

1. Identification Information

1.1 Citation

8. Citation Information

8.1 Originator: Belle W. Baruch Institute for Marine Biology and Coastal Research

8.1 Originator: Department of Geology, University of South Carolina

8.1 Originator: Leonard Robert Gardner

8.1 Originator: Howard W. Reeves

8.2 Publication Date: 20020620

8.4 Title: Groundwater Dynamics along Forest-Marsh-Tidal Creek Transects in North Inlet Estuary, South Carolina: 1994-1996

8.8 Publication Information:

8.8.1 Publication Place: Belle W. Baruch Marine Field Laboratory, Georgetown, South Carolina, USA

8.8.2 Publisher: Belle W. Baruch Institute for Marine Biology and Coastal Research, University of South Carolina

8.9 Other Citation Details:

Gardner, L.R. and H.W. Reeves, 2002. Spatial patterns in soil water fluxes along a forest-marsh transect in the southeastern United States. *Aquatic Sciences* 64:141-155.

Gardner, L.R. and H.W. Reeves, 2002. Seasonal patterns in the soil water balance of a *Spartina* marsh site at North Inlet, South Carolina, USA. *Wetlands* 22:467-477.

Gardner, L.R., H.W. Reeves, and P.M. Thibodeau, 2002. Groundwater dynamics along forest-marsh transects in a southeastern salt marsh, USA: Description, interpretation and challenges for numerical modeling. *Wetlands Ecology and Management*.

Gardner, L.R. and D.E. Porter, 2001. Stratigraphy and geologic history of a southeastern salt marsh basin, North Inlet, South Carolina, USA. *Wetlands Ecology and Management* 93:371-385.

Thibodeau, P.M., L.R. Gardner, and H.W. Reeves, 1998. The role of groundwater flow in controlling the spatial distribution of soil salinity and rooted macrophytes in a southeastern salt marsh, USA. *Mangroves and Salt Marshes* 2:1-13.

Keenan, R., J. Dickerson, L.R. Gardner, and H.W. Reeves, 1996. Inexpensive electronic water level recorders for hydrologic studies. *Ground Water Monitoring and Remediation (Spring)*, 77-83.

Thibodeau, P.M., 1997. Groundwater Dynamics Across the Forest-Marsh Interface, North Inlet, South Carolina. Ph.D. Dissertation, Department of Geological Sciences, The University of South Carolina, Columbia, SC, 278pp.

Wojcik, R. M., 1998. Soil Water Balances Along a Forest-Marsh Transect at North Inlet (SC). MS Thesis, Department of Geological Sciences, The University of South Carolina, Columbia, SC, 155pp.

Keenan, R.S., 1994. An Investigation of the Dynamics of Groundwater Flow and Salinity Distribution Along a Forest-Salt Marsh Transect. M.S. Thesis, Department of Geological Sciences, The University of South Carolina, Columbia, SC, 238pp.

8.10 Online linkage: <http://links.baruch.sc.edu/data/>

1.2.1 Abstract:

Ground water level elevations were collected every 10 to 15 days from piezometers stationed along three forest-marsh-tidal creek transects (B, C, and D) across the Crabhaul Creek basin in the North Inlet Estuary, Georgetown County, SC. At each station, a nest of three to five piezometers were installed at nominal depths (see Sections 2.1.1) of 0.6 (2ft), 1.2 (4ft), 2.4 (8ft), 3.6 (12ft) and 4.8 (16ft) meters. In all, there are 305 piezometers distributed over 73 stations. Transect B, at the head of Crabhaul Creek and the most southerly transect, is 147 meters long and has 18 nested piezometer stations while Transect D, the most northerly and seaward (closest to field lab), is 260 meters long and has 29 nested piezometer stations. In addition, a tide gauge was installed on Transect D in the channel of Crabhaul Creek at a distance of 93.6 meters (309 ft) from the northwest end of the transect. The intermediate transect, C, is 264 meters long and has 26 nested piezometer stations. The separation between nested piezometer stations along a transect ranged from 2.0 meters in the tidal channel to 37 meters in areas of little topographic and botanical variation. Near the forest-marsh boundary, where variations in both topography and botany are great, stations were spaced at 6.0 meter intervals. Data collection began March 16, 1994 and ceased May 2, 1996. Depending on the particular data logger in use, readings were taken at 10 to 15 minute intervals, but later all readings were interpolated to 15 minute intervals. In all, the total number of water-level measurements is on the

order of 5,000,000 but these are not uniformly distributed over time or space due to the limited number of data loggers available (typically 20 four-channel instruments) and other logistical problems.

1.2.2 Purpose:

These data were collected in order to determine how groundwater flow from forest to marsh to tidal creek is governed by tides, rainfall, evapotranspiration and long-term sea-level rise and how these factors in turn affect groundwater salinity and botanical zonation.

1.2.3. Supplemental Information:

Water level data have not been corrected for an update in the elevation of the Geodetic Survey benchmark used to the elevations of the piezometer stations. Therefore, we recommend that users **subtract 40 cm** from all of the water level data presented here before publishing any results based on them. (See Field Methodology for more information)

Ancillary data collected along the transects include field data collection notes, station elevations, botanical zonation, hydraulic conductivities (determined by slug tests in most of the piezometers), and groundwater salinity (at roughly bimonthly intervals). Other ancillary data include profiles of near surface salinity in the upper 60 cm of the soil. These were determined using pore water equilibrators on an irregular basis at selected stations only along transect D. Some of the ancillary data were collected before and after the study period specified for the water level data. The ancillary data are documented in this metadata file and are also available with the primary water level data.

Meteorological and tide data (in addition to that collected on Transect D) can also be obtained from monitoring stations located at Oyster Creek Landing about one kilometer north of the transects. For meteorological and tide data taken during the time period of this study, see Baruch's Long Term Ecological Research Meteorological with Water Parameters (LTERMET) database (1982-1996), located at <http://links.baruch.sc.edu/data/>. For additional tide data beginning in 1996, see the Oyster Landing portion of the North Inlet - Winyah Bay National Estuarine Research Reserve's Water Quality database, located at <http://cdmo.baruch.sc.edu> (follow the System-Wide Monitoring Program link).

Other relevant ancillary data that were taken at the B, C, and D transects but are not part of this database:

To study the stratigraphy of the site, vibracores were taken along each transect at approximately 30 meter intervals (Appendix I in Thibodeau, 1997). Aluminum irrigation pipe (5.0 cm diameter in 6.1 meter lengths) was attached to a modified concrete vibrator. The barrels were vibrated into the ground until refusal or to a maximum depth of 4.9 meters. Compaction was determined by dropping a lead line down the core barrel prior to recovery and calculating the difference between the ground level outside the barrel and the sediment surface inside the barrel. The barrels were then filled to the rim with water, plugged to provide suction, and recovered using a tripod and "comalong" assembly. Cores were sectioned into one-meter lengths and then split along the long axis using a circular saw. Lithologic descriptions based on dominant grain size, sorting, and the occurrence of organic materials and burrows were logged (Appendix I in Thibodeau, 1997).

Soil cores (30 cm length) taken along transect D also provide data on porosity, specific yield and vertical hydraulic conductivity (via falling head permeameter measurements) for the near surface soil. These data are not available with this water level data and its ancillary data, but can be found in Table 1 in Wojcik (1998).

Additional water level data were collected from a fourth transect (Transect A) located further inland, but are not part of this database. These data were collected by Tom Williams of Clemson University's Belle W. Baruch Institute of Coastal Ecology and Forest Science (Contact Telephone: (843) 546-1013, Contact Email Address: TMWLLMS@clemson.edu). Transect A is delineated in the aerial photograph supplied in the Ancillary Data subdirectory under PHOTOS. This dataset has not been published.

1.3 Time Period of Content:

9.3 Range of Dates/Times

9.3.1 Beginning Date: 19940316

9.3.3 Ending Date: 19960502

1.3.1 Currentness Reference

Ground Condition

1.4 Status:

1.4.1 Progress: Complete

1.4.2 Maintenance and update frequency: As needed

1.5 Spatial Domain

1.5.1 Description of Geographic Extent:

Landward end of Crab Haul Creek basin within the North Inlet Estuary System, Georgetown County, South Carolina, USA. Center of study area located at approximately 33.337 degrees North latitude and 79.204 degrees West longitude. Study transect begin and end locations are as follows (Transect A data are not part of this database):

Transect A: begin 33°18'59.3" North and 79°13'05.2" West
Transect A: end 33°18'58.3" North and 79°13'16.0" West
Transect B: begin 33°20'16.2" North and 79°12'22.1" West
Transect B: end 33°20'13.1" North and 79°12'17.0" West
Transect C: begin 33°20'25.6" North and 79°12'15.5" West
Transect C: end 33°20'17.3" North and 79°12'10.6" West
Transect D: begin 33°20'29.9" North and 79°12'06.7" West
Transect D: end 33°20'24.7" North and 79°11'59.5" West

The North Inlet Estuary lies east of the uplands of Hobcaw Barony (also known as the Belle W. Baruch Property). To the north of the Estuary is the Debordieu Colony Property.

1.5.2 Bounding Rectangle Coordinates:

1.5.2.1 West Bounding Coordinate: -79.192
1.5.2.2 East Bounding Coordinate: -79.167
1.5.2.3 North Bounding Coordinate: 33.350
1.5.2.4 South Bounding Coordinate: 33.327

1.6 Keywords

1.6.1 Theme

1.6.1.1 Theme Keyword Thesaurus: None
1.6.1.2 Theme Keyword: Water level
1.6.1.2 Theme Keyword: Tides
1.6.1.2 Theme Keyword: Ground Water
1.6.1.2 Theme Keyword: Coastal
1.6.1.2 Theme Keyword: Salinity
1.6.1.2 Theme Keyword: Botanical Zonation
1.6.1.2 Theme Keyword: Forest
1.6.1.2 Theme Keyword: Marsh
1.6.1.2 Theme Keyword: Estuary
1.6.1.2 Theme Keyword: Aquifer
1.6.1.2 Theme Keyword: Conductivity
1.6.1.2 Theme Keyword: Estuarine ground water level
1.6.1.2 Theme Keyword: Tide
1.6.1.2 Theme Keyword: Tidal Creek
1.6.1.2 Theme Keyword: Salinity
1.6.1.2 Theme Keyword: Saltmarsh
1.6.1.2 Theme Keyword: Elevation
1.6.1.2 Theme Keyword: Tide
1.6.1.2 Theme Keyword: Piezometer
1.6.1.2 Theme Keyword: Ground Water Salinity
1.6.1.2 Theme Keyword: Hydraulic Conductivity
1.6.1.2 Theme Keyword: Transects

1.6.2 Place

1.6.2.1 Place Keyword Thesaurus: None
1.6.2.2 Place Keyword: North Inlet
1.6.2.2 Place Keyword: North Inlet Estuary
1.6.2.2 Place Keyword: South Carolina
1.6.2.2 Place Keyword: Atlantic Coast
1.6.2.2 Place Keyword: Crabhaul Creek
1.6.2.2 Place Keyword: East Coast
1.6.2.2 Place Keyword: Southeast Coast
1.6.2.2 Place Keyword: Coastal
1.6.2.2 Place Keyword: Georgetown County

1.6.2.2 Place Keyword: USA

1.6.4 Temporal

1.6.4.1 Temporal Keyword Thesaurus:	None
1.6.4.2 Temporal Keyword:	1994
1.6.4.2 Temporal Keyword:	1995
1.6.4.2 Temporal Keyword:	1996
1.6.4.2 Temporal Keyword:	1994-1996
1.6.4.2 Temporal Keyword:	1990s
1.6.4.2 Temporal Keyword:	Quarter Hour
1.6.4.2 Temporal Keyword:	Day
1.6.4.2 Temporal Keyword:	Week
1.6.4.2 Temporal Keyword:	Month
1.6.4.2 Temporal Keyword:	Year

1.8 Access constraints: None; however, it is strongly recommended that these data be directly acquired from the Belle Baruch Institute for Marine Biology and Coastal Research and not indirectly through other sources which may have changed the data in some way.

1.9 Use constraints:

Following academic courtesy standards, the Principal Investigators (originators), the University of South Carolina's Belle W. Baruch Institute for Marine Biology and Coastal Research, and Grantor (see Data Set Credit) should be fully acknowledged in any subsequent publications in which any part of these data are used. Use of the data without completely reading and understanding the metadata is not recommended. The Baruch Institute, Baruch Institute researchers, and NSF are not responsible for the misuse of data from this database. See the section on Distribution Liability.

1.10 Point of Contact:

10.2 Contact Person Primary

10.2.2 Contact Person: Leonard Robert Gardner

10.2.1 Contact Organization: Univ. of South Carolina, Department of Geological Sciences

10.4 Contact Address

10.4.1 Address Type: Mailing Address and physical

10.4.2 Address: Department of Geological Sciences

10.4.2 Address: University of South Carolina

10.4.3 City: Columbia

10.4.4 State or Province: South Carolina

10.4.5 Postal Code: 29208

10.4.6 Country: USA

10.5 Contact Voice Telephone: 803-777-2424

10.8 Contact Electronic Mail Address: gardner@geol.sc.edu

1.12 Data Set Credit:

Funds for this study were provided under NSF grant EAR 9218972 and the Office of Sponsored Programs and Research at the University of South Carolina, with L.R. Gardner and H.W. Reeves as directors. John Dickerson designed the affordable instruments and provided the associated software that made this work possible. Rick Keenan, Jim Peace, Pete Thibodeau and John Stuart installed the piezometer network, assembled and calibrated the data loggers, ran the slug tests and obtained the vibracores used in this study. Bob Picard, Paul Kenney and Ken Hayes were largely responsible for downloading data in the field and maintaining the data loggers. Basker Mitra, Srikanth Adayapal, Christine Zoschke and Lara Jurachek processed the data logger data through the calibration, interpolation and graphics programs and archived the processed data on the USC mainframe computer. Mike Busby, John Seigle and many other students in Geology and Marine Science bailed the piezometers and measured salinity samples. Ginger Ogburn-Mathews, Melissa Ide and Dorothy Tudor helped with the archiving and documentation of this data.

1.13 Native Data Set Environment

Raw water level data files were read into a C++ program named CRD.EXE, which converted the uncalibrated pressure heads in the raw data into calibrated total heads (i.e. pressure plus elevation heads) in ASCII format. These files were then called .DAT files. Once the .DAT files were created, they were imported into PSI-PLOT (a data processing and graphics product of Poly Software International, Salt Lake City, Utah). PSI-PLOT was used to produce plots of heads versus time.

For the ancillary data (salinity, dip stick measurements, etc.) these were entered directly from field notes into EXCEL or PSI-PLOT spreadsheets or as WORDPERFECT or WORD documents.

1.14 Cross Reference:

8. Citation Information

8.1 Originator: Thomas M. Williams

8.1 Originator: Belle W. Baruch Forest Science Institute of Clemson University

8.2 Publication Date: 1979

8.4 Title: Freshwater Input to North Inlet

8.8.1 Publication Place: Georgetown, South Carolina USA

8.8.2 Publisher: Belle W. Baruch Forest Science Institute of Clemson University

2. Data Quality Information

2.1 Attribute Accuracy

2.1.1 Attribute Accuracy Report:

Where the depth to the basal mud was greater than 4.9 meters (16.2 ft), piezometers were installed at depths of 0.6 (2 ft), 1.2 (4 ft), 2.4 (8 ft), 3.6 (12 ft) and 4.8 (16 ft) meters. If, however, the basal mud happened to be at 4.7 meters, the deepest piezometer was installed at about 4.6 meters. Similar truncations occur at stations where the basal mud rises to depths of 3.6 or 2.4 meters. ***Thus in some water level data files the depth of the deepest piezometer may be a nominal depth and not the actual depth. Actual depths can be found in the file PZDEPTHS in the ancillary data subdirectory described in Section 5.2.1. See the Water Level Data Methodology Description Section for more information.***

All of the edited water level data presented herein are referenced to the 1987 listing of the Baruch 1932 benchmark at 3.0 meters. Later, the Geodetic Survey revised the elevation of this benchmark downward to an elevation of 2.6 meters. This revision has NOT been incorporated in the water level data presented here. ***Therefore we urge all users to subtract 40 cm from all of the water level data presented here before publishing any results based on them.***

We attempted to place each transducer at a depth that was likely to be lower than the lowest water level that might occur, but not so low that the highest water level would be above the range of the transducer. This objective was generally met, ***but there were occasional deployments when the water level may have fallen below the elevation of the transducer or rose above its upper limit.*** This “set depth” was recorded in the field notebook for use in later calculations. At insertion, a clamp was fastened around the transducer pipe in order to maintain the transducer at the desired set depth. ***Any error in the measurement or recording of the set depth or slippage of the clamp could be a source of error in the water level data.*** The clamp was also fitted with a skirt that was intended to deflect rainwater from running down the transducer pipe into the piezometer. ***In some cases the skirt was not entirely effective as was later revealed by the spiky behavior of water levels during heavy storms.***

Occasionally there was evidence of timing problems in that tidal signals and/or rain recharge events were not coincident with those present in other records from other nearby stations.

Once the data loggers were assembled they were tested and calibrated. Calibration consisted of submerging the pressure transducer to progressively greater depths (0 to 1.0 meters in increments of 5 cm, as the transducers have a full scale range of 0 to 1.45 psi) and recording the hexadecimal output of the A/D converter (00 to FF, as the A/D converter is an 8 bit processor) as a function of depth. The hexadecimal outputs were then converted to ordinary base-10 decimal numbers and these were then fitted to their corresponding depths by linear regression with depth the dependent (Y) variable. The correlation coefficients (R^2) for the regressions were almost always greater than 0.99 with Y intercepts typically between 120 and 140 cm (with standard errors of about 0.3 cm) and slopes between -0.600 and -0.680 cm (with standard errors of about 0.004 cm). ***Nevertheless, it should be noted that, if after calibration and during deployment, a transducer was mistakenly plugged into a channel to which it was not calibrated, erroneous data would result. If the slope of the mistakenly installed transducer was similar to that stored in the calibration file for the channel, but the intercept was significantly different, then the recorded relative changes in water level would be correct, but the absolute values would be in error by an amount equal to the difference in intercepts. Similarly erroneous data would result if the depth at which the pressure was set in the piezometer pipe was mismeasured or misrecorded. Evidence for such errors is present in some of the unedited data.***

2.1.2 Quantitative Attribute Accuracy Assessment

2.1.2.1 Attribute Accuracy Value

For Final Water Level dataset only:

<u>Variable</u>	<u>Number of Decimal Places</u>
Time (h.hh from start time)	2
Water Level (cm)	1

2.1.2.2 Attribute Accuracy Explanation

The attribute accuracy values above were based on the determined accuracy of the measurements. The number of decimal places published in the final database is meant to best represent the precision and accuracy of the data.

Time: The time values were interpolated to 15-minute increments and are reported as quarter (.25) hours. Thus the values are accurate to the 100th place.

Water Level: The water levels are accurate to the 10th place as the pressure transducers have a full scale range of about 100cm which is divided into 256 intervals by the A/D converter on the data logger.

2.2 Logical Consistency Report

Not applicable

2.3 Completeness Report:

Some gaps in water level data are due to battery power failure to the memory chip. If power failure occurred, the data stored on the memory chip is lost.

Missing Data:

Missing data occur in the following Water Level files at the following times and depths. In the converted raw .DAT files, missing data were denoted by either an empty cell, "1.0", or "1.nan". These values were all replaced with a common missing data marker "." in the final published data files.

BHEADDATA

APR1196.B170.B490411E: 19951.75 @ 12ft
NOV0595.B130.B431105E: 16079.25 @ 16ft
DEC1795.B316.B461217E: 17167.5 – 17169.75 @ 12ft

CHEADDATA

DEC2194.C330.C471221E: 8293.00 – 8305.00 @ 12ft
8314.50 – 8410.00 @ 12ft
JAN1796.C756.C250117E: 17915.75 @ 12ft
JUN1095.C716.C080610E: 12391.50 – 12427.75 @ 12ft
MAR2996.C636.C560329E: 19408.00 – 19527.00 @ 8ft
OCT1994.C523.C511019E: 6849.25 – 6992.25 @ 2ft, 4ft, and 8ft

DHEADDATA

APR2294.D309.D700422E: 2675.50 @ 2ft
AUG0794.D309.DTG0807E: 5244.00 @ 2ft
AUG0794.D294.D070807E: 5124.00 @ 8ft
JUL1394.D294.D070713E: 4565.25 @ 8ft

Missing data that occur in the ancillary data files can be found in the appropriate ancillary data subdirectory in both .DOC and .TXT formats.

Anomalous Data:

Anomalous data occurred in the following Water Level files, at the following times and depths. These data remain in the .DAT files, but were determined to be erroneous and replaced with a missing data marker "." in the final published data files.

DHEADDATA

MAY3195.D794.D440531E: 12153.25 – 12366.50 @ 12ft
JUN0294.D300.D100602E: 3469.50 – 3650.00 @ 4ft
JUN1095.D794.D440610E: 12367.00 – 13113.75 @ 12ft
JUL0195.D794.D440701E: 12897.50 – 13113.75 @ 12ft

All tide gauge data from station D309 taken after November 30, 1994 were determined to be erroneous, removed, and replaced with missing data markers “.”. The erroneous data were contained in the following water level files (which still contain valid water level data for the piezometers at this station):

DHEADDATA

APR0295.D309.D700402E
APR1495.D309.D700414E
DEC0994.D309.D701209E
FEB0795.D309.D700207E
FEB1995.D309.D700219E
JAN0395.D309.D700103E
JAN1695.D309.D700116E
JAN2695.D309.D700126E
MAR0395.D309.D700303E
MAR1295.D309.D700312E
MAR2395.D309.D700323E
MAY0695.D309.D700506E

All data in the following station D150 files were determined to be erroneous and the entire files were removed from the final dataset.

DHEADDATA

MAR0395.D150.D080102E
MAR1295.D150.D080312E
MAY0695.D150.D080506E

No anomalous data were identified in the ancillary data sets.

2.5 Lineage

2.5.1 Methodology

2.5.1.1 Methodology Type: Field Collection Procedures and Protocols of Primary Water Level Data

2.5.1.3 Methodology Description:

A total of 305 piezometers were installed along transects B, C and D during July and August of 1993 and were distributed at depths of 0.6 to 4.8 meters in nests of three to five piezometers. Transect B, at the head of Crabhaul Creek and the most landward transect, is 147 meters long and has 18 nested piezometer stations while Transect D, the most seaward, is 260 meters long and has 29 nested piezometer stations. The intermediate transect, C, is 264 meters long and has 26 nested piezometer stations. The number and maximum depth of piezometers at a given station was limited by the depth to the basal mud that underlies the surficial aquifer along the transects (Gardner and Porter, 2001; Thibodeau, 1997). Nests along the transects were spaced at intervals of two to 37 meters with closer spacing in areas of steep topographic or botanical gradients. Individual piezometers are identified according to their transect station and depth so that, for example D170-2 is located on transect D, at a station located 170 feet southeast of the transect origin and at a depth of 2 feet (0.6 meters) below the ground surface. Where the depth to the basal mud was greater than 4.9 meters piezometers were installed at depths of 0.6 (2ft), 1.2 (4ft), 2.4 (8ft), 3.6 (12ft) and 4.8 (16ft) meters. If, however, the basal mud happened to be at 4.7 meters the deepest piezometer would be installed at about 4.6 meters. Similar truncations occur at stations where the basal mud rises to depths of 3.6 or 2.4 meters, as at station D309 where the deepest piezometer is at a depth of 5 feet. (At this station there is also a tide gauge with its pressure transducer resting on the bed of the tidal channel at a depth equal to zero). ***Thus in some data files the depth of the deepest piezometer may be a nominal depth and not the actual depth.*** Nominal piezometer depths in the final data set are reported in feet.

Piezometers were constructed from 1.5-inch inner diameter PVC pipe which could accommodate 1.25 inch outer diameter bailers and pressure transducer housings. The bottom of each piezometer pipe was capped. Holes (0.62 cm diameter) were drilled into the wall of the pipe just above the cap along the lowermost 7.6 cm portion of the pipe (or lowermost 15.2 cm for piezometers installed at depths greater than 1.5 meters) to give 28 (or 56) cm² of drill hole area in the lowermost part of the pipe. Six wraps of fiberglass house screen were wound around the open interval to prevent flow of sand into the pipe.

Three techniques were employed to install the piezometers. For shallow piezometers a combination of post-hole digging and auguring was used to create a hole of sufficient depth. Deeper excavations required a casing to prevent sidewall collapse. Casings consisted of 10 cm diameter by 300 cm lengths of PVC pipe. The casing was hammered into the ground when auguring became impractical. Repeated hammering and auguring through the casing proved successful to depths of

about three meters, at which point the flow of sand or casing refusal forced the use of jetting. Casings were jetted down using a gasoline pump, fire hose and water from the tidal creek or nearby ditches. Water flow was estimated at 230 liters per minute, and most of the water returned to the surface through the top of the casing along with suspended sediments.

Commonly two piezometer pipes were inserted into a single auger or jet hole. Usually the 1.2 and 3.6 meter piezometers were paired, as were the 2.4 and 4.8 meter piezometers. Natural backfill was allowed to collapse around the piezometers as the casing was withdrawn. Paired piezometers were separated by bentonite clay or cement grout placed midway between their screened openings to prevent preferential vertical flow along the pipes.

After installation of the piezometers the elevations of all of the piezometer stations were surveyed with a TopCon Total Station using as a reference the National Geodetic Survey benchmark near the intersection of Clambank and Marsh Roads (Name = Baruch 1932, QIDQSN = 330792130009, LAT = 33 20 13.17364N, LONG = 079 12 25.58697W). In March of 1987 the elevation of this benchmark was listed at 3.0 meters above mean sea level. Using this as a reference elevation, all of the piezometers (except those at station B000) were trimmed to a common rim elevation of 8.0 feet (243.8 cm) in the expectation that this would be high enough to prevent flooding by even the highest spring tides (typically seven feet above mean low water) but not be too high to prevent extraction of water samples for chemical analysis. **[At station B000 the ground elevation (241.2 cm) is almost as high as the standard rim elevation so the rims at this station were trimmed at an elevation 25 cm higher than the ground elevation, that is at 266 cm.]** All of the edited water level data presented herein are referenced to the 1987 listing of the Baruch 1932 benchmark at 3.0 meters. Later, after much of the data had been processed and archived on the USC mainframe computer, it was discovered that the Geodetic Survey had revised the elevation of this benchmark downward to an elevation of 2.6 meters. This revision has **NOT** been incorporated in the water level data presented here. ***Therefore we recommend that users subtract 40 cm from all of the water level data presented here before publishing any results based on them.***

After trimming the rims of all of the piezometers (except at B000) to 243.8 cm, they were flushed and cleaned by extracting 240 liters of water from each nest using a small gasoline pump. Extractions were continued in 60-liter increments until the measured salinity reached repeatable values.

After flushing the piezometers, some of them were equipped with data loggers and pressure transducers, which from time to time were redeployed to other piezometers so that eventually all of the piezometers were monitored for at least several weeks, and in some cases nearly a year. The data loggers are described in Keenan et al. (1996). They consist of a circuit board designed by Dr. John Dickerson (USC Dept. of Civil Engineering) on which is housed a Motorola MC68HC11 microprocessor, a Motorola MC601256AP 32K RAM memory chip and associated switches and timers. Although the circuit board and microprocessor can handle inputs from up to seven sensors we used only four channels because of the limited memory (32K) that was available. Between each pressure transducer and the circuit board an amplifier circuit was assembled in order to boost the 0 to 250 millivolt signal from the transducer (Motorola MPX2010D series transducers) to the 5.0 volt full-scale range required by the analog-to-digital converter on board the microprocessor. Each pressure transducer was housed in a rubber stopper inserted into the bottom of a 1.25 inch outer diameter PVC pipe and connected to the data logger by a 20 foot length of shielded four-conductor cable. Prior to inserting the pressure transducer pipe into the piezometer pipe, a manual measurement was made of the distance between the rim of the piezometer pipe and the ambient water level in order to estimate how far below the rim to position the pressure transducer. The objective was to place the transducer at a depth that was likely to be lower than the lowest water level that might occur but not so low that the highest water level would be above the range of the transducer. This objective was generally met ***but there were occasional deployments when the water level may have fallen below the elevation of the transducer or rose above its upper limit.*** The depth thus selected (i.e. the "set depth") was recorded in the field notebook for use in later calculations. At insertion, a clamp was fastened around the transducer pipe in order to maintain the transducer at the desired set depth. ***Any error in the measurement or recording of the set depth or slippage of the clamp could be a source of error in the water level data.*** The clamp was also fitted with a skirt that was intended to deflect rainwater from running down the transducer pipe into the piezometer. ***In some cases the skirt was not entirely effective as was later revealed by the spiky behavior of water levels during heavy storms.***

The data loggers were housed in plastic project boxes, which in turn were placed in wooden field boxes atop four to five foot tall pilings along with 6 volt, 9 amp-hour batteries. One battery can power the transducers and data logger for about two weeks. ***Because data stored on the memory chip is lost if the power fails, some of the gaps in the water level data are due to battery failures.***

Prior to deployment an Assembler language data acquisition program (4CHAN.IRQ) was loaded into the nonvolatile memory of each microprocessor. This program counts the number of square wave signals that have been generated by the timing circuit and, if this number exceeds a pre-selected number, it instructs the data logger to read the inputs from the four data channels and store the results as hexadecimal numbers on the memory chip along with a running tally of the number of

observations that have been collected up to the present time. It then resets the square wave count to zero and waits until the square wave count again reaches the pre-selected value before taking the next observation. It should be noted that the actual time of each observation is not stored in the memory but only the cumulative number of observations. To the extent that the capacitors and resistors that make up the square wave timing circuit remain stable, the interval between observations should be constant so that the time of each observation can be calculated later from the known starting and ending times of the deployment and the total number of observations taken. The calculated interval can also be compared to the square wave frequency, which can be measured with a volt meter and stop watch. Usually these closely agree **but occasionally there is evidence of timing problems in that tidal signals and/or rain recharge events are not coincident with those present in numerous records from other nearby stations.**

The tide gauge installed at station D309 consisted simply of a vertically oriented PVC pipe with a pressure transducer mounted at the bottom just above the creek bed, that is at a set depth equal to zero. Piezometer pipes were also installed at this station at depths of 2, 4, and 5 feet below the bed of the creek.

2.5.1 Methodology

2.5.1.1 Methodology Type: Field Collection Procedures and Protocols of Ancillary Data

2.5.1.3 Methodology Description:

Field notes/histories of datalogger deployments:

These data document the deployment history of data loggers along transect B, C, and D across the Crabhaul Creek basin. (Data file names: BHISTORY, CHISTORY, and DHISTORY). Each field entry consists of 6 or 7 lines. The first line indicates the instrument box number, transect and station location in feet from the beginning of each transect. The second line documents the datalogger start time (military clock) and date, and the third line the end time and date. The fourth line gives the number of observations taken during the deployment, which can be used to calculate the date and time of each observation. The fifth and sixth lines give the nominal depths of the piezometers assigned to each channel. One observation consists of reading the data on each channel. Any additional lines in an entry are remarks. No guarantee is given that the information in this file is complete or entirely accurate nor is it to be assumed that every entry in the file yielded head data that could be calibrated, edited and archived. Refer to Masters thesis by R. Keenan (1994).

Station Elevations (Topographic Survey) Data:

Topographic survey data for transects B, C, and D were collected by R. Keenan in 1993 and R. Wojcak and M. Busby in 1996 (Data file named TOPODATA). The 1993 survey was conducted using a TopCon total station and prism reflector while the 1996 survey was conducted using a leveling telescope. Because of Keenan's greater experience in surveying and the more precise instrumentation used in the 1993 survey, the Keenan data is probably more accurate than the Busby data. However the Busby data was used in the rim elevation releveing survey presented in files PZELEVB.XLS, PZELEVC.XLS and PZELEVD.XLS in the LEVELS subdirectory. The 1993 data are referenced relative to the BARUCH1932 geodetic benchmark near the intersection of Marsh and Clambank Roads. The most recent published elevation for this benchmark is 2.60 meters above mean sea level. The 1996 data are referenced to an arbitrary temporary benchmark which, based on regression of the 1996 data against the 1993 data, appears to be 37 cm higher than the BARUCH 1932 benchmark. The regression equation relating the two data sets is:

$$Y=1.029*X+37.4$$

where X is the 1993 station elevations and Y is the 1996 elevations. The correlation coefficient is 0.981.

Dip Stick Measurements:

In order to supplement the instrumental water level measurements manual measurements of the depth to water in the piezometers were taken on a roughly bimonthly schedule between 1994 and 1996 and biannually thereafter until 2001 (Data files called BDIPSTICK, CDIPSTICK, and DDIPSTICK). The "dip stick" consisted of a graduated piece of PVC pipe with two wires protruding from holes in a rubber stopper at the bottom end of the pipe. The wires were connected to a battery and a buzzer, which sounded whenever the wires were shorted by immersion in water. ***Note that these measurements are depths to water below the piezometer rims and are NOT water elevations.*** Piezometers that happened to be instrumented with data loggers at any given time were not measured with the dipstick. Most dipstick measurements were taken during times of falling tide, ***so are biased towards times of low water.***

Salinity Measurements from piezometers:

Salinities were measured on samples collected from most of the piezometers along the transects (data files called BPZSALINITY, CPZSALINITY, and DPZSALINITY). Following dip stick measurements, the piezometers were bailed at least three times to flush out any stale water that might reside in the pipes. Approximately three well volumes were removed before a sample was taken. Sample bottles were returned to the lab and stored in an upright position for several days to allow any suspended sediment in the water to settle. Then several drops of water were removed from the bottle and placed on an optical refractometer that was stored at the same temperature as the samples. The precision of the refractometer readings is about 2 ppt. The refractometer was checked occasionally with standard seawater and found to be accurate to within the limits of the precision. Between collections caps were placed over the piezometers to inhibit the entry of rainwater but they were not general effective as they were commonly knocked off by strong winds or by wild pigs that roam this area. ***Thus to the extent that the salinity measurements are erroneous they probably underestimate the actual salinity.***

Salinity Measurements from shallow (upper 60cm) pore water equilibrators:

Salinities were also measured on samples collected from equilibrators inserted into the marsh soil at selected stations along transect D only (data file called PROBE). The equilibrators consisted of 3.5 foot lengths of half-inch diameter electrical conduit pipe with a bolt screwed into the bottom end. Holes (0.25 inch diameter) were drilled along the length of the pipe so that, when the pipe was pushed into the soil, the holes were at depths of 1.0, 2.0, 3.0, 5.0, 7.0, 10.0, 15.0, 20.0, and 25.0 inches below the ground surface. Snug fitting rubber stoppers were inserted into the pipe so that each hole became the opening to an isolated chamber about one inch long. Each chamber was filled with cotton and then saturated with tap water immediately before insertion of the pipe into the marsh soil. The chambers in each pipe were allowed to equilibrate with the ambient soil water for at least two weeks before they were withdrawn. Upon withdrawal the pipes were immediately wiped dry and cleaned of mud and then the holes were sealed with tape to prevent loss by leakage or evaporation. Later a needle and syringe were used to extract a drop of water from each chamber for measurement of salinity with a refractometer. Before the next deployment, the cotton and water in each chamber were replaced by fresh cotton and water.

Hydraulic Conductivity from Slug Tests:

In order to estimate the hydraulic conductivity of the aquifer in the vicinity of each piezometer, once-only slug tests were conducted in 292 of the 306 piezometers installed in this project (data file called PERMEABL). To conduct these tests the timing circuit of one of the data loggers was modified with appropriate capacitors and resistors so as to generate a square wave with a frequency of about one second, which allowed the data acquisition program to collect data at the same frequency. The pipe housing the pressure transducer was used as the slug because when suddenly inserted into the piezometer the water level in the piezometer would suddenly rise to a level a meter or so above the pre-insertion level. The data logger then recorded the decline of the water level toward its ambient level, which usually required about five minutes depending on the hydraulic conductivity. A number of field parameters were measured prior to each test: saturated aquifer thickness at each station, piezometer depth, static water level in the test piezometer, height of the piezometer casing above the ground, length of the screened interval, internal diameter of the piezometer, slug external diameter, effective piezometer radius, and the slug depth of penetration. The saturated aquifer thickness and the static water level in the piezometer were the only time-dependent parameters and these were measured immediately prior to conducting each test. All slug test data were downloaded in the field and checked to assure that a valid test was obtained. During testing at each station, a minimum of five minutes was given between tests at adjacent piezometers to allow the aquifer to fully recover between tests. The field data were edited and all data files were imported into AQTESOLV (Geraghty and Miller, 1989) where they were analyzed using the Bouwer and Rice (1976) method for solution of slug tests performed in partially penetrating wells.

Post-study Piezometer Rim Elevation Survey:

Files PZELEVB, PZELEVC and PZELEVD contain the results of a releveled survey of the piezometer rims on transects B, C, and D done in June of 1996 by Mr. Michael Busby in order to determine whether the piezometer rims had remained at a common elevation since their installation in the summer of 1993. The data in these files are based on a topographic resurvey of the piezometer station elevations in May of 1996. The results of the topo resurvey are given in file TOPODATA in subdirectory TOPOS, along with the original 1993 topo survey by R. Keenan. The original 1993 topo survey is probably more accurate because it was conducted by more experienced personnel using more accurate equipment (TopCon total station versus leveling telescope). As indicated in the Topodata methodology above, the 1993 survey was referenced to the BARUCH1932 geodetic survey benchmark near the intersection of Marsh and Clambank Roads; whereas, the 1996 survey was referenced to a local temporary benchmark which appears to be about 37 cm higher than the BARUCH1932 benchmark. In both surveys the piezometer surveyed was always the deepest at a given station (8, 12 or 16 foot).

After the topo resurvey, Mr. Busby stretched a taut string from the 2ft piezometer pipe to the deepest piezometer pipe (usually a distance of 10 ft) at each station and leveled it with a carpenters level. He then measured the distance at each piezometer pipe between the ground surface and the level line and between the level line and the pipe rim.

Observations/Notes: The rim elevations at a station are generally consistent, with maximum differences usually less than 3 cm. Notable exceptions are stations B280, C090, C190, D294, D386 and D474. **At C090 the 12ft piezometer was not trimmed and is 19.5 cm higher than the common rim elevation. The water level data in the CHEADDATA and CDIPSTIK files have been corrected for this error.** There are also consistent differences between some stations, for example, between D000 and D050. In most cases, large between station differences coincide with large differences between the 1993 and 1996 station elevations. If the 1993 station elevations were used instead of the 1996 elevations, these between station discrepancies would largely disappear, with the exception of B000 where the ground elevation (201 cm) is nearly as high as the rim elevations at the other stations (204 cm relative to BARUCH1932 = 260cm AMSL). **Thus the rims at B000 were intentionally trimmed to a higher elevation (201+25=226cm, or 241+25=266cm relative to Baruch1932=300cm AMSL).**

Botanical Surveys. In the summer of 1993 L.R Gardner made detailed descriptions of plant communities along transects B, C, and D. Distances were noted where each community began and ended, along with species names and plant heights. These can be found in ancillary file BOTANY and in Appendix 2 of Thibodeau (1997).

2.5.1.4 Methodology Citation:

8. Citation Information

8.1 Originator: L.R. Gardner

8.1 Originator: D.E Porter

8.2 Publication Date: 2001

8.4 Title: Stratigraphy and geologic history of a southeastern salt marsh basin, North Inlet, South Carolina, USA.

8.8.1 Publication Place: Unknown

8.8.2 Publisher: Wetlands Ecology and Management

8.9 Other Citation Details: Vol. 93:371-385.

8. Citation Information

8.1 Originator: P.M. Thibodeau

8.1 Originator: L.R. Gardner

8.1 Originator: H.W. Reeves

8.2 Publication Date: 1998

8.4 Title: The role of groundwater flow in controlling the spatial distribution of soil salinity and rooted macrophytes in a southeastern salt marsh, USA

8.8.1 Publication Place: Unknown

8.8.2 Publisher: Mangroves and Salt Marshes

8.9 Other Citation Details: Vol. 2:1-13.

8. Citation Information

8.1 Originator: R.S. Keenan

8.1 Originator: J. Dickerson

8.1 Originator: L.R. Gardner

8.1 Originator: H.W. Reeves

8.2 Publication Date: 1996

8.4 Title: Inexpensive electronic water level recorders for hydrologic studies.

8.8.1 Publication Place: Unknown

8.8.2 Publisher: Ground Water Monitoring and Remediation

8.9 Other Citation Details: (Spring) 77-83.

8. Citation Information

8.1 Originator: P.M. Thibodeau

8.2 Publication Date: 1997

8.4 Title: Groundwater Dynamics Across the Forest-Marsh Interface, North Inlet, South Carolina

8.8.1 Publication Place: Unknown

8.8.2 Publisher: Department of Geological Sciences, The University of South Carolina, Columbia, SC

8.9 Other Citation Details: Ph.D. Dissertation, 278pp.

8. Citation Information

8.1 Originator: R.S. Keenan
8.2 Publication Date: 1994
8.4 Title: An Investigation of the Dynamics of Groundwater Flow and Salinity Distribution Along a Forest-Salt Marsh Transect.
8.8.1 Publication Place: Unknown
8.8.2 Publisher: Department of Geological Sciences, The University of South Carolina, Columbia, SC
8.9 Other Citation Details: M.S. Thesis, 238pp.

8. Citation Information

8.1 Originator: R.M. Wojcik
8.2 Publication Date: 1998
8.4 Title: Soil Water Balances Along a Forest-Marsh Transect at North Inlet (SC).
8.8.1 Publication Place: Unknown
8.8.2 Publisher: Department of Geological Sciences, The University of South Carolina, Columbia, SC
8.9 Other Citation Details: M.S. Thesis, 155pp.

8. Citation Information

8.1 Originator: H. Bouwer
8.1 Originator: R.C. Rice
8.2 Publication Date: 1976
8.4 Title: A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells.
8.8.1 Publication Place: Unknown
8.8.2 Publisher: Water Resources Research
8.9 Other Citation Details: Vol. 12:423-428

8. Citation Information

8.1 Originator: Geraghty and Miller Modeling Group
8.2 Publication Date: 1989
8.4 Title: AQTESOLV: Aquifer Test Solver, computer code version 1.10.10700
8.9 Other Citation Details: Park Ridge Boulevard, Suite 600, Reston, VA 22091.

2.5.3.1 Process Description:

Water Level Data Processing From Data Loggers.

As noted in the Field Methodology section, the data stored in the data logger memory are in the form of a string hexadecimal numbers with the first two being a running tally of the total number of observations taken up to a given point in time. During download the data retrieval program reads the first two hexadecimals converts these to base 10 decimal numbers and displays the results on the computer screen. The operator then enters a file name based on the transect (B, C, or D), the instrument box number (two digits) and the month and day (four digits) and an extension (.RAW). The program then converts the remaining hexadecimals to a string of base 10 decimals and stores the results on either the A or C drive of the laptop computer. The raw data files were then shipped to the USC Department of Geological Sciences in Columbia, SC, along with the field notes pertaining to the deployment.

In Columbia the raw data files were read into a C++ program named CRD.EXE, which converts the uncalibrated pressure heads in the raw data into calibrated total heads (i.e. pressure plus elevation heads) in ASCII format. CRD.EXE prompts the user to enter the name of the raw data file, the number of observations, and the start and end times of the deployment in mm/dd/yy format. The program then uses the first two digits (i.e. box number) of the file name following the transect designation to link to the calibration file for the box used in the deployment. It then computes the time of each observation based on the start and end times and the number of observations. The times thus computed are in units of hours since the beginning of 1994, that is, the zero point of the time scale begins at midnight of December 31, 1993. Using the slope and intercept of the regression equation stored in the calibration file, the program then converts the raw uncalibrated pressure heads into calibrated pressure heads (in cm). Finally using the pressure transducer set depths stored in the calibration file and the piezometer pipe rim elevation (243.8 cm, based on the 1987 Baruch 1932 bench mark elevation of 3.0 meters) the elevation of each pressure transducer was computed and added to the calibrated pressure head to give the total head. The data files thus created were given the same name as the corresponding raw data file, but given a .DAT extension rather than a .RAW extension name. ***Because the Baruch 1932 benchmark was later lowered to 2.6 meters, users are again urged to subtract 40 cm from the archived head data before publishing any results based on this data.***

Once the .DAT files were created, they were imported into PSI-PLOT (a data processing and graphics product of Poly Software International, Salt Lake City, Utah). PSI-PLOT was used to produce plots of heads versus time (in hours since the beginning of 1994). The graphic files thus created were given the same name as the parent .DAT file but with the standard PSI-PLOT extension of .PSG. Unfortunately these graphics files are not included in this data set because they can only be read with PSI-PLOT software and because their conversion to .TIF or .JPG files would be extremely time consuming and would require storage resources an order of magnitude greater than the parent .DAT files. However, several examples of these plots were converted to .TIF and .JPG files and are contained in the GRAPHICS subdirectory of the Ancillary Data (see section 5.2.1).

L.R. Gardner then inspected the PSI-PLOT plots. Typically roughly 80 percent of the plots generated for a given deployment did not appear to have any obvious problems or peculiarities. The most common problems fall into four categories: 1) the occurrence of occasional heads that are clearly unrealistic with values of ten or more meters, 2) sudden shifts upward or downward of 10 to 20 cm in the data from one piezometer, without similar shifts in the data for piezometers at the same station or nearby stations, 3) spiky data during heavy rains with some heads exceeding the elevation of the land surface, and 4) head time series with a clear tidal signal but which is out of phase with similar time series from nearby stations (and with times of known high tide) or that has a distinctly non-tidal frequency (e.g. 15 hours). Where possible, attempts were made to edit out these problems by correcting what appeared to be erroneous data. For type one problems, the erroneous values were simply replaced by values interpolated from adjacent data in the time series. For type 2 problems, the shifted data was adjusted en masse so that the gap between the erroneous channel and its neighbors at a station resembled that typically observed in the manual dipstick measurements. If the data showed many short-lived shifts, data for that piezometer were simply deleted. Sometimes such shifts only occurred immediately after recalibration of the data logger or its replacement by another instrument. In such cases the shifts might involve more than one piezometer with one shifting upward and its neighbor shifting downward. Again dipstick measurements were used to guide the corrections. For type 3 problems, the spikes were truncated to a maximum value equal to the ground elevation as the aquifer commonly saturates to the surface during heavy rains. For type 4 problems the starting and ending times of the deployment were checked as well as the number of observations and if found to be in error CRD.EXE was rerun. If this did not solve the problem, it was often possible to mathematically correct the time data so as to produce the correct tidal frequency and agreement with nearby data. It almost always also produced agreement in the timing of rain and evapotranspiration events seen at nearby stations, thus indicating the correction was reasonable. ***The user should note the editing process was a learning process on the part of the editor so it is not likely that it was applied consistently to all of the data.***

After editing the DAT files, the time series data were interpolated at 15 minute intervals centered on the hour, quarter hour, half hour and three quarter hour using the cubic spline option in PSI-PLOT and then replotted. The edited files were given the same name as their parent DAT files but with an E following the digits that specify the day of download. Thus for example the file named D110422E.DAT contains edited data from data logger number 11 on transect D, downloaded on April 22. In order to archive the data on the USC mainframe, the hidden tabs produced by PSI-PLOT had to be removed and the line record length set to 80. This was done by importing the file into the DOS editor program ED.EXE and setting the line record length to 80 characters. The file was then saved with the same name as its parent but with an F in place of E (e.g. D110422F.DAT). The files were then uploaded from the desktop computer to the mass storage facility on the USC mainframe computer. The following example protocol was used in naming the files sent to mass storage:

N310006.BHEADAT.APR1096.B352.B280410E

N310006 is the account number for L.R. Gardner,

BHEADAT is the name of the directory in which the data for transect B was stored,

APR1096 is the download date (i.e. April 10, 1996),

B352* is the distance (in feet) of the station from the northwestern end of transect B,

*If the file contained data from more than one station, this designation included both stations (e.g. D50D70)

B280410E* is the transect identifier, followed by the data logger number (28), the month and day of download in mmdd format (0410) and a notation indicating to the author that the file had been edited (E).

*The files containing tide gauge data from station D309 end in DTGmmddE

Water Level Final File Processing:

Each .DAT file was imported into Microsoft Excel from mass storage and examined for problems with interpolation, anomalous/erroneous data, missing data, or problems with the import process. Instances of missing data were noted and the appropriate cells were filled with missing data markers “.”. The missing data are reported in the Completeness Report portion of this document. In addition, column headers were edited for consistency and water level data were formatted to one decimal place. Occasionally, problems with the interpolation of files or the presence of anomalous/erroneous or repetitive data were discovered. These files were corrected and/or reinterpolated by L.R. Gardner, then re-examined and

edited. If erroneous data could not be corrected, they were removed from the file, marked with a missing data marker “.”, and reported in the Completeness Report.

These final files were then saved as .CSV (comma delimited) files, to ensure that importing into any software application would be convenient and error free. The D transect directory name was changed from HEADDAT to DHEADDATA, and the files were renamed as “DHEADDATA”, instead of “HEADDATA”, to avoid confusion. The .DAT files for all transects were retained as process files. All process files were archived on CD, along with the raw data files, and can be obtained by contacting the author or Baruch’s Data Manager. As a result of this editing process, all HEADDATA files were removed from Mass Storage and will be replaced with a final version of the database.

Ancillary Data processing.

The field notes pertaining to the deployment were shipped to the USC Department of Geological Sciences in Columbia, SC. For each instrument box number, the notes identify the transect and station at which it was deployed and the piezometer depths pertaining to each data channel. The notes also contain the date and time the box was started and the date and time of the download. Other items of information in the notes are the number of observations in hexadecimal format, the file name assigned to the data, the battery voltages at the beginning and end of the deployment, the raw water level readings in hexadecimal format at the beginning and end of the deployment and comments pertaining to any problems encountered during the download. Some of this information has been summarized in the HISTORY subdirectory of the ancillary data.

Process Date:
200212

3 Spatial Data Organization Information

3.1 Indirect Spatial Reference

North Inlet Estuary which is part of Hobcaw Barony is located in Georgetown County, South Carolina, USA

5 Entity and Attribute Information

5.2 Overview Description

5.2.1 Entity and Attribute Overview

Water Level Data (Primary Dataset)

For a complete list of water level data file names, please see either of the following documents included in this database HEADDATA.FINAL.BYDATE.LIST or HEADDATA.FINAL.BYSTATION.LIST. Both documents are provided in both .DOC and .TXT formats.

Directory (Folder) BHEADDATA.FINAL.CSV (Data files for Transect B)

Directory Size: 13.0 MB

Contains 2 Folders: BHEADDATA.FINAL.BYSTATION.CSV

Directory Size: 6.18 MB

Contains 183 Files in 14 Subdirectories; each file is < 55 KB

BHEADDATA.FINAL.BYDATE.CSV

Directory Size: 6.18 MB

Contains 183 Files in 29 Subdirectories; each file is < 55 KB

Directory (Folder) CHEADDATA.FINAL.CSV (Data files for Transect C):

Directory Size: 23.0 MB

Contains 2 Folders: CHEADDATA.FINAL.BYSTATION.CSV

Directory Size: 11.4 MB

Contains 364 Files in 25 Subdirectories; each file is < 55 KB

CHEADDATA.FINAL.BYDATE.CSV

Directory Size: 11.4 MB

Contains 364 Files in 53 Subdirectories; each file is < 55 KB

Directory (Folder) DHEADDATA.FINAL.CSV (Data files for Transect D):

Directory Size: 38.0 MB

Contains 2 Folders: DHEADDATA.FINAL.BYSTATION.CSV

Directory Size: 18.8 MB

Contains 629 Files in 31 Subdirectories; each file is < 75 KB

DHEADDATA.FINAL.BYDATE.CSV

Directory Size: 18.8 MB

Contains 629 Files in 66 Subdirectories; each file is < 75 KB

The final file names in each directory above have the following naming protocol (the same protocol used when transferring them to mass storage):

BHEADDAT.APR1096.B352.B280410E

BHEADDAT* represents the directory (BHEADDATA) in which the data for transect B was stored,

*DHEADDATA directory files are named "DHEADDATA" as opposed to "BHEADDAT" and "CHEADDAT"

APR1096 is the download date (i.e. April 10, 1996),

B352 is the distance (in feet) of the station from the northwestern end of transect B,

*If the file contained data from more than one station, this designation included both stations (e.g. D50D70)

B280410E* is the transect identifier, followed by the data logger number (28), the month and day of download in mmdd format (0410) and a notation indicating to the author that the file had been edited (E). (In the final files this notation may also be an F, C, or I if the file had to be reinterpolated or corrected)

Variable	Column(s)	Type (total size of value.# of decimal places)	Range of Measurement (min-max)
Time	1	Real (8.2)	1502.25 – 20463.00, quarter hour (.25) increments
Water Level	2, 3, 4, 5	Real (5.1)	26.0 – 218.0 cm

Column Names and Naming Protocols for each data file:

Column 1 = Time

Column 2, 3, 4, etc. =Water Level for the piezometer denoted by the column header:

Column header = Transect (B, C, D), Station Number (station number = distance in feet from end of transect), and piezometer depth in feet (p2ft, p4ft, p8ft, p12ft, p16ft)

*For the tide gauge at station D309, the column header is D309TG

Data/Column Definition:

Time: Not actual time of data collection. The series data were interpolated at 15 minute intervals centered on the hour, quarter hour, half hour and three quarter hour using the cubic spline option in PSI-PLOT and then replotted. The times are computed in units of hours since the beginning of 1994, that is, the zero point of the time scale begins at midnight of December 31, 1993.

Water Level: A calculated value, using the slope and intercept of the regression equation stored in the calibration file, a program converted the raw uncalibrated pressure heads into calibrated pressure heads (in cm). Finally using the pressure transducer set depths stored in the calibration file and the piezometer pipe rim elevation (243.8 cm, based on the 1987 Baruch 1932 bench mark elevation of 3.0 meters) the elevation of each pressure transducer was computed and added to the calibrated pressure head to give the total head. *Note that these values are 40 cm higher than the actual final value, because the Baruch 1932 benchmark was later lowered from 3.0 to 2.6 meters. Users are again urged to subtract 40 cm from the archived head data before publishing any results based on this data.*

Ancillary Data

The ancillary data are found in the subdirectory ANCILLARY, which is further subdivided into the following subdirectories: HISTORY, BOTANY, DIPSTICK, SALINITY, PERMEABL, TOPOS, LEVELS, PZDEPTHS, GRAPHICS, and PHOTOS. Each WORD (.DOC) or EXCEL (.XLS) file within these directories is accompanied by a duplicate .TXT or .CSV version, in an attempt to ensure the future readability of the files. Also in the subdirectory ANCILLARY is an extended version of the following table, named AncillaryDataTable, which includes information on each file type. Contents of the ANCILLARY subdirectories are as follows:

Directory	Filenames	Contents
HISTORY	BHISTORY	Field History of datalogger deployments for transect B
	CHISTORY	Field History of datalogger deployments for transect C
	DHISTORY	Field History of datalogger deployments for transect D
TOPOS	TOPODATA	Station Elevations (topographic surveys)
	README.TOPODATA	Important information about the Topographic Survey data
	MISSING.TOPODATA	Missing data report for the TOPODATA file

PERMEABL	PERMEABL	Hydraulic Conductivities from Slug Tests
LEVELS	MISSING.PERMEABL	Missing data report for the PERMEABILITY file
	PZELEV B	Post-study piezometer rim elevation survey for transect B
	PZELEV C	Post-study piezometer rim elevation survey for transect C
	PZELEV D	Post-study piezometer rim elevation survey for transect D
	README.LEVELS	Important information about the LEVELS files
	MISSING.LEVELS	Missing data report for the LEVELS files
DIPSTICK	BDIPSTICK	Manual readings (for ground-truthing) of water depth in piezometer wells
	CDIPSTICK	Manual readings (for ground-truthing) of water depth in piezometer wells
	DDIPSTICK	Manual readings (for ground-truthing) of water depth in piezometer wells
	README.DIPSTICK	Important information about the DIPSTICK files
	MISSING.DIPSTICK	Missing data report for the three DIPSTICK files
SALINITY	BPZSALINITY	Salinity readings taken from piezometer wells and water color readings
	CPZSALINITY	Salinity readings taken from piezometer wells and water color readings
	DPZSALINITY	Salinity readings taken from piezometer wells and water color readings
	PROBE	Salinity readings from shallow (upper 60cm) pore water equilibrators
	README.SALINITY	Important information about the four SALINITY files
	MISSING.SALINITY	Missing data report for the four SALINITY files
BOTANY	BOTANY	Botanical zonation descriptions along all transects
PZDEPTHS	PZDEPTHS	Actual (rather than nominal) depths of the deepest piezometers at each station.
	README.PZDEPTHS	Important information about the PZDEPTHS file
GRAPHICS	JPG	Graphical examples of piezometer water level time series in .JPG format.
	TIF	Graphical examples of piezometer water level time series in .TIF format.
	README.GRAPHICS	Important information about the GRAPHICS files.
PHOTOS		Some ground and air photos of the Crabhaul Creek study area in .JPG format.

HISTORY contains files which record the history of data logger deployments along transects B, C, and D. These files record the data logger identification number, the transect and station at which it was deployed, the piezometers to which each data logger channel was assigned, the number of observations collected, and the starting and ending dates and times of the deployment.

Data/Column Definitions for HISTORY files:

Each entry consists of 6 or 7 lines.

The first line gives the instrument box number, transect and station location in feet from the northwest end of the transect.

The second line gives the start time (military clock) and date

The third line gives the end time and date.

The fourth line gives the number of observations taken during the deployment, which can be used to calculate the date and time of each observation.

The fifth and sixth lines give the nominal depths of the piezometers assigned to each channel. One observation consists of reading the data on each channel. Unless noted otherwise, channels 4 to 7 correspond to piezometers at depths of 2, 4, 8 and 12 feet below ground surface. At some stations the depth of the deepest piezometer is a nominal depth rather than the actual depth. For example the nominal depth may be given as 12 feet whereas the actual depth may only be 10 feet. **For the actual depths of the deepest piezometer at each station refer to Masters thesis by R. Keenan (1994) or to ancillary data file PZDEPTHS.CSV. For the other piezometers the nominal depths are equal to the actual depths.**

Any additional lines in an entry are remarks.

TOPOS contains the file TOPODATA, which gives the results of topographic surveys of the piezometer stations conducted in 1993 and 1996.

Data/Column Definitions for TOPODATA file:

Column 1 = Transect identifier (B, C, or D).

Column 2 = Station location. Locations are given in feet from station 000 at the northwest end of each transect.

Columns 3 and 5 give 1993 station elevations relative to the BARUCH1932 benchmark in feet and centimeters respectively.

Columns 4 and 6 give the 1996 station elevations relative to the arbitrary benchmark in feet and cm respectively.

PERMEABL contains the file PERMEABL, which tabulates the hydraulic conductivities obtained from slug tests in most of the piezometers along the transects. It also gives a description of the lithology of the sediment or soil associated with each slug test. This file is based on slug test results performed by Keenan (1994) and taken from Appendix 3 in Thibodeau (1997).

Data/Column Definitions for PERMEABL file:

Column 1 = Station location with transect identifier. Locations are given in feet from station 000 at the northwest end of each transect.

Column 2 = Piezometer depth. Nominal (rather than actual) depths in feet below ground surface.

Column 3 = Hydraulic conductivities in units of centimeters/second.

Column 4 = Lithology of sediment/soil sample. Shorthand notation for the description of lithologic units used in this data.

File is as follows (refer to core logs in Appendix I of Thibodeau (1997) for more detailed descriptions):

1. fine-med sand.spod - fine to medium grain sand coinciding with the spodic soil horizon.
2. fine-med sand.cln - clean fine to medium grain sand, very little or no silt, clay or fine organics.
3. fine sand.cln - clean, well sorted fine grain sand.
4. fine muddy sand - fine sand with notable silt and clay content.
5. fine-crs sand.spod - fine to coarse grain sand coinciding with the spodic soil horizon.
6. fine-crs sand.cln - fine to coarse grain sand with little or no silt, clay or fine organics.
7. sandy marsh mud - fine marsh silt and clay with little fine sand.
8. marsh mud - typical silt and clay marsh deposition.
9. fine-v. crs sand.cln - clean fine to very coarse sand, may have pebble size grains.
10. fine-crs sand.muddy - fine to coarse grain sand with notable silt and clay content.
11. fine sand.shell - fine sand mixed with crushed shell.

LEVELS contains the results of a releveled survey for transects B, C, and D of piezometer rim elevations conducted in June of 1996.

Data/Column Definitions for LEVELS files:

Column 1 = Station location with transect identifier. Locations are given in feet from station 000 at the northwest end of each transect.

Column 2 = Piezometer depth. Nominal (rather than actual) depths in feet below ground surface.

Column 3 = Elevation of the level line relative to the temporary benchmark (in meters).

Column 4 = Distance of level line above ground (in meters).

Column 5 = Elevation of the ground (in meters).

Column 6 = Distance of rim above level line (in meters).

Column 7 = Elevation of the rim relative to the temporary benchmark (in meters).

DIPSTICK contains files which record the history of dipstick readings taken from piezometers along transects B, C, and D. These are manual readings of the depths to water below piezometer rims taken intermittently between 1995 and 2000.

Data/Column Definitions for Dipstick files:

Column 1 = Date (m/d/yyyy).

Column 2 = Hours since beginning of 1994.

Column 3 = Station location. Locations are given in feet from station 000 at the northwest end of each transect.

Column 4 = Piezometer depth. Nominal (rather than actual) depths in feet below ground surface.

Column 5 = Depth to water level below piezometer rim (in centimeters).

SALINITY contains files with several different types of salinity data collected along transects B, C, and D between 1993 and 2000. The PZSALINITY files record the history of salinity readings taken from piezometers along each transect and contain incomplete data on watercolor as percent transmission relative to distilled water.

Data/Column Definitions for PZSALINITY files:

Column 1 = Date (m/d/yyyy)

Column 2 = Hours since beginning of 1994.

Column 3 = Station location. Locations are given in feet from station 000 at the northwest end of each transect.

Column 4 = Piezometer depth. Nominal (rather than actual) depths in feet below ground surface.

Column 5 = Salinity in grams per liter.

Column 6 = Water color in percent transmission relative to distilled water at wavelength of 660 nm.

SALINITY also contains the PROBE file, which records the history of salinity readings obtained from shallow pore water equilibrators deployed during 1994 and 1995 along some of the marsh stations on transect D.

Data/Column Definitions for PROBE file:

Column 1 = Station location. Locations are given in feet from station 000 at the northwest end of each transect.

Column 2 = Depth below ground surface of the probe ports (in inches).

Column 3 = Period of measurement of the first probe deployment in hours from beginning of 1994.

Column 4 = Salinity data in parts per thousand for the first deployment.

Column 5 = Period of measurement of the second probe deployment in hours from beginning of 1994.

Column 6 = Salinity data in parts per thousand for the second deployment.

Column 7 = Period of measurement of the third probe deployment in hours from beginning of 1994.

Column 8 = Salinity data in parts per thousand for the third deployment.

Column 9 = Period of measurement of the fourth probe deployment in hours from beginning of 1994.

Column 10 = Salinity data in parts per thousand for the fourth deployment.

Column 11 = Replicate probe salinity data in parts per thousand for the fourth deployment.

Column 12 = Period of measurement of the fifth probe deployment in hours from beginning of 1994.

Column 13 = Salinity data in parts per thousand for the fifth deployment.

Column 14 = Period of measurement of the sixth probe deployment in hours from beginning of 1994.

Column 15 = Salinity data in parts per thousand for the sixth deployment.

Column 16 = Period of measurement of the seventh probe deployment in hours from beginning of 1994.

Column 17 = Salinity data in parts per thousand for the seventh deployment.

Column 18 = Period of measurement of the eighth probe deployment in hours from beginning of 1994.

Column 19 = Salinity data in parts per thousand for the eighth deployment.

Column 20 = Period of measurement of the ninth probe deployment in hours from beginning of 1994.

Column 21 = Salinity data in parts per thousand for the ninth deployment.

Column 22 = Period of measurement of the tenth probe deployment in hours from beginning of 1994.

Column 23 = Salinity data in parts per thousand for the tenth deployment.

Column 24 = Period of measurement of the eleventh probe deployment in hours from beginning of 1994.

Column 25 = Salinity data in parts per thousand for the eleventh deployment.

BOTANY contains the file BOTANY, which gives a description of the botanical zonation along transects B, C, and D taken from Appendix 2 in Thibodeau (1997). Column headings are not relevant for these files.

PZDEPTHS contains the file PZDEPTHS which gives the nominal and actual depths of the deepest piezometers for each station along the transects.

Data/Column Definitions for PZDEPTHS file:

Column 1 = station identifier for transect B in feet from B000.

Column 2 = nominal depth in feet below ground surface for deepest piezometer

Column 3 = actual depth in feet below ground surface for deepest piezometer

Column 4 = station identifier for transect C in feet from C000.

Column 5 = nominal depth in feet below ground surface for deepest piezometer

Column 6 = actual depth in feet below ground surface for deepest piezometer

Column 7 = station identifier for transect D in feet from D000.

Column 8 = nominal depth in feet below ground surface for deepest piezometer

Column 9 = actual depth in feet below ground surface for deepest piezometer

GRAPHICS contains graphical examples of piezometer water level time series along the transects, in both .JPG and duplicate .TIF formats. It also includes a graphical example of problems that sometimes occurred with the data. See the AncillaryDataTable file in the Ancillary Data subdirectory for a complete list of file names and the stations, depths, and time periods they cover. Elevations shown on graphs are not corrected for the change in the elevation of the Baruch1932 benchmark. Column headings are not relevant for these files.

PHOTOS contains .JPG ground photographs of the Crabhaul Creek study area and a .JPG aerial photograph (DOQQ) of the study site with each transect labeled. See the AncillaryDataTable file in the Ancillary Data subdirectory for a complete list of file names. Column headings are not relevant for these files.

5.2.2 Entity and Attribute Detail Citation:

Definitions of entities and attributes are not from any published source; however, the general use of label names and their definitions are understood by the geologic community at large. Other specific definitions and labels that were used are defined by the authors in this document.

6 Distribution Information

6.1 Distributor:

10.2 Contact Organization Primary

10.1.2 Contact Organization: Univ. of South Carolina's Baruch Institute

10.1.1 Contact Person: Ginger Ogburn-Matthews

10.3 Contact Position: Research Data Manager & Analyst

10.4 Contact Address

10.4.1 Address Type: Mailing Address

10.4.2 Address: USC Baruch Marine Field Lab

10.4.2 Address: PO Box 1630

10.4.3 City: Georgetown

10.4.4 State or Province: South Carolina

10.4.5 Postal Code: 29440

10.4.6 Country: USA

10.4 Contact Address

10.4.1 Address Type: Physical Address

10.4.2 Address: Highway 17 N

10.4.2 Address: Hobcaw Barony

10.4.3 City: Georgetown

10.4.4 State or Province: South Carolina

10.4.5 Postal Code: 29440

10.4.6 Country: USA

10.5 Contact Voice Telephone: (843) 546 6219

10.7 Contact Facsimile Telephone: (843) 546-1632

10.8 Contact Electronic Mail Address: ginger@belle.baruch.sc.edu

10.9 Hours of Service: 8:30 am to 4:30 pm EST/EDT Mon.- Friday

6.2 Resource Description:

- > North Inlet Crabhaul Creek Ground Water Study
- > Crabhaul Creek Piezometer Data
- > North Inlet Forest-Marsh-Tidal Creek Groundwater Dynamics Data

6.3 Distribution Liability:

The datasets are only as good as the quality assurance and quality control procedures outlined in the Metadata. The user bears all responsibility for its subsequent use in any further analyses or comparisons. No warranty expressed or implied is made regarding the accuracy or utility of the data on any data collected, managed, or disseminated for general or scientific purposes by the Belle W. Baruch Institute for Marine Biology and Coastal Research. This disclaimer applies both to individual use of the data and aggregate use with other data. It is strongly recommended that careful attention be paid to the contents of the Metadata file associated with the particular data. The Baruch Institute, Baruch Institute researchers & students, and NSF shall not be held liable for the use and/or misuse of the data described and/or contained herein.

6.4 Standard Order Process

6.4.2. Digital Form

6.4.2.1 Digital Transfer Information

6.4.2.1.1. Format Name: Primary water level files = .CSV file (comma delimited). Other ancillary data are in .XLS or .DOC format with replicates in .CSV or .TXT (text only) format.

6.4.2.2 Digital Transfer Option

6.4.2.2.1.1 Computer Contact Information

6.4.2.2.1.1.1 Network Address

6.4.2.2.1.1.1.1 Network Resource Name: <http://links.baruch.sc.edu/data/>

6.4.3 Fees: None

6.5 Custom Order Process

As an offline option, CD-ROMs are available at the cost of \$5.00 each. This fee pays for the CD, the creation of the CD, and mailing charges.

7 Metadata Reference Information

7.1 Metadata Date: 20021204

7.4 Metadata Contact:

10.2 Contact Organization Primary

10.1.2 Contact Organization: Univ. of South Carolina's Baruch Institute

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7.5 Metadata Standard Name:

Content Standard for National Biological Information Infrastructure Metadata.

7.6 Metadata Standard Version: FGDC-STD-001-1998