1. Introduction
Salt marsh groundwater dynamics provide important controls for:

- submarine groundwater discharge and associated solute fluxes
- the subsurface distribution of solutes
- porewater redox states.

In the southeastern United States, areas of acute marsh dieback developed coincident with a period of severe drought in 2001-2002, suggesting a link to hydrology. Acute marsh dieback is defined by its rapid development and sharp boundaries between dead plants and healthy marsh, further suggesting geologic and structural differences between dieback and unaffected marsh sites.

2. Hypotheses
This experiment was designed to test the following hypotheses:

- Stratigraphy below the dieback site is variable and affects groundwater flow dynamics and discharge locations.
- The dieback site elevation is lower than the surrounding marsh.
- There were unusual mean sea level changes coincident with the drought years of 2001-2002.

3. Study Site
North Inlet-Winyah Bay NERR

- Semi-diurnal tide, average amplitude 1.4 m
- Low marsh populated primarily by medium and tall form Spartina alterniflora

Fig. 1a: Map of the North Inlet-Winyah Bay National Estuarine Research Reserve with dieback sites as red dot and star.

Fig. 1b: Satellite image of study site showing location of piezometer nests. The dieback area is within the circle.

4. Stratigraphy

- Fig. 2a and 2b: Stratigraphic sections of the north-south and east-west transects. Red blocks indicate locations and lengths of piezometer screened intervals. Sand layer is highlighted in tan.

- Fig. 3a: Hydraulic head record from nest EW1, showing vertical gradient indicating downward flow. The red circle highlights one of the 24-hour periods during which the marsh was not inundated. Fig. 3b: Tide record corresponding to Fig. 3a. NOTE: the vertical hydraulic gradient increases during extreme low tides.

- Figs. 4a and 4b: Hydraulic head record at nests NS2 and EW4. The lack of vertical gradient at NS2 indicates stagnant flow conditions, and the vertical gradient at EW4 is greater than EW1 as a result of the increased thickness of sand.

5. Elevation Differences

LIDAR data collected 2003 (J. T. Morris)

Fig. 5: The lowest elevation is indicated by the dark blue color. Colors change with increasing elevation from dark blue, light blue, green, yellow, orange, to red. The study site is circled and shows no difference in elevation from the surrounding marsh.

6. Mean Sea Level

NOAA Tide Data, Charleston, SC (8665530)

Fig. 6: January 2002 monthly mean sea level was lowest since 1990 (NOAA), coincident with the drought. The tide record from the Charleston, SC gauge correlates to Oyster Landing (North Inlet) with an average r = 0.8.

7. Exploratory Model

USGS SUTRA Model (Voss, 1984)

Fig. 7: Snapshot at low tide from exploratory model results. Note that the vertical gradient in hydraulic head is greater on the east side of the marsh—corresponding well to field data.

8. Conclusions

Variable Stratigraphy

Hydraulic gradient is greatest on the eastern marsh edge corresponding to thicker sands at that location

Marsh Surface Elevation

Site elevation is not lower than the surrounding marsh

Tidal Influence

Approximately 5% of tidal record \( \rightarrow \) no inundation

Drainage is enhanced at low tide extremes

Monthly mean sea level in January 2002 lowest since 1990, coincident with drought period

Exploratory 2-D Model

Preliminary hydraulic gradient variability corresponds well to field data

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