How will tidal restoration to diked salt marshes affect our freshwater aquifer?

Collaboration with hydrologists since 1980:

Mapping Provincetown landfill plume with NPS, EPA & Univ. Rhode Island
Herring River groundwater studies with NPS & US Geological Survey
Vernal pool hydrogeology with NPS & Cape Cod Commission
Groundwater discharge into Nauset Marsh with NPS & Univ. Rhode Island

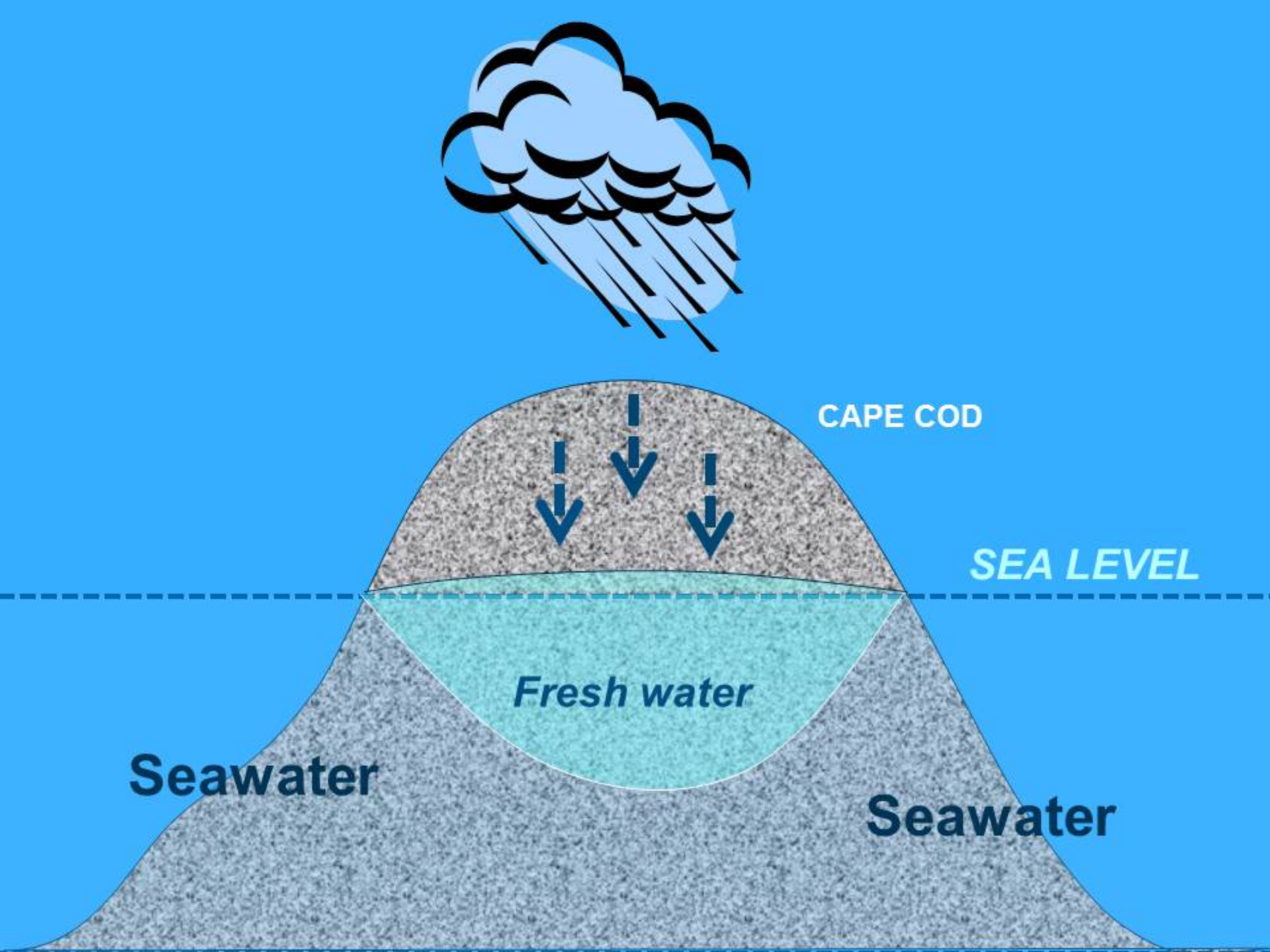
Publications:

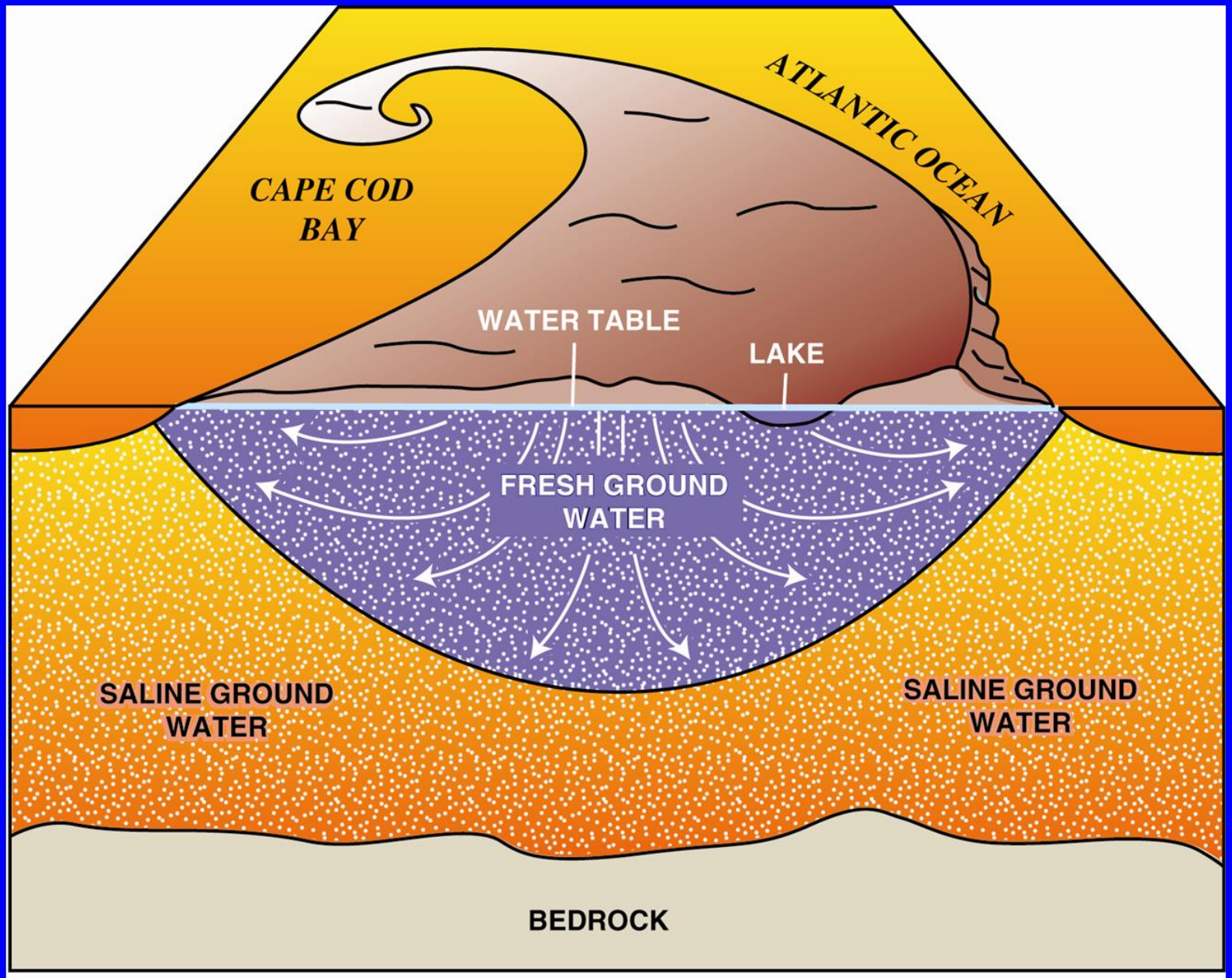
Portnoy, J.W., et al. 1998. The discharge of nitrate-contaminated groundwater from developed shoreline to marsh-fringed estuary. Water Resources Research 34:3095-3104.

Masterson, J..P. & J.W. Portnoy. 2005. Potential changes in ground-water flow and their effects on the ecology and water resources of the Cape Cod National Seashore, Massachusetts. US Geological Survey. General Information Product 13.

Portnoy, J.W. 1999. Salt marsh diking and restoration: Biogeochemical implications of altered wetland hydrology. Environmental Management 24:111-120.

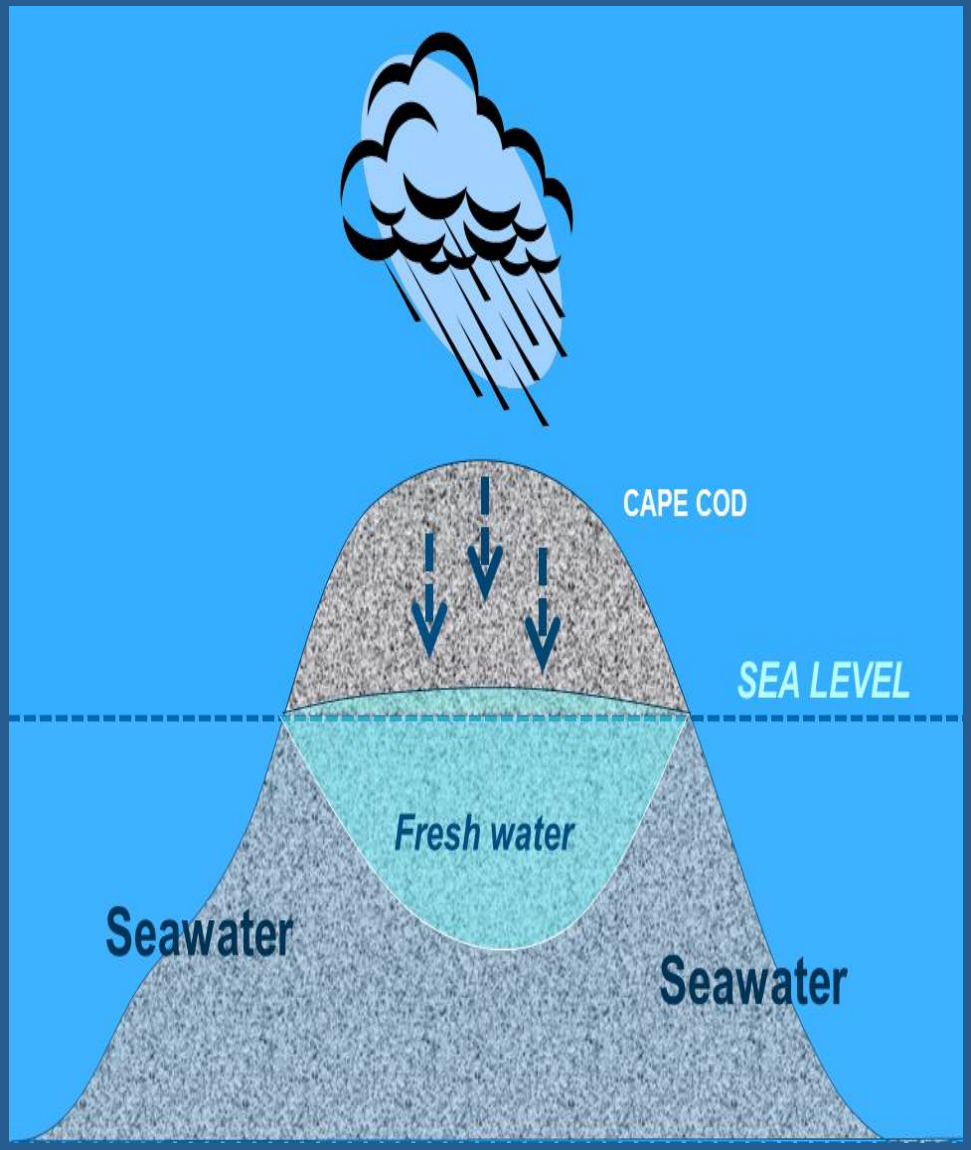
Well drillers...


CAPE COD
SEA LEVEL
Fresh water
Seawater
Seawater



Schematic diagram, not to scale

Shape of freshwater lens depends on:

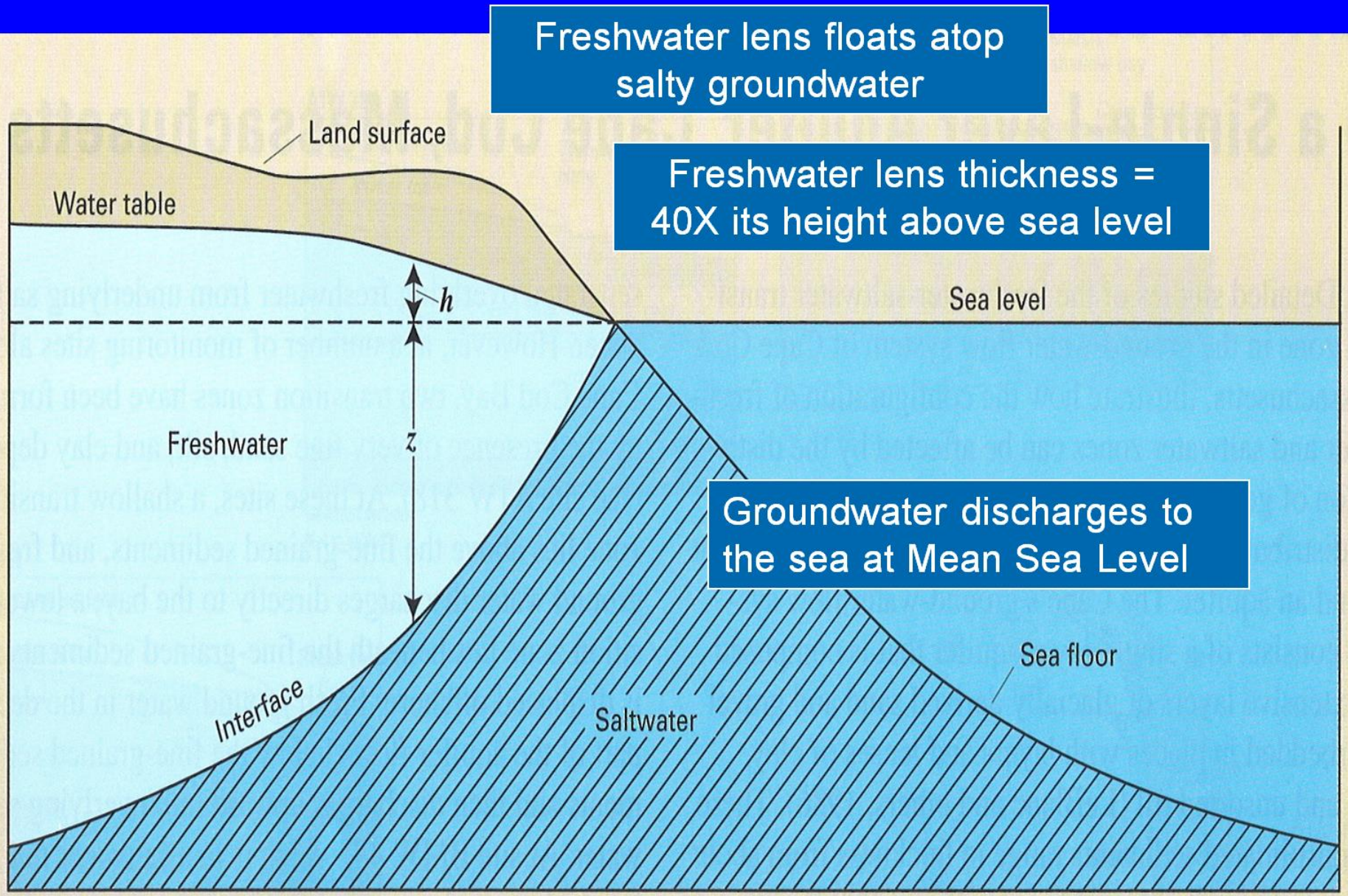


Rain, snowfall

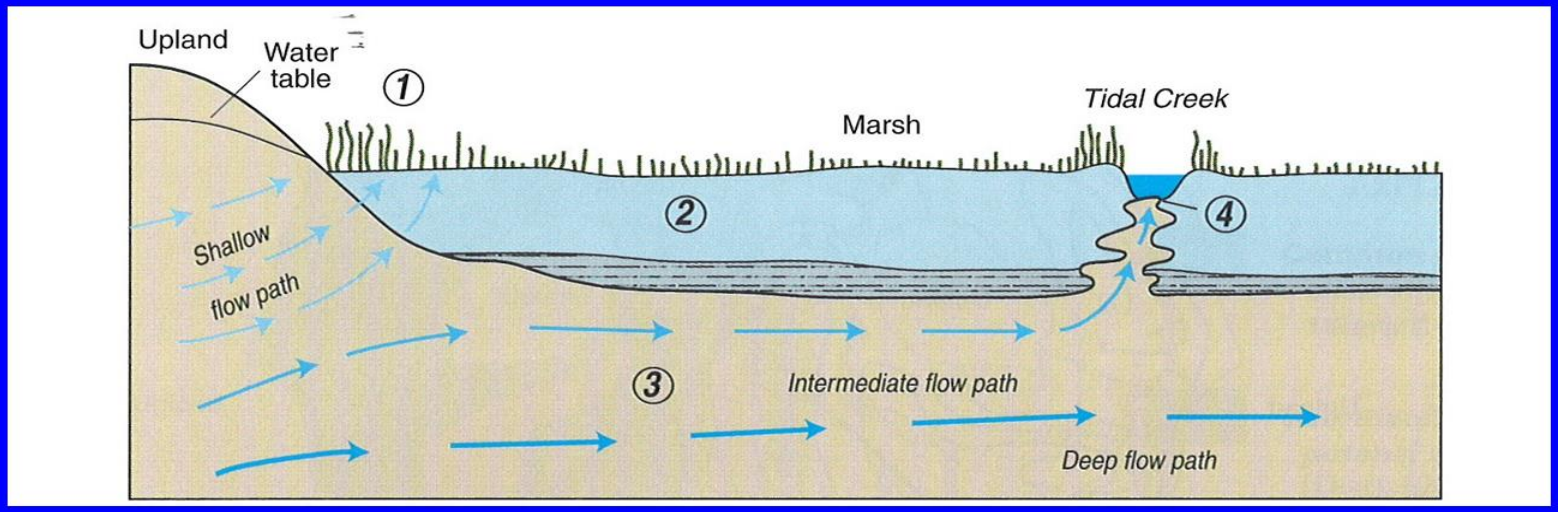
Size of the land mass

Permeability of the soil

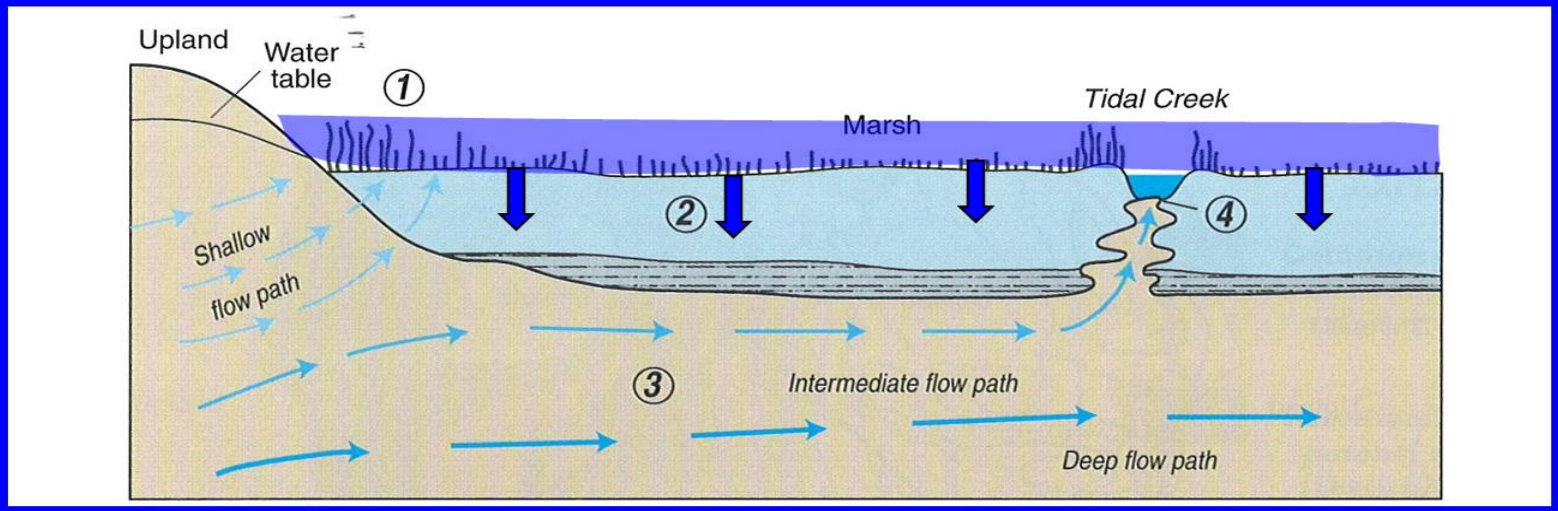
Groundwater Discharge along a **Oceanic** Shoreline



Groundwater Discharge along a **Marsh-fringed** Coast



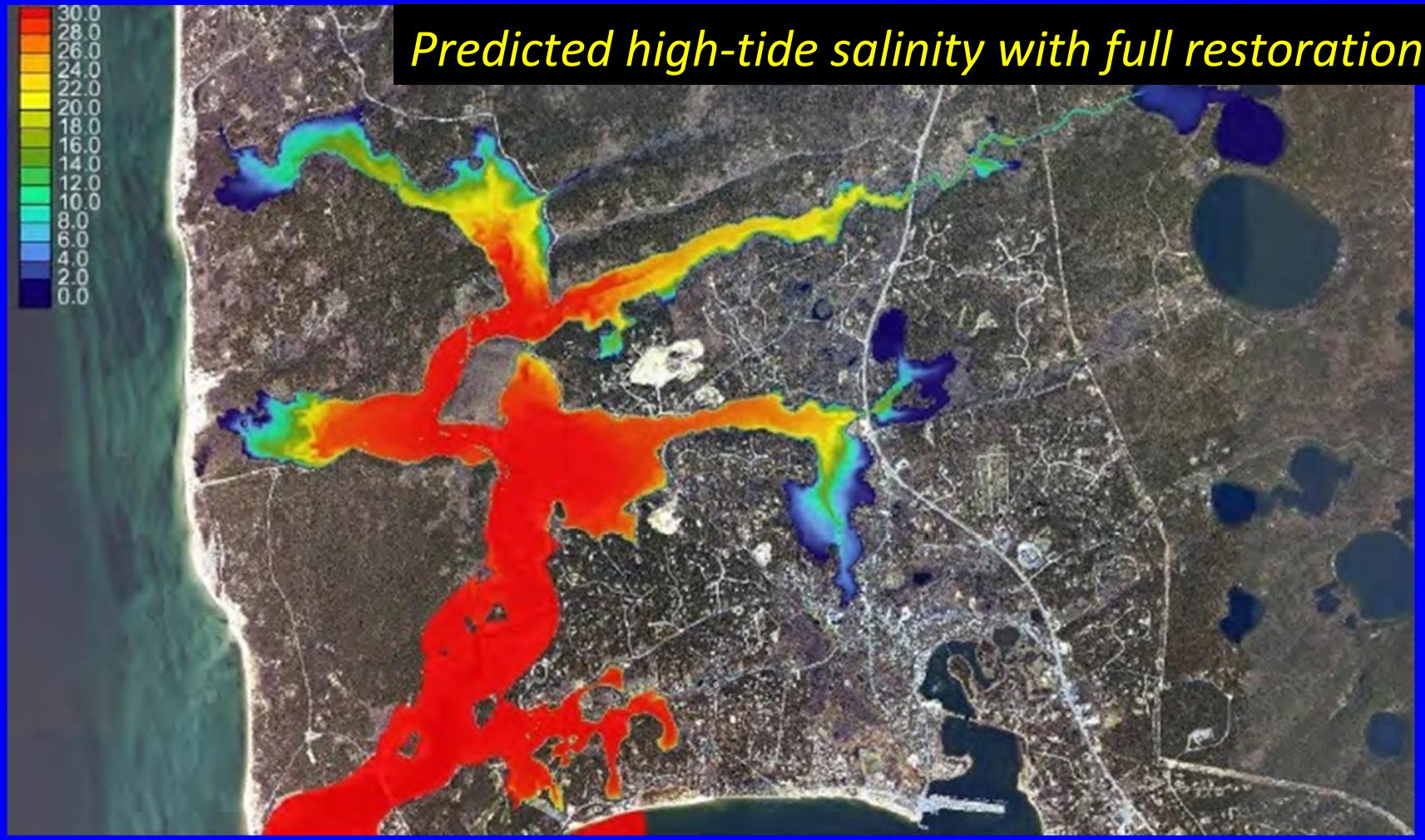
Low Tide, Fresh Groundwater Flows to Creeks



High Tide, Salt Water Infiltrates Shallow Sediments

Barlow, PM. 2003. USGS Circular 1262

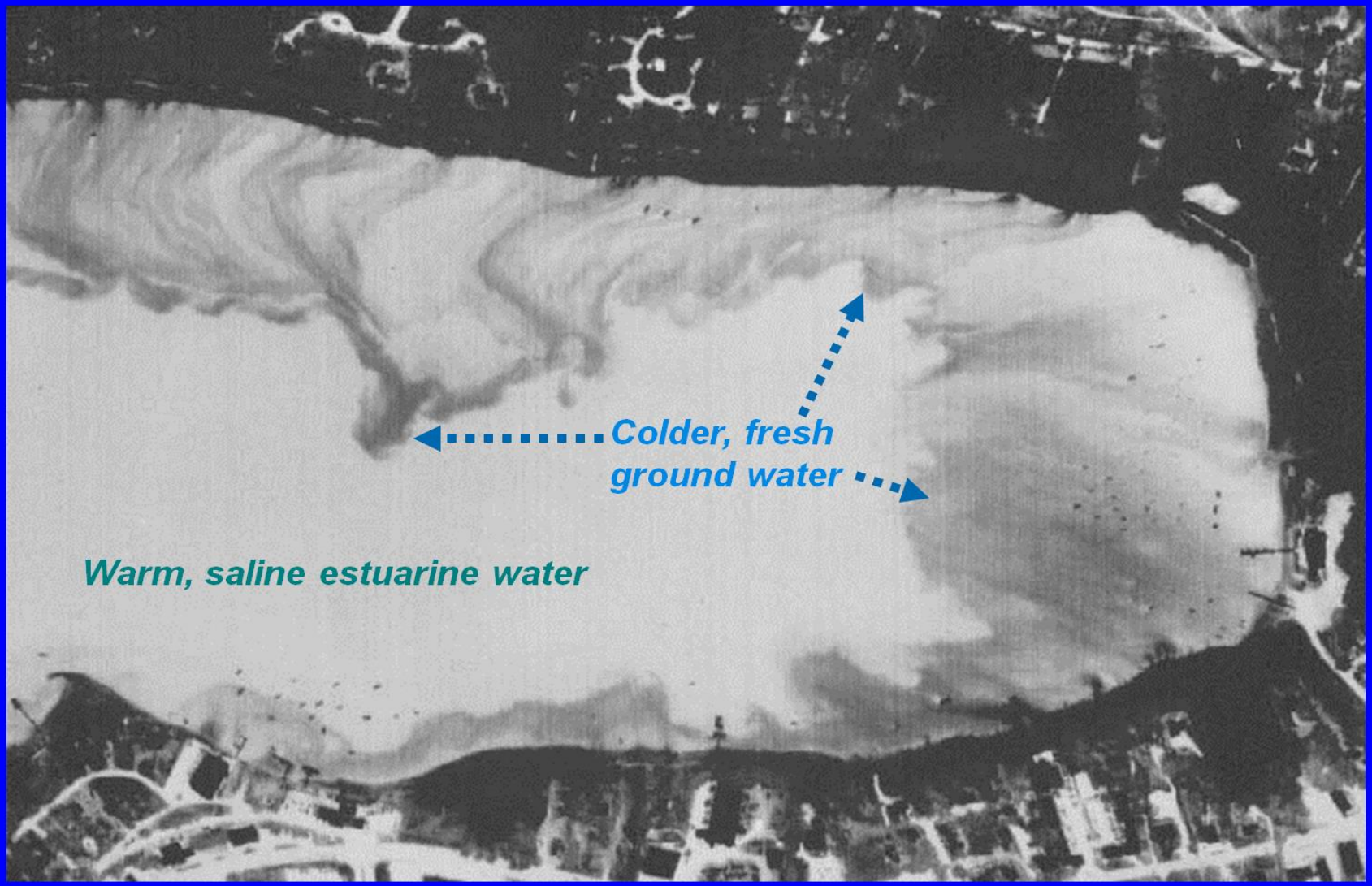
Restored Herring River will NOT have full-strength seawater throughout.



Note decreasing salinity with distance upstream

Groundwater discharge into marsh-fringed embayments,

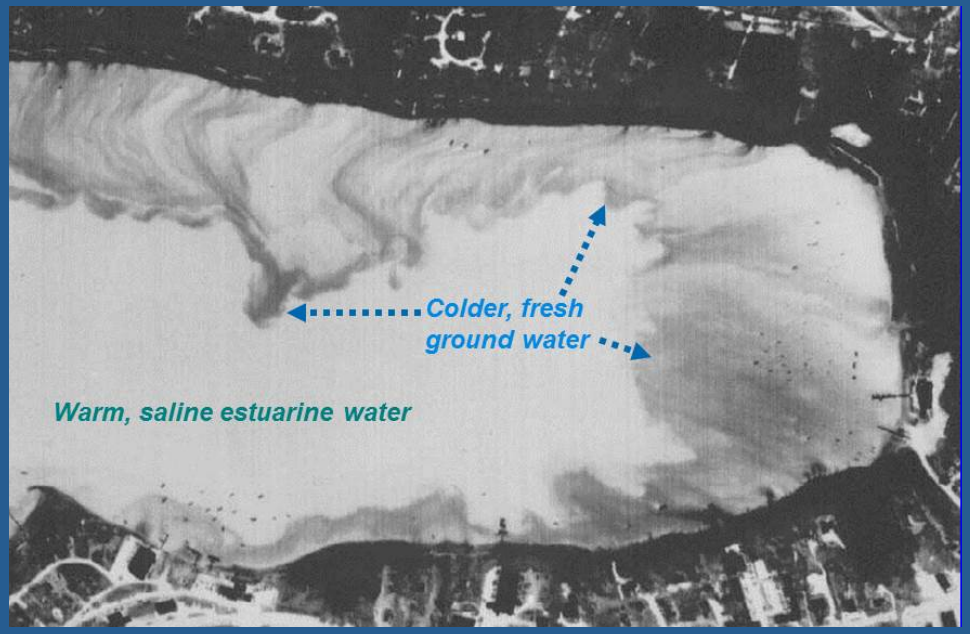
Town Cove, Orleans, Aug 1994



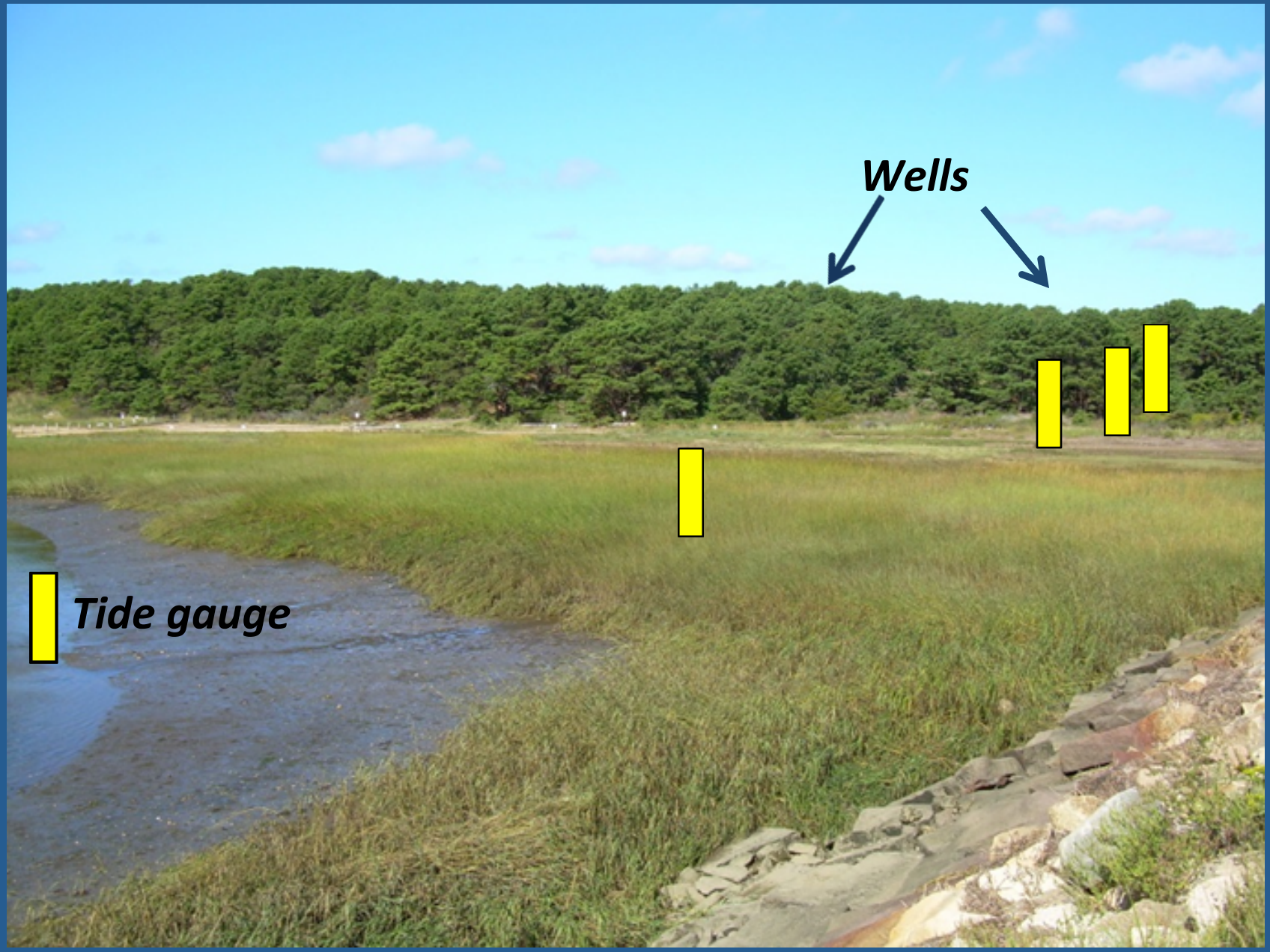
Portnoy et al. 1999. Water Resources Research 34:3095-3104

Tidal areas in salt-marsh estuaries are underlain by fresh groundwater

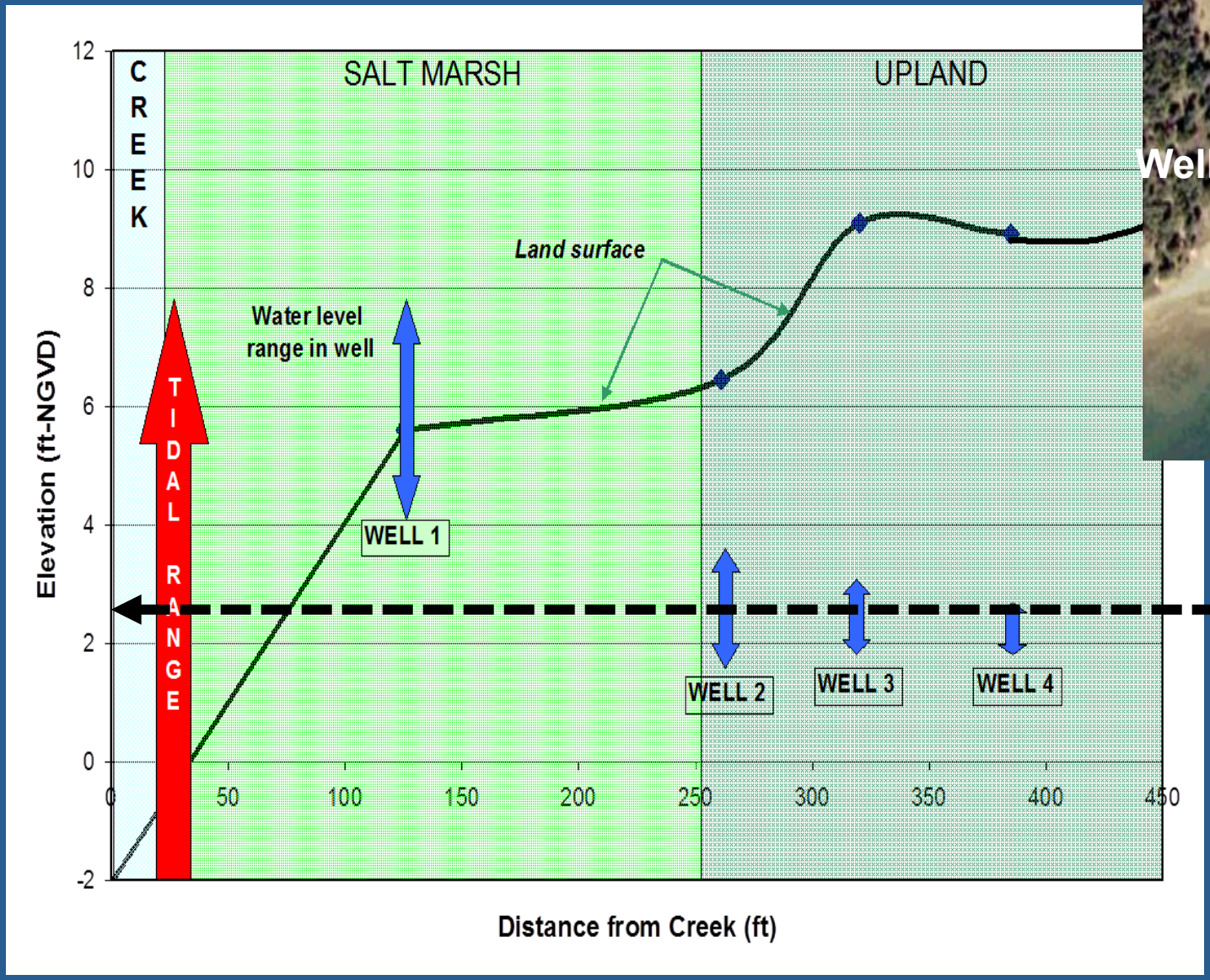
Namskaket Marsh
Sagamore Marsh
Boat Meadow Creek
Pamet River
Salt Pond, Eastham
Nauset Marsh



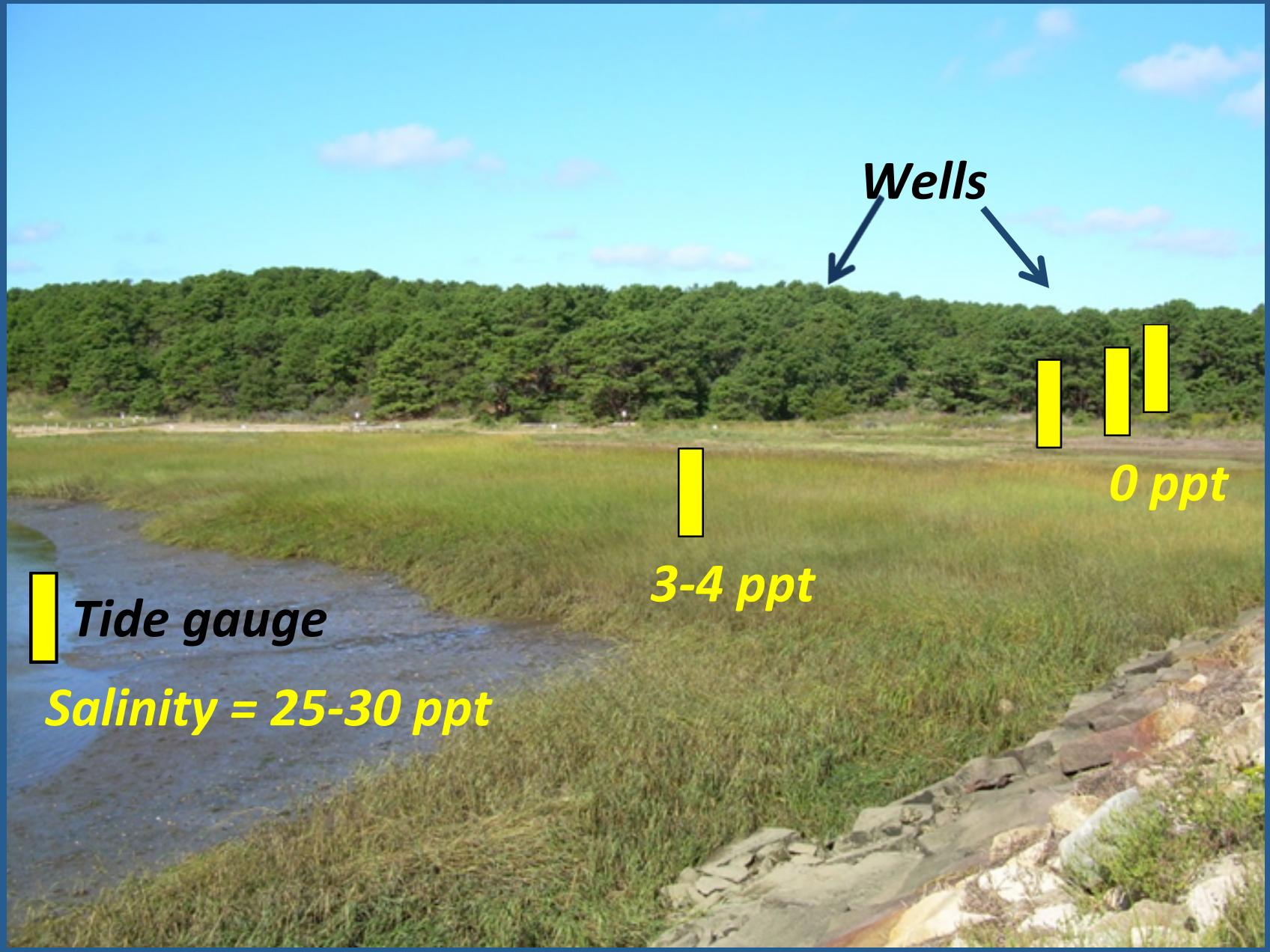

Wells
Image MassGIS, Commonwealth of Massachusetts EOEA
Google
Pointer 41°55'54.54" N 70°03'52.52" W elev 18 ft
Streaming 100%
Eye alt 1623 ft


Wells
Tide gauge

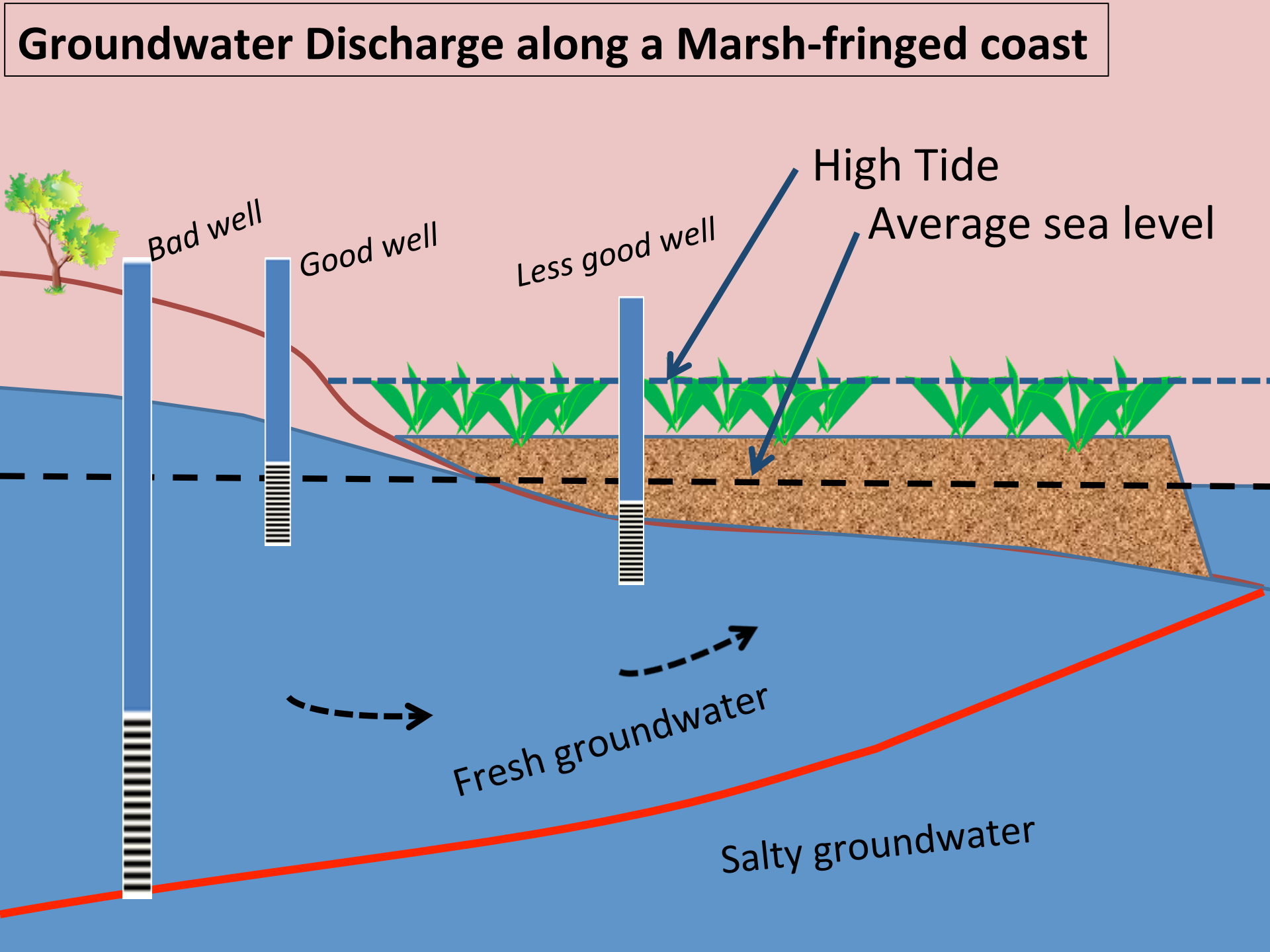
Groundwater discharges at the coast at the elevation of **MEAN SEA LEVEL**.



Portnoy & Martin. 2007. NPS Report.


Wells
0 ppt
3-4 ppt
Tide gauge
Salinity = 25-30 ppt

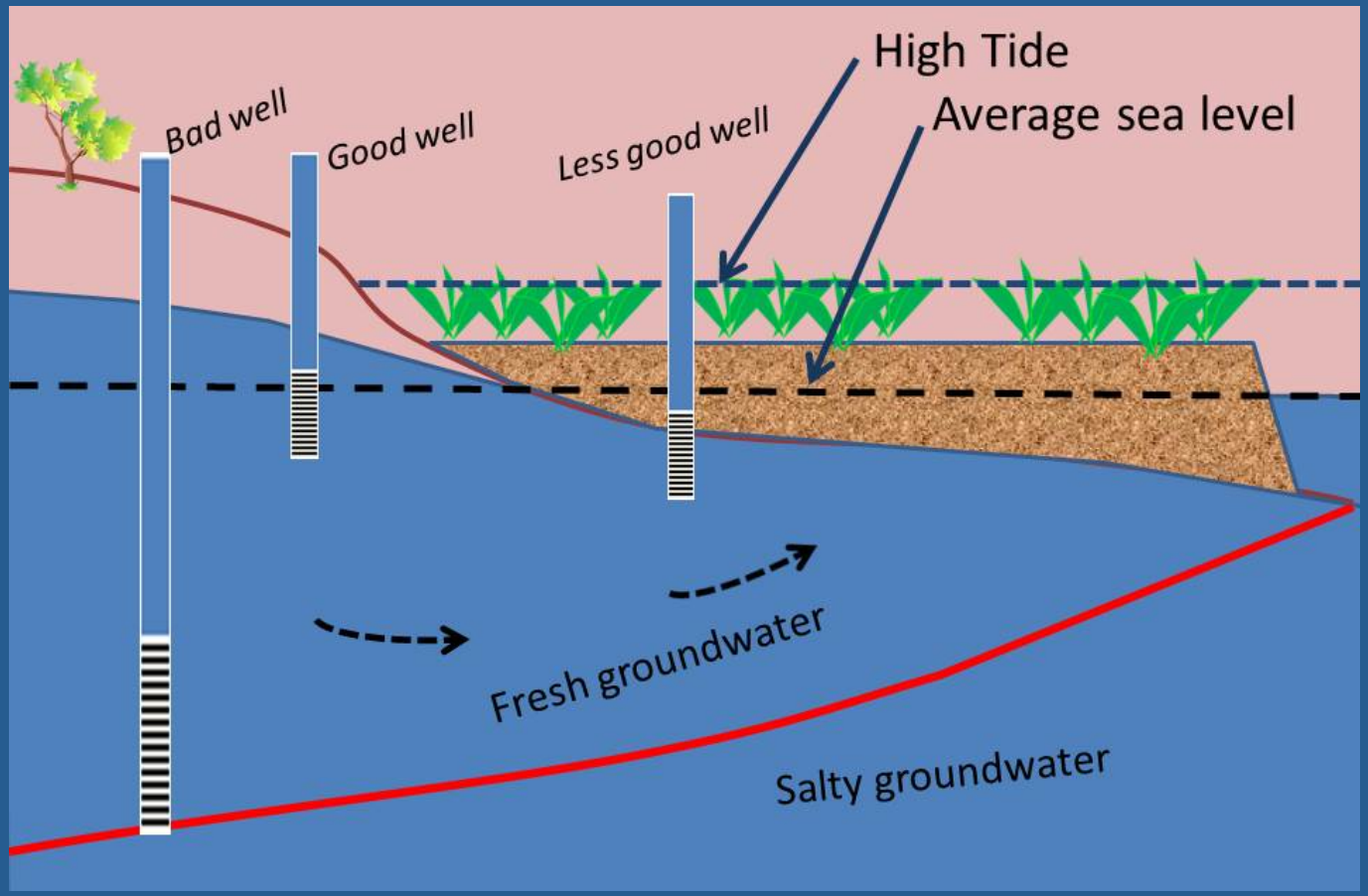
Groundwater Discharge along a Marsh-fringed coast



The best place for a well screen is:

1) **10-20 feet below the water table**, to ensure it is submerged even in the driest years, and

2) **Enough above the fresh/saltwater interface** to avoid the withdrawal of salty water.



UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

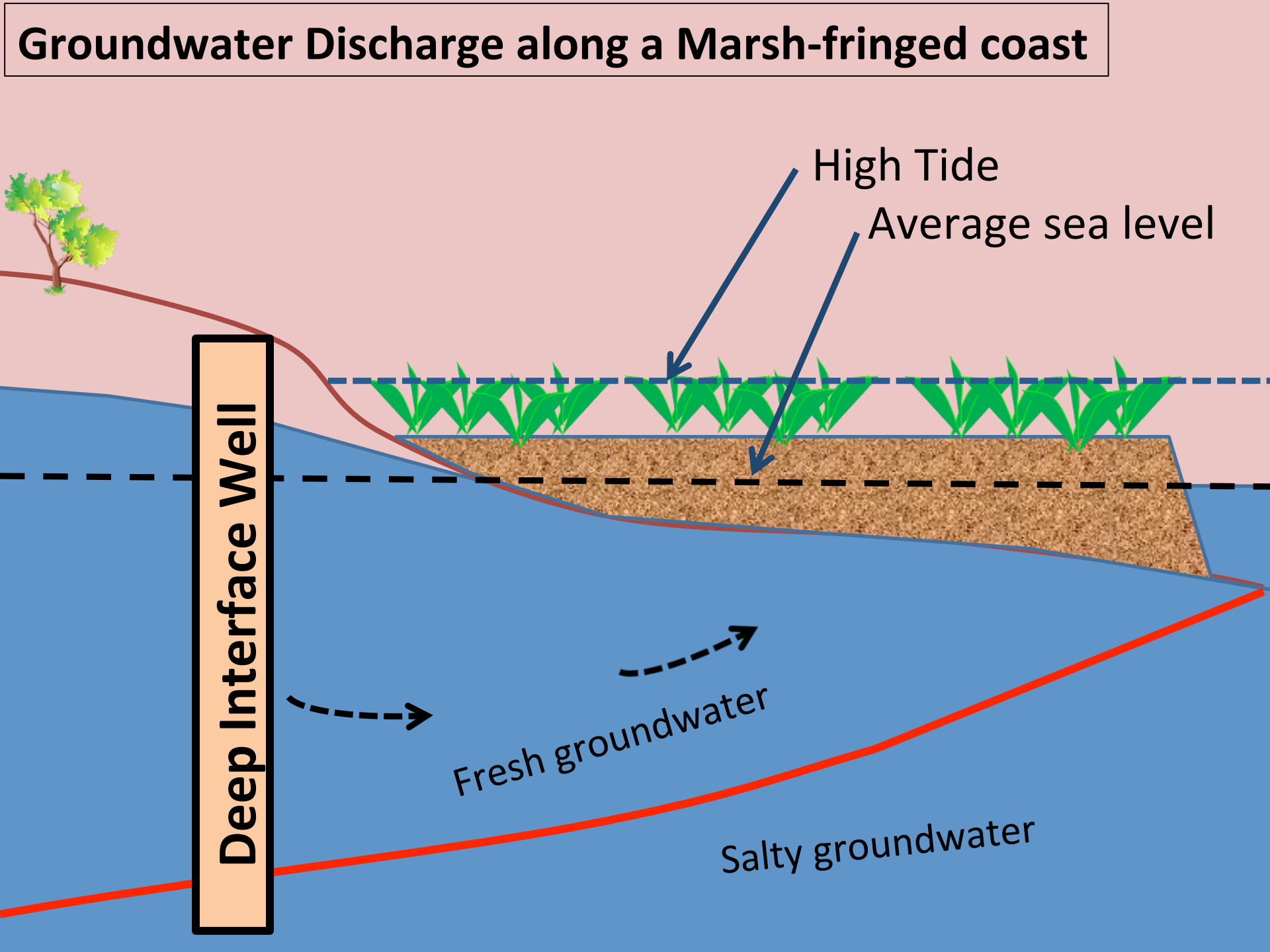
Verification of Geophysically Determined Depths to Saltwater Near the Herring River (Cape Cod National Seashore), Wellfleet, Massachusetts

David V. Fitterman[1] and Kevin F. Dennehy[2]

Geophysical soundings by USGS in 1989 showed that:

There was **ample freshwater lens thickness all around the Herring River estuary** to meet these criteria and provide excellent quality drinking water.

Groundwater Discharge along a Marsh-fringed coast

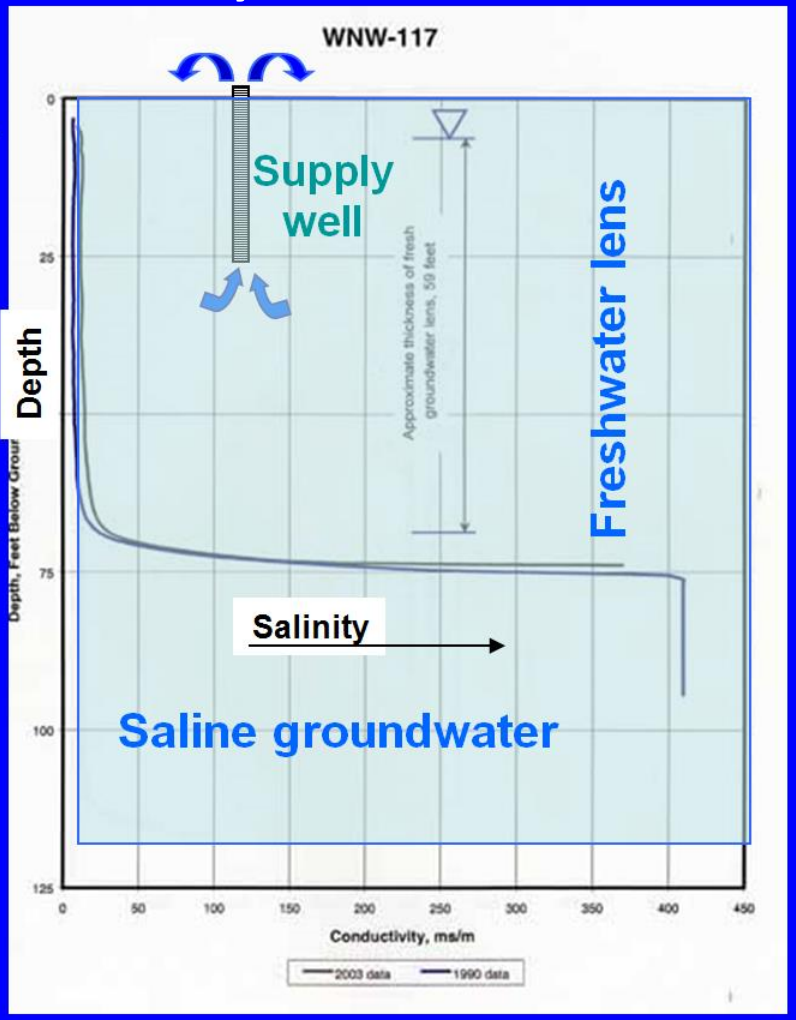


Deep well installation to monitor the fresh/salt groundwater interface

water table

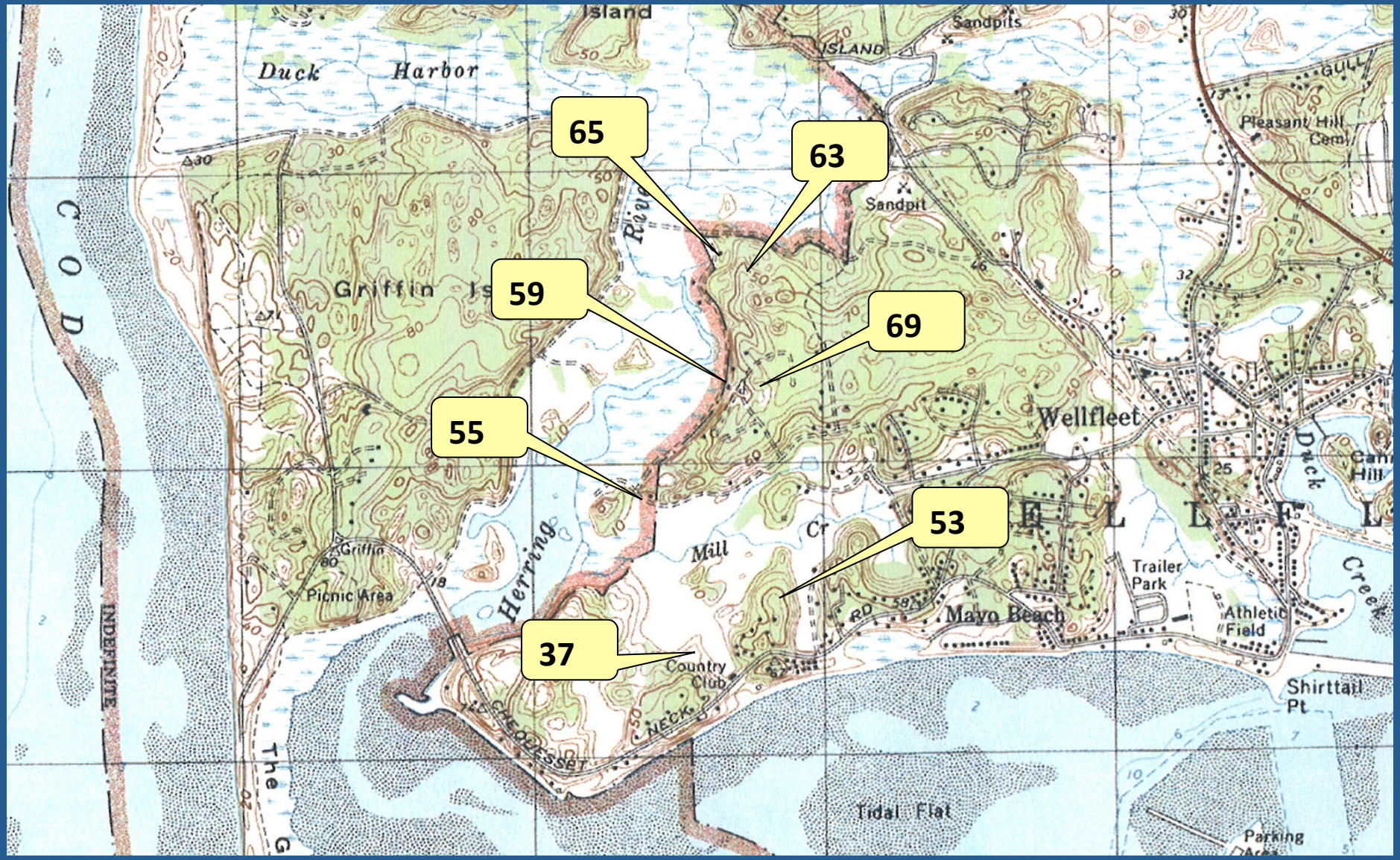
Salt/fresh interface

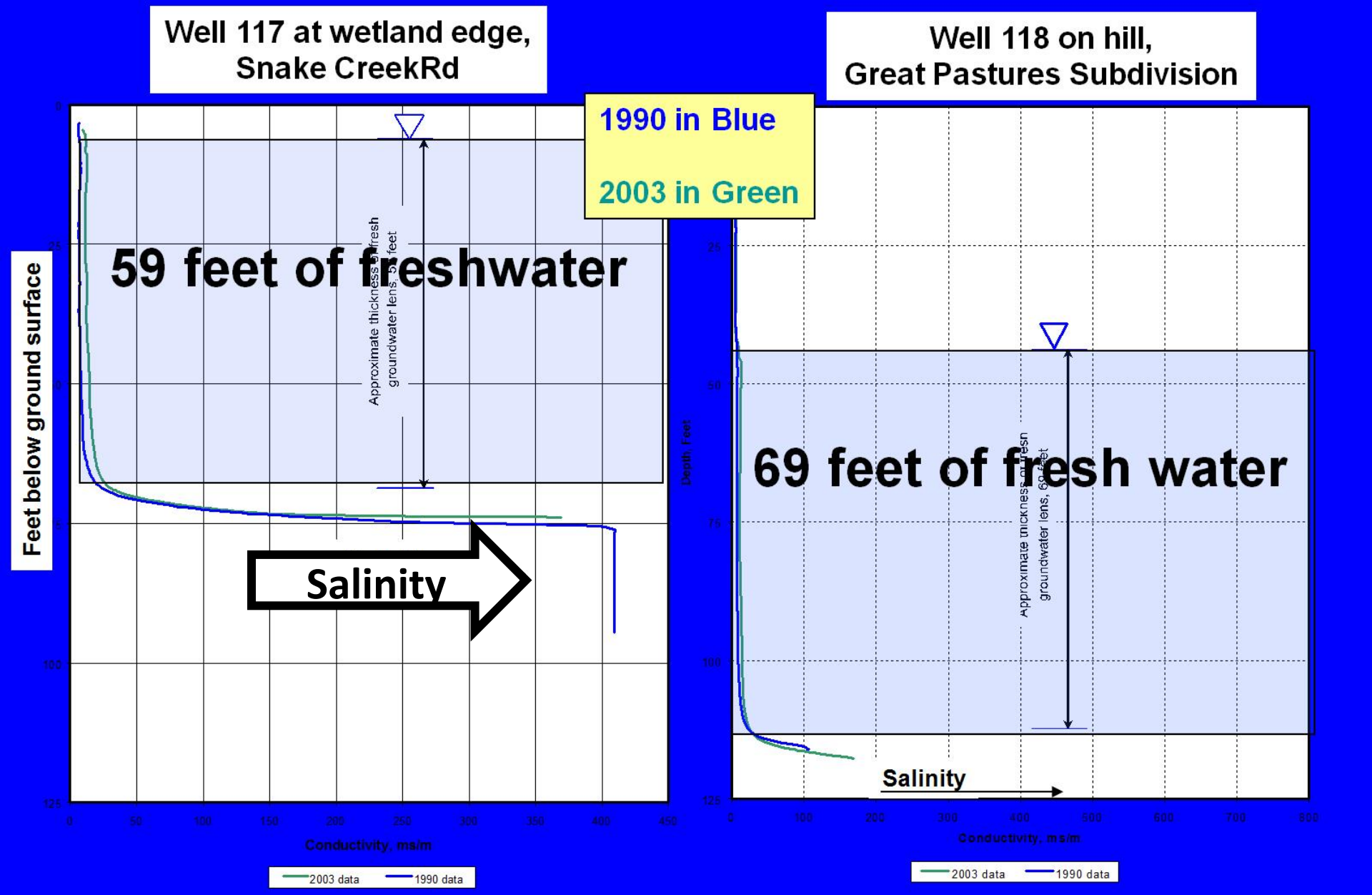
Salinity 1990 & 2003

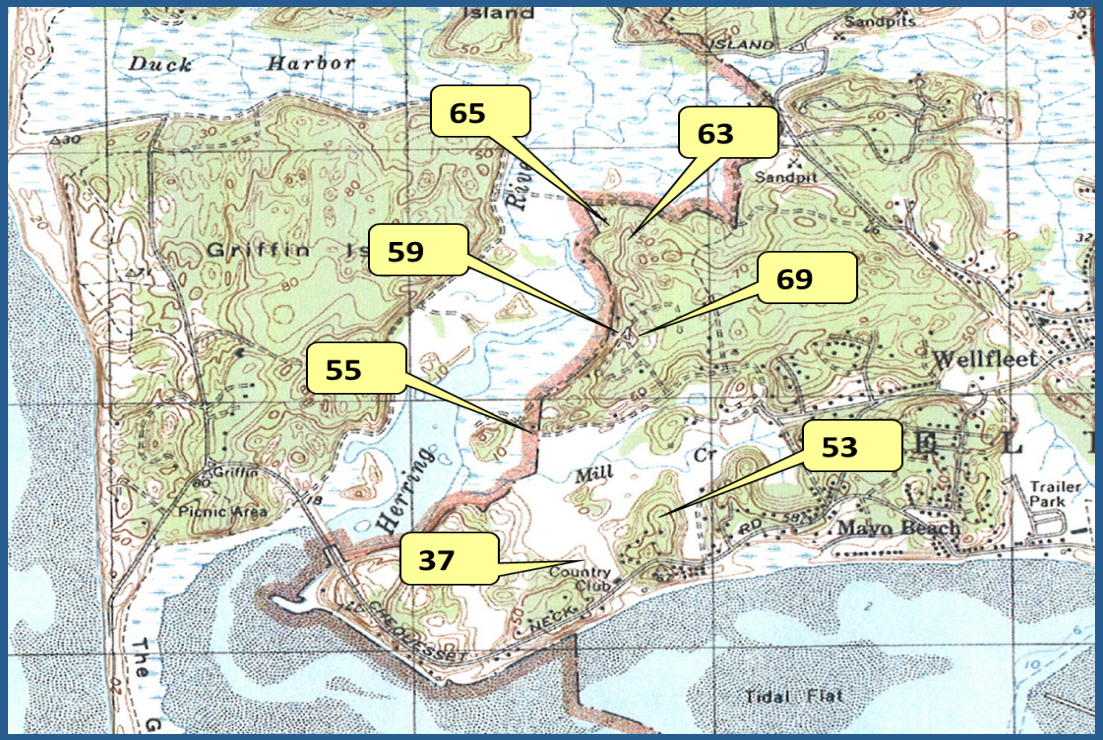


Herring River deep well monitoring by US Geological Survey:

Numbers are freshwater lens thickness in feet.




Well 117 at wetland edge,
Snake CreekRd
1990 in Blue
2003 in Green
Well 118 on hill,
Great Pastures Subdivision
59 feet of freshwater
Approximate thickness of fresh groundwater lens, 59 feet
Salinity
Feet below ground surface
Conductivity, ms/m
2003 data
1990 data
69 feet of fresh water
Approximate thickness of fresh groundwater lens, 69 feet
Salinity
Depth, Feet
Conductivity, ms/m
2003 data
1990 data



- In general, the freshwater lens around Herring River is at least 35-40 feet thick even at the upland/salt-marsh boundary.
- This freshwater lens is over 50 feet thick in surrounding developed uplands.
- **A network of deep wells is in place for long-term monitoring of the fresh/salt groundwater interface.**

CONCLUSIONS

- *Saltwater does not intrude laterally into the freshwater aquifer; i.e. the groundwater flow direction is always towards the sea.*

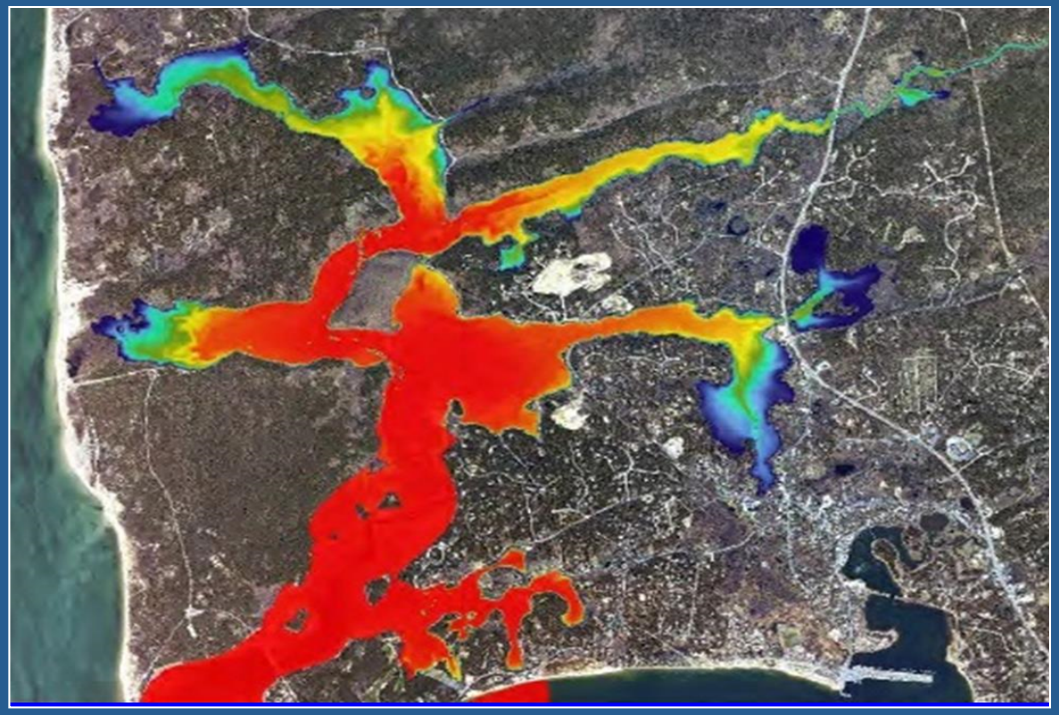
- *Nearly all residential wells draw water from a depth that is far less than the thickness of the freshwater lens.*

- *Salt water does not penetrate more than a few meters into salt-marsh sediments.*

- *Freshwater will continue to be present under the tidal wetlands after restoration.*

- *Except for wells drilled in original tidelands,*

tidal restoration is highly unlikely to damage well water quality.



Given 1) well-studied hydrogeology, and 2) hydrodynamic modeling predictions of changes in surface-water levels and salinity, Herring River tidal restoration will result in little change in current fresh/salt groundwater relationships.