampling results, which are presented in the Administrative Record.

A detailed description of remedial activities completed or in progress from approximately 1995 to 2001 are documented in Sections 3.0 and 5.0 of this report.

It should also be noted that in-kind services were provided to USEPA by Manistique Papers Inc. and Edison Sault Electric Company during the sediment dredging activities. The cost associated with the donated services is estimated to be in excess of $1.6 million. The in-kind contributions included the following:

- Use of private property for site access for staging, prescreening and storage of treated water from sediment dewatering activities, with a lease value of approximately $10,000 per month;
- Use of an existing storage pad for drying, storage and shipping of impacted sediments, with a lease value of $20,000 per month;
- Use of utility poles and lighting in the sediment dredging, dewatering and storage operating areas;
- Rail access and rail car switching services;
- Supplying the USEPA with filter fabrics and electrical cable.

Section 2.0
THE MANISTIQUE RIVER AREA OF CONCERN

2.1 ECOSYSTEM DESCRIPTION

2.1.1 Geographical

The Manistique River is located in Schoolcraft County in Michigan's central Upper Peninsula (Figure 1). The river flows from the northeast and discharges into Lake Michigan at the City of Manistique.

2.1.2 Physical

The AOC lies primarily within the City of Manistique, beginning at the dam and extending through the Manistique Harbor to Lake Michigan. The east side of the river and harbor is primarily utilized for residential, business and recreational uses. The region of Schoolcraft County along the Lake Michigan shoreline and including the AOC is fairly level and characterized by low sandy or gravely ridges alternating with swales and swamps (Foster and Veatch, 1939). Soils surrounding the AOC are primarily sand underlain by limestone and dolomite.

The Manistique River substrate adjacent to the Manistique Papers, Inc. flume upstream of the U.S. 2 highway bridge is comprised primarily of limestone bedrock strewn with large boulders. The substrate below the U.S. 2 highway bridge adjacent to the flume consists of rocks and smaller boulders overlying the limestone bedrock, with sand deposition occurring in the area of slower moving water on the eastern side of the River. Between the end of the rapids and the U.S. 2 highway bridge the substrate is primarily sand and silt overlying limestone bedrock. The substrate downstream of the channels in the River and Harbor is a combination of sand and silt with some gravel, cobble and slab wood overlying limestone bedrock (MDNR, 1987). The deposition zones in the River and Harbor continue to accumulate sand and silt, primarily from erosion of bank materials in the upper watershed due to forestry practices (MDNR, 1995).

Surveys conducted by MDNR in 1976, 1978 and 1985 documented that the substrate in the Manistique Harbor had been altered due to the accumulation of sawdust and woodchips. These materials originated primarily from lumber-making and paper-making (from wood pulp) activities that historically occurred on the lower Manistique River. With the closing of the sawmills, improved wastewater treatment, and the switch from pulpwood to recycled magazines (materials including magazines plus mixed papers) as raw material at the paper mill, the discharge of the woody materials has been eliminated (MDNR, 1987).

2.1.3 Biological

Aquatic habitat in the AOC downstream of the dam supports a variety of seasonal sport fish including northern pike, yellow perch, channel catfish, smallmouth bass, rock bass, walleye, chinook salmon, coho salmon, pink salmon, brown trout and steelhead (MDNR 1980-1986, 1987). The area in the vicinity of the flume where the elevation of the river drops approximately 26 feet and flows over shelves of limestone and gravel bars is considered an excellent spawning location for many of the fish species. The remaining length of the river and harbor is basically at the level of Lake Michigan and is not considered important for spawning of fish.

Land habitat in the AOC is primarily sandy beach, low shrubs, and developed sites, which is used by shorebirds and gulls. In addition, bald eagles forage along the shoreline in the vicinity of the AOC. Waterfowl habitat is available primarily on the eastern shore of the River near U.S. 2, where the dead end channel creates a marsh. Waterfowl have also been observed along the River shoreline and around the islands created by the boat channels. There is little available wildlife habitat elsewhere in the AOC, since the entire site lies within the City of Manistique and the shoreline and nearby areas are relatively developed.

Greater detail for the geographical, physical, and biological aspects of the AOC can be found in the 1987 RAP, the 1994 Engineering Evaluation/Cost Analysis, and the 1997 RAP Update.

Section 3.0
SUMMARY OF BENEFICIAL USE IMPAIRMENTS

Annex 2 of the 1987 amendments to the GLWQA lists 14 beneficial use impairments to be evaluated in each AOC. In 1997, the PAC and the RAP Technical Team identified five impairments in the Manistique River and Harbor system. A list of the five impairments and their current status are summarized below. Included in the summaries are remedial and/or monitoring activities completed or in progress, general and site specific delisting criteria, and recommended activities that need to be completed prior to delisting an impairment for beneficial use and ultimately to delist the AOC from the program (IJC 2001).

3.1 RESTRICTIONS ON FISH AND WILDLIFE CONSUMPTION

In 1987, MDPH issued a fish consumption advisory (no consumption) for carp caught in the Manistique River and Harbor below the dam. The advisory was issued because PCB concentrations in carp tissue exceeded the Federal Drug Administration (FDA) and MDPH action level of 2 parts per million (ppm). Currently, the Michigan Department of Community Health (MDCH) fish consumption advisory indicates a ban on the consumption of carp. The advisory also suggests for the general population one meal per week for channel catfish and for women and children one meal per month. For more information regarding fish consumption advisories visit the MDCH website at www.michigan.gov/mdch, then click on statistics and reports. Fish consumption advisory information can also be obtained wherever fishing licenses are sold. The MDCH toll free telephone number is 1-800-648-6942. At this time there are no restrictions on consumption of wildlife in the AOC.

Remedial Actions

1986	The west bank of the Manistique River adjacent to the Manistique Papers, Inc. property was stabilized with crushed stone, which was expected to reduce erosion of PCB impacted soil to the Manistique River.
1993	USEPA placed a 110-foot by 240-foot cap over an area where PCBs were found in sediment samples in concentrations up to 120 ppm at the surface (Figure 2).
1995	The United States Congress reauthorizes the navigational channel depth requirements from 18 feet to 12.5 feet.
1995 – 1996	USEPA initiated demonstration level dredging activites in September 1995 through October 1996 in Area B (Figure 3). Approximately 32 tons of sediment containing PCBs at concentration of greater than 50 ppm and approximately 1,372 tons of sediment containing PCBs

concentrations of less than 50 ppm was dredged from the Manistique River and Harbor.

1997

USEPA continued dredging activities at the mouth of the Manistique River and within the Harbor (Figure 4). An estimated 44,000 cu yds of sediment were dredged. Figures 5 and 6 present the post-dredging average PCB concentrations in sediment in the 0 to 1-foot (average 50.3 parts per million (ppm)) and the 0 to 2-foot (average 56.2 ppm) sampling intervals, respectively, in the 1997 dredged areas.

1998

USEPA continued dredging operations (Figure 7). Figures 8 and 9 depict the distribution of confirmation samples taken after the cessation of the dredging operations in 1998. The dredging was concentrated in two major portions of the AOC, the outer River and the outer portion of the Harbor. The average concentration of PCBs in the 0 to1 foot sampling interval was 21.5 ppm. The average concentration of PCBs in the 0 to 2-foot sampling interval was 23.0 ppm.

1999

USEPA continued dredging operations (Figure 10). Confirmation sampling locations for the 0 to 1 and 0 to 2-foot intervals are depicted on Figures 11 and 12, respectively. The average PCB concentrations in the 0 to 1 and 0 to 2-foot sampling intervals ranged from 17.9 to 21.2 ppm, respectively.

Pre- and post-1999 dredging PCB concentrations are shown on Figure 13. On average, PCB concentrations decreased by approximately 10 ppm.

The temporary cap was removed.

2000

USEPA continued dredging operations (Figure 14). Average PCB concentrations in the 0 to 1-foot sampling interval (11.4 ppm) is presented on Figure 15. Average PCB concentrations in the 0 to 2-foot (11.9 ppm) sampling interval are depicted on Figure 16.

Dredging of PCB impacted sediments is completed and confirmational sediment sampling was initiated.

2001

Confirmational sediment sampling was completed ensuring that the 10-ppm average PCB concentration goal for the River and Harbor was met. The distribution of confirmation samples and the average PCB concentrations (7.2 ppm) in the 0 to 1-foot interval is presented on Figure 17. Figure 18 depicts the location of confirmation sampling and average PCB concentrations (8.2 ppm) in the 0 to 2-foot interval. Figure 19 presents the cumulative distribution of samples as a

function of the total PCB concentrations in sediment. The probability density function for total PCB concentrations is presented on Figure 20, which indicates that well over 90 percent of all the sediment samples collected had result values of less than 10 ppm. A short discussion about the interpolation of the total PCB values and the statistical analyses results is contained in Appendix A.

2002

A caged fish study was initiated by the Water Division of MDEQ on July 24, 2002. The results obtained during this study will be compared to a reference site study, which is located within the Manistique River watershed above the dam.

The USEPA is currently developing a sampling plan for follow up monitoring, which will potentially include a study of the edible portion of carp, channel catfish, and one other fish yet to be determined. An analysis of the woodchips located in the River and Harbor downstream of Manistique Papers, Inc. will also be conducted. The results of the woodchips analyses will be released in a supplement to the summary report that this scheduled to be released in late 2002 or early 2003.

Delisting Criteria

- When PCBs in fish tissue from caged fish studies do not exceed background levels at the selected reference site.

Recommendations

- Perform caged fish studies as part of post-remediation PCB monitoring. This will assist in determining PCB availability to fish in the Manistique River and Harbor. Caged fish studies were performed by the MDNR and MDEQ in 1990 and 2002, respectively.

- MDEQ complete the analysis and publish the resultant report of the latest caged fish study by December 1, 2002 to facilitate and expedite the River and Harbor delisting process.

- Preparation of a request to delist the impairment, which would include all the supporting monitoring data, indicating that the locally derived delisting target has been meet, providing the USEPA remedial summary report and any supplements to that report concur.

Post-remedial PCB sampling and analysis was completed by USEPA in 2001. The interpolated average PCB concentrations in the 0 to 2 foot interval was 8.2 ppm. Summary data for the total dredging operation is being compiled and evaluated by USEPA Region 5, and should be released by late 2002 or early 2003 (Bohlen, 2002, pers.com).

3.2 DEGRADATION OF BENTHOS

In 1978, the MDNR conducted a benthic survey above and below the dam in Manistique. The survey indicated that there was a lower average density and less diversity of organisms downstream of Manistique Papers, Inc. and/or the Manistique WWTP compared to locations upstream of the dam. In addition, the survey indicated that the diversity and density of organisms found within the AOC were dominated by pollution tolerant benthic organisms. Consequently, the objective set forth in the 1997 RAP Update included reducing or eliminating the availability of sawdust, woodchips and PCBs in surficial sediments in order to improve the substrate of the River and Harbor.

Remedial Actions

1993 The USEPA installed a 110-foot by 240-foot cap in the vicinity of a CSO that discharged directly to the Manistique River down stream of the City marina. PCB concentrations in sediment in this area were approximately 120 ppm at the surface.

1995-2000 During dredging activities of PCB impacted sediments, approximately 31,100 cu yds of wood chips, sawdust, and other solid materials were removed coincidently.

2002 USEPA conducted a post dredging bathymetry survey. The results of the survey will be reported in or as a supplement to the USEPA summary report that should be released by in late 2002 or early 2003.

Delisting Criteria

- When the benthic macroinvertebrate community structure does not significantly diverge from non-impacted reference sites of comparable physical and chemical characteristics.
- When toxicity of sediment-associated impacts are not significantly higher than reference sites.
- Establishment of a clean non-sawdust substrate in the dredged areas to support a healthy population of native organisms.

Recommendations

- Report detailed pre- and post-dredging bathymetry and substrate type to assess sediment thickness and substrate type and quality in the dredged areas of the River and Harbor. USEPA conducted the fieldwork documenting post-dredging bathymetry in the summer of 2002.

- Development of a monitoring plan/strategy to document the diversity and population of the benthos communities in the vicinity of the dredged areas.

- Request that the state focus monitoring efforts in the River and Harbor, as needed, to facilitate the delisting process.

- Prepare a request to delist the impairment, which would include all the supporting monitoring data, indicating that the locally derived delisting target has been met.

Summary data for the total dredging operation including bathymetry and substrate type is being compiled by USEPA Region 5 and should be released in late 2002 or early 2003 (Bohlen, 2002, pers.com).

3.3 LOSS OF FISH AND WILDLIFE HABITAT

Fisheries management goals in Manistique have been closely tied to dam and flume operation, since the structures were built in the original river channel and have greatly reduced fish habitat. These structures also block sea lamprey and salmon from migrating up the river.

Remedial Actions

- Increase flow in the river channel that parallels the flume from a minimum of 50 cubic feet per second (cfs) to 250 cfs. The flow would be increased due to proposed modifications to the dam and flume. The increased flow would re-water gravelly areas and rocky ledges, which will create excellent fish spawning and benthic invertebrate habitat.

Delisting Criteria

- When the amount and quality of physical, chemical, and biological habitat required to meet fish and wildlife management goals has been achieved and protected within the AOC.

Recommendations

- Evaluate the improvements in the fish populations and benthic invertebrate habitat since and/or upon the completion of the proposed modifications to the dam and flume.

- Complete and implement a comprehensive fisheries management plan for the AOC.

- Prepare a request to delist the impairment, which would include all the supporting monitoring data, indicating that the locally derived delisting target has been met.

At this time, the MDNR has indicated that the Manistique River and Harbor Fish Management Plan is in its "infancy" and will not be completed until the summer of 2003 (PAC, 2002).

3.4 RESTRICTIONS ON DREDGING ACTIVITIES

The United States Army Corps of Engineers is responsible for navigational dredging in the Manistique River and Harbor. The navigational channel has not been dredged since 1967, due in part to the lack of demand, and in part due to PCB and heavy metal impacts to the sediment. Consequently, in 1969 the Corps adopted a 12-foot maintenance depth for the Manistique Harbor.

In the mid-1980's, at the request of a local business, the Corps evaluated the sediments in the navigational channel for dredging to restore the 18.5 foot channel depth. PCB concentrations were found to be greater than 50 ppm in sediment. Consequently, dredging of the channel was not pursued by the Corps.

Remedial Actions

1993	The USEPA installed a 110-foot by 240-foot cap in the vicinity of a CSO that discharged directly to the Manistique Harbor.
1995-2000	Manistique River and Harbor AOC Update sheet estimates that 141,000 cu yds of PCB and heavy metal impacted sediment have been successfully removed from the River and Harbor system from 1994 to 2000 (USEPA fact sheet).
1995	United States Congress reauthorizes a change in the depth of the navigational channel for the Manistique River and Harbor from 18 feet to 12.5 feet.
1999	The temporary cap is removed.
2000	Dredging of impacted sediments is completed, and confirmational sediment sampling was initiated.
2001	Confirmation sediment sampling was completed to insure the 10-ppm average PCB concentration goal for the River and Harbor was met.

Note that completed dredging depth in the navigational channel was to bedrock, with depths ranging from approximately 20 to 22 feet.

Delisting Criteria

- When contaminants in sediments do not exceed standards, criteria, or guidelines, such that there are restrictions on dredging or disposal activities.

- When there are no restrictions on dredging to the authorized 12.5' commercial navigation channel depth.

Recommendations

- The two delisting criteria appear to be met. USEPAs preliminary PCB concentrations in sediment in the River and Harbor meet the standards, criteria and guidelines. Sediment laden with heavy metals was assumed to be removed coincident with the dredged sediment containing PCBs. The reported final completed dredging depth in the channel currently exceeds the authorized 12.5-foot commercial navigational depth.

- Prepare a report detailing pre- and post-dredging bathymetry and substrate to assess sediment thickness and substrate type and quality in the lower River and Harbor. A bathymetry survey was completed by USEPA in the summer of 2002.

- Prepare a request to delist the impairment, which would include all the supporting monitoring data, indicating that the locally derived delisting target has been met.

Summary data for the total dredging operation including bathymetry and substrate type is being compiled by USEPA Region 5 and should be released late 2002 or early 2003 (Bohlen, 2002, pers.com).

3.5 POTENTIAL RESTRICTIONS ON BODILY CONTACT (OR BEACH CLOSINGS)

Remedial Actions

Since the 1987 RAP was written, the City has completed two sewer separation projects, closing two of the three CSO pipes that discharged to the River and/or Harbor. A third CSO that discharges directly to the Manistique Harbor is scheduled for sewer separation before the year 2020. Complete details of the MDEQ-approved plan can be found in the City WWTP NPDES discharge permit available from the City or MDEQ (see list of contacts in Section 9.0).

Delisting Criteria

- When waters, which are commonly used for total body or partial body contact recreation do not exceed the most restrictive standards, objectives, or guidelines for such use.

Recommendations

- Prepare a request to delist the impairment. Currently, there are no swimming beaches located in the Harbor. In addition, the one remaining CSO will be eliminated by the year 2020 based on the requirements of the MDEQ-approved NPDES wastewater discharge permit. The PAC should prepare documentation and a letter to the MDEQ and IJC outlining the delisting rationale.

A survey of community citizens, MDNR reports, USEPA reports, and U.S. Army Corps of Engineers reports were used for reference materials in determining the use impairments. Results for the initial community survey are found in Appendix B of the 1997 Update. This RAP Update also solicited input from the citizens in a second survey. The results of the second survey are located in Appendix B of this document.

Section 4.0
CHRONOLOGY OF AREA OF CONCERN ACTIVITIES

Following is a summary of restoration/remedial activities completed or currently in progress in the Manistique River and Harbor AOC since 1995 (with review of important events prior to the 1997 RAP update).

1950's to 1970's – The MDNR and fisheries groups noticed general impacts to aquatic biota from wood fibers, sawmill waste, paper mill operations, sanitary waste from the city of Manistique, chemical wastes, and PCB and heavy metal (lead, zinc, cadmium, chromium and copper) contamination of the sediments within the area of concern.

Carp PCB tissue concentration levels were found to be above the 2 ppm action level. Fish consumption advisories were posted for the River and Harbor.

1977– Manistique WWTP upgraded to secondary (biological) treatment. Manistique Papers upgraded its wastewater treatment facilities to provide secondary treatment of process wastewater from its paper making operations. Manistique Papers dredged and filled the de-inking wastewater settling lagoon.

1978– MDNR conducts a benthic macro-invertebrate study.

1986– Manistique Papers, Inc. placed an erosion barrier along the west bank of the main river channel upstream from U.S. 2 to control erosion of PCB impacted soils from the former de-inking lagoon.

1987– MDNR conducts a benthic macro-invertebrate study. The Remedial Action Plan for the Manistique River and Harbor AOC was prepared by the Michigan Department of Natural Resources.

1988– The United States Army Corps of Engineers conducted sediment sampling of the River and Harbor; additional benthic surveys are done in the River and Harbor.

1990– A caged catfish study was conducted by the MDNR in the River and Harbor: PCB concentration levels in catfish after 30 days exposure was 0.055 ppm.

1992– MDNR Environmental Response Division completed sampling for PCBs in terrestrial and aquatic sites adjacent to the River and Harbor AOC.

The Manistique River Watershed Partnership was established to examine fish management planning problems in the watershed.

1993– USEPA AOC Progress Report (FRANZ); *EPA FACT SHEET RE: Site History & Nature Of Contamination*; USEPA has identified several potentially responsible parties for the PCB contamination.

On April 19, 1993 the first Manistique River AOC PAC Meeting was held to set up committees, discuss the USEPA remedial plans for the River and Harbor, and to determine how to get community input into the plans.

On September 30 1993, the USEPA sent out its first Action Memorandum to companies in the AOC thought to be potentially responsible parties.

The USEPA and its contractors completed a time-critical "removal" action by placing an 110' by 240' cap over a spot where PCBs were detected in sediment samples in concentrations up to 120 ppm at the surface. See Figure 3 for approximate location of temporary cover.

Extensive sediment core sampling is undertaken by potentially responsible parties and USEPA in the River and Harbor. Some of the sediment cores in the navigational channel are completed to bedrock. Initial estimations of the areal extent of impacted sediment associated with these studies range up to 22 acres of surface area, with a potential of 104,000 cu yds of impacted sediment in the system. See Figure 3 for the initial extent of dredged area proposed by the EPA.

The USEPA's fact sheet issued in August of 1994, outlined recommendations for dredging the impacted sediments in the River and Harbor with an estimated $11.1 million cost and a range of $ 7.8 million to $16.7 million.

1994– The temporary cap was inspected in the fall of 1994. In 1994, the potentially responsible parties and their consultants produced ecological and human health risk assessments and an Engineering Evaluation/Cost Analysis of various remedial alternatives for the River and Harbor.

During the winter of 1994 the PAC conducted and evaluated their first community survey.

The USEPA on-scene coordinator requests an extension to the time-critical "removal" action.

1995– USEPA issued its final determination regarding remediation for PCB-impacted sediments. USEPA determined that it would dredge the west side of the river by hydraulic dredging, including diver-assisted dredging (17,000 cu yds estimated in 1997).

Re-authorization of the navigational channel depth requirements was altered by the U.S. Congress from 18 feet to 12.5 feet.

The USEPA and contractors initiated demonstration level dredging activities in September 1995 in Area B (See Figure 3), continuing until October of 1996. USEPA fact sheets and AOC Update information obtained from the Administrative Record indicated that over this time frame approximately 25,000 cu yds or almost 32 tons of dewatered TSCA (>50 ppm) sediment and approximately 1,372 tons of dewatered non-TSCA sediment, was dredged from the AOC. It was estimated that approximately 16,000,000 gallons of river water was treated and discharged back to the Manistique River. In October 1995, the project funding ceiling was raised.

1996– USEPA continued dredging activities in the River as described above, and an estimated 2,116 total tons of sediment and other waste materials had been shipped off-site, and over 35 million gallons of river water treated. In September 1996, the USEPA requested and had approved a funding ceiling increase to $14, 809,228.

1997– USEPA continued dredging activities (Figure 4). An estimated 44,000 cu yds of sediment were dredged, and approximately 12,000 tons of waste was shipped off-site for disposal. Figure 5 presents the post dredging sampling efforts and the average PCB concentrations in parts per million (ppm) in the 0 to 1-foot sampling interval, Figure 6 shows the average PCB concentrations in ppm for the 0 to 2-foot sampling interval.

USEPA issued its Manistique River and Harbor AOC site update fact sheet in April 1997. USEPA also requested for and received approval to raise the funding ceiling for cleanup from $14,809,228 to $19,852,000. Total sediment volume in the River and Harbor that would need to be removed is now estimated at approximately 122,200 cu yds.

1998– USEPA continued dredging operations (Figure 7). The dredging was concentrated in two major portions of the AOC, the outer River, and the outer portion of the Harbor. Figure 8 shows the distribution of samples collected after the dredging operations in 1998 ceased, and indicates that the average PCB concentration in the top 0 to 1-foot interval was 21.5 ppm. Figure 9 shows the sampling locations and distribution of average PCB concentrations (23.0 ppm) in the 0 to 2-foot interval.

In February 1998, the USEPA released another Manistique River and Harbor fact sheet. In May 1998 the USEPA requested and received approval to raise the funding ceiling from $19,852,000 to $25,824,000.

An average of 124 cu yds of sediment was removed per day from May 11 to October 14, 1998. During 1998, about 31,100 cu yds of wood chips, sawdust, and other solid materials were dredged from the Harbor area and 12,600 tons of waste was shipped offsite to an USEPA approved landfill in Utah. Approximately 1,525 cu yds of sand containing less than 1 ppm of PCB was collected year-to-date during the dredging process.

USEPA released another Manistique River and Harbor AOC site Update in November 1998.

1999– USEPA continues dredging operations (Figure 10). Figure 11 presents the distribution of samples, collected after the dredging operation in 1999 ceased and indicates that the average PCB concentration in the 0 to 1-foot sample interval was 17.9 ppm. The sediment sampling results for the 0 to 2-foot interval (21.2) is presented on Figure 12. The average PCB concentration in the 0 to 2-ft interval was 21.2 ppm.

Figure 13 shows the pre- and post- dredging PCB concentrations in the harbor, and that an average reduction of approximately 10 ppm occurred in the system over the 1999 dredging season.

The Manistique PAC helped to fund interpretive signs along the Manistique boardwalk and river walk. These signs added value to an outdoor recreational resource within the AOC that is currently heavily used. The signs have allowed the citizens the chance to examine the history and environmental "balance" that exists alongside the boardwalks.

USEPA requests that the MDEQ relax/increase the surface water PCB discharge standard from 0.1 part per billion (ppb) to 1 ppb (approved).

USEPA requests and is approved for the funding ceiling for the project to be increased from $25,8245,000 to $47, 224,000.

2000– USEPA dredging activities were completed. Final dredging is conducted by divers under the auspices of the U.S. EPA Emergency Response Branch, with hydraulic techniques to ensure minimized resuspension during dredging, and a "clean" substrate when completed. Confirmational sediment sampling was initiated.

Figure 14 presents the extremely complicated layout of the dredged areas for 2000, which lie not only in the Harbor areas but also in the River channel. Figure 15 shows the distribution of confirmational samples and the average PCB concentration in the surface 0 to 1 foot sample interval (11.4 ppm), with a maximum outlier of 1172.6 ppm, just behind the inner harbor secondary breakwater. Figure 16 presents the confirmation sampling distribution and the average PCB concentration values for the 0 to 2 foot sample interval (11.9 ppm), with the same outlier as in the 0 to 1 foot interval.

USEPA fact sheet/Manistique River and Harbor AOC Update sheet estimates that 141,000 cu yds of PCB and heavy metal impacted sediment have been successfully removed from the River and Harbor system from 1995 to 2000.

2001– Confirmational sediment sampling was conducted to insure the 10 ppm average PCB concentration goal for the River and Harbor was met. Figure 17 presents the

distribution of 381 sample locations with the interpolated average PCB concentration for the AOC sediments in the 0 to 1 foot interval at 7.2 ppm. Figure 18 presents the average PCB balance at 8.2 ppm in the 0 to 2 foot sample interval. Figure 19 presents the cumulative distribution of samples as a function of the total PCB concentrations in the sediment samples. In another view of this same distribution, Figure 20 indicates that the probability density function for total PCB concentrations also shows that well over 90% of all of the samples had final values less than 10 ppm.

The RAP Update is in progress, with the final due in September 2002.

2002– RAP Update was completed in September 2002. Delisting criteria for each of the five impairments were established for the AOC, along with implementational strategies. The delisting criteria and implementation strategies will require close cooperation with MDEQ, USEPA, and the PAC to fund and produce the data needed to restore and successfully delist the Harbor.

A caged fish study was initiated by the Water Division of MDEQ on July 24, 2002. The results obtained during this study will be compared to a reference site study, which is located within the Manistique River watershed above the dam.

The USEPA is currently developing a sampling plan for follow up monitoring, which will potentially include a study of the edible portion of carp, channel catfish, and one other fish yet to be determined. An analysis of the woodchips located in the River and Harbor downstream of Manistique Papers, Inc. will also be conducted. The results of the woodchips analyses will be released in a supplement to the summary report that this scheduled to be released in late 2002 or early 2003.

Section 5.0
RECOMMENDATIONS FOR POTENTIAL FUTURE WORK

Further evaluate the extent, if appropriate, of two potential beneficial use impairments, "degraded fish and wildlife populations" and "bird and animal deformities or reproductive problems," which were identified in the 1997 RAP Update. These were noted for additional study in the 1997 RAP Update.

5.1 ADDITIONAL STUDIES, IF NEEDED

Sentinel resident wildlife in the AOC may need to be sampled to determine incidence of deformities, reproductive problems or population problems due to impacts in the AOC.

Certain fish populations (such as lake sturgeon) may be impaired due to the loss of fish habitat. This does not require further study at this time because the impairment may be addressed by actions taken for the loss of habitat impairment.

5.2 MONITORING PLAN, IF NEEDED

Complete a sampling plan that was proposed in 1997 by the MDNR Wildlife Division for the potential wildlife studies. The plan should be based on collection and autopsy of resident mammals to determine if growth or reproductive abnormalities are present. A caged fish study was initiated by the Water Division of MDEQ on July 24, 2002. The results obtained during this study will be compared to a reference site study, which is located within the Manistique River watershed above the dam. PCB concentrations in tissue would be determined at the same time.

5.3 REMEDIAL ACTION

Remediation of the PCBs in the River and Harbor should lower or eliminate much of the potential PCB exposure of wildlife and directly address these two potential beneficial use impairments. Monitoring programs need to be put in place to indicate that the restoration and remediation efforts have been successful. It was determined in the 1997 RAP Update that the above referenced studies may not be needed if post-remediation monitoring programs document that PCBs are no longer available to the biota in the AOC and that fish populations are meeting management goals.

Section 6.0
POTENTIAL FUNDING SOURCES FOR CONTINUING RAP ACTIVITIES

Potential funding sources for Community RAP activities provided below.

- Great Lakes Remedial Action Plans and Sediment Remediation Planning Assistance
  USEPA
  (312) 886-4013
  www.epa.gov/glnpo
  russ.Michael@epa.gov

- Aquatic Ecosystem Restoration
  www.aquatics.org
  Mike Moore
  mmoore@aquatics.org

- Great Lakes Restoration Grants
  www.great-lakes.net/lists/glin-announce/2001-03/msg00058.html
  glinpost@great-lakes.net

- Great Lakes Coastal Wetlands
  Ric Lawson, Project Manager, Great Lakes Commission
  (734) 665-9135
  www.glc.org/monitoring/wetlands
  rlawson@glc.org

- Coastal Zone Management Programs
  John King, Division Chief, NOAA, Office of Ocean and Coastal Management
  (301) 713-3155
  www.ocrm.nos.noaa.gov/czm

- Coastal Wetlands Planning, Protection, and Restoration Act Program
  (703) 358-2435
  www.fa.r9.fws.gov
  ieshafields@fws.gov
  sallyvaldes-cogliano@fws.gov

- National Coastal Wetlands Conservation Grant Program
  USEPA
  (703) 358-2201
  sally_valdescogliano@fws.gov

- Partners for Fish and Wildlife Program
  (703) 358-2201
  www.fws.gov/r9dhcpfw/index.htm
  www.fws.gov/cep/coastweb.html

- Michigan Great Lakes Protection Fund
  Office of the Great Lakes
  Emily Finnell (517) 241-7927
  finnelle@michigan.gov

  Roger Eberhardt (517) 335-4227
  eberharr@michigan.gov

- Great Lakes Protection Fund
  Jolie Krasinski, Project Development Manager
  joliek@glpf.org

- Great Lakes Fisheries Trust
  (517) 371-7468
  glft@glft.org
  www.glft.org

- Great Lakes Habitat Network
  A project of "Tip of the Mitt Watershed Council"
  (213) 347-1181
  jill@watershedcouncil.org
  www.glhabitat.org/grants.html

- Watershed Assistance Grants
  USEPA
  (202) 260-4538
  cole.james@epa.gov
  www.rivernetwork.org/howwecanhelp/howwag.cfm#wag

- Clean Michigan Initiative
  Michigan Department of Environmental Quality
  www.glc.org/robin/finance/Finance_state.html

Section 7.0
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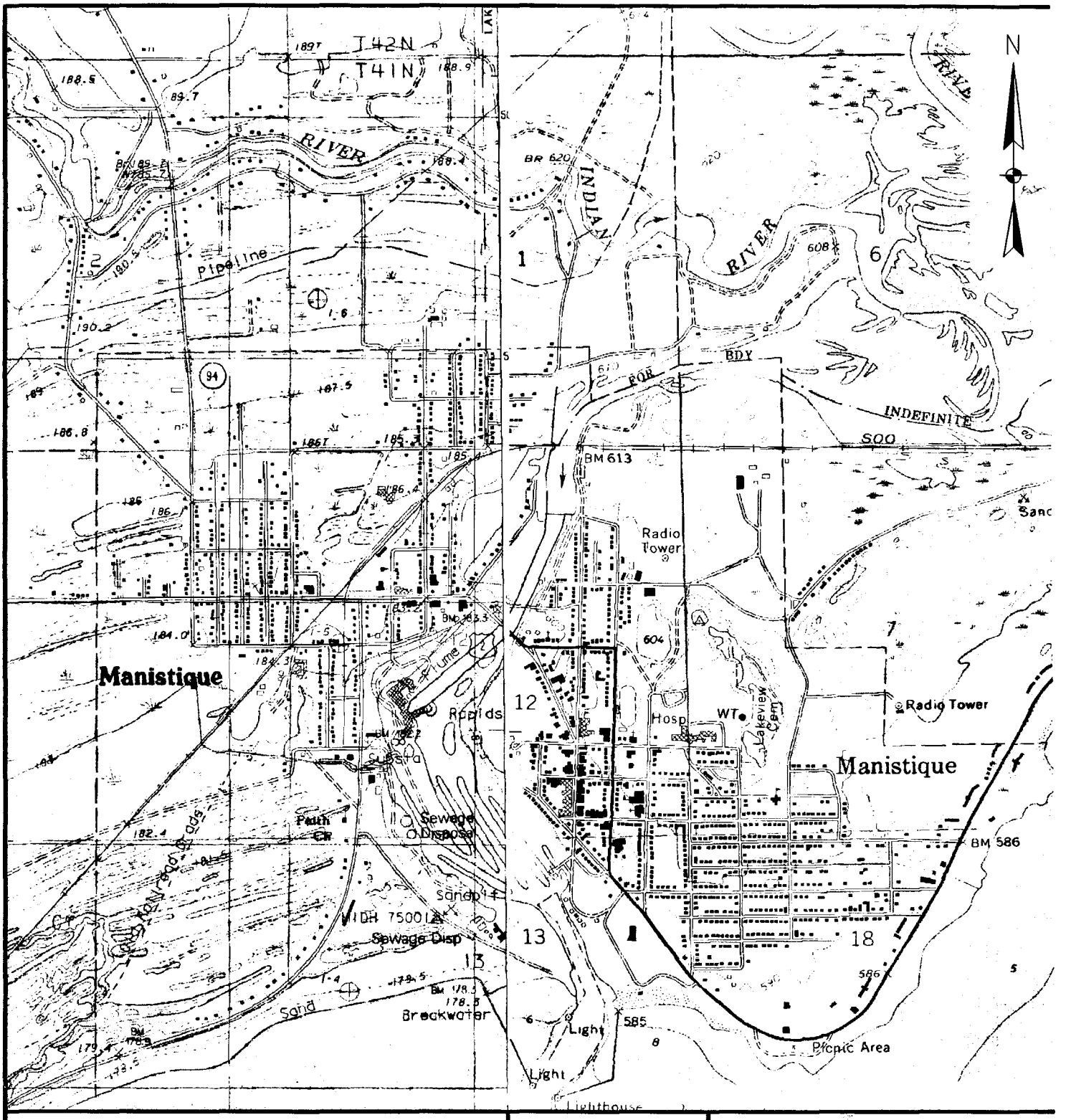
FIGURES



0 1/2 1 MILE

0 2000 4000 FEET

0 .5 1 KILOMETER

CONTOUR INTERVAL 10 FEET

DASHED LINES REPRESENT HALF – INTERVAL CONTOURS

NATIONAL GEODETIC VERTICAL DATUM OF 1929

LATITUDE
46° 00' 00"

LONGITUDE
86° 15' 00"

QUADRANGLE LOCATION

MANISTIQUE EAST–WEST, MI

USGS QUADRANGLE

1972

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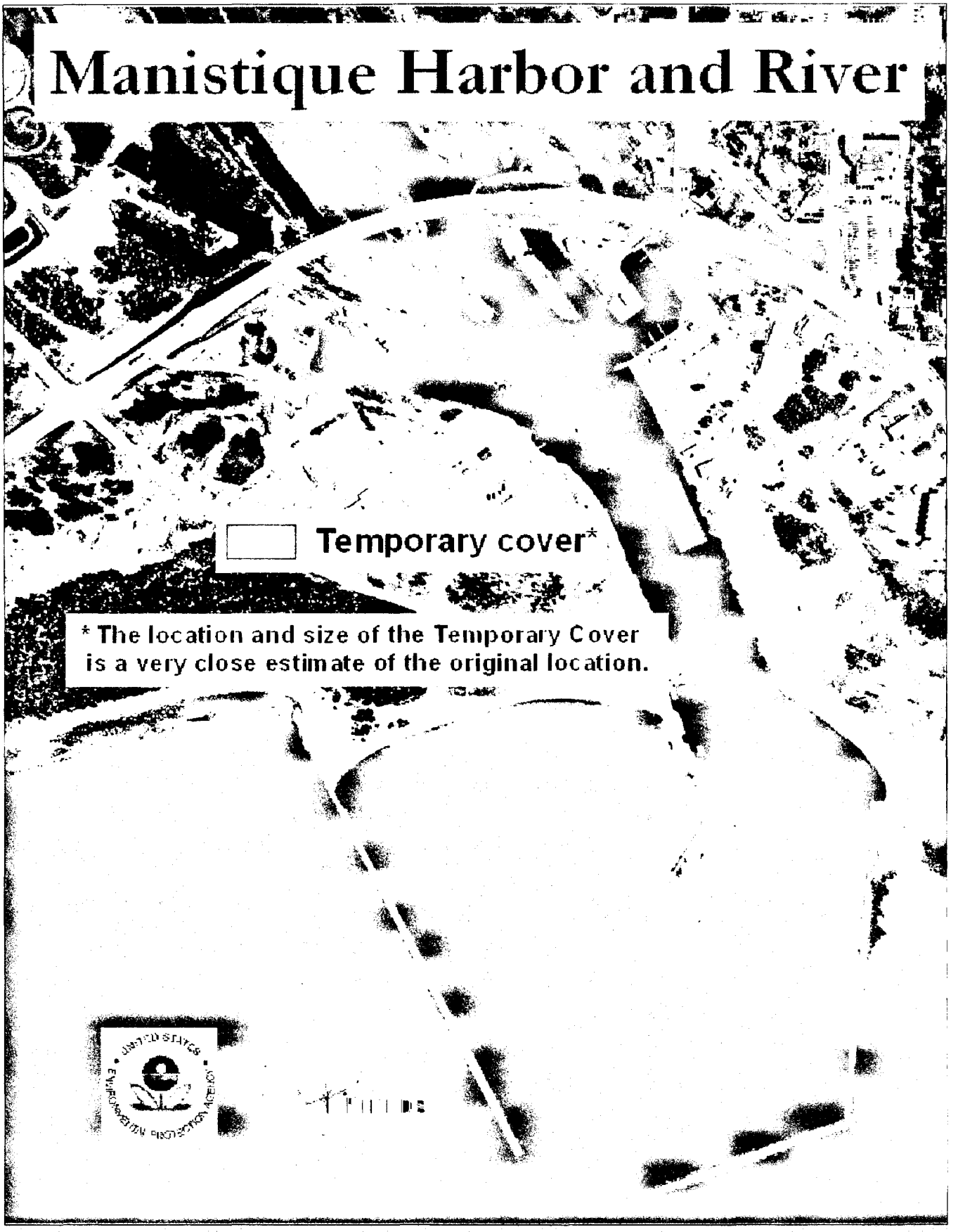
TRIAD ENGINEERING INCORPORATED

FIGURE 1
SITE LOCATION AND LOCAL TOPOGRAPHY



TRIAD ENGINEERING INCORPORATED	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 2 LOCATION OF TEMPORARY COVER	SHEET NO. FIGURE 2 DWG NO. 02 DATE Sep 2002 PROJ NO. W023452

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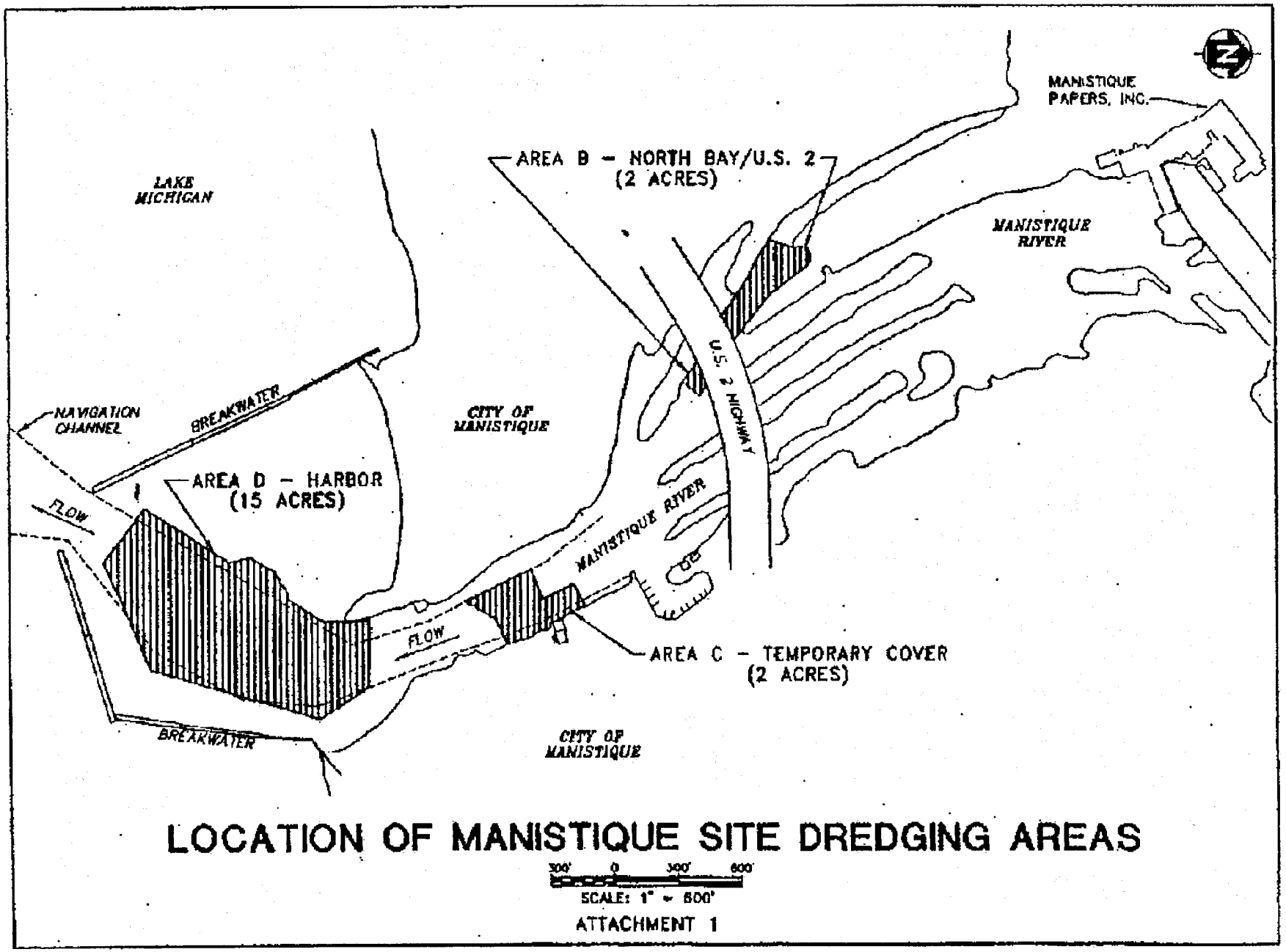

LOCATION OF MANISTIQUE SITE DREDGING AREAS

300' 0 300' 600'

SCALE: 1" = 600'

ATTACHMENT 1

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TRIAD ENGINEERING INCORPORATED
325 East Chicago Street
Milwaukee, Wisconsin 53202
(414)-291-8840
FAX 291-8841

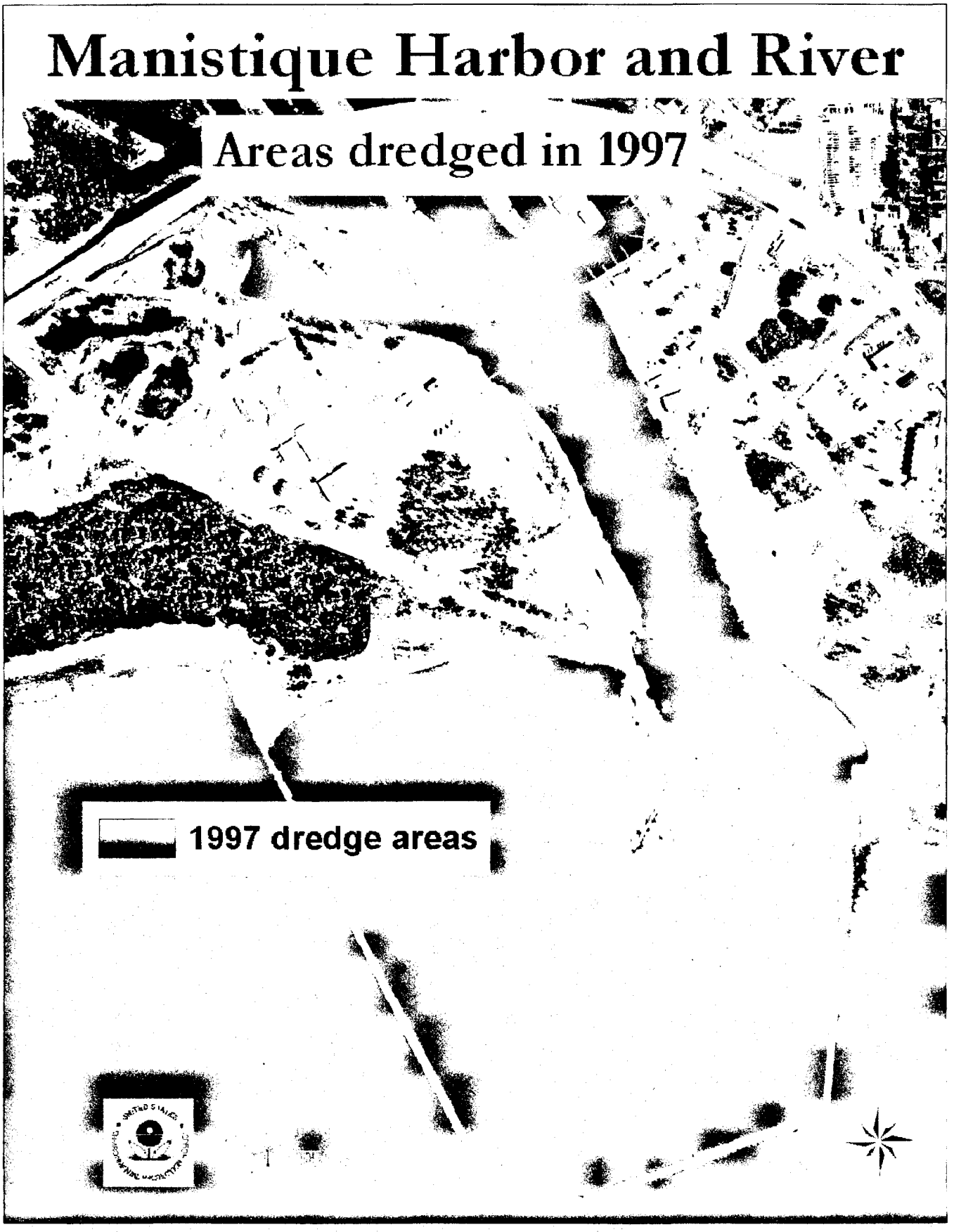
VERIFY SCALE	DSGN	TAR
BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.	DR	EHM
	CHK	
	APVD	

MANISTIQUE RIVER & HARBOR
AREA OF CONCERN
REMEDIAL ACTION PLAN UPDATE

FIGURE 3
EPA DESIGNATED DREDGE AREAS IN MANISTIQUE RIVER & HARBOR AOC

SHEET NO.	FIGURE 3
DWG NO.	03
DATE	Sep 2002
PROJ NO.	W023452

Manistique Harbor and River



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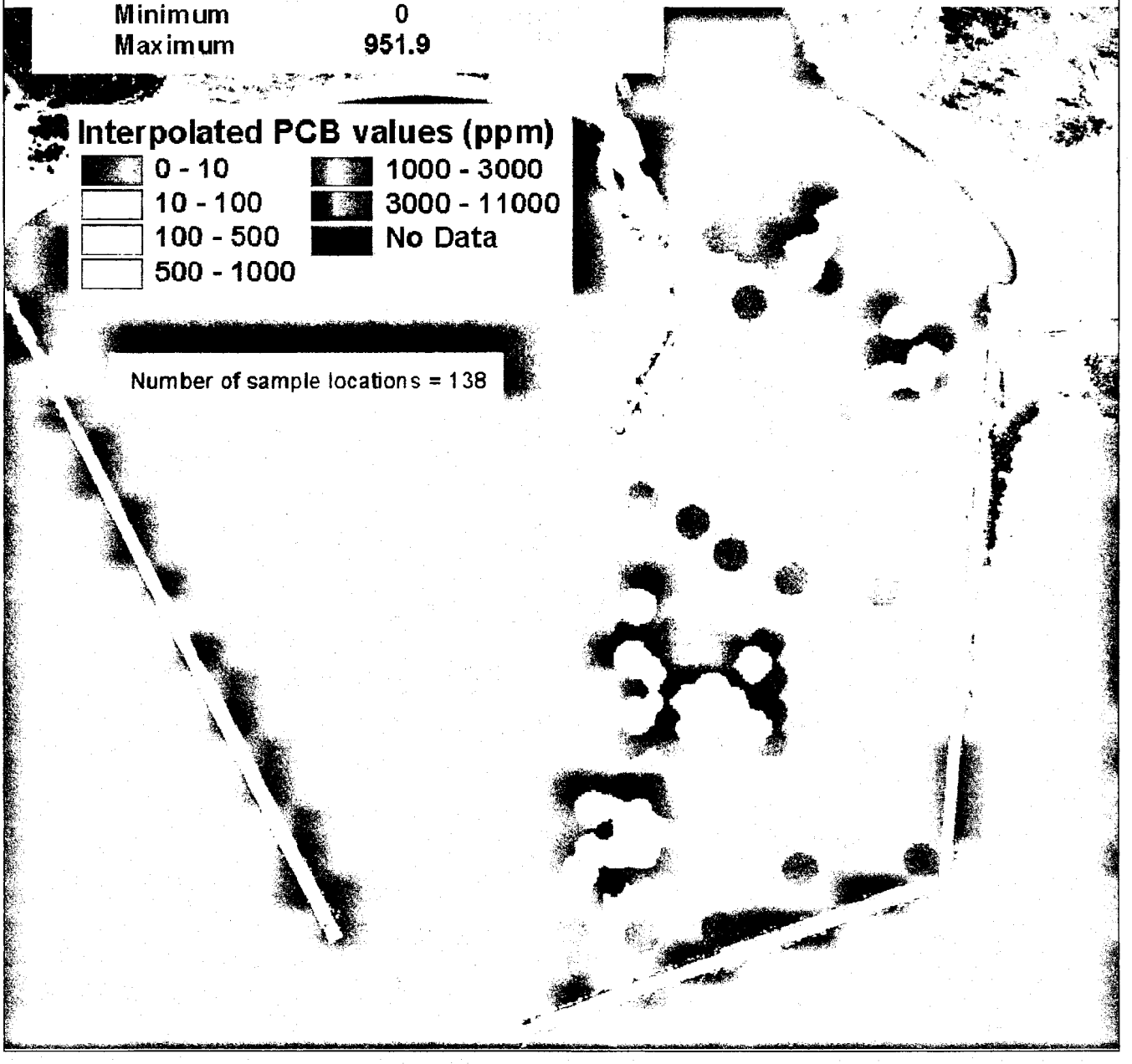
TRIAD ENGINEERING INCORPORATED © 2002 Triad Engineering	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 4 EPA DESIGNATED DREDGE AREAS IN 1997	SHEET NO. FIGURE 4 DWG NO. 04 DATE Sep 2002 PROJ NO. W023452

Manistique Harbor

Top 1 foot, interpolated PCB values
End 1997 Dredging Season

End 1997 Statistics (interpolated values, in ppm)

Average	50.3
Minimum	0
Maximum	951.9



TRIAD ENGINEERING INCORPORATED	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 5 1997 INTERPOLATED PCB VALUES FOR THE TOP 0–1 FOOT INTERVAL	SHEET NO. FIGURE 5 DWG NO. 05 DATE Sep 2002 PROJ NO. W023452

J:\Projects\W023452\05-W023452.dwg Sep 20,2002 - 2:44pm maass

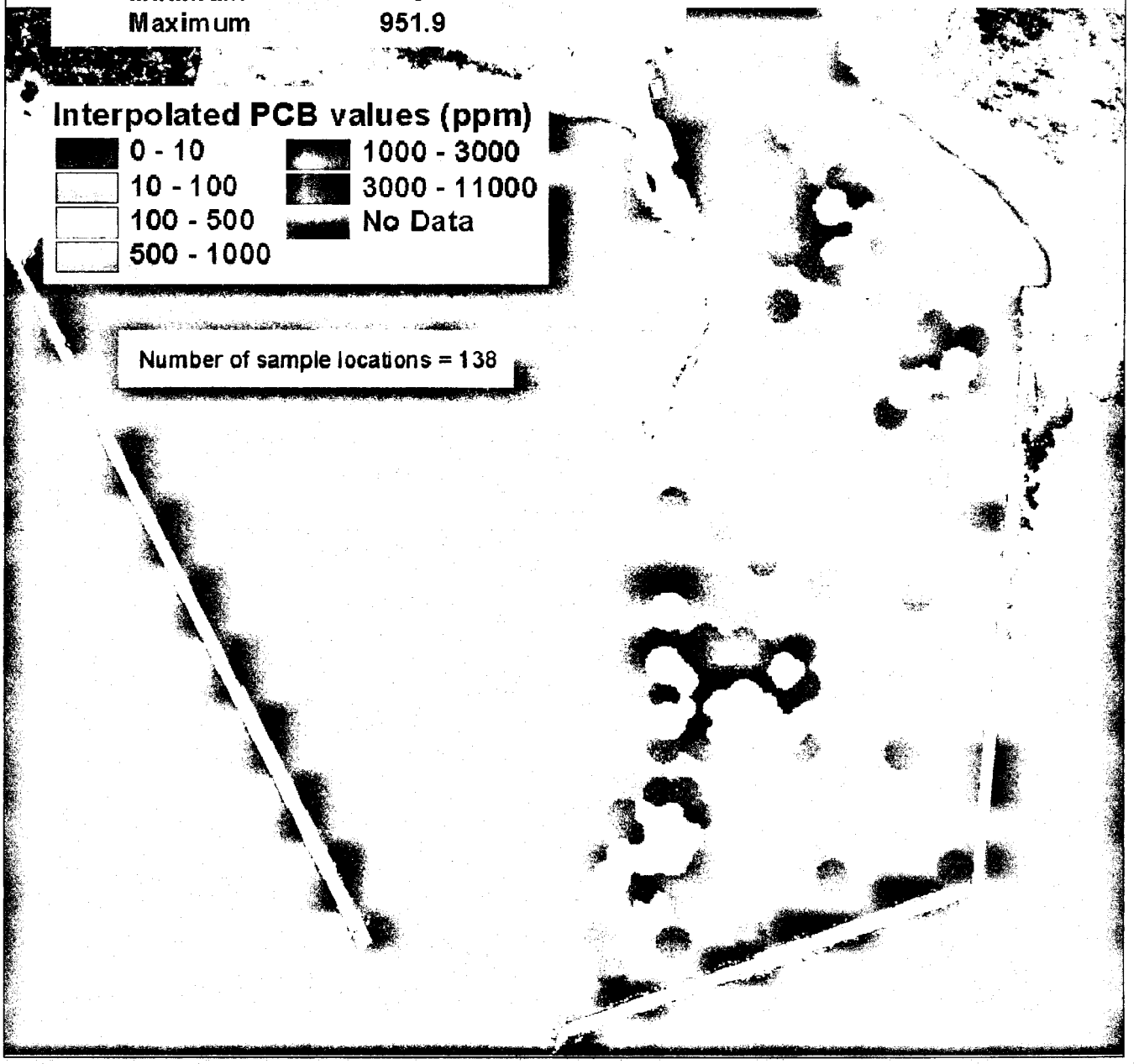
Manistique Harbor

FIELDS

Top 2 feet, interpolated PCB values
End 1997 Dredging Season

End 1997 Statistics (interpolated values, in ppm)

Average	56.2
Minimum	0
Maximum	951.9



TRIAD ENGINEERING INCORPORATED	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 6 1997 INTERPOLATED PCB VALUES FOR THE TOP 0–2 FOOT INTERVAL	SHEET NO. FIGURE 6 DWG NO. 06 DATE Sep 2002 PROJ NO. W023452

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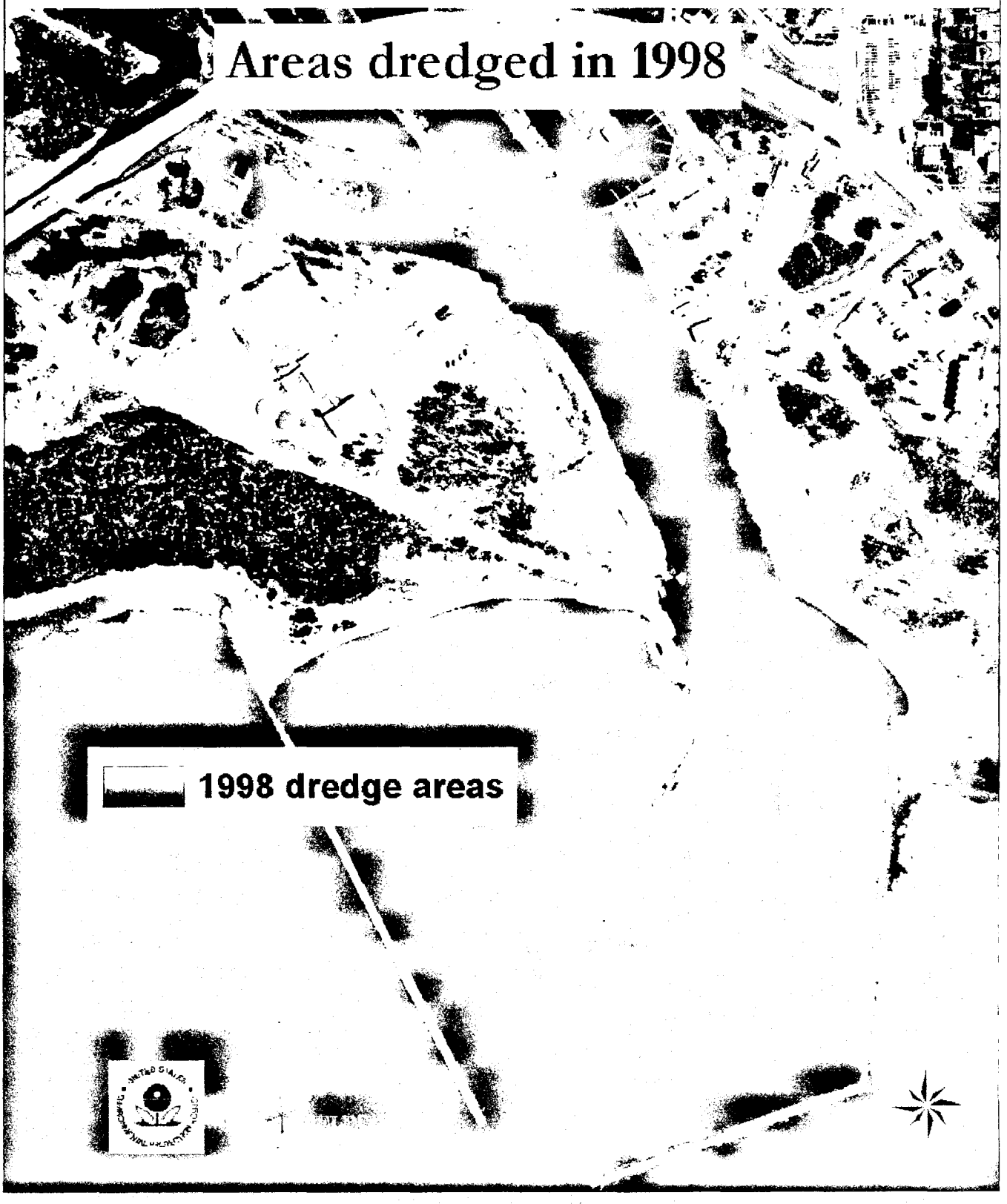
Manistique Harbor and River

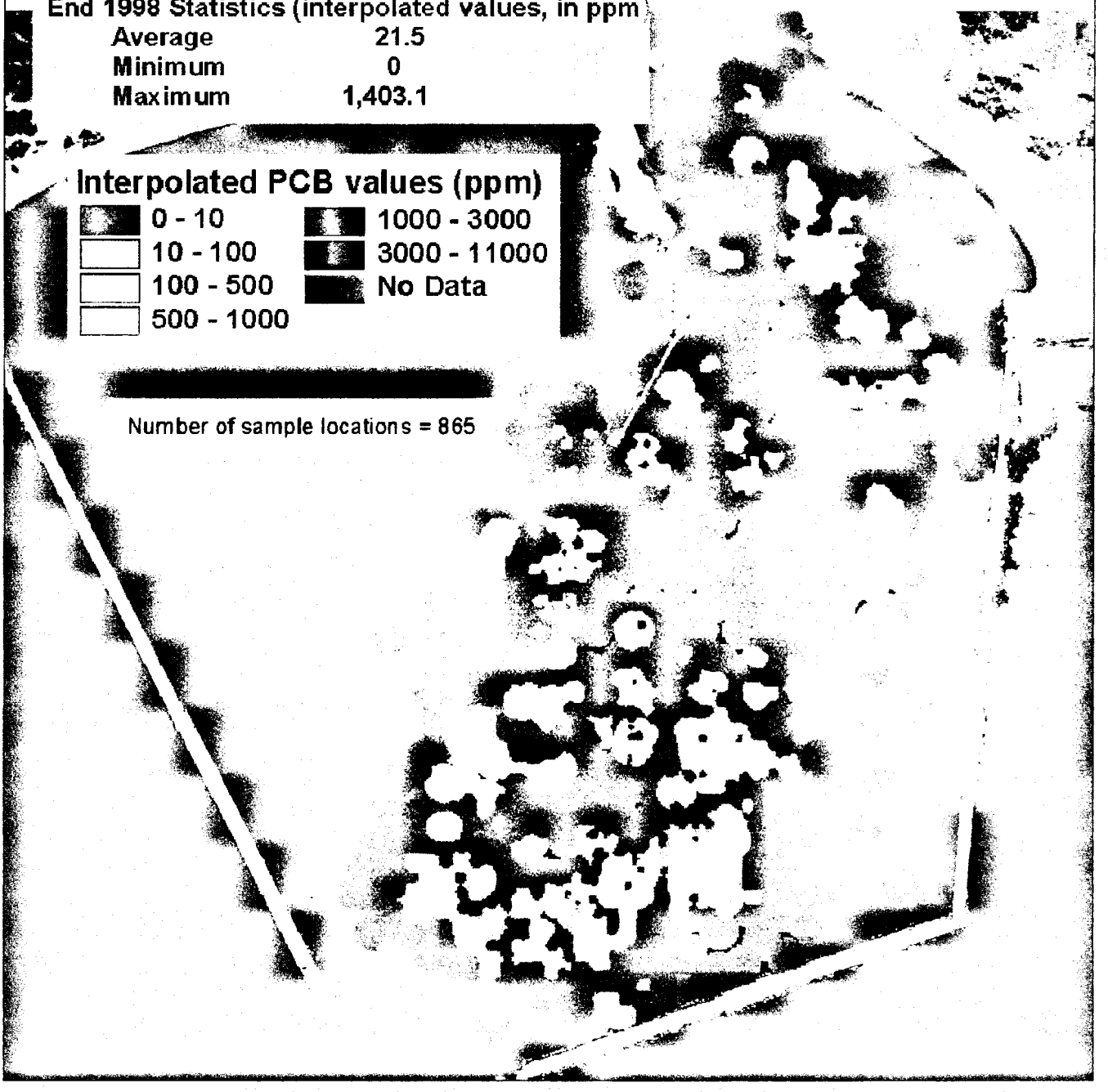


TRIAD ENGINEERING INCORPORATED © 2002 Triad Engineering	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 7 EPA DESIGNATED DREDGE AREAS IN 1998	SHEET NO. FIGURE 7 DWG NO. 07 DATE Sep 2002 PROJ NO. W023452

J:\Projects\W023452\07-W023452.dwg Sep 20,2002 - 2:46pm maass

Manistique Harbor

Top 1 foot, interpolated PCB values
End 1998 Dredging Season



TRIAD ENGINEERING INCORPORATED © 2002 Triad Engineering	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 8 1998 INTERPOLATED PCB VALUES FOR THE TOP 0–1 FOOT INTERVAL	SHEET NO. FIGURE 8 DWG NO. 08 DATE Sep 2002 PROJ NO. W023452	

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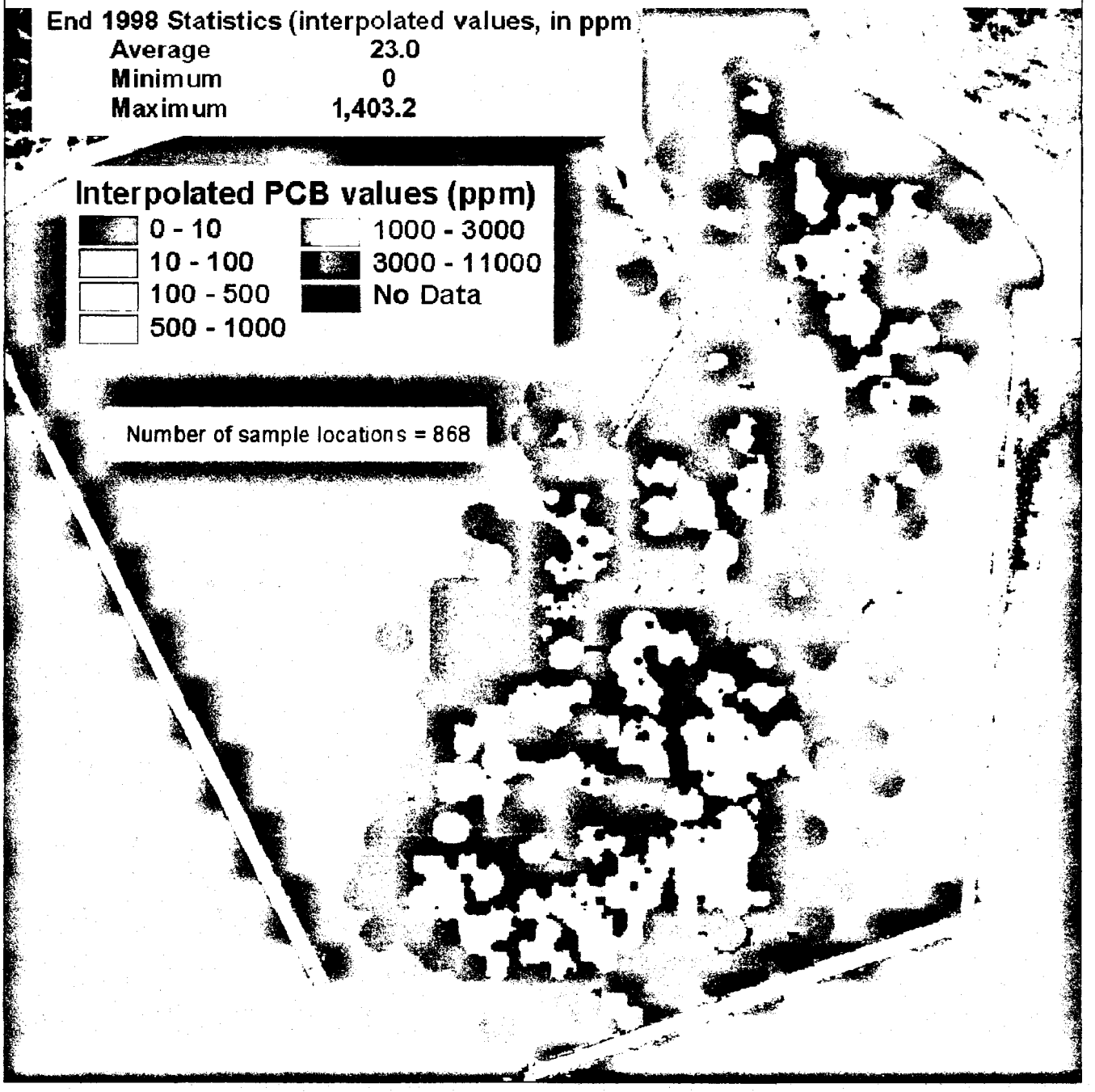
Manistique Harbor

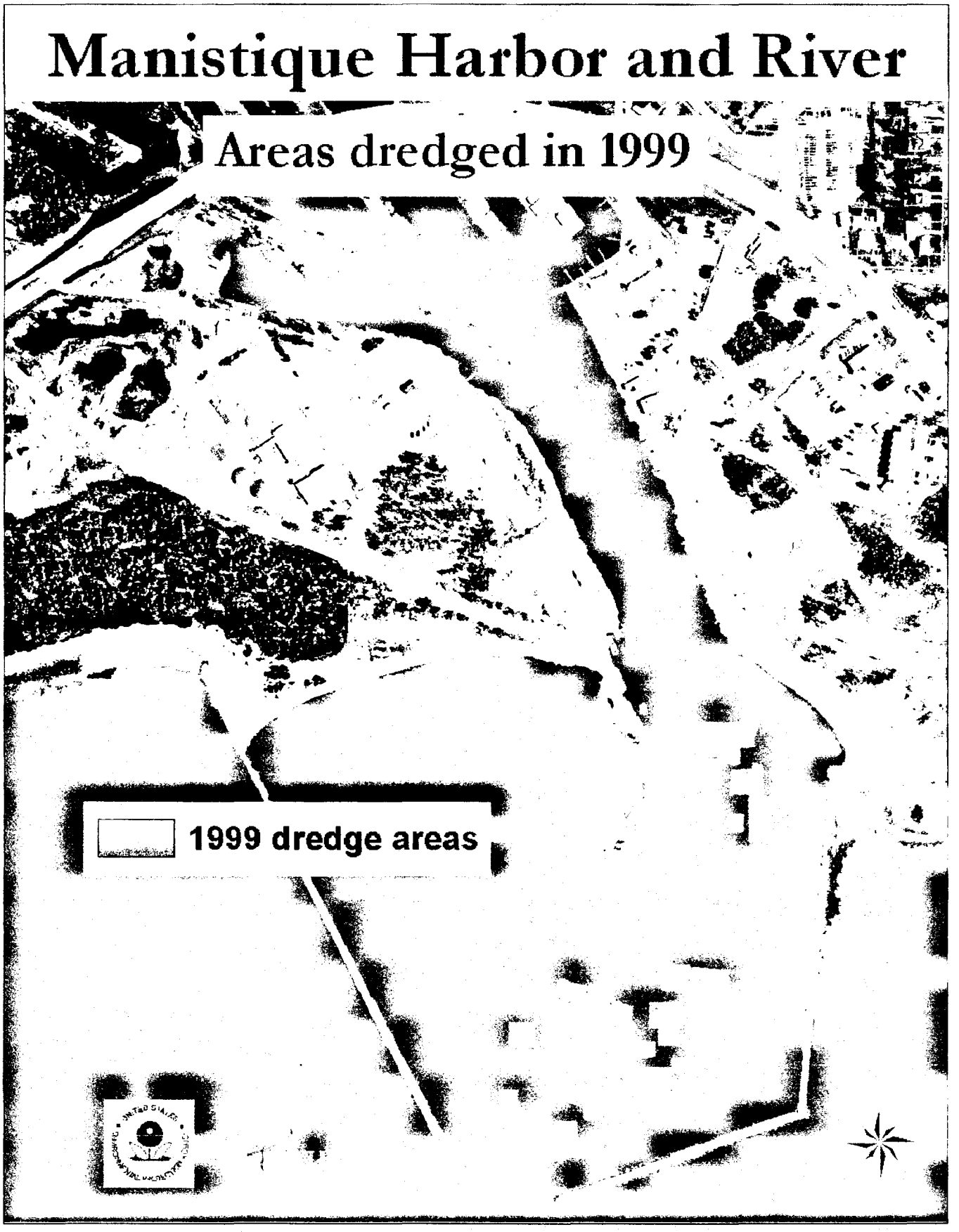
Top 2 feet, interpolated PCB values
End 1998 Dredging Season



TRIAD ENGINEERING INCORPORATED	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 9 1998 INTERPOLATED PCB VALUES FOR THE TOP 0–2 FOOT INTERVAL	SHEET NO. FIGURE 9 DWG NO. 09 DATE Sep 2002 PROJ NO. W023452

J:\Projects\W023452\09-W023452.dwg Sep 20,2002 - 2:47pm maass

Manistique Harbor and River



J:\Projects\W023452\10-W023452.dwg Sep 20,2002 - 2:48pm maass

TRIAD ENGINEERING INCORPORATED © 2002 Triad Engineering	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 10 EPA DESIGNATED DREDGE AREAS IN 1999	SHEET NO. FIGURE 10 DWG NO. 10 DATE Sep 2002 PROJ NO. W023452

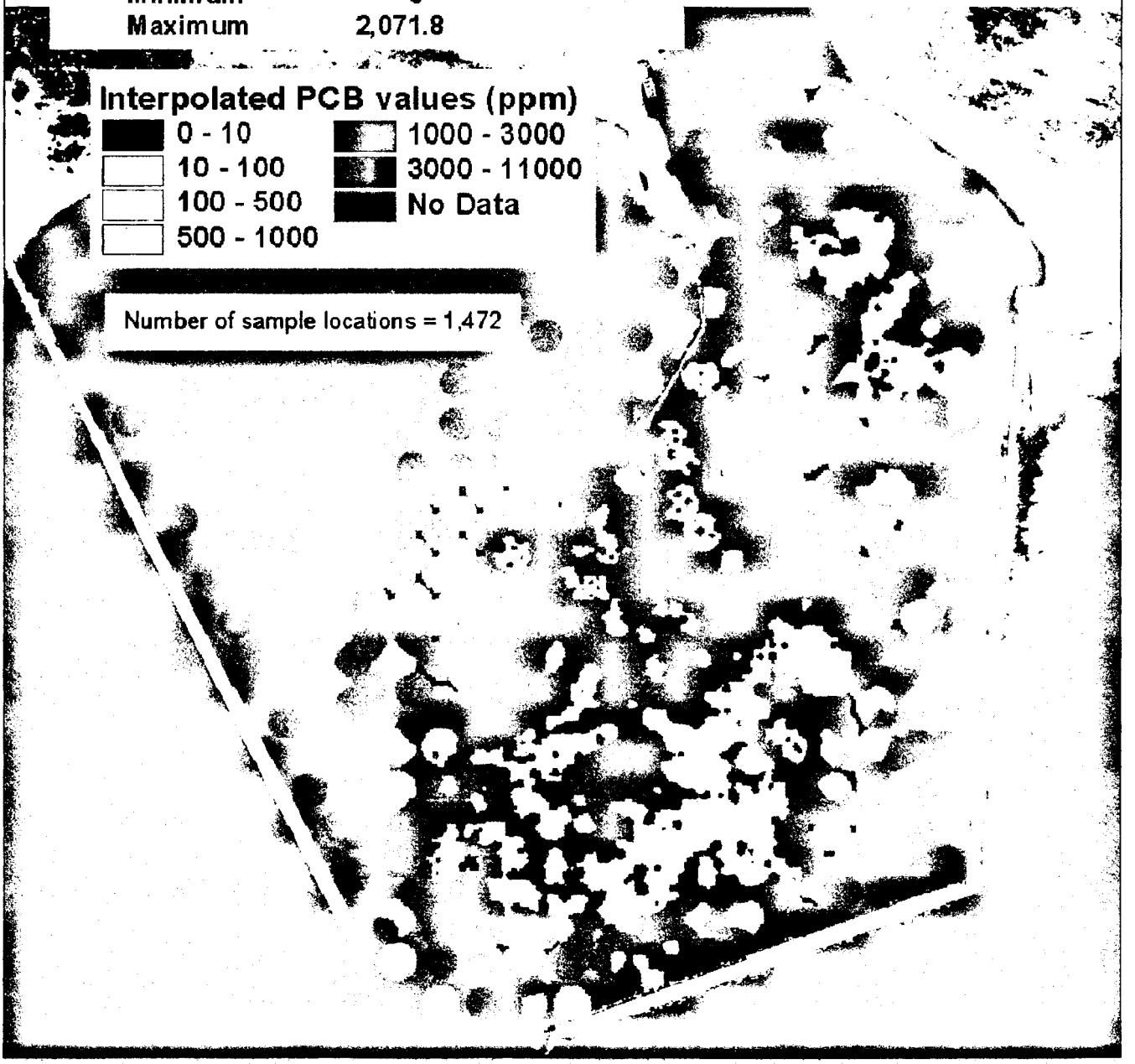
Manistique Harbor

FIELDS

Top 1 foot, interpolated PCB values
End 1999 Dredging Season

End 1999 Statistics (interpolated values, in ppm)

Average	17.9
Minimum	0
Maximum	2,071.8



TRIAD ENGINEERING INCORPORATED	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 11 1999 INTERPOLATED PCB VALUES FOR THE TOP 0–1 FOOT INTERVAL	SHEET NO. FIGURE 11 DWG NO. 11 DATE Sep 2002 PROJ NO. W023452

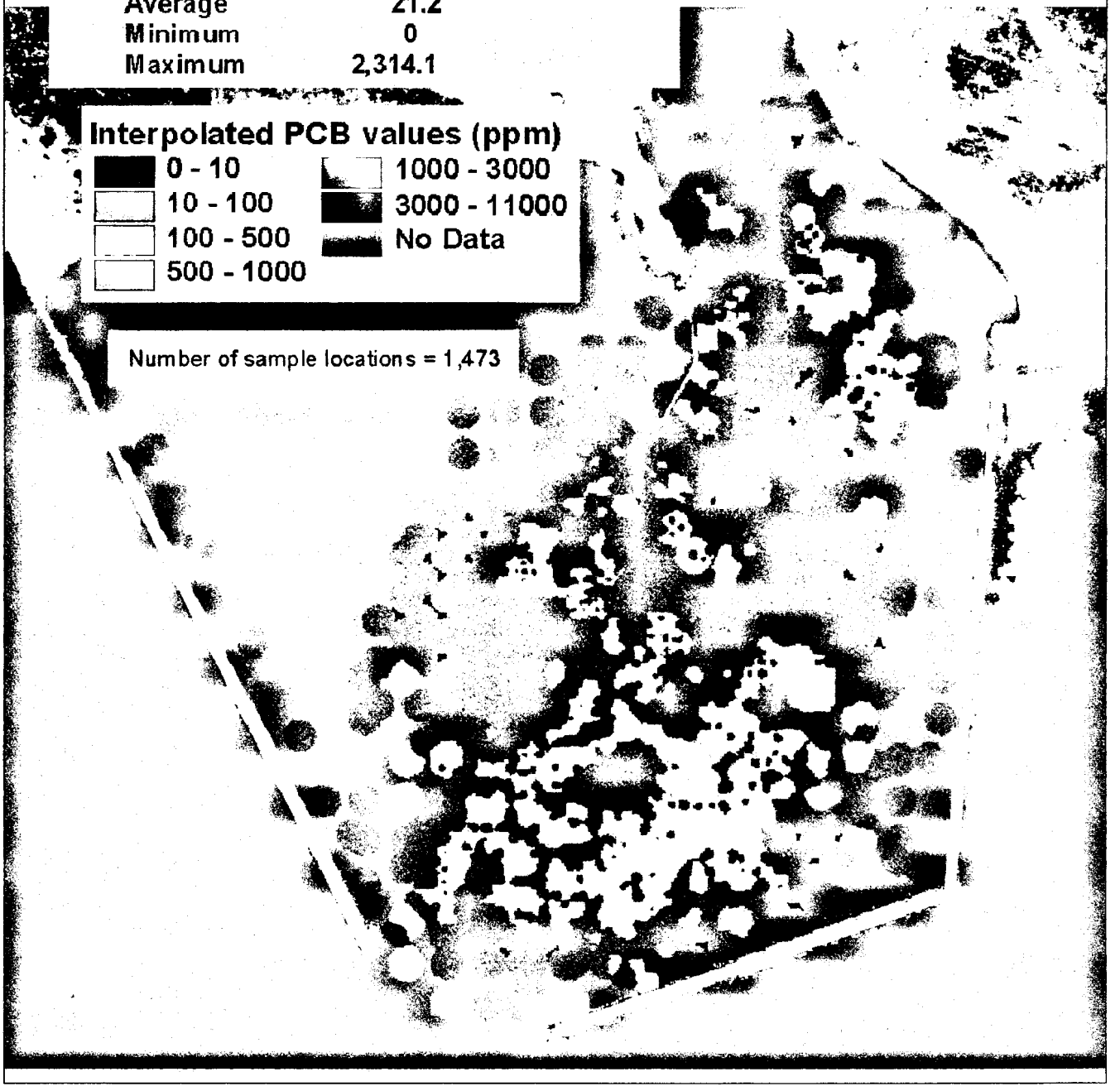
J:\Projects\W023452\11-W023452.dwg Sep 20,2002 - 2:54pm maass

Manistique Harbor

Top 2 feet, interpolated PCB values
End 1999 Dredging Season

End 1999 Statistics (interpolated values, in ppm)

Average	21.2
Minimum	0
Maximum	2,314.1



J:\Projects\W023452\12-W023452.dwg Sep 20,2002 - 2:55pm moss

TRIAD ENGINEERING INCORPORATED © 2002 Triad Engineering	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 12 1999 INTERPOLATED PCB VALUES FOR THE TOP 0-2 FOOT INTERVAL	SHEET NO. FIGURE 12 DWG NO. 12 DATE Sep 2002 PROJ NO. W023452

Manistique Harbor

Interpolated PCB values for the top 1 foot of sediment
Pre-Dredge versus Post-Dredge

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

FIELDS

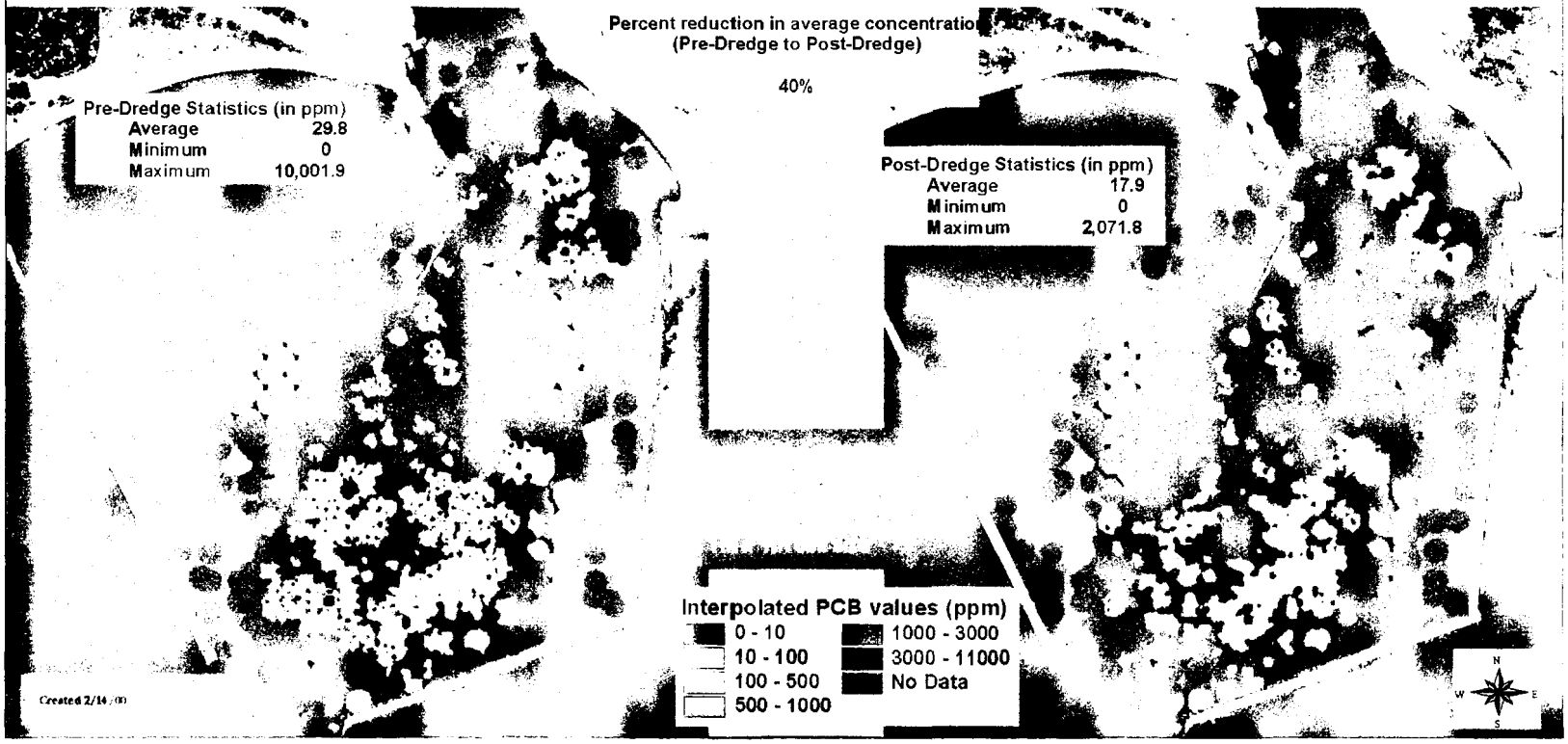
Pre-Dredge **Post-Dredge**

Data from 12/2/99 database
(1999 Dredging Season Completed)

Post-dredge data does not include samples with a point removal date

Percent reduction in average concentration
(Pre-Dredge to Post-Dredge)

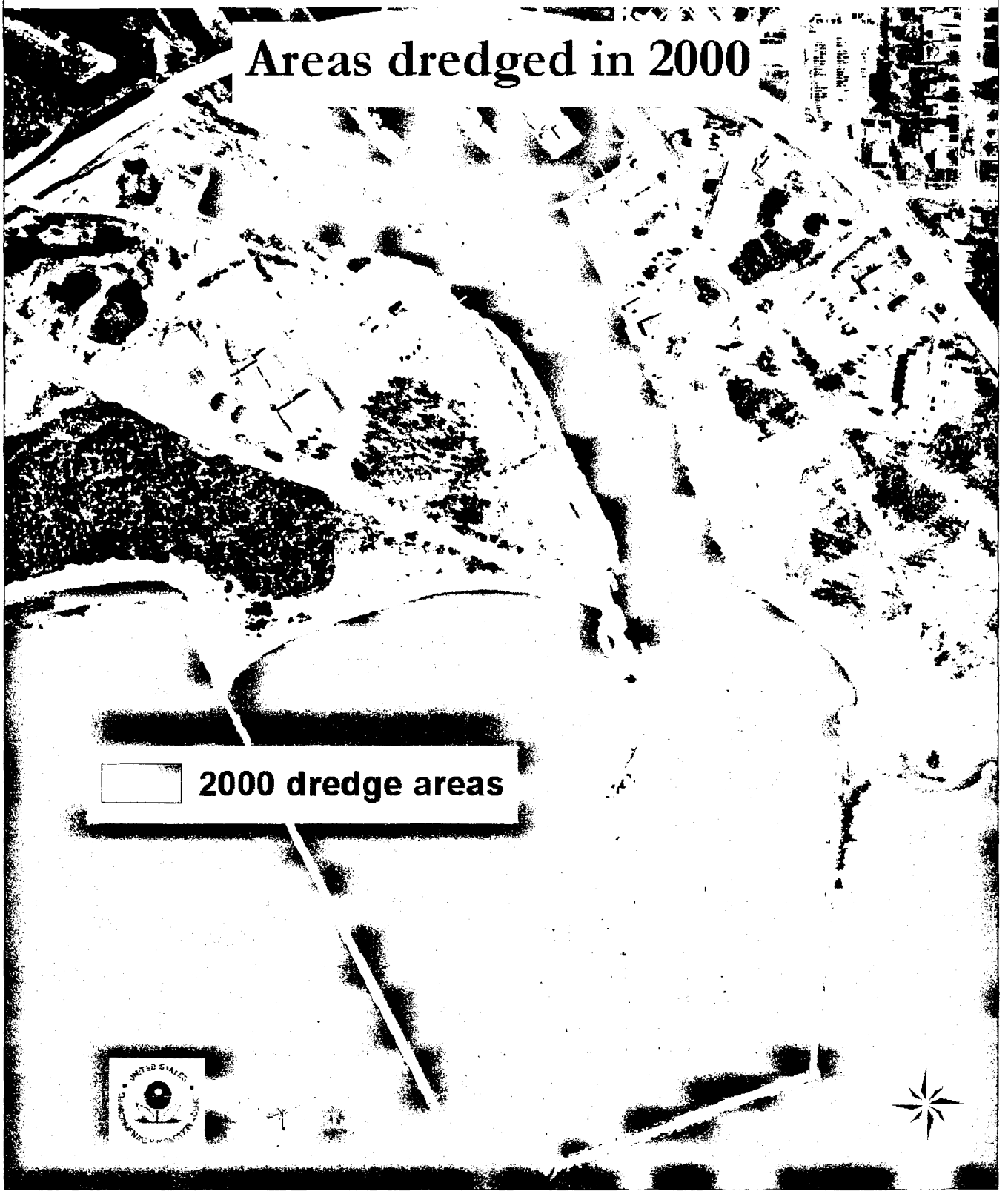
40%



J:\Projects\W023452\13-W023452.dwg Sep 20,2002 - 2:56pm maass

TRIAD ENGINEERING INCORPORATED © 2002 Triad Engineering	325 East Chicago Street Milwaukee, Wisconsin 53202 (414)-291-8840 FAX 291-8841	VERIFY SCALE BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 13-INTERPOLATED PCB VALUES FOR THE TOP 0-1 FOOT INTERVAL PRE-DREDGE VERSUS POST-DREDGE	SHEET NO. FIGURE 13 DWG NO. 13 DATE Sep 2002 PROJ NO. W023452

Manistique Harbor and River

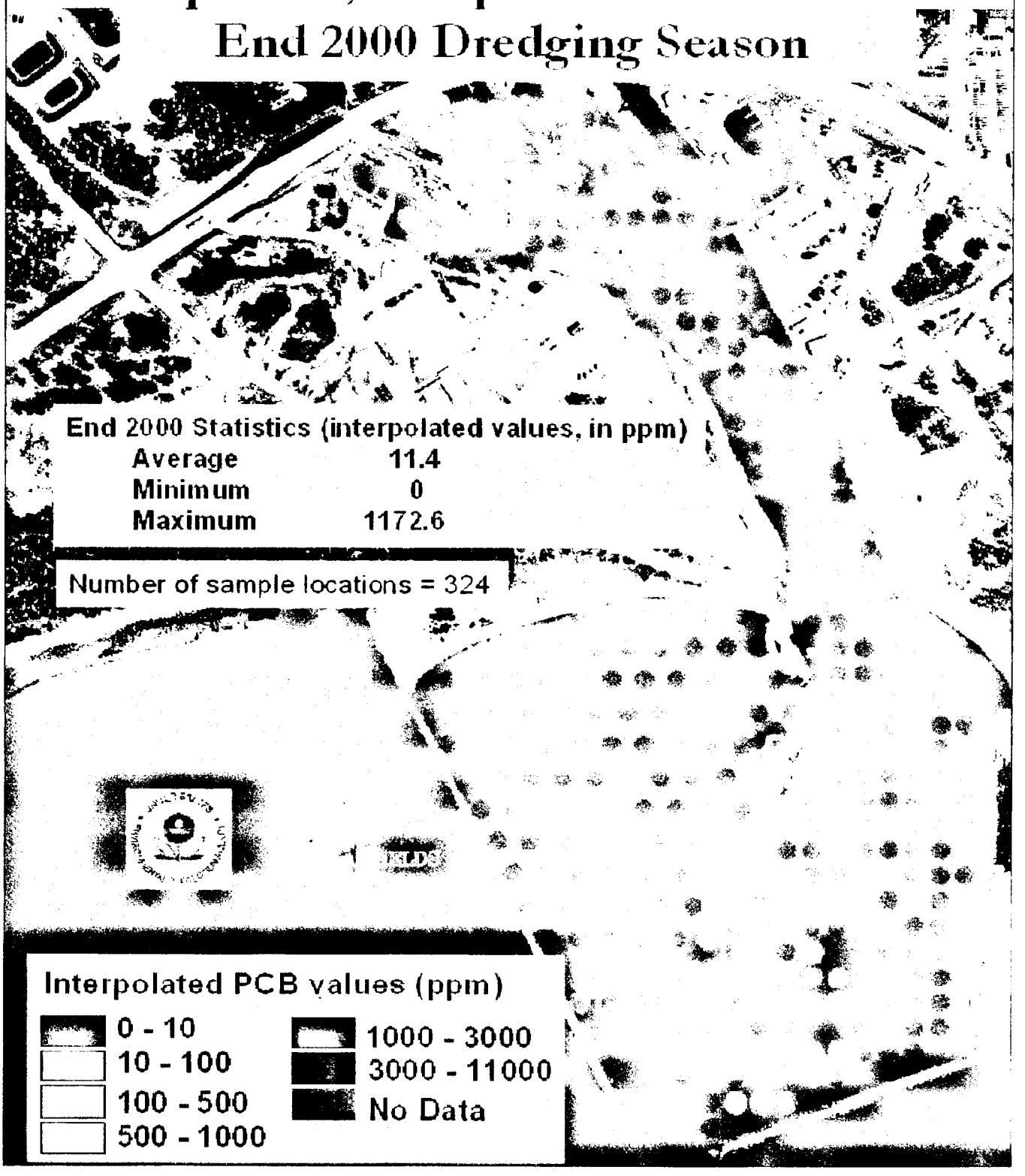


TRIAD ENGINEERING INCORPORATED	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 14 EPA DESIGNATED DREDGE AREAS IN 2000	SHEET NO. FIGURE 14 DWG NO. 14 DATE Sep 2002 PROJ NO. W023452

J:\Projects\W023452\14-W023452.dwg Sep 20,2002 - 2:57pm maass

Manistique Harbor and River

Top 1 foot, interpolated PCB values
End 2000 Dredging Season

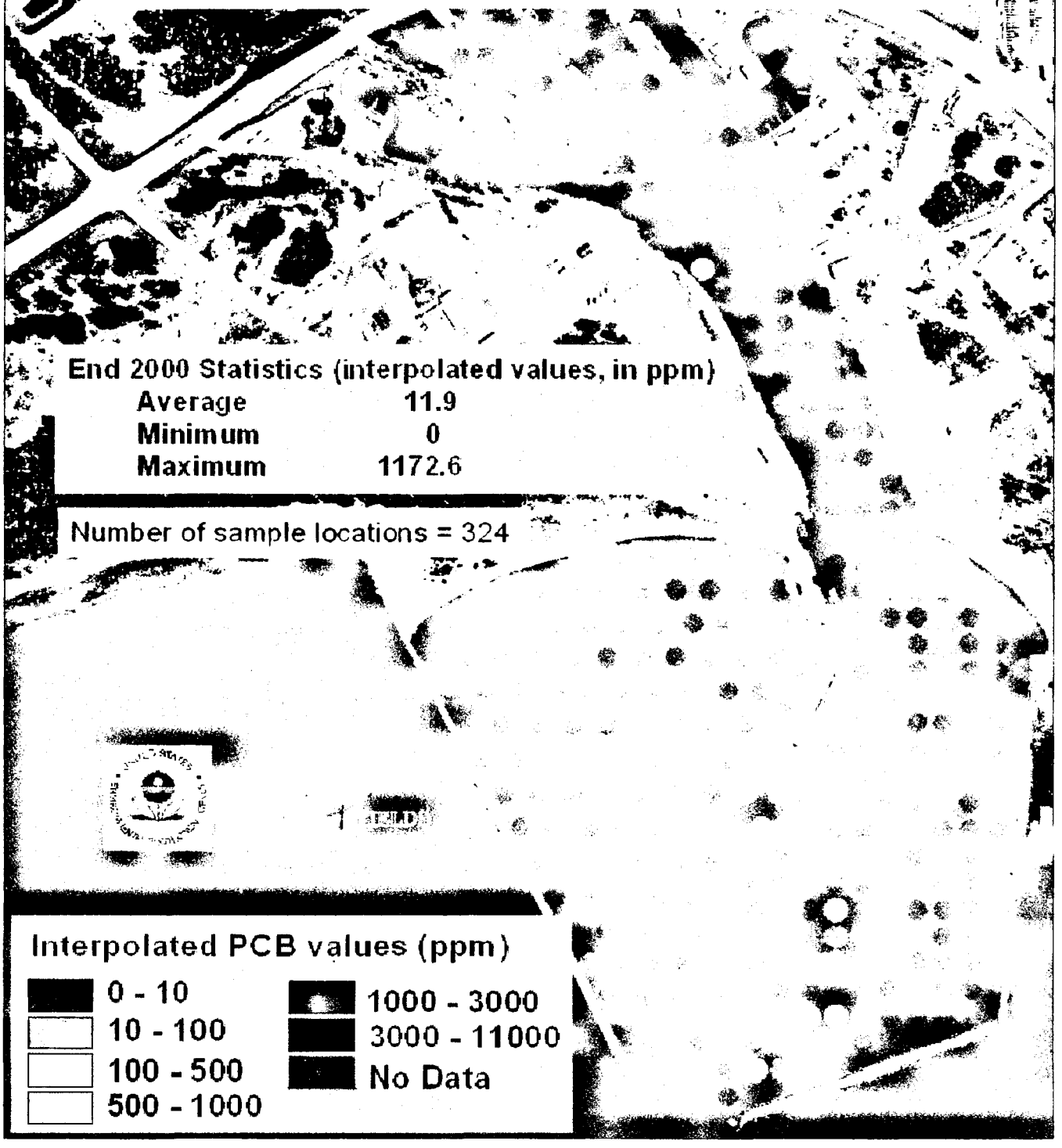


J:\Projects\W023452\15-W023452.dwg Sep 20,2002 - 2:57pm maass

TRIAD ENGINEERING INCORPORATED © 2002 Triad Engineering	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 15 2000 INTERPOLATED PCB VALUES FOR THE TOP 0-1 FOOT INTERVAL	SHEET NO. FIGURE 15 DWG NO. 15 DATE Sep 2002 PROJ NO. W023452

Manistique Harbor and River

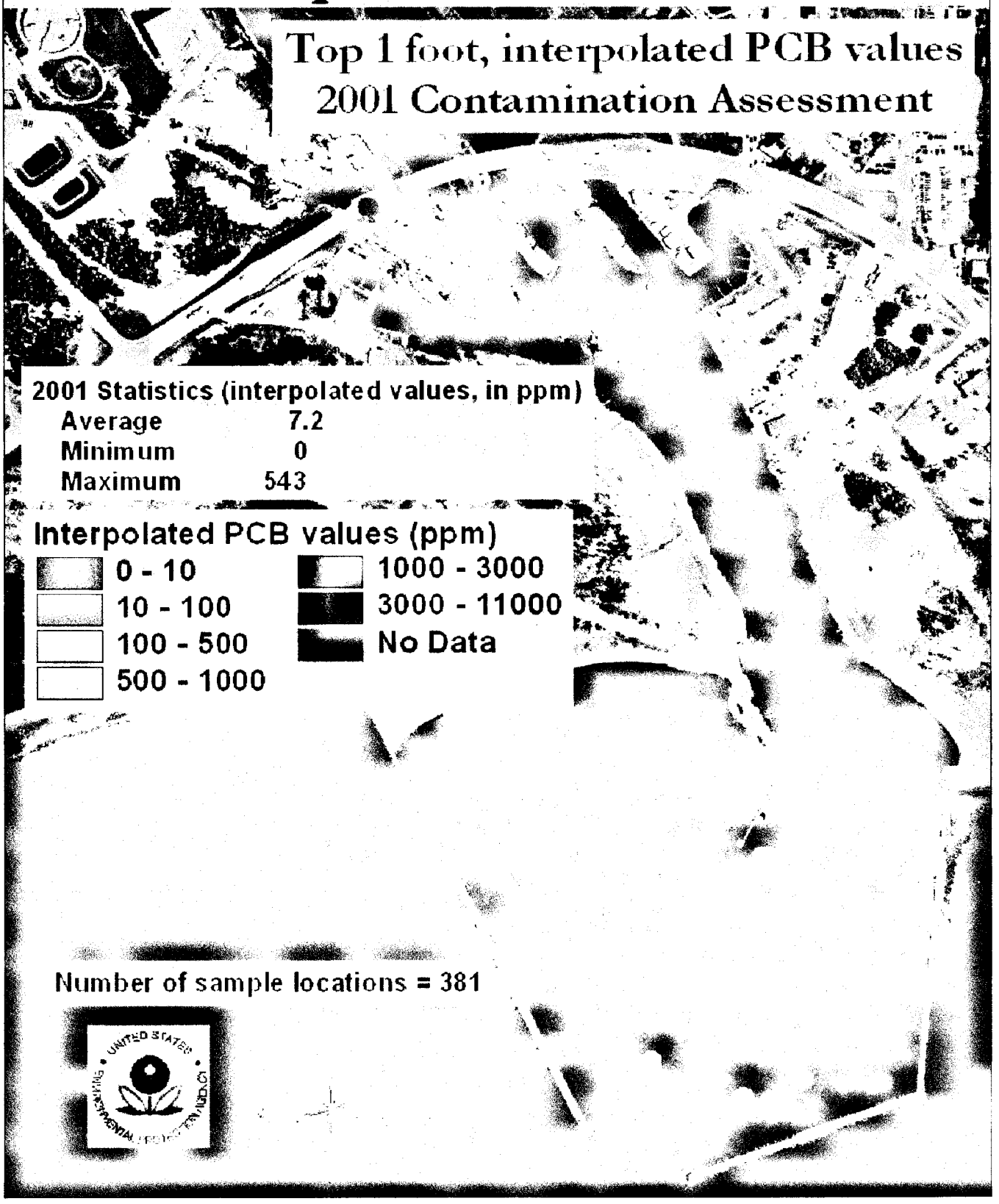
Top 2 feet, interpolated PCB values
End 2000 Dredging Season



J:\Projects\W023452\16-W023452.dwg Sep 20,2002 - 2:58pm moass

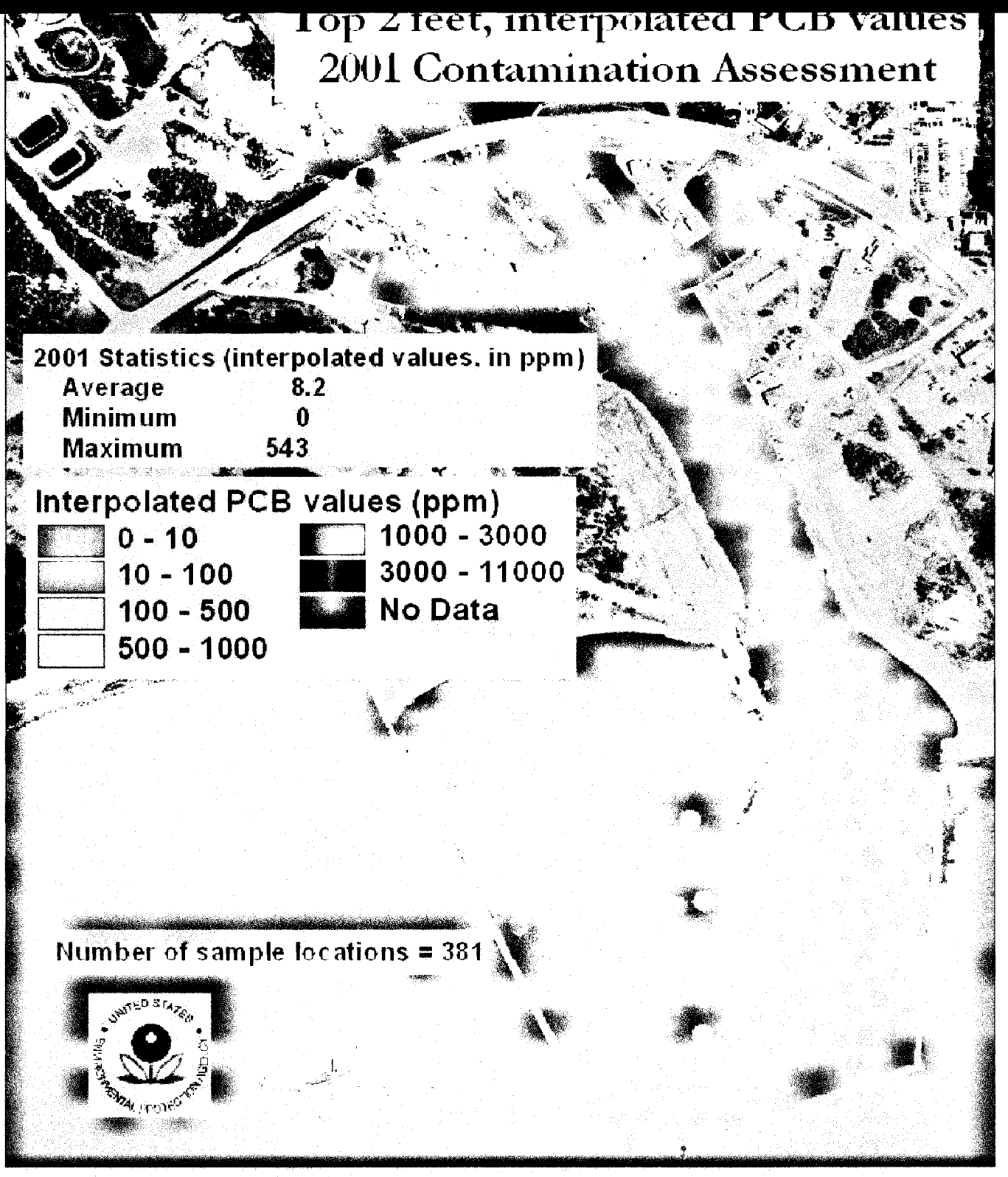
TRIAD ENGINEERING INCORPORATED © 2002 Triad Engineering	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 16 2000 INTERPOLATED PCB VALUES FOR THE TOP 0-2 FOOT INTERVAL	SHEET NO. FIGURE 16 DWG NO. 16 DATE Sep 2002 PROJ NO. W023452	

Manistique Harbor and River



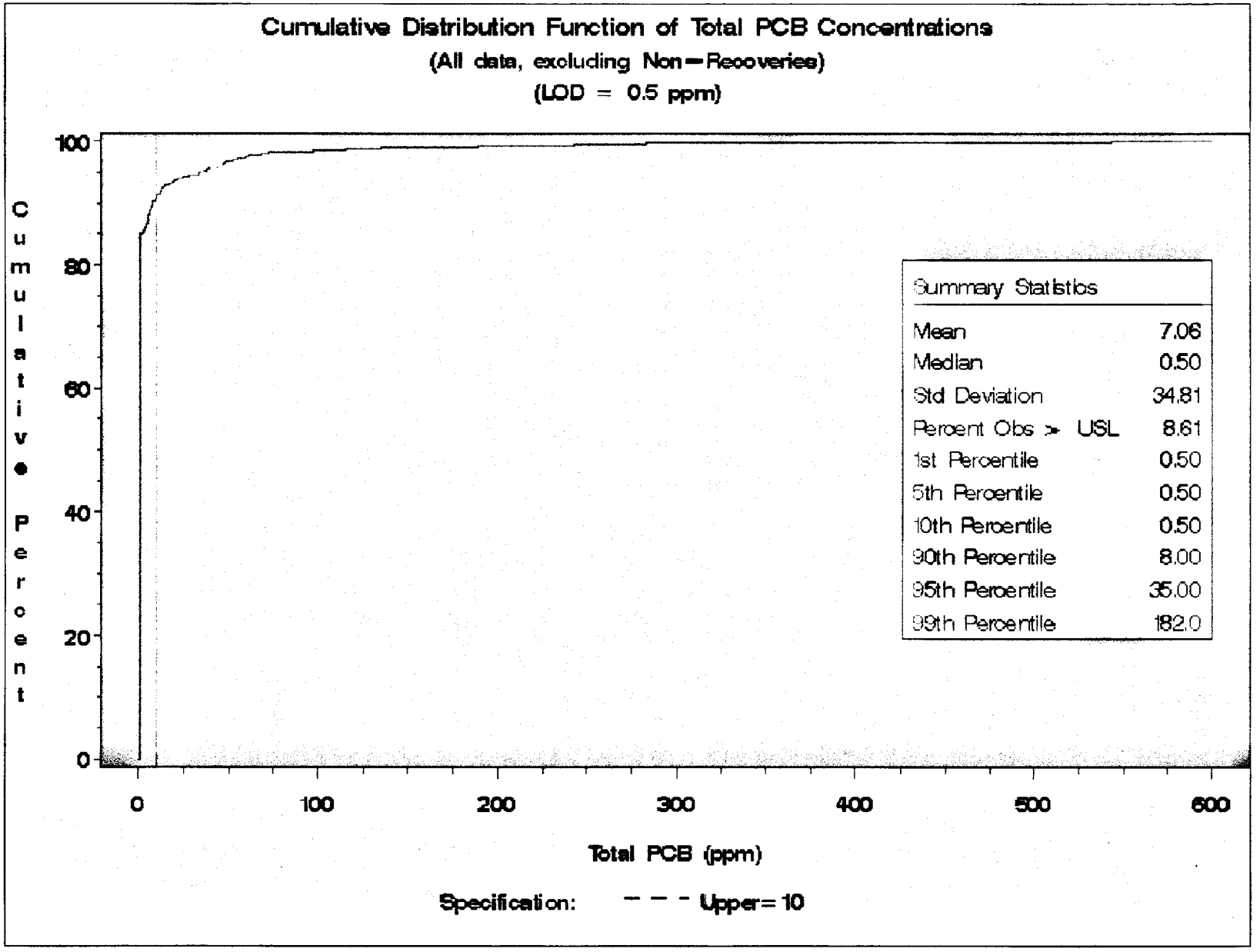
J:\Projects\W023452\17-W023452.dwg Sep 24,2002 - 4:20pm maass

TRIAD ENGINEERING INCORPORATED © 2002 Triad Engineering	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 17 2001 INTERPOLATED PCB VALUES FOR THE 0–1 FOOT INTERVAL	SHEET NO. FIGURE 17 DWG NO. 17 DATE Sep 2002 PROJ NO. W023452



TRIAD ENGINEERING INCORPORATED © 2002 Triad Engineering	DSGN TAR DR EHM CHK APVD	MANISTIQUE RIVER & HARBOR AREA OF CONCERN REMEDIAL ACTION PLAN UPDATE	FIGURE 18 2001 INTERPOLATED PCB VALUES FOR THE TOP 0–2 FOOT INTERVAL	SHEET NO. FIGURE 18 DWG NO. 18 DATE Sep 2002 PROJ NO. W023452

J:\Projects\W023452\18-W023452.dwg Sep 24,2002 - 4:12pm maass



J:\Projects\W023452\19-W023452.dwg Sep 24,2002 - 3:33pm maass

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0 1"
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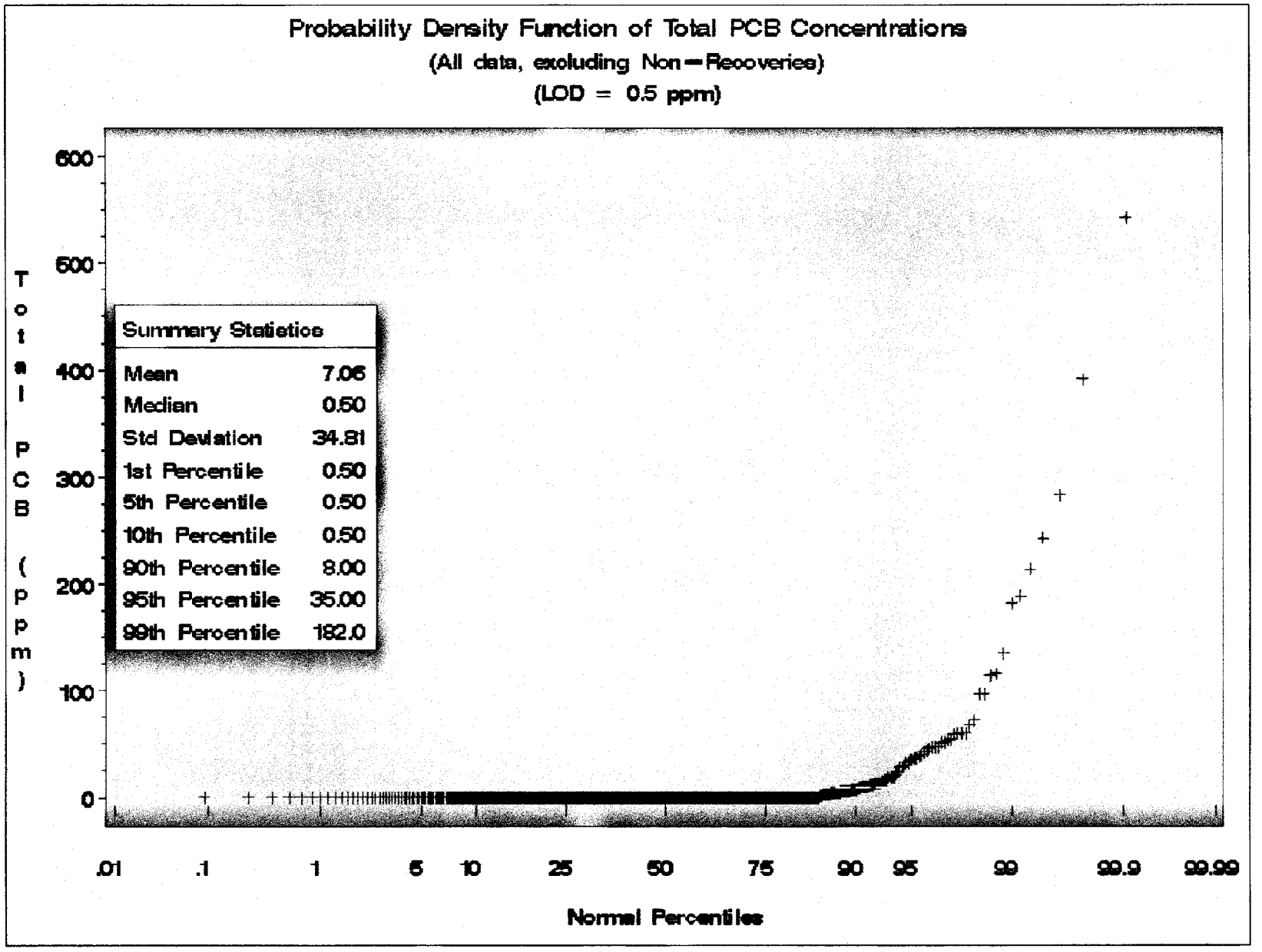
DSGN	TAR
DR	EHM
CHK	
APVD	

MANISTIQUE RIVER & HARBOR
AREA OF CONCERN
REMEDIAL ACTION PLAN UPDATE

FIGURE 19
CUMULATIVE DISTRIBUTION FUNCTION
OF TOTAL PCB CONCENTRATIONS

SHEET NO.	FIGURE 19
DWG NO.	19
DATE	Sep 2002
PROJ NO.	W023452



J:\Projects\W023452\20-W023452.dwg Sep 24,2002 - 3:33pm maass

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VERIFY SCALE
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0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

DSGN	TAR
DR	EHM
CHK	
APVD	

MANISTIQUE RIVER & HARBOR
AREA OF CONCERN
REMEDIAL ACTION PLAN UPDATE

FIGURE 20
PROBABILITY DENSITY FUNCTION
OF TOTAL PCB CONCENTRATIONS

SHEET NO.	FIGURE 20
DWG NO.	20
DATE	Sep 2002
PROJ NO.	W023452

APPENDICES

APPENDIX A

STATISTICAL ANALYSES OF MANISTIQUE HARBOR AND RIVER

The Manistique River and Harbor Area of Concern RAP Update Survey (1997-2002) Results

The Manistique Community Survey was administered by the Public Advisory Council (PAC) as an opportunity for Manistique area residents to express their opinions on the remediation project and cleanup in the Area of Concern (AOC). The survey included specific questions on the impairments of use to the impacted areas. Residents' answers are confidential.

Four hundred surveys were distributed to the Manistique Community. The persons receiving the surveys were randomly selected by an independent party (Pioneer Tribune), based on the tax roles.

Approximately one third of the surveys received were incomplete. Some were missing questions or entire pages, prompting incorrect answers to select questions. The responses from incomplete surveys have been documented throughout the results tally by parentheses. However, only 8 of the original 20 questions have been answered on the incomplete surveys.

The survey was also an indicator of how the Manistique residents use the River and Harbor area. The answers indicate what they perceive to be the impairments and benefits of the area, prior to and following the completion of the remediation project. Following is a brief summary of some key factors of the survey.

The majority of residents surveyed lived greater than one mile from the River and/or Harbor area. The vast majority of residents have lived in the area more that 20 years and are older than age 51. When asked for occupation, manufacturers employed the majority, followed by retired, service business, "other" and education. Nearly three quarters of those surveyed indicated that they would not be interested in volunteering for programs to support the delisting of the Harbor.

The 3 most common uses of the water were for boating, fishing and recreation. Only a small fraction perceived the Manistique River and Harbor as a water source, and the fewest responses were reported for business use. Nearly all residents responded that they enjoy the Harbor, boat launch, picnic and walking areas. Approximately one half of responses were "neutral" for the presence of dogs, bikes, the marina, and it's location for business and industry. However, the dislike of the presence of pollution drew the highest number of responses. More than three quarters of the respondents knew that the Manistique River and Harbor area were designated as an AOC before participating in the survey, and as many were aware of the cost for cleanup as well. However, nearly half did not know the cost to local companies, and nearly all do not think that they have gotten their money's worth from the clean-up efforts.

Residents have been kept informed of the River and Harbor clean up by various sources; the local news received the most tallies. Of 16 possible concerns in the AOC, only game fish stocking and sawdust were considered overwhelming major problems, however nearly

half of all responses were for "No Response." Water odor and fish abnormalities were most often considered as "No Problem."

Most residents claim to have used the Harbor and River for recreation between 1 to 10 days, followed by 11 to 20 days, and 51 or more days. However, when asked how often the residents would use the waterways for recreational use *if they had no concerns about the impairments*, the number of days actually dropped, indicating that perhaps the intent of the question was not understood. About two-thirds of respondents were aware of public health advisories for fish consumption in the river, and a variety of fish were listed, with carp listed most often as under advisory.

When asked about the number of fish caught (of legal size) and the number of fish kept, as compared to the number of fish that *would have been kept if major problems were a concern,* the answers indicate almost all fish would not have been kept, and no one claimed to have kept any carp or white sucker at all. The survey questionnaire follows, as well as the tally of responses to each question.

Manistique River and Harbor Area of Concern RAP
Update Survey (1997-2002) Results

Additional answers from incomplete surveys, i.e., missing questions or pages, or surveys with invalid responses, are indicated by parentheses.

1. How close to the Manistique River or Harbor do you live?

Less than 0.5 mile	18 (7)
Between 0.5 and 1 miles	16 (7)
Greater than 1 mile	28 (12)

2. What do you normally use the Harbor for?

Boating	24 (6)
Business	7 (1)
Fishing	26 (9)
Food Source	8 (2)
Recreation	29 (15)
Water Source	9 (2)
Other	18 (3)

3. What do you like or dislike about the Manistique River?

	Like	Neutral	Dislike
Boardwalk	46	4	1
Boat Launch	48	12	0
Harbor on Lake Michigan	46	10	2
Location for Business	30	19	8
Location for Industry	41	15	4
Marina	27	23	3
Part-year Resident Attraction	42	15	2
Place for Boating	39	14	1
Place for Fishing	25	16	4
Place for Picnicking	53	7	0
Place for Walking	53	7	0
Scenic Views	51	8	1
Tourist Attraction	41	15	1
Adjacent Beach	26	17	5
Bikes	14	26	10
Dogs	10	21	21
Pollution	4	14	32

9. Do you think any of the following are problems in the Manistique River and Harbor since the completion of the cleanup activities?

	[1]No Pro blem	Major Problem	No Response
Algae Growth	32	10	24
Cleanliness of water for swimming	35	14	27
Fish Abnormalities	32	6	18
Fish Cleaning Waste	31	10	16
Fish Contamination	25	11	17
Fish Habitat Quantity	24	12	17
Fish Taste	29	8	18
Game Fish Stocking	23	19	17
Industrial Waste	25	12	17
Polychlorinated biphenyls	24	7	19
Sawdust	21	21	12
Scenic Views	38	12	5
Sewage	30	13	10
Shoreline Access	38	8	13
Snags on River Bottoms	26	13	14
Water Odor	33	5	17

(9). Do you think any of the following are problems in the Manistique River and Harbor since the completion of the cleanup activities?

	[1]No Pro blem	Major Problem	No Response
Cleanliness of water for swimming	5	5	8
Fish Abnormalities	2	2	12
Fish Cleaning Waste	2	3	10
Fish Contamination	3	4	9
Fish Habitat Quantity	1	2	11
Fish Taste	2	2	11
Game Fish Stocking	1	2	11
Industrial Waste	5	3	9
Polychlorinated biphenyls	7	2	12
Sawdust	4	7	6
Scenic Views	14	0	4
Sewage	4	3	8
Shoreline Access	7	4	6
Snags on River Bottoms	4	5	7
Water Odor	6	2	9

[1] *the choice "No Problem" was located in two columns, prompting answers in each, therefore, the two sets of responses were combined.*

Name(s) of fish under advisory:

Trout	3	Suckers	3
Carp	13	Coho	3
Walleye	3	Rock Bass	1
Sturgeon	1	Salmon	5
Chinook	3	All	2
Steelhead	2		

15. How long have you been a resident of the Manistique area?

Less than 1 year	1
1-10 years	4
11-20 years	5
more than 20	49
Part-year resident	1

16. What is your age category?

18-29 years	1
30-50 years	27
51 + years	31

17. What is your occupation category?

Education	6	(4)
Federal Gov.	0	(1)
Local Gov.	1	(1)
Manufacturing	24	(0)
Retail Sales	4	(4)
Retired	13	(12)
Service Business	8	(4)
State Gov.	2	(2)
Other	8	(6)

18. Would you consider being a volunteer on citizens' or friends' group, or help with programs supporting the monitoring and delisting of the Harbor?

YES 16(5) NO 41(19) Not Sure 1 Current Volunteer 1

19. (Question No. 4 from survey) What do you think has changed in the Manistique River of Harbor since 1995?

- It was dredged at taxpayer's expense for no reason.
- Lower water levels.
- Not a thing.
- Not much, perhaps less pollution.
- Big effort has been made obvious.

APPENDIX B

MARCH 2000 COMMUNITY SURVEY AND RESULTS

last updated 05 September 2002

Analyses of Manistique Harbor and River

Outline

Some comments about interpolation and the maps

The ArcView® Software was used to interpolate Total PCB values at unsampled locations in Manistique Harbor. ArcView's Inverse Distance Weighting (IDW) algorithm was used to create interpolated Total PCB values. IDW is a weighted, moving average technique. IDW assumes that each input point has a local influence that diminishes with distance. Hence, the interpolated values will be more influenced by nearby points than more distant points. The influence of nearby points is modified by the power value chosen. Hence a power of 6 puts greater influence on nearby points as opposed to far away points compared to a power value of 2.

In the below interpolated maps, the nearby points used for interpolation were based on a radius of 10 meters. The power value chosen was 4 which gives more influence to nearby points than far away points. A radius value of 10 meters was chosen as this value most closely represented the distance (20 meters) at which PCB values begin to be unrelated (uncorrelated).

Some comments about the statistical analyses

Normality: The PCB concentration values in the sediment of Manistique Harbor and River are highly skewed to the right, i.e., a small number of very high values. This phenomenon is

common with environmental data. Unfortunately, skewed (non-normal or non-Gaussian) data cause problems when parametric inferential tests (e.g., t-test, confidence limits) are performed. These tests require the assumption that the data are normally (Gaussian) distributed. However, the Centeral Limit Theorem can be used to justify the use of these inferential tests. The Central Limit Theorem states that although the underlying distribution may not be normal, random sampling of the population will generate mean values that are normal. Hence, given a large enough data set (as with the Manistique data set), parametric inferential tests can be used for non-normally distriubuted data. (See, for example, Fundamentals of Biostatistics by Bernard Rosner or Applied Regression Analysis and Other Multivariate Methods by David Klienbaum, Lawrence Kupper, and Keith Muller.)

1993

The location of the temporary cover installed near the end of 1993 is shown in this figure. The temporary cover was removed in 1997.

1997

The areas dredged in 1997 are shown in this figure.

The post dredging picture of Manistique Harbor demonstrates that significant reduction in PCB values occurred.

- End of 1997 dredging season, top 1 foot of sediment
- End of 1997 dredging season, top 2 foot of sediment

1998

The areas dredged in 1998 are shown in this figure.

The post dredging picture of Manistique Harbor demonstrates that significant reduction in PCB values occurred.

- End of 1998 dredging season, top 1 foot of sediment
- End of 1998 dredging season, top 2 foot of sediment

1999

The areas dredged in 1999 are shown in this figure.

The before dredging and after dredging picture of Manistique Harbor demonstrates that significant reduction in PCB values occurred. In addition, a picture of the post dredging also demonstrates a reduction in PCB values.

- Pre-dredge versus Post-dredge, top 1 foot of sediment
- End of 1999 dredging season, top 1 foot of sediment
- End of 1999 dredging season, top 2 foot of sediment

2000

The areas dredged in 2000 are shown in this figure.

The post dredging picture of Manistique Harbor and River demonstrates that significant reduction in PCB values occurred.

- End of 2000 dredging season, top 1 foot of sediment
- End of 2000 dredging season, top 2 foot of sediment

2001

Overview

The goal of a site-wide average concentration of PCBs less than or equal to 10 ppm throughout the sediment column in the Manistique Harbor and River was achieved. The average concentration of PCBs was 7.06 ppm. The 95% confidence interval for this value ranges from 4.40 to 9.72 ppm. In other words, there is a 95% confidence that the mean PCB

value in Manistique Harbor and River is between 4.40 and 9.72 ppm.

Background

The Manistique Harbor and River Superfund site is located in Manistique, Michigan. The contaminant of concern is PCB (polychlorinated biphenyl). The U.S. EPA and the FIELDS Team have been active at the site since 1995. In the summer of 2001, the site underwent a final extent of contamination assessment to determine PCB values that remained. The analyses presented below provide an understanding of the PCB data from a statistical and spatial (GIS) perspective.

Statistical Analyses

Statistical analyses of the Total PCB (ppm) dataset were performed using the SAS® statistical analysis software. The Total PCB concentration values in the sediment of Manisitique Harbor and River are highly skewed to the right, i.e., a small number of very high values (see Histogram). This phenomenon is common with environmental data.

Basic stastics of the Total PCB data are provided in the descriptive statistics output (see Descriptive Statistics). These statistics show that the mean Total PCB value is 7.06 ppm and that the data are highly skewed (see the Skewness value and the difference between the Mean of 7.06 and the Median of 0.5). The 95% confidence interval for the mean ranges from 4.40 to 9.72 (see 95% Confidence Interval).

A visualization of the data and their relationship to the clean-up goal of 10 ppm is provided in the Probability Density Distribution Function. The figure demonstrates that the vast majority of Total PCB values in Manistique Harbor and River are below this clean-up goal. The exact proportion of Total PCB values greater than the clean-up goal is 8.61% (see Cumulative Density Function). Hence, 91.39% of all Total PCB values are less than or equal to 10 ppm.

Spatial (GIS) Analyses

The post dredging picture of Manistique Harbor and River demonstrates that significant reduction in PCB values occurred.

- 2001 contamination assessment, top 1 foot of sediment
- 2001 contamination assessment, top 2 foot of sediment

All results and analyses may be subject to change.

95% Confidence Intervals for Total PCB Mean Concentration (All Data, excluding Non-Recoveries) (LOD = 0.5 ppm)

95% Confidence Intervals			
Parameter	**Estimate**	**LCL**	**UCL**
Mean	7.0604	4.4037	9.7172
Std Dev	34.8125	33.0330	36.7963
Variance	1211.9116	1091.1758	1353.9657

Descriptive Statistics for Total PCB Concentrations (All Data, excluding Non-Recoveries) (LOD = 0.5 ppm)

The UNIVARIATE Procedure
Variable: TotalPCB (ppm)

Moments			
N	662	Sum Weights	662
Mean	7.06042296	Sum Observations	4674
Std Deviation	34.8125211	Variance	1211.91162
Skewness	9.83355892	Kurtosis	119.640512
Uncorrected SS	834074	Corrected SS	801073.583
Coeff Variation	493.06566	Std Error Mean	1.35302705

Basic Statistical Measures			
Location		Variability	
Mean	7.060423	Std Deviation	34.81252
Median	0.500000	Variance	1212
Mode	0.500000	Range	542.50000
		Interquartile Range	0

Tests for Location: Mu0=0				
Test		Statistic	p Value	
Student's t	t	5.218242	Pr > |t|	<.0001
Sign	M	331	Pr >= |M|	<.0001
Signed Rank	S	109726.5	Pr >= |S|	<.0001

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.183158	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.425262	Pr > D	<0.0100
Cramer-von Mises	W-Sq	42.7949	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	200.0386	Pr > A-Sq	<0.0050

Quantiles (Definition 5)	
Quantile	Estimate
100% Max	543.0
99%	182.0
95%	35.0
90%	8.0
75% Q3	0.5
50% Median	0.5
25% Q1	0.5
10%	0.5
5%	0.5
1%	0.5
0% Min	0.5

Extreme Observations			
Lowest		Highest	
Value	Obs	Value	Obs
0.5	662	214	399
0.5	661	243	335

0.5	660	283	329
0.5	659	392	488
0.5	658	543	369

```
                    Histogram                           #          B
 525+*                                                  1
    .
    .
    .*                                                  1
    .
 275+*                                                  1
    .*                                                  2
    .*                                                  2
    .*                                                  3
    .*                                                 12
  25+**********************************************   640          +
     ----+----+----+----+----+----+----+----+----+-
     * may represent up to 14 counts
```

Descriptive Statistics for Total PCB Concentrations (All Data, excluding Non-Recoveries) (LOD = 0.5 ppm)

The UNIVARIATE Procedure
Variable: TotalPCB (ppm)