LAKE MICHIGAN POTENTIAL DAMAGES STUDY
For the U.S. Army Corps of Engineers

NTH/Wade-Trim Joint Venture under contract to the U.S.A.C.E.

DRAFT MEMORANDUM

TO: Lake Michigan Potential Damages Study Team

FROM: David White, Wade-Trim
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DATE: October 22, 1999

RE: Task 2.6 – Determine Estuarine Backwater Effects

The purpose of Task 2.6 is to evaluate the potential for using existing Floodplain Insurance Studies and Floodplain Management Studies to determine estuarine backwater effects. This memorandum presents our results and recommendations.

Objective

The objectives of Task 2.6 – Determine Estuarine Backwater Effects include:

- Obtain, document, and review existing Flood Insurance and Floodplain Management Studies for three river study areas in Michigan and one in Wisconsin

- Compare flood studies with regards to the Lake Michigan hydrologic scenarios (the High, High and Low, Low condition)

- Define the limits of Lake Michigan influences**.** The limits were defined under the Task 2.6 scope as the distance upstream where Lake Michigan backwater effects no longer influence the inundation levels; or, where projected land use development no longer exists.

- Determine if additional calculations are needed to define the limits of Lake Michigan influences on backwater

The results of Task 2.6 will be used to define project boundaries for use in subsequent project tasks related to future development projections and estimation of damages.

Study Areas

Four river/lake systems were identified:

Grand River beginning at Grand Haven, MI (Ottawa County)
Kalamazoo Lake and River beginning at Saugatuck, MI (Allegan County)
Macatawa Lake and River beginning at Holland, MI (Ottawa County)
Sheboygan River beginning in Sheboygan, WI (Sheboygan County)

Existing Flood Studies and Floodplain Maps

Available Flood Insurance Studies and Floodplain Management Studies for the four systems were obtained through the aid of the Corps of Engineers (COE), Federal Emergency Management Agency (FEMA), Wisconsin Department of Natural Resources (WDNR), the Michigan Department of Environmental Quality (MDEQ), and the Ottawa County Drain Commission. Water surface profile model code which contains cross-sectional data was not obtained as a part of this work. Table 1 presents a listing of the available studies and maps obtained to date.

The flood studies were reviewed with regards to Lake Michigan elevations, available floodplain mapping, and defined limits of Lake Michigan backwater effects.

Lake Michigan Elevations

Each flood study was reviewed to identify the range of Lake Michigan elevations that had been considered in the development of flood profiles and mapping. Lake Michigan elevations evaluated in the studies corresponded to a 10, 50, 100, and 500-year return period. Table 2 presents the Lake Michigan elevations used in each study.

Table 2
Flood Insurance Study Lake Michigan Elevations [(1)]

Return Period	Grand and Kalamazoo [(2)]	Macatawa [(3)]	Sheboygan [(4)]
10-year	582.8	583.3	582.8
50-year	583.7	584.4	583.9
100-year	584.0	584.8	584.3
500-year	584.6	585.7	585.2

(1) All elevations are in NGVD, 1929.

(2) U.S. Army Corps of Engineers document titled Great Lakes 100-Year Open-Coast Flood Levels , February 1977. According to the FIS report, these elevations were based on mean levels from long term lake level monitoring.

(3),(4) U.S. Army Corps of Engineers document titled Revised Report on Great Lakes Open-Coast Flood Levels dated April 1988. According to the FIS report, these elevations include both still water elevations from long term elevation data and surge/setup effects.

Variations in Lake Michigan levels can be attributed to the source of the elevation information. These sources are noted below Table 2.

Floodplain Mapping

Detailed 100-year and 500-year floodplain mapping was found to be available for all four study areas. The floodplain maps identify flooding due to both Lake Michigan and upstream tributary flood flows.

Existing Defined Limits of Lake Michigan Backwater Effects

The limits of Lake Michigan backwater effects are specifically identified on the flood profile plots included in each study. These limits were defined as the point where the

Lake Michigan elevations intersect the upstream river flood profiles for the 10, 50, 100 and 500-year flood flows. Table 3 presents the approximate limits of the Lake Michigan impacts as defined in the flood studies. The limit is presented in terms of stream length from the Lake Michigan boundary with the river/lake system.

Table 3
Limits of Lake Michigan Impacts as Defined in Flood Insurance Studies

Study Area	Distance Along River Upstream of Lake Michigan	Approximate Location of Limits of Lake Michigan Influences on River
Grand River	21,300 ft (4.0 mi)	At confluence of Lloyd Bayou outlet within the City of Grand Haven
Kalamazoo Lake and River	27,500 ft (5.2 mi)	Between Peach Orchard Creek and Indian Point within Saugatuck Township
Macatawa* Lake and River	33,800 ft (6.4 mi)	Between Butternut Drive and the CSX railroad within the City of Holland
Sheboygan River	8,900 ft (1.8 mi)	Upstream of the 14th Street Bridge within the City of Sheboygan

* Includes the effects of Lake Macatawa backwater which connects to Lake Michigan through a narrow channel.

Lake Michigan Elevations for Hydrologic Scenarios

Approximate High, High and Low, Low Lake Michigan elevations were identified for the hydrologic scenarios by WT under Task 2.6 for use in assessing the flood studies. Elevations were converted to the NGVD, 1929 data as the flood insurance studies and DRG maps are in the NGVD, 1929 system.

High, High Condition

It is our understanding that the High, High condition elevation includes the high still water elevation plus the effects of storm surge/ setup due to strong wind effects. WT assumed that the influence of waves on inland river backwater elevations would be negligible. The still water elevation was obtained from the Lake Michigan Level Scenarios – Frequency Analysis Figure, Paleo Lake Levels – The Last Four Thousand Years, Workshop at Great Lakes Environmental Research Laboratory report, April 1999. Storm surge was determined by W.F. Baird, Associates to be approximately 2.0 feet. Thus, the High, High elevation was determined in NGVD, 1929 as:

High, High Condition Lake Michigan Elevation
= 582.0 ft (IGLD, 1955) + 2.0 ft surge + 1. 43 ft (Conversion to NGVD, 1929)
= 585.5 ft (NGVD, 1929)

For Task 2.6, WT assumed that the High, High condition elevation was applicable to both the eastern (Michigan side) and western (Wisconsin side) shore of Lake Michigan.

Low, Low Condition

It is our understanding that the Low, Low condition elevation includes the low still water elevation only. At this time, estimates of "drawdown" effects that storm surges may have on lowering this water level are not yet available. The Low, Low elevation was also obtained from the GLERL report. Thus, the Low, Low elevation was determined in NGVD, 1929 as:

Low, Low Condition Lake Michigan Elevation
= 573.7 ft (IGLD, 1955) + 1.43 ft (Conversion to NGVD, 1929)
= 575.1 ft (NGVD, 1929)

For Task 2.6, it was assumed that the Low, Low condition elevation is applicable to both the eastern (Michigan side) and western (Wisconsin side) shore of Lake Michigan.

Assessment of Use of Existing Studies

The limits of each study area can be defined as the distance upstream where Lake Michigan backwater effects no longer influence the inundation levels. For the High, High condition, this involves defining the point or location along the river system at which Lake Michigan no longer influences flood inundation. For the Low, Low condition, this involves defining the point along the river bed at which Lake Michigan no longer influences low water inundation. A key concept in assessing the limits of the Lake Michigan impacts is the issue of defining impacts with or without upstream flows. For this Phase of the Lake Michigan study, it is our understanding that the focus will be on Lake Michigan backwater impacts due to the Lake and not necessarily in combination with local tributary flood flow conditions. With this concept, the use of existing flood studies to define the limits and project boundaries are assessed below.

High, High Condition Limits

Three possible approaches to defining the limits of flooding due to Lake are identified below along with the advantages, disadvantages and levels of effort associated with each approach. Options 1 and 3 account for effects of upstream flows. Option 2 does not account for the effects of upstream flows.

Option 1 – Use existing Flood Studies. Lake Michigan elevations in studies are reasonable in comparison to the High, High condition elevations. Defines limits assuming upstream flood flows.

Advantage: Limits already defined; no further work needed. Considers contributions of upstream flood flows. Good approximation of limits under large flood flows.

Disadvantage: Does not define impacts of Lake Michigan on flooding upstream of this limit. May underestimate area subject to potential damages.

Level of Effort: Minor.

Option 2 – Do not use existing Flood Studies. Perform additional calculations using GIS data. Use limits as defined by the intersection of Lake Michigan elevations with topography data. Defines limits assuming no upstream flows.

Advantage: Extends limits further upstream than those identified in Option 1.

Disadvantage: Does not consider increased flooding impacts due to Lake Michigan on upstream flows. May overestimate area subject to potential damages. Existing topographic DEM data may not be sufficient to define the wetted perimeter to a 0.5 ft to 1.0 ft accuracy.

Level of Effort: Moderate. Requires additional work with GIS and DEM models to identify limits.

Option 3 – Do not use existing Flood Studies. Use limits as calculated from detailed hydraulic analysis with computer models for selected upstream flow conditions.

Advantage: Limits of Lake Michigan influences for a range of flow conditions can be determined. Flooding caused by Lake Michigan under low, average or storm flow conditions can be defined.

Disadvantage: Requires significant work in obtaining models, updating to current coding standards, and running simulations. May not provide significant difference in limits beyond the first two methods to justify cost.

Level of Effort: Extensive.

Based on a review of the three options, Option 1 is recommended for use in this Phase of the Lake Michigan Potential Damages Study for the High, High condition. The possibility of using Option 2 was explored and found at this time not to be feasible with the current DEM grid of 30 meter resolution.

Low, Low Condition Limits

Three possible approaches to defining the limits of flooding due to Lake are identified below along with the advantages, disadvantages and levels of effort associated with each approach. Option 1 and 2 does not account for effects of upstream flows. Option 3 accounts for the effects of flooding from upstream flows.

Option 1 – Use existing Flood Studies. Determine limit as the intersection of the Low, Low Lake Michigan elevation with the river bed profiles. Assumes no upstream flows.

Advantages: Defines the upstream limit or point of Lake Michigan influences with minimal effort.

Disadvantage: Approximate inundation area is unknown. Existing studies do not provide backwater profiles for Lake Michigan levels lower than approximately 583 ft (NGVD, 1929) or mapping for elevations lower than approximately 584.0 ft (NGVD, 1929).

Level of Effort: Minor.

Option 2 – Do not use existing Flood Studies. Use Limits as defined by the intersection of the Low, Low Lake Michigan Elevation with bathymetry data of the river bed. Defines limits assuming no upstream flows.

Advantage: Defines the low water line with moderate effort. Needed to defined the extent of low water inundation. Existing flood studies do not provide mapping of low water levels.

Disadvantage: Does not consider contributions from upstream flows. Upstream flows may result in a reduction of low water line limits due to contributions of flows from upstream. May overestimate area subject to potential damages.

Level of Effort: Moderate. Requires additional work with GIS and DEM models to identify limits.

Option 3 – Do not use existing Flood Studies. Use limits as defined by detailed hydraulic analysis with computer models. Allows for definition of limits based on varying upstream flows.

Advantage: Limits of the low water line for any upstream flow condition can be determined.

Disadvantage: Requires significant work and additional cost in obtaining models and running simulations. May not provide significant difference in limits beyond the first method.

Level of Effort: Extensive.

Based on a review of the three options, Option 2 is recommended for use in this Phase of the Lake Michigan Potential Damages Study for the Low, Low condition. However, at this time, bathymetric data is not available for use in defining a low water project boundary.

Projected Land Use Development

To date, projected land use development along the four rivers has yet to be defined. For this reason, it is recommended that projected limits of Lake Michigan influences be compared with land use projections as developed under Task 5.2. Final project boundaries can be adjusted, if needed, once this has been performed.

Recommendations

Based on our review of the available flood studies in combination with the task objectives, Wade-Trim recommends:

- No further backwater modeling or analysis should be performed to define Lake Michigan backwater limits.

Thus, in order to define the project boundary under Task 5.2, Wade-Trim recommends:

- For the High, High condition:

    1. The limits of the High, High Lake Michigan influences should be defined according to the existing flood studies.

    2. An approximate High, High condition project boundary should be developed using the floodplain mapping information as defined in the Flood Insurance Studies.

    3. The final High, High project boundary for the four study areas should be reduced if areas within the boundary are determined to not include proposed development as defined under Task 5.2.

- For the Low, Low condition:

    1. Additional GIS computations should be performed using available data to define the Lake Michigan backwater limits. The area of inundation for the Low, Low Lake Michigan influences should be determined by finding the intersection of the Lake elevations with available bathymetric contour data.

        Data needs for each of the four study areas:

            (a) Bathymetric contour data for for each of the four river study areas

            (b) Water Elevation for the Digital Orthophotos in IGLD 1955, IGLD 1985 and NGVD 1929 for each of the four river study areas

            (c) Digitized water line contour (wetted perimeter) from the Digital Orthophotos for each of the four river study areas

    2. The final Low, Low project boundary for the four study areas should be reduced if areas within the boundary are determined to not include proposed development as defined under Task 5.2.