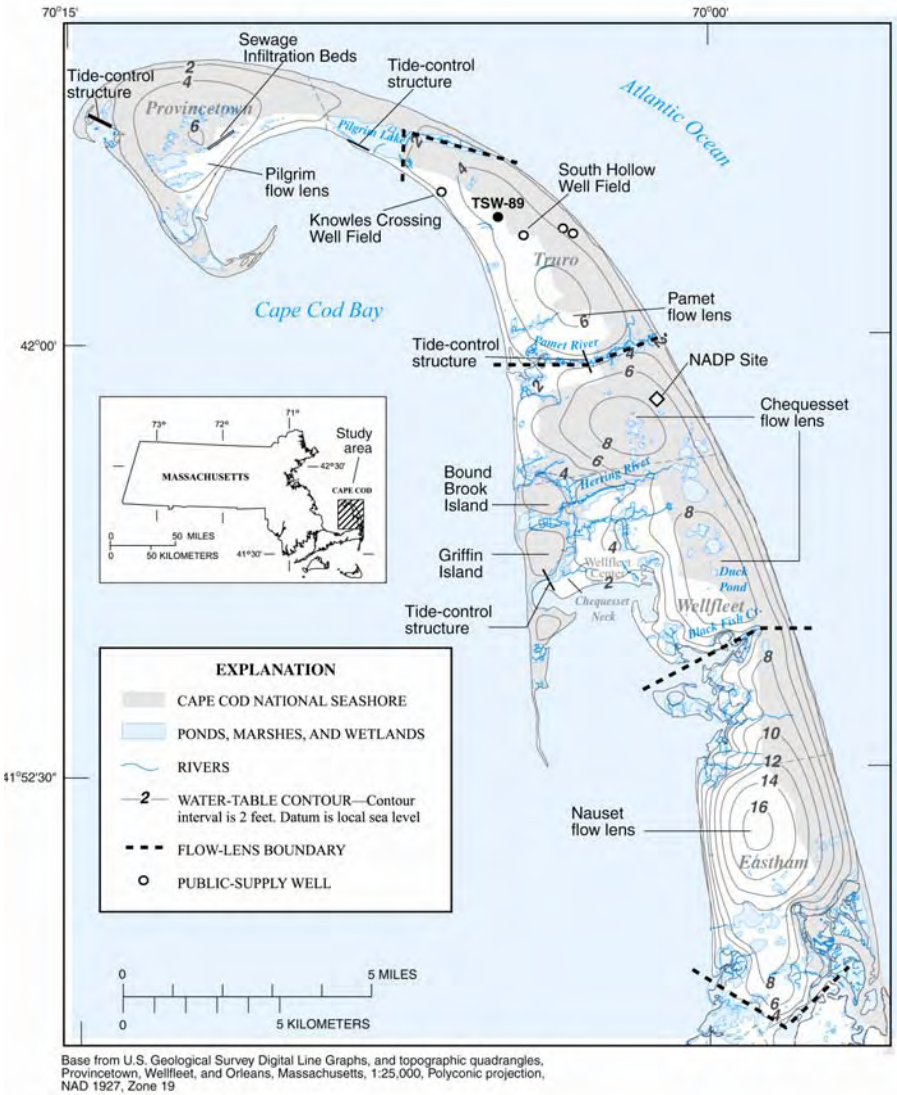
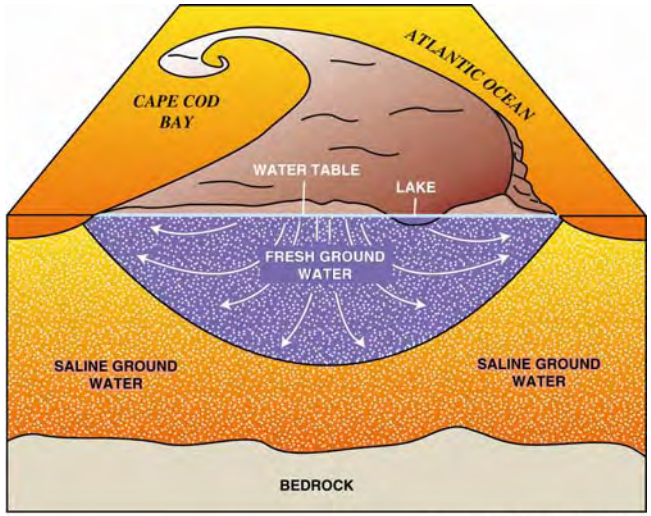
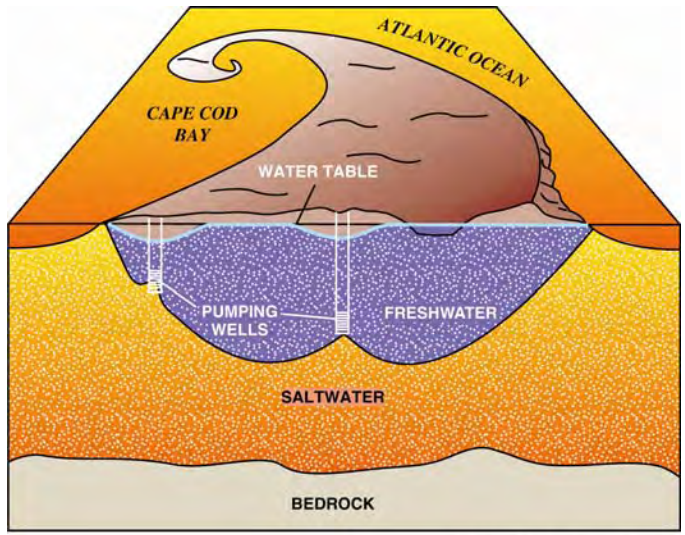
Groundwater quality



Base from U.S. Geological Survey Digital Line Graphs, and topographic quadrangles, Provincetown, Wellfleet, and Orleans, Massachusetts, 1:25,000, Polyconic projection, NAD 1927, Zone 19

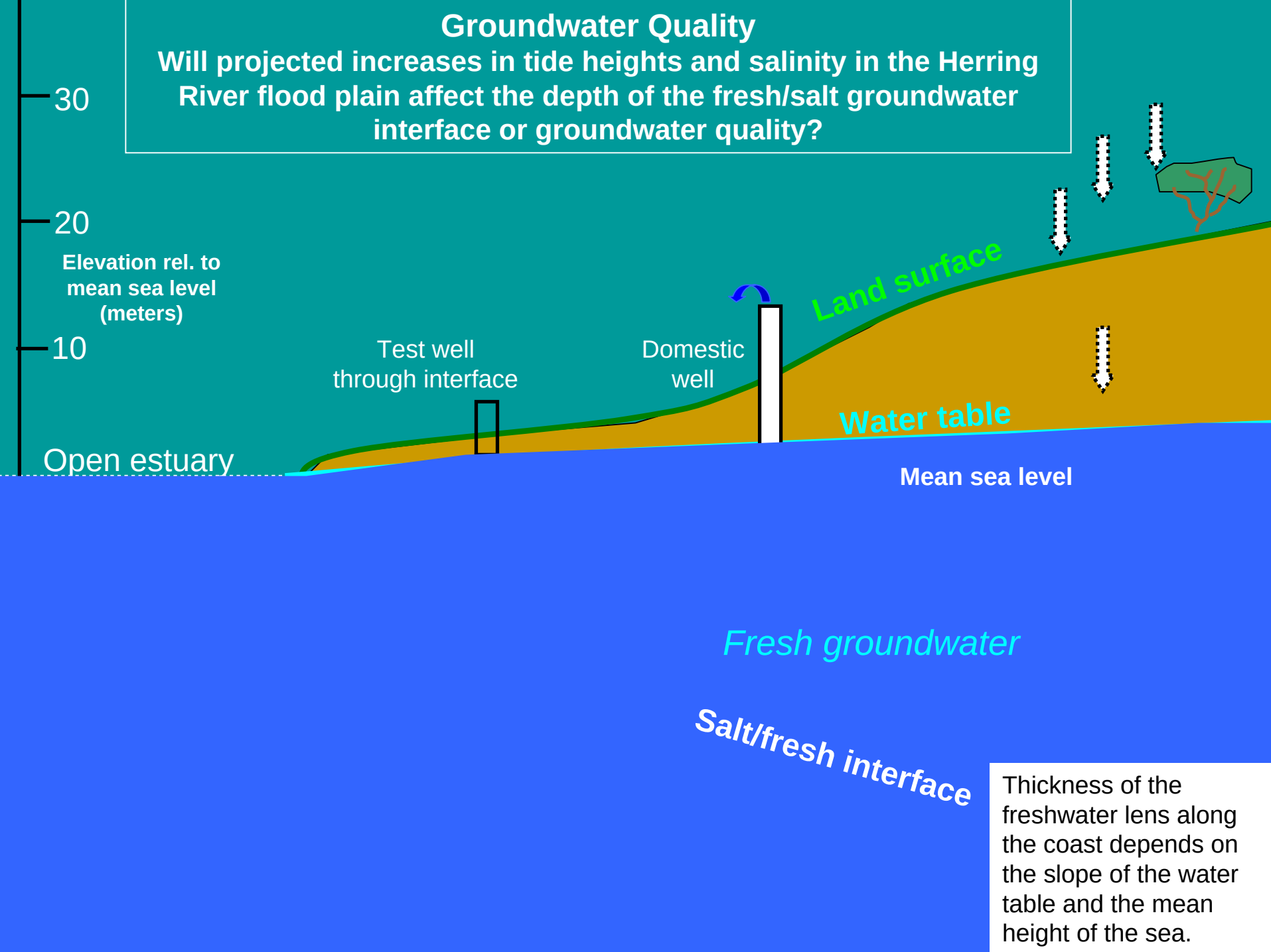


Schematic diagram, not to scale

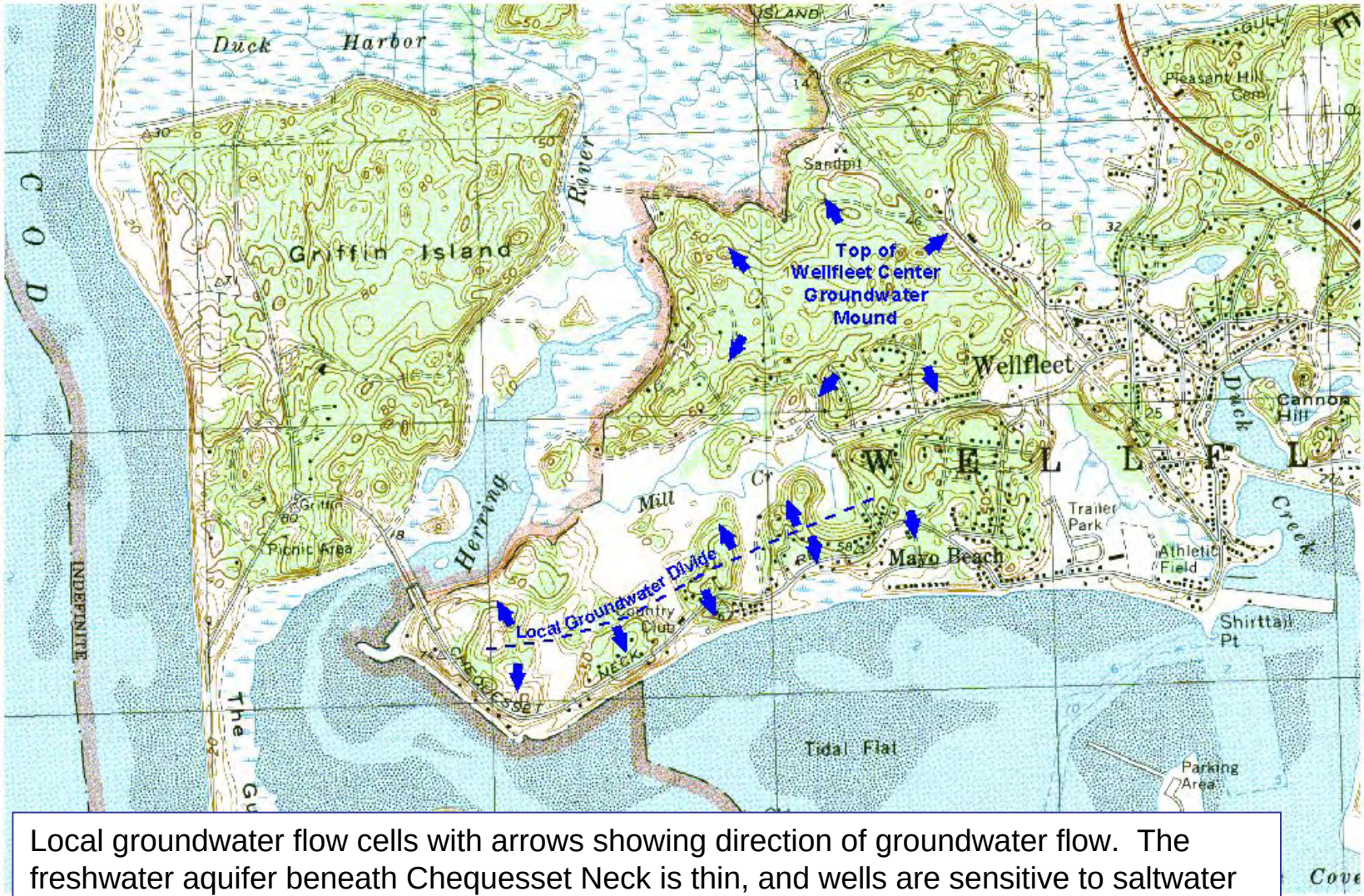


Schematic diagram, not to scale

Left panel: Fresh groundwater on the outer Cape forms a series of mounds or lenses floating on top of saline groundwater. *Upper right panel*: The fresh/salt interface is deepest, and the freshwater lens is thickest, in the center of the peninsula, tapering toward the Bay and Ocean. *Lower right panel*: The interface is generally fairly stable unless disturbed by high-volume pumping which can cause saltwater upconing.


Groundwater Quality
Will projected increases in tide heights and salinity in the Herring River flood plain affect the depth of the fresh/salt groundwater interface or groundwater quality?
30
20
Elevation rel. to mean sea level (meters)
10
Test well through interface
Domestic well
Land surface
Water table
Open estuary
Mean sea level
Fresh groundwater
Salt/fresh interface
Thickness of the freshwater lens along the coast depends on the slope of the water table and the mean height of the sea.

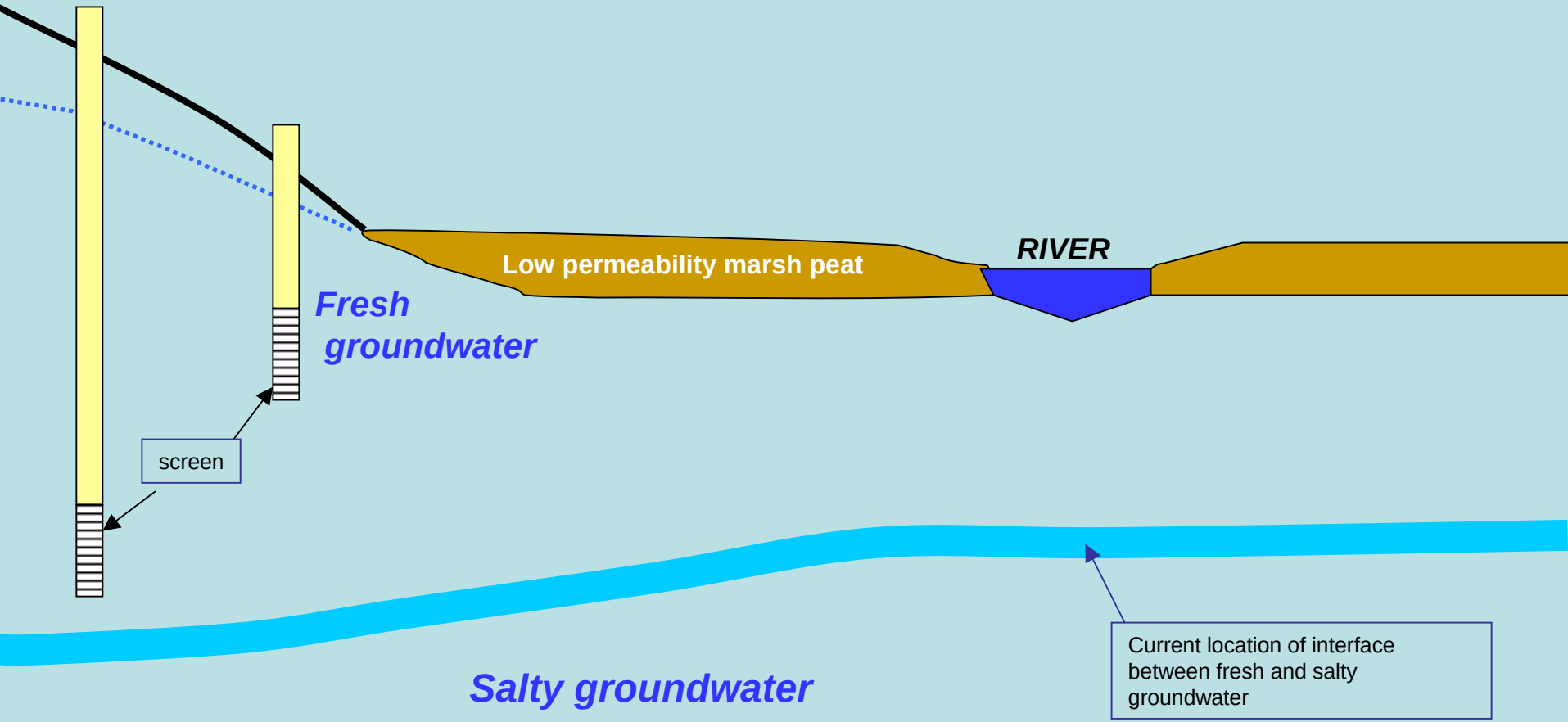
Groundwater aquifers in developed areas near Herring River



Local groundwater flow cells with arrows showing direction of groundwater flow. The freshwater aquifer beneath Chequesset Neck is thin, and wells are sensitive to saltwater intrusion, because of 1) the small area for groundwater recharge and 2) the proximity of the harbor; however, hydrologic modeling shows that tidal restoration in Herring River, and Mill Creek, will not increase salt intrusion (see below).

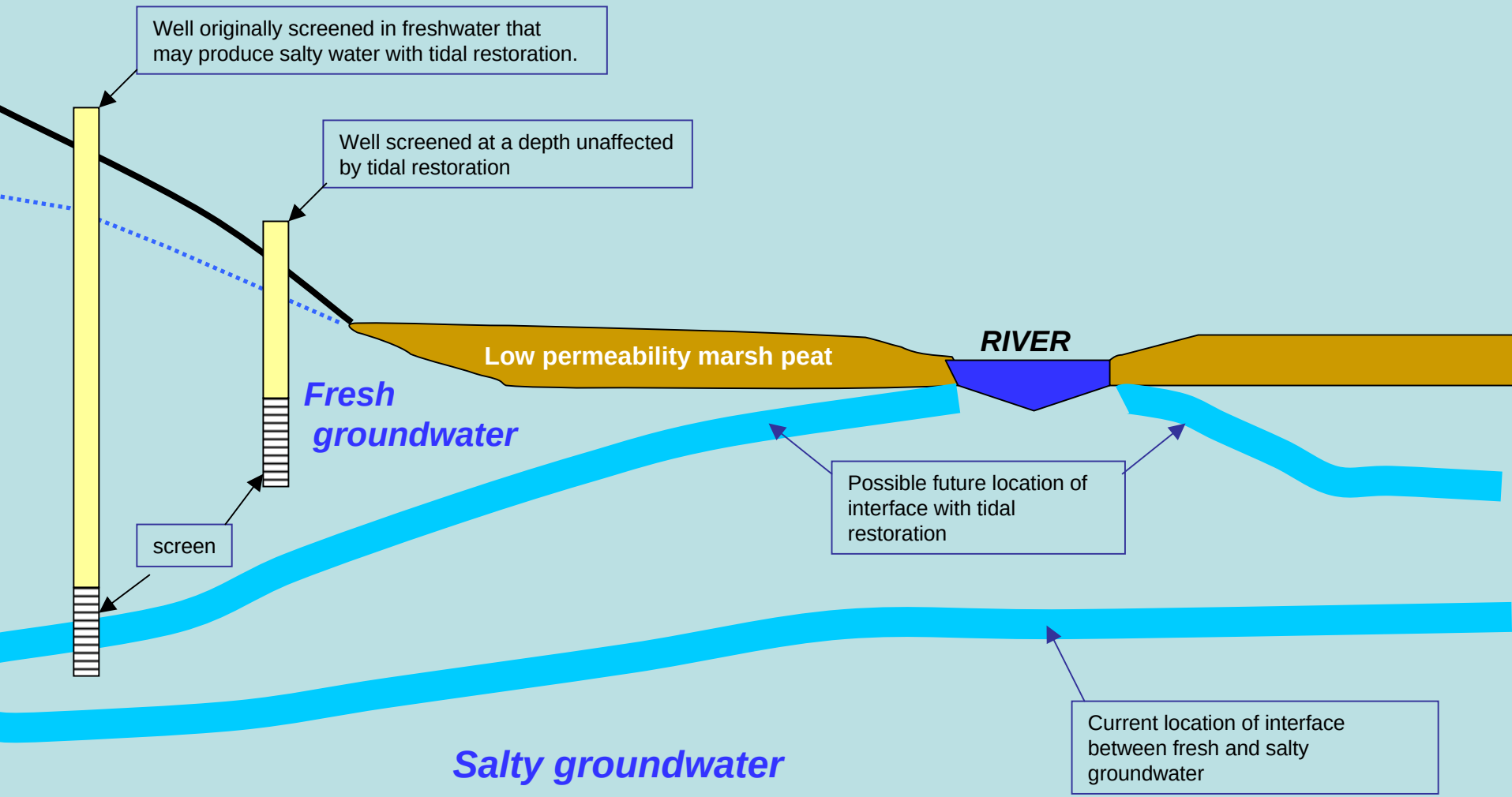
Fresh/salt interface and tidal restoration

Presently (2005) the salt/fresh groundwater interface is deep near Herring River, with the freshwater aquifer nearly 60 feet thick even at the edge of the flood plain and extending underneath the diked wetland.



Fresh/salt interface and tidal restoration

Some options for tidal restoration could cause the interface to rise, and there is concern that wells with screens set just above the present interface could become salty.



Well installation, groundwater monitoring and modeling

Wells have been drilled completely through the fresh/salt interface to monitor its position and to calibrate a numerical model to assess the effects on groundwater quality of increasing tide heights and salinity in Herring River.

water table

Salt/fresh interface

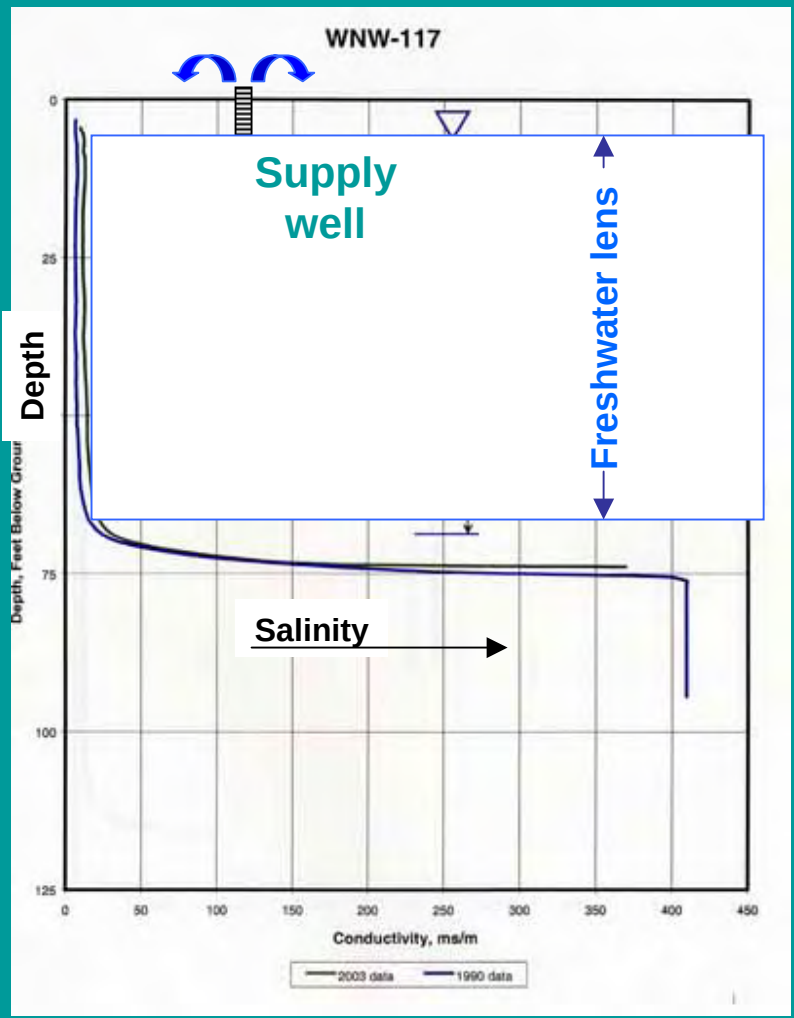
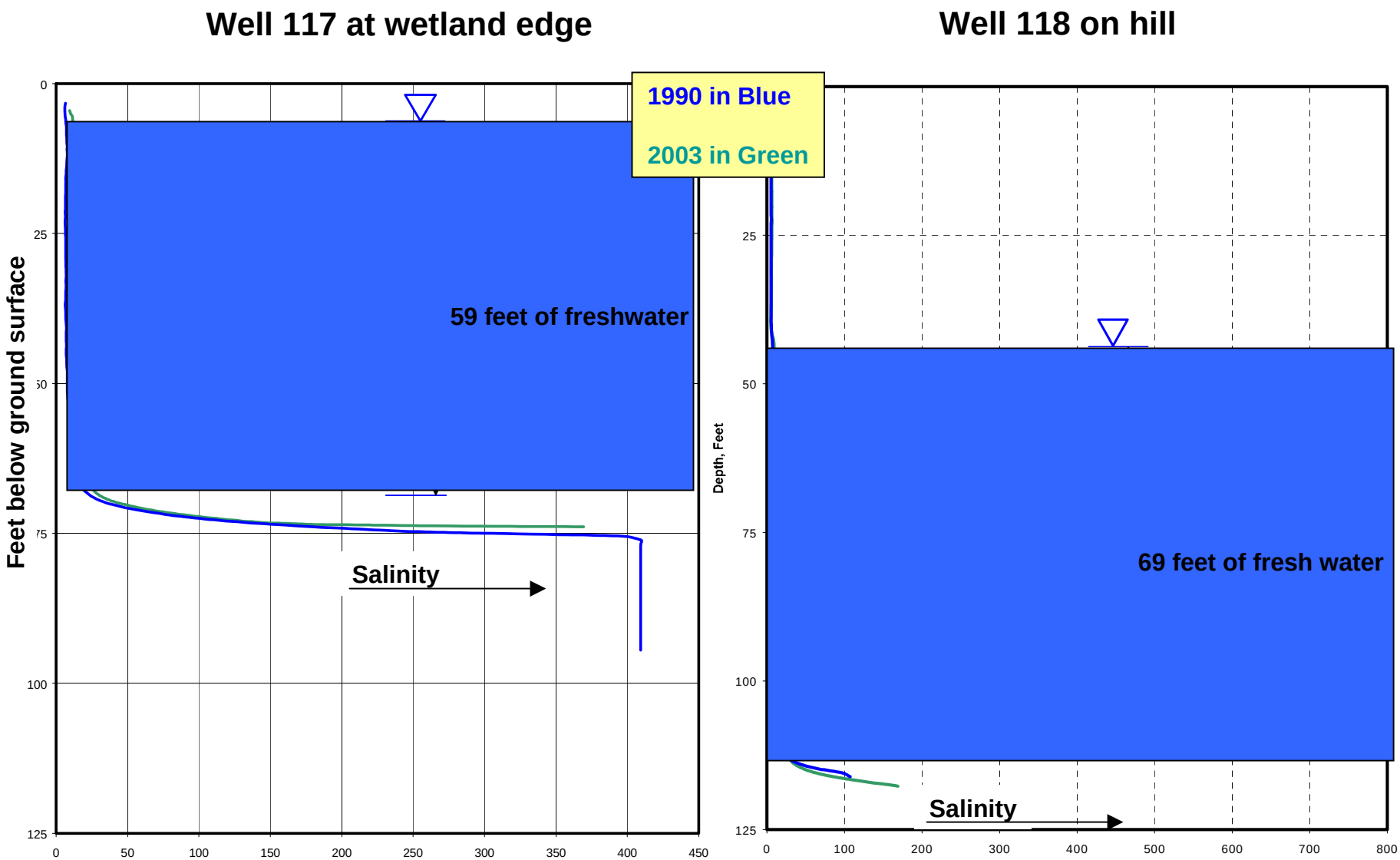
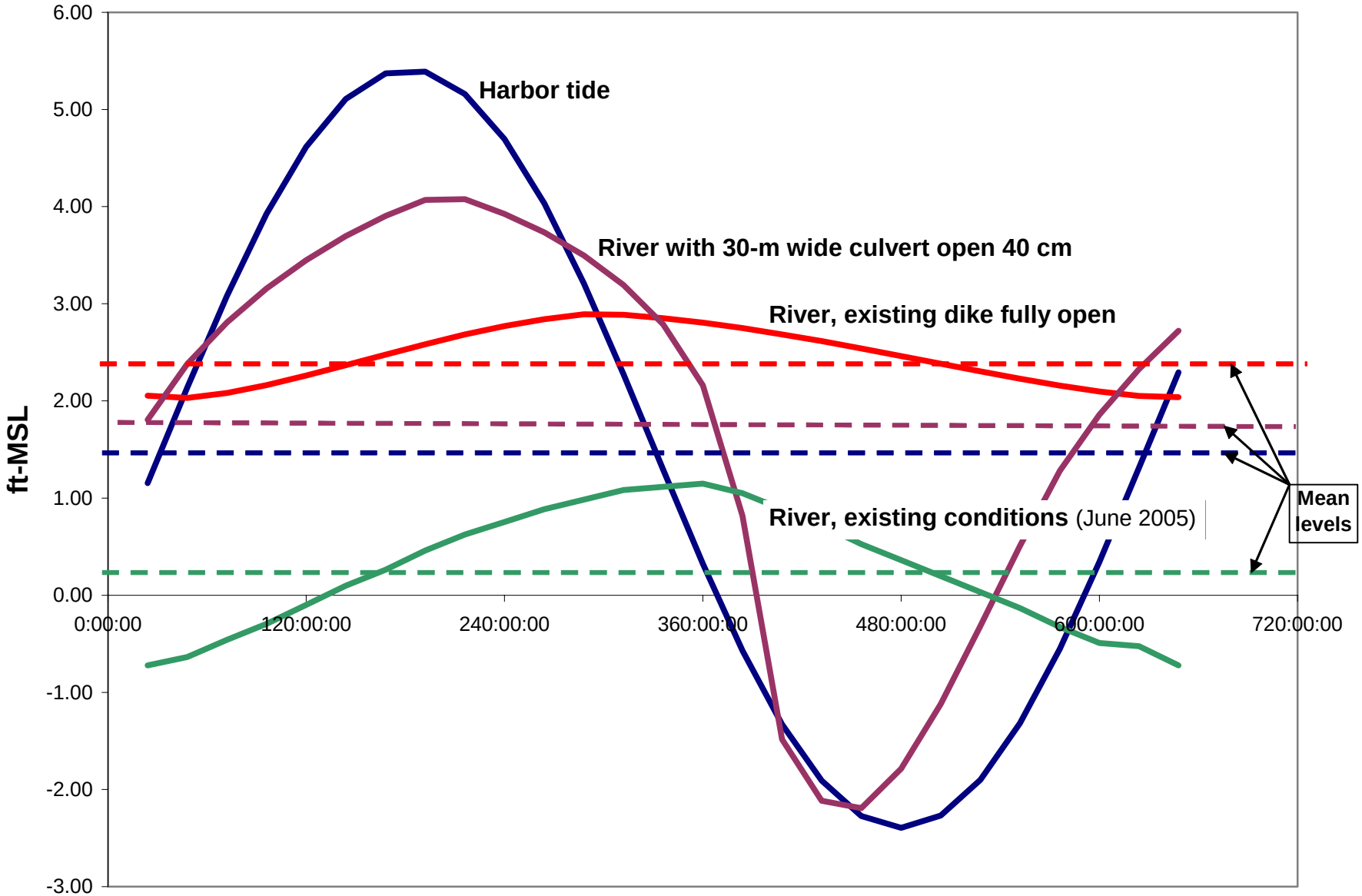


Figure 5. Locations of interface monitoring wells

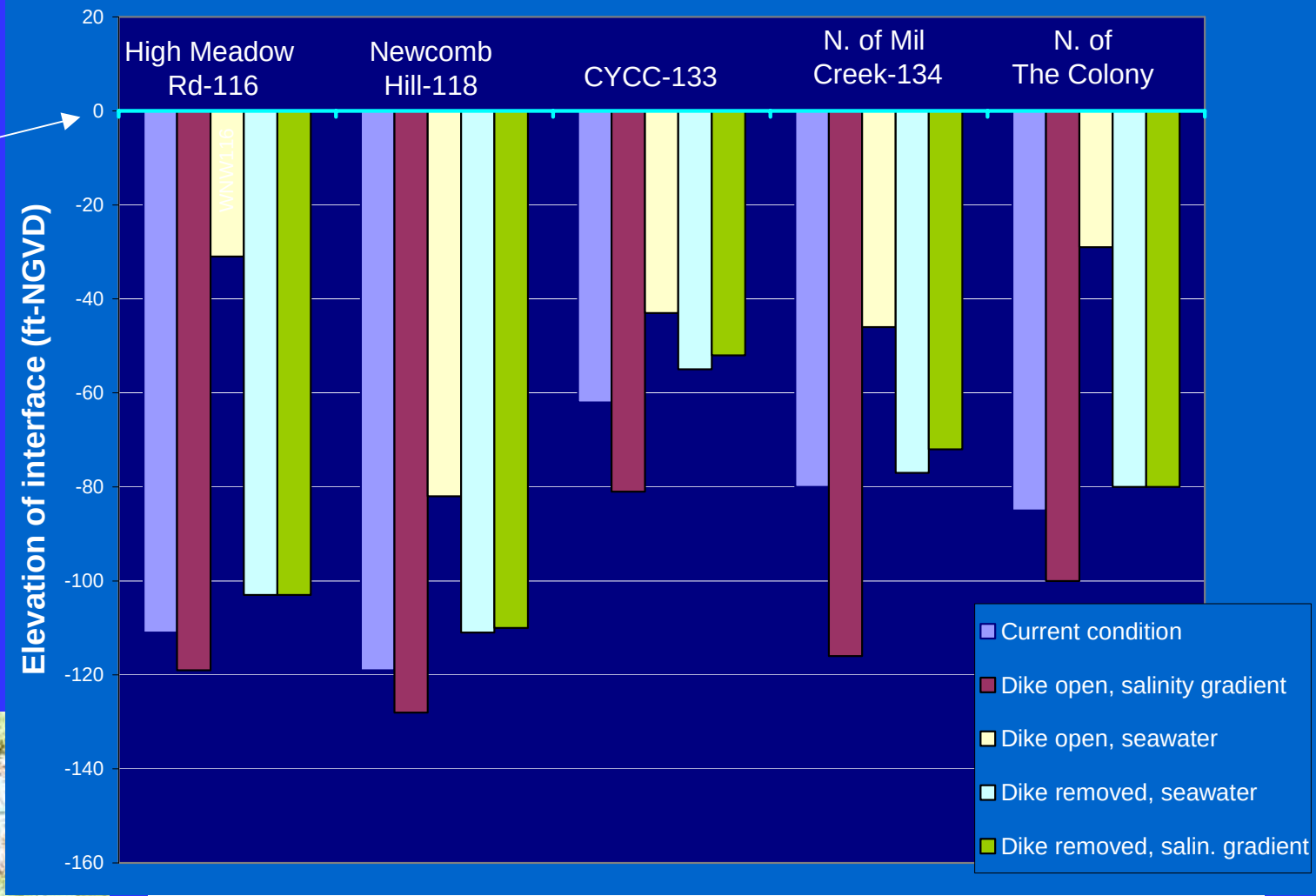


Vertical profiles of groundwater quality (conductivity or salinity) adjacent to Herring River show that the freshwater aquifer is nearly 70 feet thick several hundred feet back from the river (right panel), and nearly 60 feet thick at the very edge of the flood plain (left panel).



Field observations of current conditions, and hydrodynamic modeling estimates of Herring River tide heights for various tide-restoration scenarios, show that mean river height will increase over existing conditions with tidal restoration.

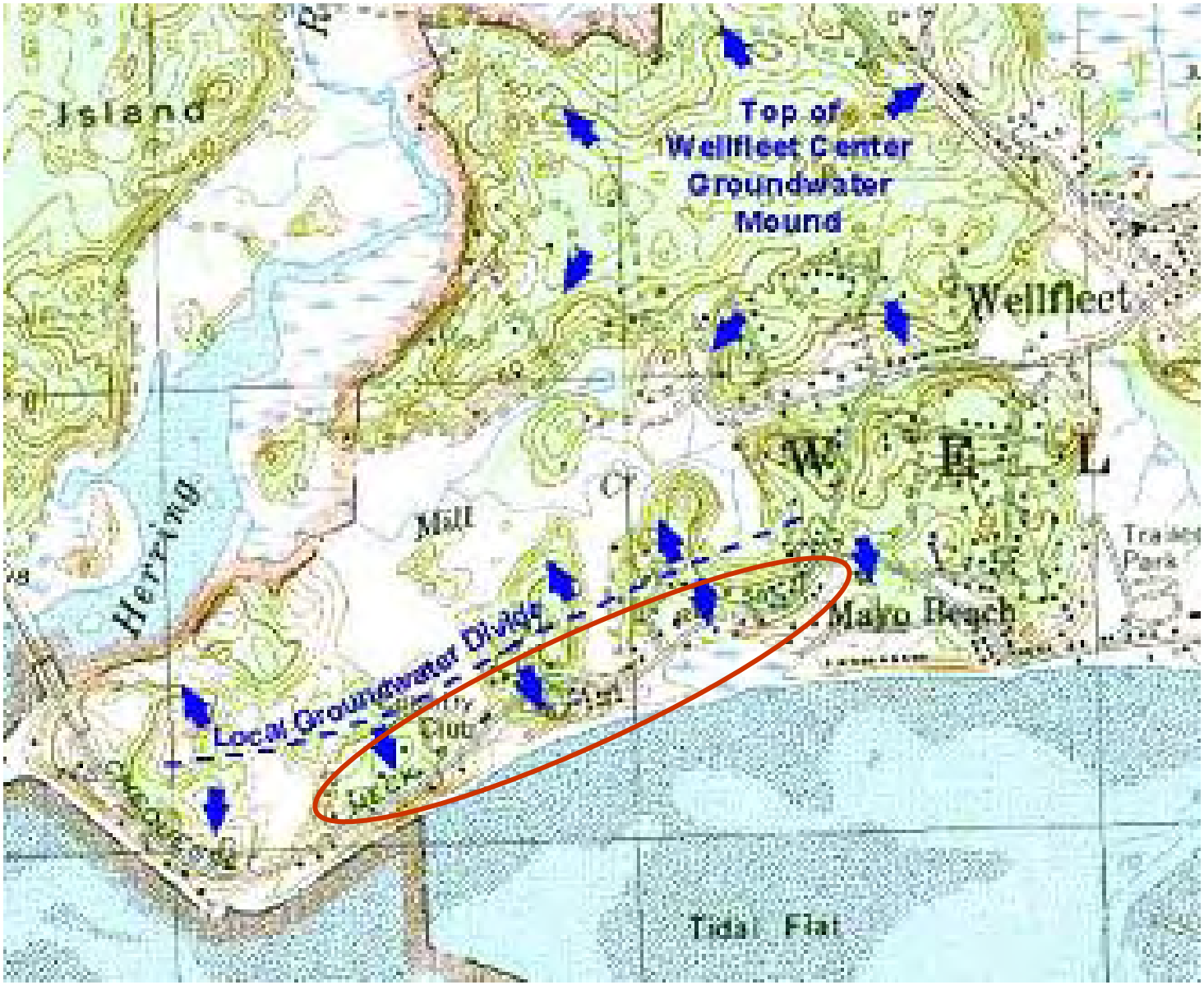
Salt-fresh interface Model Results



These mean-river-water-level predictions have been applied to a computer model of the salt/fresh interface in the groundwater system. The model was run, for a theoretical 300 years, with surface flooding by both full-strength seawater, and with surface-water salinity declining with distance upstream, a more realistic alternative.

For all alternatives and at all monitoring-well locations, the freshwater lens remains at least 30 feet thick with tidal restoration.

Domestic wells along Chequesset Neck Road are on the opposite side of the groundwater divide from Mill Creek (red ellipse), and will therefore be unaffected by tidal restoration.



Conclusions: Groundwater Quality

With restoration of seawater flow into Herring River:

- Domestic water-supply wells in adjacent uplands would not be affected because the freshwater aquifer is too thick relative to projected rise in mean river tides.
- Wells on Chequesset Neck close to the harbor and/or screened too deeply will continue to have high sodium unrelated to tide heights in Herring River.
- Wells at least 150 feet from salt water bodies, and those screened close to the water table will continue to have good quality water.
- A network of deep wells is in place to monitor the fresh/salt groundwater interface adjacent to Herring River and Mill Creek.
- The groundwater aquifer is more resistant to salt penetration with the dike removed (or replaced with a less restrictive opening), than with the present dike fully open.