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Project Title: Sediment and Contaminant Transport in the Maumee River

Project Category: Contaminated Sediments

Rank by Organization (if applicable): 0

Total Funding Requested ($): 203,947 **Project Duration:** 2 Years

Abstract:

The Maumee River is an Area of Concern due to bottom sediments heavily contaminated primarily with PCBs, but also with PAHs and heavy metals. At the same time, a large amount of data on flow rates, suspended sediment concentrations, and sediment contaminants is available for this river. For these reasons, it is proposed to apply, verify, and demonstrate a realistic and predictive model of sediment and contaminant transport and fate in the Maumee River. Preliminary calculations to predict the effects of various proposed remedial actions will also be made. Model parameters (most importantly for sediment erosion, deposition, and bulk properties) will be determined a priori on the basis of field and laboratory tests. Sediment erosion will be measured as a function of depth in the sediments with shear stress as a parameter by means of Sedflume. Little calibration or fine-tuning of the parameters will be required. The emphasis of the modeling will be on sediment and contaminant transport from "hot spots," especially during big events. The models to be used are based on previous research and modeling by us, and minimal modifications will be needed for applications to the Maumee.

Geographic Areas Affected by the Project

States:

- ☐ Illinois
- ☐ Indiana
- ☐ Michigan
- ☐ Minnesota
- ☐ New York
- ☐ Pennsylvania
- ☐ Wisconsin
- ☒ Ohio

Lakes:

- ☐ Superior
- ☐ Huron
- ☐ Michigan
- ☒ Erie
- ☐ Ontario
- ☐ All Lakes

Geographic Initiatives:

☐ Greater Chicago ☐ NE Ohio ☐ NW Indiana ☐ SE Michigan ☐ Lake St. Clair

Primary Affected Area of Concern: Maumee River, OH

Other Affected Areas of Concern: Great Lakes Areas of Concern that are affected by Contaminated Sediments (almost all).

For Habitat Projects Only:

Primary Affected Biodiversity Investment Area:

Other Affected Biodiversity Investment Areas:

Problem Statement:

Many contaminants are sorbed to sedimentary particles and are buried at depths of up to several meters in the bottom sediments of rivers, harbors, and depositional areas of the Great Lakes. Possibilities for remediation include no-action (depending on natural attenuation), dredging, capping, in situ treatment, and combinations of these actions. In order to determine effective and efficient remedial actions for this type of problem, it is necessary to know whether buried sediments and their associated contaminants can be exposed and transported (a) during big events, i.e., large floods and storms, (b) during present (no-action) conditions over long periods of time, which will normally include big events, and (c) during conditions as modified by potential remedial actions, again over long periods of time and as affected by big events. For these purposes, a quantitative understanding and ability to predict sediment and contaminant transport are needed.

At present, there are numerous sites where there are contaminated sediments and ongoing remedial actions, both in the Great Lakes and elsewhere. In these locations, it is often the case that the bottom sediments are heavily contaminated, clean up costs are extremely high, and the choice of remedial action is heavily dependent on the potential effects of sediment erosion and deposition. In addition, there is often considerable disagreement among the principal parties and enforcing agencies as to the appropriate remedial action and to the predictions of models which purport to predict water quality (essentially sediment and contaminant transport) for different scenarios.

In the work proposed here, we will apply, verify, and demonstrate a realistic and predictive model of sediment and contaminant transport and fate in the Maumee River. Reasons for choosing the Maumee are that it is an Area of Concern due to heavily contaminated bottom sediments (primarily PCBs, but also heavy metals, ASCI (1996)), has an active Remedial Action Group, and has a large amount of data on flow rates and sediment concentrations. This data (much of it on a daily basis for several locations on the Maumee and tributaries) has been obtained by the USGS and the Ohio EPA with the assistance of GLNPO (summarized by Myers, 2000). This data is necessary for verification of the model and for demonstrating that the model can accurately predict sediment and contaminant transport for a wide range of conditions.

Model parameters (most importantly for sediment erosion, deposition, and bulk properties) will be determined a priori on the basis of field and laboratory tests. Sediment erosion will be measured by means of Sedflume. The emphasis of the modeling will be on sediment and contaminant transport from "hot spots," especially during big events. The models to be used are based on previous research and modeling, and minimal modifications to the model will be needed for application to the Maumee.

Relevance.

1. The most obvious significance of this work is the verification, demonstration, and application of a model to predict sediment and PCB transport and fate in the Maumee River; this model will be valid for a wide range of conditions, including big events and the prediction of sediment and PCB fluxes over long periods of time for no-action and remedial action scenarios.
2. This model is easily portable to other systems since relatively little calibration and fine-tuning of parameters is

required. As for the Maumee, erosion rates and bulk properties must be determined a priori from field and laboratory experiments for each system. Inclusion of other contaminants can also be made with the addition of the appropriate chemical reactions. It should be emphasized that, for all hydrophobic contaminants (which generally are the ones of interest), the flux due to erosion/deposition is generally the dominant process and has been the least known. This investigation will alleviate this problem.

3. The verification and demonstration of the model for the Maumee with its extensive data set will build confidence in the predictive capability of the model for a wide range of conditions and sites. Confidence in this capability should greatly reduce the disagreements between principal parties and agencies about potential effects of no-action and/or remedial actions. This is a major problem at the present time.

Proposed Work Outcome:

Previous Work.

One of the most widely used hydrodynamic and sediment transport models is that developed by Ziegler and Lick (1987, 1988). An extensive application of this model was first made to the Fox River (Gailani et al., 1991). Excellent agreement with field observations was obtained. This model was later applied to the Saginaw River, Green Bay, and Lake Erie by us at UCSB (Lick et al., 1994, Cardenas et al., 1995, Chroneer et al., 1996) and at numerous other locations by other investigators. It has also been extended to include PCB transport (Cardenas et al., 1996)

At the time this model was developed, erosion rates of sediments were generally not known and could not be measured. Only erosion rates for surficial sediments (the top few millimeters) could be measured. However, contaminated sediments are buried at depths of up to several meters. In addition, erosion rates are highly variable with horizontal location and with depth. In order to measure erosion rates at high shear stresses, with depth, and at different locations, we have developed and applied a unique flume, called Sedflume (McNeil et al., 1996; Jepsen et al., 1997). This flume has been widely used by us as well as others and, for at least one river (the Housatonic in Connecticut), is being required by EPA for the determination of erosion rates.

In order to include the data from Sedflume in the modeling of sediment transport, the model by Ziegler, Gailani, and Lick has been modified; it has also been extended to accurately include the effects of bed coarsening, deposition as a function of flow rate, and bed load - all of which are important in sediment transport (Lick et al., 1998; Jones and Lick, 2000).

Proposed Work.

A realistic and predictive model of sediment and contaminant transport and fate in the Maumee River will be verified, demonstrated, and used to predict the effects of various proposed remedial actions. The basic hydrodynamic and sediment transport model will be the model recently developed by Jones and Lick (Lick et al., 1998; Jones and Lick, 2000). This is an extension of models that we have previously developed and used and includes erosion rates as a function of horizontal location and depth as measured by Sedflume, different size classes, bed armoring, deposition rates as a function of size class and flow rate, bed load, and changes in erosion rates due to bed armoring, bed load, and deposition of different size classes. The transport and fate of PCBs will be modeled as done previously.

Erosion rates of relatively undisturbed sediments from 15 to 20 cores from the Maumee will be measured by means of Sedflume. For each core, these rates will be determined as a function of depth with shear stress as a parameter. Bulk densities of the sediments will be measured non-destructively as a function of depth by means of a gamma radiation device, dubbed the Density Profiler (Gotthard 1997; Roberts et al., 1998). The bulk properties of water content, particle size (mean and distribution), approximate mineralogy, and organic content will be determined by standard procedures. From a knowledge of the bulk density and water content, the gas content can be determined (Jepsen et al., 2000). The gas content has a significant effect on erosion rates but has been generally ignored in the past. For this field work, we are requesting the use of the Mudpuppy for approximately two weeks in the summer of 2001.

Extensive measurements of flow rates and suspended sediment concentrations for the Maumee River have been obtained and are summarized by Myers et al. (2000). Flow rates have been measured at eight locations in the Maumee River and its tributaries on a daily basis for many years, most of them from about 1920 to the present. At two locations on the main stem of the Maumee and at one location on the Auglaize, a tributary of the Maumee, suspended sediment concentrations as well as particle size have been measured on a daily basis. At the other stations, suspended sediment concentrations and particle size have also been measured, but at more irregular intervals. This type of data is necessary for input data for the model and for accurate verification of the model.

Extensive data is also available on contaminants in the bottom sediments (ASCI, 1996; funded by GLNPO). Although

the investigation was a screening analysis, the report indicates that the bottom sediments are contaminated with PCBs, PAHs, and heavy metals. Total PCBs exceeded their ER-M value (0.40 micrograms/gram) in 91% of the samples with a measured maximum of 717 micrograms/gram. Hot spots were located (a) near the former Toledo Coke facility, (b) near the mouth of Swan Creek, and (c) near the mouth of the Maumee River. In our modeling, the sediment and contaminant transport in these areas will be emphasized.

The general plan of investigation is as follows. First, apply and preliminarily verify the sediment and contaminant transport in the river using our best estimates of erosion rates, deposition rates, and bulk properties as well as existing data for flow rates, suspended sediment concentrations, and bottom PCB concentrations. Preliminary calculations for the main stem of the Maumee (including Swan Creek) will then be made. This work will be done in the first year.

The locations of sediment cores for Sedflume tests will then be determined on the basis of these calculations and the resulting information on erosional/depositional areas and the approximate magnitude of erosion/deposition. Potential remedial actions and their locations will also be considered in this determination. Field work to determine erosion rates for sediments from 15 to 20 cores will then be done in summer 2001.

The parameters in the transport model will then be modified based on the Sedflume data and the measured sediment bulk properties. Improved calculations will then be made for verification, for the basic understanding of transport in the system, and for the preliminary investigation of potential remedial actions. This latter will be primarily for demonstration purposes. Serious consideration of potential remedial action will necessitate further field work, possibly on sediment properties but primarily on a finer and more accurate resolution of contaminant concentrations in the bottom sediments.

This model and advice on use of the model will be made available to all interested parties. In particular, it is expected that the Ohio EPA will be interested in and will make use of the model for the understanding and prediction of effects of possible remedial actions in the Maumee River Basin. It is also expected that the USGS will make use of the model for the Maumee but also for other rivers of interest.

Project Milestones:	**Dates:**
Project Start	07/2000
Preliminary Modeling and Calculations	06/2001
Field Work	09/2001
Analysis of Field and Laboratory Data	12/2001
Improved Parameters in Model	12/2001
Calculations for Understanding and	/
for Potential Remedial Actions	06/2002
Project End	06/2002

☐ Project Addresses Environmental Justice

If So, Description of How:

☐ Project Addresses Education/Outreach

If So, Description of How:

Project Budget:

	Federal Share Requested ($)	Applicant's Share ($)
Personnel:	99,288	19,388
Fringe:	17,512	3,296
Travel:	14,000	0
Equipment:	0	0
Supplies:	8,000	0
Contracts:	0	0
Construction:	0	0
Other:	4,000	0
Total Direct Costs:	142,800	22,684
Indirect Costs:	61,147	0
Total:	203,947	22,684
Projected Income:	0	0

Funding by Other Organizations (Names, Amounts, Description of Commitments):

We will receive no other funding directly applicable to this work. However, basic research on sediment erosion and deposition is being funded by the U.S. Army Corps of Engineers ($450,000 from August, 1999 to July, 2003).

A preliminary meeting has been held for the purpose of proposing a wider and more extensive investigation of sediment and contaminant transport throughout the Maumee River Basin (including soil erosion, land run-off, transport through the Maumee River tributaries as well as the Maumee River into Lake Erie, interactions with Lake Erie currents and oscillations, and possibly meteorological interactions). This meeting was hosted by the USACE, the USGS, and NRCS. Approximately 12 interested parties from government, academia, and industry participated. If this proposal is developed, accepted, and funded, a portion of the funds will be used to supplement the investigation proposed here. In particular, more accurate descriptions of sediment and contaminant run-off from the land, flocculation, and sediment-water fluxes of PCBs will be developed and applied. The development of this proposal is in progress.

Description of Collaboration/Community Based Support:

This work will be done in collaboration with the USGS (Donna Myers) and with the Ohio EPA (Tom Balduf and other personnel). Donna Myers will assist in obtaining and interpreting existing data on flow rates and sediment concentrations in the Maumee. Tom Balduf will assist in obtaining and interpreting existing data on contaminants in the sediments of the Maumee. No funds for their time are being requested. It is expected that UCSB, USGS, and OEPA investigators will meet approximately each six months for planning and review purposes. The local RAP group (John Kusnier, personal communication) strongly supports this proposal and will meet with us at intervals for information and so as to participate in decision making.