Harbor Dredging & Impacts of Changing Lake Levels on Great Lakes Shipping

Gene Clark, PE
Coastal Engineering Specialist
U W Sea Grant Institute
DISCUSSION OVERVIEW

- Introduction to Great Lakes Water Levels & Impacts to Great Lakes Shipping
- Introduction to Harbor Dredging & Beneficial Re-use of Dredged Materials
Great Lakes Water Levels

Why Water Levels Vary – Hydrologic Cycle

Lakes are just part of the overall cycle!

HYDROLOGY

The hydrologic cycle is a world-wide natural circulation system in which water evaporates from oceans, other large bodies of water (such as the Great Lakes) and land areas, condenses to form clouds, and is returned to the earth’s surface as precipitation.
Great Lakes Water Levels
System Overview
Great Lakes Water Levels
System Overview
Great Lakes Water Levels
Physical Dimensions

<table>
<thead>
<tr>
<th></th>
<th>Area (square kilometres)</th>
<th>Shoreline Length (kilometres)</th>
<th>Water Volume (cubic kilometres)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Land (2)</td>
<td>Water</td>
<td></td>
</tr>
<tr>
<td>Lake Superior</td>
<td>127700</td>
<td>82100</td>
<td>4380</td>
</tr>
<tr>
<td>St. Mary's River</td>
<td>2600</td>
<td>230</td>
<td>397</td>
</tr>
<tr>
<td>Lake Michigan</td>
<td>118000</td>
<td>57800</td>
<td>2630</td>
</tr>
<tr>
<td>Lake Huron</td>
<td>131300</td>
<td>59600</td>
<td>6160</td>
</tr>
<tr>
<td>St. Clair River</td>
<td>3290</td>
<td>60</td>
<td>101</td>
</tr>
<tr>
<td>Lake St. Clair</td>
<td>12430</td>
<td>1110</td>
<td>413</td>
</tr>
<tr>
<td>Detroit River</td>
<td>2230</td>
<td>100</td>
<td>212</td>
</tr>
<tr>
<td>Lake Erie</td>
<td>58800</td>
<td>25700</td>
<td>1400</td>
</tr>
<tr>
<td>Niagara River</td>
<td>3370</td>
<td>60</td>
<td>171</td>
</tr>
<tr>
<td>Lake Ontario</td>
<td>60600</td>
<td>18960</td>
<td>1150</td>
</tr>
<tr>
<td>St. Lawrence (1)</td>
<td>7190</td>
<td>610</td>
<td>1050</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>527510</td>
<td>246330</td>
<td>18064</td>
</tr>
</tbody>
</table>

(1) Measured from the outlet of Lake Ontario to Cornwall, Ontario/Massa, New York.
(2) Land area includes other small lakes and rivers in the basin.
(3) Including islands.
Great Lakes Water Levels
Balanced Water Supplies

**Diagram Description:**
- **Legend:**
  - Thousands of cubic feet per second
  - Runoff from land draining into the lake
  - Precipitation on the lake
  - Evaporation from lake
  - Flow in connecting channels

**Hydrologic Factors Affecting Water Supplies to Each of the Great Lakes:**

**Note:** The numbers above the symbols for the hydrologic factors are average values in thousands of cubic feet per second (cfs) for the period October 1950 to September 1960. The outflows are adjusted so that supplies to the lakes equal withdrawals; i.e., conditions of no change in lake storage (lake levels constant).
Great Lakes Water Levels
Lake Superior Water Budget

Natural Factors Affecting the Levels of the Great Lakes

- Evaporation
- Precipitation

---

Lake Superior

- Inflow
- Runoff
- Groundwater
- St. Marys River
- Outflow
Great Lakes Water Levels

### Lake Superior Water Budget

#### Inputs

<table>
<thead>
<tr>
<th>Source</th>
<th>C.F.S. *</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>74,000</td>
<td>57</td>
</tr>
<tr>
<td>Run-off</td>
<td>50,000</td>
<td>39</td>
</tr>
<tr>
<td>Diversion</td>
<td>5,000</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>129,000</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

#### Output

<table>
<thead>
<tr>
<th>To</th>
<th>C.F.S. *</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michigan/Huron</td>
<td>78,000</td>
<td>60</td>
</tr>
<tr>
<td>Evaporation</td>
<td>51,000</td>
<td>40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>129,000</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

*Cubic Feet Per Second*
Great Lakes Water Levels

Water Budget Control???

What Could We Possibly Vary or Control?

• Inflows:
  • Precipitation? No (climate change?)
  • Runoff? In theory, Yes but practically, No
  • Diversion? Yes

• Outflows:
  • Evaporation? No (climate change?)
  • Outflow? Yes
  • Water consumption rates? Yes
Great Lakes Water Levels

Lake Superior Outlet Control Works

• Outlet completely controlled since 1921

• Combination of locks, hydropower plants and control structures

• Regulated by IJC
Great Lakes Water Levels
Lake Superior Outlet Control Works

Outflow To St Mary’s River

Ave Outflow is 78,000 cfs (ranges from 55,000 cfs to 134,000 cfs)

What if the “average” outflow was completely stopped???????

Lake Superior would raise 2.8 inches per month
Lake Superior would raise 33.3 inches per year

What if we could reduce “average” outflow to the “minimum” outflow??????

Lake Superior would raise 0.8 inches per month
Lake Superior would raise 9.8 inches per year

Note: July 2007 outflows are approximately 55,000 cfs,
March 2007 were 45,000 cfs!
Great Lakes Water Levels
Recent Lake Level Trends
Great Lakes Water Levels
Recent Lake Level Trends

LAKE ERIE WATER LEVELS - JULY 2007

LAKE ONTARIO WATER LEVELS - JULY 2007

LEGEND
LAKE LEVELS

AVERAGE **
1985

Maximum **
1985

Minimum **
1934

# Average, Maximum and Minimum for period 1918-2005
Great Lakes Water Levels

Near Record Lows – WHY???

- Average Lake Superior Precipitation (30.5 inches per year) down 6 inches in 2006
- Recent Warm Winters meant Less Ice Cover (More Evaporation)
- 2006-2007 Winter Snow Pack 60% Below Normal
- Part of Watershed in Drought Conditions Since May 2006
Great Lakes Water Levels
Effects On Commercial Ports of High Lake Levels

• Increased Waves & Currents (Erosion & Agitation)
• Slower Ship Speeds In Harbor (Erosion)
• Flooding (Low Areas & Seiche effects greater)
• Runoff & Nutrient Issues (Water Quality & Sediment)
• Structure Issues (Stability, Access)
• More Cargo Can Be Loaded (Good!)
Great Lakes Water Levels
Effects On Commercial Ports of Low Lake Levels

• Light Loading of Ships – Less Cargo
Great Lakes Water Levels
Effects On Commercial Ports – Low Water

• Dock Access
  (smaller facilities)
Great Lakes Water Levels
Effects On Commercial Ports – Low Water

• Infrastructure Issues
  (Steel, wood, concrete)
Great Lakes Water Levels
Effects On Commercial Ports – Low Water

- Infrastructure Issues – Ice Problems
  Port Wing, WI (2007)
Great Lakes Water Levels
Effects On Commercial Ports – Low Water

• Facility Water Intake Issues
Great Lakes Water Levels
Effects On Commercial Ports of Low Water Levels

- Increased Channel Maintenance – Dredging!
  If you can’t *Raise* the water, *Lower* the channel!
Harbor Dredging & Beneficial Re-Use
What is Dredging & Why Dredge?
Harbor Dredging & Beneficial Re-Use
Great Lakes Army COE Federal Harbors

- Commercial, deep draft 53
- Commercial, shallow draft 1
- Recreational, deep draft 3
- Recreational, shallow draft 60

- Total “Federal” Harbors 117

(* shallow draft typically under 10 feet)
Harbor Dredging & Beneficial Re-Use
How is Dredging Done? Mechanical Dredging

- Wide variety of equipment
- Requires rehandling (barges)
- Typically better for finer material disposal
- Greater % solids
- Accuracy methods (crude)
Harbor Dredging & Beneficial Re-Use
How is Dredging Done? Hydraulic Dredging

- Specialized equipment
- Can pump long distances
- Uses water to transport
- Typically better for coarse material disposal
- Less % solids
- Accuracy methods (better)
Harbor Dredging & Beneficial Re-Use
What else can you do with all that material?

Beneficial Use of Dredged Material in the Great Lakes

Select an icon to learn more about projects related to each topic.
A new window will appear to display the information.
Harbor Dredging & Beneficial Re-Use
What Does Duluth/Superior Harbor Typically do?
Harbor Dredging & Beneficial Re-Use
Duluth/Superior Harbor 2007 Dredging Project

120,000 cy (How many trucks would this be?)

Project Details
• Working 6 days a week, this will take 90-120 days!
• They will use one dredge (mechanical) with a 6 cy bucket
• They expect to average 50-80 cy/hr (approx 1 bucket per minute)
• They will use two barges, each with a 600 cy capacity
• Each barge takes approx 2 hrs to unload into Erie Pier
• All 120,000 cy from lift bridge to Port Terminal area!
Harbor Dredging & Beneficial Re-Use
Duluth/Superior Erie Pier Management Plan

ERIE PIER OPERATIONS

Fines flowing down the sluiceway

Washed Material being staged for removal
Harbor Dredging & Beneficial Re-Use
Duluth/Superior Erie Pier Management Plan

Plan Outline

4. Preparation of Material for Reuse
   • Preference for large Projects
   • Types of Possible Projects to Date
     • Mineland reclamation
     • WLSSD Soils Program
     • Landfill cover
     • Construction uses

5. Plan Implementation
   • Public Education & Business Outreach
   • Memorandums of Understanding
Harbor Dredging & Beneficial Re-Use
Duluth/Superior Erie Pier Management Plan

Major Issues To Solve

**Water Management**
- Filter Systems being designed
- Long-term testing plan
- Agreements needed on discharge limits

**Invasive Species**
- Removal from Erie Pier
- Long-term monitoring plan of sites where material is placed

**Marketing Material**
- Need to get material tested
- Support from Government Agencies
  - Cities, Counties, State DOTs, and others
- Long-term testing plan