Minimizing Harbor Siltation

PIANC A.D. 1885 AIPCN NAVIGARE NECESSE

Working Group 43

Current Deflecting Wall
Hamburg, Germany

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Moffatt & Nichol

WG-43 REPORT OBJECTIVES

- **Promote Sound, Economical, Physics-Based Solutions**
- **Advance Concepts that Keep the Sediment in the System (KSIS)**
- **Encourage Comprehensive Sediment Management Considering:**
  - **Life-Cycle Economics**
  - **Environmental Impacts/Benefits**

HOW CAN WE MINIMIZE SILTATION IN HARBORS?

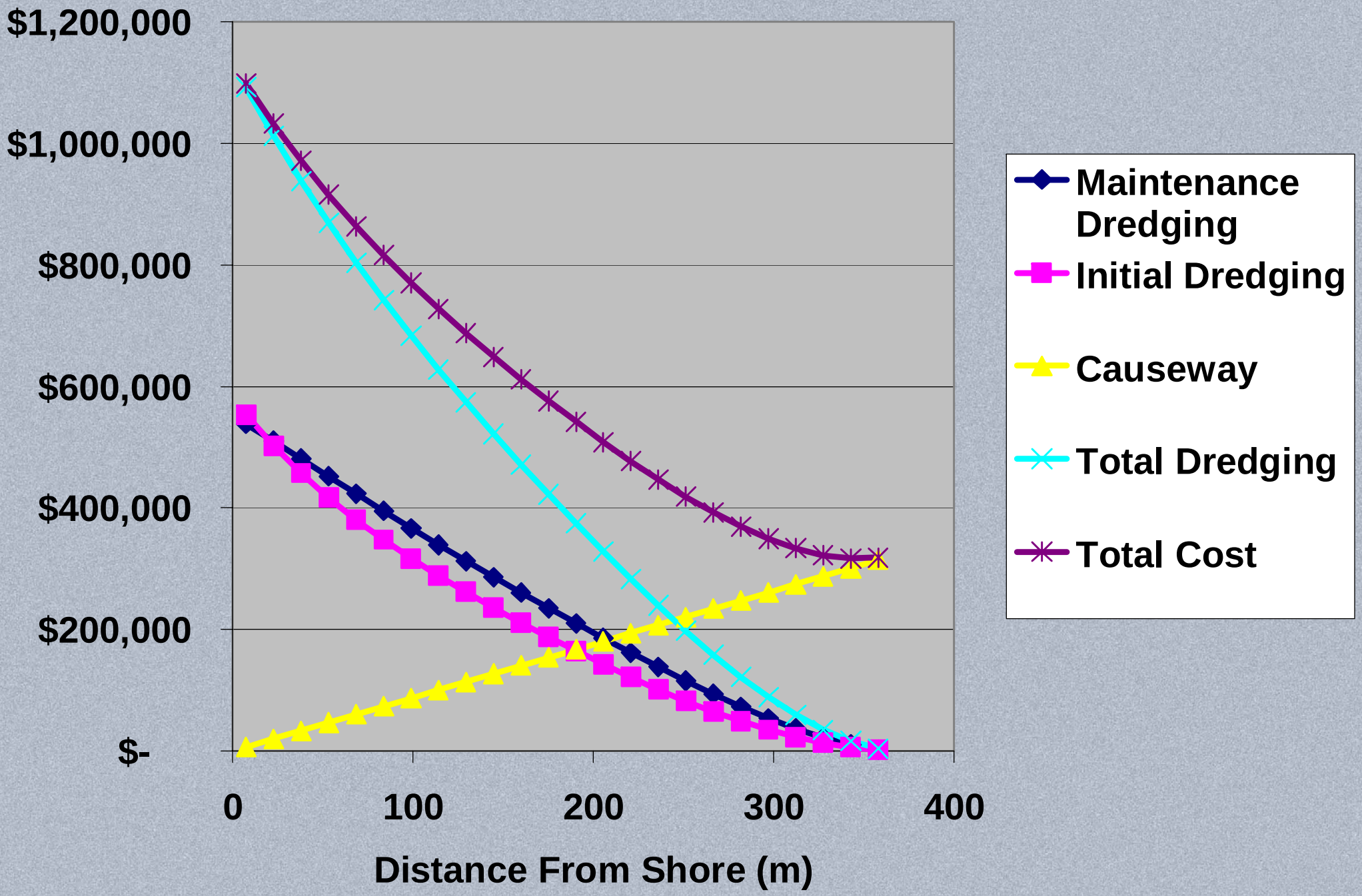
- **Build In Naturally Deep Water**
- **Otherwise:**
  - **Keep Sediment Moving (KSM)**
  - **Keep Sediment Out (KSO)**
  - **Keep Sediment Navigable (KSN)**
- **KSM & KSO Involve Managing Flow, KSN, Sediment Density**

DEEP WATER CONSTRUCTION

Berth Parallel To Flow

Wilmington, Delaware, USA

Minimizing Harbor Siltation

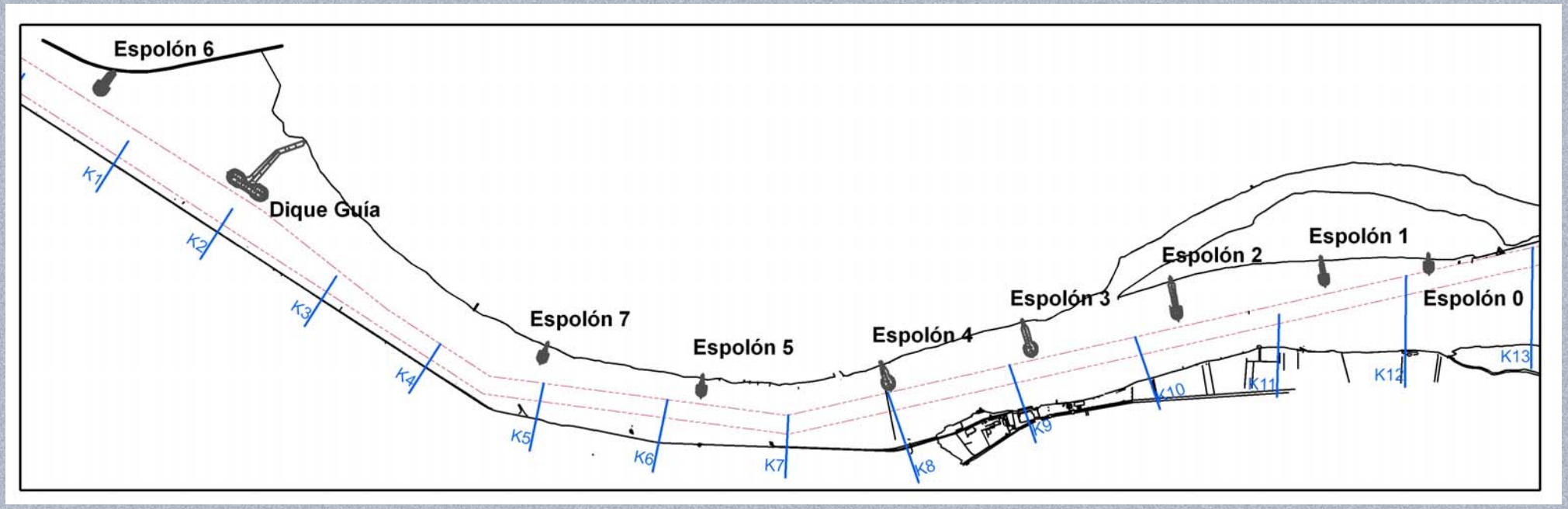


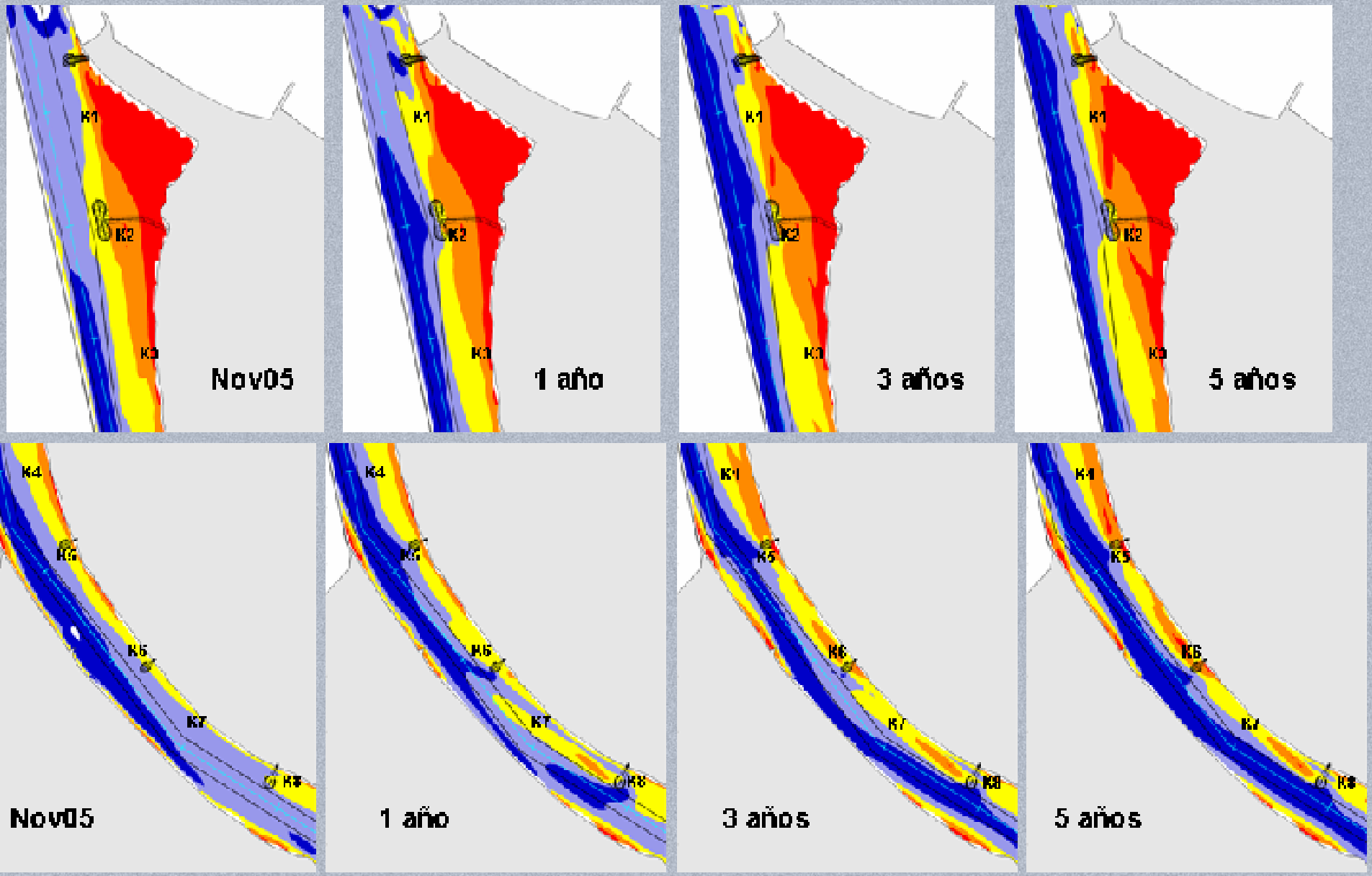
KSM IN FLOW-THRU HARBORS & CHANNELS

Strategy is to:

- **Increase velocity in deepened area**
  - ➢ **Channel or harbor basin realignment**
  - ➢ **Flow Training Structures that Maintain Velocities**
  - ➢ **By flow augmentation with prop/scour jets**
  - ➢ **Injection dredging**

Training Dikes, Magdalena River, Colombia




K1
K2
K3
Nov05
1 año
3 años
5 años
K4
K5
K6
K7
K8
Nov05
1 año
3 años
5 años
Profundidad con referencia al nivel medio del mar (pies)
< 10
20
30
> 40

Yangtze River, China

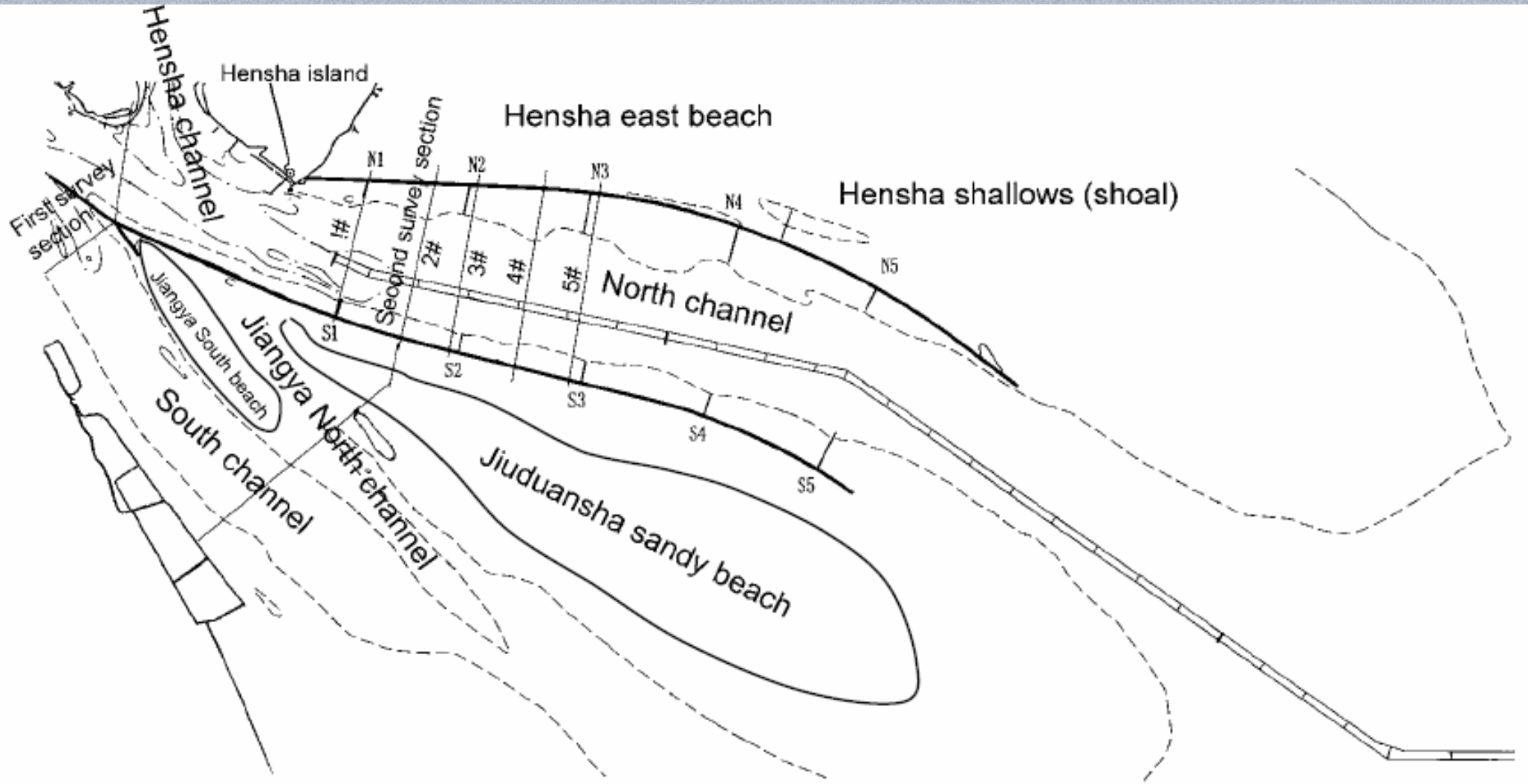
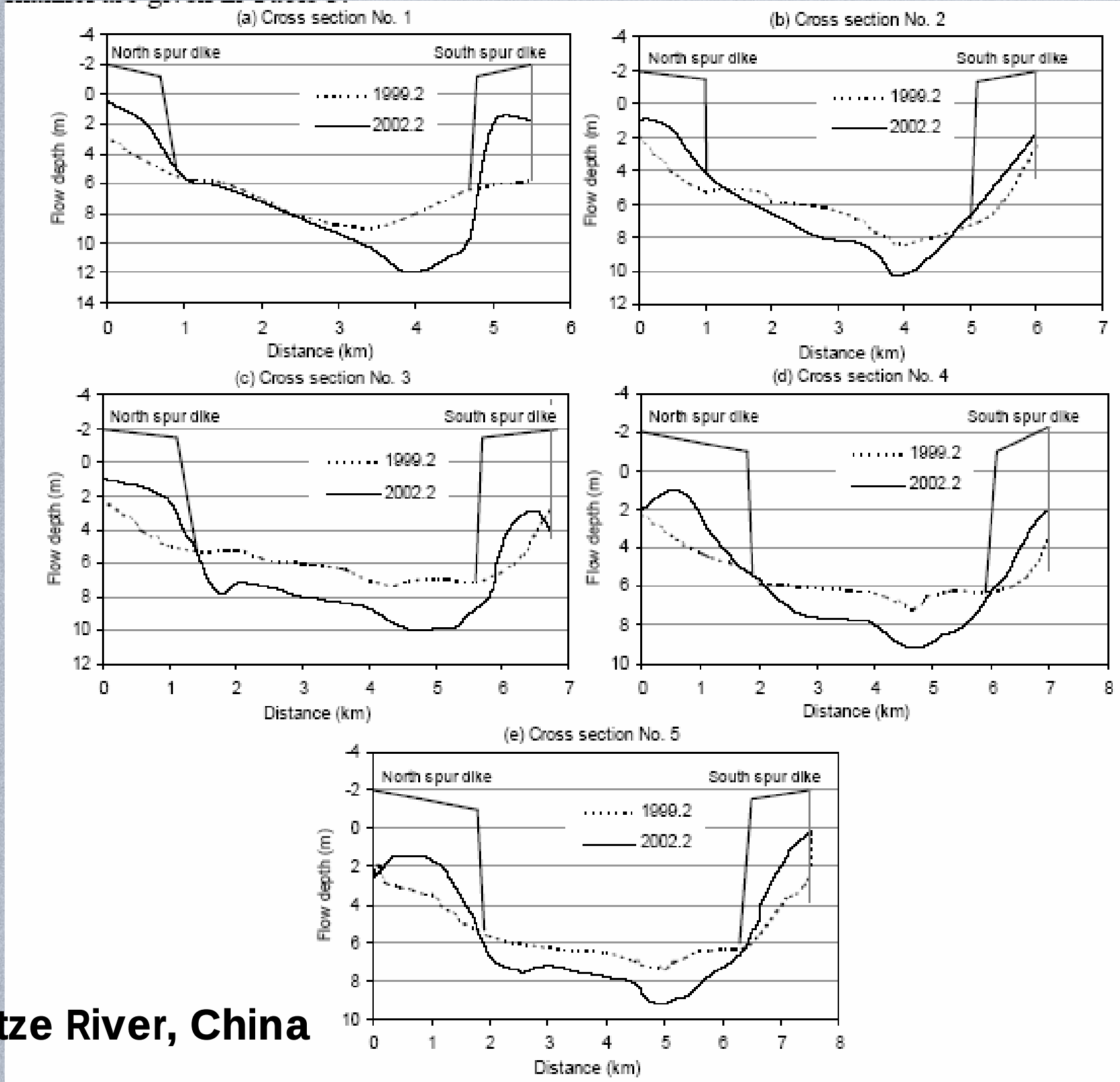


Fig. 1 Plan view of the first phase of deep navigation channel in the Yangtze River Estuary

Yangtze River, China

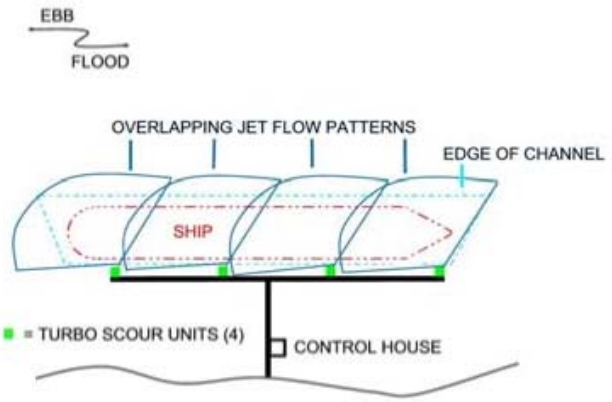


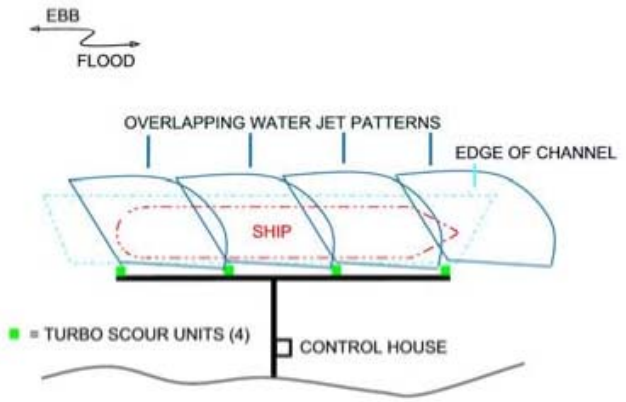
Yangtze River, China

KSM- SCOUR AND PROPELLOR JETS

EBB CYCLE

FLOOD CYCLE



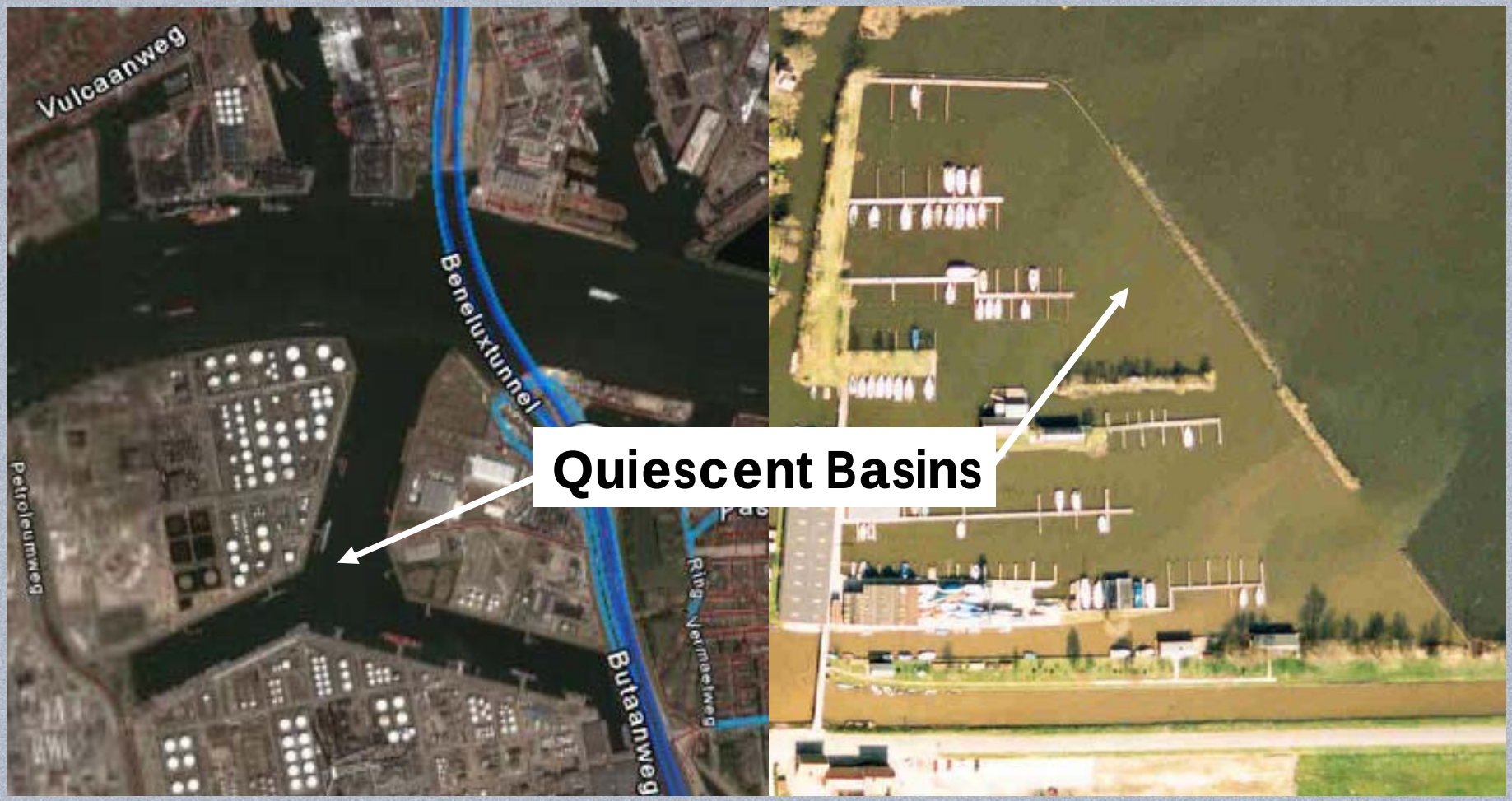


Propeller Jet System, Scour Systems, Inc.

KSM- PROPELLOR/SCOUR JETS

- **Systems Have Been Installed:**
  - **King's Bay, GA**
  - **Savannah, NC**
  - **Linden, NJ**
  - **Gray's Harbor**
- **Each Installation Has Eliminated Dredging**
- **Best-Suited For Berthing Areas**
- **System Keeps Sediment In the Natural System**

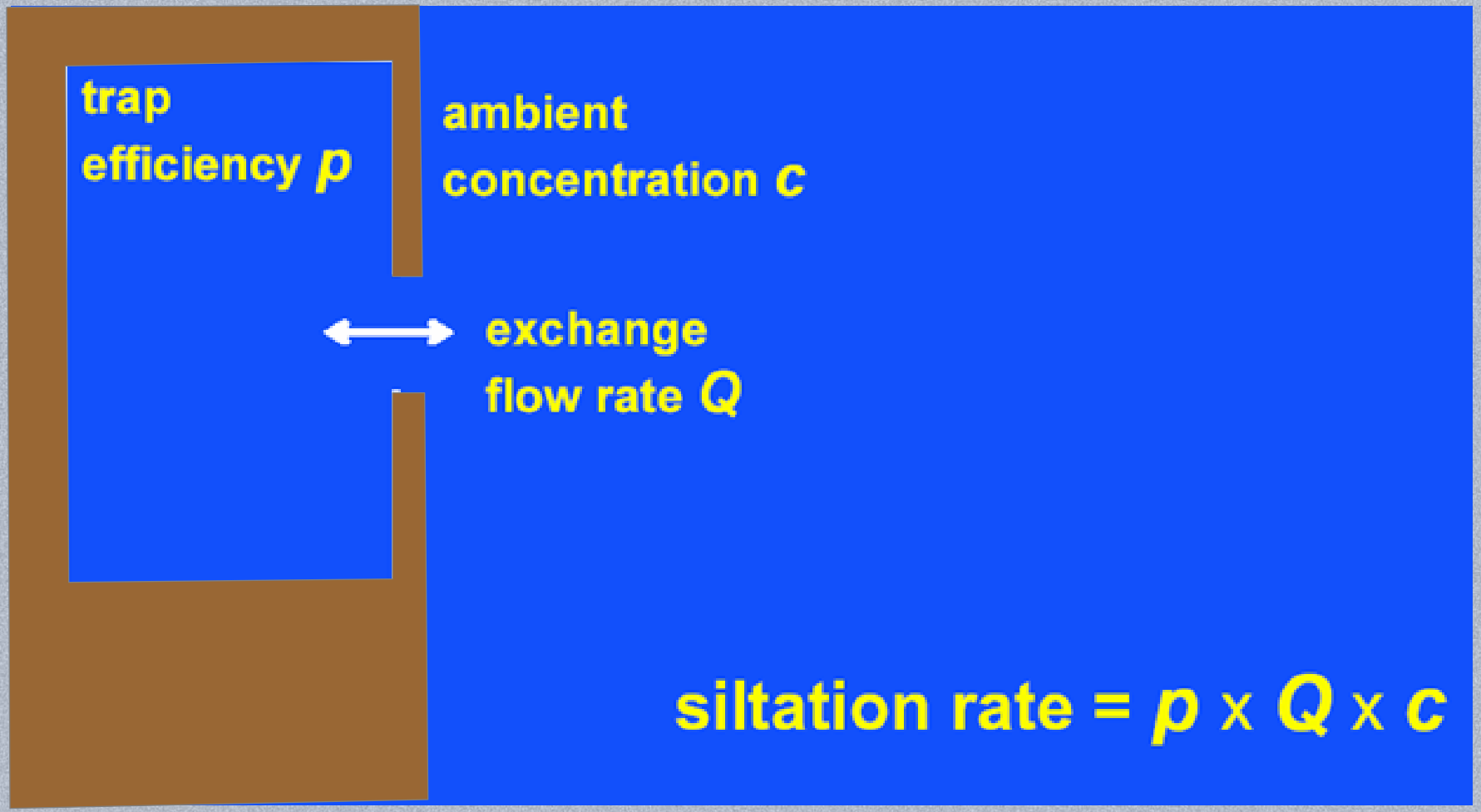
HARBOUR BASINS

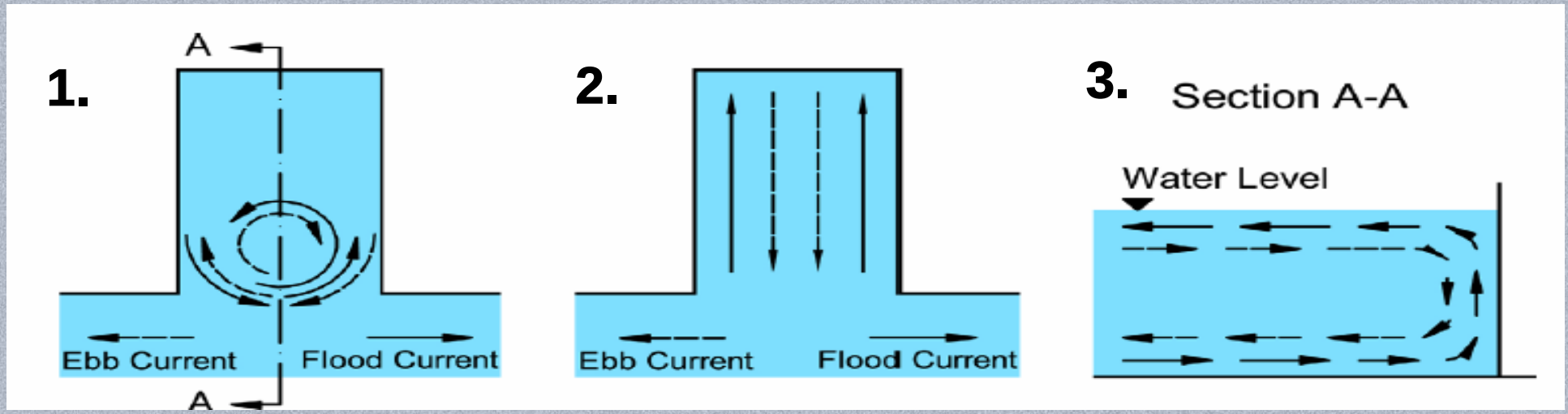


Port of Rotterdam

Manten, Holland

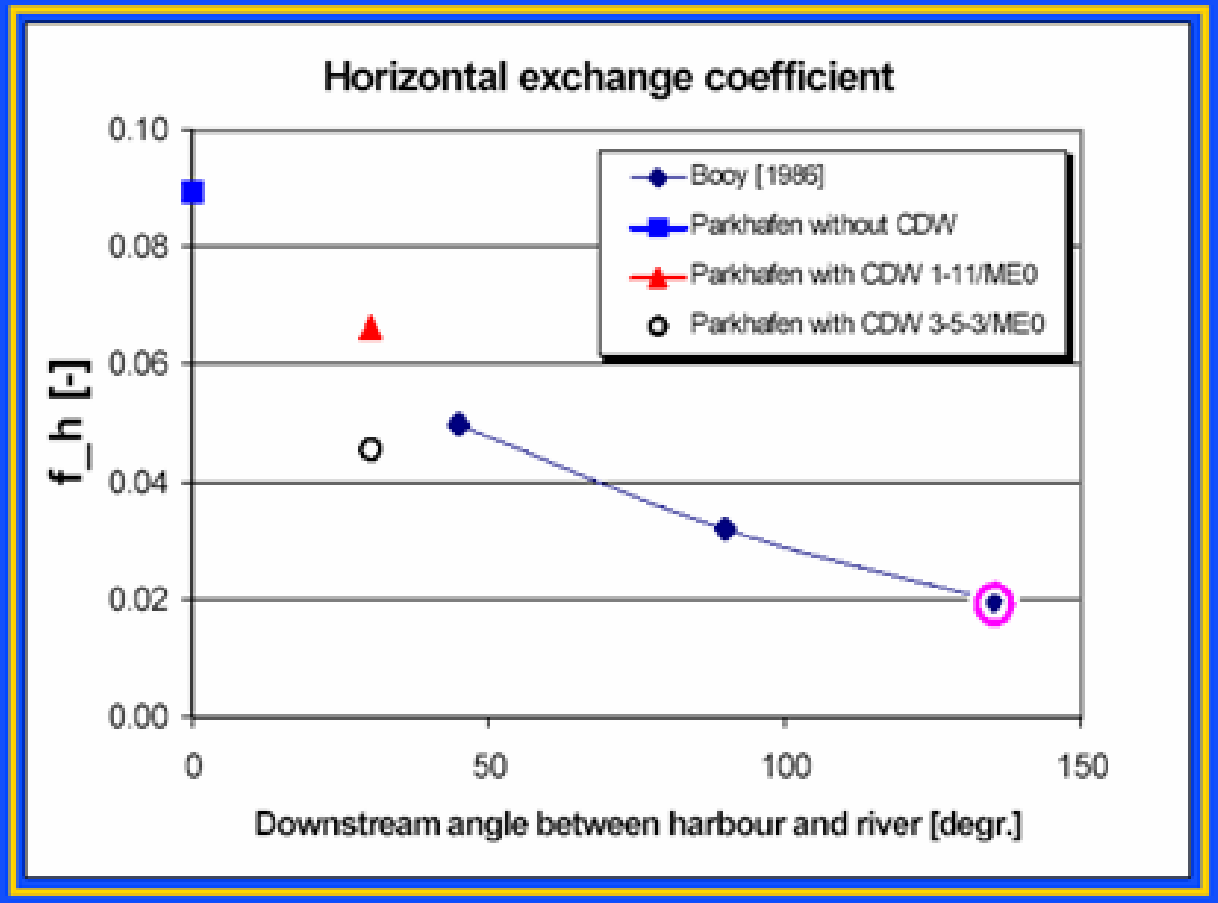
SIMPLIFIED PHYSICS OF SEDIMENTATION IN IN BASIN HARBORS





1. **Horizontal Eddy Exchange (Can Be Reduced)**
2. **Tidal Exchange (Cannot Be Changed)**
3. **Density Currents (Can Be Reduced)**

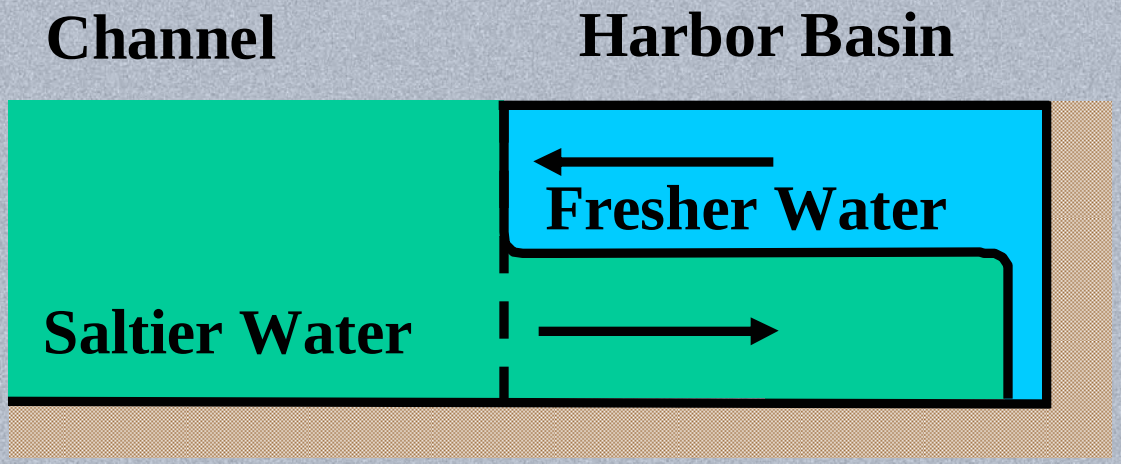
HORIZONTAL EDDY EXCHANGE



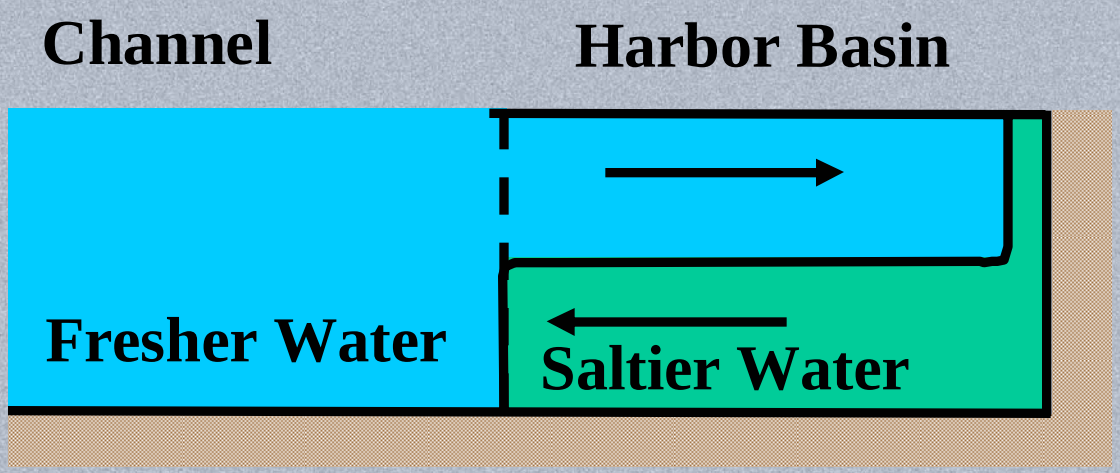
$$Q_h = f_h \times u \times A$$

SALT/FRESH WATER DENSITY CURRENTS

Incoming Tide:
Brings Saltier/Heavier Water To Basin



Outgoing Tide:
Brings Fresher/Lighter Water To Basin

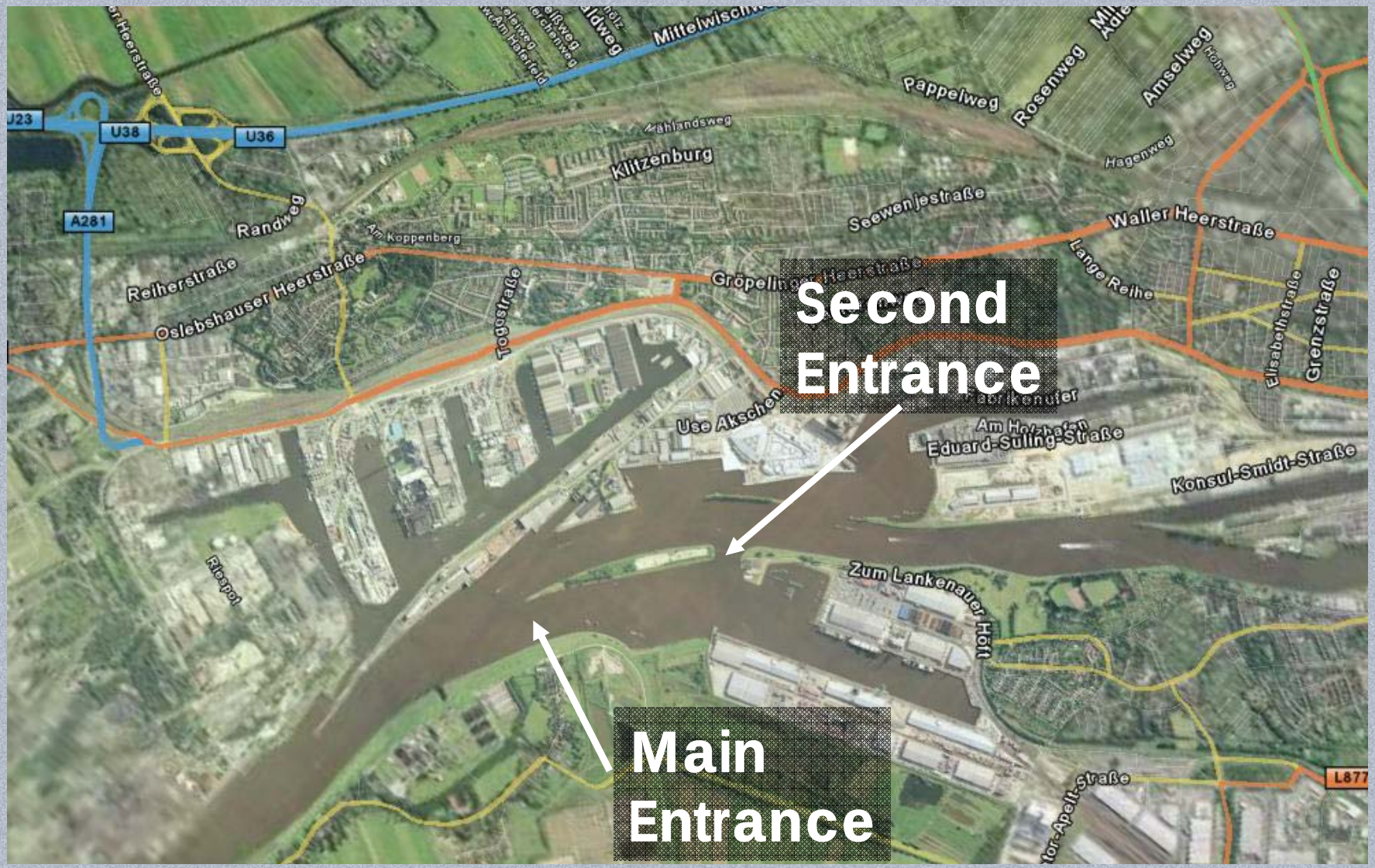


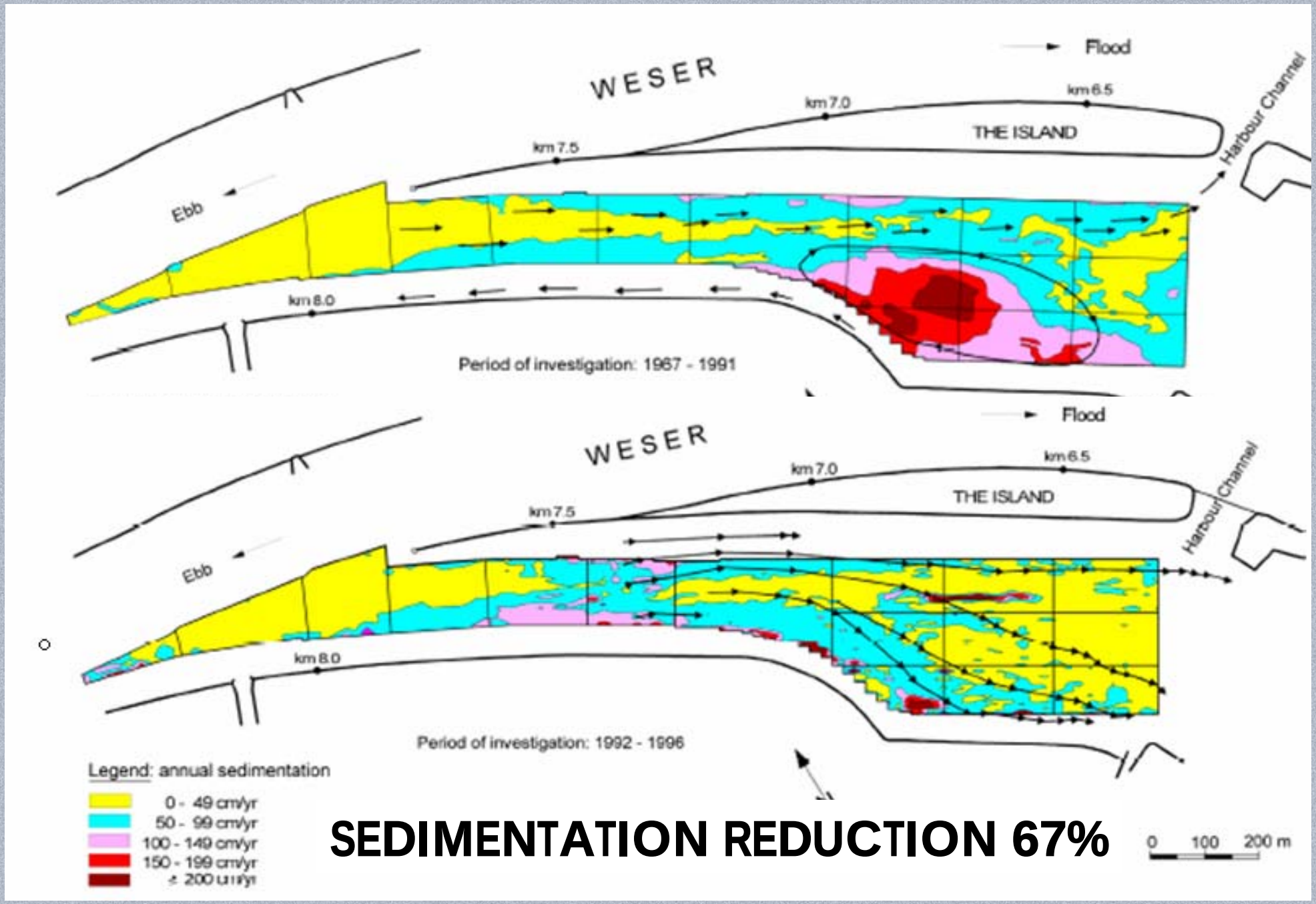
Even a Small Change In Salinity (i.e., 1-2 ppt) Can Exchange A Very Large Volume Of Water, More Than Tide or Eddy Exchange!!

METHODS TO REDUCE EXCHANGE (KSO)

- Narrow Entrance
- Use Only 1 Entrance
- Change Entrance Orientation
- Use of Structures
  - Pile Groin
  - Current Deflecting Wall (CDW)
  - Modified CDW For Density Currents

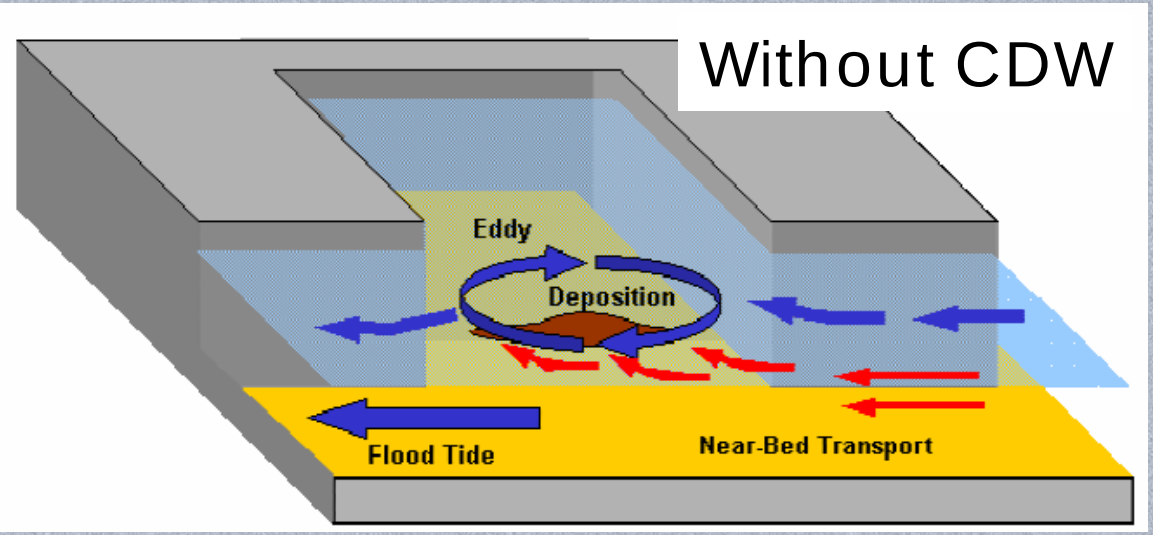
PORT OF BREMEN, GERMANY

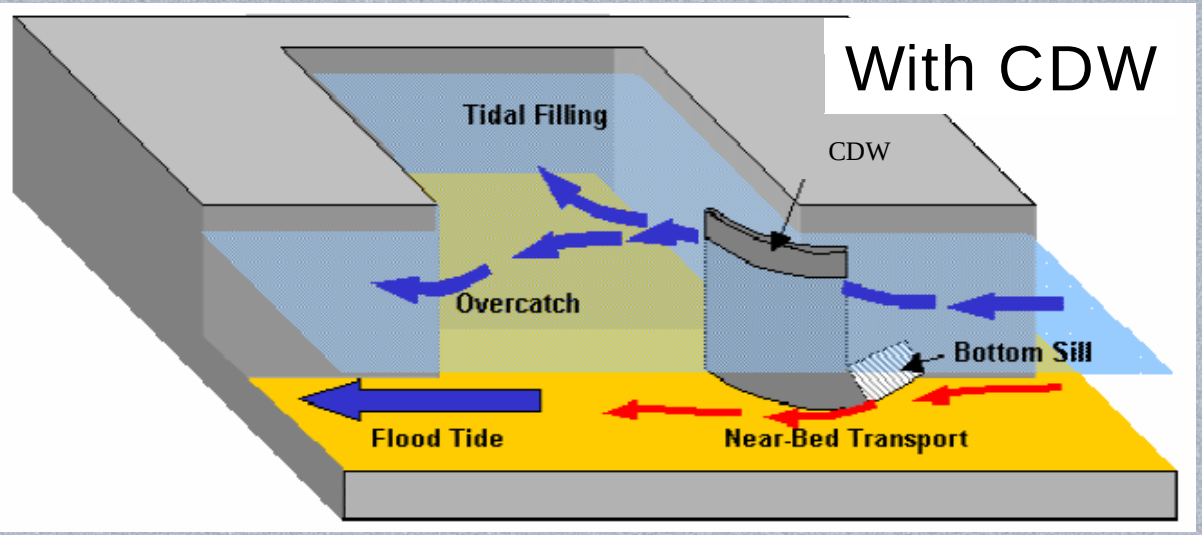




SEDIMENTATION REDUCTION 67%

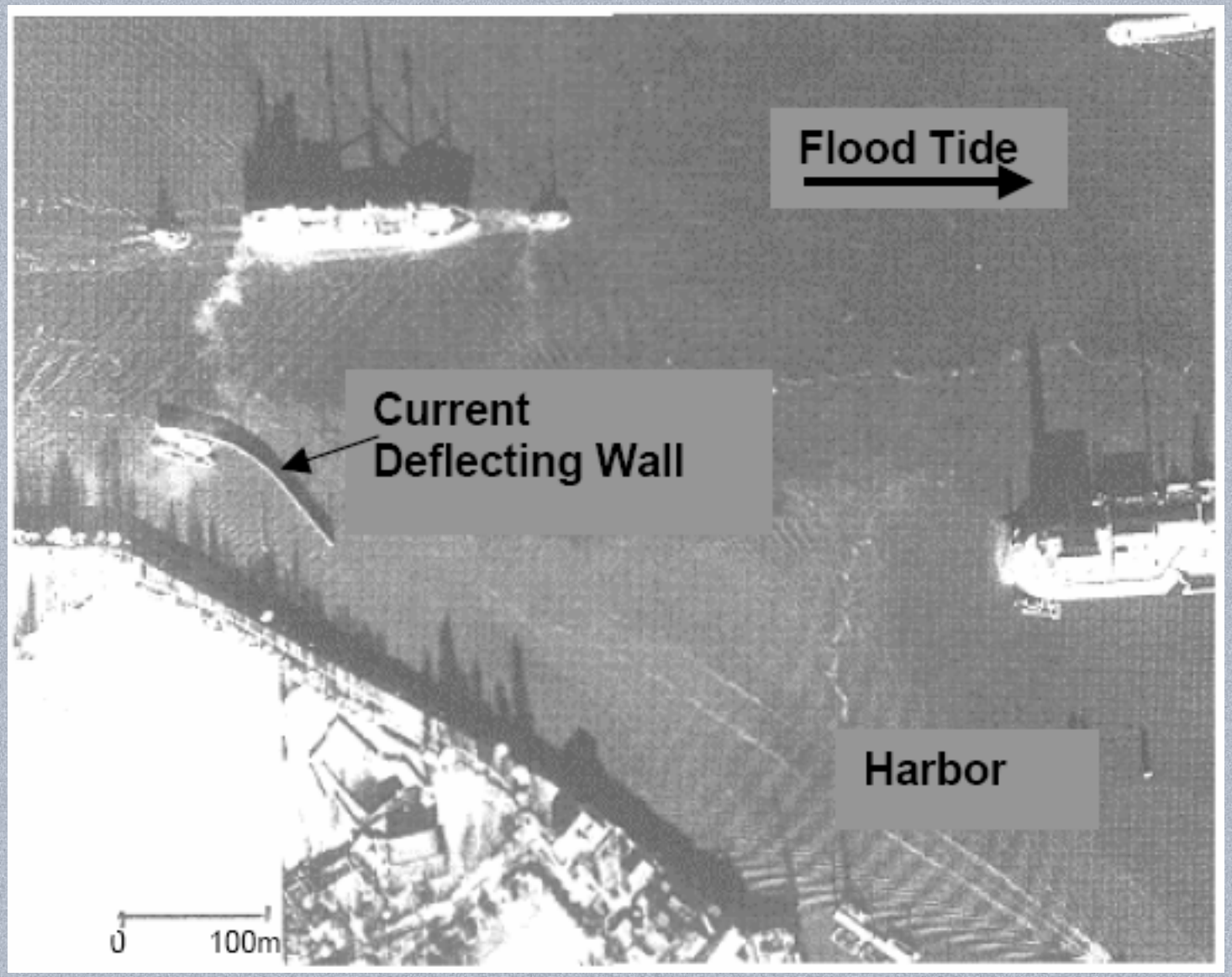
CURRENT DEFLECTING WALL TO REDUCE EDDY EXCHANGE



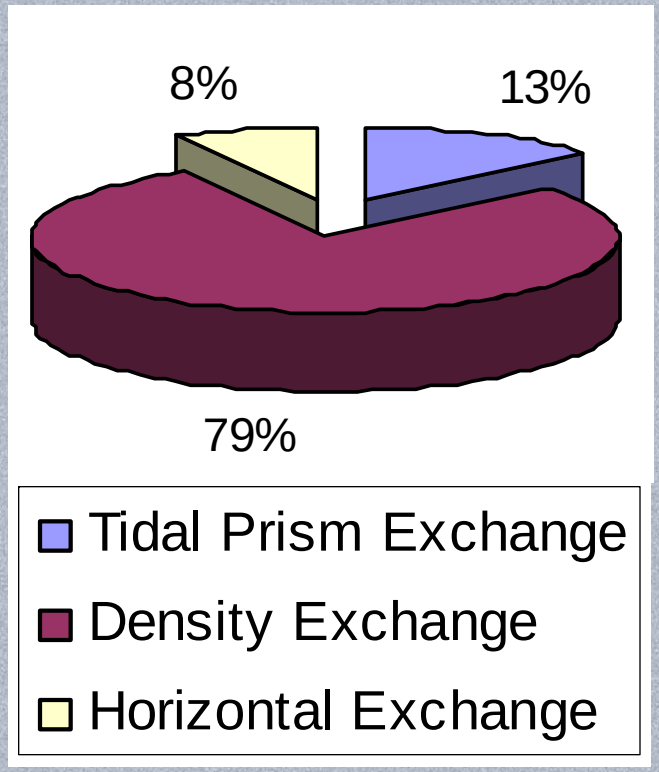


Kohlfleet Harbor Basin
Hamburg, Germany

CURRENT DEFLECTING WALL- KOHLFLEET BASIN

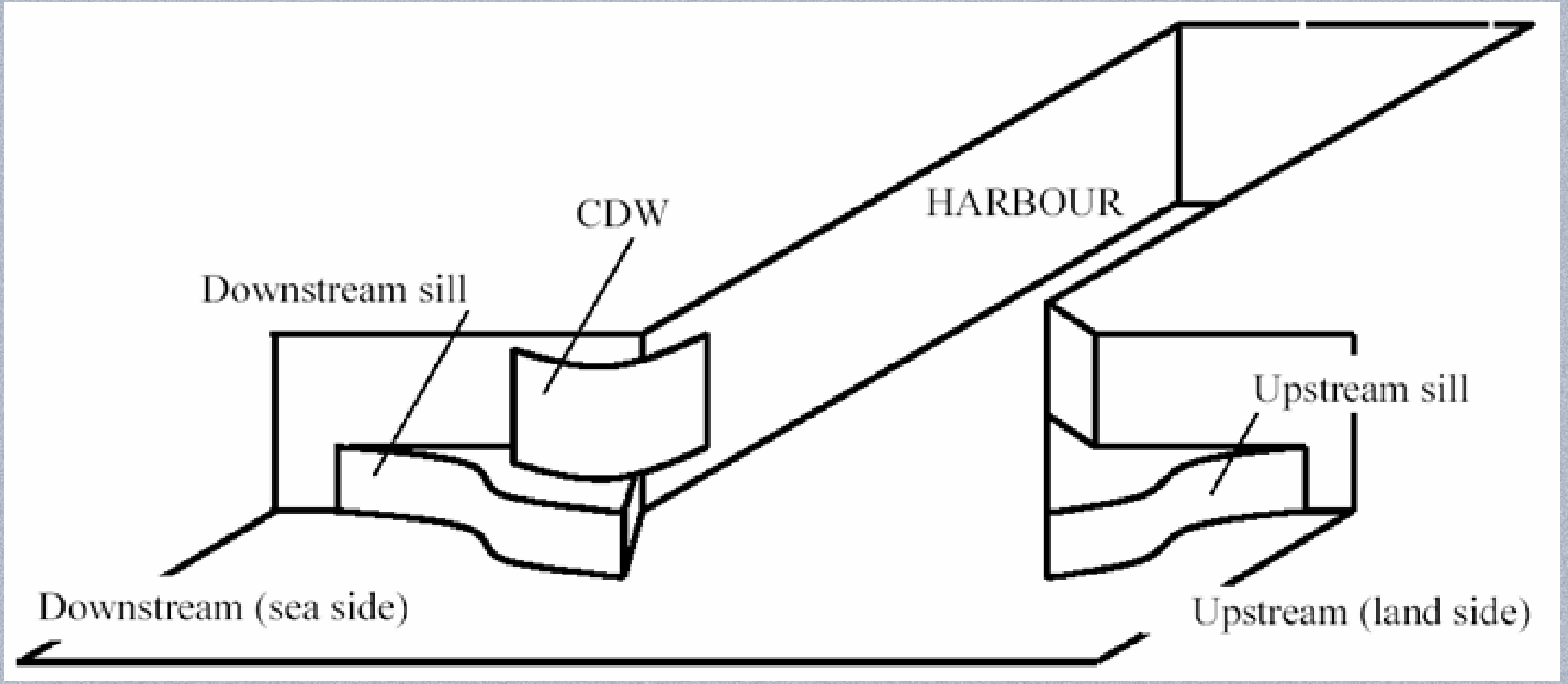


Petroleum Haven 2e, Port of Rotterdam



~8% reduction

CURRENT DEFLECTING WALL FOR DENSITY CURRENTS

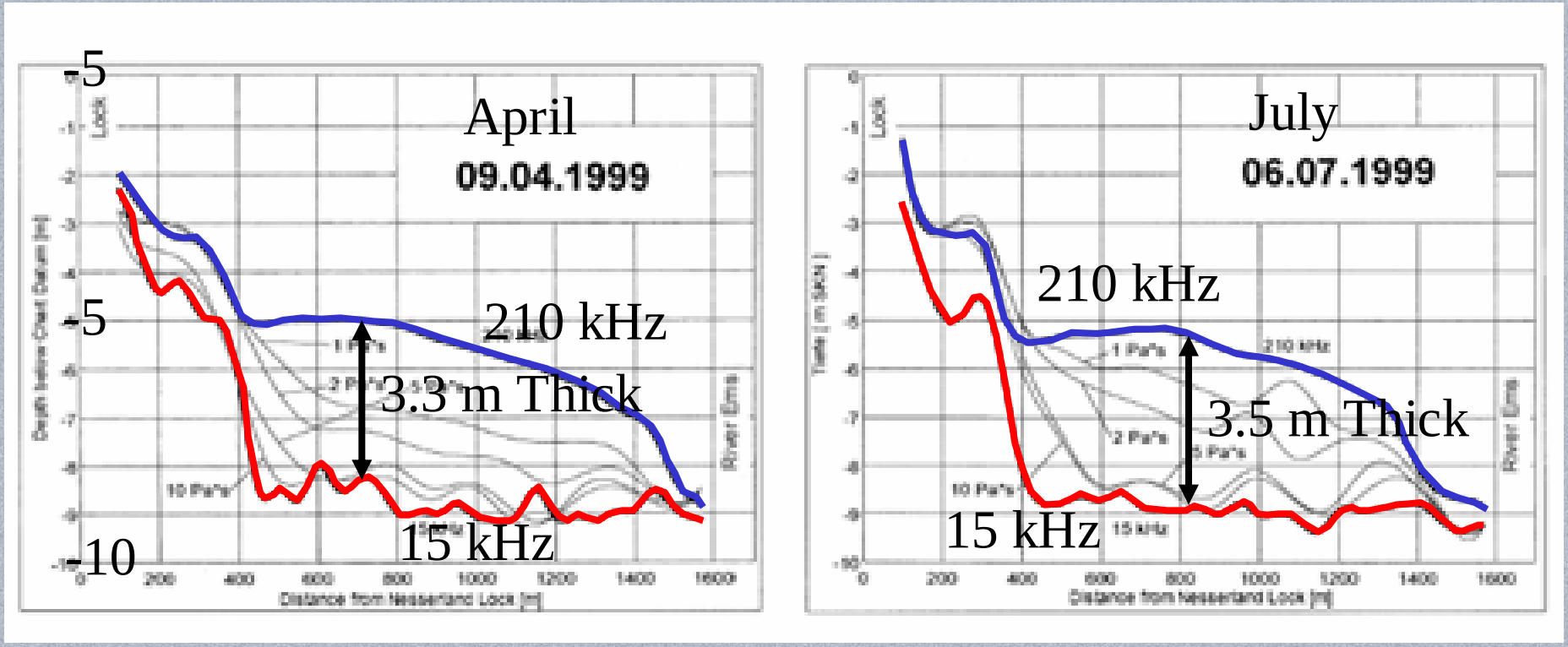


CURRENT DEFLECTING WALL FOR DENSITY CURRENTS

- **Creates a Helical Flow Across the Entrance during Flood Tide**
- **Model tests suggest that the system reduces Flood Exchange by 70%**
- **Not Yet Tested in Field Conditions**

PORT OF EMDEN, GERMANY – FLUID MUD PROBLEM

FLUID MUD THICKNESS PORT OF EMDEN, GERMANY

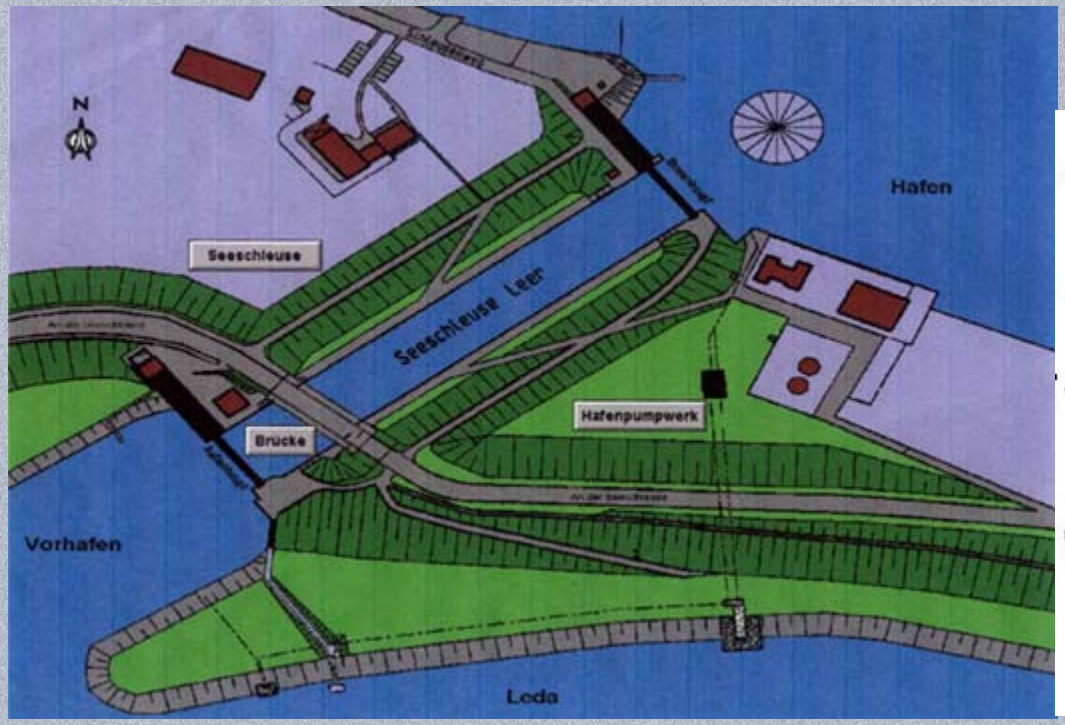


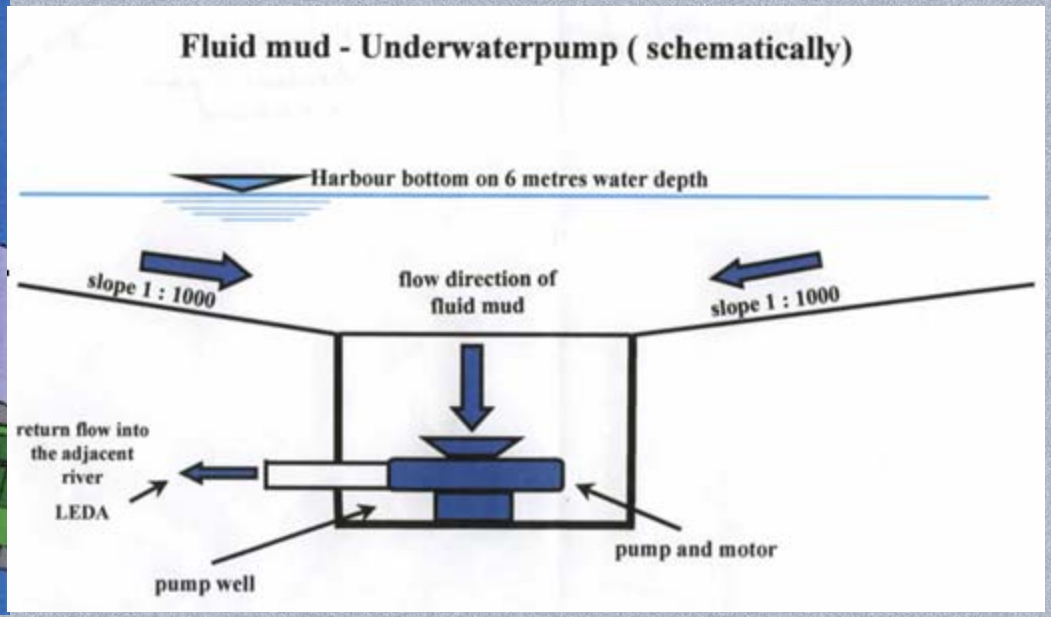
FLUID MUD IS IN EQUILIBRIUM WITH RIVER/SEDIMENT CONDITIONS
THICKNESS REMAINS CONSTANT OVER TIME!

In-Situ Treatment, PORT OF EMDEN, GERMANY

- The Deposit Starts As Fluid Mud & Eventually Consolidates
- In the past, dredging of 2.5 M cubic meters per year (deposited upland and/or offshore) was required
- IST: Remove Sediment From the Bottom into a Dredge Hopper, Exposing it to Oxygen, and then Depositing it Back on the Bottom
- Ships Sail Right Thru The Fluid Mud
- IST, Performed Every 3 Months, Eliminated the Need For Dredging

PUMPING SYSTEM- PORT OF LEER, GERMANY





CONCLUSIONS

- **Minimizing Harbor Siltation should be key element of Dredged Material Management Plans**
- **Siltation Is Governed by Basic Physics**
- **Fundamental Strategies Exist For Reducing Sedimentation**
- **The Best Strategies Keep Sediment In the System (KSIS)**
- **Strategies Can Be Cost-Effective and those Based on Physics Are Universally Applicable**