Summary of USGS Monitoring and Assessment Activities, Namskaket Marsh, Creek, and Adjacent Aquifer, Orleans, Mass.

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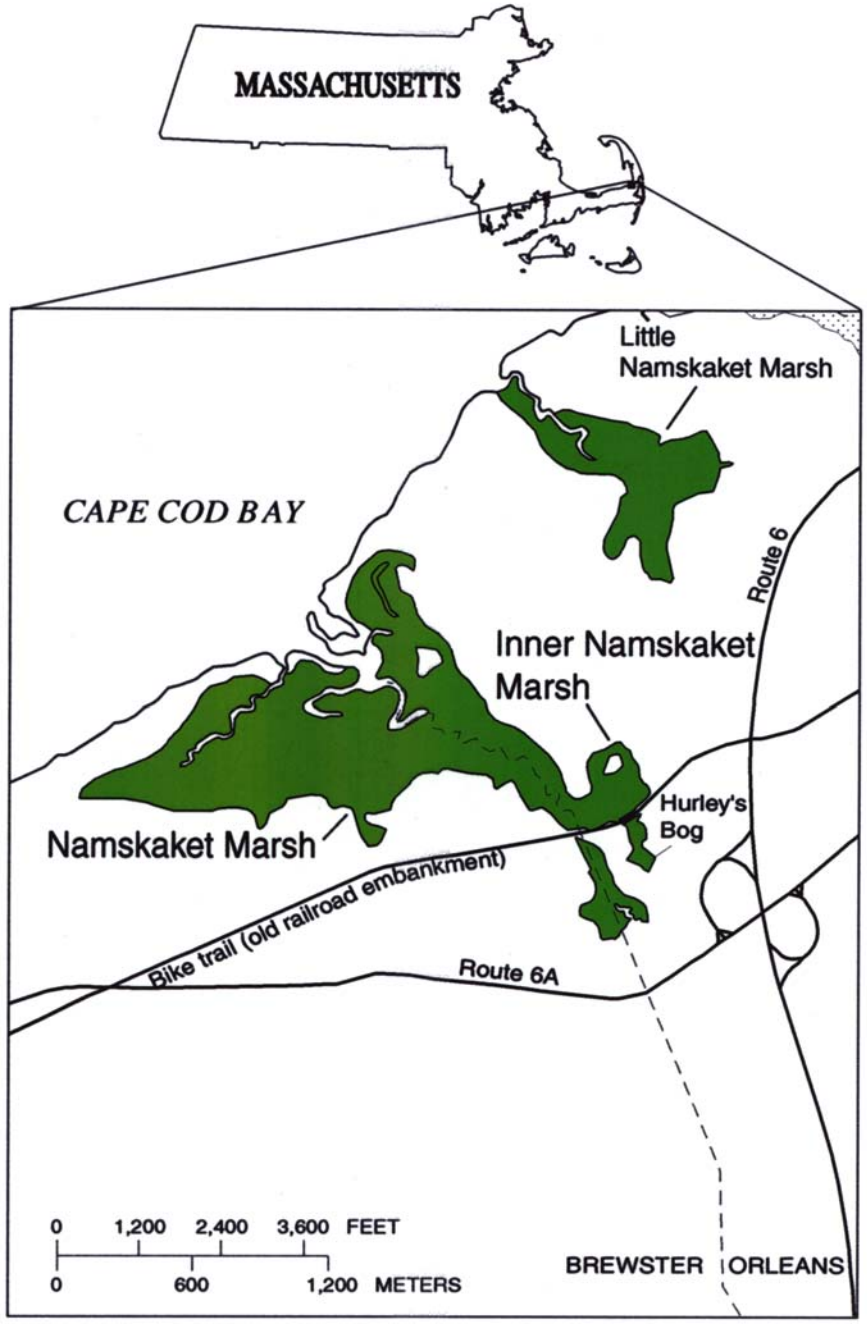

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Overview:

- USGS research activities at the site

- Last known location of the zone of nitrogen-enriched groundwater ("plume"); direction of movement

- Intervening silt/clay layer and effect on plume movement

- Potential for plume discharge ("breakout") and potential locations.

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USGS activities at the site:

- Hydrogeologic investigations, and tracking early development of the nitrogen plume (1989 – 1999).

- Baseline ecology, Namskaket Marsh (1994-96); baseline water quality Namskaket Creek (1993-95).

- Sampling of aquifer below marsh, to test for presence of elevated nitrogen (2003).

- Resumption of creek water-quality sampling, (2004: 2010 – present), check for elevated nitrogen in creek.

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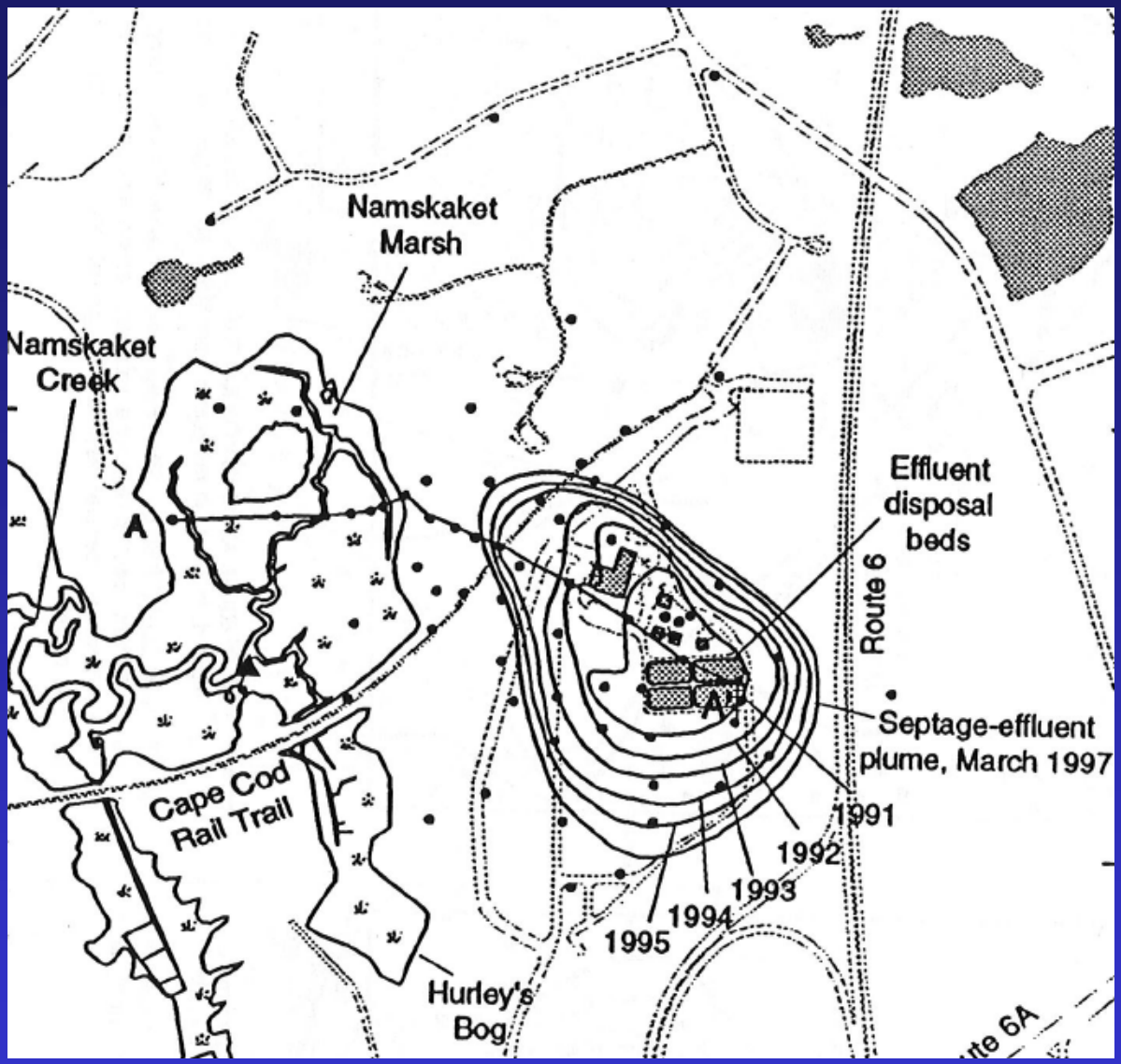
Namskaket Marsh:

Last known extent of entire plume, March 1997



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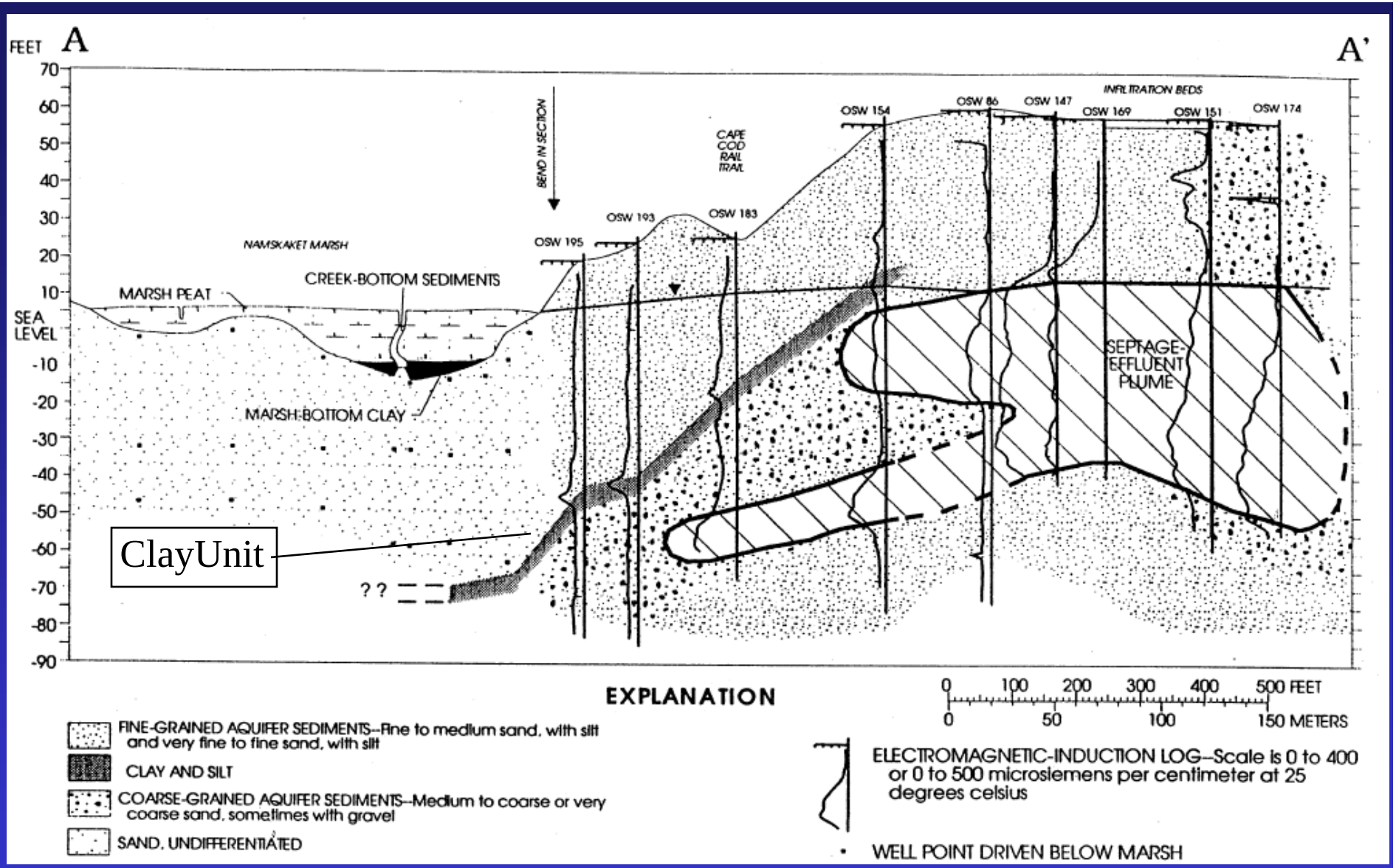
Weiskel and others, *Environment Cape Cod*, v. 1, no. 2, p. 17



Long Section A-A', showing plume and clay unit, 3-1997

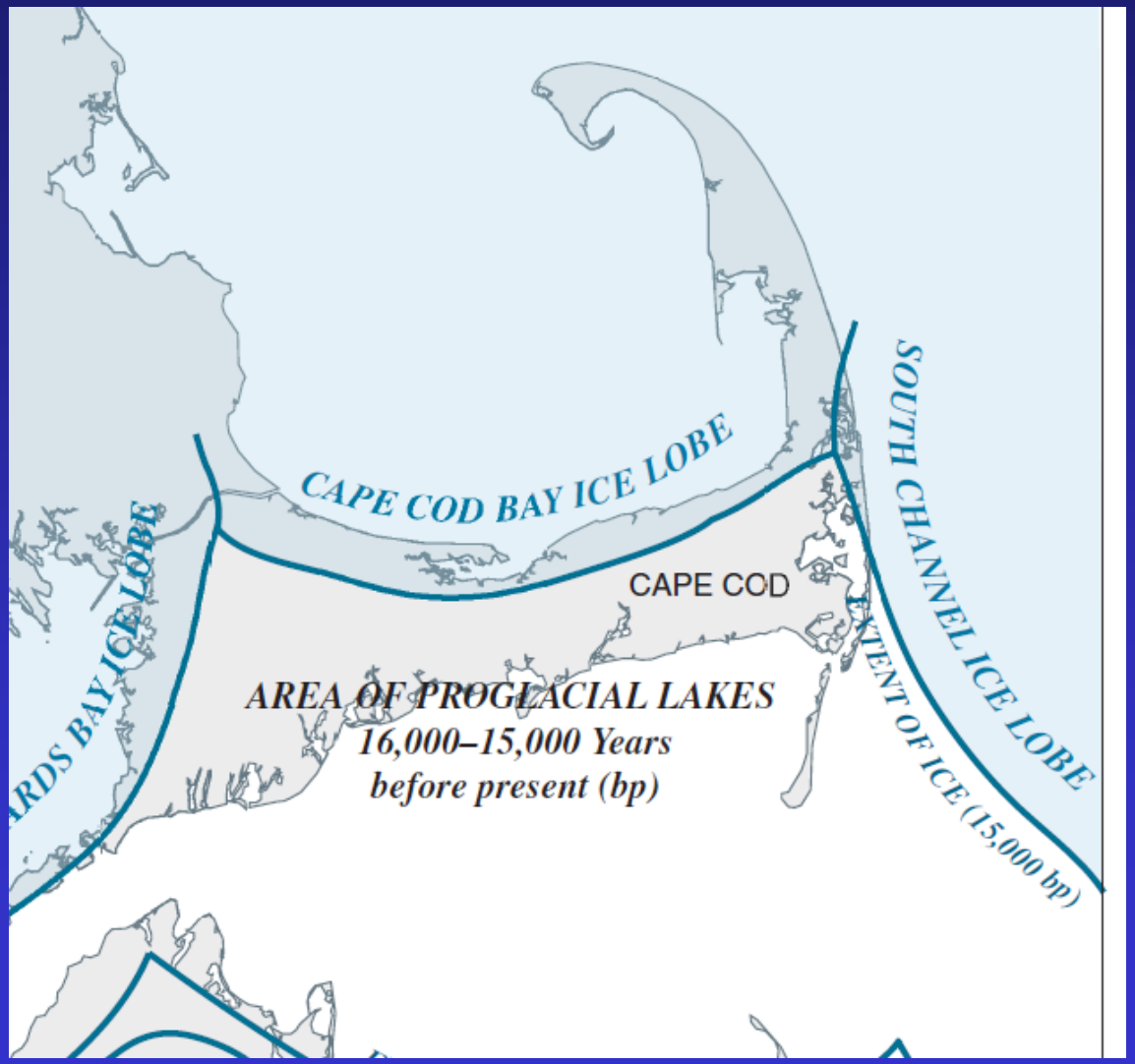
Weiskel and others, *Environment Cape Cod*, v. 1, no. 2, p. 19

Cape Cod, 16,000 – 15, 000 yrs ago:

- A large glacial lake formed in CC Bay after ice-lobe retreat

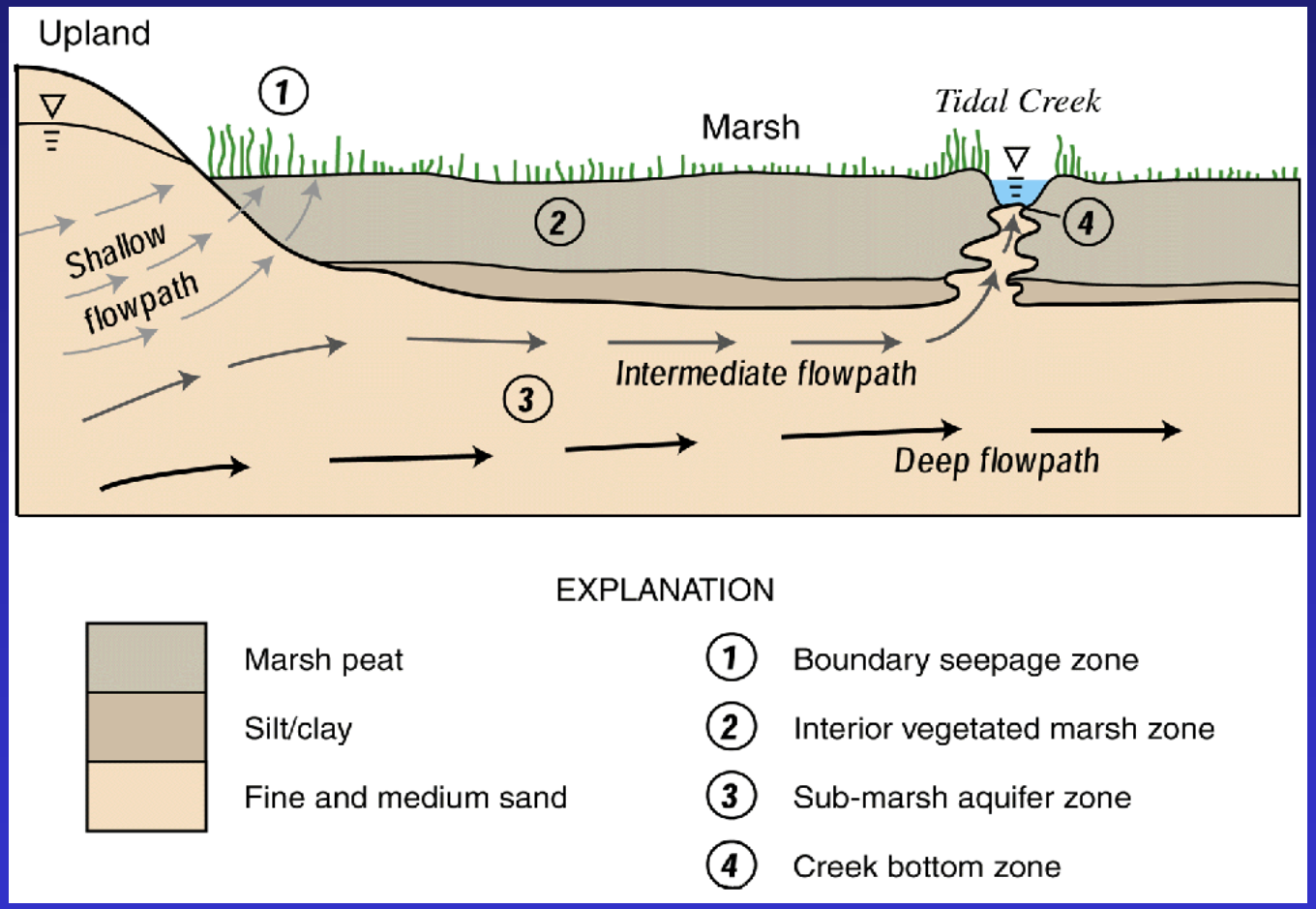
- A silt/clay layer was laid down in this lake, when sea level was 200 - 300 ft lower.

- Could act as confining unit for main body of the Orleans plume.



Each groundwater flow path (shallow, intermediate, deep) has an associated groundwater discharge zone:

- Boundary zone
- Vegetated marsh surface
- Creek zone
- Downgradient receptors (e.g., Little Namskaket Marsh, Cape Cod Bay)



Schematic marsh cross section

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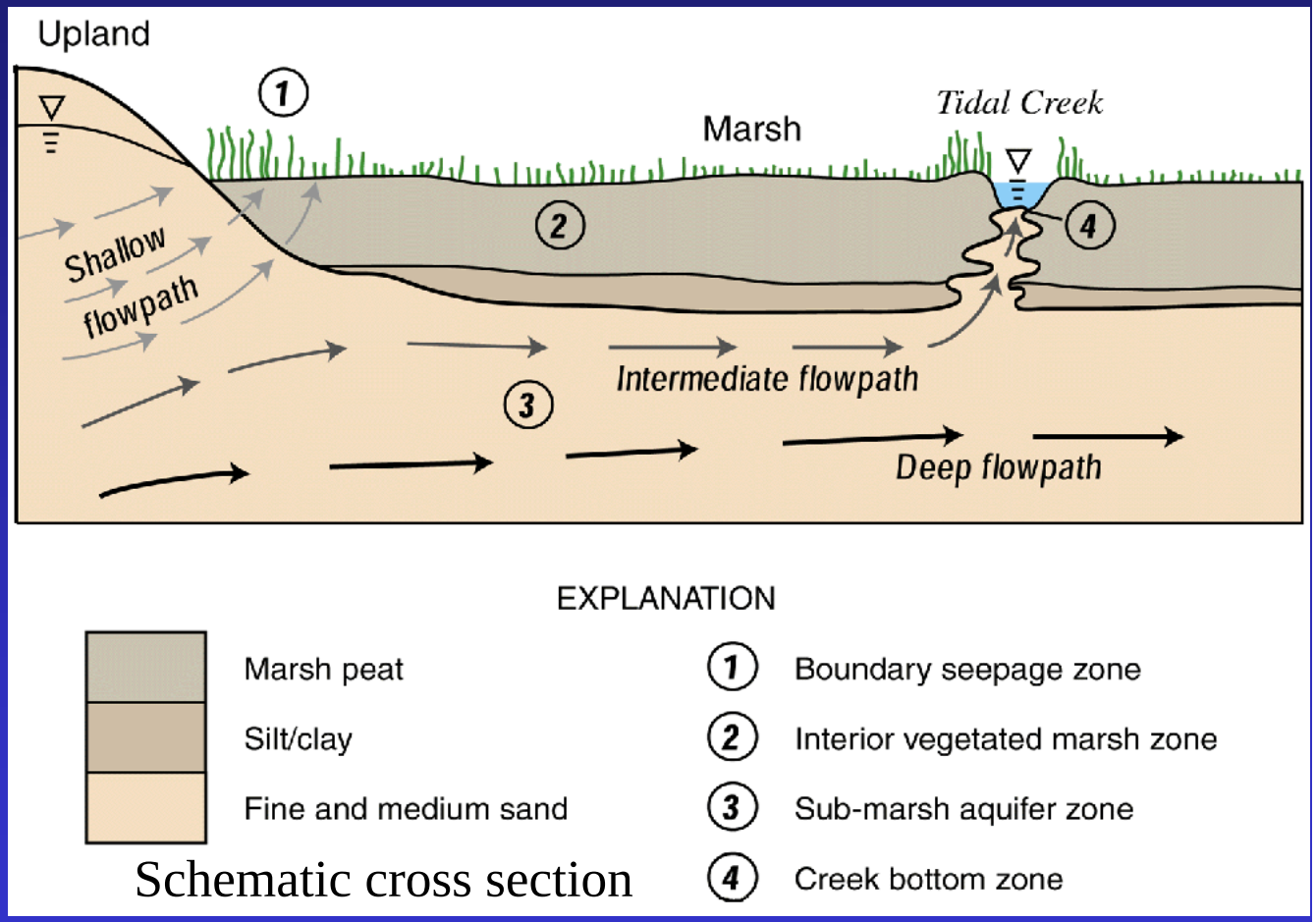
Likelihood of plume discharge to various zones

- Boundary zone (unlikely; even shallow portion of plume is too deep)
- Vegetated marsh (unlikely; impervious basal marsh clay).
- Creek zone (well point sampling needed to determine)
- Downgradient receptors (additional wells needed to determine)



Schematic cross section

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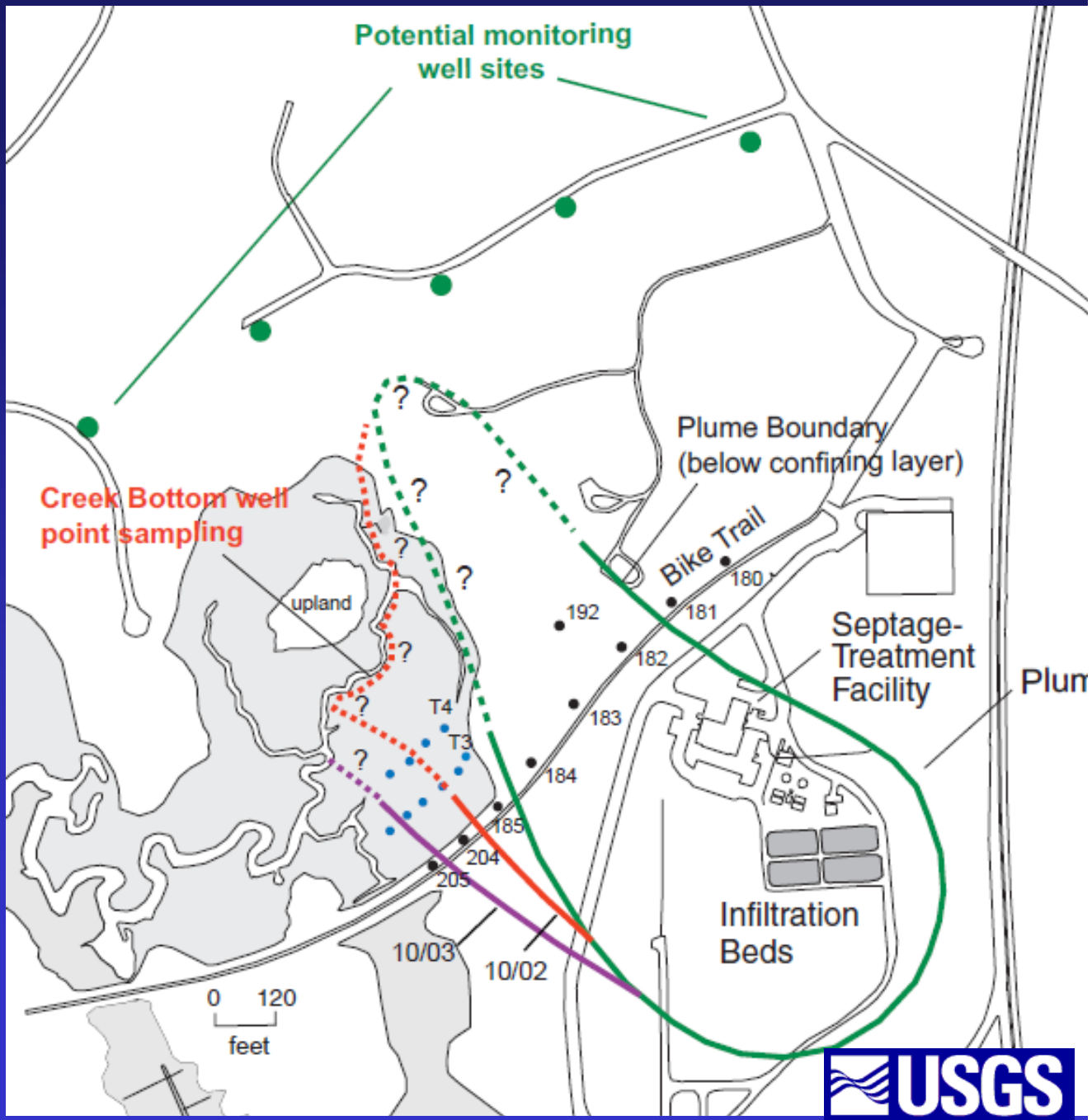
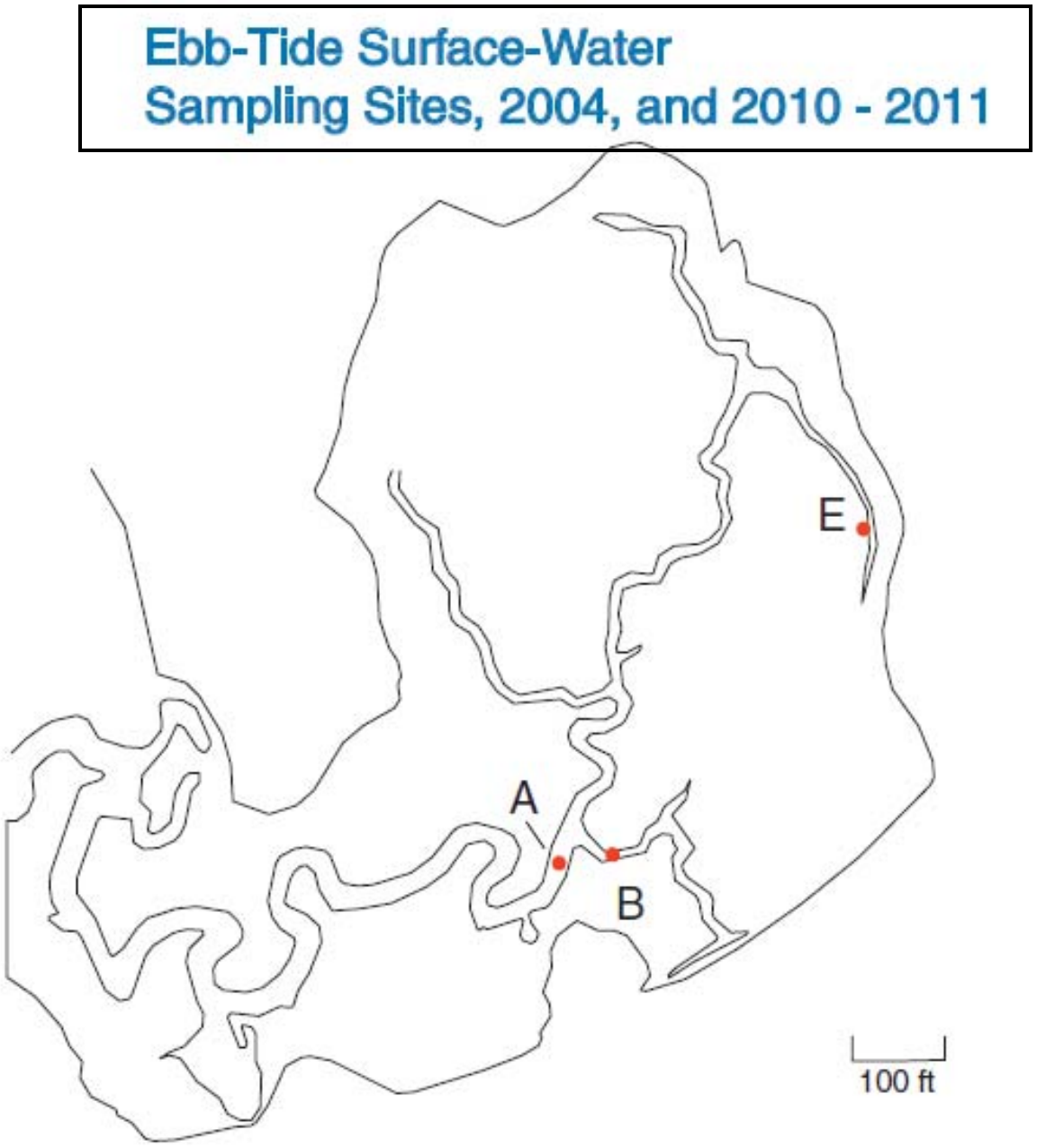
Potential future monitoring sites

- Creek bottom discharge zone (well- point sampling needed to determine extent)
- Downgradient receptors (more monitoring wells needed to determine downgradient extent of plume over time)



Potential Long-term monitoring

- Creek zone discharge (Surface-water sampling, at low tide to detect any increases of nitrogen above the 1990s creek baseline concerntration)



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Namskaket Creek, Site A

Sept-Oct 2010 data…

Compared to Sept-Oct baseline (1993 – 1996)…

Fall 2010 concentrations are within 1990s baseline.