SEDIMENT DISTRIBUTION OF THE LOWER MAUMEE AND OTTAWA RIVERS

Final Report

Submitted in fulfillment of Lake Erie Protection Fund grant #98-21

by

S.D. Mackey
D.L. Liebenthal
J.A. Fuller

Ohio Department of Natural Resources
Division of Geological Survey

May 15, 2001

SEDIMENT DISTRIBUTION OF THE LOWER MAUMEE AND OTTAWA RIVERS

Final Report

Submitted in fulfillment of Lake Erie Protection Fund grant #98-21

by
S.D. Mackey, D.L. Liebenthal,
and J.A. Fuller
Ohio Department of Natural Resources
Division of Geological Survey
May 15, 2001

Statement of Problem

Surface-sediment samples and cores provide information on the type, distribution, and thickness of sediments present on the beds of the Maumee and Ottawa Rivers. Geochemical analyses provide data on the type and concentration of contaminants within these sediments. Unfortunately, these types of sampling are both spatially limited. Sediment distribution must be inferred between sampling points, resulting in potential errors in estimates of sediment type, area, and volume. Moreover, even with repetitive sampling, limited data are available to document areas that are undergoing active erosion or deposition. Cores may not successfully sample the upper sediment layers to accurately depict the distribution of sediments present on the beds of these rivers. Because resuspension of contaminated sediments by dredging is a serious concern within the lower Maumee River, knowledge of the areas of deposition and erosion are needed to best plan dredging projects. In addition, limited data are available to document the areas where "natural" erosion causes resuspension of contaminated sediments. Quantifying the spatial distribution of riverine sediments is critical to developing an understanding of sediment transport processes, sediment transport rates, and resuspension of contaminated sediments in both the Maumee and Ottawa Rivers.

Objectives

The principal goal of this study was to characterize and map sediments on the bed of the Maumee and Ottawa Rivers (Figure 1) using side-scan sonar and Geographic Information System (GIS) technologies. Existing surface-sediment and core data were integrated with side-scan sonar data to generate GIS layers illustrating surface-sediment distribution and identify areas of potential active erosion or deposition. Products resulting from this work include:

1. Geographically referenced side-scan mosaics of the lower reaches of the Maumee and Ottawa Rivers;
2. Sediment substrate data layers that overlay the geographically referenced side-scan mosaics;
3. Surface-sample/core location data layers that overlay the geographically referenced side-scan mosaics;
4. Summary report of findings;
5. CD-ROM containing GIS data layers, images, datasets, and this summary report of the project.

Methods

Side-scan sonar is an acoustic tool that is used to detect and map objects underwater. The device uses transmitted sound reflected from the bottom (backscatter) to generate an acoustic image of the bottom that may extend hundreds of meters on either side of the vessel. The display consists of the vessel trackline and a left and a right panel containing continuous backscatter images generated from the acoustic return from the bottom. Scale lines can be added to denote distance from the vessel (left or right). Objects or materials with a relatively strong acoustic return are displayed as dark areas on the record, and objects or materials with a relatively weak acoustic return are displayed as light areas. The Ohio Division of Geological Survey owns and operates a dual-frequency (100 and 500 kHz) Klein 595® side-scan sonar unit which is operated from either the Division's 14.5-meter research vessel (*R/V GS-1*) or the Division's 7.6-meter research vessel (*R/V GS-3*). All of the side-scan sonar data used in this study were acquired using the *R/V GS-3* with a bow-mount for the side-scan sonar sensor.

The Division of Geological Survey owns and operates an ISIS® side-scan data-acquisition system that collects and stores the digital data signals from the Klein during fieldwork. A real-time differential global positioning system (GPS) (Trimble DSM 212H®) was used to determine location during the year 2000 side-scan sonar survey. Data from the GPS was inputted into the ISIS system in the field. The ISIS system also has processing capabilities that were used to remove the slant distortion and then stitch together the side-scan lines into a side-scan mosaic. The processing places each pixel in correct coordinate space. This process, in effect, produces a seamless, continuous acoustic image that is geographically referenced and can be placed as a data layer directly into a GIS.

Primary Tasks

1. Acquire side-scan Sonar data for the navigable portions of Maumee and Ottawa Rivers.

Three side-scan sonar surveys were completed on the Maumee River and one Side-scan sonar survey was completed on the Ottawa River (Table 1). A reconnaissance survey on the Maumee

River was completed in September and October 1997 prior to initiation of this study. The Division had not yet acquired the ISIS system, so the only data available for 1997 are in the form of original thermal analog paper records. Examples from that survey were included in the Lake Erie Protection Fund proposal for this project.

Table 1. Side-scan Sonar Data Acquisition

River	Field Date	Kilometers Of Trackline	Area Covered	Digital Mosaic Included
Maumee	Sept./Oct. 1997	57	Mouth to downstream of Ewing Island	No
Maumee	Oct./Nov. 1999	53.5	Mouth to Ohio Turnpike bridge	No
Maumee	August 2000	59.5	Mouth to downstream of Ewing Island	Yes
Ottawa	August 2000	5	Mouth to near the Summit St. bridge	Yes

Lower lake levels in 1999 limited access to shallower portions of the Maumee River. Data were not collected from the Ottawa River in 1999 due to extreme shallow-water conditions. Additional side-scan data were collected from both the Maumee and Ottawa Rivers during the August 2000 survey. All surveys were run at a nominal 100-meter range; planned overlap with adjacent lines was 30 meters. For the 1999 and 2000 surveys, both the 100-kHz and 500-kHz side-scan data were printed on paper and stored digitally on the ISIS system. Because there were significant improvements made in navigation equipment and software prior to the 2000 survey, the 2000 data were used for the mosaics included in with this report.

2. Construct a geographically referenced side-scan mosaic illustrating bottom characteristics.

Digital processing of the side-scan data included applying a slant-range correction that removed the water column and applying geographic corrections to each line. The number and scale of pixels determined the resolution of the processed records. The Maumee and Ottawa River records were processed at a 20-centimeter resolution. After correction, the side-scan sonar lines were then plotted in coordinate space, creating a geographically referenced mosaic of the riverbed. During the 2000 Maumee River surveys, eight separate side-scan mosaics using the 500-kHz data were created, covering the area from the mouth of the Maumee River to just below the downstream edge of Ewing Island (Maumee River mosaics, reaches 1 through 8). A single side-scan mosaic was created for the lower reach of the Ottawa River (Ottawa River mosaic). The mosaics were printed at a scale of 1:3000. Thus, object identification is at best limited to about a half meter by the printing process.

3. **Interpret side-scan data to generate sediment-substrate maps that overlay the side-scan mosaic and identify areas of erosion/deposition.**

Sample Data

The quality of side-scan data was generally good except in localized areas where a thermocline blocked out data. The scale of the side-scan imagery is such that small bedforms such as ripples and small dunes could not be readily detected on these records. Sediment-substrate maps are based on backscatter characteristics of the side-scan data and historical sample data. Interpretation of the mosaicked side-scan backscatter maps was aided by using the original paper records (both the100- and 500-kHz frequencies). The backscatter groups that could be identified on the 2000 mosaics were subtle, making interpretation difficult.

Numerous historic cores, jetted holes, and bottom samples were used for ground-truthing the mosaics. The majority of these sample data came from work by the Ohio EPA Northwest District Office in Bowling Green, Ohio. The Ohio EPA acquired more than 60 short cores from the Maumee River below the I-75-Michael V. DiSalle Bridge. These cores were taken in 1995 and 1996 and all were described as having silt at the sediment-water interface (AscI Corp., 1996). Seven samples taken in the same area in 1983 for the U.S. Army Corps of Engineers (USACE) (Floyd Browne Associates, 1984) and repeated in 1988 (USACE, 1990) all were generally described as either mud (a mixture of silt and clay) or sandy mud.

Herdendorf (1970) reported on 48 bottom samples taken in the Maumee River in 1964 between the Mid-States Terminals and the Libby-Owens-Ford (LOF) glass plant that is just upstream of the I-75 bridge. Most of these samples (33) were described as mud, three were described as silt, and 12 were described as sand (or coarser) sediment. Herdendorf's report includes results from 30 jetted holes collected in 1964, 1965, and 1967 from between the Mid-States Terminals and the downstream edge of Ewing Island (the approximate upriver extent of these side-scan surveys in this study). Twenty-two of the samples upstream of the LOF glass plant were described as a mixture of silt and sand or a mixture of silt, sand, and gravel.

In the Ottawa River, nine Ohio EPA cores were taken in 1995 and 1996 from between the river mouth at Maumee Bay and the Summit Street bridge (Ohio EPA file data). For these cores the surficial-sediments were described as silt. Another set of Ohio EPA samples from 1998 included about 40 samples from below the Summit Street bridge. The surficial sediments in these samples were primarily mud and peat.

Side-Scan Sonar Mapping

Surface- and core-sample data were used to help assign physical characteristics to the areas of similar backscatter on the mosaicked side-scan sonar maps. Historic bottom samples were used for this ground-truthing. On the basis of backscatter characteristics and sample data, four major substrate units were identified and mapped in these surveys: bedrock, sand, cohesive clay with gravel, and mud. Other features that were noted and interpreted include; slumps, scour areas, wrecks, submerged breakwalls. Examples of some of these features and drag marks, and cutter-head dredge marks are presented in Figures 2-8.

The Maumee River from the mouth to just below the I-75 bridge is dominated by mud, although small areas of sand are present. The scour areas around the bridges also may be dominated by sand but, again, the areas are very small and poorly defined. Upriver of the I-75 bridge to the marina area at Rossford, there are both sand and mud areas. Continuing upriver from Rossford to about 500 meters below the Ohio Turnpike bridge (I-80/90), sand is the dominant surficial-sediment. Areas of cohesive clay with gravel can be seen on some riverbanks, and some areas of mud are present in protected shoal areas. A bedrock bottom dominates the rest of the study area, although some patches of sand and cohesive clay with gravel overlie the bedrock bottom.

In the Ottawa River, only two substrates could be defined on the side-scan sonar mosaics: mud and muddy sand. The majority of the area is mud; muddy sand is confined to patches along the south bank of the river. No areas of peat could be identified on the side-scan records in 2000 even though surface samples taken in 1998 identified areas of peat near the middle of the river.

Areas of Erosion and Deposition

Areas of possible erosion or instability can be interpreted using sediment grain size, the presence or absence of exposed bedrock, bedforms, and depressions scoured into the riverbed. Areas of nondeposition include all areas where bedrock is exposed on the riverbed. These are reaches of high stream power where shear stresses are great enough to transport bedload sediments easily downstream. Areas containing sand also may reflect areas of higher flow and shear stress and are potentially unstable areas of erosion or nondeposition. Large bedforms such as dunes, sand bars, or sand waves are transitory and migrate in a downstream direction. This migration occurs as a result of erosion or scour at the upstream edge of the bedform and deposition at the downstream edge of the bedform. In general, areas containing these types of bedforms are unstable. Muddy reaches generally represent areas of deposition or at least stability. The October to September average flow volumes at Waterville Ohio, 12 kilometers upriver from the study area, were tabulated starting in October 1963 and continuing to September 2000 (U.S. Geological Survey, 2001, and Ohio Division of Water file data). The lowest annual average flow was 79 cubic meters per second (m^3s) (1963-1964) and the highest was 241 m^3s (1992-1993). This range in average values documents the variability of river flows and, therefore, the variability of the potential bedload sediment transport. The presence of a large suspended-sediment load can be seen by simply noting the appearance of the water in both rivers. The brown color and opacity suggest that there is a large amount of suspended sediment passing though each of the rivers to the lake.

In a few areas of the Maumee River the riverbanks show scattered evidence of slumping (Figure 2). Such slumping may expose glacial material in the walls, but the side-scan records of the exposed banks are not particularly distinctive, making the interpretation somewhat questionable. A 1910 navigation chart shows a dredged channel in approximately the same location as present. In comparing the 1910 and 1991 navigation charts, the general sense is that in areas that are not actively dredged or filled there has been an overall shallowing of the river adjacent to the navigation channel. Above the I-75 bridge there is a short (2 km) section of river that is upriver of the present dredged navigation channel which appears to have been deepened by several meters over the width of the river.

Because the majority of the Ottawa River sediments are muds it can be assumed that for the most part the area is depositional. A 1910 navigation chart shows wetlands extending out from either bank to make a narrow central channel that averaged about 3 meters deep. The present morphology is a broad, shallow water channel from bank to bank; the wetlands are gone and the deep channel is nearly filled.

Comparison of Maumee River 1999 and 2000 Mosaics

A comparison of the mosaic made from the year 2000 records with that made from the 1999 records covered the river from its mouth to just below the I-75 bridge which covers the extent of the dredged navigation channel. Subtle changes in backscatter and substrate characteristics can be seen over this one-year period of time and are best described as a muting of the 1999 features. Cutter-head dredge marks are very apparent in the lower most reaches of the river on the 1999 mosaic. During the 1999 survey, the river was being actively dredged, and the dredge marks exhibited a crisp acoustic signature (Figure 3). Some dredge marks are present on the 2000 mosaic, but they have clearly been filled or modified by deposition of fine-grained sediment (Figure 3). A drag mark, possibly from an anchor, can be seen on the 1999 records. There is still a hint of the same mark on the 2000 records (Figure 4). Also on Figure 4, dredge marks can be seen on the 1999 records but are missing from the 2000 records. These differences suggest an accumulation of sediment in some areas of the navigation channel since 1999. Scour areas around most of the hard features such as the bridge abutments seem softer (acoustically) and more muted in the 2000 mosaics (Figure 5). Lower energy river-flow conditions and higher lake levels for the 2000 survey versus the 1999 survey could have set the stage for the deposition which can be seen. The lake level at the time of the 1999 survey was about 2 feet lower that during the 2000 survey. The flows for the October 1 to September 30 time periods in 1998-1999 versus 1999-2000 were 129 and 109 cubic meters per second (m^3s) respectively. Both of these conditions, deeper water and lower flow, would promote deposition of mud in the lower Maumee. The presence of recognizable bottom features on both the 1999 and 2000 mosaics implies that although deposition of fine-grained sediment occurred, there was not enough accumulation to bury many of the bottom features.

Almost all the records from the 1997 survey showed darker backscatter patterns when the original paper records were compared visually with the records from the 1999 survey for the area downstream of the I-75 bridge. As with the comparison of the 1999 and 2000 records, outside the dredged navigation channel, many of the same bottom features were visible on the 1997 records, but they generally seemed more pronounced. The darker backscatter patterns seen on the 1997 records probably reflect a firmer bottom surface, which had been significantly cleared of soft, fine-grained material by a year of higher flow discharges; for October 1996 to September 1997, average flow was 218 m^3s. Again the occurrence of the same bottom features implies that there hadn't been a lot of sediment accumulation between 1997 and 1999, as features could still be seen through the soft bottom in 1999.

The Ohio EPA samples from the lower Maumee River were taken in May 1995 and September 1996. Maumee River flows from October through September 1994-1995 and 1995-1996 were 100 and 162 m^3s respectively. These relatively lower flows may have allowed the deposition of finer grained material throughout the lower river, accounting for the soft, fine-grained samples collected, which were then swept away prior to the side-scan survey of 1997. The 1983 USACE samples taken in 1983 from the lower river had a bit more sand in the upper reaches of the dredged channel than the USACE samples collected 1988. A higher flow volume in 1983 could easily explain this slight variance; less of the fine-grained material was able to settle out in the greater flow velocities (186 and 137 m^3s respectively).

The Herdendorf surface samples and surface samples from the 5 jetted holes taken in 1964 and 1965 (all from above the dredged navigation channel portion of the river, above the I-75 bridge) were generally finer grained than the 25 samples from the 1967 jetted holes. This difference is not totally unexpected because the earlier period had much lower annual flow velocities that the October 1966 to September 1967 time period (102 and 180 m^3s respectively). Herderndorf (1970) put the bedrock/sand contact upriver of the Ohio Turnpike bridge, but this study places it at about 500 meters downstream of the Ohio Turnpike bridge. This difference suggests that sand has been stripped off the bedrock surface and transported downstream. Two possible causes are: (1) the sand source has been reduced (successful land conservation?), or (2) the riverbed is still equilibrating following a period of commercial sand dredging between the I-75 bridge and Ewing Island. The second possibility has the added evidence of the deepening of the river just upstream of the I-75 bridge (upstream of the dredged navigation channel and turning basin), as was noted earlier.

4. **Incorporate side-scan sonar data, sediment-substrate maps, and surface-sample/core locations into GIS data layers using ArcInfo® or ArcView® GIS.**

The substrate data were interpreted on paper copies (scale 1:1800) of the side-scan mosaics and then digitized into ArcView® GIS as a separate data layer. These layers are printed as an overlay in yellow to the 1:3000-scale side-scan mosaics included with this report. Area and perimeter data were calculated for each of the substrate types. Tables 2 and 3 summarize the area data for the Maumee and Ottawa River surveys.

Table 2. 2000 Maumee River Survey

Substrate Type	Area (square meters)	% of Survey Area
Bedrock	1,004,000	12
Sand	3,682,000	42
Mud	3,969,000	45
Cohesive clay with gravel	52,000	1

Table 3. 2000 Ottawa River Survey

Substrate Type	Area (square meters)	% of Survey Area
Sand	49,000	6
Mud	839,000	94

Project Benefits

For the Maumee River, the identification of the downstream movement of the sand/bedrock contact suggests erosion of sand from the upper reaches of the study area. A psudo-equilibrium seems to exist in the sandier areas downstream to where the dredged navigation channel starts. Although there seems to have been a significant loss of material in the lower reaches of the sand stretch since 1910, the loss can be attributed to the commercial sand dredging activities that were halted in about 1980. Deposition within the dredged navigation channel is not in question, as evidenced by the need to dredge annually. Evidence of deposition alongside the navigation channel can be seen on the side-scan mosaics, but the range of river-discharge volume suggests that sediment-deposition volumes may be extremely variable.

The study area in the Ottawa River seems to be a bit simpler. The streamside wetlands that existed in 1910 have either been drowned or eroded, and the deeper channel that existed has been filled in to its present depth.

Identifying areas of active erosion and deposition and quantifying the spatial distribution of sediments are critical to developing an understanding of sediment transport processes, sediment transport rates, and resuspension of contaminated sediments in the Maumee River. This research has helped characterize the fate and transport of nutrient enriched or contaminated sediments within the coastal area and complements existing research undertaken by the Ohio Division of Geological Survey, Ohio EPA, USACE, and the Maumee River Remedial Action Plan Committee (RAP). Moreover, data collected from this project will assist fisheries biologists by providing substrate information for a lakewide fisheries habitat assessment program undertaken by the Habitat Advisory Board of the Great Lakes Fisheries Commission. The Division of Geological Survey has provided substrate data and information to the Habitat Advisory Board for the Ohio portion of Lake Erie and its tributaries.

Information Dissemination

The results of the Ottawa River portion of the study were presented at a meeting of the Ottawa River Remediation Team in March 2001. The data from both rivers will be presented at a June 2001 meeting of the Maumee River RAP. GIS coverage and a summary report will be distributed via CD-ROM to appropriate state, federal, and local agencies and organizations active within the Maumee River area of concern (AOC). The Lake Erie Protection Fund will distribute copies of the summary report and the mosaics to collaborating groups and institutions. Additional copies may be available through the Division of Geological Survey's publication offices (Columbus and Sandusky), local Soil and Water District offices, Ohio EPA Northwest District Office, Maumee River RAP, and Toledo Metropolitan Area Council of Governments (TMACOG).

References

AscI Corporation, 1996, Screening analysis sediment quality assessment study of the Maumee River area of concern, 1995 & 1996: Report prepared for Ohio Environmental Protection Agency, Northwest District Office, 150 p.

Floyd Browne Associates Limited, 1984, Analysis of sediment from Toledo Harbor - Maumee River, Toledo, Ohio: Report prepared by Aqua Tech for U.S. Department of the Army, Corps of Engineers, Buffalo District, Contract # DACW499-83-D-0006, 87 p.

Herdendorf, C. E., 1970, Sand and gravel resources of the Maumee River estuary, Toledo to Perrysburg, Ohio: Ohio Division of Geological Survey Report of Investigations 76, 19 p., 4 pl.

U.S. Army Corps of Engineers, 1990, Environmental assessment and Section 404(b)(1), evaluation dredging and disposal of dredge material at Island 18 confined disposal facility, Toledo Harbor, Lucas County: U.S. Department of the Army, Corps of Engineers, Buffalo District, 125 p.

U.S. Geological Survey, 2001, Historical stream flow daily values for Maumee R at Waterville Oh. (04193500): http://waterdata.usgs.gov/nwis-w/OH/index.cgi?statnum=04193500, (as accessed April 2001).

Original Budget

Activity	LEPF	Match
Side-scan sonar interpretation/GIS layer development:		
PI salary 0.5 month (85 hours @ $28.00/hour):		$ 2,380 (salary)
PA salaries 2 months (340 hours @ $23.00/hour):	$ 3,910	$ 3,910 (salary)
Data collection-entry/GIS layer development:		
Intern salaries 3 months (510 hours @ $ 10.00/hour):	$ 5,100	
Fringe (32% of PA salaries only)	$ 1,251	$ 2,013 (fringe)
Expendables (recording paper, data tapes, CD-ROM)	$ 500	
Travel (3 staff @ 5 days field - $ 100/person/day)	$ 1,500	
Publications and presentations	$ 500	
Side-scan sonar data collection:		
(Boat time and side-scan sonar - $1,000/day)	$ 3,000	$ 2,000 (in-kind)
Indirect (10% of salaries and fringe)	$ 1,576	
Total	**$17,337**	**$ 10,303**

LEPF funds were used to cover data acquisition costs (boat time, side-scan sonar), salary time for data acquisition and interpretation, expendable equipment costs (paper, tapes, CD ROM media), and indirect charges for administrative support.

Sediment Distribution of the Lower Maumee and Ottawa Rivers

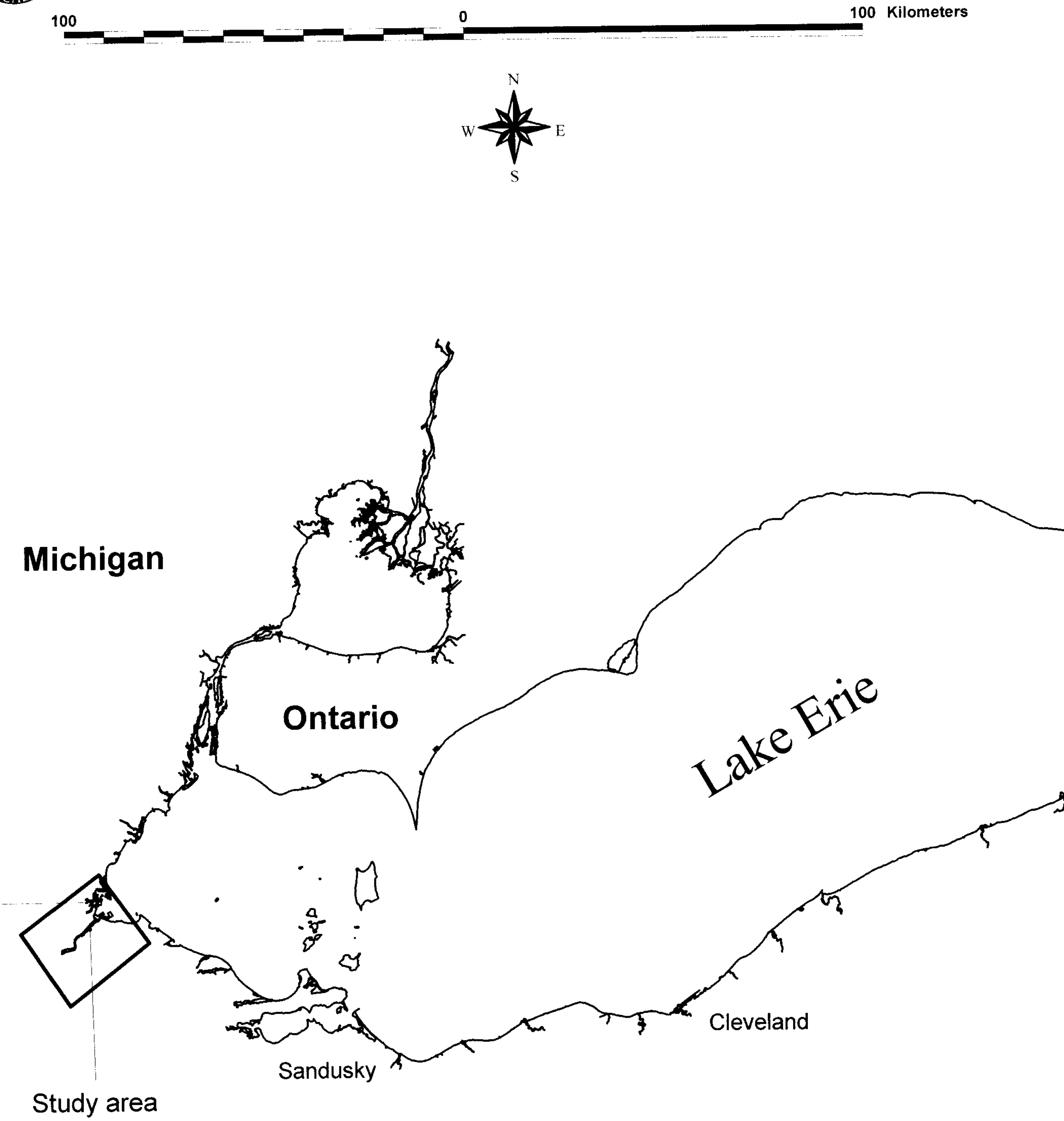

Figure 1
Location map

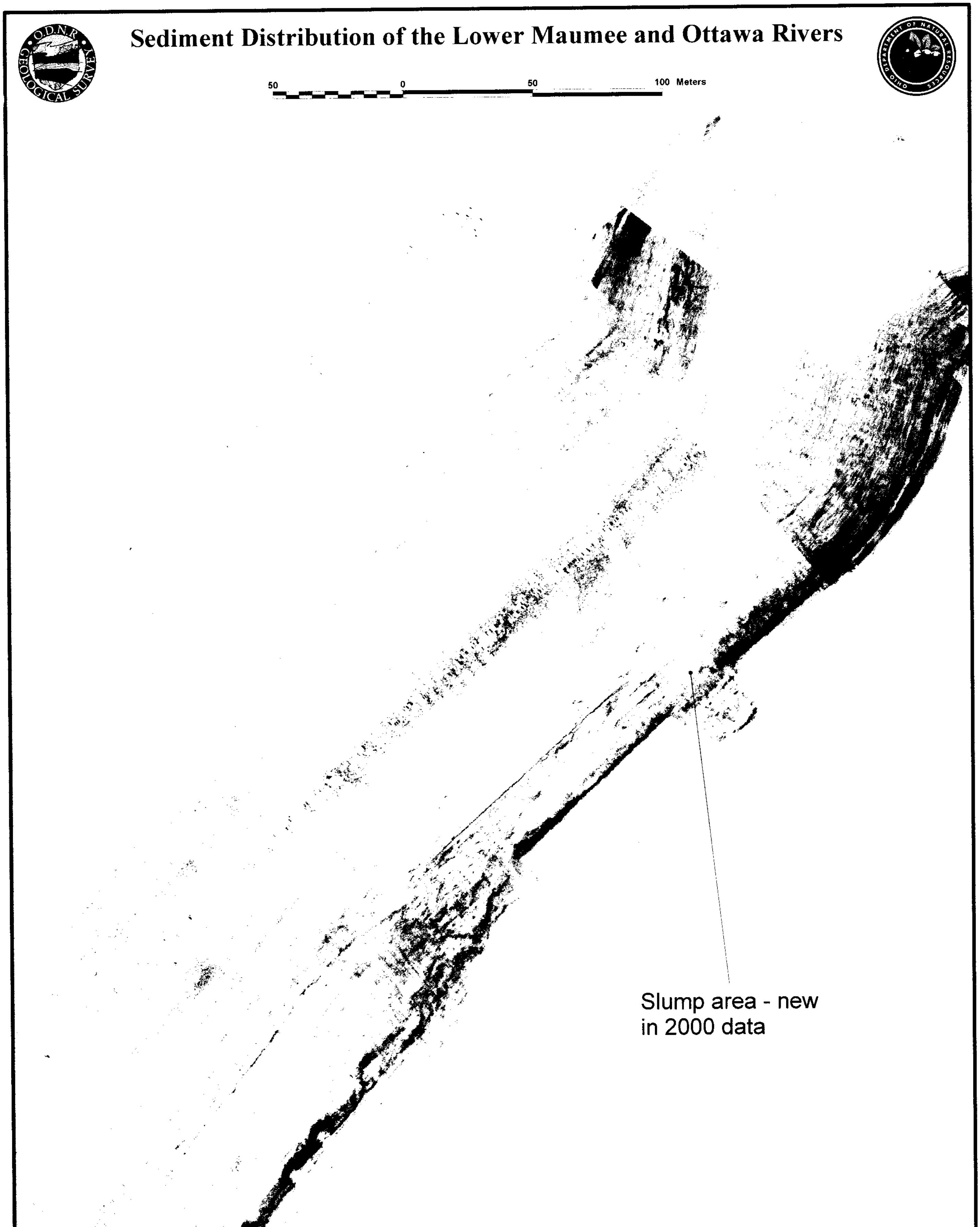

Figure 2
Slumping on Maumee River

Sediment Distribution of the Lower Maumee and Ottawa Rivers

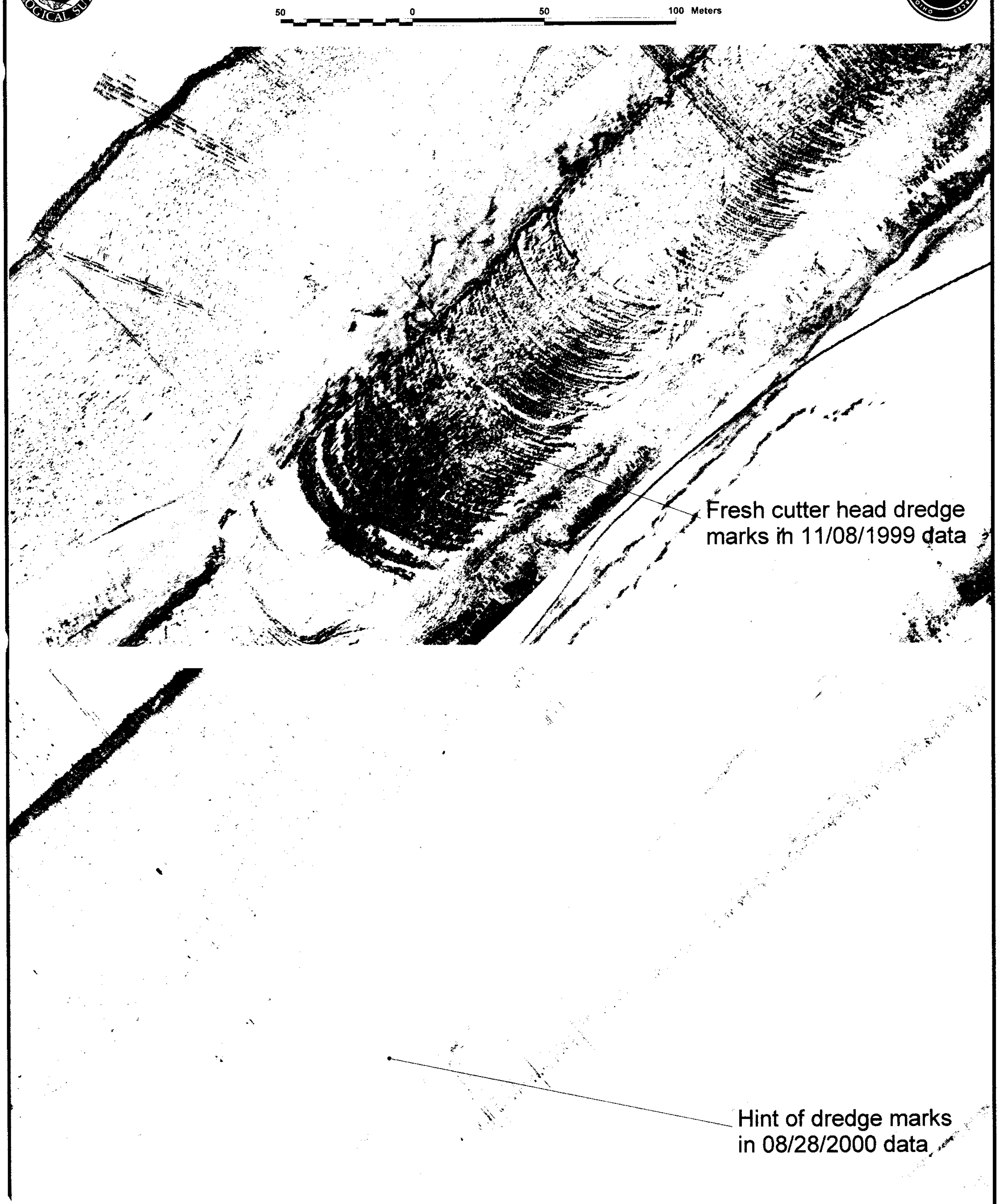

Figure 3
Dredge marks on bed of Maumee River

Sediment Distribution of the Lower Maumee and Ottawa Rivers

Figure 4
Drag marks on bed of Maumee River

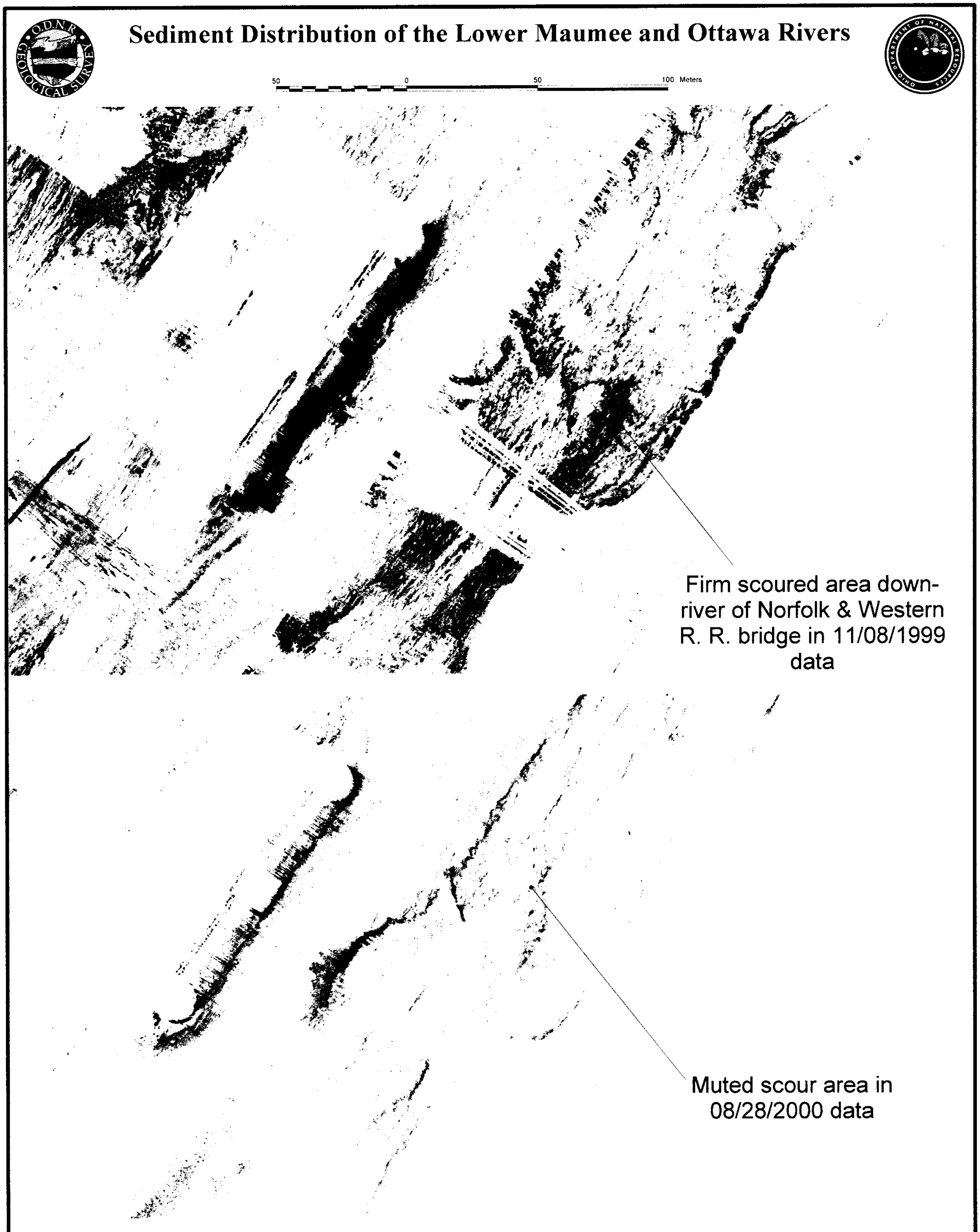

Figure 5
Scour area on bed of Maumee River