Cascade

An Integrated Coastal Regional Model for Decision Support and Engineering Design

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Cascade

Motivation

- Need for predicting response of multiple-system, evolving coastal regions with interacting projects & coastal processes
- Oceanic and watershed scales involved: sea-level rise, storms, river sediment yields, sediment supply
- Coastal projects influence coast for centuries & on regional scale
- These process scales have not been studied! → Big benefit!

Objective

Develop a new class of model, called “Cascade,” for calculating

- Longshore sediment transport
- Inlet channel infilling, inlet morphology change, and bypassing
- Multiple projects, regional time and space scales
- Changes barrier islands, inlets, jetties, rivers, washover, wind-blown sand, and processes where data are not readily available

Cascade Overview

Simulate longshore and cross-shore sediment transport and long-term coastal evolution with respect to:

- **Complex regional trends**
- **Multiple, interacting projects with cumulative impacts**
- **Inlet sediment storage and transfer**
- **Breaching, washover (storms)**
- **Sources & sinks (beach nourishment, wind-blown sand, rivers)**
- **Jetty construction (impoundment, bypassing)**
- **Navigation channel maintenance**
- **Large-scale gradients in forcing**

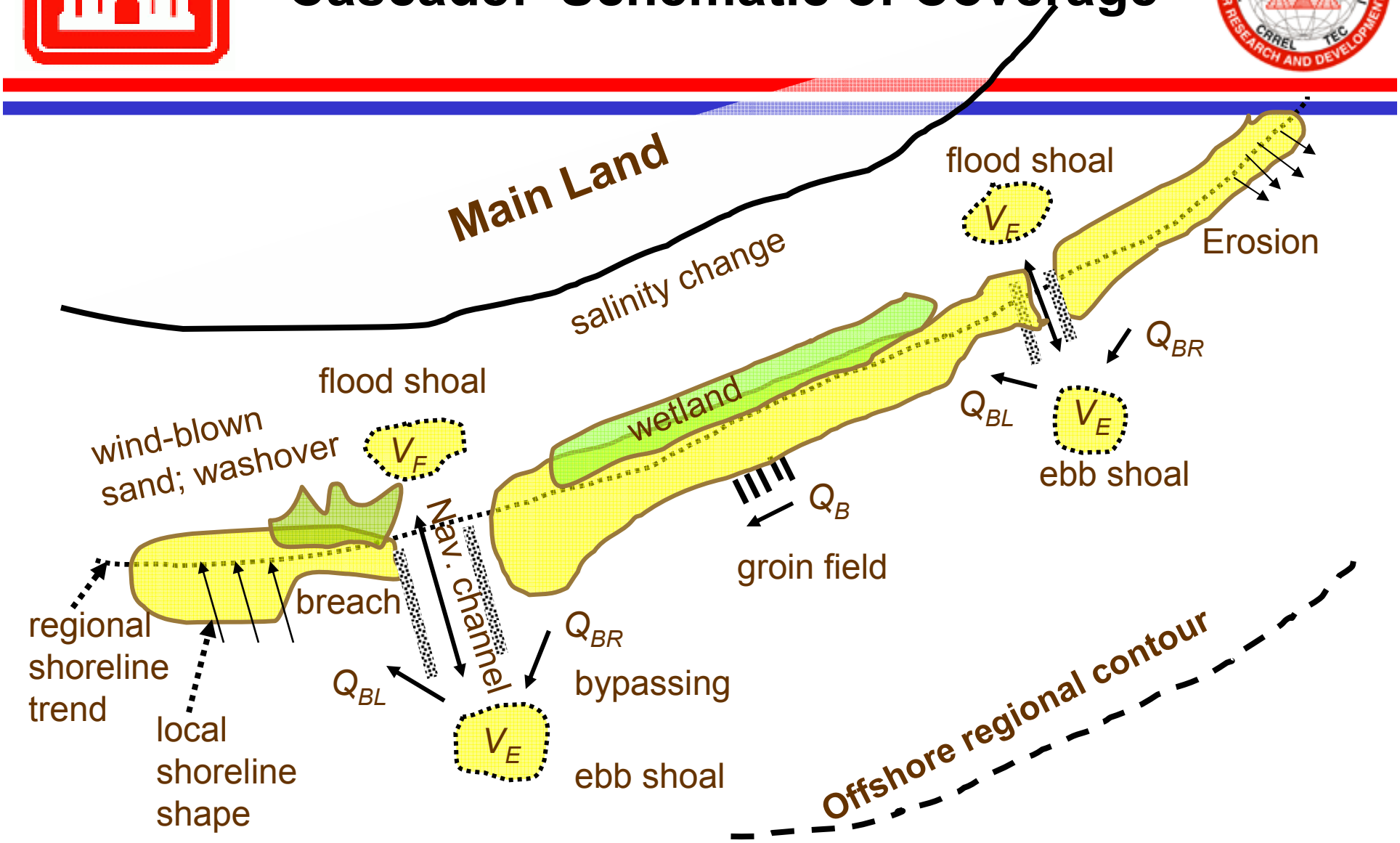
Cascade Model Details

1. Process identification
2. Equation selection
3. Numerical technique selection

1. Baseline conditions
2. Calibration
3. Validation
4. Sensitivity analysis
5. Uncertainty estimate

1. Analysis
2. Prediction
3. Design
4. O&M
5. ”What if?”

Cascade: Schematic of Coverage



Longshore Sediment Transport Rate

New, General Meso-scale Theory

$$Q = \frac{\varepsilon}{(\rho_s - \rho)(1-a)gw} FV$$

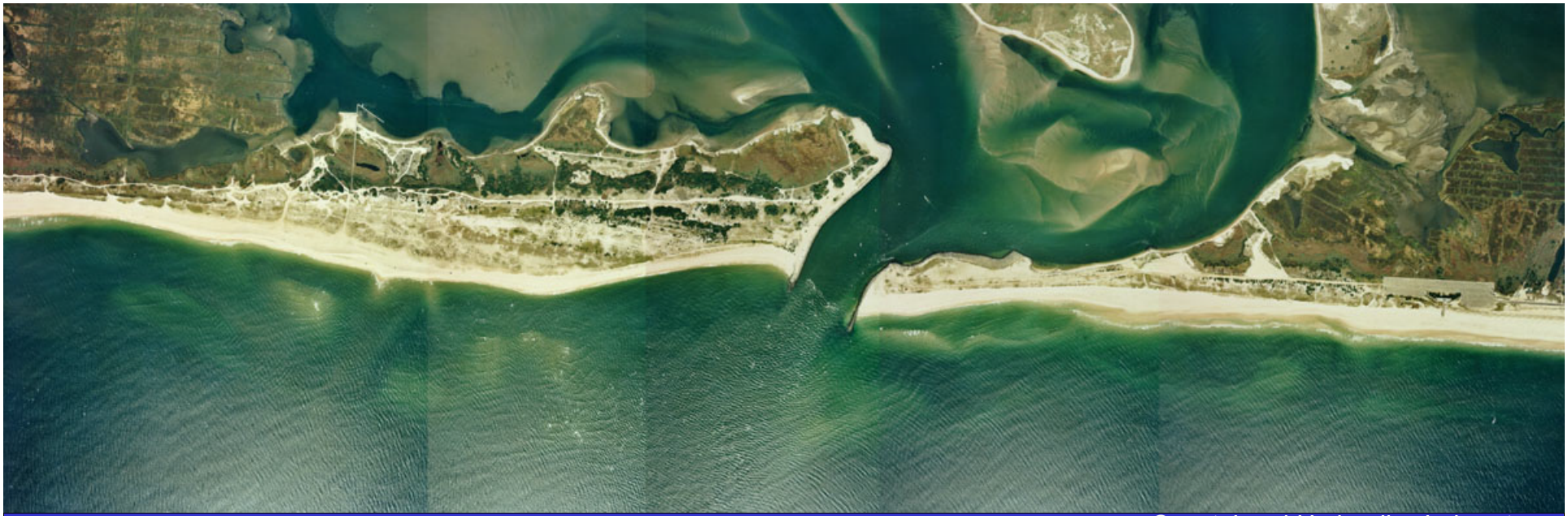
Q = longshore sed. transport rate

ε = efficiency factor $\varepsilon = 0.77 c_f K$

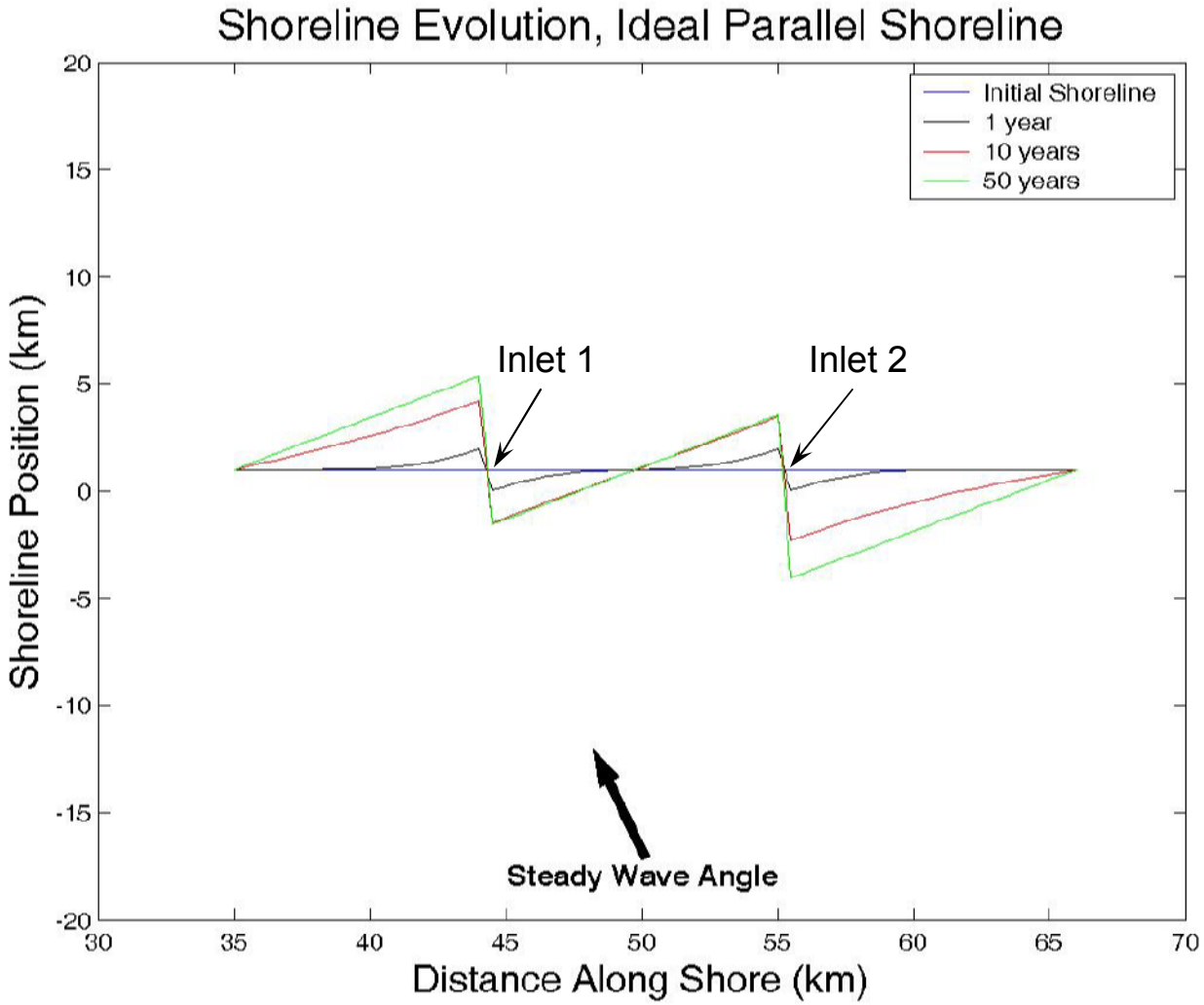
F = wave energy flux towards shore

V = mean longshore current

w = sediment fall speed



Cascade Sensitivity Analysis

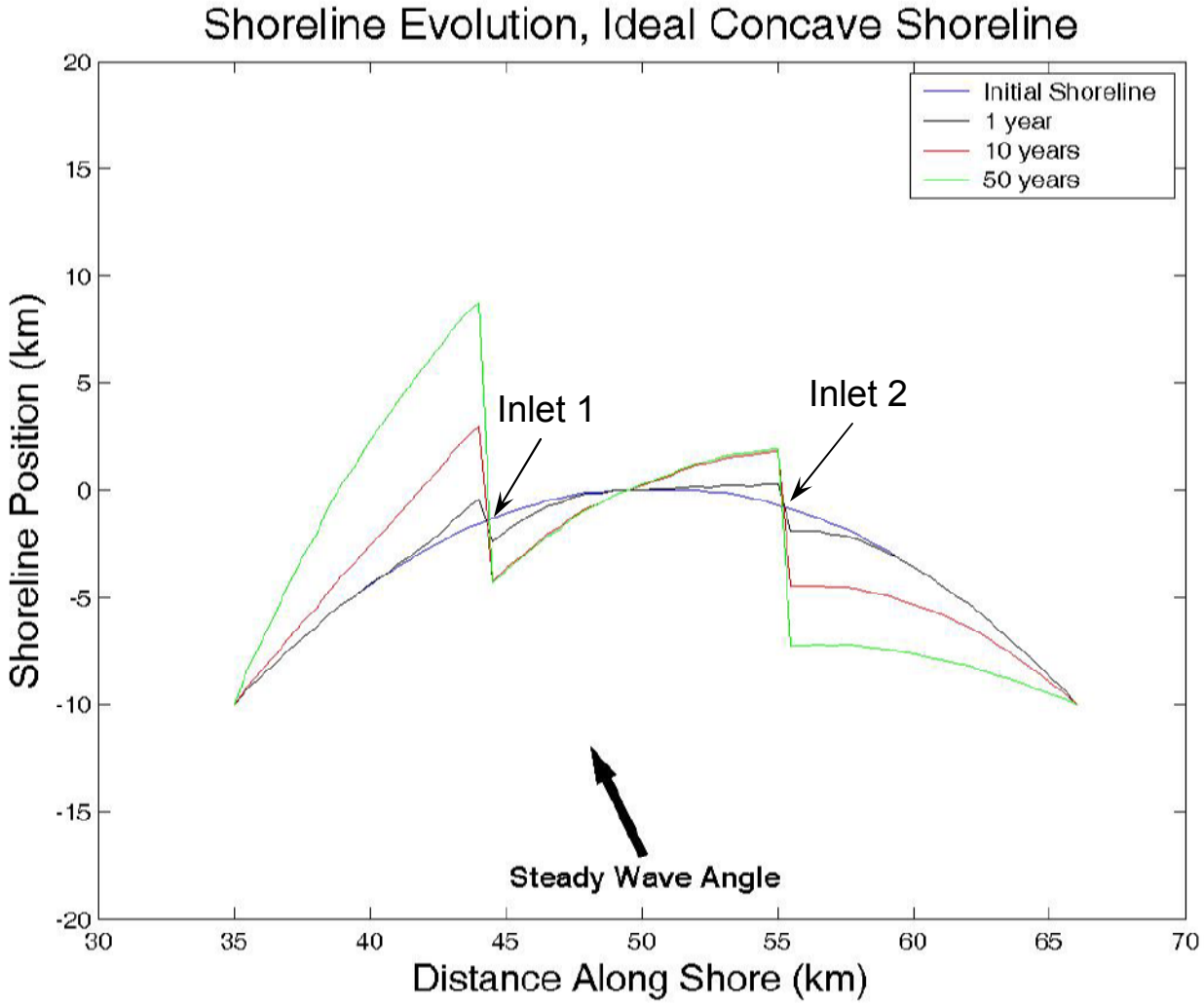


Idealized case:

- Three barrier islands
- Two inlets
- Constant wave height and angle
- Straight regional shoreline trend

Test to examine wave & shoreline angle with evolving shoreline

Cascade Sensitivity Analysis



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Test Sites
Cascade Development and Validation

Present applications

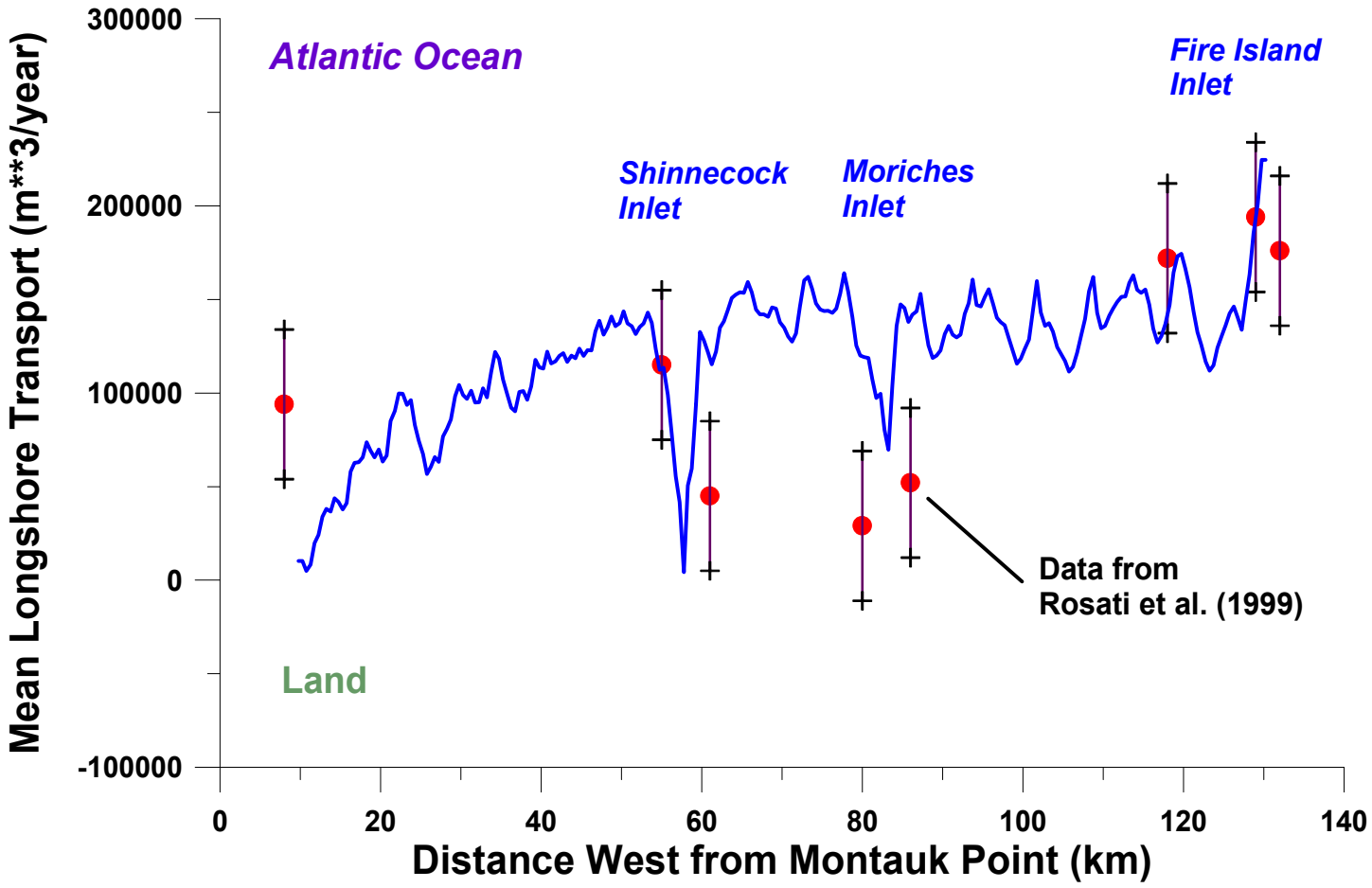
- South Shore of Long Island (Montauk Point to Fire Island Inlet), NY (~ 80 miles)
- Ocean City Inlet with Fenwick and Assateague Island (Cape Henlopen to Chincoteague), Delmarva Peninsula (~ 75 miles)

Future applications

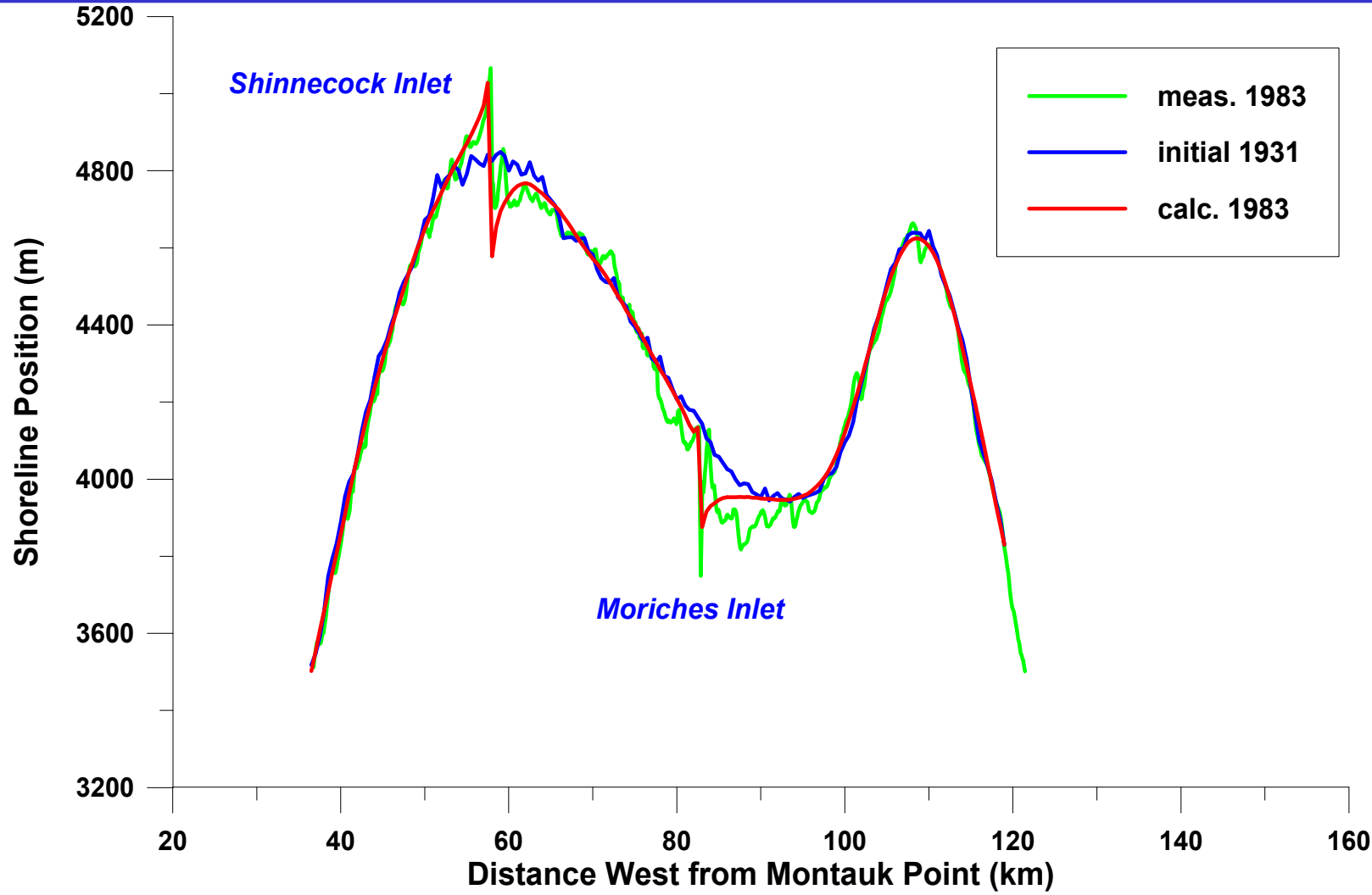
Searching for leveraging partners

Long Island, NY

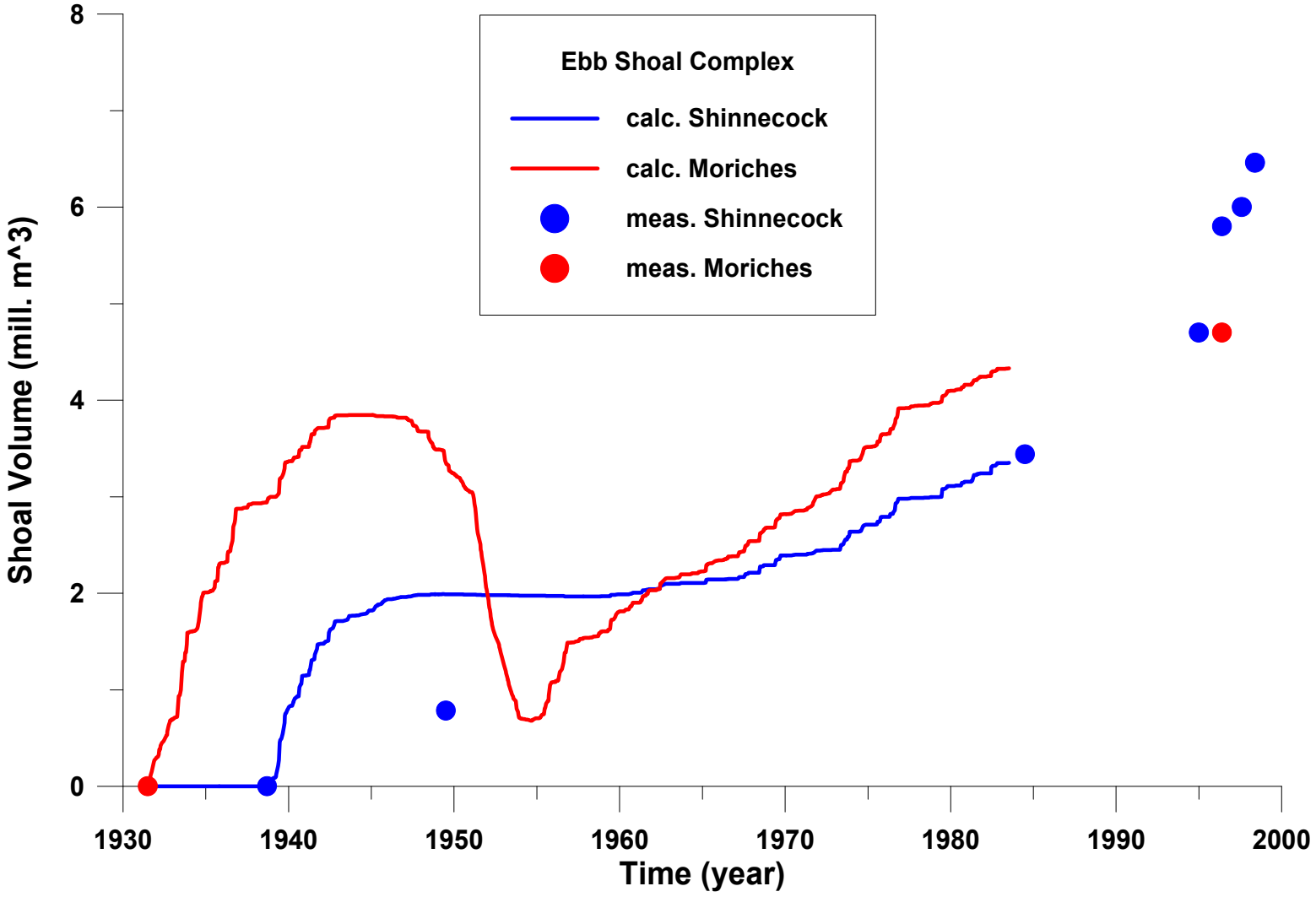
Cascade-Calculated Regional Net Longshore Sediment Transport Along South Shore of LI



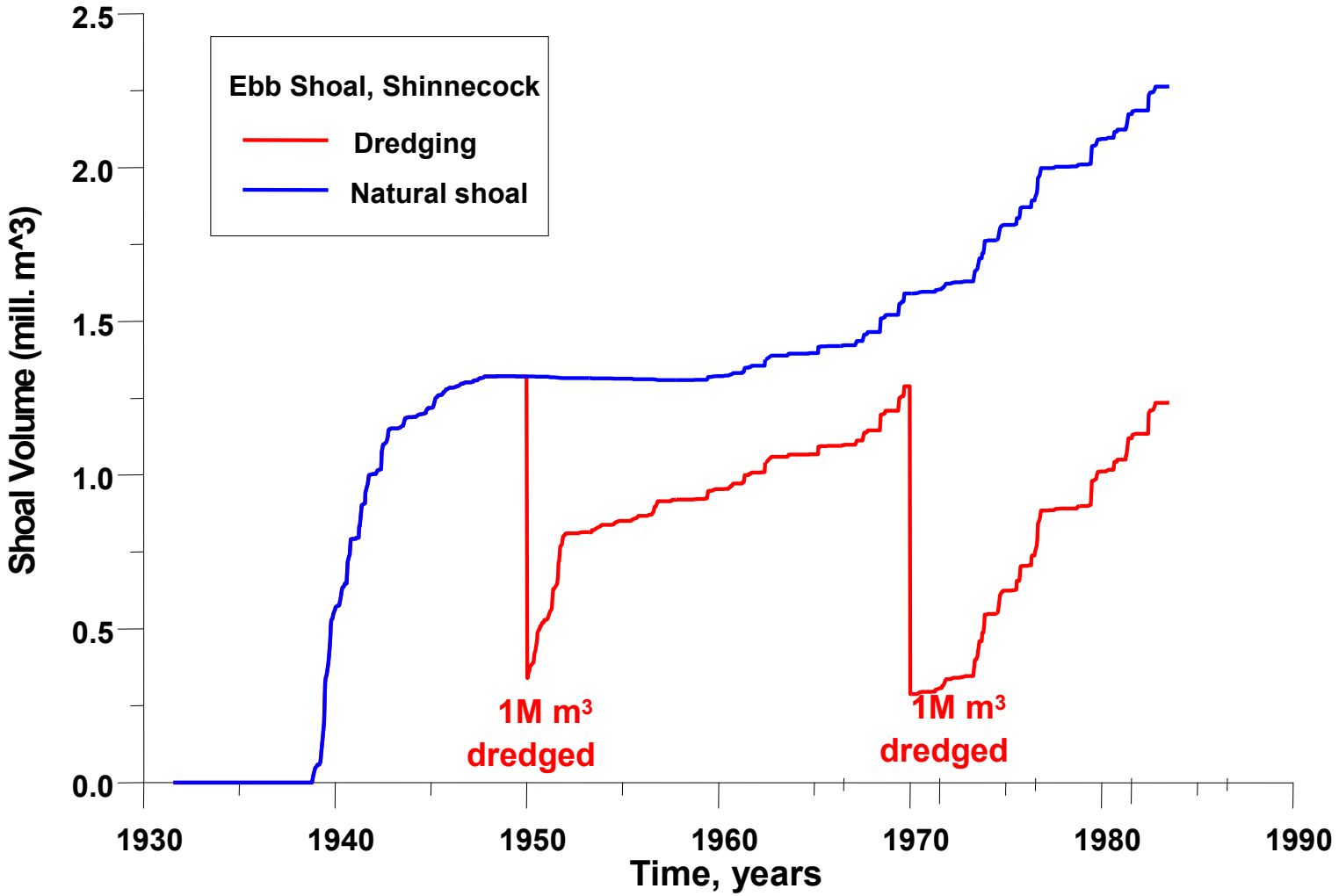
Simulation of Shoreline Evolution at Long Island, 1931-1983 (detail)



Time Evolution of the Ebb Shoal Complex at Shinnecock and Moriches Inlets

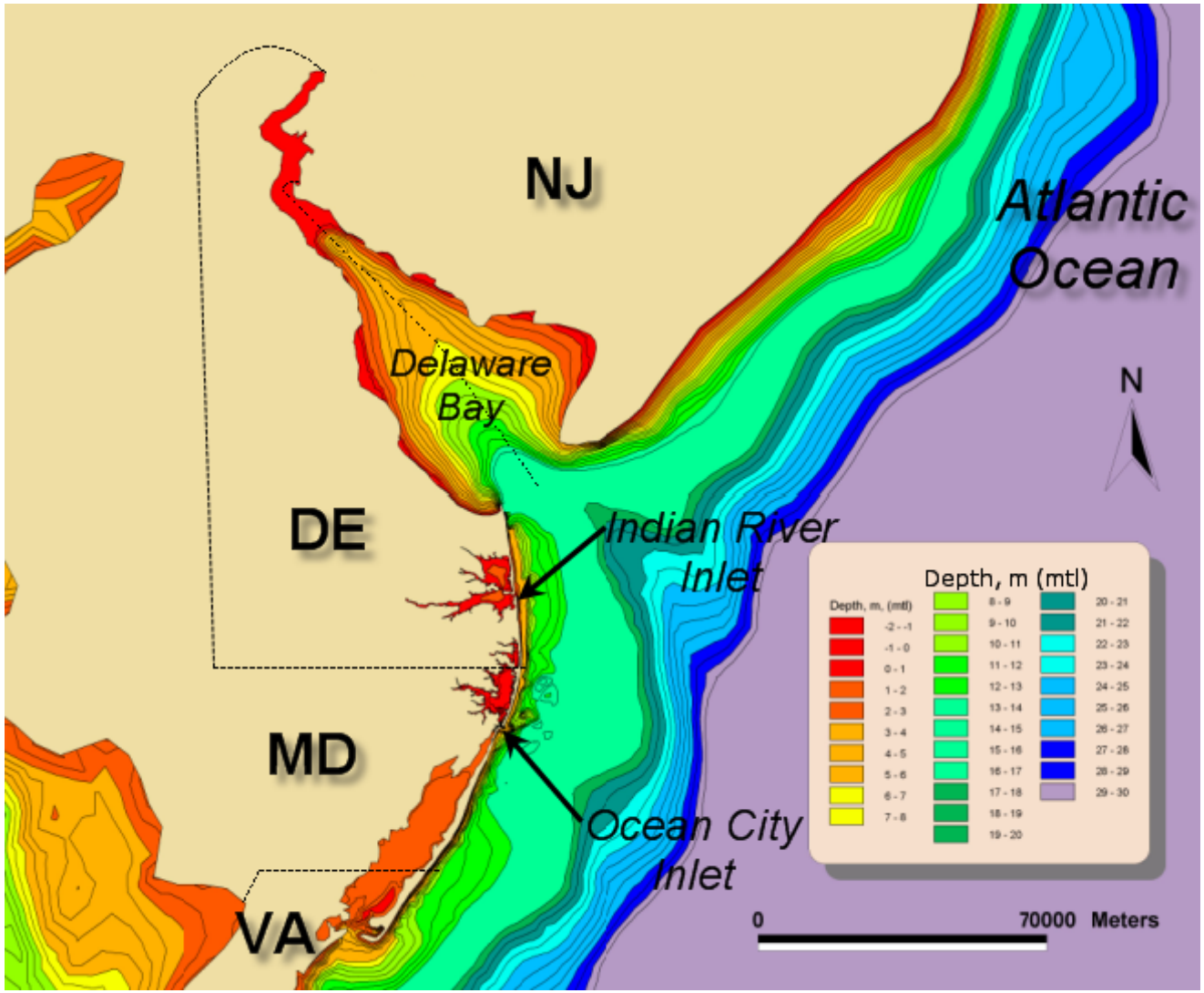


Simulation of Ebb Shoal Dredging, Shinnecock Inlet-Recovery of Shoal

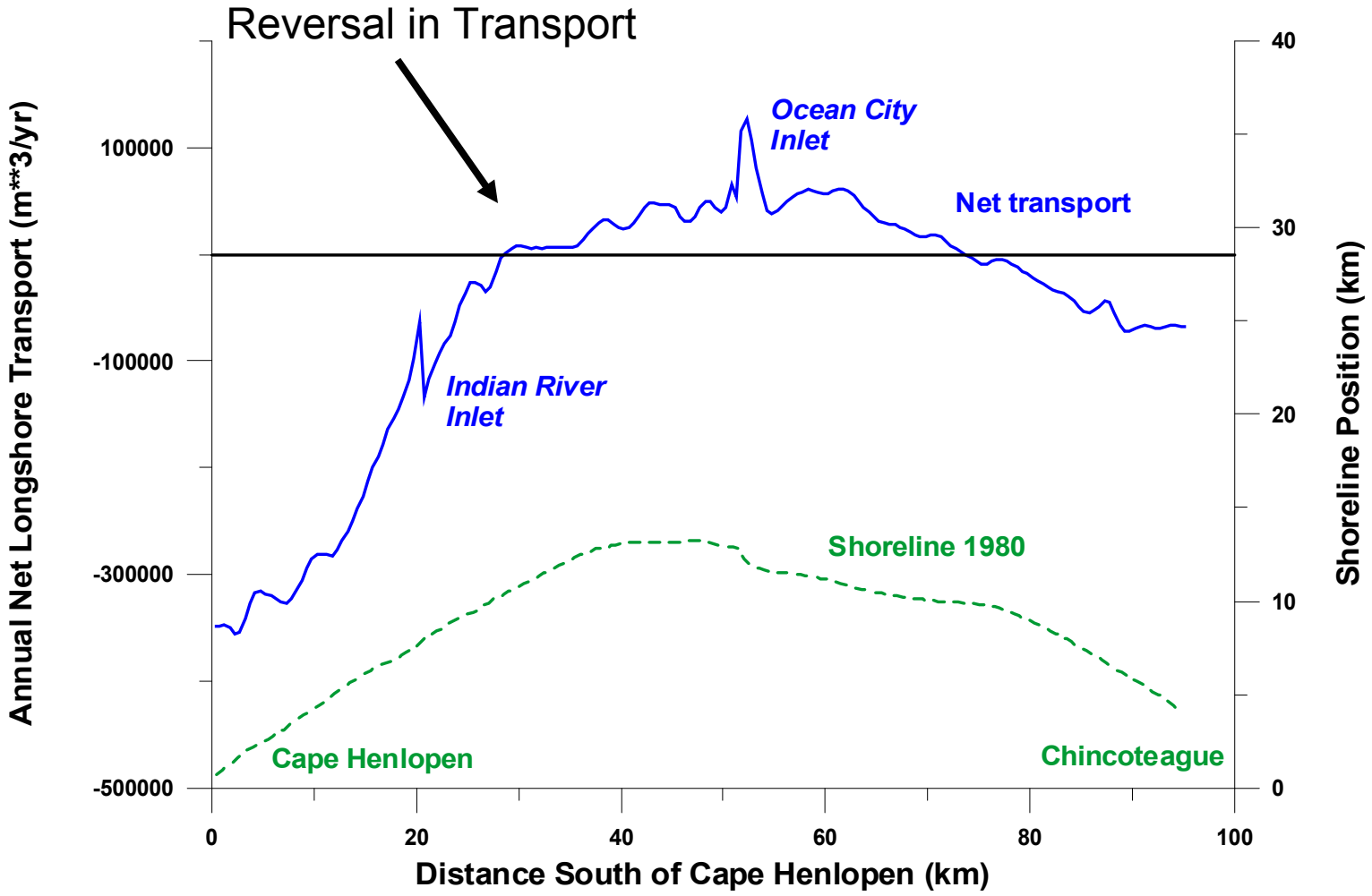


Delmarva Case Study

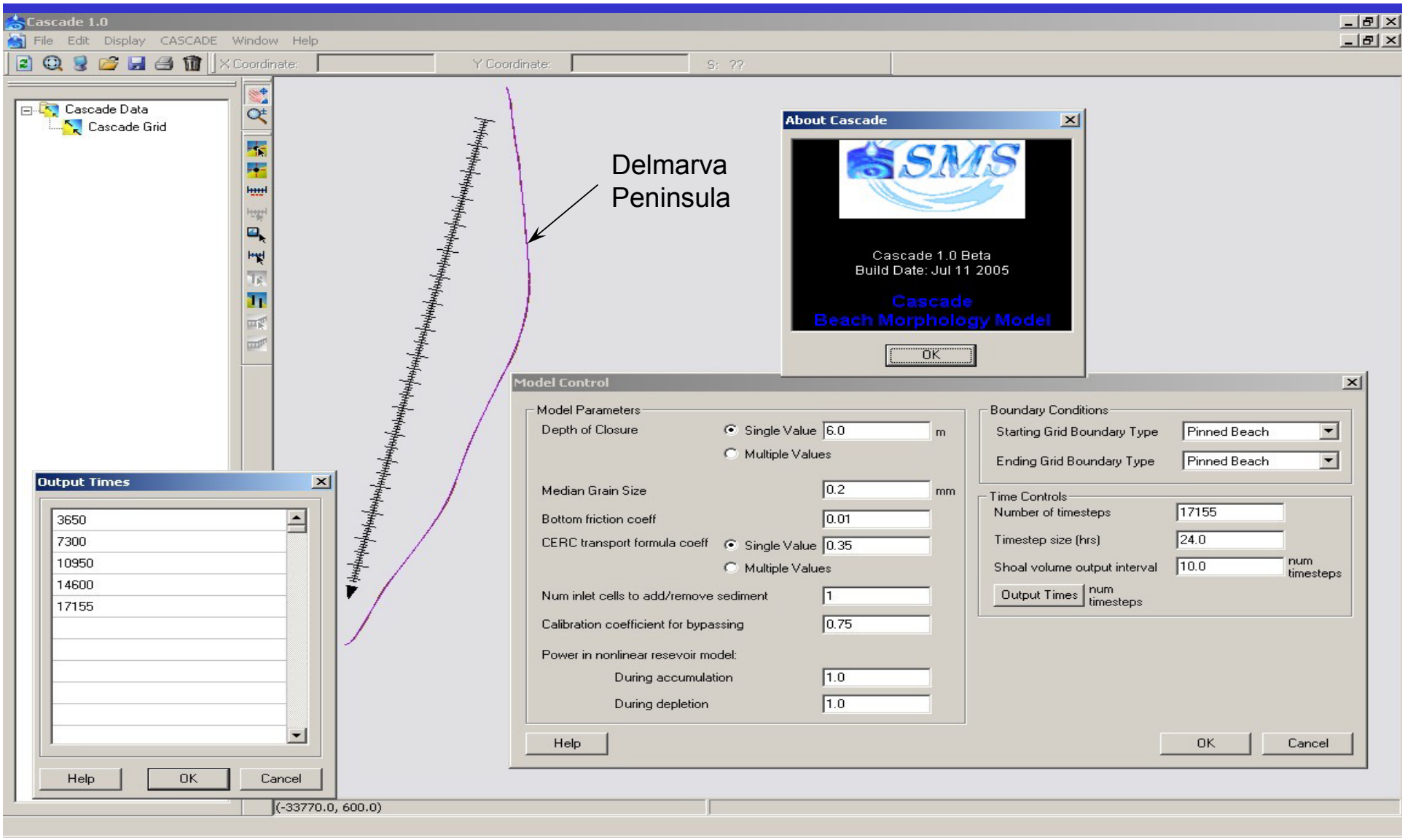
Large-Scale Topography of the Study Area



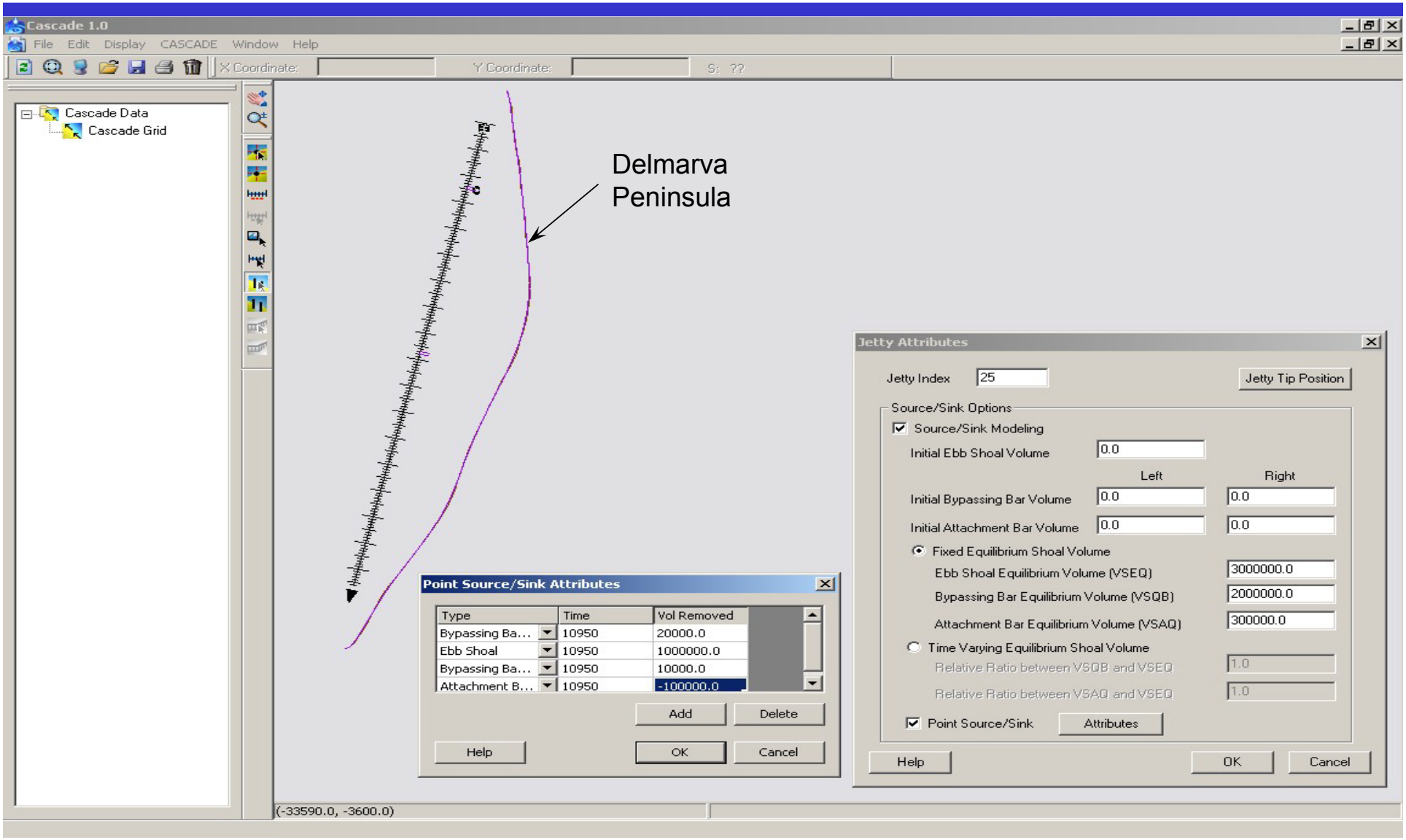
Calculated Net Annual Longshore Sediment Transport Along Delmarva Peninsula



Cascade SMS Interface as Technology-Transfer Delivery Mechanism



Cascade SMS Interface



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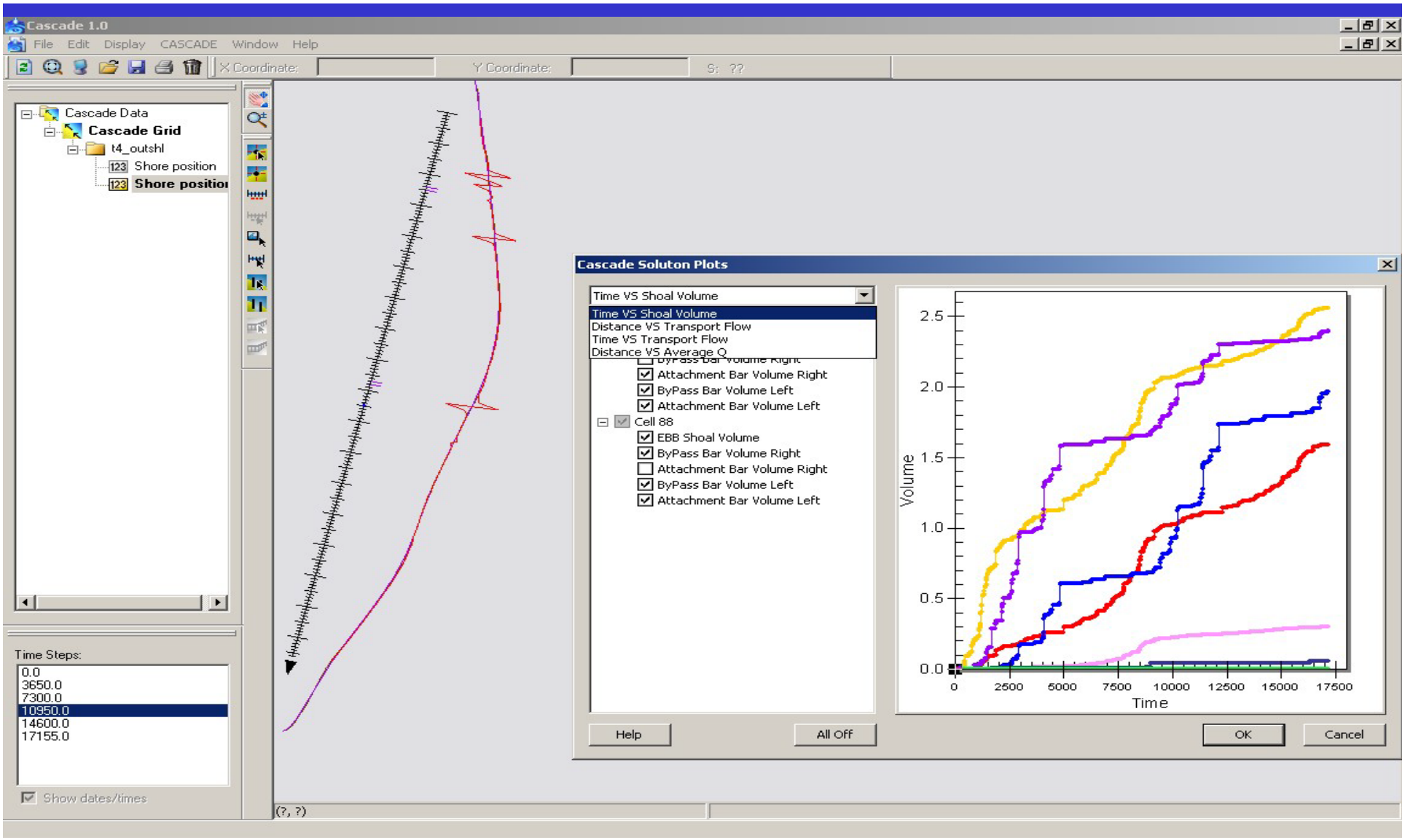

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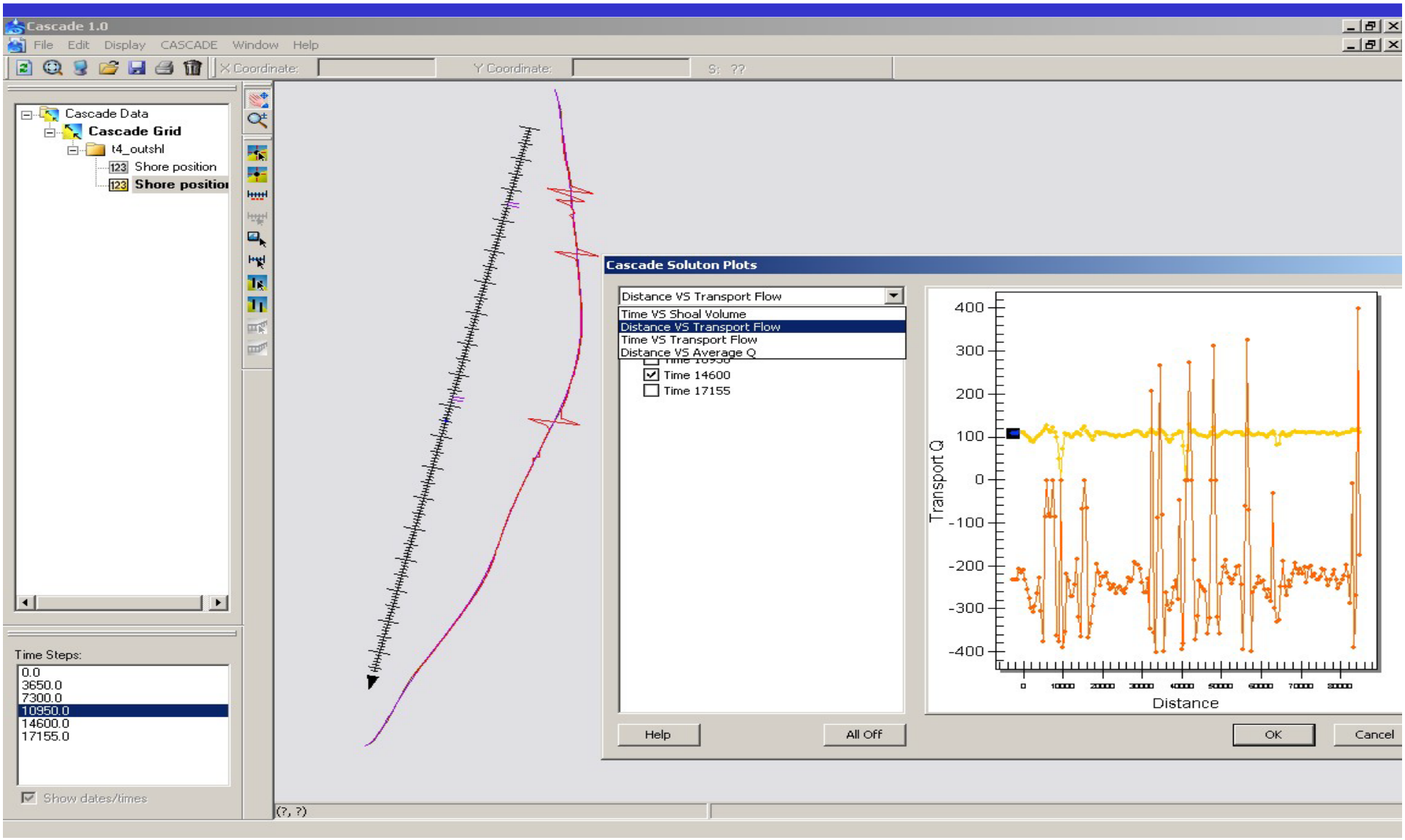

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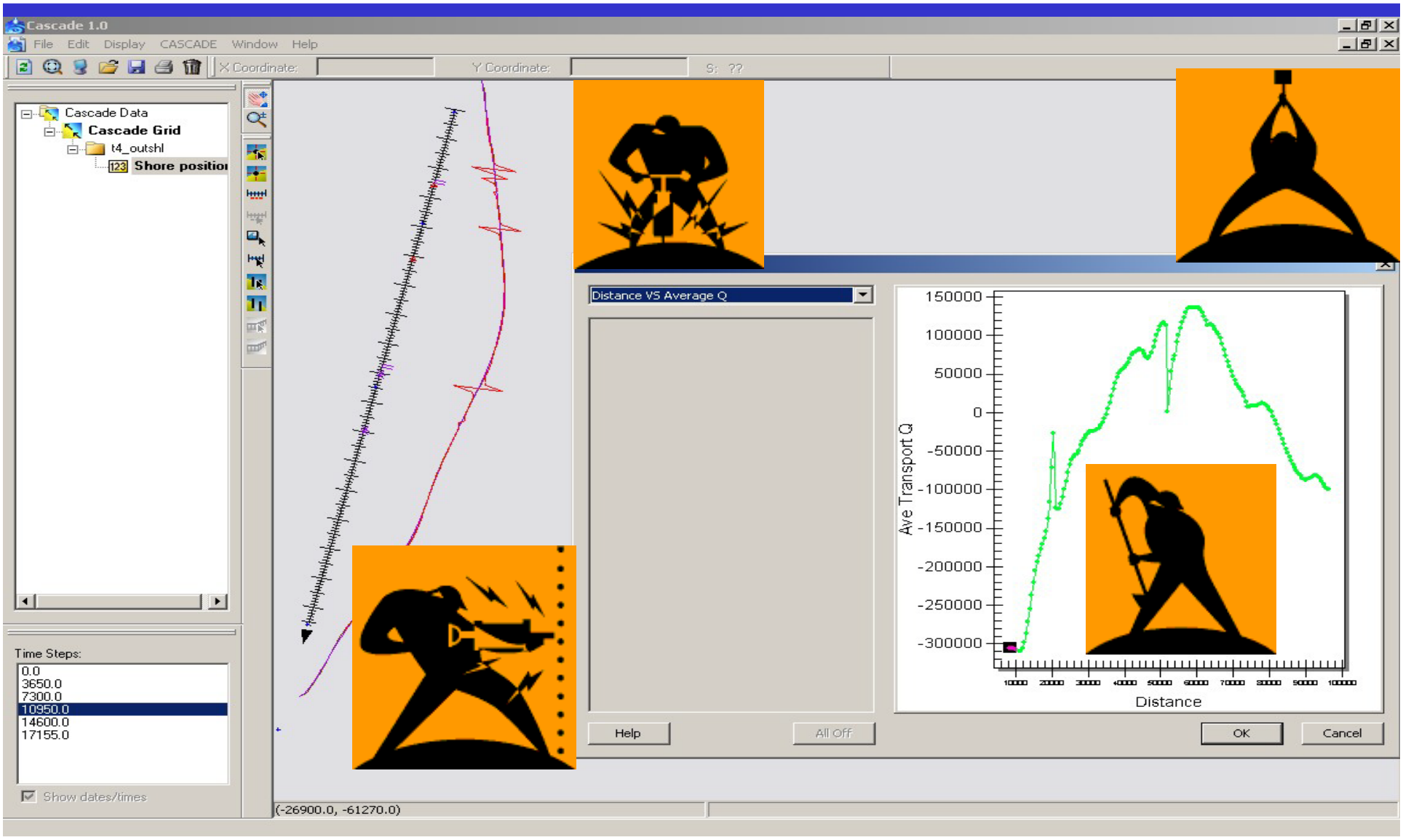

Cascade Applicability

- Coastal inlet maintenance
- Channel management
- Inlet and structure bypassing plans
- Fate of beach fill
- Beach fill project planning
- Storm erosion hazard management
- Overwash & breach susceptibility
- Unifying technology for multiple projects (RSM)

Cascade: Conclusions

1. Sediment transport & coastal evolution occur at many different scales with implications for modeling
2. Engineering projects require considerations at regional scale, → dictating need for modeling processes & controls at this scale
3. Cascade can simulate coastal evolution within complex regional trends, including inlet sediment storage & transfer, engineering activities, & structures
4. Cascade SMS interface provides turn-key system to support practicing engineers & scientists in efficiently solving coastal watershed problems

Cascade: Current & Future Developments

- Improved ebb & flood shoal bypassing
  - -Integrated reservoir model (Kraus 2000)
- Spit evolution
- Automated breach opening & closure
- Improved dune & cliff dynamics based on driving forces

- Further applied testing
  - ➢Partnerships welcome!