Geotechnical Aspects of 3 Storm Surge Barrier Sites

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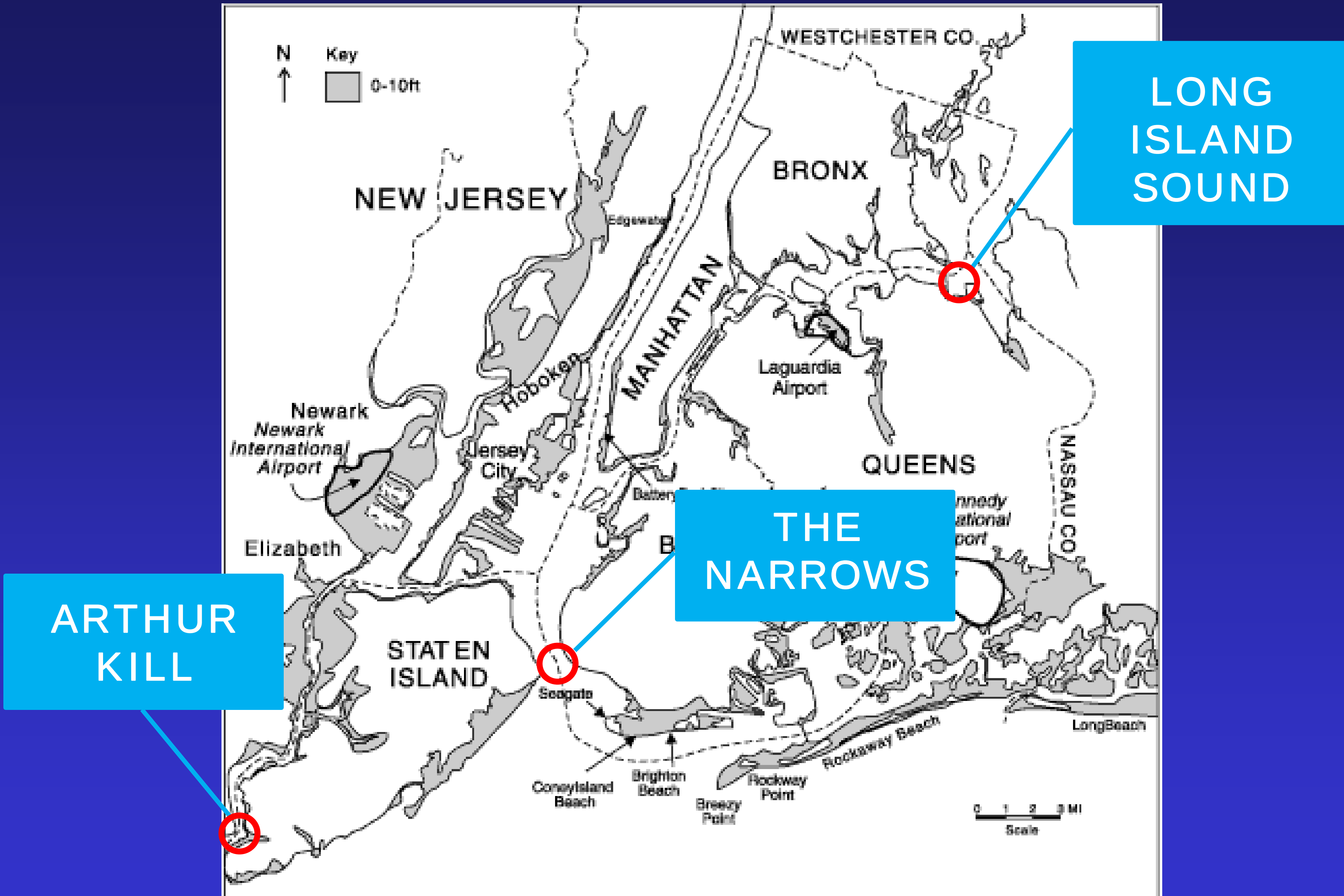
Storm Surge Barriers

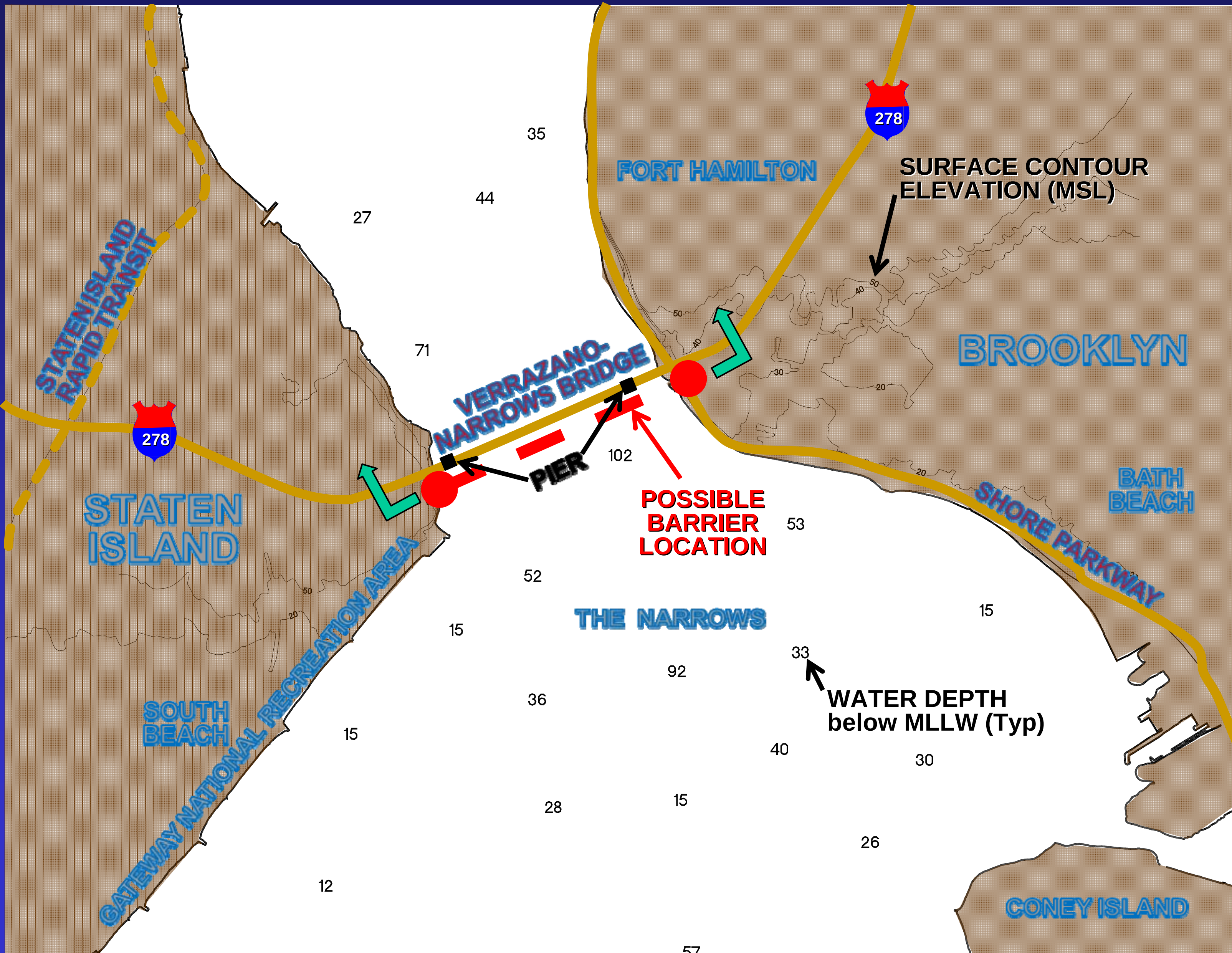
- Geotechnical Aspects
  - ✓ Soil type and strength
  - ✓ Erodability
- Other Related Factors
  - ✓ Water depth
  - ✓ Sedimentation from restricted cross section
  - ✓ Restriction of vessel travel
  - ✓ Impact on fish migration
  - ✓ Impact of land portions on existing neighborhoods
    - Streets
    - Buildings
  - ✓ Esthetics
  - ✓ Areas outside of barrier

Proposed Barrier Locations

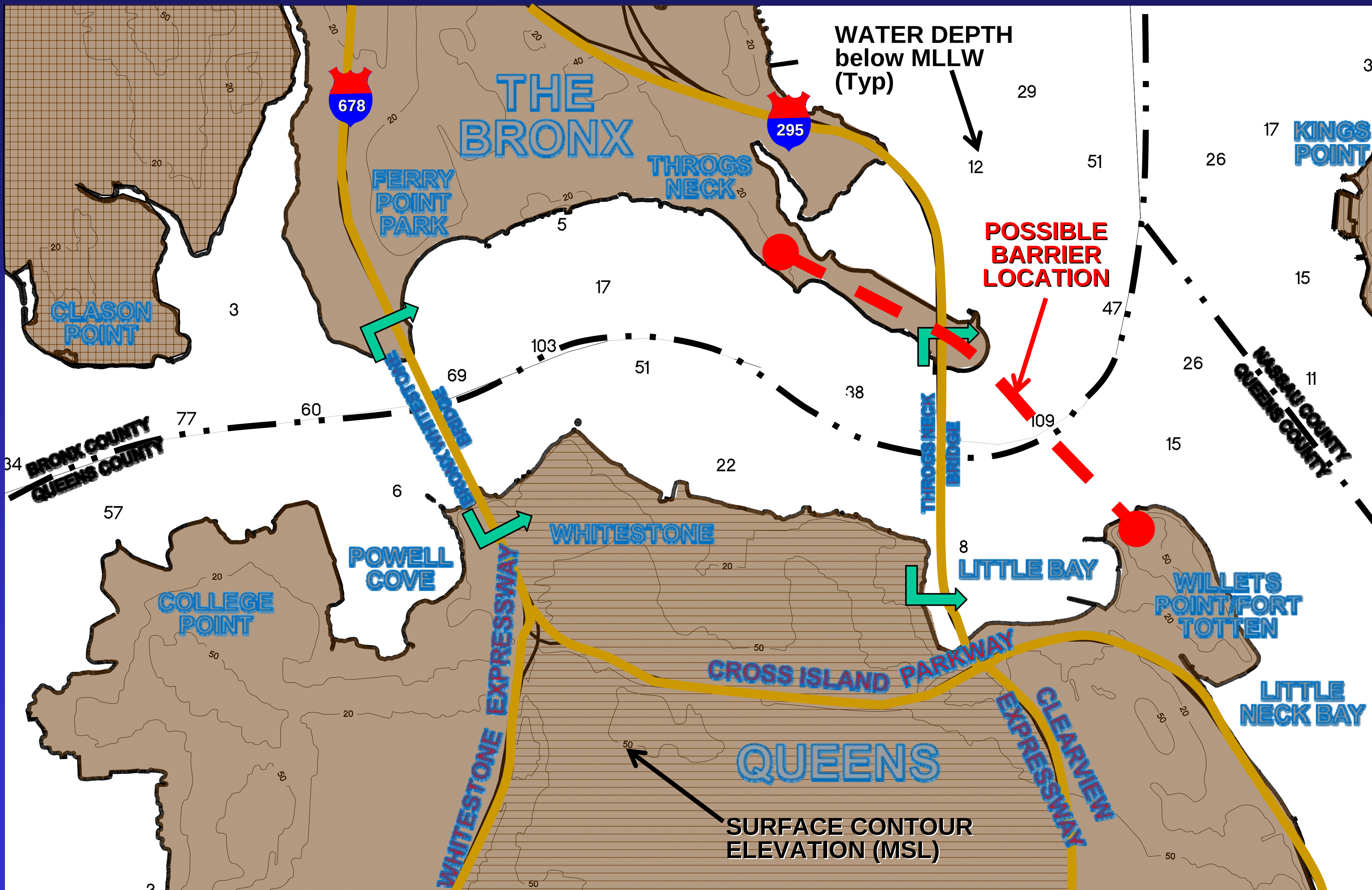


The 100-year flood at present Mean Sea Level (from Gornitz, 2001)

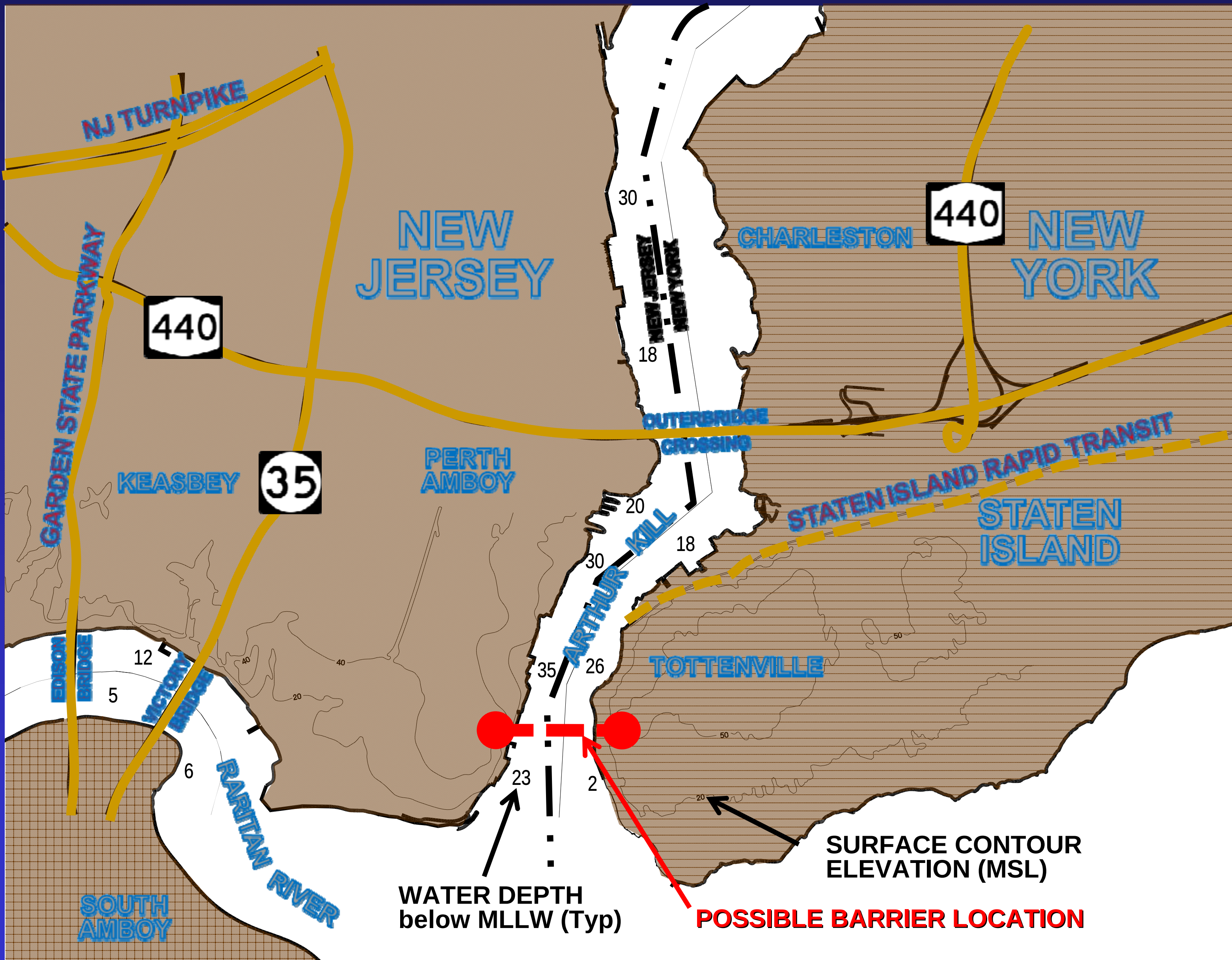
The Narrows Storm Surge Barrier Plan



Long Island Sound Storm Surge Barrier Plan

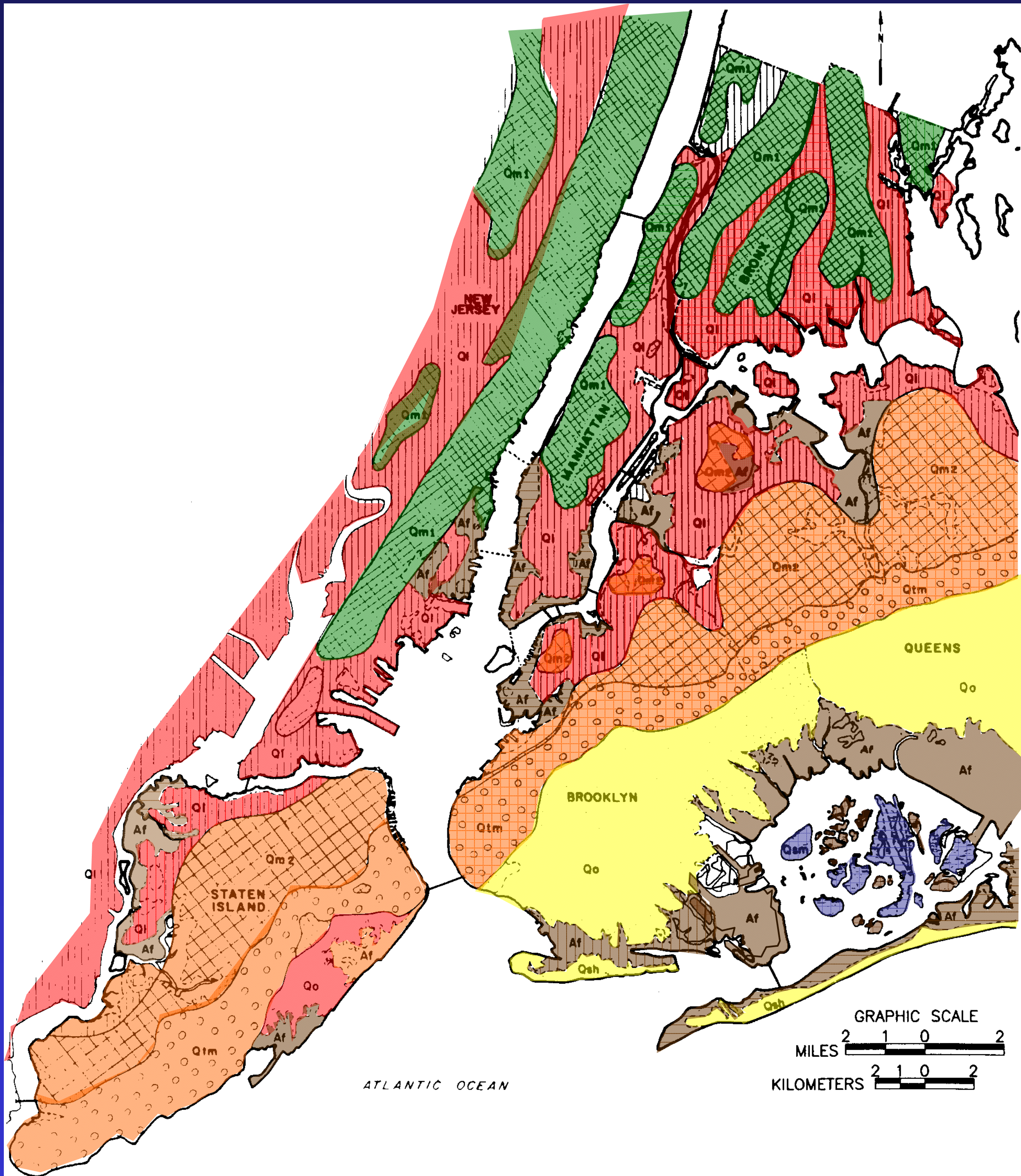


Arthur Kill Storm Surge Barrier Plan



Geology of NY Area

- Recent Deposit
  - ✓ River silts, sands and clays
  - ✓ Marsh soils (Organic Deposits)
- Pleistocene Deposits of Sand, Silts and Clays
  - ✓ Glacial outwash deposits
  - ✓ Glacial Till
- Cretaceous Coastal Plain Sediments
  - ✓ Lloyd Sand
  - ✓ Raritan Clay



LEGEND

PERIOD	EPOCH	DEPOSITS	SYMBOL
Quaternary	Holocene or Recent	Artificial Fill	Af
		Organic Silt & Peat Deposits	Qsm
		Beach Deposits (sand, gravel & dune sand)	Qsh
	Pleistocene	Glacial Lake Deposits (varved silt, clay & fine sand)	Ql
		Glacial Outwash Deposits (sand)	Qo
		Terminal Moraine (sand, gravel, clay, silt, boulders & cobbles)	Qtm
		Till (sand, gravel, silt, clay)	Qm2
		Rock, with Thin Till Over Rock	Qm1

Surficial Map of New York City and the Eastern Part of New Jersey

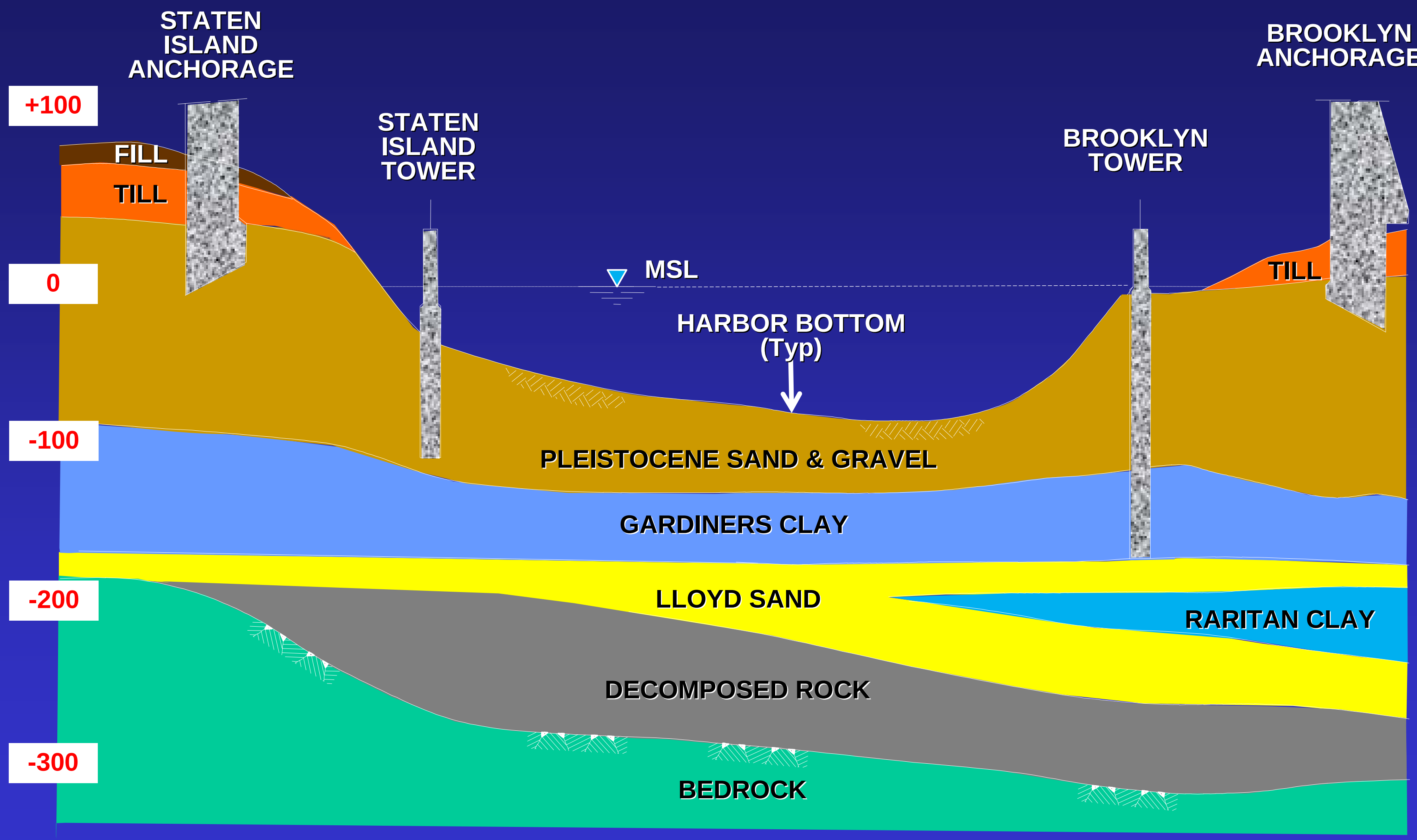
Soil Conditions

- **Verrazano-Narrows Bridge**
- **Brooklyn**
  - ✓ **Glacial Till**
  - ✓ **Pleistoscene Sand and Gravel**
  - ✓ **Gardiners Clay**
  - ✓ **Lloyd Sand**
  - ✓ **Raritan Clay**
  - ✓ **Decomposed Rock**
  - ✓ **Bedrock**

Soil Conditions

- **Verrazano-Narrows Bridge**
- **Staten Island**
  - ✓ **Fill**
  - ✓ **Glacial Till**
  - ✓ **Pleistoscene Sand and Gravel**
  - ✓ **Gardiners Clay**
  - ✓ **Lloyd Sand**
  - ✓ **Bedrock**

The Narrows Geologic Section
Verrazano-Narrows Bridge



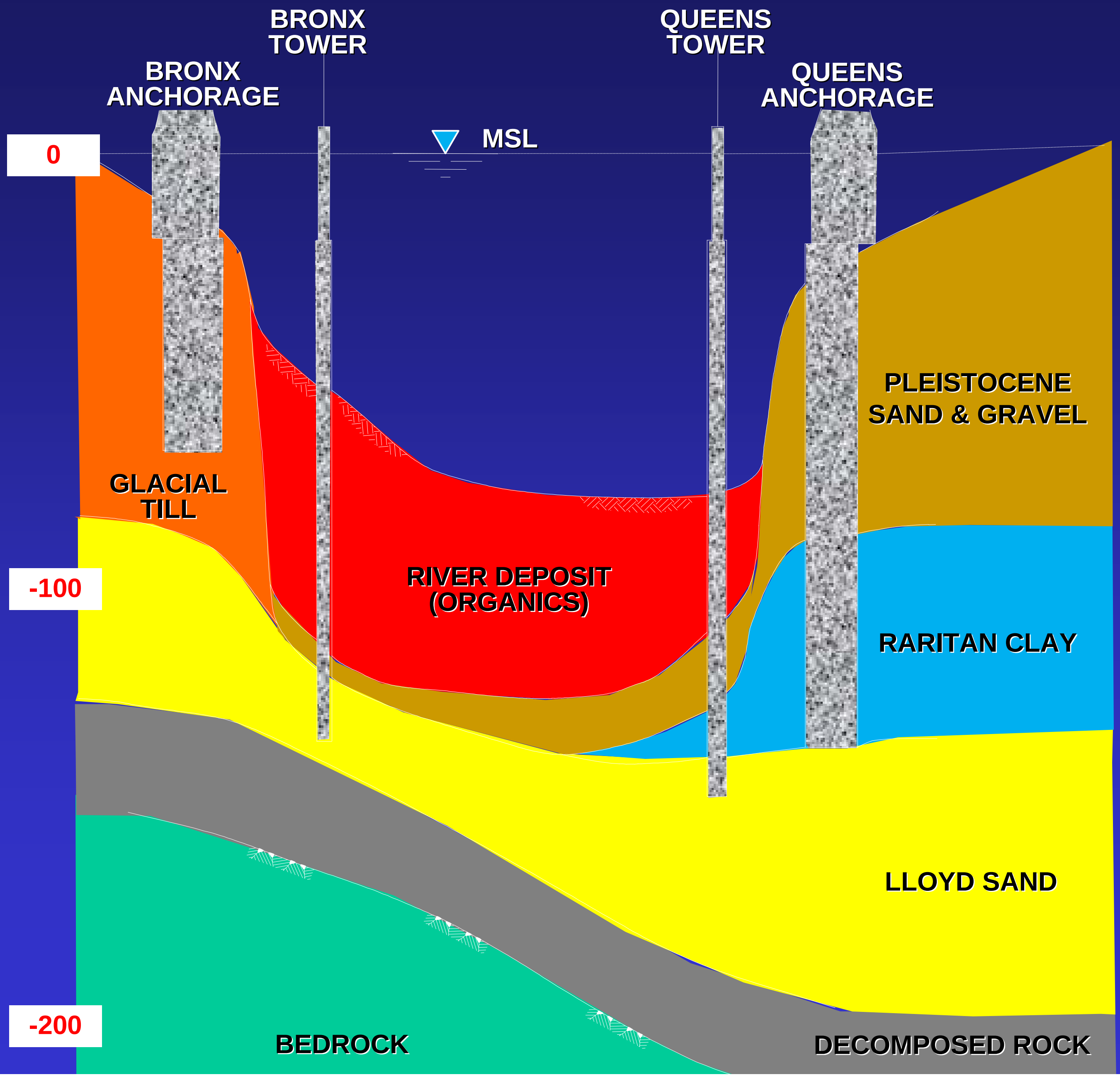
Soil Conditions

- Throgs Neck Bridge
- Queens
  - ✓ Glacial Deposits
  - ✓ Raritan Clay
  - ✓ Lloyd Sand
  - ✓ Decomposed/Weathered Rock

Soil Conditions

- Throgs Neck Bridge
- Bronx
  - ✓ Glacial Deposits
  - ✓ Lloyd Sand
  - ✓ Decomposed/Weathered Rock
  - ✓ Bedrock

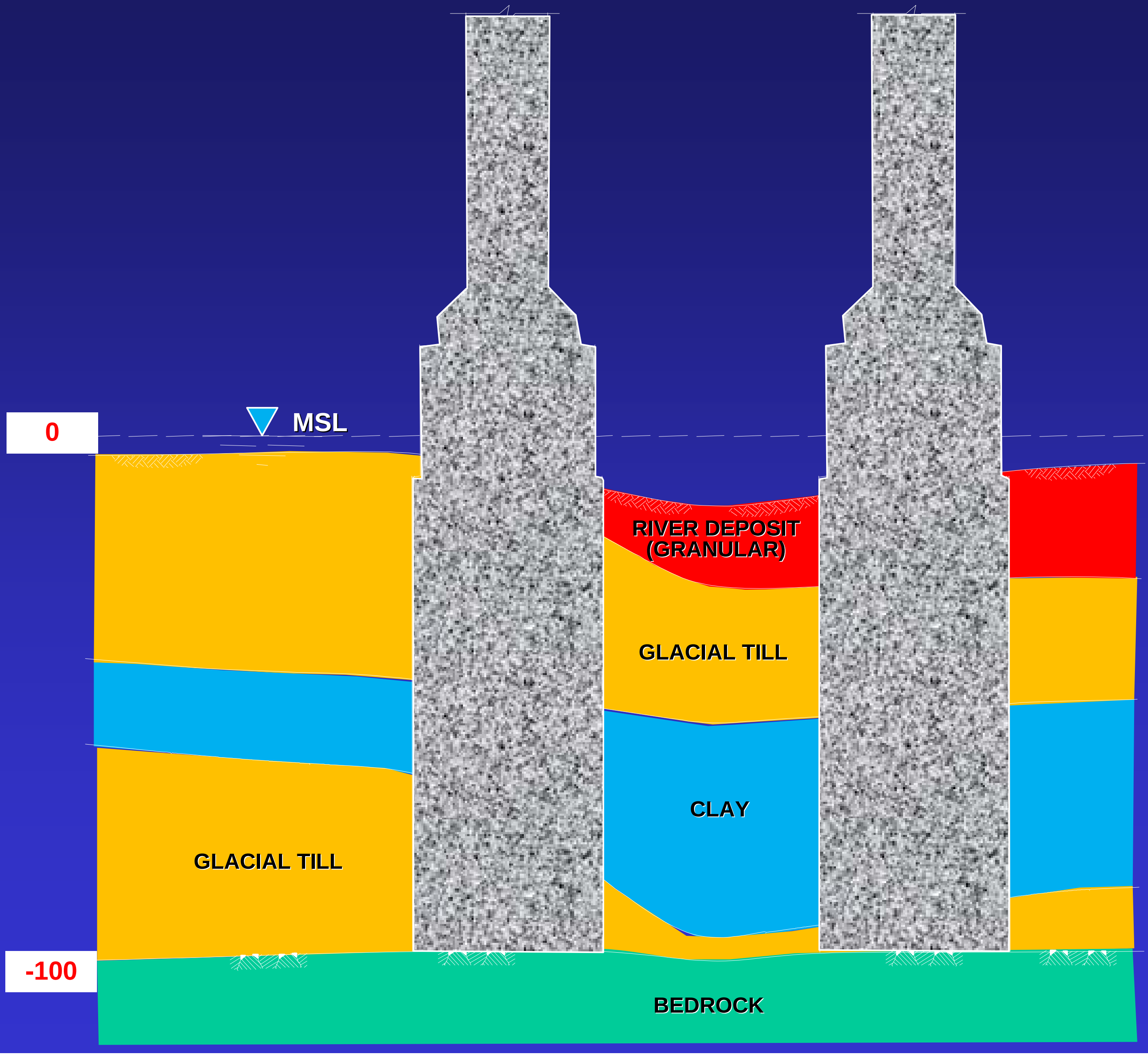
Long Island Sound Geologic Section
Throgs Neck Bridge



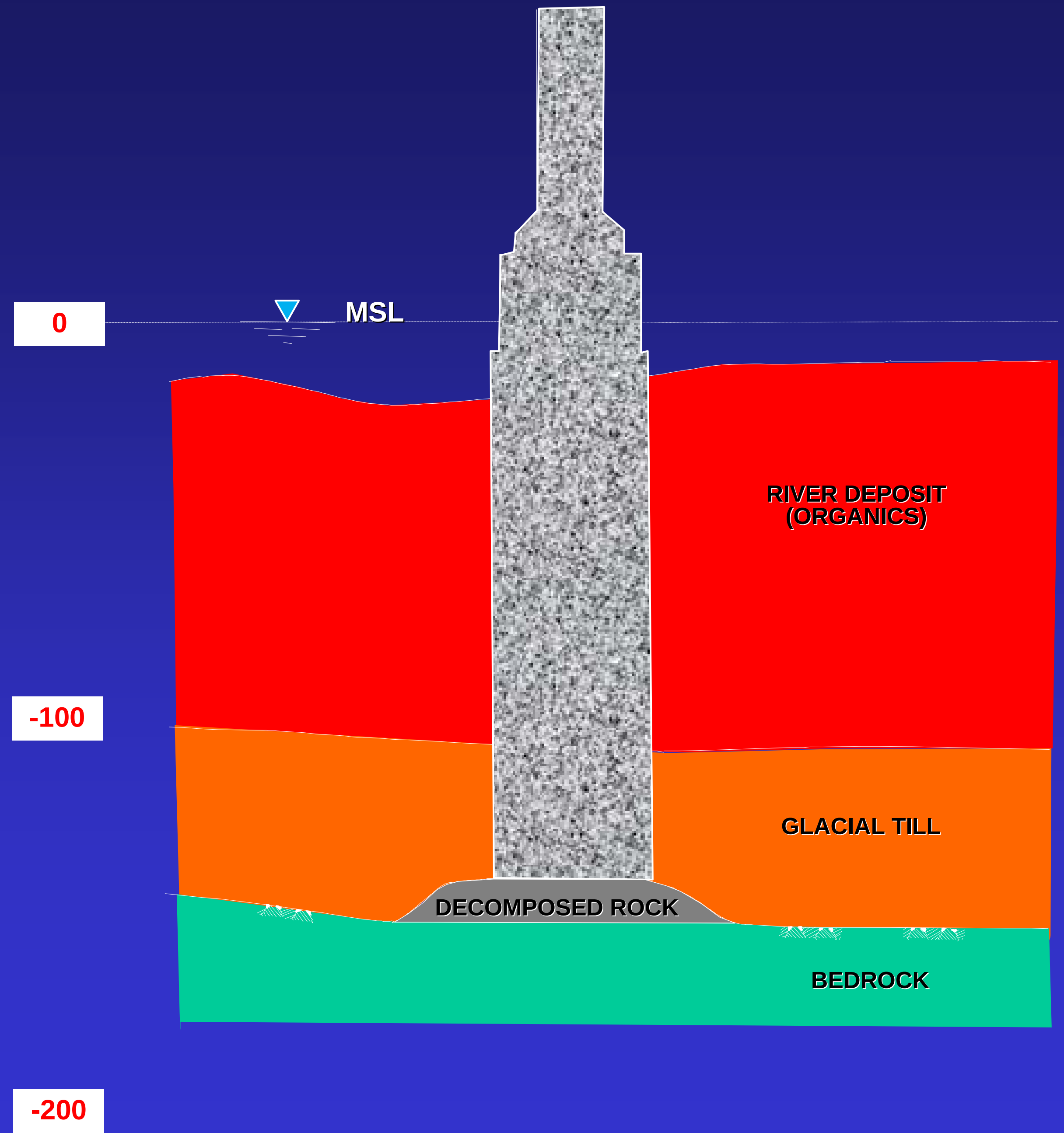
Soil Conditions

- **Whitestone Bridge**
- **Bronx**
  - ✓ **River deposit (sand)**
  - ✓ **Glacial Till**
  - ✓ **Bedrock**
- **Queens**
  - ✓ **River deposit (organic silt, clay and peat)**
  - ✓ **Glacial Till**
  - ✓ **Decomposed/Weathered Rock**
  - ✓ **Bedrock**

Long Island Sound Geologic Section
Whitestone Bridge - Bronx



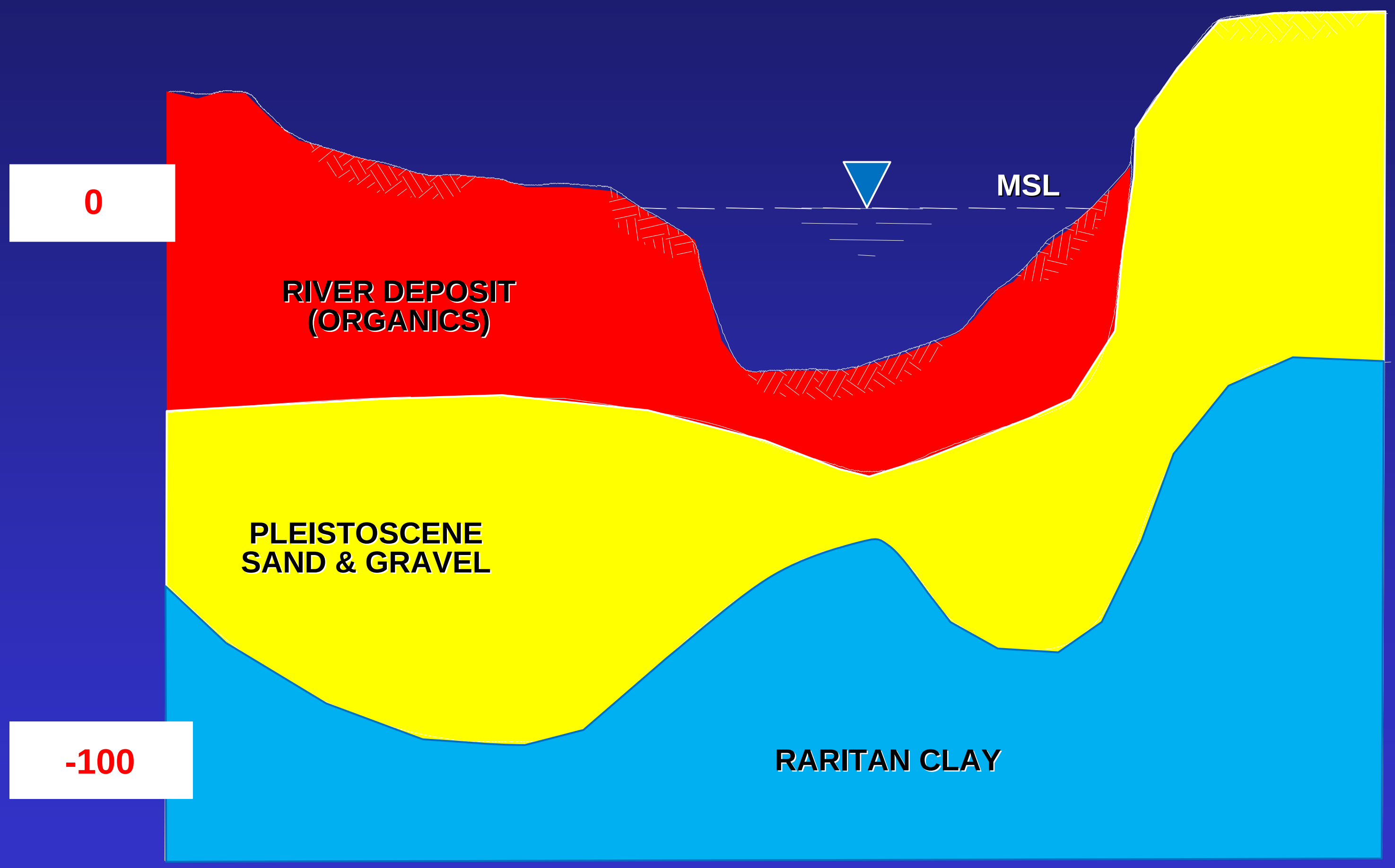
Long Island Sound Geologic Section
Whitestone Bridge - Queens



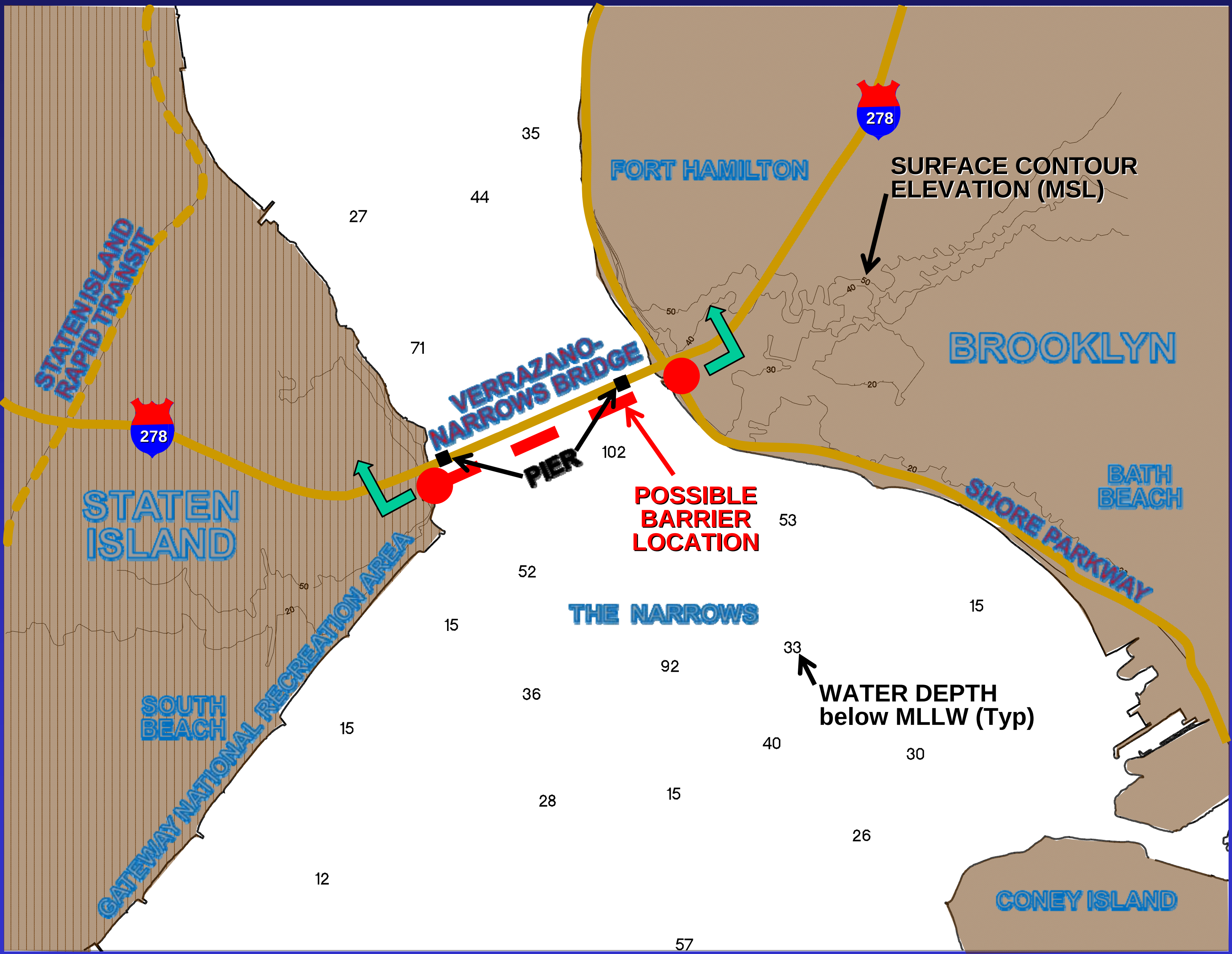
Soil Conditions

- Outerbridge
- Staten Island
  - ✓ Pleistoscene Sand and Gravel
  - ✓ Raritan Clay
- New Jersey
  - ✓ River deposit (organic)
  - ✓ Pleistoscene Sand and Gravel
  - ✓ Raritan Clay

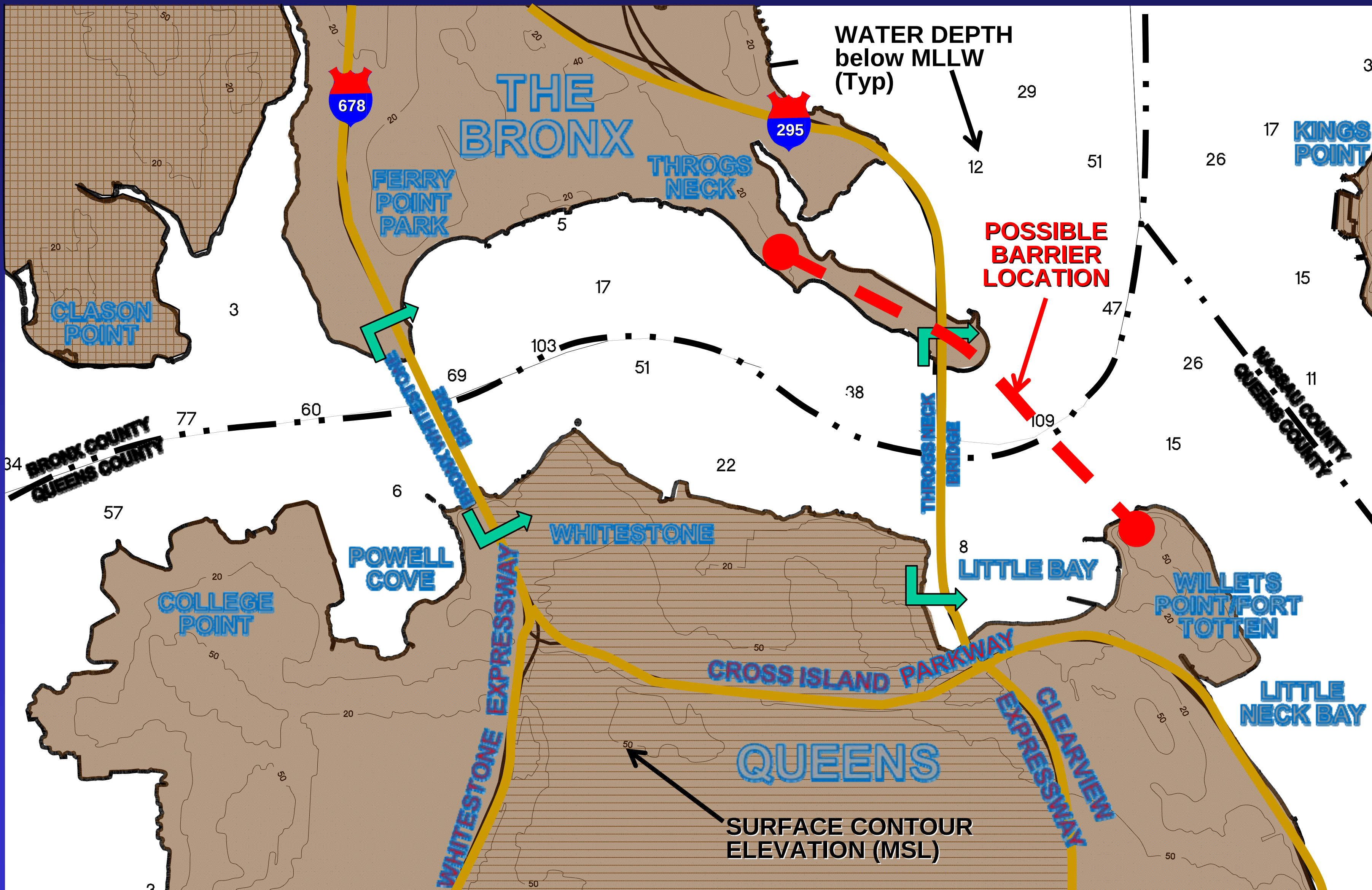
Arthur Kill Geologic Section
Outerbridge Crossing



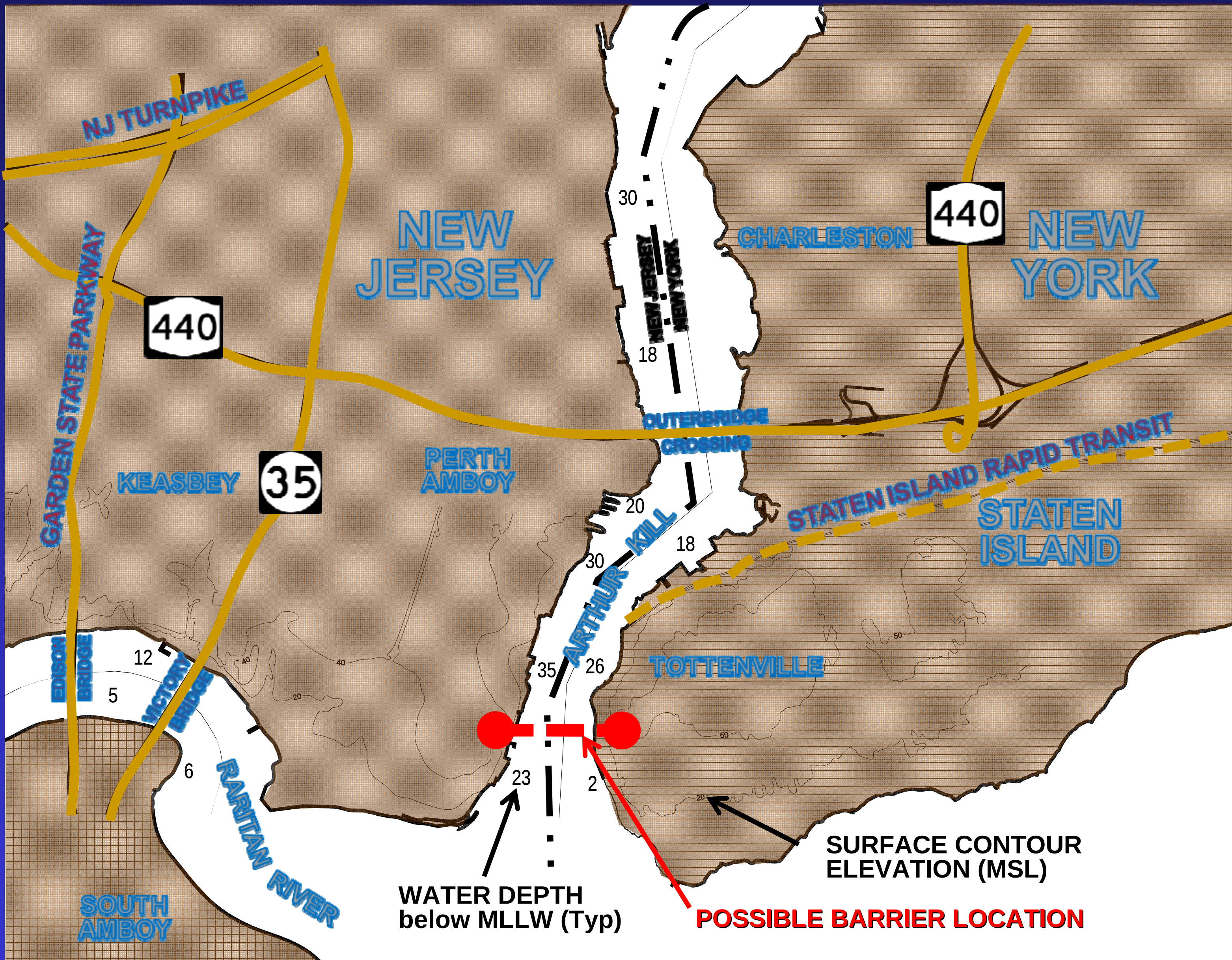
The Narrows Storm Surge Barrier Plan



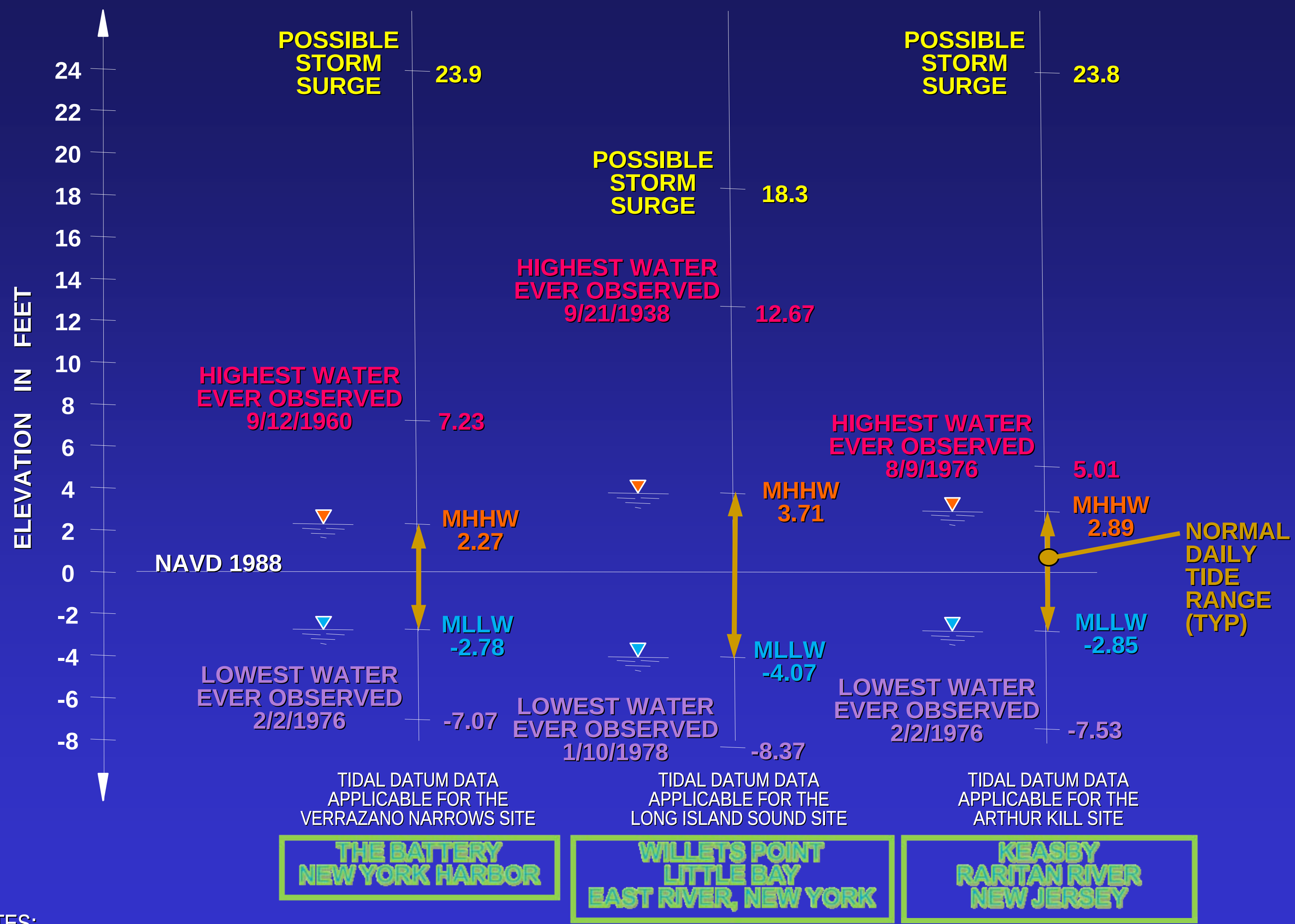
Long Island Sound Storm Surge Barrier Plan



Arthur Kill Storm Surge Barrier Plan



Tide and Surge Data

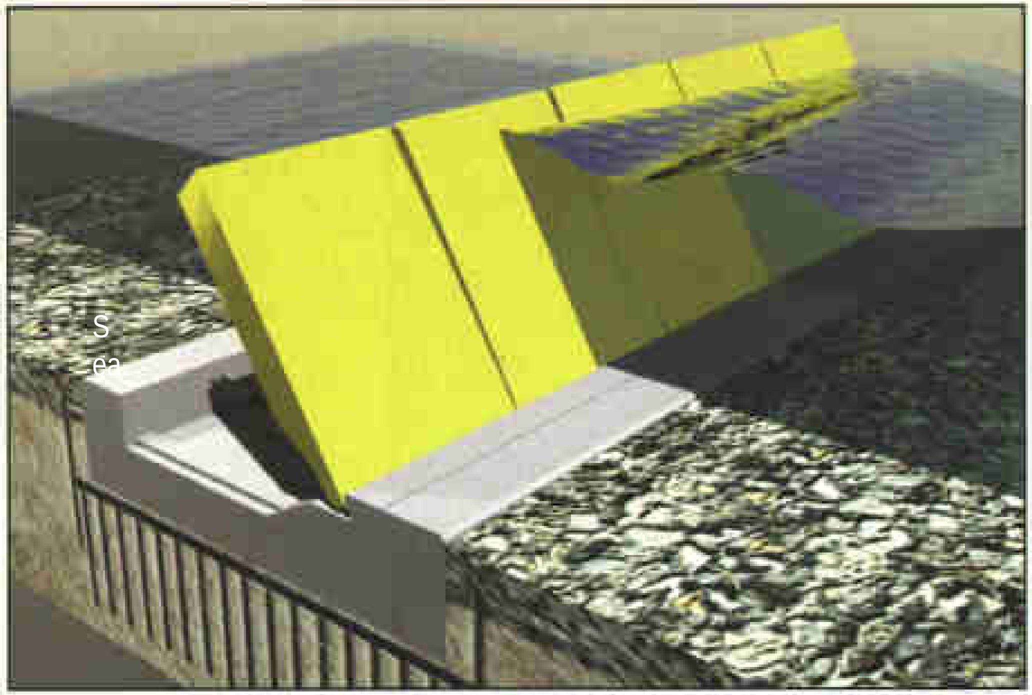


NOTES:
1.Data from U. S. Department of Commerce, NOAA, National Ocean Service for Tidal Epoch 1983-2001. Reference www.co-ops.nos.noaa.gov
2.NAVD 1988 was taken to be equivalent to Mean Sea Level (MSL) for Keasby, Raritan River, New Jersey.
3.Possible storm surge elevations provided by SUNY Stony Brook University.

Basic Types Of Surge Barriers

- Navigable Lock and Dam (Ubiquitous)
- Fold Flat Buoyant Floating Gate (Venice)
- Rotating Type (London, Thames River)
- Swinging Hinged Gate (Netherlands, elsewhere)
- Tainter Gates (Providence, Rhode Island)

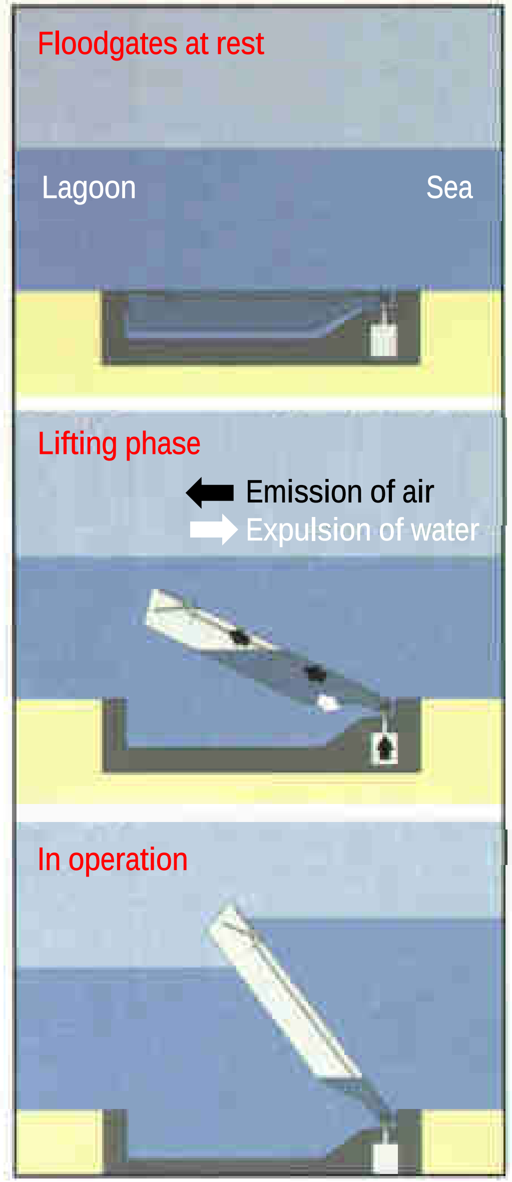
Venice Lagoon Design, 2012



Under normal tidal conditions the gates fill with water and rest on the inlet canal bed.

When tides reach 100 cm, the gates fill with compressed air and rise to isolate the lagoon from the sea.

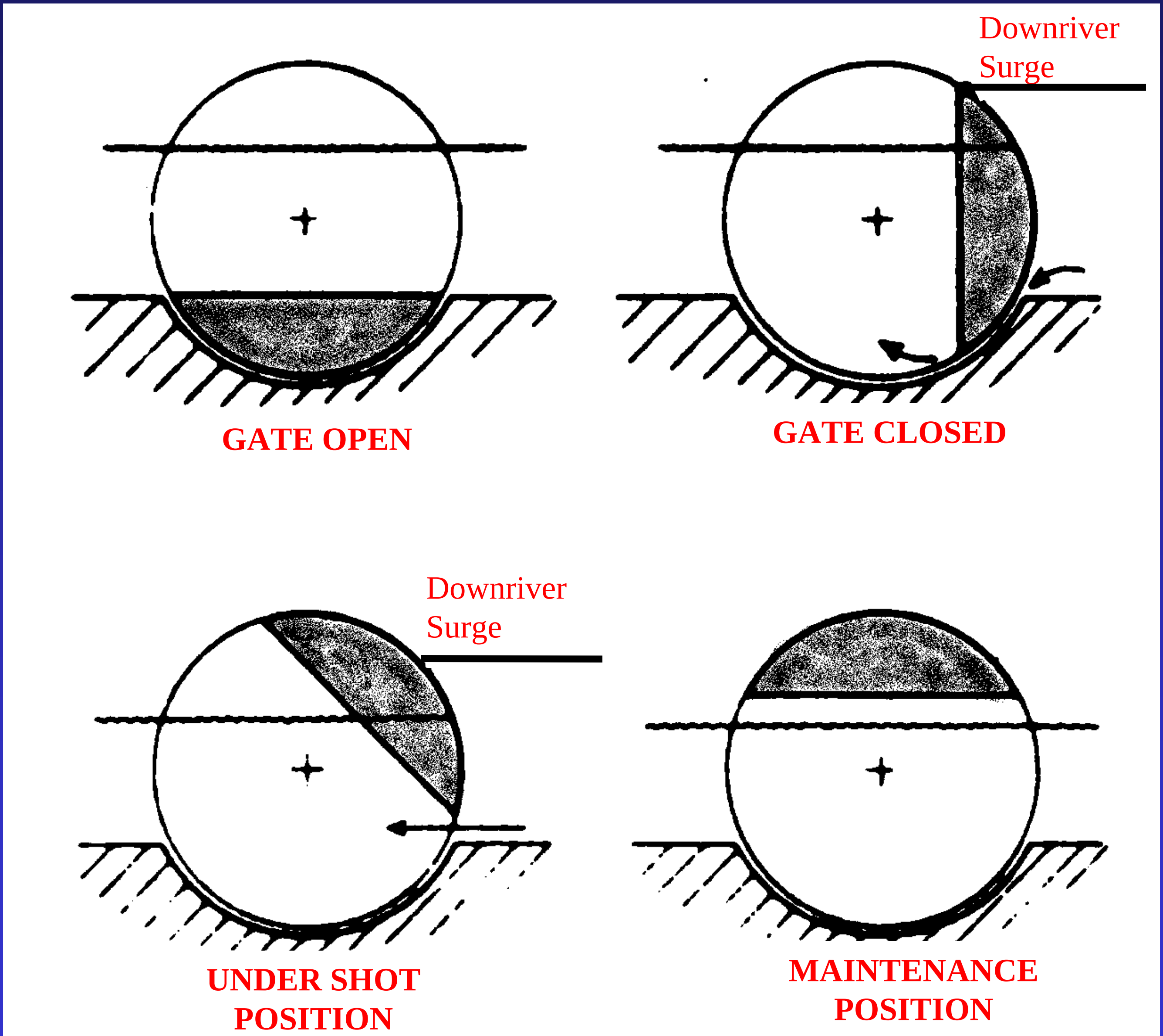
79 gates. 30 m (= 98 ft) high, 20 m (=65 ft) wide,
4-5 m (=13-16 ft) thick. $2.6 to 7 billion.



Thames River Tidal Barrier, England, 1982

4 - 200ft main openings & 2 103-ft nav openings.
Gate chord 66 ft. Sill -34.1 ft. River width 1,870 ft (= 0.35 mi).

Thames Barrier rotating gates - Operation

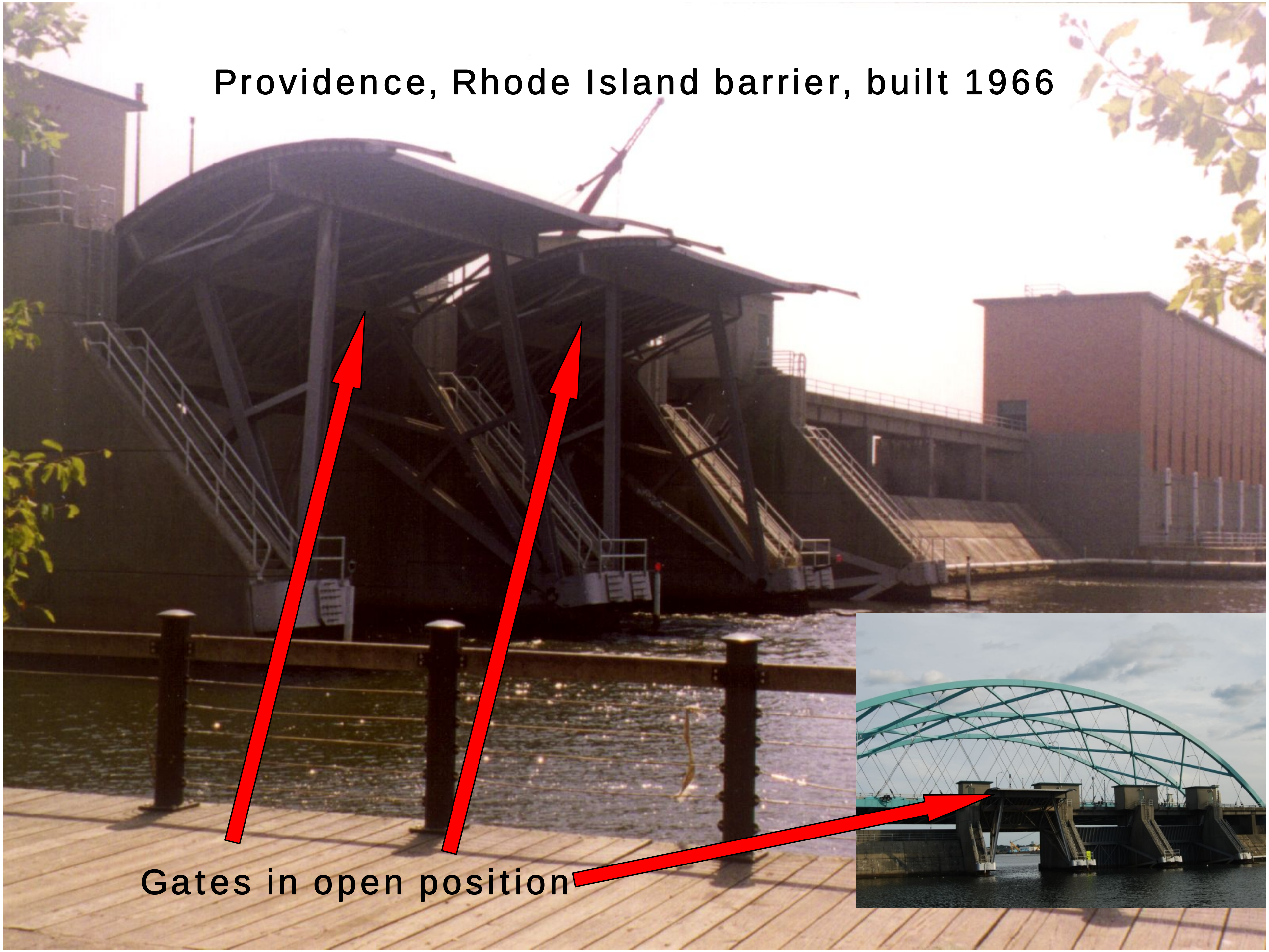


New Waterway, The Netherlands, 1997

2 trusses @ 240 m length ==480 m (= 1,575 ft = 0.3 miles).
Height 20 m (= 65 ft). Sill depth -17 m (= 56 ft).

Providence, Rhode Island barrier, built 1966

Gates 40x40 ft. Sill -15 ft msl. Max vert clearance +25 ft. 5 Pumps each 4,300 hp, 1,400 fs @ 20’ head. Height 25 ft msl. Length 290 ft. $11.4 million.


Providence, Rhode Island barrier, built 1966
Gates in open position

Foundation Options

- Piles
- Caissons or Drilled Shafts
- Large prismatic or cylindrical caisson walls sunk with internal dredge and perimeter anchor pilings as needed
- Subaqueous stable slope stone fill below concrete sills or bases
- Stone-faced embankments for some on-shore portions

Foundation Design Concerns

- Soil conditions
- Allowable bearing pressures
- Design loads
  - ✓ Overturning moments
  - ✓ Tension
  - ✓ Mass stability

Foundation Design Concerns

- Underseepage
- Seismic loading
- Liquefaction
- Vessel impact
- Ice development
- Water pressure load reversals
- Environmental considerations

Factors in Conceptual Design

- Required height of storm surge protection
- Water depth at a given site
- Depth to sound bearing material
- Overall length of the gate system
- Special structures, gates or other means to extend the system on to land

Environmental Considerations

- Allowing for flow reversals
- Setting up a system to flush the harbor
- Flow velocities may change significantly as a result of cross sectional area changes at these river locations because of the addition of new tide gate structures.
- Changes in the areas and amounts of nearby sedimentation and scour may become significant if flows change greatly.

Specific Issues Related to Each Site

- **The Narrows – Advantages**
  - ✓ Least wide gap to be closed, as compared to constructing the barrier well north or south of the bridge.
  - ✓ Existing bridge piers and stone protection berms would provide a good start for the barrier system at this location.
  - ✓ There is about a 5000 foot overall gap between banks. The concrete foundation piers for the bridge are each about 200 feet wide, and counting some benefit of adjacent stone berms meant to protect the piers, about 10 percent of the cross section is already blocked off.

Specific Issues Related to Each Site

- **The Narrows – Disadvantages**
  - ✓ Deep cutoff sheeting or other means necessary to block underseepage below barrier structure and avoid failure during extreme tidal surges.
  - ✓ Potential for significant increase in the flow velocity at The Narrows
  - ✓ Land parts of barriers need to tie into high ground.
  - ✓ Studies needed to determine if Parkway could be raised in this area or whether a gate would have to be installed across this critical artery.

Specific Issues Related to Each Site

- **Long Island Sound – Advantages**
  - ✓ Crossings have relatively narrow widths as compared to similar locations nearby and thus would require smaller sized barriers.
  - ✓ Throgs Neck Bridge is further east and would protect more sections of northwest

Specific Issues Related to Each Site

- **Long Island Sound – Disadvantages**
  - ✓ **Most of north shore of Long Island unprotected**
  - ✓ **Soil conditions vary across the Long Island Sound**
  - ✓ **Land-based barrier would have to extend some distance inland on the Bronx side**
  - ✓ **Cut-off may be needed on land in low elevations between Willets Point/Fort Totten and the Bayside, Queens land mass.**

Specific Issues Related to Each Site

- **Arthur Kill - Advantages**
  - ✓ Location protects west shore of Staten Island and parts of east coast of New Jersey
- **Arthur Kill – Disadvantages**
  - ✓ South shore of Staten Island exposed
  - ✓ Deep cutoff may be needed to prevent underseepage failure

Thank You!

Questions?

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