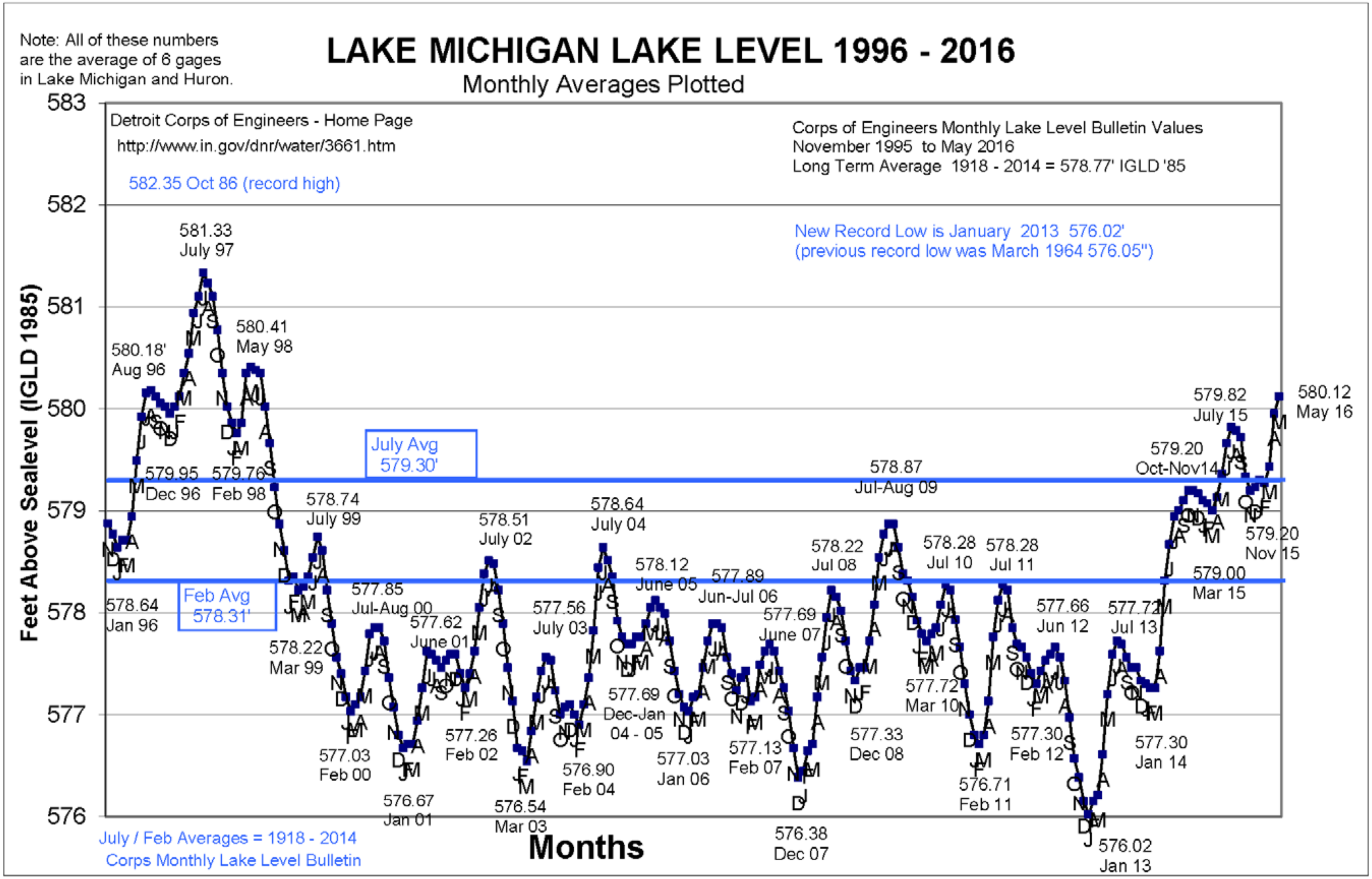
Coastal Processes 101
Physical Lake Dynamics

Indiana Department of Natural Resources
Steve Davis
Date 06 / 29 / 2016

Jan 1996 – May 2016 Lake Level Graph



Wave Driven Currents = Breaker Zone
Beach a River of Sand and Water

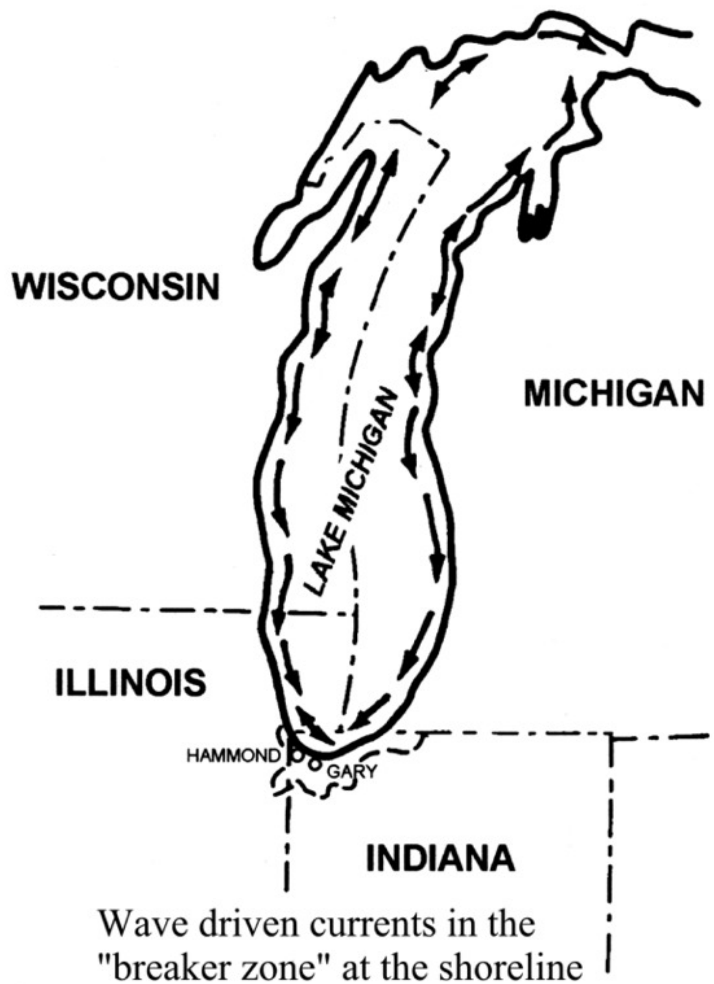


Figure 25. Net direction of littoral transport,
Lake Michigan shoreline

Burns Waterway Harbor – Port of Indiana Industrial Complex
Burns Small Boat Harbor
Ogden Dunes

Wave Dynamics

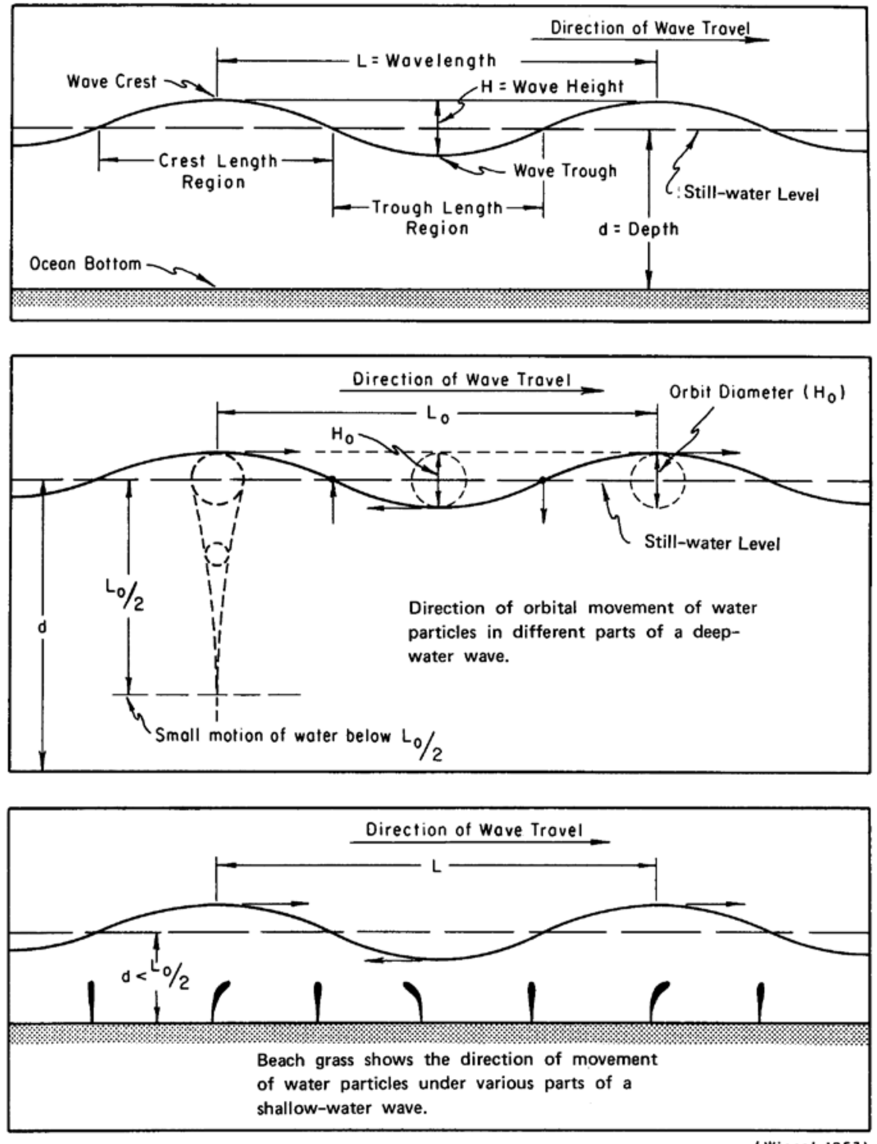
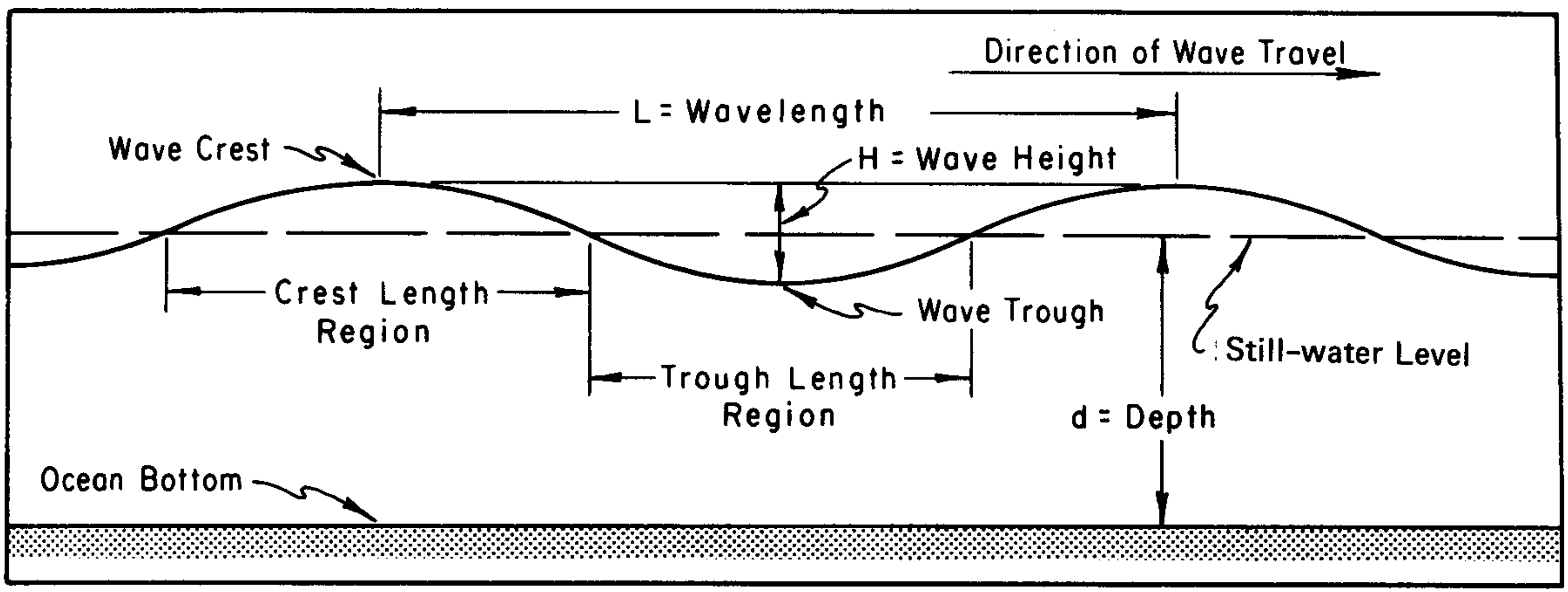
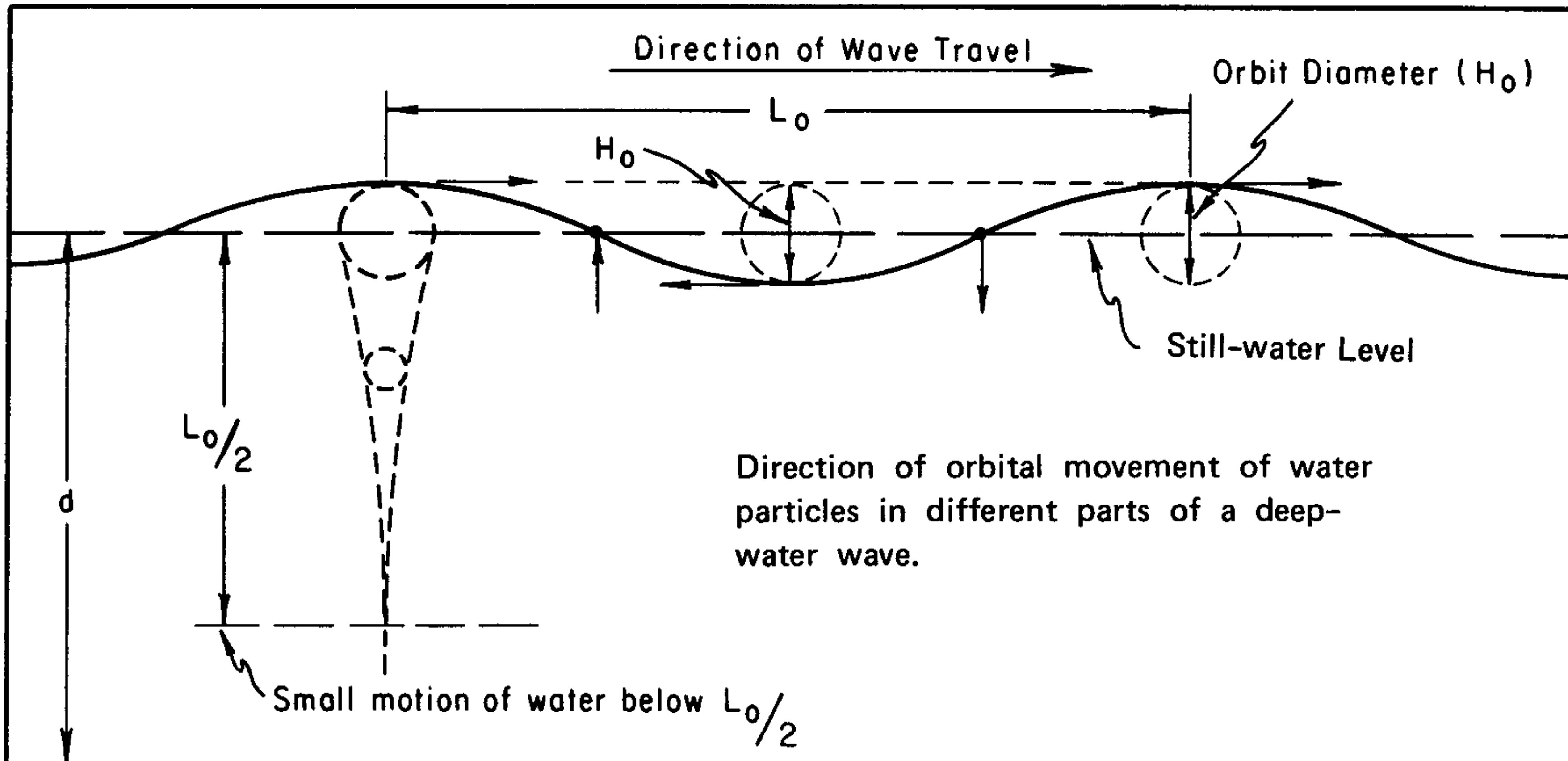


Figure A-3. Wave characteristics and direction of water particle movement.

Wave Characteristics
Wave Length = Crest to Crest



Wave Base = ½ Wave Length down in the water column
Deep Water Wave - Only wave energy moves



Deep Water Waves move into Shallow Water

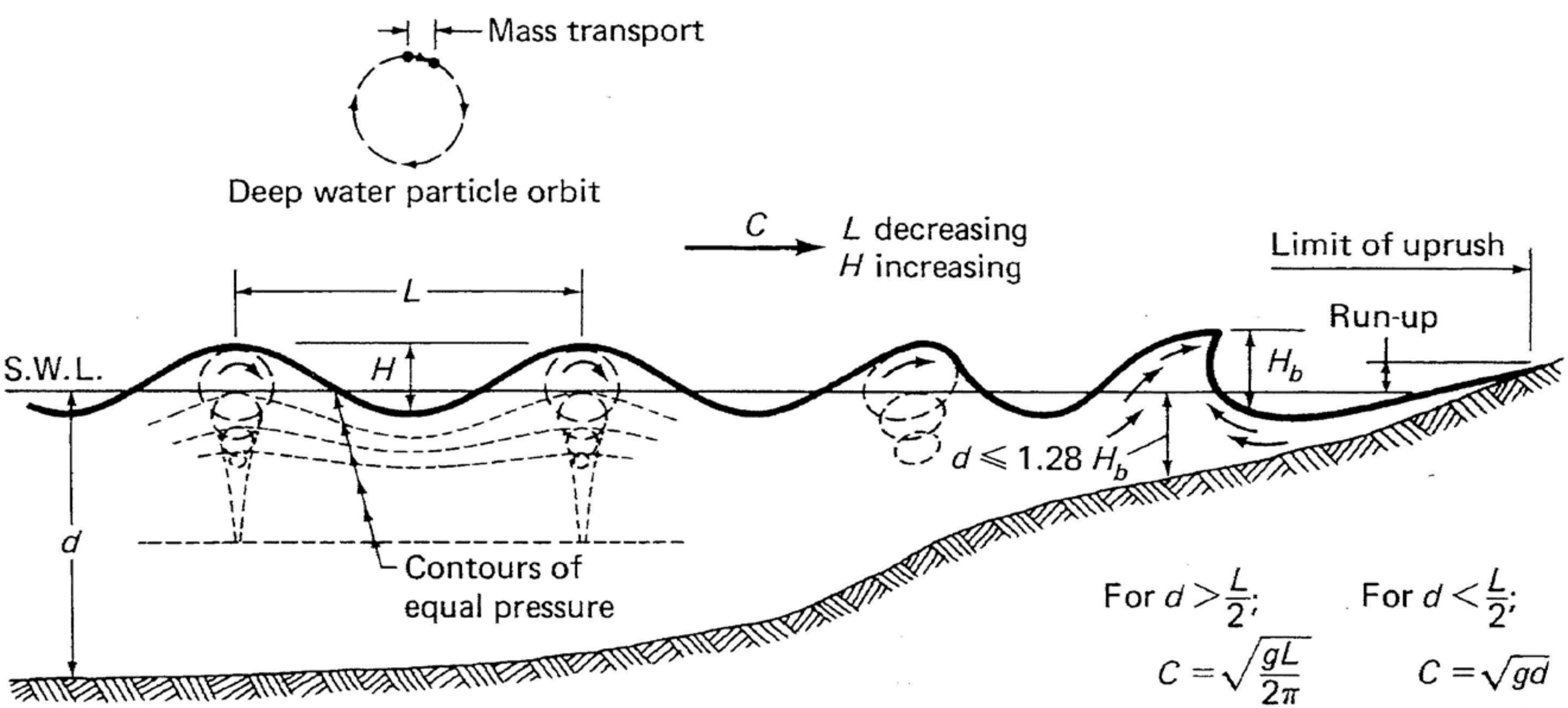


Fig. 3.7. Summary sketch of wave characteristics. (wave propagating toward coast).

What Determines How Big Waves Get?

WIND SPEED

- Fast winds = Large waves
  - Slow winds = Small waves

FETCH

- Distance wind blows over Water

WIND DURATION

- How long the wind blows

Wind Speed; Fetch; Duration

Limiting Factors:
* Wind Speed
* Fetch (distance)
* Duration (time)

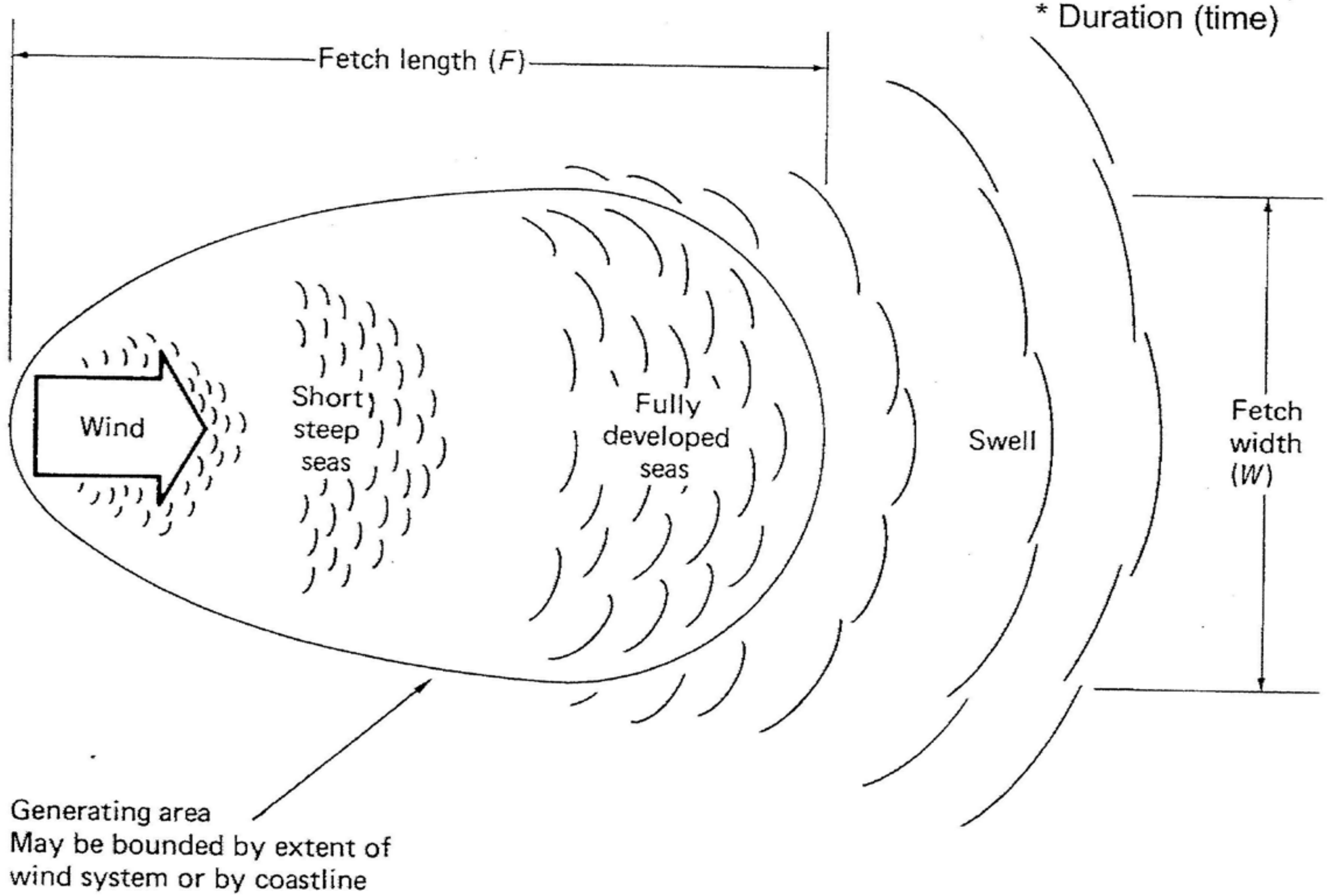


Fig. 3.8. Development of waves within generating area.

Wave Energy is Dissipated by Breaking on Offshore Sand Bars and the Beach

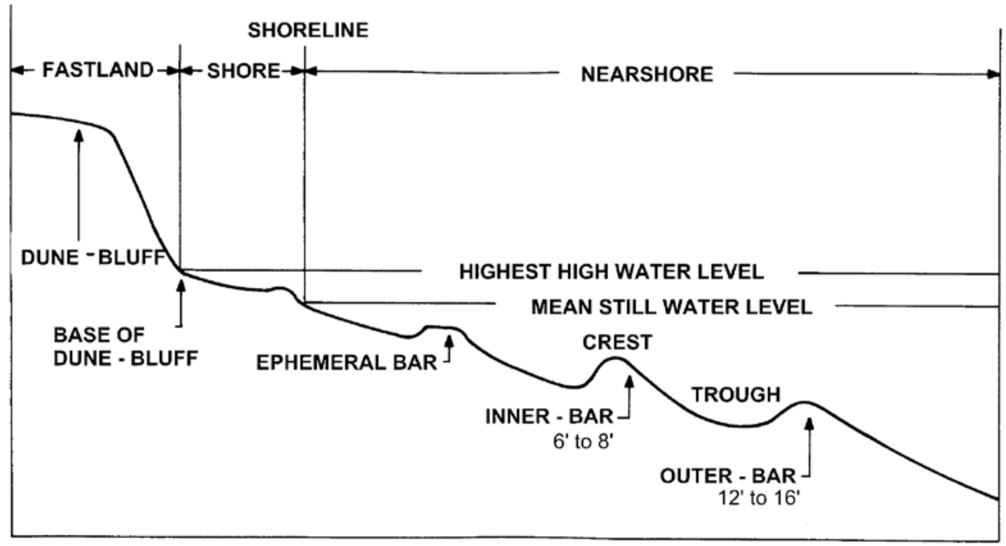
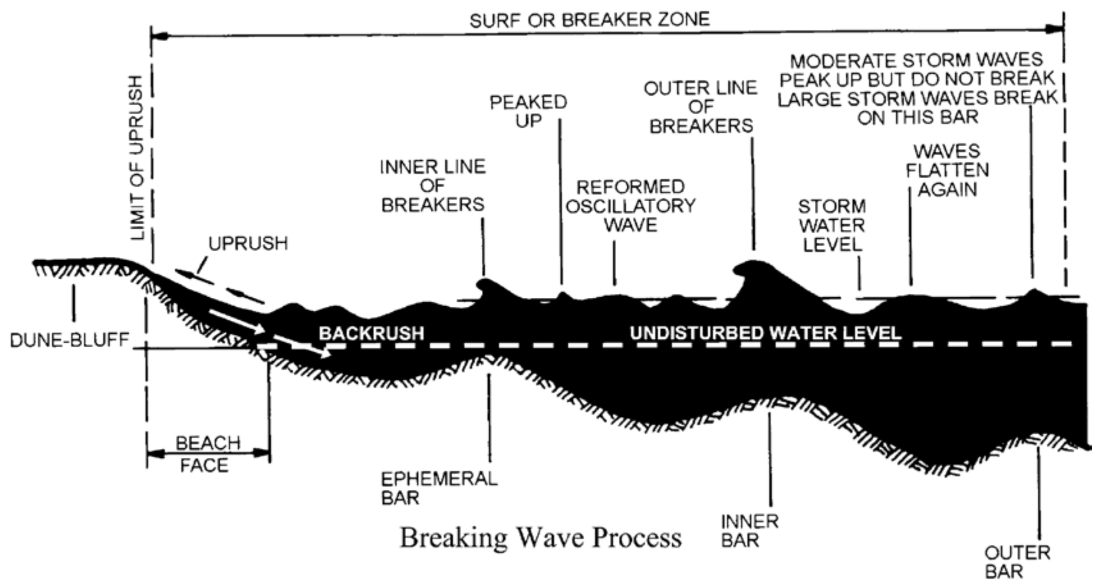


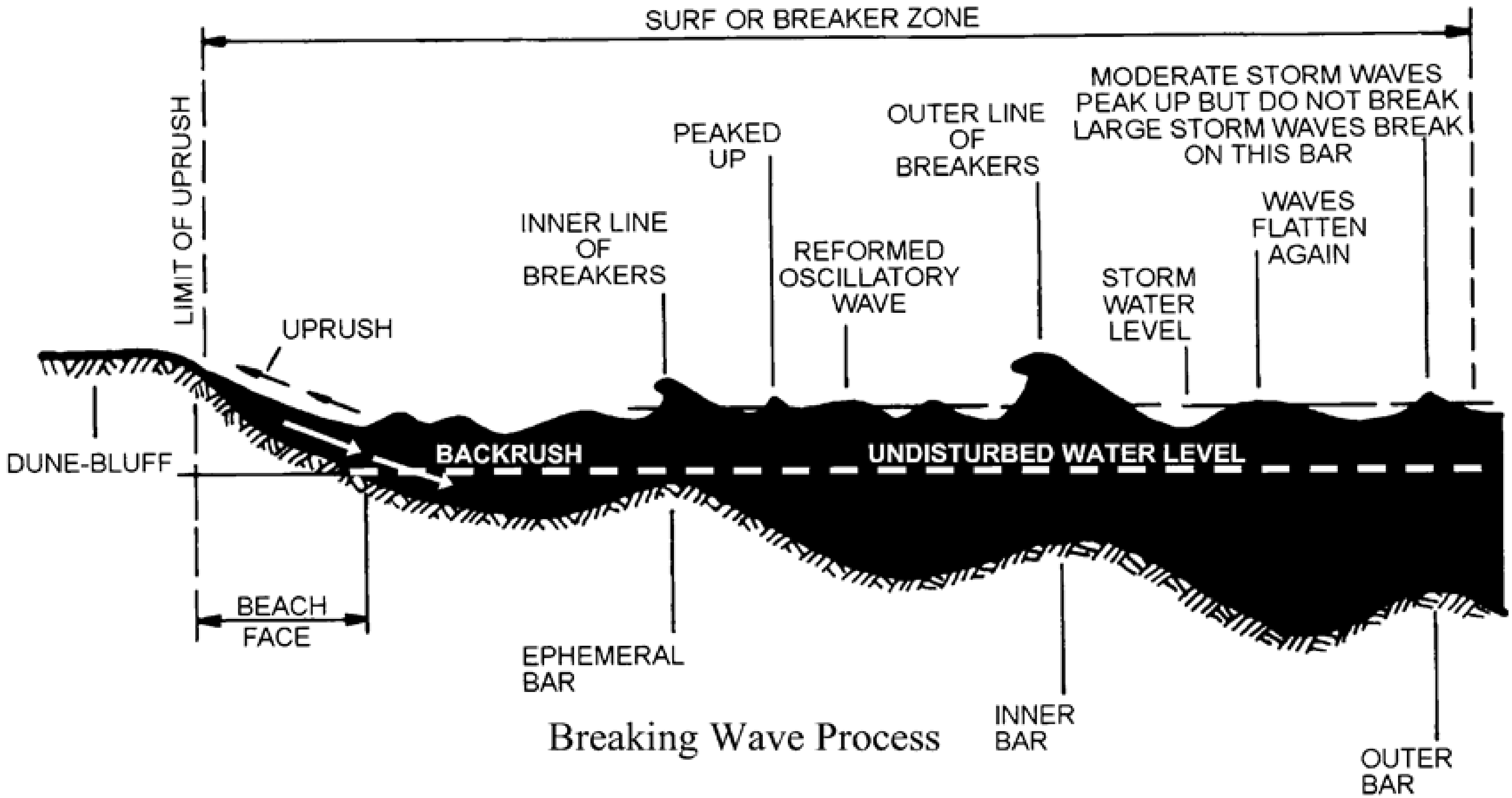
FIGURE 1. REPRESENTATIVE PROFILE ACROSS LAKE MICHIGAN COASTAL ZONE.



Breaking Wave Process

Wave Energy is Dissipated by Breaking on Offshore Sand Bars and the Beach and Moving sand and water

FIGURE 1. REPRESENTATIVE PROFILE ACROSS LAKE MICHIGAN COASTAL ZONE.



Breaking Wave Process

Storms Generate the Wind

Wind Generates Waves

Breaking Waves Generate Longshore Currents (littoral drift) in Shallow Water

Wave Refraction

Waves slow in shallow water = bend to become parallel to shore and Move Sand and Water in the Breaker Zone

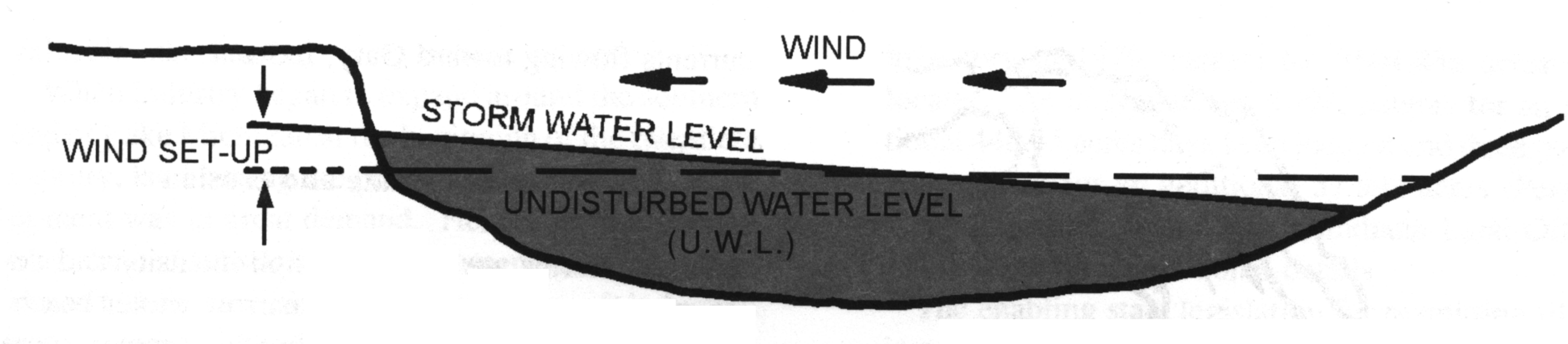
45 degree angle of attack = strongest current

Storm Generated Longshore Currents (Littoral Drift)

Wind Setup = higher water level

(Storm Surge)

Wind Stops = Seiche (Water oscillation (bath tub))



Wind Setup (storm surge) = higher water level

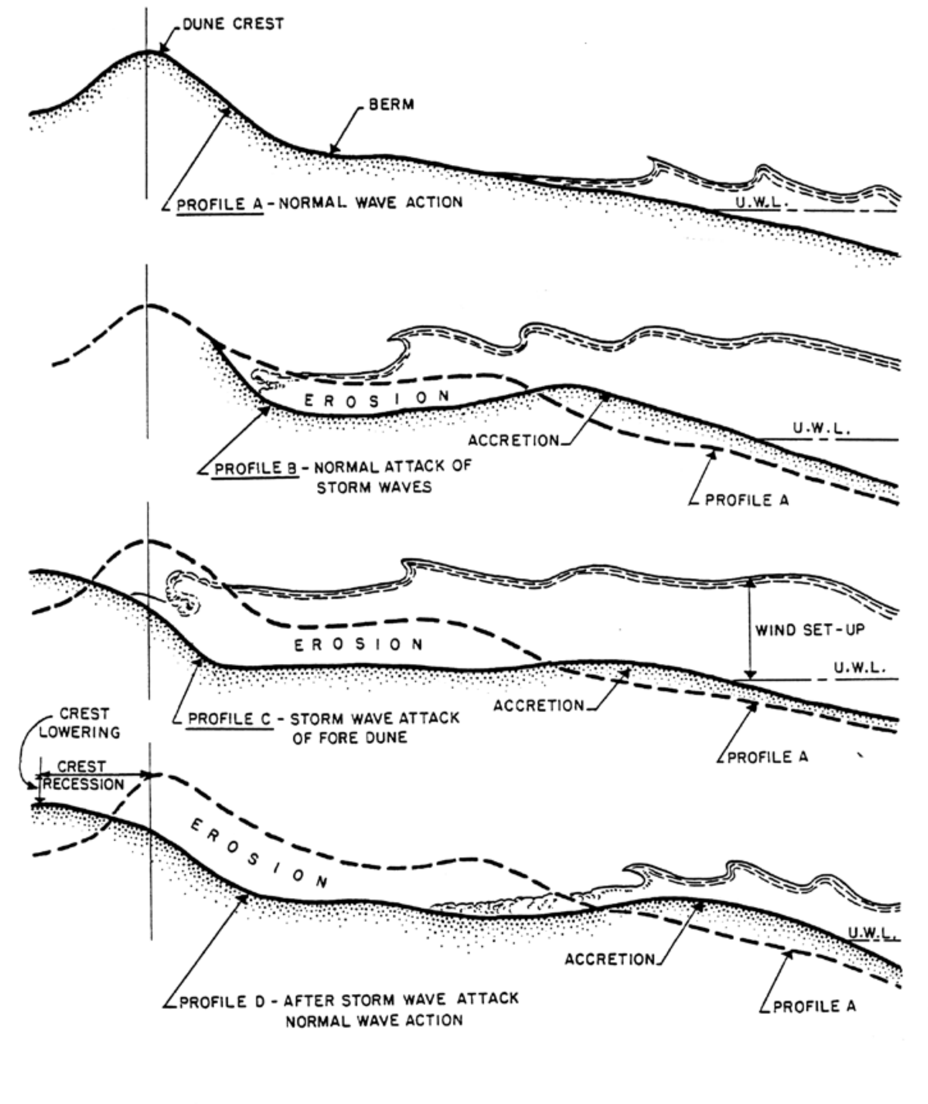
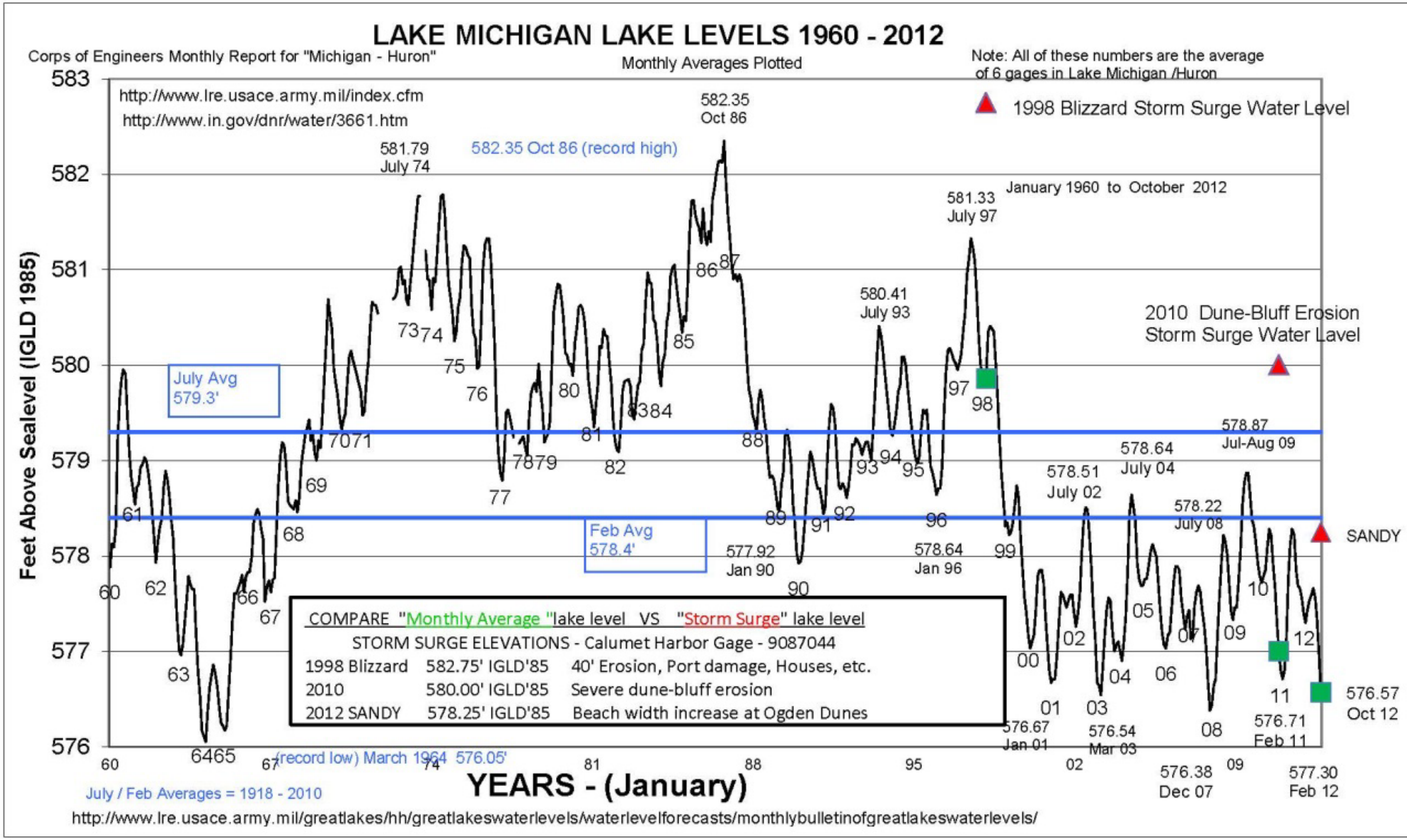


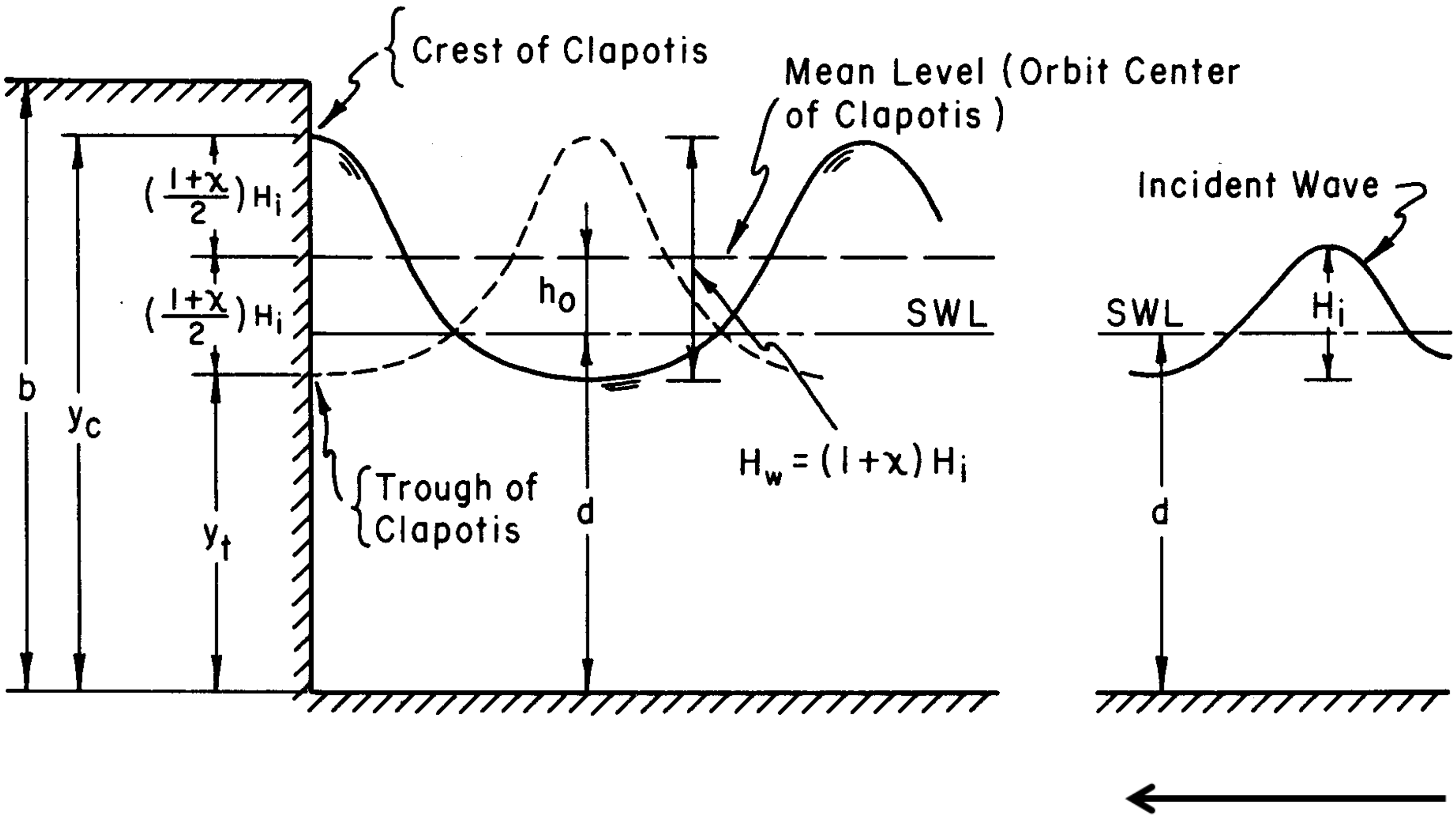
Figure 3-7. Schematic of Wind Set-Up and Resulting Erosion.

Wind Setup/Storm Surge effect on Water Levels (red triangles)



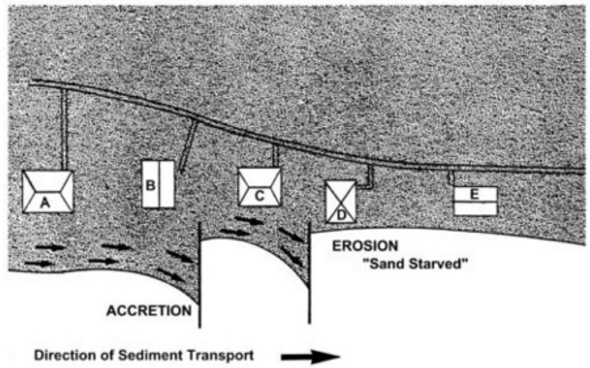
Incoming Wave Energy (right) Adds to Reflected Wave Energy = Doubles Energy

Steel Sheet Pile Seawalls



Sand Trapping Effect on Beach and Offshore Sand Bars / Sand starved condition

Figure 4-3. Diagram of Groin Impact On the Shoreline.



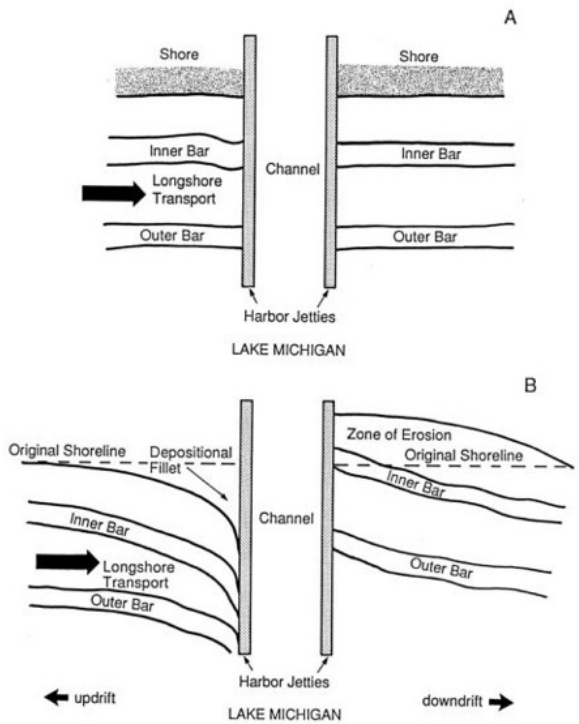


Figure 4-2. **Shoreline and Nearshore Response to Placement of Primary Coastal Structures.**

Effect of a Shore-crossing Structure on the Beach and Offshore Sand Bars

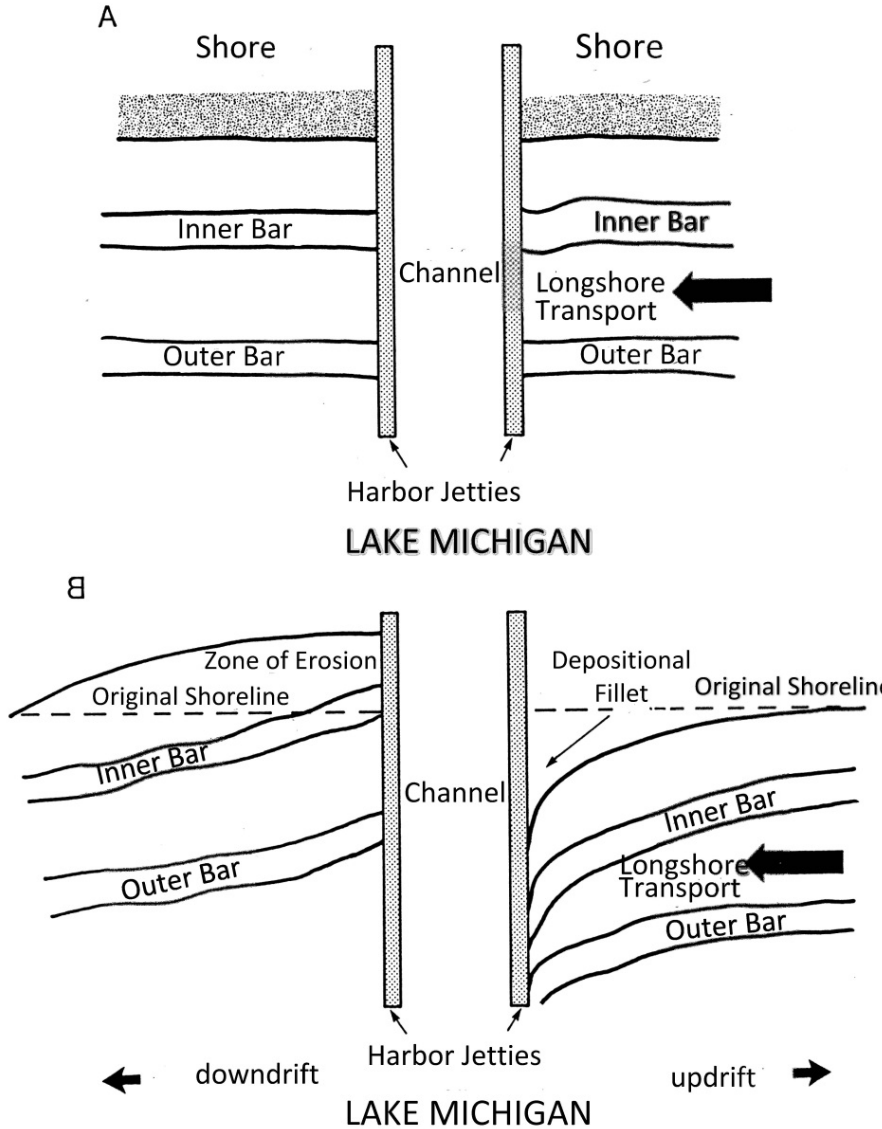
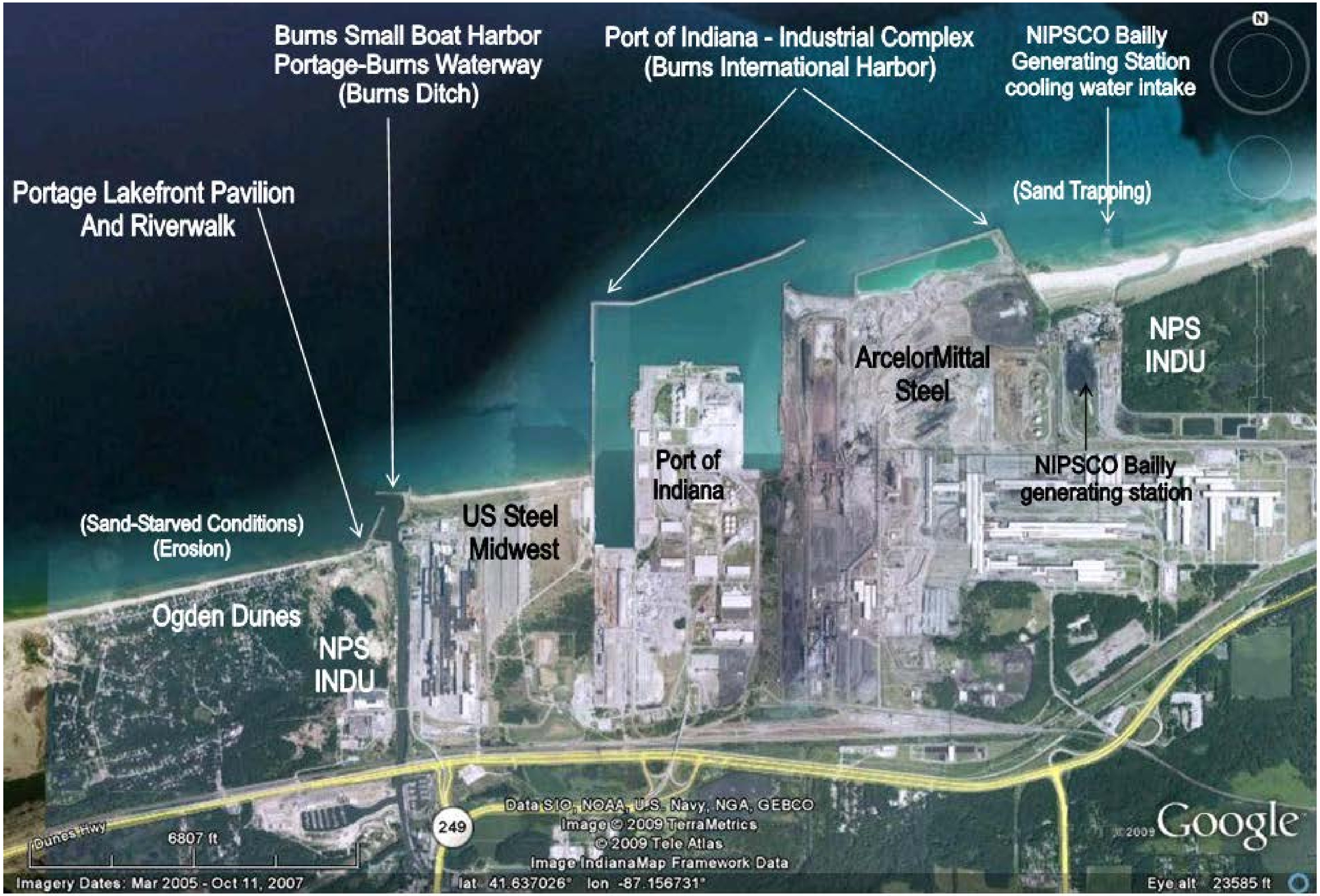


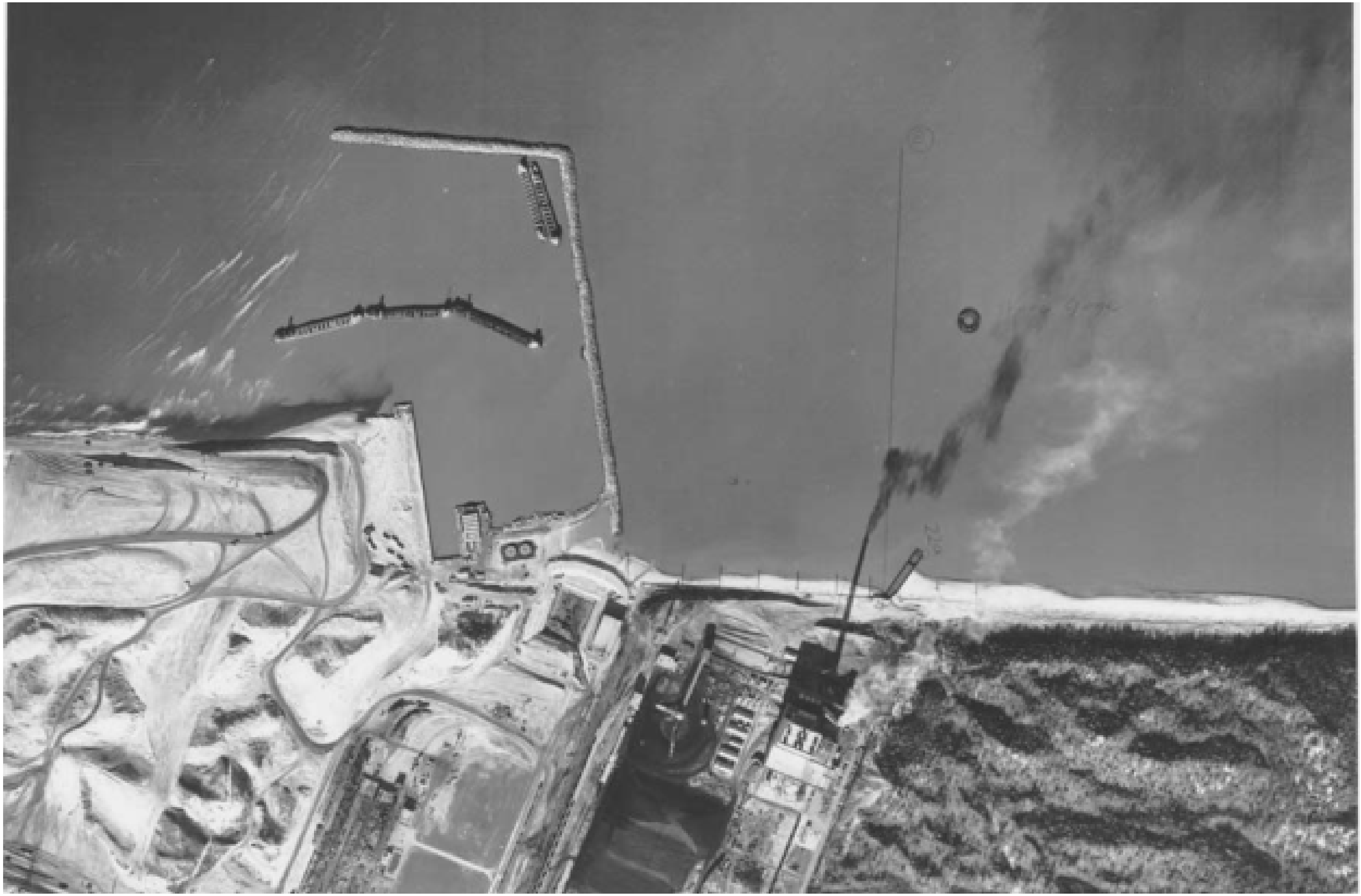
Figure 4-2 Shoreline and Nearshore Response to Placement of Primary Coastal Structures

Burns Waterway Harbor – Port of Indiana Industrial Complex
Burns Small Boat Harbor
Ogden Dunes



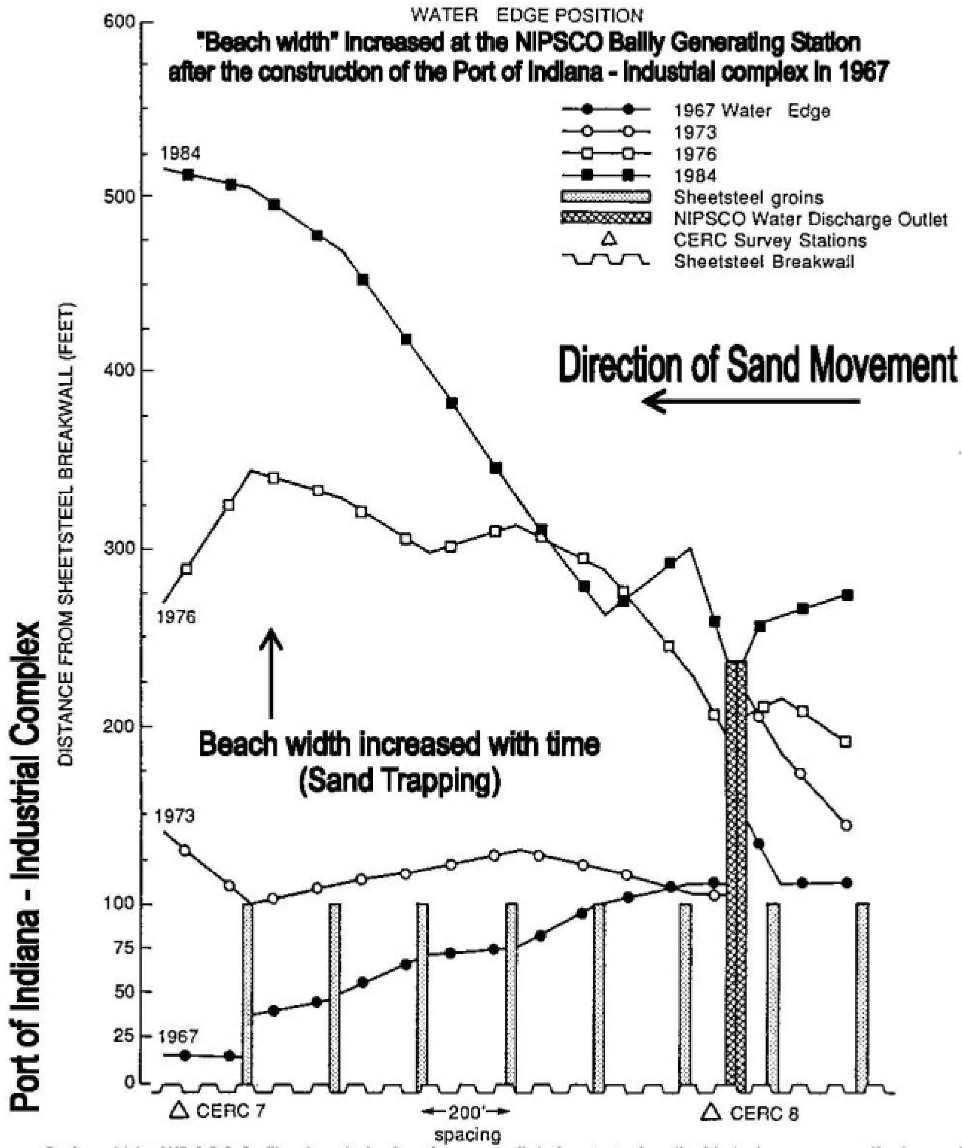
1966 NIPSCO Bailly Generating Station
Shore parallel seawall, 8 groins, and warm water discharge

1967 – Bethlehem Steel / NIPSCO Bailly Shoreline



1987 Sand Trapping Updrift of ArcelorMittal East Breakwater
Total Littoral Barrier (traps 100% of sand transport)

SAND TRAPPING ON THE EAST SIDE OF THE PORT OF INDIANA

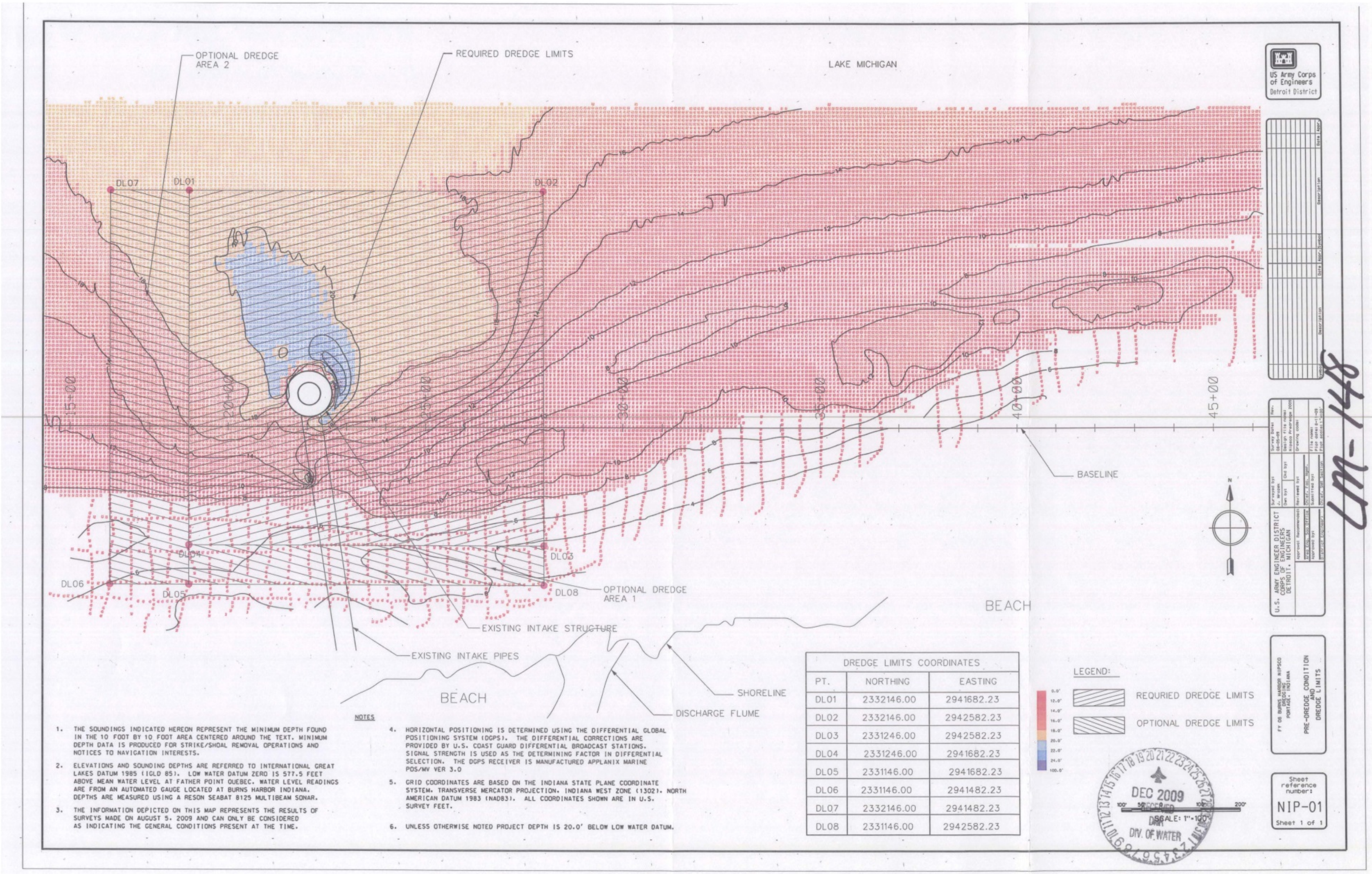


Before 1967 NIPSCO Bailly already had a shore-parallel sheet steel wall with 8 shore-perpendicular groins; and a warm water discharge outlet.

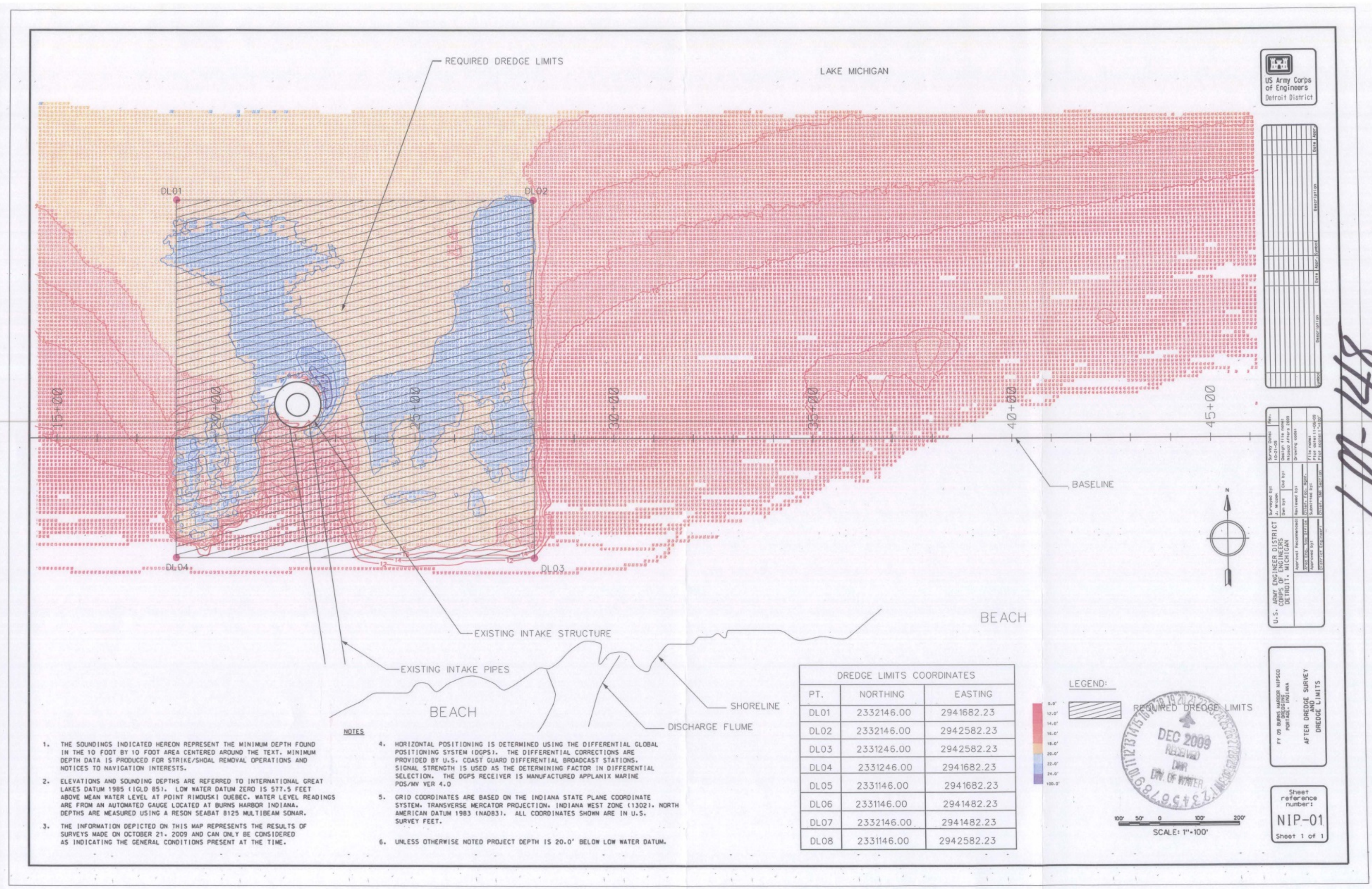
Before 1967 the East groins filled with sand first : After the Port complex was built the West groins filled quickly

Figure 6-22. Water Edge Position Change at NIPSCO, 1967 to 1984.

NIPSCO Bailly water intake Aug 5, 2009 – PRE DREDGE
Blue (20’) and Yellow = Deep ; Red = Shallow (18’)



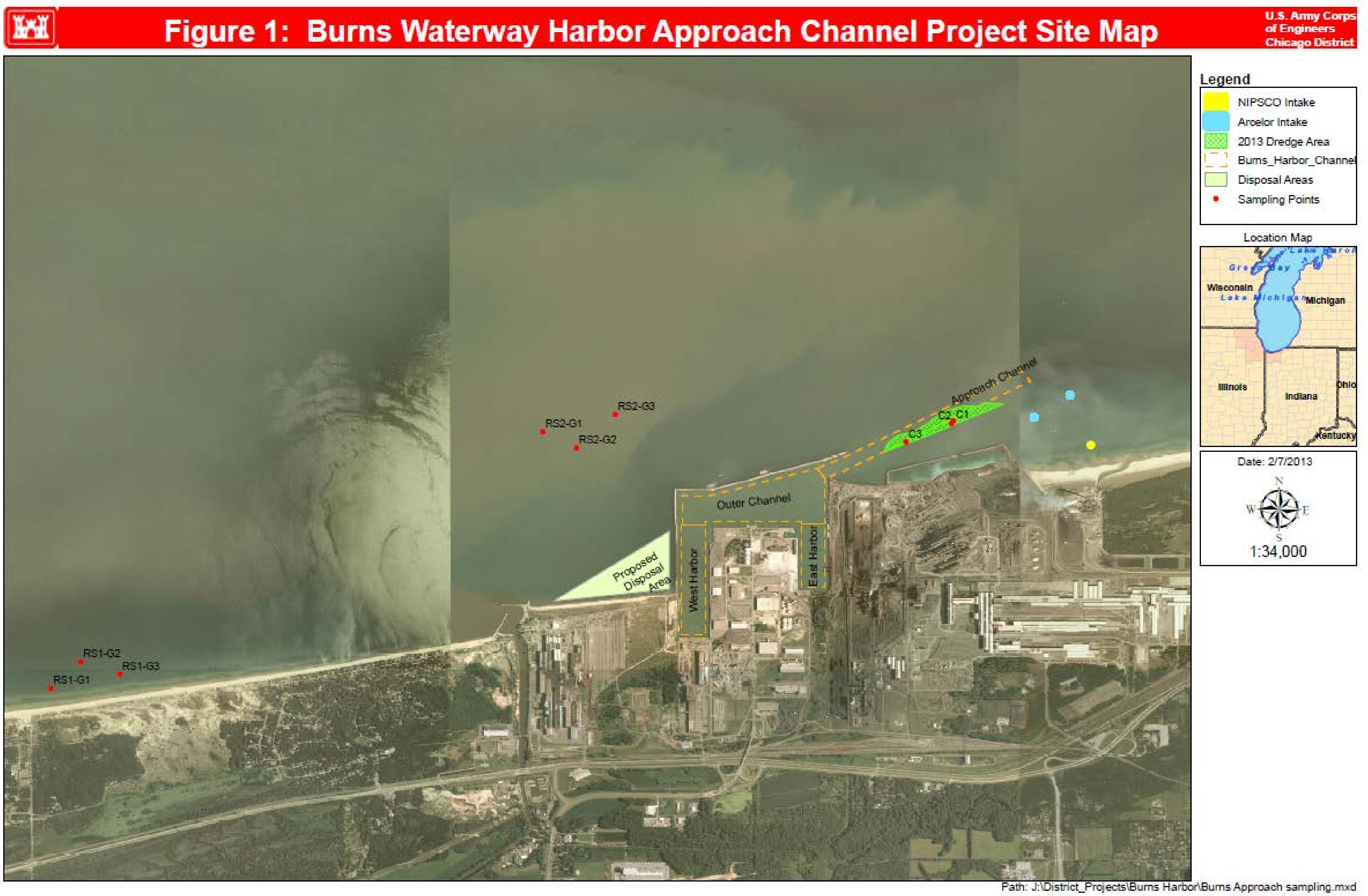
NIPSCO Bailly water intake Oct 21, 2009 – POST DREDGE
Blue and Yellow = Deep ; Red = Shallow



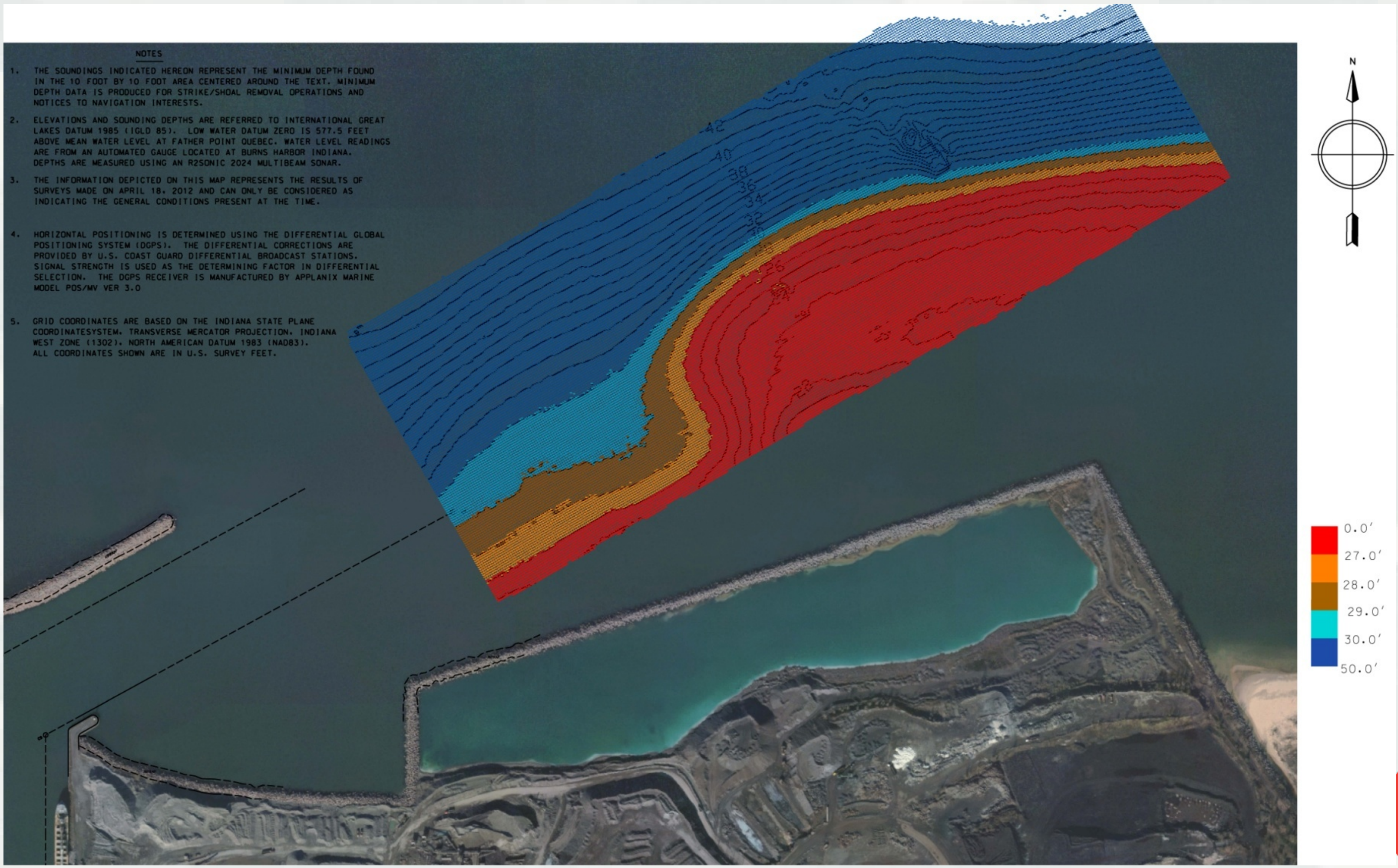
2008 Sand Trapping Updrift of ArcelorMittal East Breakwater Reached Dynamic Equilibrium

Sand bypassing the East Breakwater into the Approach Channel to the Port of Indiana (bright green)

2 ships ran aground; Nov 28, 2011 and April 15, 2012



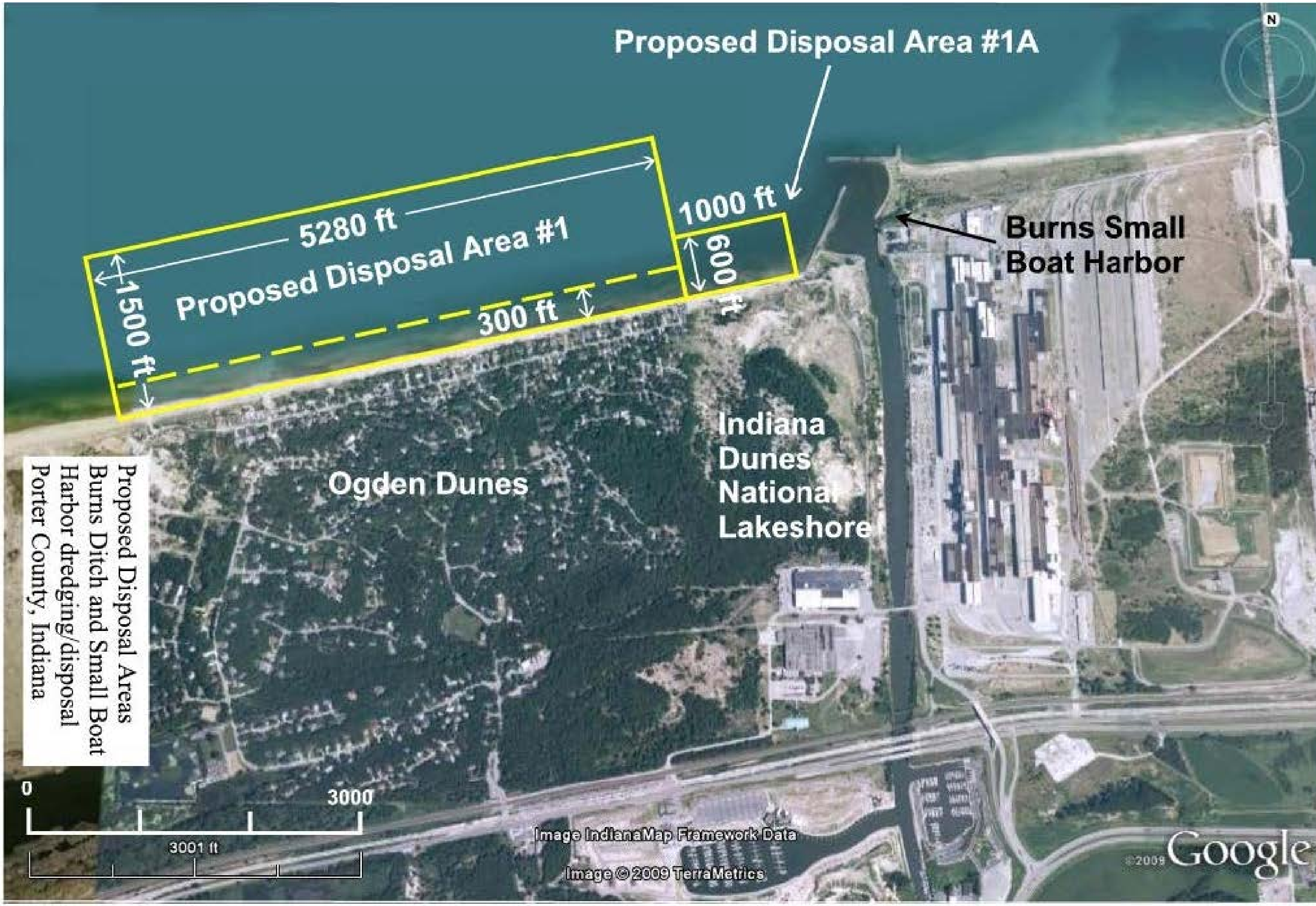
Burns Harbor



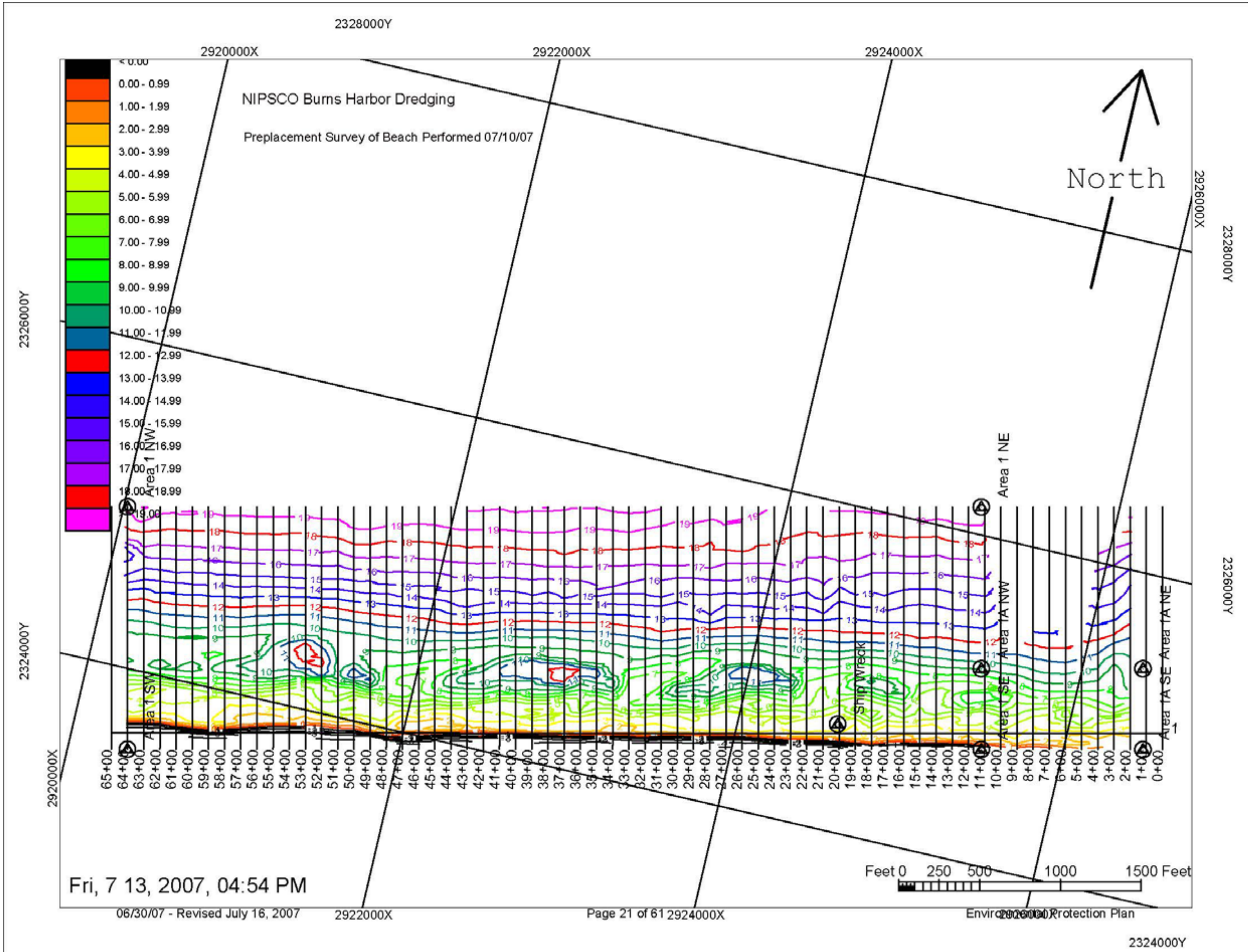
Survey date April 18, 2012

Tug and Bottom Dump Barge (12 feet to open bottom doors)

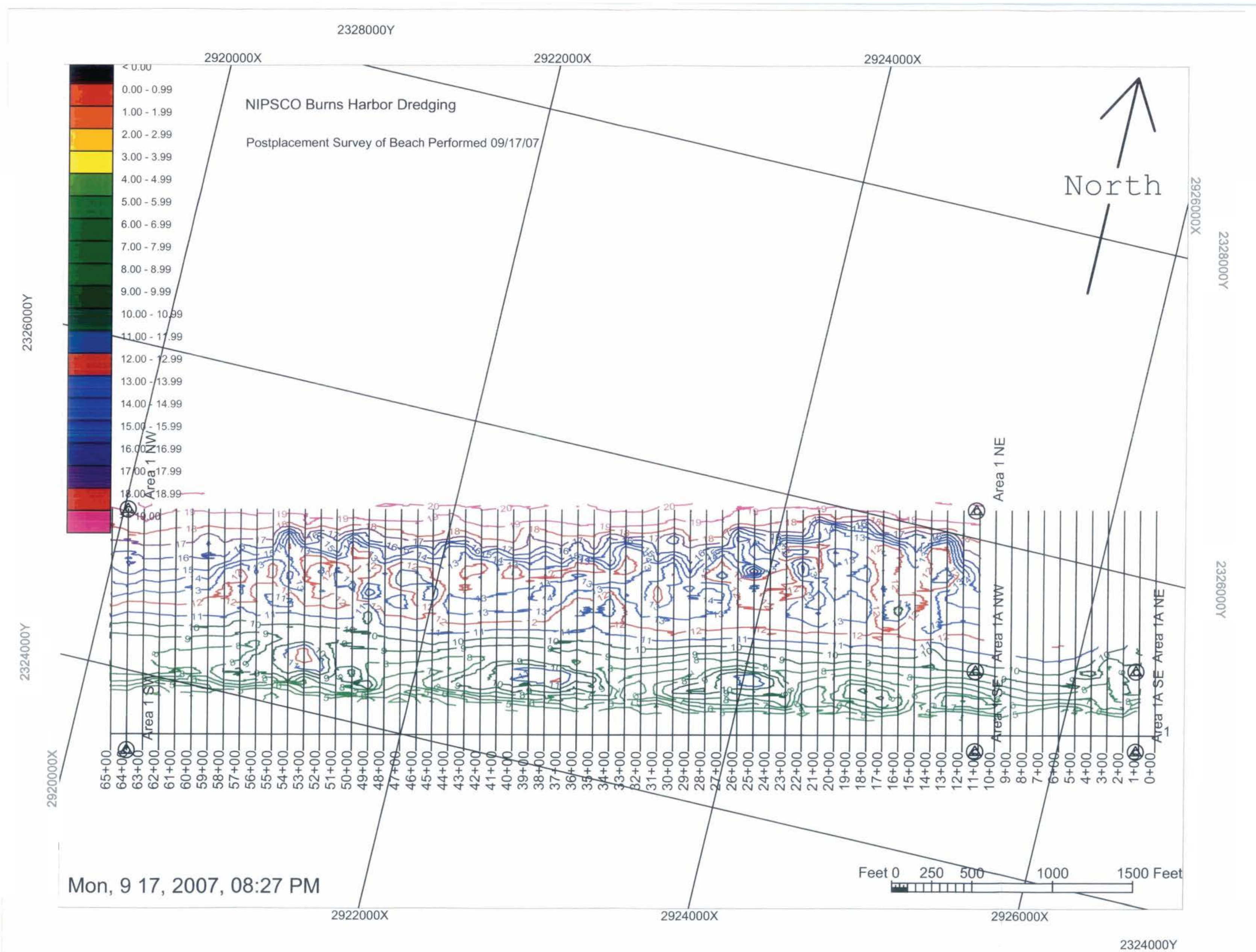
Disposal Sites #1 and #1A



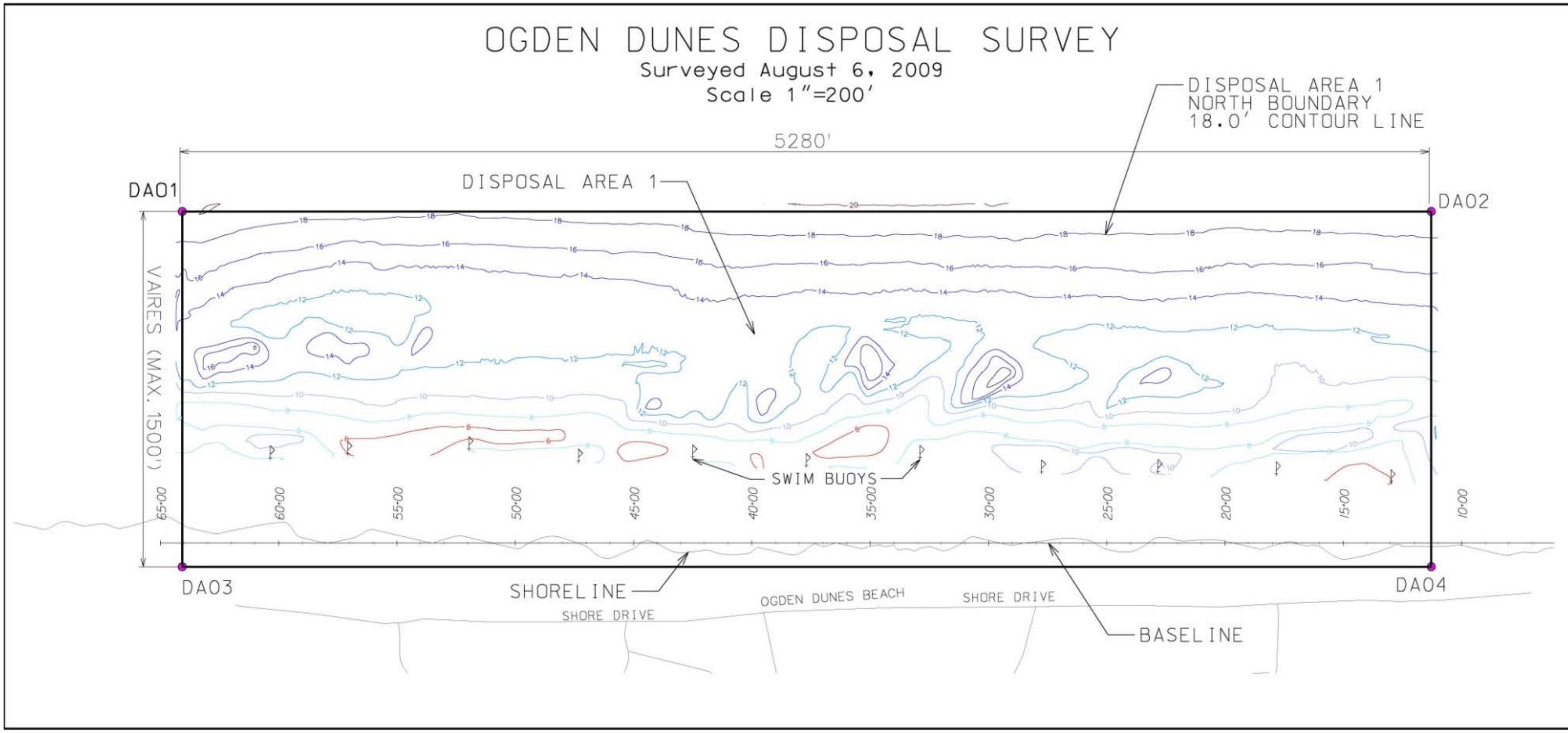
Ogden Dunes Pre-Deposit Offshore Contours July 2007



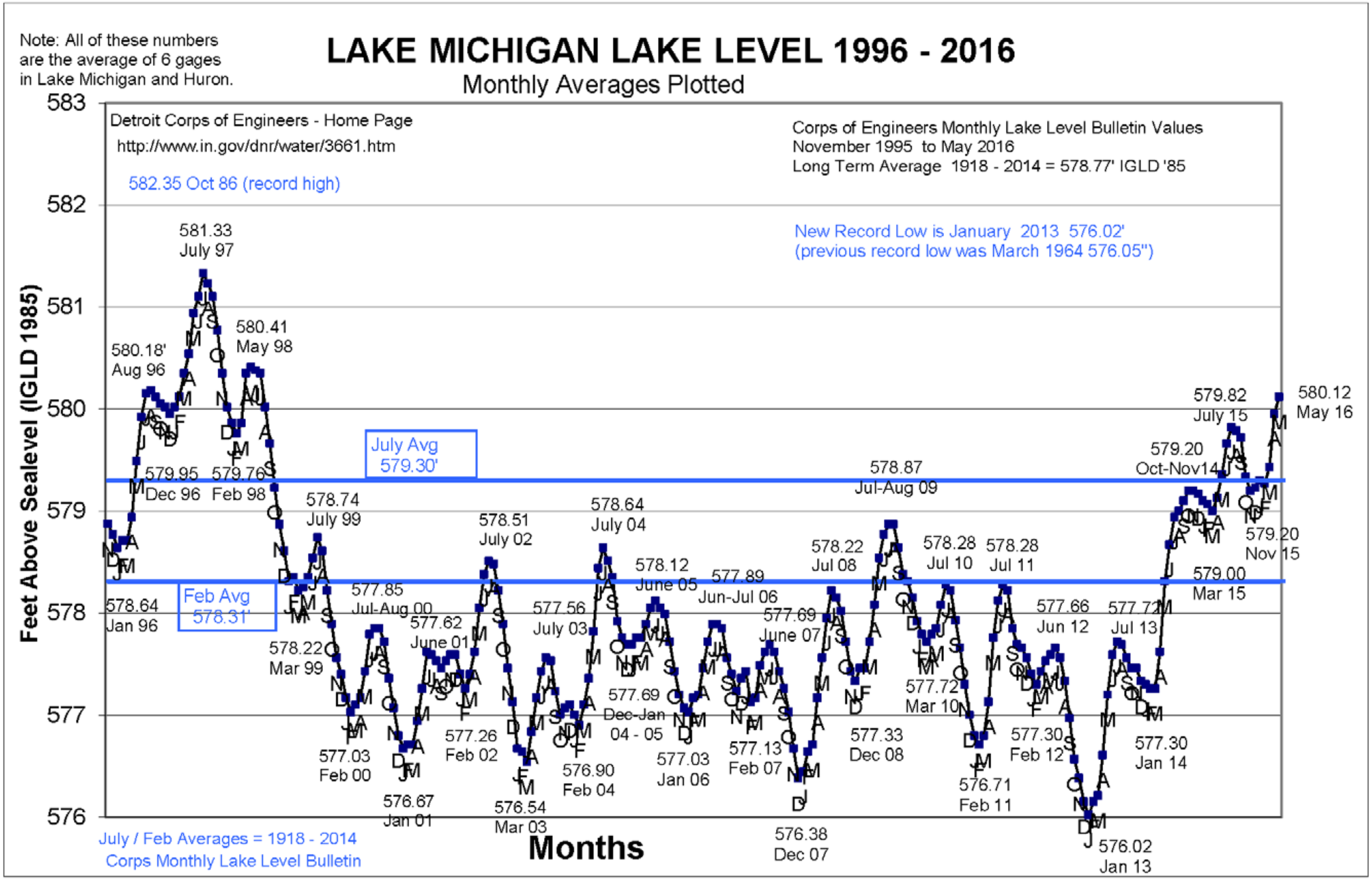
Ogden Dunes Post – Deposit Offshore Contours Sept 2007



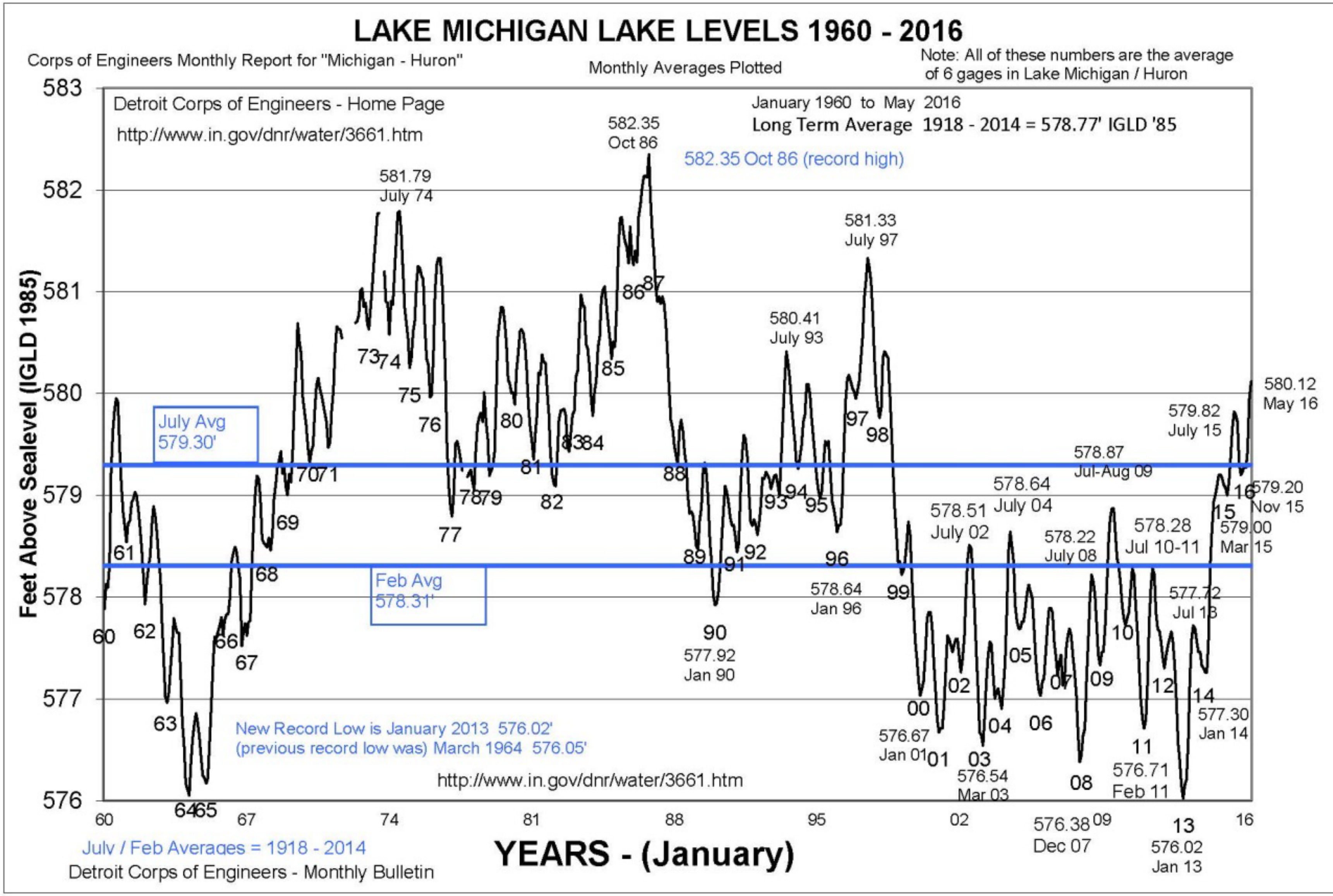
Ogden Dunes 2009 offshore profile



1996 – 2016 Lake Level Graph

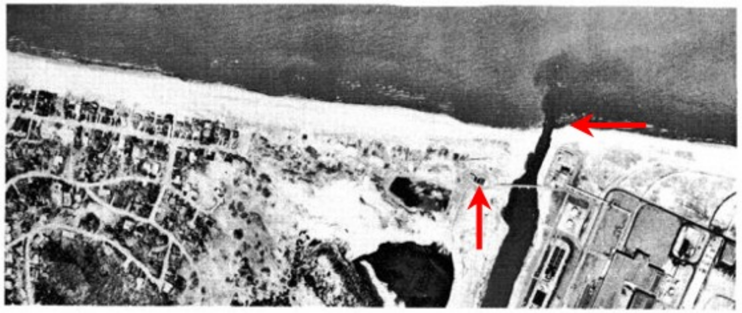


Lake Level Graph 1960 - 2016

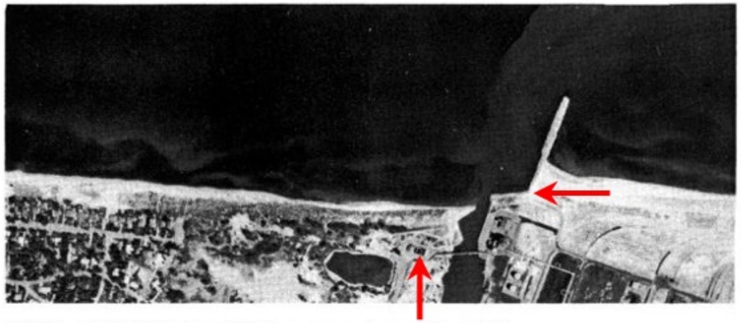


THANK YOU!

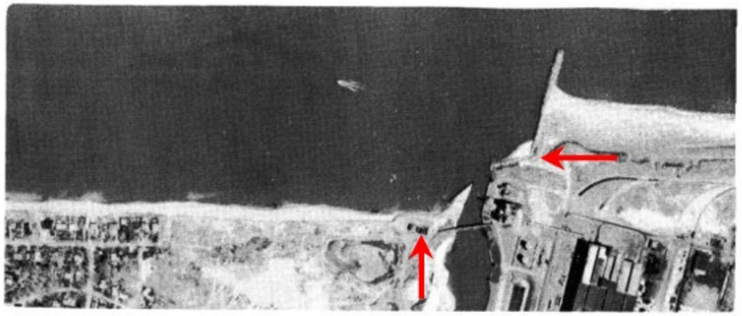
US Steel Midwest Breakwater/ West erosion
Red arrows fixed position



7-37a Burns/Portage Waterway entrance in 1967



7-37b Burns/Portage Waterway entrance in 1969



7-37c Burns/Portage Waterway entrance in 1982

Incoming Wave Energy (right) Adds to Reflected Wave Energy = Doubles Energy