Great Lakes
Navigation

Great Lakes Dredging Evaluation

Inland Nav CoP Workshop
20 Sep 2007

Jon Brown
Buffalo District

Great Lakes
Navigation

Great Lakes Dredging Evaluation Overview

- Need for O&M Economic Metrics
- Physical GL System
- Existing GL Navigation System
- Existing GLLAPOM
- Proposed GL-SAND

Great Lakes Navigation

O&M Metric Needs

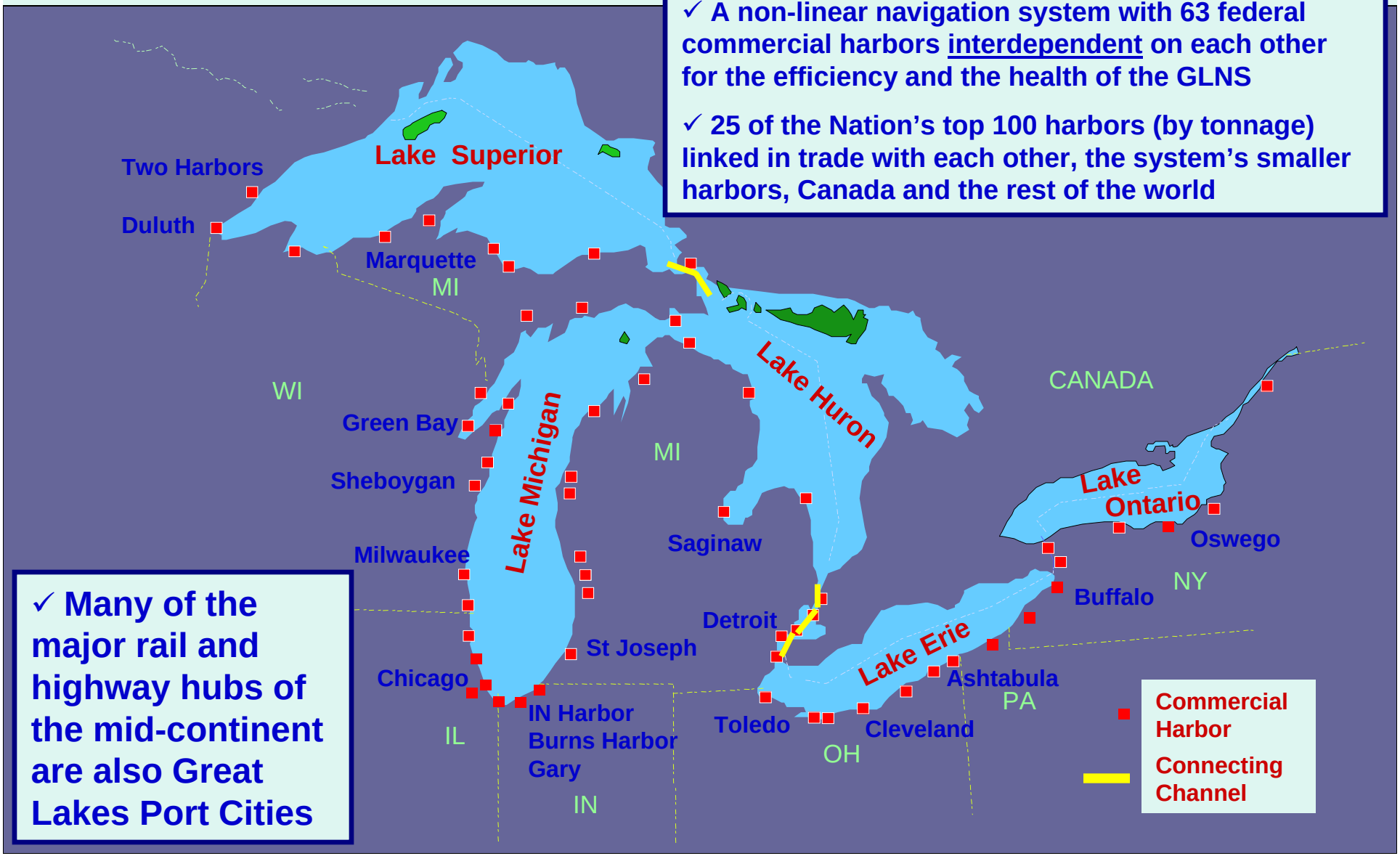
- LRB O&M planning studies history
- Budget prioritization requirements
- OMB wants to see return on investment
- Derive NED benefits
- Dredging – Determine transportation cost impacts of not dredging
- Harbor Structure maintenance, repair and Rehabilitation – Delay cost avoided & damages avoided

Great Lakes Navigation

Great Lakes Navigation System (GLNS)

✓ A non-linear navigation system with 63 federal commercial harbors interdependent on each other for the efficiency and the health of the GLNS

✓ 25 of the Nation's top 100 harbors (by tonnage) linked in trade with each other, the system's smaller harbors, Canada and the rest of the world



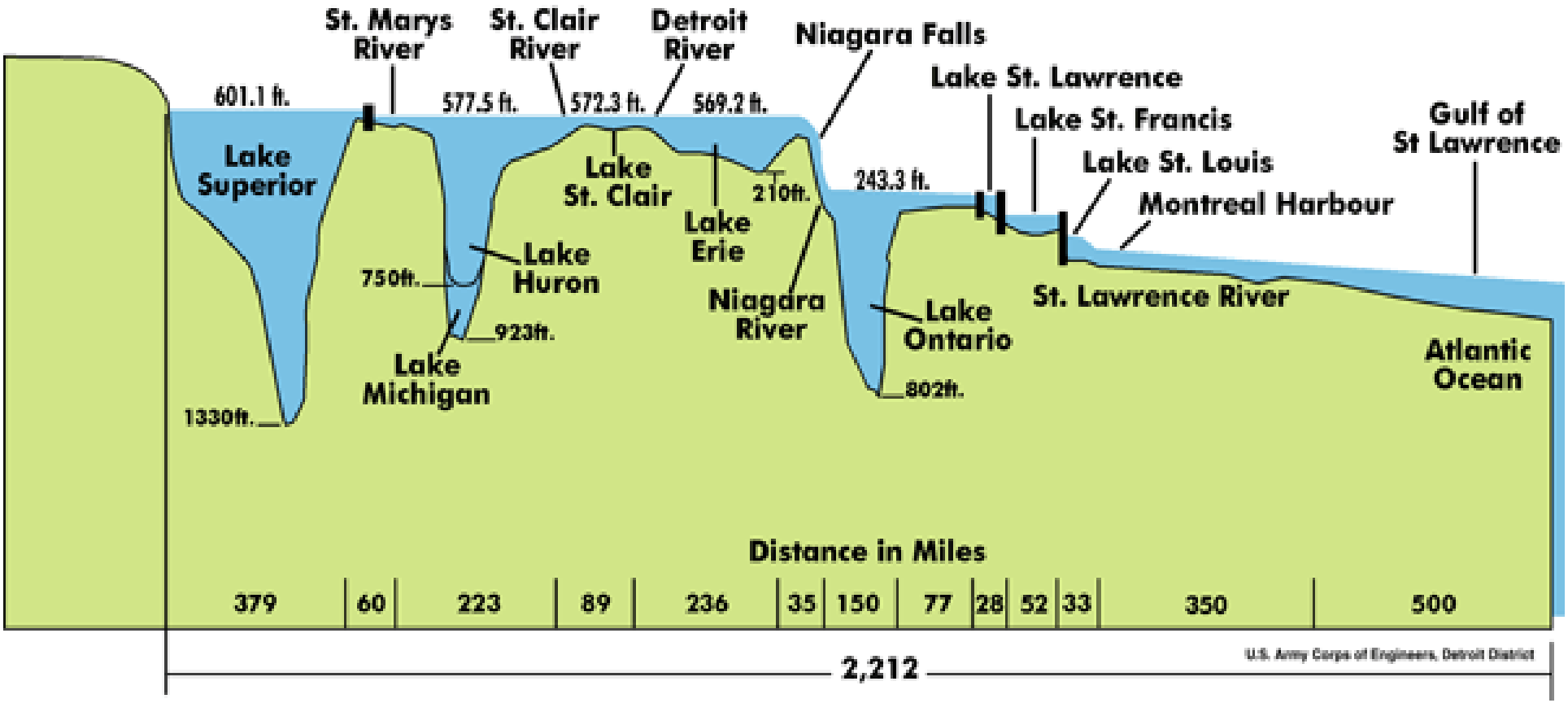
✓ Many of the major rail and highway hubs of the mid-continent are also Great Lakes Port Cities

Great Lakes
Navigation

Great Lakes – St. Lawrence Seaway

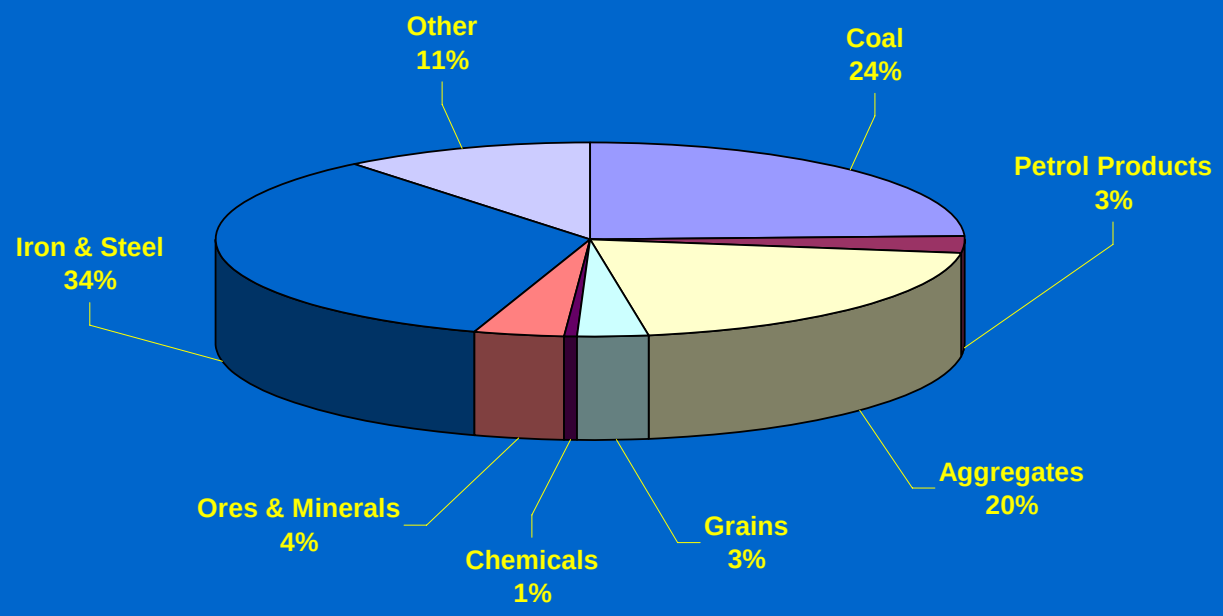
Great Lakes Navigation

Great Lakes System Profile



Great Lakes Navigation

Great Lake System Traffic and Rate Savings



Commodity	2005 Tons		Rate Savings
Coal	42,186,438	$	553,486,067
Petrol Products	4,979,764	$	115,430,930
Aggregates	35,329,206	$	568,800,217
Grains	5,056,971	$	95,627,322
Chemicals	1,041,941	$	21,026,369
Ores & Minerals	6,633,840	$	131,814,401
Iron & Steel	59,426,036	$	618,625,035
Other	18,524,217	$	594,256,881
	173,178,413	$	2,699,067,221

Great Lakes Navigation

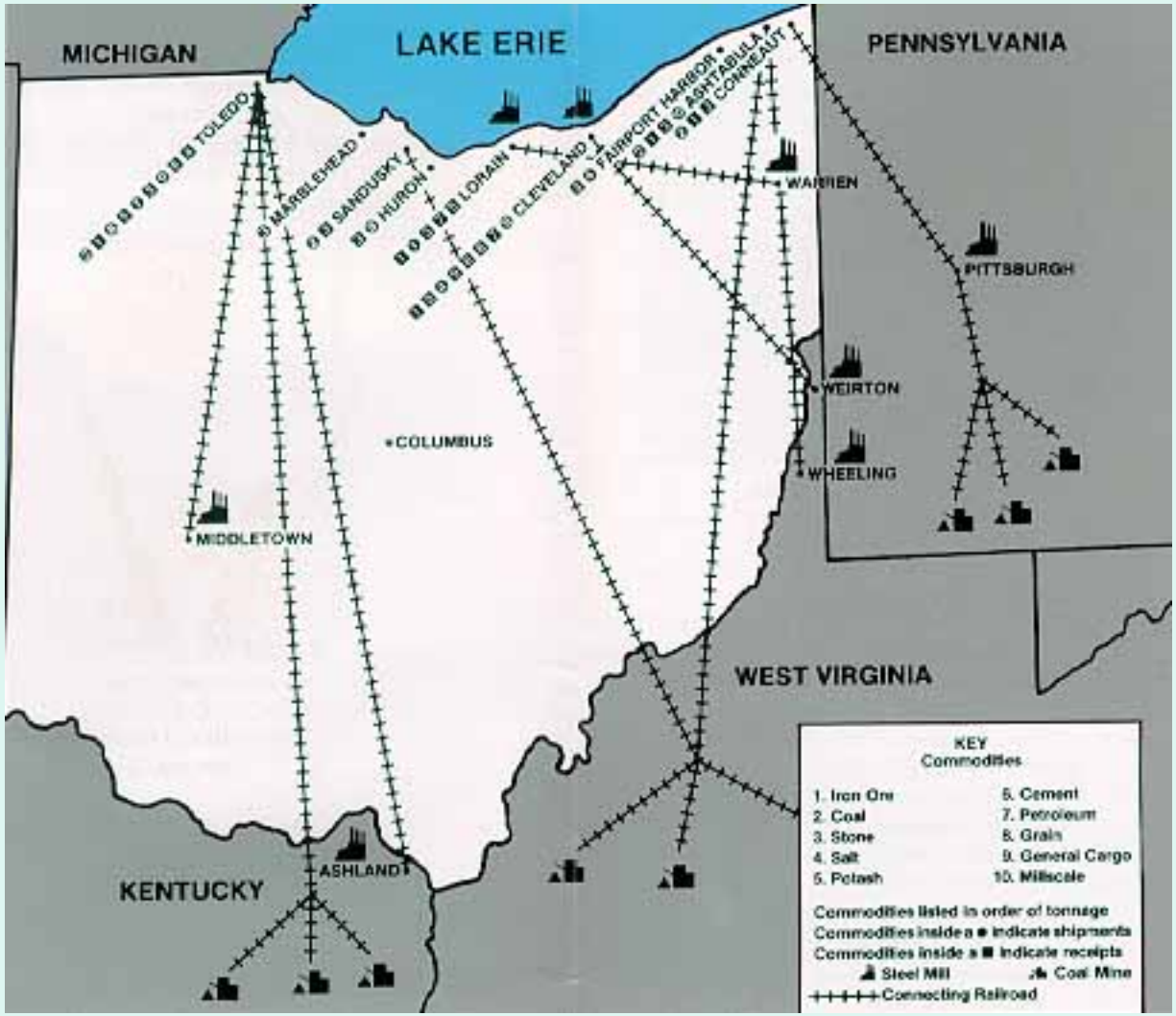
Iron Ore Pellets

Great Lakes Navigation

Eastern Coal

Great Lakes Navigation

Source of Eastern Coal



Great Lakes Navigation

Western Coal

Great Lakes Navigation

Limestone

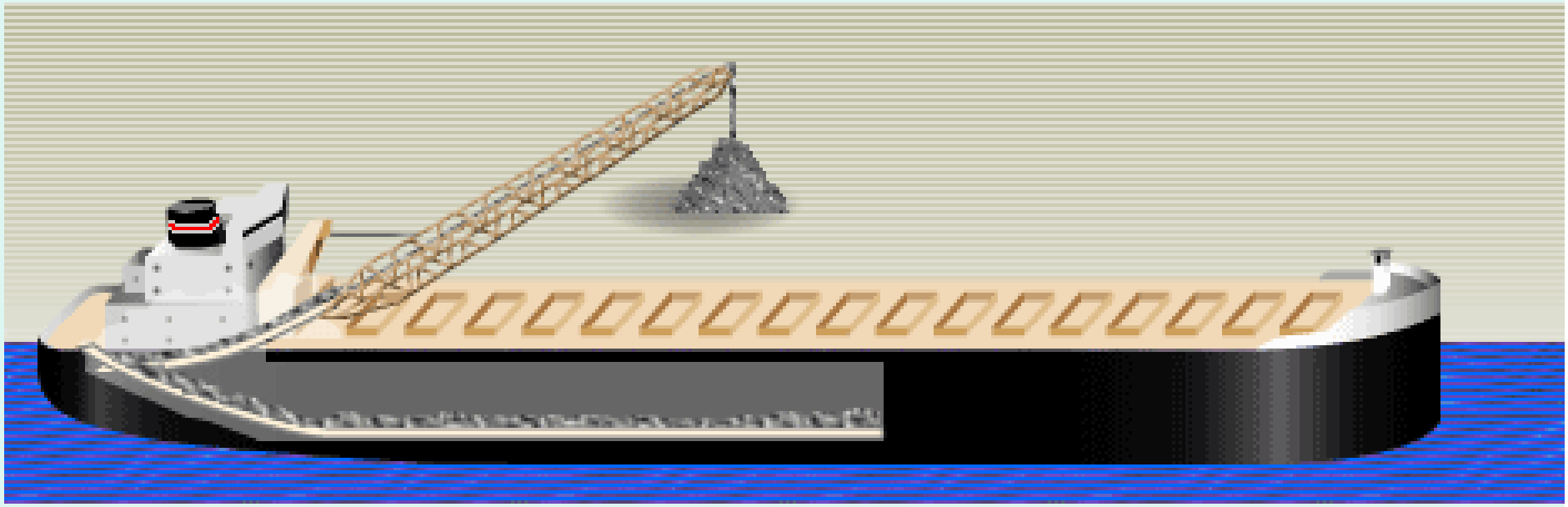
Great Lakes Navigation

Great Lakes Fleet Self-Unloaders & Bulk Freighters

Vessel Class	U.S.	Canadian	Total
1 (<400 ft)	6		6
2 (400-499 ft)	1		1
5 (600-649 ft)	15	6	21
6 (650-699 ft)	7	4	11
7 (700-730 ft)	7	51	58
8 (731-849 ft)	12	3	15
9 (850-949 ft)	1		1
10 (950-1,099 ft)	13		13
	---	---	---
	53	70	126

Great Lakes
Navigation

Self Unloader



Great Lakes Navigation

Class X

Great Lakes Navigation

Class VII

Great Lakes
Navigation

Class V

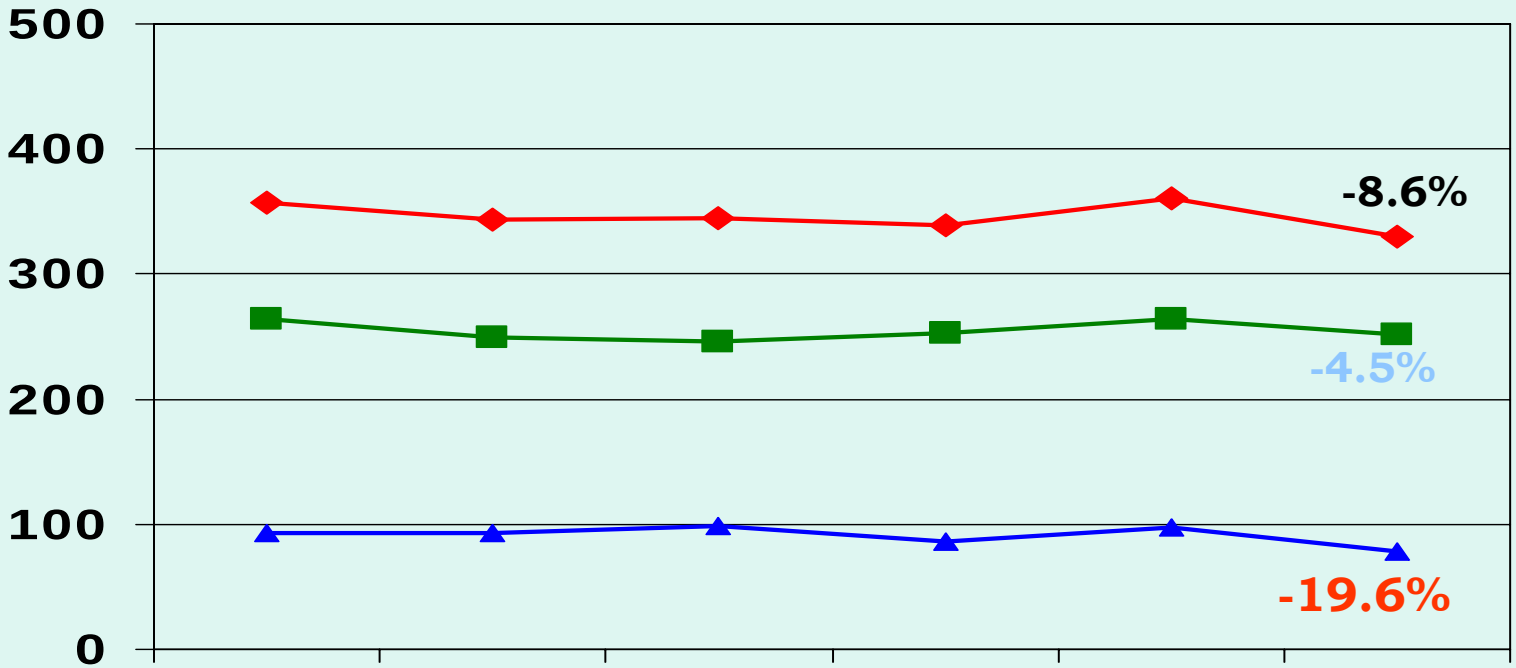
Great Lakes Navigation

Challenge: Aging Infrastructure & Restricted Navigation Channels

- Many navigation structures are greater than 100 years old.
- Large drainage basins, which typically discharge at Federal harbors, are responsible for rapid and heavy shoaling.

Great Lakes Navigation

Operations & Maintenance (O&M) (x000)



	FY01	FY02	FY03	FY04	FY05	FY06
LRD	357	343	345	339	361	330
Ohio River	264	250	246	253	264	252
Great Lakes	93	93	99	86	97	78

Great Lakes Navigation

Breakwaters

Great Lakes Navigation

- 140+ miles of breakwaters on the Great Lakes
- Most built between 1860 and 1940
- Timber crib construction (typical)
- Low Lake water levels are accelerating deterioration

Great Lakes Navigation

Summary of Ave Annual Maintenance – Buffalo District

- About million CY at 10 harbors dredged annually
- Up to 2,000 linear feet of navigation structures repaired by floating plant
- Approx. 1 major construction contract let for repairing navigation structures (1-3 million $$)

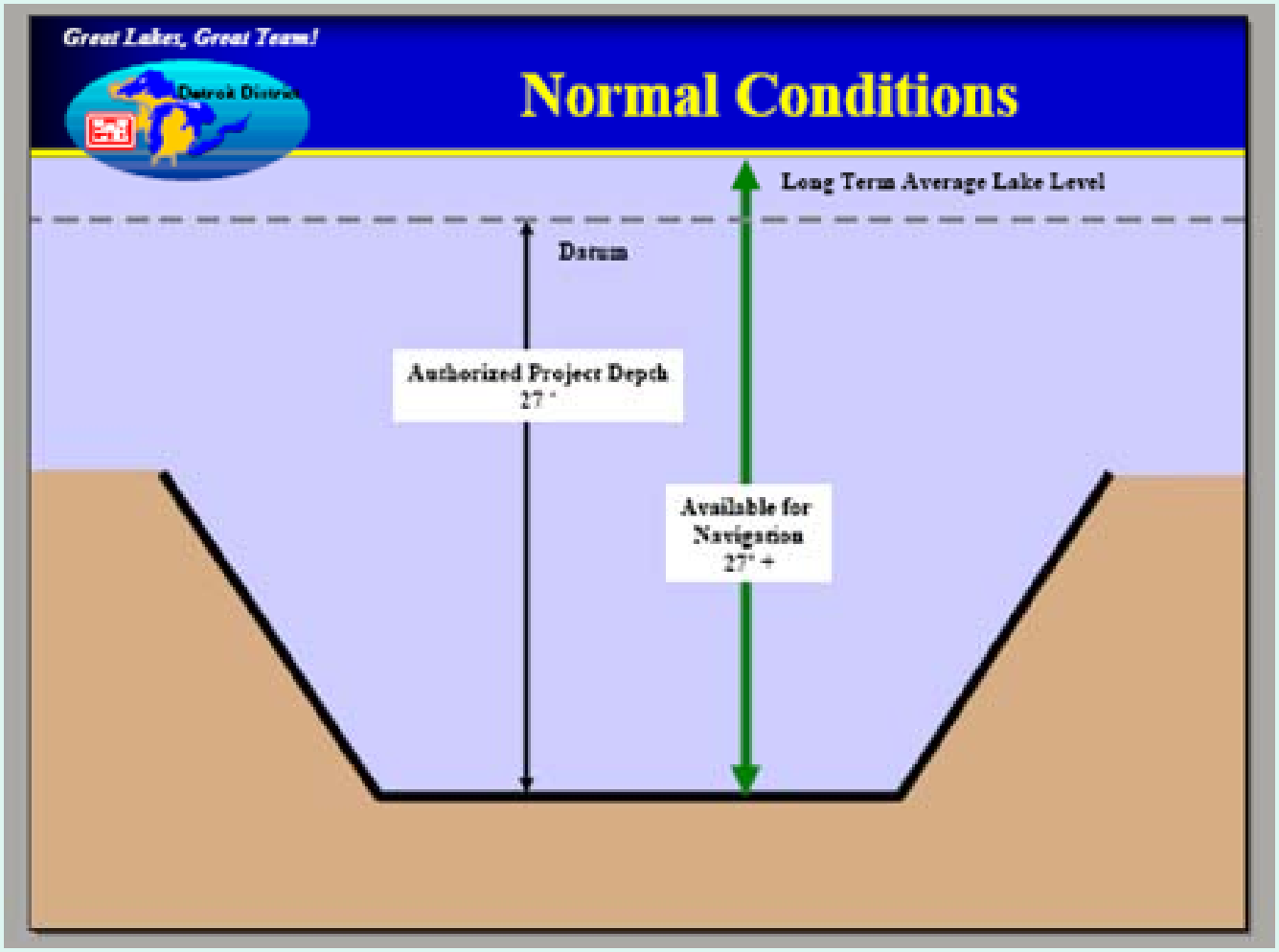
Great Lakes
Navigation

Lake Level Variation

- During 106 year period of record, lake levels have varied by:
  - 5.3 feet on Lake Ontario (Apr & May)
  - 5.6 feet on Lake Erie (Dec)
  - 5.9 feet on Lake Michigan-Huron (Oct)
  - 3.2 feet on Lake Superior (May)

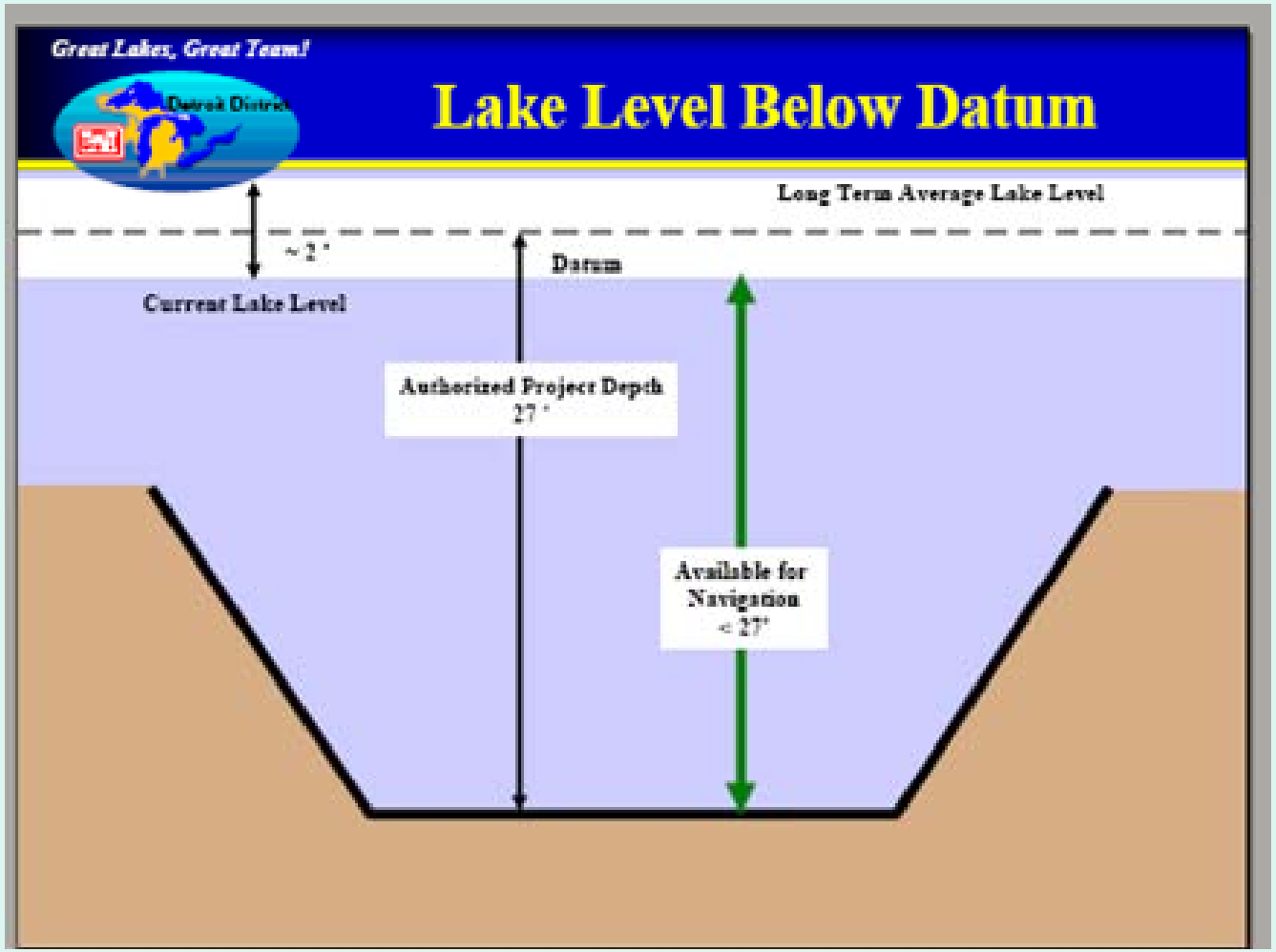
Great Lakes Navigation

Available Water Column- Normal Conditions



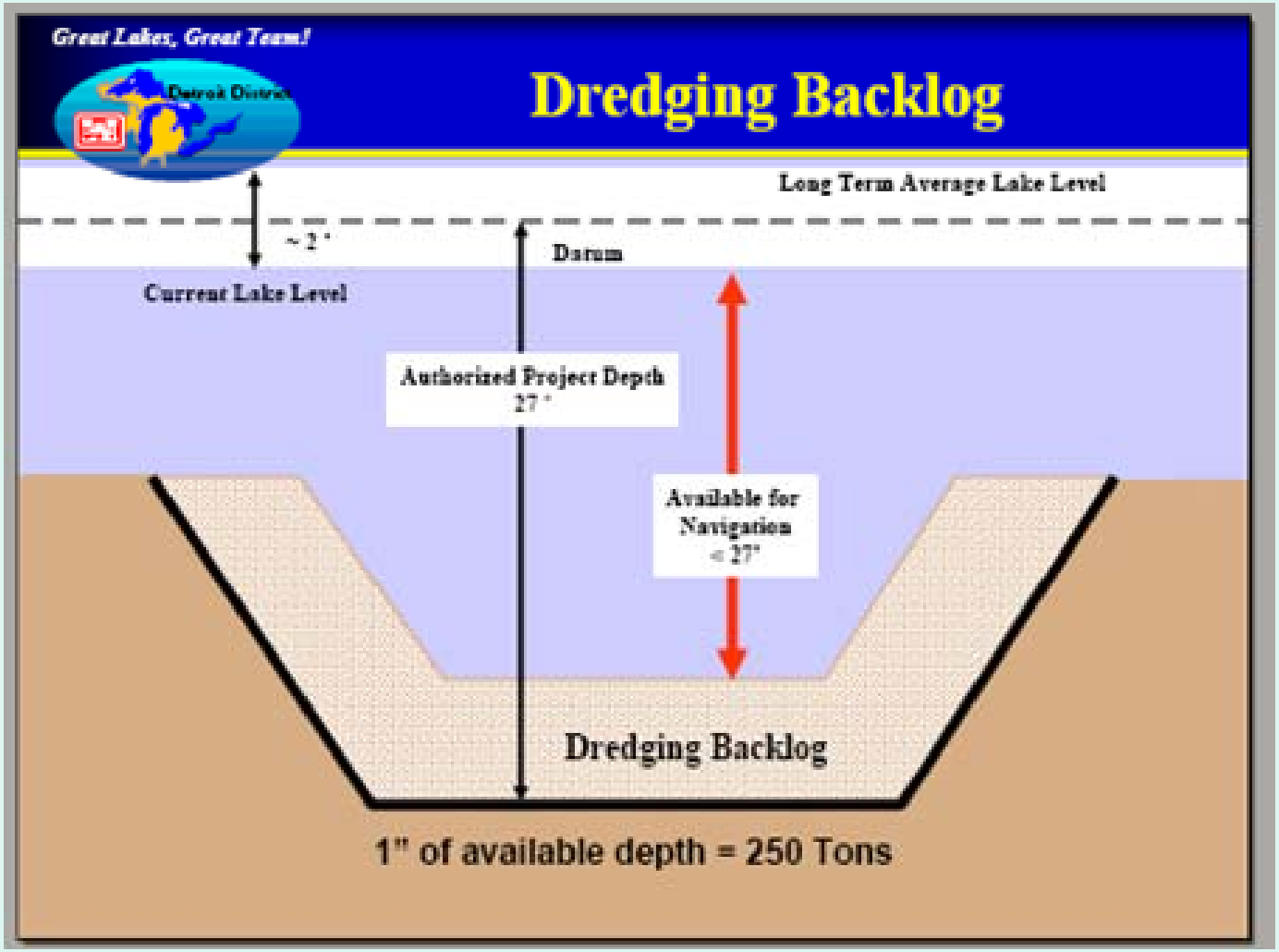
Great Lakes Navigation

Available Water Column- Below Datum



Great Lakes Navigation

Available Water Column- Dredging Backlog



Great Lakes
Navigation

GLLAPOM

Great

Lakes

Levels

Analysis of

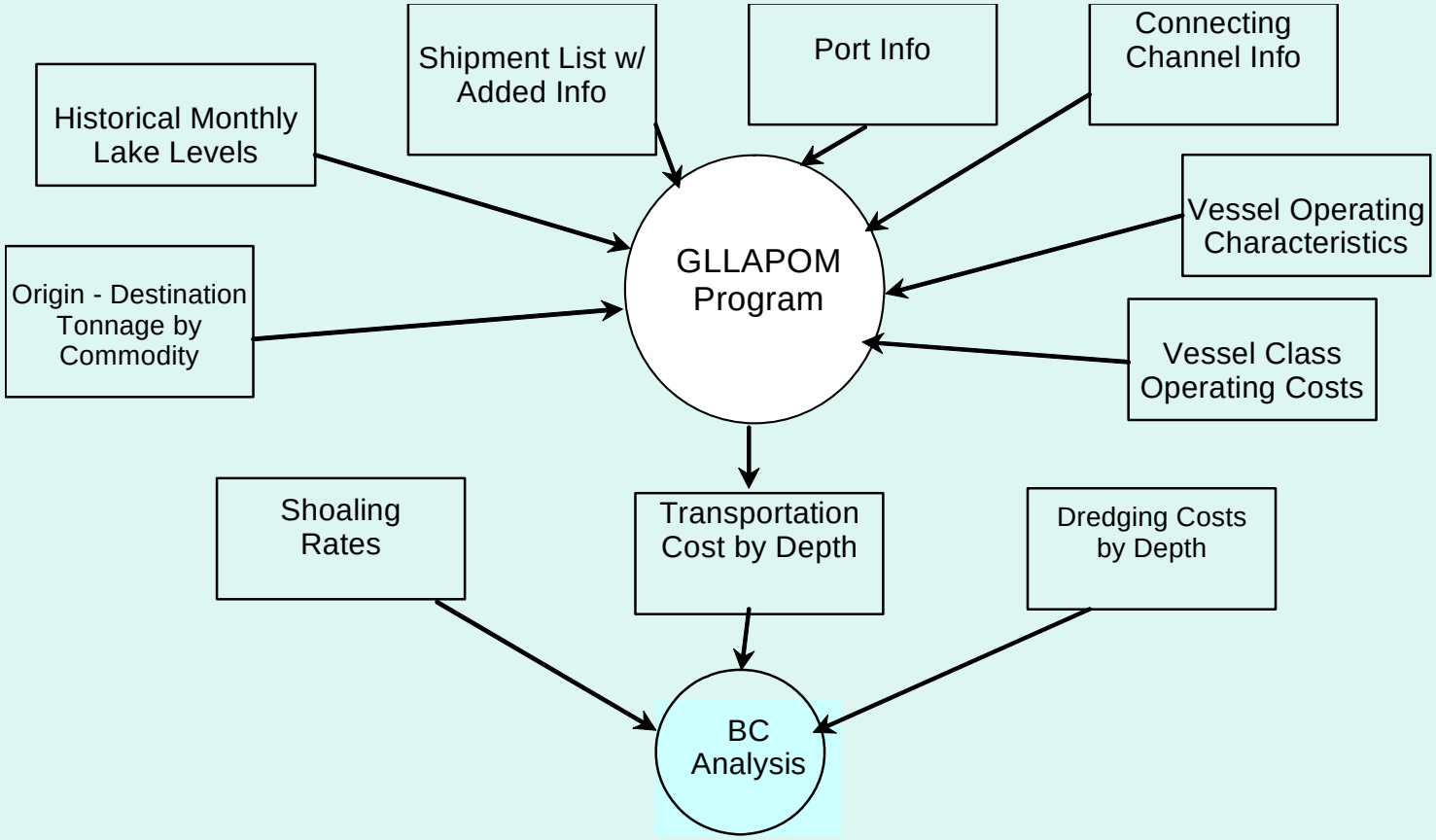
Ports

Operations &

Maintenance

Great Lakes Navigation

Model Schematic



Great Lakes Navigation

Benefit Framework

- Calculate Transportation Costs under WOPC (no dredging)
- Calculate Transportation Costs under WPC (Dredging to authorized depth)
- Benefit is $TC_{wpc} – TC_{wopc}$ (Transportation Cost Savings Benefit)
- Need to know shoaling rate in harbor channel(s)
- Need to know total cost of dredging of harbor channel(s)

Great Lakes
Navigation

Input Data – Shipment List

- List of historic boat movements for base data year
- Data Items
  - Vessel number
  - Trips (Multiple origin or destination flag)
  - Origin port
  - Origin date
  - Destination port
  - Destination date
  - Commodity type

Great Lakes
Navigation

Input Data – Shipment List

- Origin - Destination tonnage by commodity
- Use representative historic year's shipment list data
- Ordered by vessel through system
- Objective is to estimate the cost of each individual commodity movement based on given constraints
- Leftover tonnage moves at ave rate for given O-D-C triplet

Great Lakes Navigation

Input Data – Vessel Operating Characteristics

- Mid Summer draft and tonnage capacity for 13 commodity types
- Maximum draft for Summer, Intermediate and Winter seasons (US Coast Guard limits)
- Cubic capacity
- Immersion factor (tons per inch of draft)
- Vessel class

Great Lakes Navigation

Great Lakes Average Hourly Vessel Operating Costs

- For Each Class – 2 through 10
- Total Daily Variable Operating Costs
  - Wages, subsistence, stores, supplies & equip, insurance, maintenance & repair, fuel & overhead factor
- Total Daily Fixed Costs
  - Annual fixed cost based on construction costs, amortization factor, season length & profit factor

Great Lakes
Navigation

Input Data - Ports/Docks

- Each port is unique
- Many ports serve multiple commodity types
- Each commodity type can have its own limiting depth
- Many docks have loading and unloading equipment, which has hourly handling rates
- Many ports require additional maneuvering time

Great Lakes Navigation

Other Input Data

- Connecting Channel Depths
  - St Lawrence River, Welland Canal, Detroit River, Lake St Clair, St Clair River, Straits of Mackinac, St Mary's River, Soo Locks, Vidal Shoals
- GL port to port mileage tables
  - (169 X 168 distances)
- Unique harbor maneuvering time (e.g Cleveland, Toledo)

US Army Corps of Engineers

Great Lakes Levels Analysis of Ports

Operations & Maintenance

Increased Transportation Cost by Lost Dredged Depth
Based on 2005 Tonnage Movements &
Simulated Historical Water Levels 1900 - 2005 **

Great Lakes Navigation System

Port / Channel Number	Port Name	Tons (2005)	Shoal Depth: 0 - foot	1-foot	2-foot	3-foot	4-foot	5-foot	6-foot
76133	Alpena Harbor, MI	2,830,635	$ -	$ 567,309	$ 1,559,593	$ 3,028,768	$ 4,858,168	$ 7,254,904	$ 10,662,431
79245	Ashland Harbor	98,460	$ -	$ 21,927	$ 59,086	$ 101,616	$ 159,076	$ 227,967	$ 314,323
72101	Ashtabula Harbor, OH	9,165,629	$ -	$ 774,461	$ 2,215,861	$ 4,332,955	$ 5,865,222	$ 7,744,454	$ 10,006,804
72350	Buffalo Harbor, NY	787,780	$ -	$ 208,137	$ 517,619	$ 909,365	$ 1,378,998	$ 1,947,973	$ 2,657,298
77625	Burns Harbor, IN	7,257,664	$ -	$ 816,739	$ 2,348,471	$ 4,376,591	$ 6,821,094	$ 9,667,039	$ 12,936,809
77641	Calumet Harbor and River, IL & IN	6,083,332	$ -	$ 297,270	$ 868,450	$ 1,700,307	$ 2,830,205	$ 4,325,253	$ 6,196,335
00004	Channels in Lake St. Clair	63,283,690	$ -	$ 925,988	$ 5,692,895	$ 14,889,610	$ 29,089,618	$ 46,824,362	$ 69,677,208
77433	Charlevoix Harbor	1,216,085	$ -	$ 10,605	$ 33,722	$ 76,126	$ 141,939	$ 263,320	$ 472,543
72073	Cleveland Harbor, OH	11,832,781	$ -	$ 3,462,811	$ 7,637,404	$ 12,639,409	$ 18,655,678	$ 25,959,583	$ 34,939,806
72108	Conneaut Harbor, OH	7,414,170	$ -	$ 135,437	$ 828,457	$ 2,017,224	$ 3,524,887	$ 5,218,263	$ 7,115,341
73013	Detroit Port, MI	4,869,908	$ -	$ 1,300,000	$ 2,729,022	$ 4,348,389	$ 6,227,574	$ 8,477,009	$ 11,208,614
00003	Detroit River Channel	66,159,124	$ -	$ 667,877	$ 4,686,070	$ 12,778,631	$ 26,420,406	$ 43,056,827	$ 64,963,150
79286	Duluth Harbor, MN	21,360,619	$ -	$ 3,180,348	$ 7,926,030	$ 13,864,338	$ 20,821,162	$ 29,000,978	$ 39,022,124
72145	Dunkirk Harbor, NY	143,957	$ -	$ 44,609	$ 98,450	$ 165,164	$ 252,547	$ 376,052	$ 566,750
72122	Erie Harbor, PA	842,998	$ -	$ 182,486	$ 396,676	$ 629,243	$ 884,468	$ 1,172,221	$ 1,501,948
72088	Fairport Harbor, OH	2,336,555	$ -	$ 380,841	$ 868,599	$ 1,483,650	$ 2,231,273	$ 3,127,520	$ 4,202,328
77567	Grand Haven Harbor	378,205	$ -	$ 173,700	$ 390,253	$ 647,761	$ 954,249	$ 1,325,420	$ 1,791,562
77825	Green Bay Harbor	2,602,086	$ -	$ 532,856	$ 1,352,972	$ 2,563,051	$ 4,232,087	$ 6,395,430	$ 8,997,562
76029	Harbor Beach Harbor, MI*	209,507	$ -	$ 26,123	$ 63,503	$ 110,201	$ 168,556	$ 238,328	$ 323,425
77578	Holland Harbor, MI	562,992	$ -	$ 113,301	$ 270,663	$ 471,207	$ 717,222	$ 1,015,492	$ 1,386,629
72051	Huron Harbor, OH	982,905	$ -	$ 21,953	$ 124,074	$ 320,894	$ 603,061	$ 929,427	$ 1,299,429
77632	Indiana Harbor, IN	10,656,566	$ -	$ 2,097,358	$ 4,709,457	$ 7,643,055	$ 10,953,127	$ 14,724,547	$ 19,053,535
72060	Lorain Harbor, OH	2,733,804	$ -	$ 54,513	$ 345,576	$ 896,616	$ 1,586,806	$ 2,346,245	$ 3,193,345
77535	Ludington Harbor, MI	103,240	$ -	$ 54,466	$ 128,067	$ 227,497	$ 370,564	$ 572,073	$ 572,073
77523	Manistee Harbor, MI	218,639	$ -	$ 47,957	$ 107,904	$ 183,978	$ 280,677	$ 403,232	$ 557,804

* Impact may be greater due to insufficient depths for certain commodities restricted practical use for certain vessels for a no. of simulated water level yrs.
** TC impacts presented are prelim results; the model requires a detailed tech review.

US Army Corps of Engineers

Great Lakes Levels Analysis of Ports

Operations & Maintenance

Increased Transportation Cost by Lost Dredged Depth
Based on 2005 Tonnage Movements &
Simulated Historical Water Levels 1900 - 2005 **

Great Lakes Navigation System

Port / Channel Number	Port Name	Tons (2005)	Shoal Depth: 0 - foot	1-foot	2-foot	3-foot	4-foot	5-foot	6-foot
77726	Manitowoc Harbor	381,318	$ -	$ 97,279	$ 235,795	$ 413,719	$ 634,276	$ 921,933	$ 1,316,923
79076	Marquette Harbor	1,096,348	$ -	$ 145,414	$ 325,863	$ 538,596	$ 787,739	$ 1,083,194	$ 1,437,759
77850	Menominee Harbor, MI & Wi	24,112	$ -	$ 4,927	$ 13,551	$ 26,598	$ 46,534	$ 74,387	$ 109,848
77690	Milwaukee Harbor, WI	3,324,502	$ -	$ 899,782	$ 2,116,067	$ 3,742,865	$ 5,840,114	$ 8,451,381	$ 11,704,340
72007	Monroe Harbor	1,815,633	$ -	$ 800,688	$ 1,755,397	$ 2,887,409	$ 4,240,414	$ 5,886,296	$ 7,933,600
77562	Muskegon Harbor*	1,916,801	$ -	$ 133,852	$ 334,054	$ 695,991	$ 972,260	$ 1,300,641	$ 1,668,724
70245	Ogdensburg Harbor, NY	144,951	$ -	$ 2,344	$ 34,193	$ 90,083	$ 161,130	$ 244,109	$ 338,255
79205	Ontonagon Harbor	228,629	$ -	$ 368,260	$ 769,847	$ 1,221,871	$ 1,806,916	$ 2,599,322	$ 3,717,624
71184	Oswego Harbor, NY	371,199	$ -	$ 16,646	$ 39,573	$ 79,619	$ 130,204	$ 191,598	$ 264,927
79077	Presque Isle Harbor	10,940,775	$ -	$ 690,929	$ 1,785,560	$ 3,326,329	$ 5,280,676	$ 7,539,991	$ 10,065,432
71039	Rochester Harbor, NY	139,799	$ -	$ 33,111	$ 74,031	$ 125,849	$ 193,842	$ 287,312	$ 425,087
73012	Rouge Riv (Dearborn Mich)	9,067,515	$ -	$ 2,279,203	$ 5,000,417	$ 8,196,468	$ 11,968,582	$ 16,492,624	$ 22,057,876
76077	Saginaw River*	1,276,764	$ -	$ 274,908	$ 610,795	$ 1,023,060	$ 1,455,217	$ 1,993,883	$ 2,687,802
72046	Sandusky Harbor, OH	3,407,389	$ -	$ 168,996	$ 386,927	$ 678,561	$ 1,139,516	$ 1,938,747	$ 3,133,748
00008	Sault St. Marie (Soo Locks)	71,404,670	$ -	$ -	$ -	$ -	$ 2,811,274	$ 13,859,531	$ 29,665,198
00005	St. Clair River	72,473,425	$ -	$ 2,987,312	$ 10,386,050	$ 23,059,200	$ 39,869,467	$ 61,227,479	$ 88,508,106
77601	St. Joseph Harbor, MI*	422,946	$ -	$ 386,068	$ 876,626	$ 1,387,642	$ 1,874,289	$ 2,148,954	$ 2,532,410
00007	St. Marys River	74,603,173	$ -	$ 3,874,119	$ 13,270,779	$ 28,302,672	$ 47,702,115	$ 71,817,111	$ 101,717,585
00006	Straits of Mackinac	98,824,231	$ -	$ -	$ 1,978	$ 1,494,053	$ 8,451,925	$ 22,204,320	$ 41,845,011
79283	Superior, MN	22,698,680	$ -	$ 2,710,612	$ 7,660,527	$ 14,489,576	$ 22,828,220	$ 32,569,406	$ 43,790,273
72014	Toledo Harbor, OH	9,734,557	$ -	$ 221,582	$ 784,587	$ 1,899,378	$ 3,566,322	$ 5,636,674	$ 8,095,864
79297	Two Harbors, MN	10,958,982	$ -	$ 3,291,161	$ 6,722,608	$ 10,379,749	$ 14,572,270	$ 19,360,695	$ 24,839,604
00009	Vidal Shoals	71,404,670	$ -	$ 7,312,331	$ 21,290,031	$ 39,098,703	$ 61,273,574	$ 88,123,030	$ 120,496,687
77665	Waukegan Harbor, IL	642,335	$ -	$ 595,495	$ 1,211,731	$ 1,781,408	$ 2,330,011	$ 2,968,227	$ 4,167,854

* Impact may be greater due to insufficient depths for certain commodities restricted practical use for certain vessels for a no. of simulated water level yrs.
** TC impacts presented are prelim results; the model requires a detailed tech review.

US Army Corps of Engineers®

Increased Transportation Cost ($000) by Lost Dredged Depth on the Great Lakes*

Great Lakes Navigation System

Lake/Channel Name	2005 Tons (000)	Shoal Depth						
		0-ft	1-ft	2-ft	3-ft	4-ft	5-ft	6-ft
Detroit River Channel	66,159	$ -	$ 668	$ 4,686	$ 12,779	$ 26,420	$ 43,057	$ 64,963
Channels in Lake St. Clair	63,284	$ -	$ 926	$ 5,693	$ 14,890	$ 29,090	$ 46,824	$ 69,677
St. Clair River	72,473	$ -	$ 2,987	$ 10,386	$ 23,059	$ 39,869	$ 61,227	$ 88,508
Straits of Mackinac	98,824	$ -	$ -	$ 2	$ 1,494	$ 8,452	$ 22,204	$ 41,845
St. Marys River	74,603	$ -	$ 3,874	$ 13,271	$ 28,303	$ 47,702	$ 71,817	$101,718
Sault St. Marie (Soo Locks)	71,405	$ -	$ -	$ -	$ -	$ 2,811	$ 13,860	$ 29,665
Vidal Shoals	71,405	$ -	$ 7,312	$ 21,290	$ 39,099	$ 61,274	$ 88,123	$120,497
Lake Ontario/SLR	656	$ -	$ 52	$ 148	$ 296	$ 485	$ 723	$ 1,028
Lake Erie	51,198	$ -	$ 6,457	$ 15,960	$ 28,860	$ 43,929	$ 62,283	$ 84,646
Detroit and Rouge River Ports	13,937	$ -	$ 3,579	$ 7,729	$ 12,545	$ 18,196	$ 24,970	$ 33,266
Lake Huron	4,317	$ -	$ 868	$ 2,234	$ 4,162	$ 6,482	$ 9,487	$ 13,674
Lake Michigan	35,791	$ -	$ 6,262	$ 14,998	$ 25,938	$ 38,999	$ 54,557	$ 73,465
Lake Superior	67,382	$ -	$ 10,409	$ 25,250	$ 43,922	$ 66,256	$ 92,382	$123,187

References: 2005 Tonnage Movements and Historical Water Levels 1900 - 2005

*Transportation cost impacts presented are preliminary results: the model requires a detailed technical review.

Great Lakes Navigation

GLLAPOM
Model Weaknesses

- Does not chose optimum boat for trip
- No alternative mode analysis
  - Cannot calculate savings over next least costly mode
- Fleet cannot easily be changed
- Does not incorporate risk & uncertainty
- Not using a system approach (double counting is inherent)

Great Lakes
Navigation

GL-SAND

Great

Lakes

System

Analysis of

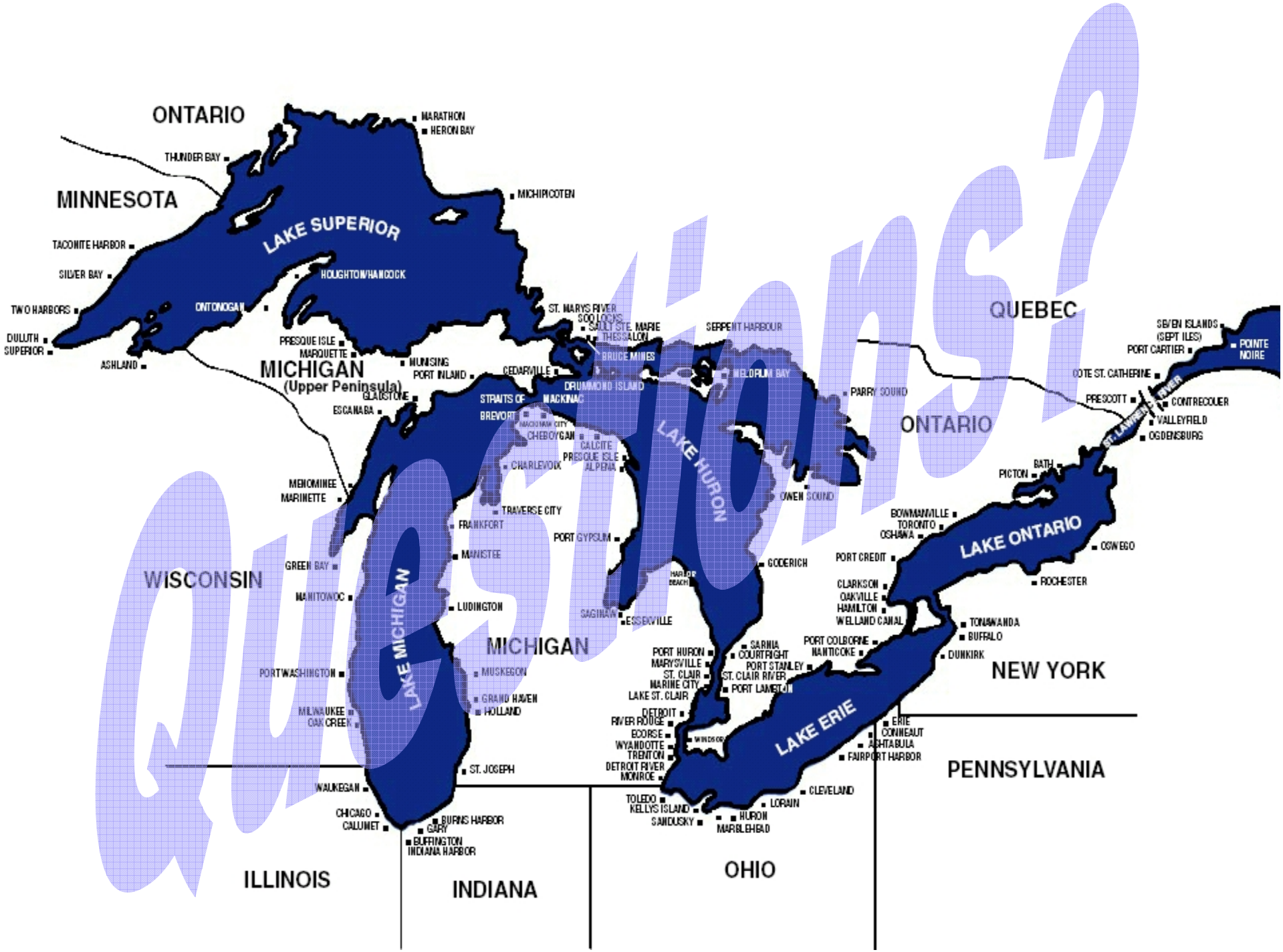
Navigation

Depths

Great Lakes Navigation

GL-SAND Design

- Model is being designed from a system perspective
- Model can Measure Impacts for Deepening and Continued O&M
- Model to be Risk-Based
- Refined and Added Data


ONTARIO
MARATHON
HERON BAY
THUNDER BAY
MINNESOTA
MICHIPICOTEN
LAKE SUPERIOR
TACONITE HARBOR
SILVER BAY
HOUGHTON/HANCOCK
TWO HARBORS
ONTONOGAN
DULUTH
SUPERIOR
ASHLAND
PRESQUE ISLE
MARQUETTE
MUNISING
MICHIGAN
(Upper Peninsula)
PORT INLAND
GLADSTONE
ESCANABA
ST. MARYS RIVER
SOO LOCKS
SAULT STE. MARIE
THESSALON
BRUCE MINES
CEDARVILLE
DRUMMOND ISLAND
STRAITS OF MACKINAC
BREVORT
MACKINAW CITY
CHEBOYGAN
CALCITE
PRESQUE ISLE
ALPENA
CHARLEVOIX
SERPENT HARBOUR
MELDRUM BAY
PARRY SOUND
QUEBEC
SEVEN ISLANDS
(SEPT ILES)
PORT CARTIER
POINTE NOIRE
COTE ST. CATHERINE
PRESCOTT
CONTRECOEUR
VALLEYFIELD
OGDENSBURG
ST. LAWRENCE RIVER
ONTARIO
LAKE HURON
OWEN SOUND
MENOMINEE
MARINETTE
TRAVERSE CITY
FRANKFORT
PORT GYPSUM
MANISTEE
GREEN BAY
WISCONSIN
MANITOWOC
LUDINGTON
LAKE MICHIGAN
SAGINAW
ESSEXVILLE
HARBOR BEACH
GODERICH
BATH
PICTON
BOWMANVILLE
TORONTO
OSHAWA
LAKE ONTARIO
OSWEGO
PORT CREDIT
ROCHESTER
CLARKSON
OAKVILLE
HAMILTON
WELLAND CANAL
TONAWANDA
BUFFALO
PORT COLBORNE
NANTICOKE
DUNKIRK
NEW YORK
MICHIGAN
PORT WASHINGTON
MUSKEGON
GRAND HAVEN
HOLLAND
MILWAUKEE
OAK CREEK
PORT HURON
MARYSVILLE
ST. CLAIR
MARINE CITY
LAKE ST. CLAIR
SARNIA
COURTRIGHT
PORT STANLEY
ST. CLAIR RIVER
PORT LAMBTON
DETROIT
RIVER ROUGE
ECORSE
WYANDOTTE
TRENTON
DETROIT RIVER
MONROE
WINDSOR
LAKE ERIE
ERIE
CONNEAUT
ASHTABULA
FAIRPORT HARBOR
PENNSYLVANIA
ST. JOSEPH
WAUKEGAN
CLEVELAND
TOLEDO
KELLYS ISLAND
SANDUSKY
LORAIN
HURON
MARBLEHEAD
CHICAGO
CALUMET
BURNS HARBOR
GARY
BUFFINGTON
INDIANA HARBOR
ILLINOIS
INDIANA
OHIO

Questions?