ABSTRACT

SMITH, HEATHER CHRISITINE. Time Required for Anaerobic Conditions to Develop in Saturated Soils (Under the direction of M. J. Vepraskas)

The amount of time required for a saturated soil to become anaerobic has been used to establish the regulations that define and protect wetlands in the U.S. Virtually no field data are available on the time or factors that control development of anaerobic conditions. The objectives of this work were to determine the amount of time required to develop anaerobic conditions in saturated wetland soils, and to determine the effect that soil organic carbon and temperature had on the time required. Anaerobic conditions were evaluated at a wetland restoration site in Robeson Co., and at three natural wetlands in Bladen Co. Seven automated sites were installed in the restoration site to record hourly soil redox potential at 25 and 61 cm and mean soil temperature. Manual measurements were made at the natural areas. Duration of anaerobic conditions was estimated from water table data by determining length of time needed for anaerobic conditions to develop once soils were saturated. The redox potentials and water table measurements showed that the time to develop anaerobic conditions for organic soil and mineral soils ranged from 1 to 45 d at both 25 and 61 cm. Soil organic carbon had a significant ($p=0.009$) effect on the time to develop anaerobic conditions. Soils containing >0.03 g/g of soil organic carbon required less time (1 to 3 d) to develop anaerobic conditions than soils with <0.03 g/g (3 to 45 d). Soil temperature had no significant ($p>0.5$) impact on

development of anaerobic conditions in the soils studied, probably because soil temperature remained above 5 C.

TIME REQUIRED FOR ANAEROBIC CONDITIONS TO DEVELOP IN SATURATED SOILS

by
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A thesis submitted to the Graduate Faculty of
North Carolina State University
in partial fulfillment of the
requirements for the Degree of
Master of Science

SOIL SCIENCE

Raleigh

2004

APPROVED BY:

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Chair of Advisory Committee

BIOGRAPHY

Heather Christine Smith was born in Charlotte, NC on October 4, 1979. She spent her childhood in Matthews, NC. She received a B.S. in Textile Technology from N.C. State University in December 2001. She also received a minor in Environmental Science, which helped her decide she did not want to work in the textile industry. After spending a semester away from school she decided to head back. In the summer of 2002 she entered the Soil Science Master's program under the direction of Dr. M.J. Vepraskas. She is currently looking for a job and living in Raleigh.

ACKNOWLEGEMENTS

I would like to express my deepest gratification to Dr. Vepraskas for taking a chance on someone from a textiles background. He was rather unsure as to whether I knew that soil science involved dirt and sweat.

Also, without the help of Alex Adams and Tripp Cox I would never have been able to gather all of my data and I deeply appreciate their hard work with my project. I would like to thank my fellow graduate students, Tracy, Erik and Alex B. for their friendship and help. I would like to thank my friends outside of the department, you know who you are, for their continual support.

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INTRODUCTION

Hydric soils are defined as soils that have formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (USDA, Soil Conservation Service, 1987). Anaerobic conditions occur when O_2 levels in the soil fall to the point that organisms respiring in the soils must use electron acceptors other than O_2 to oxidize organic matter. Aerated soils become anaerobic when: 1) soils are saturated and atmospheric O_2 cannot diffuse into the soil, and 2) bacteria decompose organic tissues and use dissolved oxygen as their electron acceptor (Mitsch and Gosselink, 1995). The soil is anaerobic when virtually all the oxygen has been depleted in the soil water. Under anaerobic conditions microbial respiration continues but the microbes must use other substances as electron acceptors. It is essential that for anaerobic conditions to occur in a saturated soil the microbes must be decomposing organic material in order for the dissolved O_2 to be reduced to water.

When a soil becomes saturated, the soil water usually contains dissolved oxygen that keeps the soil redox potential in the aerobic zone. The time required to develop anaerobic conditions varies with the amount of organic matter present, rate of microbial activity, and whether the water is moving or is stagnant (Mitsch and Gosselink, 1995). Christensen et al. (1990) concluded that the lag time between the onset of soil saturation and the start of denitrification was determined by the time it took to develop an anaerobic soil volume. Denitrification began 6 to 10 d after the soil saturated. He et al. (2003) found that in four Rains sandy-loam soils (Typic

Paleaquults) the lag time for iron reducing conditions to begin ranged from, 4 to 48d. Lag time increased as soil organic carbon decreased from .025 to .002 g/g from the soil surface to a depth of 60cm. Anderson and Domsch (1980) found that the soil microbial biomass decreased rapidly as the amount of labile carbon in the system decreased. The microbial biomass increased as organic matter increased, while reduction in labile carbon to the system caused a decline in the microbial biomass. Christensen et al. (1990) found that the lag time between onset of saturation and beginning of anaerobic conditions can be decreased if microbial activity is large.

Temperature is another variable affecting lag time because microbial activity increases as temperature increases. Nishio et al. (1988) found that denitrification began within 3 to 4 d after saturation at 12 C and the lag time decreased to 1 to 2 d at 20 C. Megonial et al. (1996) showed that in the southeastern United States the soil temperature at 50 cm remained above 5 C throughout the year. They suggested that the soil may produce anaerobic conditions as quickly in the winter as in the summer. Also, Megonial et al. (1996) stated there is little available data relating longer periods of saturation to produce hydric soils in winter months than in summer months in the southeast.

The redox potential of a soil can be measured to determine if the soil is anaerobic. Anaerobic conditions form at different redox potentials in soils depending on the pH of the soil (Vepraskas and Faulkner, 2001). Multiple redox electrodes need to be used in order to obtain an accurate reading due to the large variability of redox potential measurements (Vepraskas and Faulkner, 2001). Redox measurements are made at the same depth may vary by 600 mV or more over a distance of 1 m (Vepraskas and Wilding, 1983), due to amounts of soil organic matter (Vepraskas and Faulkner, 2001).

The objectives of this study were to: 1) determine the lag times needed for anaerobic conditions to develop in soils under field conditions; 2) to determine the effects of temperature and carbon on lag time, and 3) to document lag times in sediments below depths of 4 m.

MATERIALS AND METHODS

The North Carolina Department of Transportation, NCDOT, is in the process of restoring a drained Carolina Bay in order to earn mitigation credits (Fig. 1.1). The 300 ha area is called Juniper Bay and is located in Robeson Co., NC about 16 kilometers south of Lumberton (Fig 1.2). Juniper Bay was ditched and drained for agriculture beginning in late 1970's (Ewing, 2003). NC State University is responsible for studying the changes occurring at Juniper Bay as it is restored. The areas of focus are the soils, hydrologic regime, and vegetation.

NC State is using three natural Carolina Bays as reference sites. These reference bays are located in Bladen Co, NC near Elizabethtown (Fig 1.2). The bays are named Tatum Millpond, Charlie Long Millpond, and Causeway Bay (Fig. 1.3a, b, c) and are approximately 550, 200, and 240 ha in area, respectively. Tatum Millpond was logged for Atlantic White Cedar, *Chamaecyparis thyoides (L.)*, from 1938 until 1954. Charlie Long Millpond and Causeway Bay have never been logged or burned for the past 65 years. The soils, hydrologic regime, and the vegetation were studied and characterized previously (Ewing, 2003; Lees, 2003; Luginbuhl, 2004).

Soil Characterization

The soils at Juniper Bay and the reference bays were characterized by Ewing (2003). Locations at Juniper Bay were chosen randomly and were located at the bay using GPS. A 1.0-1.5 m soil pit was dug at the corresponding field location and the soil profile was described. A trail was cut from the edge to the center of each reference bay and sampling locations were randomly chosen (Fig. 3). A McCauley peat sampler and an open bucket auger were used to describe the soil profile.

Grab samples were taken from Juniper Bay and the reference bays for laboratory analysis The Grab samples were used to determine soil organic carbon. Soil organic carbon was determined using dry combustion with a Perkin-Elmer PE2400 CHN Elemental Analyzer (Culmo, 1988). The cation exchange capacity, sum of base cations were determined at Juniper Bay and the reference bays and the pH at the reference bays was determined (Mehlich, 1976). The pH at Juniper Bay was found using a 1:1 soil to water ratio (McLean, 1982).

The bulk density at Juniper Bay was determined using Uhland cores (75 mm in diameter x 75 mm in height) for each horizon. The McCauley peat sampler (5 cm diameter) was used to obtain undisturbed samples to determine bulk density (Soil Survey Staff, 1993).

Juniper Bay

The soil redox potentials were measured at Juniper Bay using seven automated systems placed into the organic and mineral soils (Fig. 1.4). Four were placed in organic soils and three were placed into the mineral soils. The mineral soils were on the perimeter of Juniper Bay and were classified as Leon (sandy siliceous, thermic Aeric Alaquods), Pantego (fine-Loamy, siliceous, semiactive, thermic Umbric Paleaquults), and Rutlege soils (sandy, siliceous, thermic, Typic Humaquepts) (McCachren, 1978). The organic soils were located in the center of the bay and were classified as Ponzer muck (loamy, mixed, dysic, thermic Terric Haplosaprists) (McCachren, 1978). The systems were installed in the beginning of July 2002. The water table depth was monitored automatically at each of the seven sites.

Electrode Construction

Five platinum electrodes were placed at each of three depths, 25, 61 and 457 cm, for a total of 15 electrodes in each plot. In order to construct the electrodes, a brass-brazing rod was cut to the desired length, 25 or 61 cm, and a 1 mm hole 3 mm deep was drilled into the end. The platinum wire was cut into 13 mm long pieces. The drilled end of the brass rod and platinum wire were brushed with "Batterns Flux" and the platinum was inserted into the brass rod. The platinum was fused to the brass rod by heating the brass with a propane torch until the brass melted. After the rod cooled, the platinum was pulled using a pair of pliers to ensure a good bond between the platinum and the brass rod.

The tip of the electrode was waterproofed using epoxy. Epoxy was spread around the connection between the platinum wire and the brass rod using a plastic knife. At least 5 mm of the platinum wire was left exposed. After being applied to the rod the epoxy was smoothed with a gloved hand until the heat shrink tubing could be placed over it. The epoxy hardened after 24 hours and was then sanded until it was smooth. A piece of heat shrink tubing was placed around the epoxy and attached to the brass rod. Pre-cut heat shrink tubing was placed around the brass rod and melted onto it. Approximately 5 cm of brass rod was left bare. An 18-gauge copper wire (2 m long), was attached to the brass rod using a soldering iron.

The electrodes placed at a depth of 457 cm were made by modifying the method used for the 25 cm long electrodes. The 18-gauge insulated copper wire that was soldered to the brazing rod was 7 m long. The entire electrode assembly was inserted into a 20-foot section of half-inch diameter PVC pipe. There were four 150 cm long sections connected with couplings. A cap was placed on the end of the pipe and a 1 mm hole was drilled in the cap. The platinum wire was pushed through the hole and adhesive was sprayed inside the first five section of the pipe in order to waterproof the PVC pipe.

Salt Bridge

A salt bridge was used to ensure that the reference electrode had a good connection with the soil. The salt bridge was constructed using 1-inch diameter PVC pipe, potassium chloride, and agar. One liter of water was brought to a boil and mixed with 25 g of Agar and 250 mL of a saturated KCl solution. The mixture was allowed to cool into a pourable gel. The gel was poured into the PVC pipe, capped on the bottom, and allowed to completely cool. Two small holes were drilled about 10 cm from the cap into the PVC pipe to allow the salt bridge to connect to the soil. A one-inch diameter auger was used to bore a hole to a depth of 60 cm about 50 cm from the electrodes. The PVC pipe was placed in the hole and another cap was placed on the top end.

Water Table

Water table data were collected using automatic monitoring wells (Remote Data Systems, Inc., Wilmington, NC) at each of the seven sites. The wells were installed using a 4-inch diameter auger to dig a hole to a depth of 200 cm. The well was inserted and the hole was backfilled with sand to cover the slots in the well screen. A 2 cm thick layer of bentonite pellets was placed on top of the sand. Soil was placed above the bentonite and formed into a conical shape to shed water. The water table was measured every hour. The water table was manually averaged over the day to give the average water table depth for that day at each of the seven sites.

Electrode Installation

The electrodes were installed at depths of 25 and 61 cm by hand. A push probe was used to remove soil to the desired depth. The soil removed was placed into a bucket with water to create a slurry. The hole was backfilled with the slurry. The platinum tip was cleaned by scraping with a knife and the electrode was pushed through the slurry into the undisturbed ground below.

A support rack was constructed of PVC pipe with two PVC stakes and was installed in each plot by hand as a stabilizer for the electrodes (Fig. 1.5). Each electrode was attached to the PVC pipe using cable ties. The wire from the electrode was stapled to a wooden platform. The electrodes at 25 and 61 cm were placed parallel to each other about 2 m apart.

The electrodes at 457 cm were installed using a drill rig and 3-inch diameter solid stem drills. A 4.5 m deep hole was bored with the drill rig and the PVC pipe with the electrode in it was pushed through the loose soil to the base of the hole. The soil removed from the hole was used as backfill and bentonite was placed close to the surface and covered with a mound of soil.

Automated Redox System Setup

The redox electrodes were connected to an automated system using a multiplexer (Campbell Scientific 16/32 and AM 416), solar panel, battery and a data logger (Campbell Scientific CR10X) (Fig. 1.6). A watertight metal box was secured to a metal pole with a battery, multiplexer and data logger inside. The solar panel was attached to the metal pole and connected to the battery to provide constant power. Color-coded wires were run from the multiplexer through a 0.5-inch diameter PVC pipe placed on the ground that was long enough to reach the redox electrodes. A color-coded wire was then connected to each of the 15 electrodes and duct tape was used to ensure the wires remained connected (Fig. 1.7). A calomel reference electrode (Corning) was attached to the data logger and placed into the salt bridge (Fig. 1.8). The thermocouples and the air temperature probe were directly attached to the data logger. The datalogger was not grounded. The datalogger program was installed to the datalogger after all other components had been installed.

Redox Data Recording and Downloading

The soil redox potential measurements were recorded every 10 minutes for each electrode. The 10-minute readings were averaged hourly and the hourly readings were averaged daily. The readings were automatically corrected by adding 244 mV to convert the field voltage to that which would be measured using a standard hydrogen electrode. The mean annual soil temperature and the air temperature were measured at the same intervals.

Redox and temperature were downloaded monthly to a laptop computer. The data were collected in tab-delimited format and converted to Microsoft Excel workbook format.

Determining Anaerobic Conditions

The technical standard, developed by the National Technical Committee for Hydric Soils, was used to determine when anaerobic conditions began. The Eh required for anaerobic conditions was calculated for each site and depth using the following equation:

$$Eh\ (mV) = 595 - 60(pH) \quad [1]$$

The soil pH used was determined using the 1:1 soil to water ratio in the lab as described in the Methods of Soil Analysis (McLean, 1982). The pH was measured twice at both 25 and 61 cm.

Water Table and Redox

The daily average soil redox potential at each site was compared with the daily water table depth. The days where the water table rose to a depth of 25 or 61 cm were plotted along with the Eh for that site (Fig. 1.9). The duration of saturation for the site shown in Fig. 1.9 was 11d. The time it took for the soil Eh to fall below the anaerobic threshold [equation 1] was called the lag time. The time required for the Eh to rise above the anaerobic line after the water table had receded from 25 or 61 cm was called the extended anaerobic condition (Fig. 1.9). The data shown in Fig. 1.9 has a La value of 3d and the Ea value was 1d.

The La and Ea values were determined to allow the duration of anaerobic conditions to be estimated from a record of water table levels. An equation for computing duration of anaerobic conditions from the duration of saturation is:

$$Da \text{ (days)} = Ds - La + Ea \qquad [2]$$

where:

Da is duration of anaerobic conditions, Ds is duration of saturation, La is lag time for anaerobic conditions to develop after saturation begins, Ea is the extended anaerobic condition after saturation ends. The duration of anaerobic conditions for the data shown in Figure 1.9 was 9d. The La and Ea values were averaged across the seven sites based on soil type (organic and mineral soil).

Soil temperature was monitored to determine whether lag values varied with temperature. The average daily soil temperature (50 cm) was found for lag time events and was compared to the lag time value. A multiple linear regression was run using the SAS procedure PROC GLM to determine whether a significant relationship existed between the La values based on soil organic carbon and temperature (SAS, 2000).

Total Organic Carbon

Piezometers were installed to depths of 25 and 61 cm at all seven sites and to a depth of 457 cm at four sites. Using a drill rig a hole was bored down to a depth of 457 cm. Piezometers at 25 and 61 cm were installed using the same procedure used for wells. The piezometers at 457 cm were installed using a procedure similar to that used for the deep redox electrodes. The piezometer was inserted and the hole was backfilled with soil material. Water samples were collected from the piezometers using a bailer. Water was not present at many sites when sampling was done. The total organic carbon was measured in the laboratory using a Total Organic C Analyzer.

Reference Bays

The soil redox potential was measured at three sites in each of three natural reference bays, Tatum Millpond, Charlie Long Millpond, and Causeway Bay, and water table depth was measured at multiple sites along a transect in each of the reference bays (Figs. 1.3a, b, and c).

Soil Redox Potential Measurements

Five platinum tipped electrodes were installed to depths of 25 and 61 cm at three sites in each of the reference bays. The electrodes were made and installed in the same manner as described earlier. The electrodes were placed in a mineral, a deep (>80 cm) organic soil and a soil with a histic epipedon. The mineral soils were located at the perimeter of the bays and were classified as Torhunta (coarse loamy, siliceous, active, acid, thermic, Typic Humaquepts), Lynn Haven (sandy, siliceous, thermic, Typic Alaquods), and Leon (sandy, siliceous, thermic, Aeric Alaquods) (Leab, 1990). The organic soils were located in the center of the bays and were classified as Pamlico (sandy or sandy-skeletal, siliceous, dysic, thermic Terric Haplosaprist), and Croatan (loamy, siliceous, dysic, thermic, Terric Haplosaprist) (Leab, 1990). Tatum Millpond had Pamlico, Croatan, Torhunta, and Lynn Haven series soils (Leab, 1990). Charlie Long Millpond had Pamlico, Lynn Haven, and Leon series soils (Leab, 1990). Causeway Bay had Pamlico, Lynn Haven and Leon series soils (Leab, 1990). The electrodes were read manually using an AP46 Accumet voltmeter. The voltages were corrected by adding a factor of 200 mV because a Ag/AgCl reference electrode was used.

Water Table Measurements

The water table was measured using the automated wells, which were installed as described above. The wells were placed in a mineral, shallow organic (40-80 cm), and deep organic (>80 cm) soil and a soil with a histic epipedon (Fig. 1.10). The water table depth was measured every hour and the average daily water table depth was determined manually.

Duration of Anaerobic Conditions

The lag time and extended anaerobic condition values found from the redox study at Juniper Bay were used to estimate duration of anaerobic conditions at the reference bays. The periods of saturation, as determined by well data at the reference sites, were used in [equation 2] and the appropriate lag value and extended anaerobic value were used depending on whether the soil was an organic or mineral soil.

Lees (2004) found that the vegetation at three natural Carolina Bays changed across the bay and there was a correlation between soil type and plant community. There was a significant difference in the amount of several available nutrients in the A horizons between soil types and/or plant communities (Lees, 2004). The difference in nutrient availability between the soil and community types can also be attributed to the depth of organic material and corresponding shallower seasonal water table depth (Lees, 2004). The periods of anaerobic conditions between the four different plant communities (Fig. 1.10), pond pine woodland, non-riverine swamp forest, bay forest and high pocosin, were compared in order to determine if a difference existed.

RESULTS

Juniper Bay

Soil Properties and Temperature

The soil profile descriptions shown in Tables 1.1, 1.2 and 1.3 illustrate the major morphological differences among the organic, histic, and mineral soils found in

Juniper Bay. The Oa horizon in the organic soils extended to depths of 60 to 70 cm. It was capped in places by a thin mineral surface layer that was created through agricultural practices used at the site that applied material from ditch cleaning operations to the fields adjacent to the ditch. Redox electrodes at depths of 25 and 61 cm were in organic material that had coarse prismatic structure. Structural cracks were spaced approximately 7 cm apart.

The soils with histic epipedons had an organic layer that was approximately 24 cm thick. Redox electrodes at 25 cm were in organic material that had a coarse granular structure. Electrodes at 61 cm were in mineral material that had a sandy loam textural class with sub-angular blocky structure. Mineral soils ranged in texture from sandy loam to loamy sand at the depths of redox electrodes. Soil structure ranged from sub-angular at 25 cm to prismatic at 61 cm.

Table 1.4 shows selected chemical and physical properties for the three types of soils at Juniper Bay. As organic C quantities increased across the soils, the bulk densities decreased, cation exchange capacity increased, and base saturation decreased. Soil pH values tended to decrease from the mineral to organic soils. Farmers tend to apply more lime to mineral soils than organic soils because the optimum pH for growth of most crops is higher in mineral soils. This is due to aluminum toxicity which, is not a major problem found in organic soils The soil pH values shown are typical for those used for agriculture in a Carolina Bay in eastern NC (Bruland et al., 2003).

Mean monthly soil temperatures are shown for an organic and mineral soil in Fig. 1.11 at a depth of 20 cm. At this depth the soil temperature is constant throughout the day and the recorded temperature is equal to the average daily soil temperature. Soil temperatures were similar between the two soil groups and in all months were above 5 C. This indicated that the microbial population was able to remain active year round (Megonial et al., 1996).

Water Table and Redox Fluctuations

Organic Soils

Typical water table fluctuations in an organic soil are shown in Fig. 1.13. When the water table rose above a depth of 25 cm during the late spring and summer, the duration of saturation at 25 cm tended to be short (<3 d). Multiple rainfall events that occurred within a 3 d interval could maintain the water table above a depth of 25 cm for up to 9 d. Drainage of water was rapid in the upper 50 cm of the soils, and between rainfall events the water table could fall to depths of 70 to 80 cm. Longer periods of saturation did occur at 61cm than at 25 cm, with saturation lasting between 9 and 33d (Fig. 1.13).

Typical Eh changes following saturation events at 25 cm are shown in Figure 1.14. The Eh that developed between saturation events was approximately 500mV in aerobic soil and dropped quickly when the soil horizon saturated. The lag time (La) for the soil to become anaerobic was between 1 to 2d. The lowest Eh values were approximately 50 to 100mV when anaerobic conditions were maintained for at least 2 d. For example, on 5/23/03 the soil saturated at a depth of 25 cm and anaerobic conditions began on 5/24/03, producing a La value of 1d (Fig. 1.14). After the water table fell below 25cm the Eh rose quickly requiring only 2d for aerobic conditions to return (Fig. 1.14). This occurred for example on 6/22/03 and aerobic conditions returned on 6/24/03, producing an Ea (extended anaerobic conditions) of 2d.

The Eh dynamics were similar at a depth of 61cm to those found at 25cm although the ranges in Eh fluctuation were greater (Fig. 1.15). The maximum Eh between saturation events was approximately 550mV and fell quickly after saturation to approximately 150mV. The saturated horizon at 61cm had similar La and Ea values to those found at the 25cm depth. Figure 1.15 shows an example of La and Ea values at 61cm. The 61cm horizon saturated on 10/11/02 and anaerobic conditions began on 10/12/02, producing a La value of 1d. The water table fell below 61cm on 12/1/02 and aerobic conditions returned on 12/2/02 producing and Ea value of 1d.

Mineral Soil

The water table in the mineral soils did not fluctuate as often as in the organic soils and this produced longer DS values (Fig. 1.16). The water table could fall to -95 cm and rise above the soil surface during rainfall events (Fig. 1.16). The DS values at 25cm were generally short (3 to 8d) and at 61cm were between 10 to 34d (Fig. 1.16). The water table in both mineral and organic soils was not present for extended periods of time at the 25cm depth.

Typical Eh changes at 25cm are shown in Fig. 1.17 for periods before and during saturation events. The maximum Eh before saturation events was approximately 650mV and dropped quickly when the horizon saturated. The lowest Eh values were approximately 0 to 100mV when anaerobic conditions were present. Once saturated, the soil became anaerobic within 1 to 3d. After the water table fell to a depth greater than 25cm, the Eh rose quickly requiring only 2d for aerobic conditions to return (Fig. 1.17). For example, at a depth of 25cm the horizon saturated on 3/20/03 and anaerobic conditions began on 3/23/03, producing a La value of 3d. The water table fell below 25cm on 7/19/03 and aerobic conditions returned on 7/21/03, producing an Ea of 2d.

The Eh changes at 61cm in a mineral soil were comparable to those found at the 25cm depth (Fig. 1.18). The maximum Eh between saturation events was approximately 550 to 600mV and fell quickly after saturation to between 0 to 50mV. The La and Ea values were similar at both 25 and 61cm depth. As shown, in Fig. 1.18, the horizon at 61 cm saturated on 3/15/03 and anaerobic conditions began 3d later on 3/18/03. The water table fell below 61cm on 6/22/03 and aerobic conditions began on 6/25/03, producing an Ea of 3d. In the mineral soil the water table rose and fell several times around 25 and 61cm and the La and Ea values were computed for each instance.

Mean La and Ea values are shown for mineral and organic soils groups in Table 1.5. Values were computed both during the growing and outside the growing season because saturated occurred during both periods. The La values were consistently less than 3d in both organic and minerals soils at both 25 and 61cm (Table 1.5). The La value increased slightly at 61cm in an organic soil during the non-growing season, and the difference was statistically significant ($p=0.018$). The Ea values were on average longer in the mineral soils, at both depths, than the organic soil (Table 1.5). The recovery times (Ea) were longer (<10d) than the La values in both soil groups, and Ea values were slightly higher in the mineral soils than in organic soils (Table 1.5).

Diurnal Fluctuations

Diurnal fluctuations in Eh were observed in only one plot in Juniper Bay (Fig. 1.19). The soil was mineral and was saturated for the longest period of all the mineral instrumented plots at Juniper Bay. The Eh was highest during the afternoon and reached the lowest Eh at night (Fig. 1.19). The maximum diurnal change in Eh was approximately 200mV and the lowest was approximately 50mV. The diurnal fluctuations did not generally bring the soil from aerobic to anaerobic conditions because they only were observed when the soils were saturated and anaerobic (Fig. 1.19).

The timing and periodicity of the diurnal Eh changes suggested that hydrophytic vegetation produced the periodic fluctuation in Eh. The hydrophytic vegetation undergoes photosynthesis during the day and expels O_2 to the roots and oxidizes the soil around the roots and the Eh levels rise. At night photosynthesis ends and O_2 is no longer transported to the roots, and the Eh decreases in the soil around the roots (Fig. 1.20). The hypothesis that hydrophytic vegetation causes these fluctuations corresponds with the daily duration of the fluctuations and the season in which they occurred. Diurnal fluctuations were observed only during the growing season, and began in March and ended in late October to early November. The growing season in Robeson Co., NC begins on 3/14 and ends on 11/14 (McCachren, 1978). The diurnal fluctuations shown in Fig. 1.19 occurred from 10/8/03 to 10/16/03, during the growing season. Outside the growing season, the pattern shown in Fig. 1.21 was observed, where there were no apparent diurnal change. The diurnal fluctuations shown in Fig. 1.21 are from 11/13/02 to 11/21/03, at the end of the growing season. Grosse (1996) found that radial oxygen loss exhibits diurnal variation and daytime had the greatest oxygen loss to the soil. Armstrong (1978) found that radial oxygen loss can increases the redox potential of the surrounding soil. The loss of oxygen is driven by diffusion (Cronk and Fennessy, 2001) and occurs more readily under flooded conditions than drained soils (Kludze et al. 1994).

Factors Affecting La

The La values should be related to the rate that microbes consume dissolved oxygen in the soil solution. Oxygen will be consumed faster as the level of organic C increases because the size of the microbial population increases. We assumed that the size of the microbial population was related to the amount of organic C in the soil, while the rate of microbial activity was related to soil temperature. Microbes increase in activity as soil temperature increases up to approximately 35 to 40 C (Atlas and Bartha, 1987). Anderson and Domsch (1980) found that the soil microbial population increased as the amount of labile carbon in the system increased.

The relationship between daily soil temperature and La values for an organic soil is shown in Fig. 1.22. The soil temperature in the organic soil when anaerobic conditions formed ranged from 11 to 24C at 25cm and 13 to 25C at 61cm. The La values for both depths ranged from .5 to 2d across the temperature gradient (Fig. 1.22). The majority of the events had a La of 1d across an 11 or 12C temperature change.

The mineral soil had more variation in La values than the organic soil. The soil temperature when anaerobic conditions formed ranged from 7.5 to 20C at 25cm and 8 to 16C at 61cm (Fig. 1.23). The La at 25cm increased from 2 to 3d across the 12.5C temperature change (Fig. 1.23). The La at 61cm was the longest, 5d, at the highest soil temperature, 16C. Again, several observations had a La of 2d across the 12C temperature gradient. In summary, the average daily soil temperature, measured at 50cm, had virtually no detectable relationship to La values in either the organic or mineral soils during the course of this study. Temperatures were probably not low enough to slow microbial activity sufficiently.

Soil Organic Carbon

Soil organic carbon was related to La values (Fig. 1.24). Figure 1.24 includes the La values from Juniper Bay, the reference bays and two soils from a different study. He et al (2003) found the La values used in Fig. 1.24 and Hayes and Vepraskas (2000) found the corresponding soil organic carbon values. The La was consistently small, <5d when the soil OC was >0.03 g/g. The La increased where the soil OC was <0.03 g/g. The majority of La values with soil OC <0.03 were $\geq$15d. The occurrences of low soil OC and small La values, circled on Figure 1.24, had higher amounts of soil OC in the overlying soil horizons. The overlying soil OC amounts were approximately 0.03 g/g. The soil OC can be moved downward through the soil during rain events as the water table rises allowing for short La values. The other events with soil OC <0.03 and longer La values had a range of soil OC in the overlying horizons of 0.005 to 0.025g/g. These horizons did not have the presence of soil OC from overlying horizons to facilitate the onset of anaerobic conditions.

The soil organic carbon at Juniper Bay ranged from less than 0.01 in the mineral soils to 0.31g/g in the organic soils (Table 1.4). There was a significant relationship between soil organic carbon and La values at $p = 0.009$ and soil OC^2 was significant at $p = 0.004$. We hypothesize that the soil horizons with high amounts of soil OC had large microbial populations. The large microbial population was able to use the dissolved O_2 in the soil as its major electron acceptor during respiration (Fig. 1.25). This allowed anaerobic conditions to form in 1 to 2 d following the onset of saturation. The soil horizons with lower soil OC probably had smaller microbial populations that were unable to reduce the O_2 throughout the soil as quickly and produce anaerobic conditions.

Soil temperature had virtually no significant relationship ($p > 0.5$) with La, when measured at 50 cm, in these soils. The interaction of soil temperature and soil organic carbon was also not significant ($p > 0.5$). The soil temperature in the Coastal Plain of North Carolina does not generally fall below 5C, which has been taken as "biological zero" or the temperature below which microbial activity virtually stops. Therefore, the soil temperature did not reduce the microbial activity.

Deep Eh Levels

The amount of total OC at 457 cm was 45 and 220 mg C/L for the mineral and organic soils respectively (Fig. 1.26). The source of the carbon is not known but it could originate in the overlying soil and move down and through the soil into the sediments. The Eh at 457 cm remained anaerobic beneath both organic and mineral soils throughout the study (Fig. 1.27 and 1.28). There is a possibility that during the installation of the redox electrodes O_2 entered the system at 457 cm. This can be seen in Fig. 1.28, where the Eh is high immediately after the insertion of the probes and eventually the O_2 is consumed and the soil falls into the anaerobic zone. The organic soil could have had O_2 entering the system after the insertion of the probes but the high level of total organic carbon allowed for the rapid return of anaerobic conditions (Fig. 1.27). The amount of soil carbon present at this depth is able to support a microbial population that maintains continual anaerobic conditions.

Reference Bays

Soil Properties

The soil profile descriptions shown in Tables 1.6, 1.7 and 1.8 illustrate the major morphological differences among the organic, histic and mineral soils found in the reference bays. The O horizons in the organic soils extended to depths of 80 to 90 cm. The upper horizons were comprised of fibric and hemic organic material, which was not found at Juniper Bay due to drainage and agricultural practices. Redox electrodes at depths of 25 and 61 cm were in hemic and sapric organic material respectively, that had a massive structure.

The soils with histic epipedons had an organic layer that was approximately 36 cm thick. Redox electrodes at the 25 cm depth were in sapric muck that had a massive structure. Redox electrodes at 61 cm were in mineral material that had a sandy loam textural class and a massive structure. The mineral soils ranged in texture from sand to sandy loam at the depths of redox electrodes. Soil structure changed from single grain at 25 cm to sub-angular blocky at 61 cm.

Table 1.9 shows selected chemical and physical properties for the three types of soils at the reference bays. As organic C quantities increased across the soils, cation exchange capacity increased and the soils' bulk density decreased. The soil organic carbon was slightly higher at the reference bays than at Juniper Bay. Soil pH was fairly constant at each bay across the sol types because these areas have not been exposed to liming agents used in agriculture. The base saturation tends to decrease down through the soil profile.

The mean monthly soil temperatures were not measured at the reference bays. However, the reference bays and Juniper Bay have similar geographic locations and it was assumed that similar soil temperatures were present and the microbial activity was not affected by soil temperature.

La and Ea Values

The reference bays have remained saturated at depths of 25 cm and below for much of the past 2 years in both the organic and mineral soils. The water table rose above the 25 cm depth at the end of 2002 and has only fallen on several occasions at Charlie Long and Causeway Bays. The water table at Tatum Millpond has not fallen below 25cm during the past 2 years. The water table has not fallen below 61 cm during the past two years at any of the reference bays. Therefore, there are only a few examples comparing the La and Ea values, at 25 cm, at Juniper and the reference bays to determine whether they are similar at both locations.

Figure 1.29 shows the water table fluctuation at the beginning of November 2002 in an organic soil at Causeway Bay. The water table is close to saturating the 25 cm horizon on 11/6 and 11/7/02. The measured Eh on 11/7/02 is anaerobic producing a La value of 1d. It can be assumed that the soil was aerobic prior to 11/6/02 because the water table was well below 25 cm the previous 5d. The La value of 1d corresponds with La values found at Juniper Bay in organic soils at 25 cm (Table 1.5). The soil organic carbon at this site is 0.15 g/g (Table 1.9). The amount of carbon is presumably high enough to support a large microbial population, which can produce anaerobic conditions quickly.

The water table in an organic soil at Charlie Long Bay rose above 25 cm on 8/14/04 and the measured Eh on 8/24/04 was anaerobic (Fig. 1.30). The exact La value is not known because, the Eh measurements were made once every two weeks, but it is no longer than 10d. The soil organic carbon at this site is 0.41 g/g and anaerobic conditions could have formed quickly.

The mineral soils in all reference bays had more fluctuation in the water table. The water table in a mineral soil at Charlie Long Bay rose above 25 cm on 8/20/04 and the measured Eh on 8/24/04 was anaerobic, (197 mV, Fig. 1.31). The La value was no longer than 4d, which corresponds with the La value found at Juniper Bay. The soil organic carbon at this site and depth is 0.07 g/g, which allows anaerobic conditions to form quickly (< 5d, Fig. 1.24).

Causeway Bay had several water table fluctuations in the mineral soils. The soil organic carbon, 0.0039 g/g, at this site is considerably lower than mineral soils at Charlie Long, Tatum Millpond and Juniper Bay (Tables 1.4 and 1.9). Figures 1.32 and 1.33 illustrate the variability of La values at sites with low soil organic carbon. Figure 1.32 shows that the horizon at a depth of 25 cm saturated on 6/28/03 and the measured Eh on 6/30/03 was anaerobic. The La value was no greater than 3d. The soil was probably aerobic before the water table rose because the 25 cm horizon was unsaturated for 8 consecutive days prior to 6/28/03 and the Ea values found at Juniper Bay for a mineral soil at this depth, 2.5 to 5d, were shorter than 8d (Table 1.5). The water table rose above 25 cm on 7/29/04 and the measured Eh on 8/5/04 was still aerobic (Fig. 1.33). The La value for this instance was longer than 8d. The water table fell at the same site and later rose above 25 cm on 8/13/04. The Eh measured on 8/24/04 was anaerobic producing a La value no longer than

11d. The La values found at other sites with similar low soil organic carbon had La values of 19d.

There was only one Ea value found in the reference bays and it was found during the period shown in Fig. 1.34. The water table fell below 25 cm on 9/2/03 and the measured Eh on 9/4/03 was still anaerobic. The soil was anaerobic, Eh of –34 mV on 8/28/03, prior to the water table falling below 25 cm. The Ea value is at least 3d for this occurrence, which corresponds to the average Ea value found at Juniper Bay of 4d.

The La values found at the reference bays correspond well with the values found at Juniper Bay (Table 1.10). There are a few instances at Juniper Bay comparable to the reference bays where the soil organic carbon is <0.03 g/g and the La value is <5 d. The overlying soil horizons have soil organic carbon >0.03 g/g.

Automated Measurements

The Eh measurements made during the study at Juniper Bay were automated. The accepted method for redox measurements is on a weekly basis. Figures 1.35 and 1.36 compare automated and weekly redox measurements in an organic and a mineral soil. The weekly measurements do not record all of the anaerobic conditions present at the site but the automated measurements do accurately record the anaerobic conditions. The weekly measurements will record anaerobic conditions that last at least 7d. Weekly measurements are acceptable for the hydric soils technical standard because there will be three measurements that are anaerobic if the duration is 14d or greater.

CONCLUSIONS

The results of this study showed that the time for anaerobic conditions to develop after saturation begins (La) was related to soil organic carbon but not temperature. When soil organic carbon was <.03g/g the La values ranged from 3 to 48d. The soils containing higher soil organic carbon concentrations had La values that ranged from 1 to 12d. In soils that have low soil organic carbon (<0.03 g/g) the La value will be more variable than soils with higher amounts of C. The time of extended anaerobic conditions after saturation ends (Ea) ranged from 1 to 7d in the organic soils and the mineral soils ranged from 2 to 10d. The Ea value was probably related soil permeability, the greater the soil permeability the shorter the Ea values.

The La or Ea values were not determined for the soil at a depth of 457 cm because at this depth soils were anaerobic during the entire course of the study period. There is sufficient dissolved organic carbon at 457 cm to create an anaerobic environment and allow for denitrification in the presence of NO_3^-.

Diurnal Fluctuations in Eh were observed at only one location where a hydrophytic plant was near the platinum electrodes. Diurnal fluctuations ranged from 50 to 150mV during the growing season, and were not large enough to switch the soil from anaerobic to aerobic. The fluctuations did not occur during the non-growing season.

The reference bays were used to verify the La values found at Juniper Bay. The La values in the organic soils corresponded to the La values at Juniper Bay for comparable levels of OC and ranged from 1 to <4d. The La values in the mineral soils were more variable than the La values found at Juniper and ranged from 3 to <11d. The variability in La values is expected due to the lower amount of soil organic carbon than found at Juniper Bay. High amounts of soil organic carbon in overlying horizons could affect La values in horizons with low amounts and contribute to the variability. The La values at the reference bays followed the general trend of increasing La values with decreasing soil organic carbon. The exact La values were not determined at the reference bays because the measurements were not automated.

The weekly manual measurements are acceptable for determining whether the hydric soil technical standard is met when automated water table measurements are made. The redox measurement needs to be in the anaerobic zone and as long as the water table continually saturates the horizon it can be assumed the soil is anaerobic and additional weekly measurements can verify it.

Application

The periodic duration of anaerobic conditions can be computed using La and Ea values and long-term daily water table levels. Long-term daily water table levels can be estimated using DRAINMOD, and La values can be estimated using soil organic carbon. The periods of anaerobic conditions that extend for >14 d can be identified. There are little data available to determine the minimum duration of anaerobic conditions needed to distinguish between hydric and non-hydric soils. The current 14-d criteria for anaerobic conditions, created by the National Technical Committee for Hydric Soils, can be evaluated to determine whether it is suitable for separating hydric and non-hydric soils. Also, the total yearly duration of anaerobic conditions can be found from the same sets of data. This data can be used to compare different hydric soil field indicators based on total duration of anaerobic conditions. It would be possible to determine whether soils that meet a hydric soil indicator associated with the accumulation of organic matter had longer yearly durations of anaerobic conditions than soils that meet an indicator based on iron concentrations.

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Table 1.1. Soil profile of an organic soil at Juniper Bay (Ewing, 2003).

Horizon	Depth (cm)	Matrix	Texture	Structure	Comments
Ap	0-10	10Y/R 2/2	SL	Moderate Medium Granular	Aburpt boundary
Oa	10-20	N 2.5/0	sm	Moderate Fine Granular	Abrupt boundary
OA1	20-51	10YR 2/1	mSiL	Weak Very coarse Prismatic	Clear boundary
OA2	51-61	10YR 2/2	mSiL	Weak Coarse Prismatic	25% charcoal
OA3	61-68	10YR 3/3	mfSL	Very weak Coarse Prismatic	Clear boundary
Bw	68-107	10YR 5/4	vfSCL	Weak Very coarse Platy	Clear boundary
C	107-120	10 YR 6/2	SCL	Strong Medium Angular Blocky	Faint reaction to alpha alpha

Table 1.2. Soil profile of histic soil at Juniper Bay (Ewing, 2003).

Horizon	Depth (cm)	Matrix	Texture	Structure	Comments
Ap	0-22	N 2.5/0	mSL	Moderate Medium Granular	60% organic coatings Clear boundary
Oa	22-36	10YR 2/2	sm	Strong Coarse Granular	Clear boundary
Bw	36-56	10YR 3/3	SL	Weak Medium Sub-angular Blocky	2 % gray sand Clear boundary
BC	56-74	10YR 4/6	LS	Weak Medium Sub-angular Blocky	2% gray sand Clear boundary
C	74-108	10YR 6/6	S	Single Grain	2% gray sand

Table 1.3. Soil profile of a mineral soil at Juniper Bay (Ewing, 2003).

Horizon	Depth (cm)	Matrix	Texture	Structure	Comments
Ap	0-17	10YR 2/1	SL	Weak Medium Granular	Clear boundary
A/E	17-33	10YR 2/1	LS	Weak Medium Sub-angular blocky	25% light gray sand
Bhir	33-50	10YR 3/3	LS	Weak Medium Sub-angular blocky	5% gray sand Gradual boundary
Bt1	50-78	10YR 4/4	SL	Weak Very coarse Prismatic	Gradual boundary
Bt2	78-121	10YR 5/6	SCL	Weak Very coarse Prismatic	Gradual boundary
C1	121-140	10YR 6/2	S	Single Grain	12% grayish brown depletions
2C	140+	10YR 5/2	C	Massive	

Table 1.4. Mean values for selected soil physical and chemical properties for soil horizons containing redox electrodes at Juniper Bay

Soil group	Depth	Soil material	Bulk density	pH	Cation exchange capacity	Base saturation	Soil organic carbon
	cm		g cm^{-3}		$cmol_c$ kg^{-1}	%	g g^{-1}
Mineral	25	Sand	1.39	5.47	54	71	0.02
"	65	Sand	1.59	4.37	38	40	0.01
Histic	18	Sapric	0.90	4.60	217	66	0.37
"	40	Loamy sand	1.36	3.90	49	23	0.03
Organic	20	Sapric	0.57	4.5	260	46	0.31
"	60	"	0.40	3.65	196	19	0.31

Table 1.5. Lag and recovery times (mean ± sd) for two soil groups that were determined in Juniper Bay

Soil group	Depth	Lag time (La)		Recovery time (Ea)	
		Growing season	Non-growing season	Growing season	Non-growing season
	cm	days			
Organic	25	1± .3	1 ± 0	2± 1.5	4.6 ± 2.5
Occurrences		21	3	18	3
Organic	61	1± 0	3.6 ± 2.3	1± 0	1.5 ± .7
Occurrences		6	3	4	2
Mineral	25	2.2 ± .4	N/A	3.8 ± 1.3	N/A
Occurrences		5		4	
Mineral	61	2.3 ± 1.2	N/A	5.6 ± 4	N/A
Occurrences		6		5	

Table 1.6. Soil profile description of an organic soil at the reference bays (Ewing,2003).

Horizon	Depth (cm)	Matrix	Texture	Structure	Comments
Oi	0-20	10YR 2/1	fm to hm	Weak Coarse Platy	Gradual Boundary
Oe	20-50	10YR 2/2	hm	Massive	Many organic bodies
Oa	50-85	10YR 2/1	sm	Massive	Gradual Boundary
OC	85-110	10YR 2/2	mL to mSL	Massive	Gradual Boundary
2C1	110-140	10YR 2/2	SL	Massive	Gradual Boundary
2C2	140-180	10YR 4/1	S	Single Grain	

Table 1.7. Soil profile description of a histic soil at the reference bays (Ewing, 2003).

Horizon	Depth (cm)	Matrix	Texture	Structure	Comments
Oi	0-15	10YR 2/1	hm	Weak Medium Platy	Clear Boundary Root mat
Oa	15-36	N 2.5/0	sm	Massive	Clear Boundary
OC	36-65	N 2.5/0	SL	Massive	Gradual Boundary
C	65-100	10YR 2/2	S	Single Grain	

Table 1.8. Soil profile description of a mineral soil at the reference bays (Ewing , 2003).

Horizon	Depth (cm)	Matrix	Texture	Structure	Comments
Oi	0-10	7.5YR 3/4	fm	Weak Medium Platy	Root mat Leaf litter Clear Boundary
A	10-20	10YR 2/1	SL	Weak Fine Granular	Clear Boundary
E	20-40	10YR 6/1	S	Single Grain	Clear Boundary
Bh1	40-70	10YR 2/1	SL	Weak Medium Sub-Angular Blocky	Clear Boundary
Bh2	70-100	10YR 3/2	LS	Weak Coarse Sub-Angular Blocky	

Table 1.9. Selected physical and chemical properties at the reference bays (Ewing, 2003).

Soiltype	Depth (cm)	pH	Base saturation	Texture	Cation exchange capacity ($cmol_c/kg$)	Bulk density (g/cm^3)	Soil organic carbon (g/g)	Location
Mineral	20	3.4	9.0	sand	11.2	/	0.073	Charlie Long
Mineral	68	4.4	7.0	sand	5.4	/	0.0051	Charlie Long
Histic	28	3.3	5.0	loamy sand	8.2	/	0.12	Charlie Long
Histic	64	3.8	4.0	sand	5.5	/	0.025	Charlie Long
Shallow Organic	32	3.2	10.0	loam	12.4	0.29	0.25	Charlie Long
Shallow Organic	43	3.8	5.0	sandy loam	9.1	0.37	0.12	Charlie Long
Deep Organic	18	3.6	17.0	/	11.6	/	0.41	Charlie Long
Deep Organic	50	3.3	7.0	loam	10.3	0.74	0.18	Charlie Long
Mineral	32	3.7	5.0	sand	3.8	/	0.0039	Causeway Bay
Mineral	66	3.7	2.0	sand	8.9	/	0.015	Causeway Bay
Histic	26	3.5	6.0	loamy sand	10.8	/	0.15	Causeway Bay
Histic	63	4.0	7.0	sand	8.4	0.79	0.076	Causeway Bay
Shallow Organic	30	4.1	28.0	/	4.7	/	0.42	Causeway Bay
Shallow Organic	57	3.2	7.0	loamy sand	11.1	0.54	0.074	Causeway Bay
Deep Organic	19	3.6	13.0	/	11.8	/	0.4	Causeway Bay
Deep Organic	50	3.3	14.0	/	12.2	/	0.32	Causeway Bay
Mineral	20	3.7	5.0	sandy loam	8	/	0.098	Tatum Millpond
Mineral	68	4.6	10.0	sand	1.0	/	0.0009	Tatum Millpond
Histic	20	3.7	11.0	/	10.8	/	0.37	Tatum Millpond
Histic	56	3.7	4.0	loamy sand	9.1	0.5	0.075	Tatum Millpond
Shallow Organic	20	4.2	9.0	/	10.4	/	0.28	Tatum Millpond
Shallow Organic	65	3.6	5.0	sandy loam	8.8	0.4	0.13	Tatum Millpond
Deep Organic	20	3.9	8.0	/	12.2	/	0.41	Tatum Millpond
Deep Organic	69	3.4	0.0	/	11.4	0.18	0.39	Tatum Millpond

Table 1.10. Summary of La values found at the reference bays in mineral and organic soils.

Location	Soil Organic Carbon (g/g)	La Value (days)
Organic		
Charlie Long	0.41	<10
Causeway	0.15	1
Juniper Bay	0.27	1
Juniper Bay	0.0076	3
Juniper Bay	0.3	1
Juniper Bay	0.44	1
Mineral		
Charlie Long	0.07	<4
Causeway	0.004	<3
Causeway	0.004	>8
Causeway	0.004	<11
Juniper Bay	0.0072	3.25
Juniper Bay	0.028	2.5
Juniper Bay	0.04	3.5
Juniper Bay	0.061	2
Juniper Bay	0.46	1

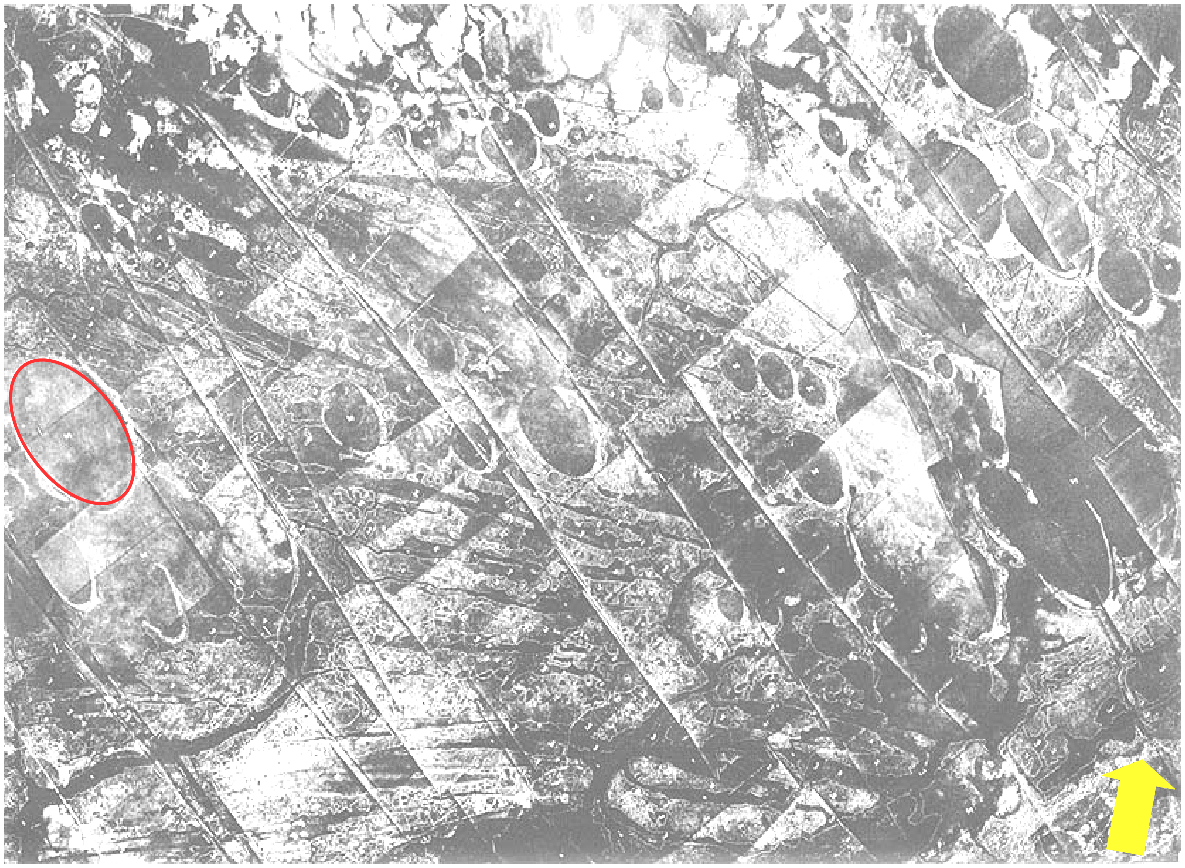


Figure 1.1. Area near Myrtle Beach, SC, showing several Carolina bays on the landscape. The red circle represents one of the many Carolina bays present.

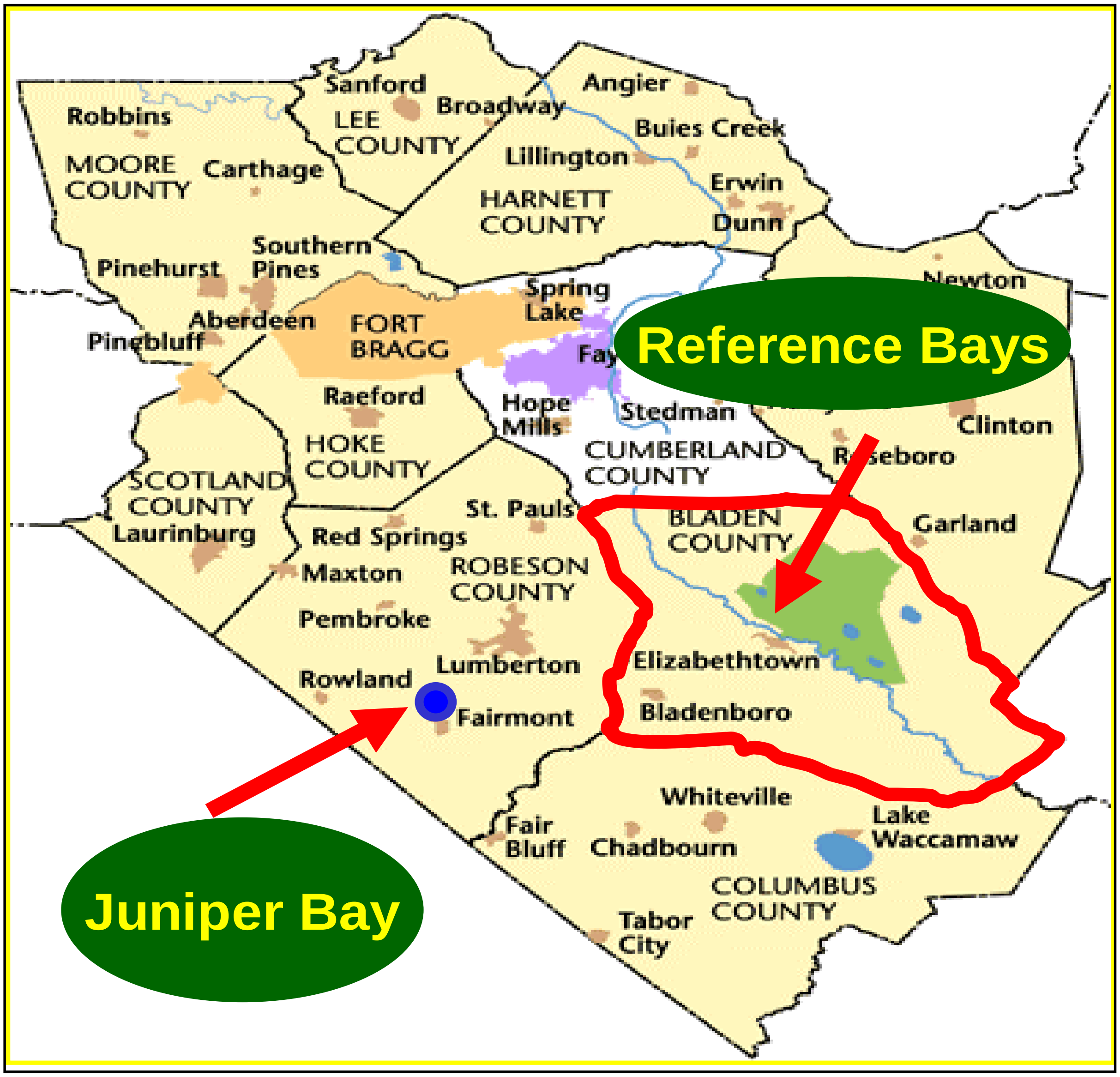
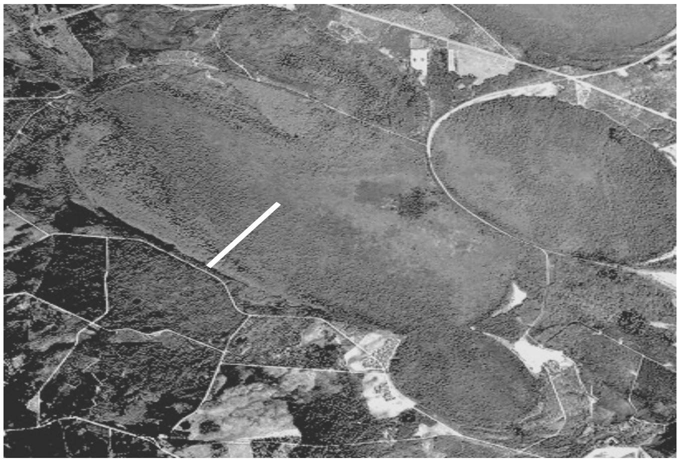
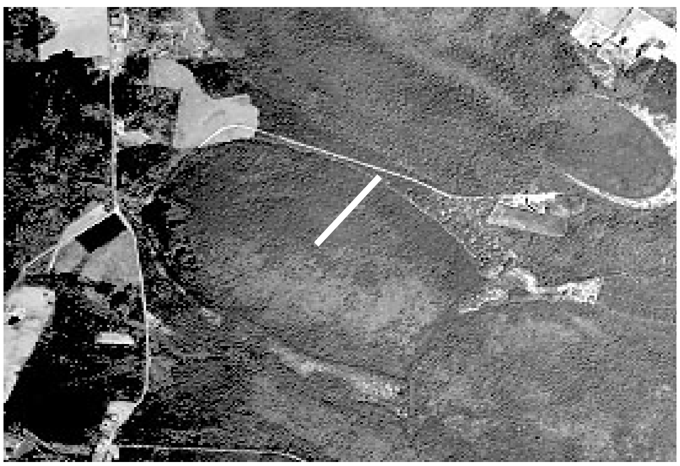


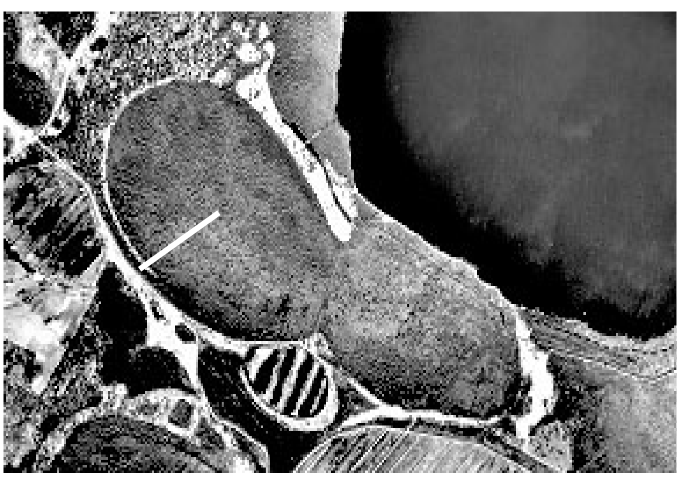
Figure 1.2. The locations of Juniper Bay and the reference bays (Ewing, 2003).



a.



b.



c.

Figure 1.3. The three reference bays a) Tatum Millpond b) Charlie Long Millpond and c) Causeway Bay (Ewing, 2003).

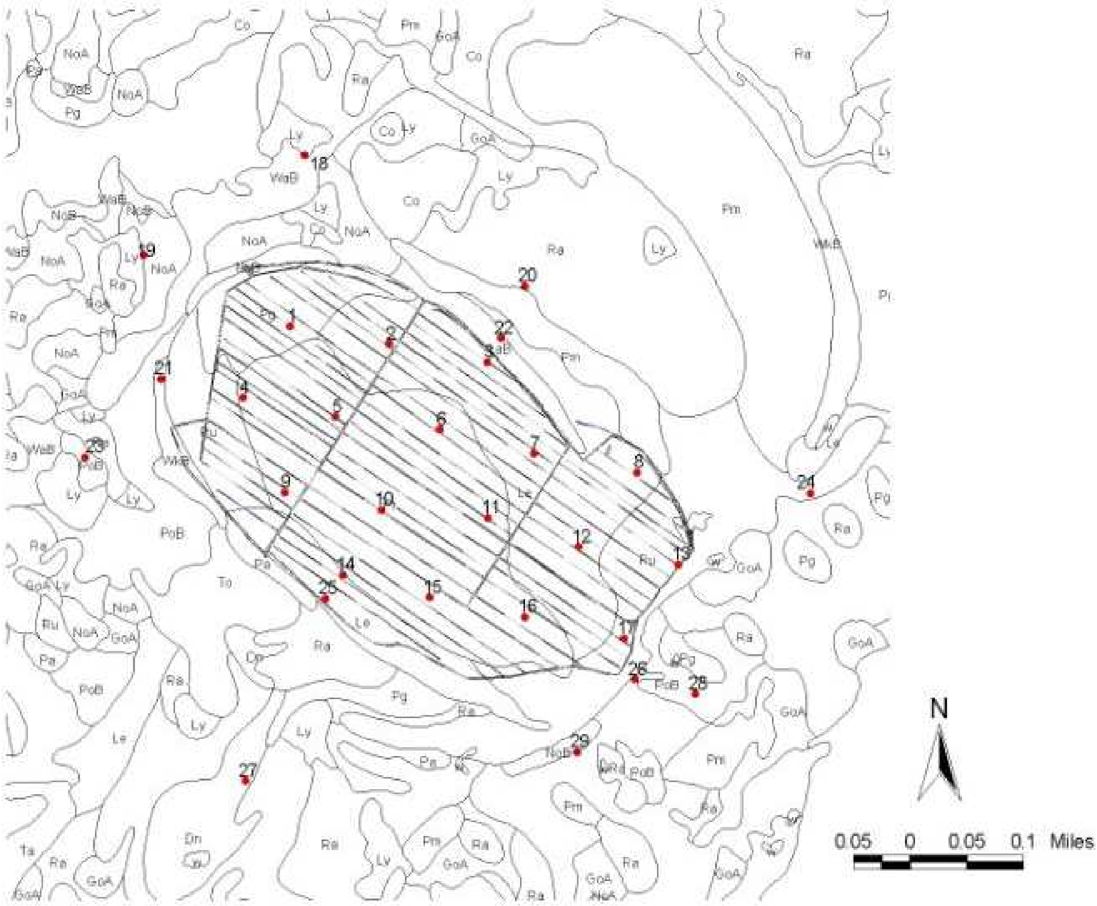


Figure 1.4. General soils map of Juniper Bay showing the distribution of organic and mineral soils.

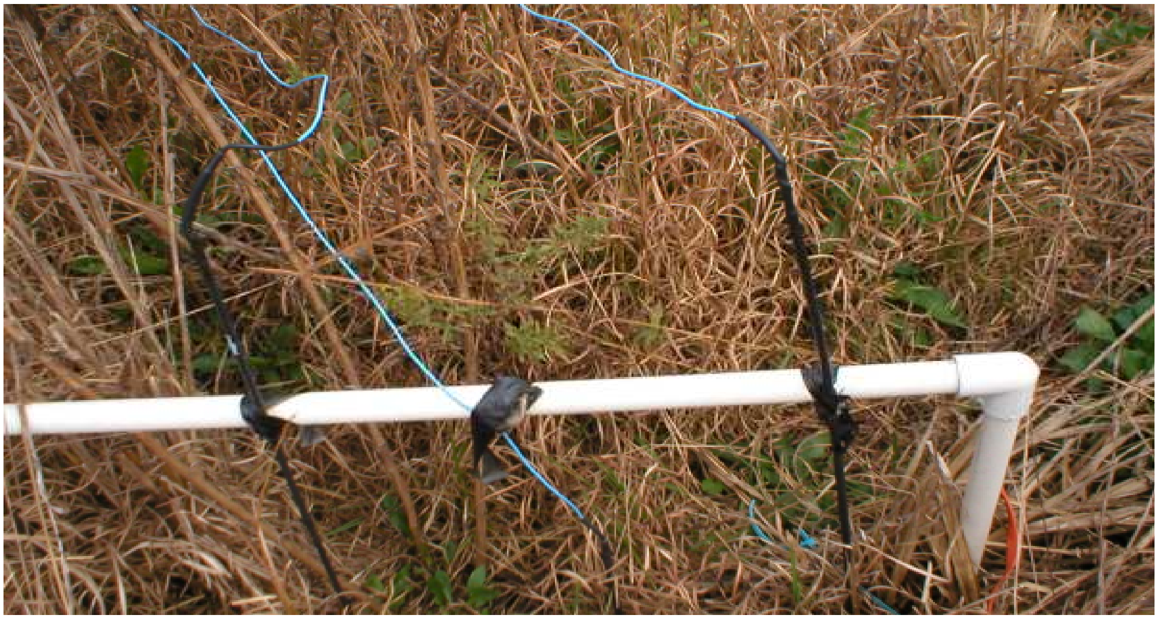


Figure 1.5. The picture of the electrodes and the PVC pipe

Figure 1.6. The picture of the datalogger, solar panel, multiplexer entire setup.

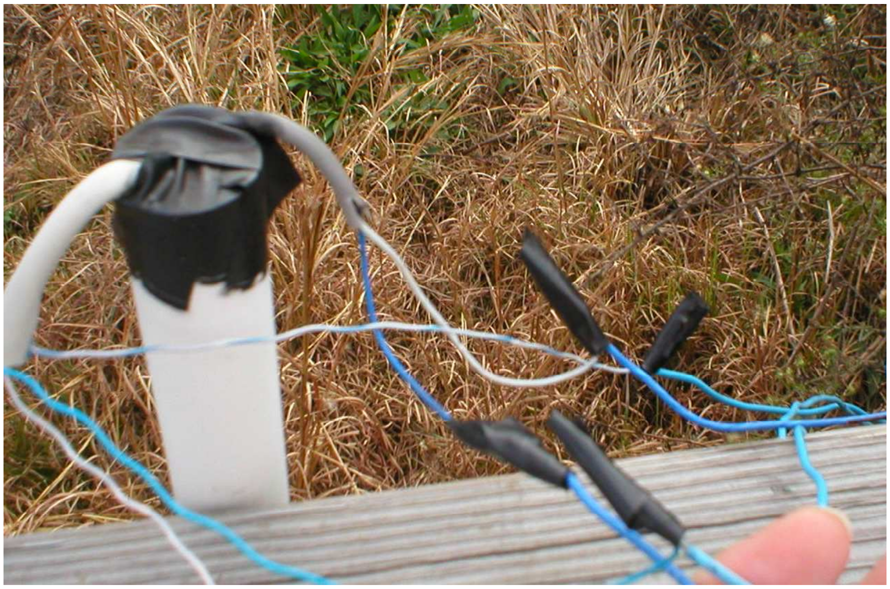


Figure 1.7. Showing wires from multiplexer to PVC pipe and electrical tape.

Figure 1.8. The reference electrode in the salt bridge.

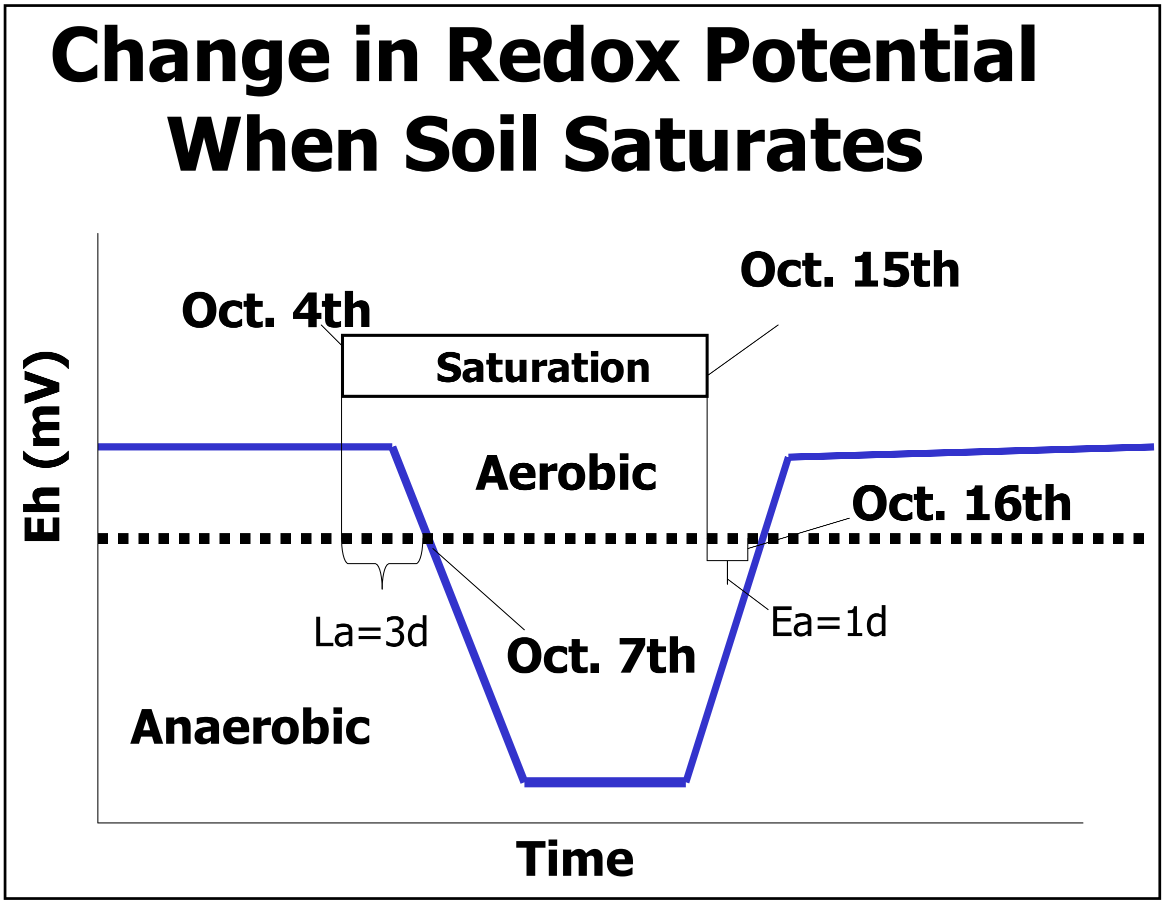


Figure 1.9. Example of computing the lag time values (La) and extended anaerobic conditions (Ea). The duration of saturation (Ds) is 11d. The La in this example is 3d and the Ea is 1d. The duration of anaerobic conditions (Da) is 9 days. Dotted line represents the aerobic/anaerobic line. The fluctuating blue line represents daily soil Eh values. The box above the Eh line is a saturation event.

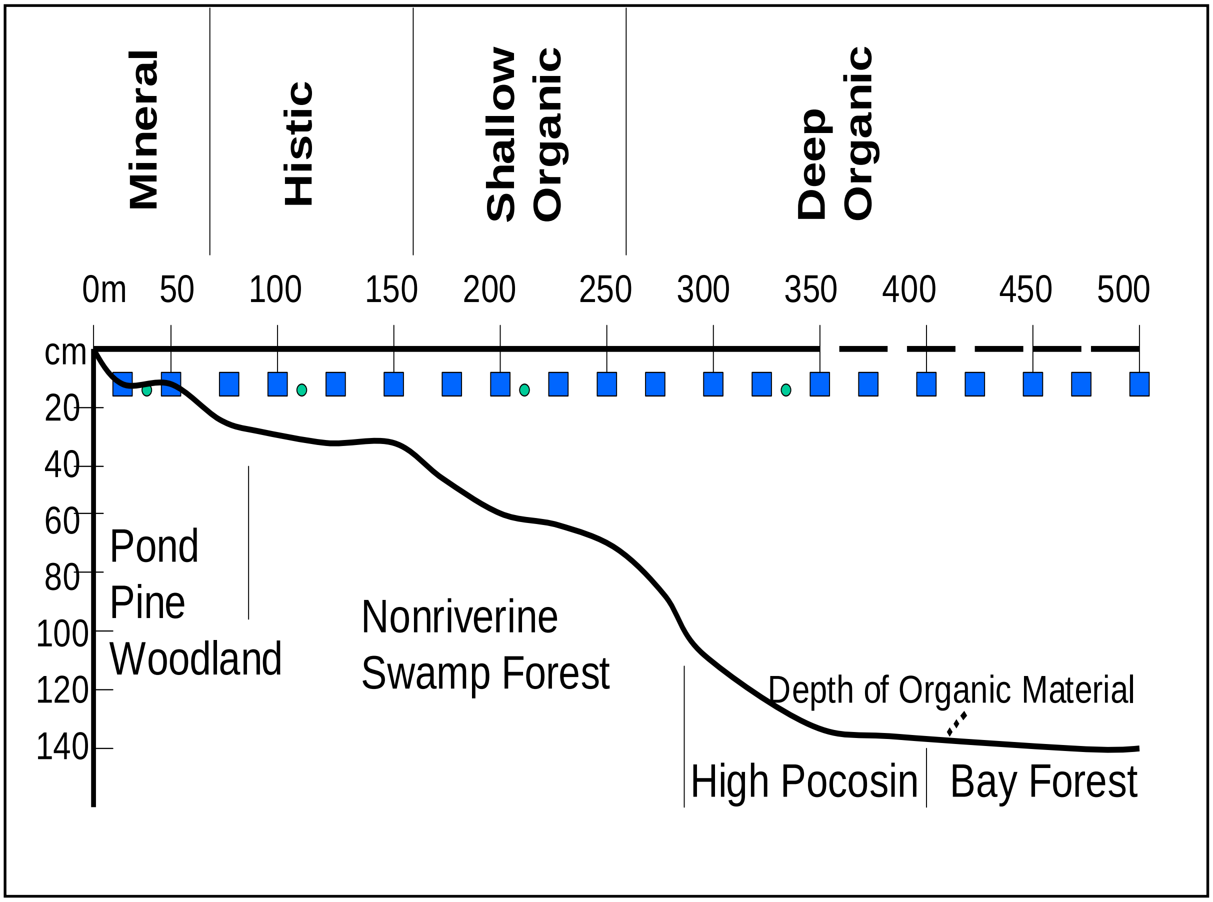


Figure 1.10. The different soil types and plant communities found at one of the reference bays. Each of the squares represents a vegetation plot and the circles are the locations of wells (Lees, 2004).

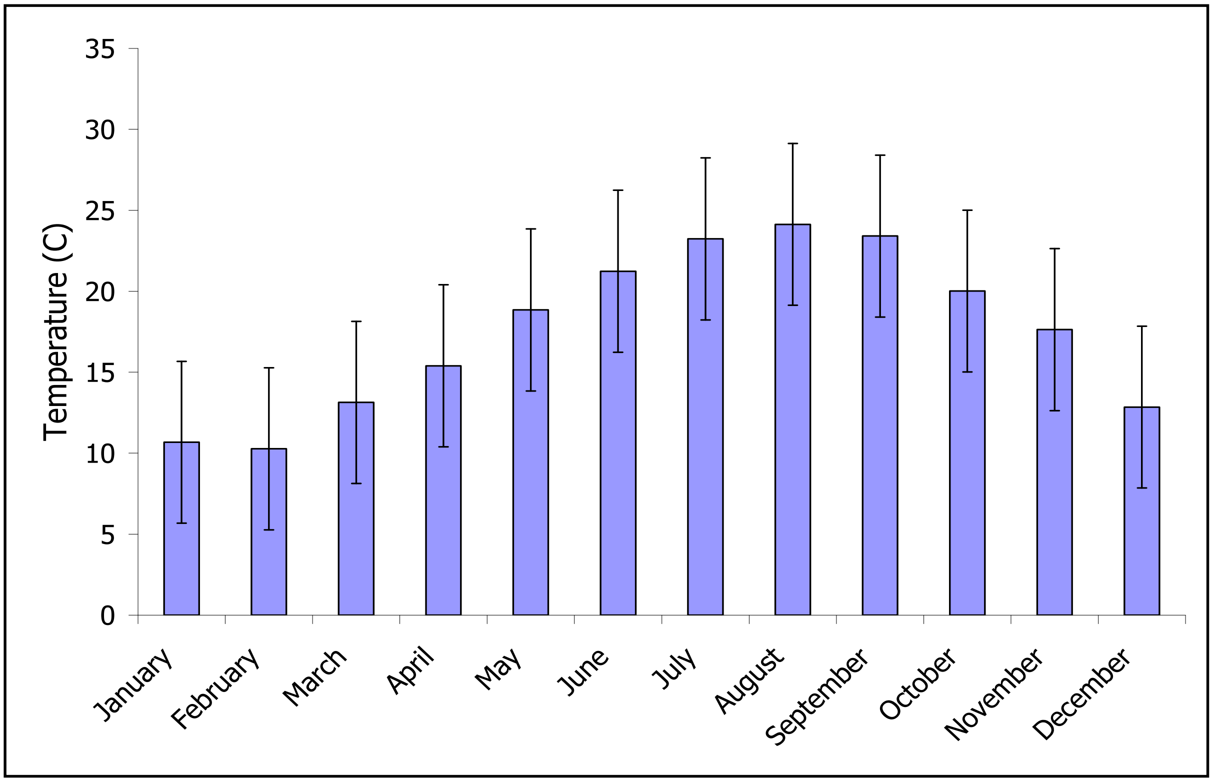


Figure 1.11. Average monthly mean soil temperatures at 50 cm in 2003 in an organic soil.

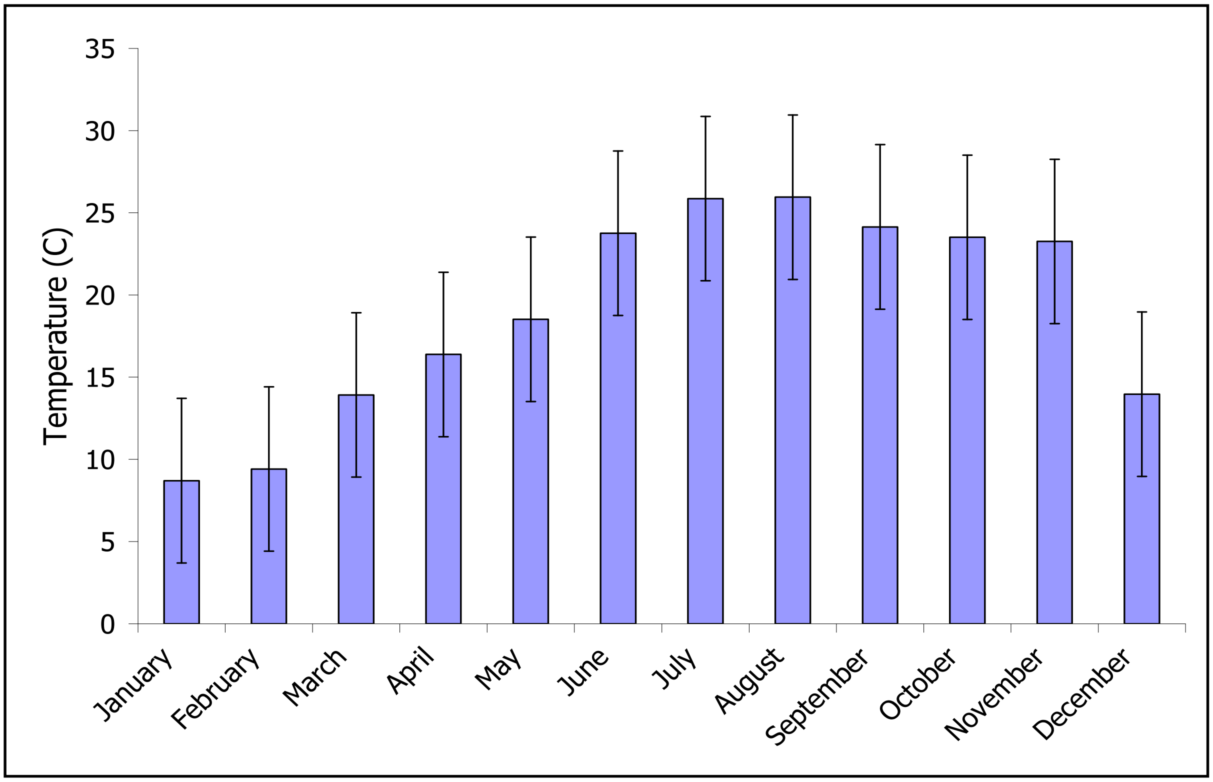


Figure 1.12. Average monthly mean soil temperatures at 50 cm in 2003 in a mineral soil.

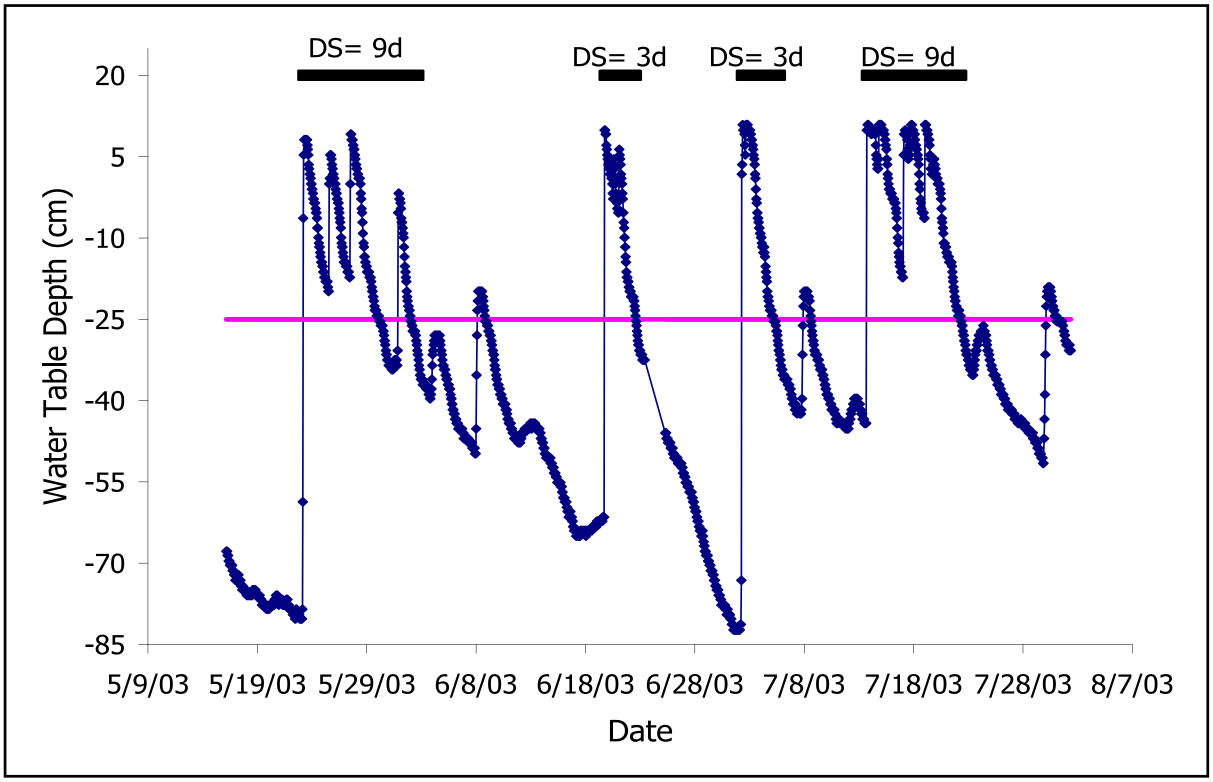


Figure 1.13. An example of water table fluctuation in an organic soil at Juniper Bay. The top line represents the duration of saturation (DS) and the bottom line represents the water table at a depth of 25 cm. Each dot represents an hourly measurement.

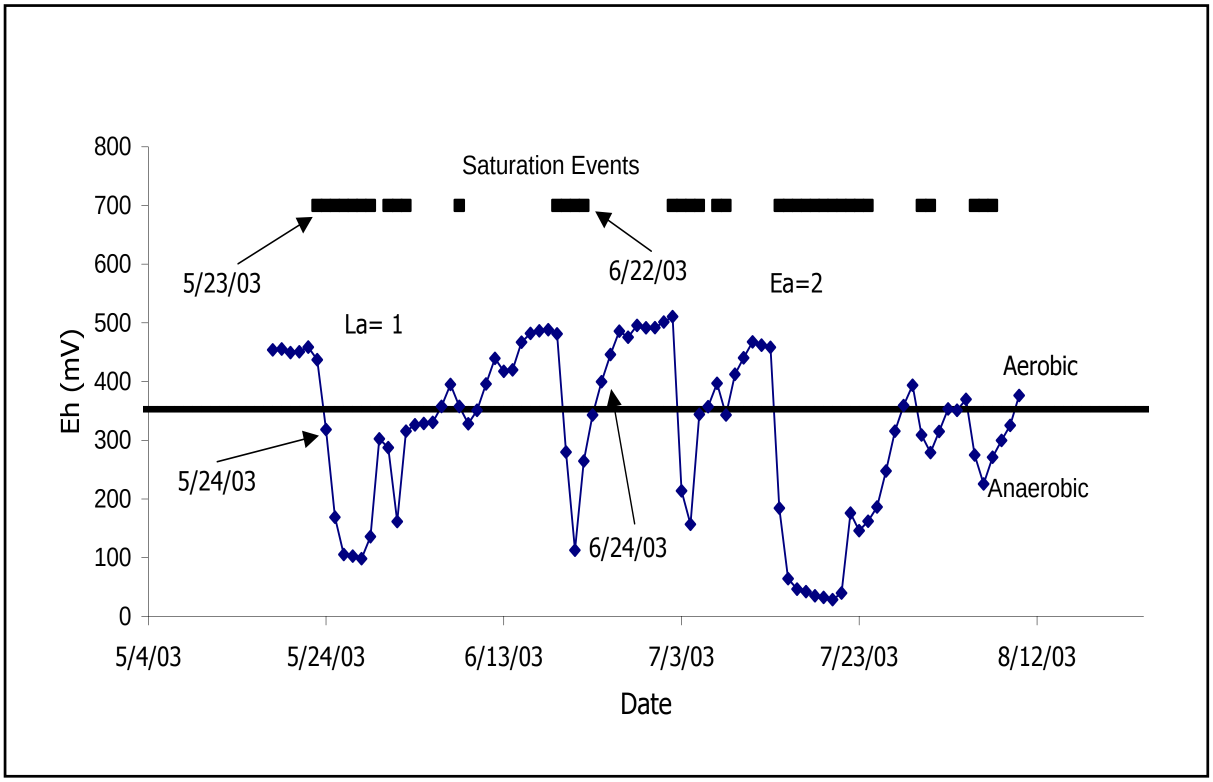


Figure 1.14. Time to develop anaerobic conditions in an organic soil at 25 cm. Each dot represents a daily Eh average.

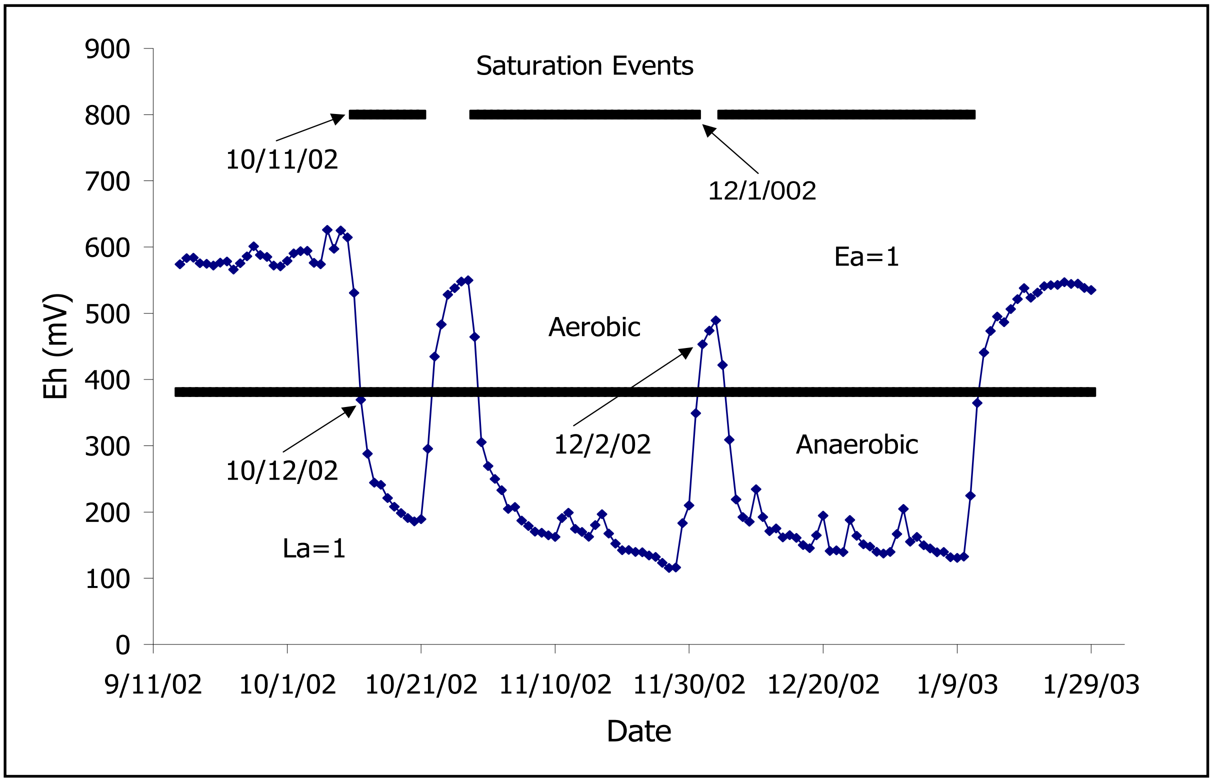


Figure 1.15. Time to develop anaerobic conditions in an organic soil at 61 cm. Each dot represents an average daily Eh average.

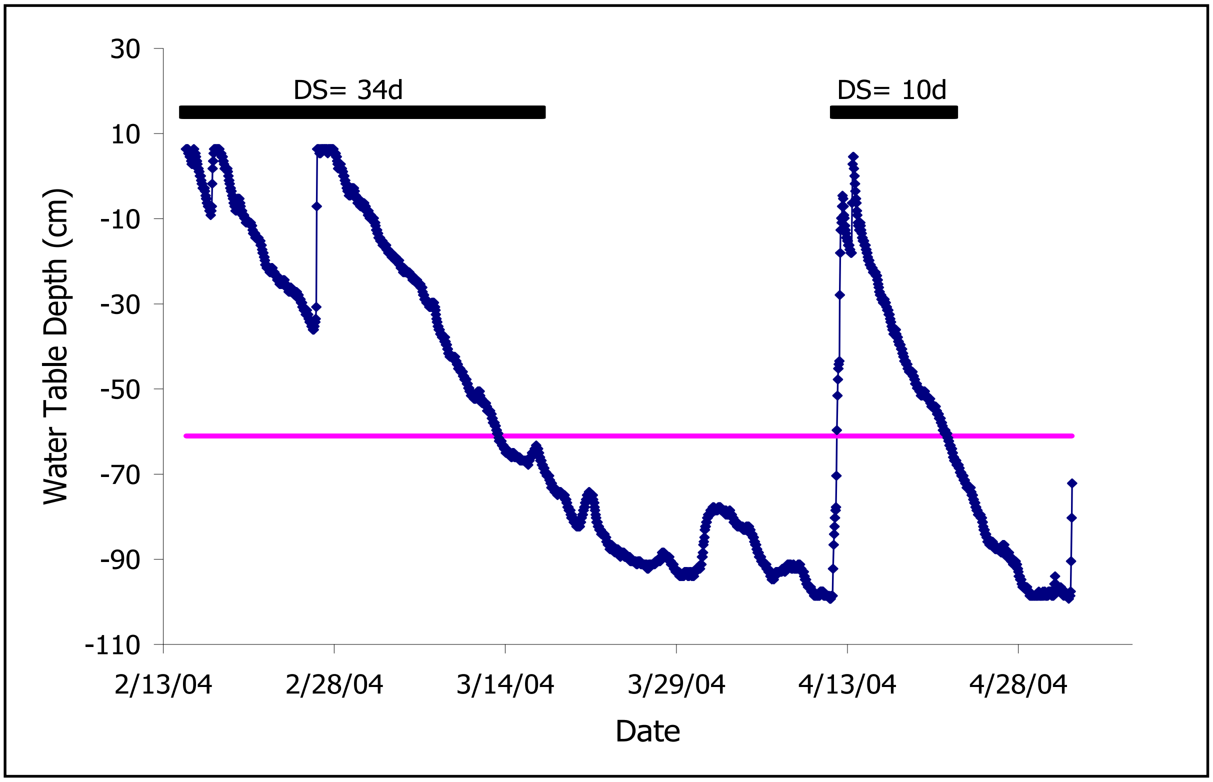


Figure 1.16. An example of water table fluctuation in a mineral soil at Juniper Bay. The top line represents the duration of saturation (DS) and the bottom line represents the water table at a depth of 61cm. Each dot represents an hourly measurement.

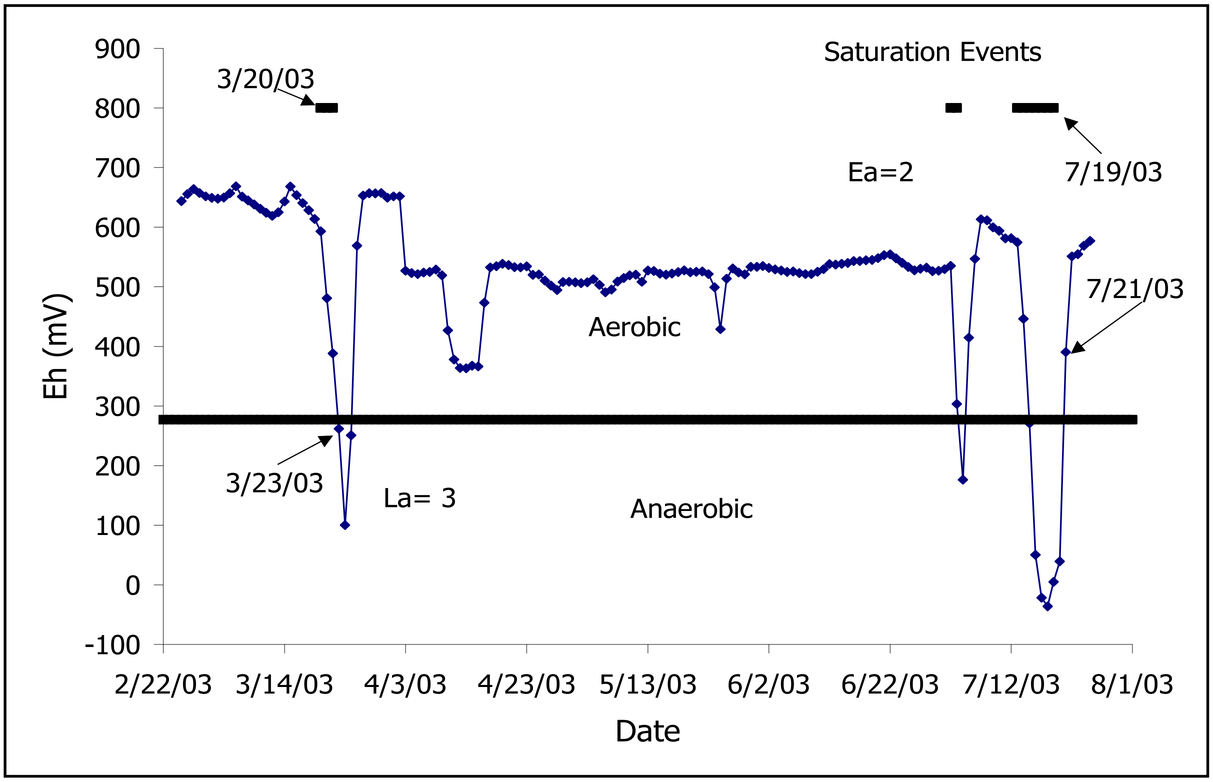


Figure 1.17. Time to develop anaerobic conditions in a mineral soil at 25 cm. Each dot represents a daily Eh average.

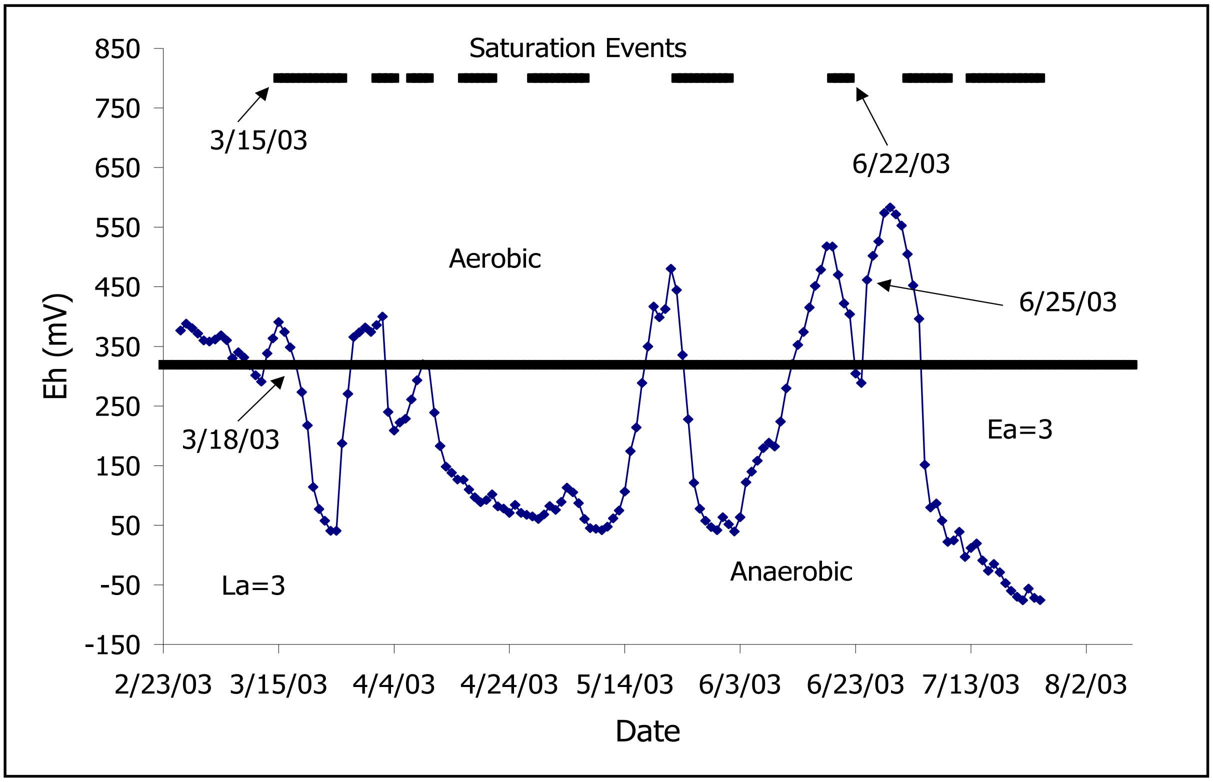


Figure 1.18. Time to develop anaerobic conditions in a mineral soil at 61 cm. Each dot represents a daily Eh average. Water table data are missing from this site.

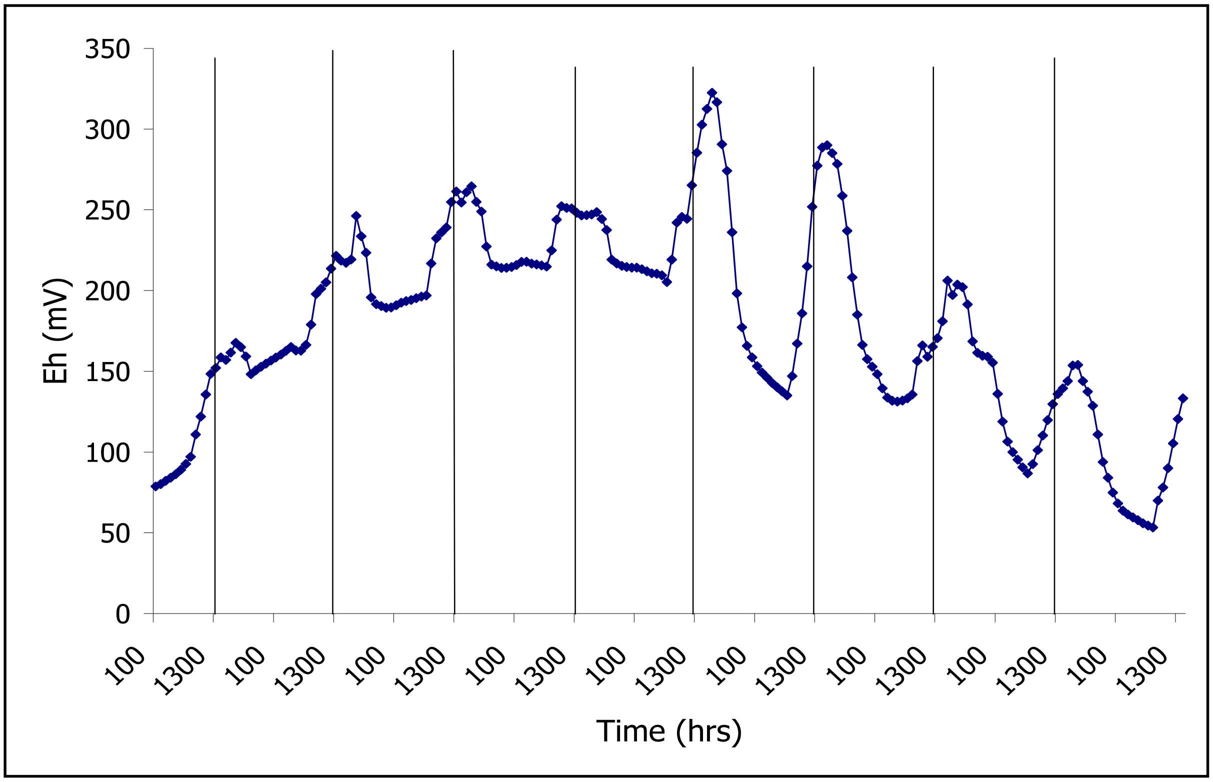


Figure 1.19. Example of diurnal fluctuations at one site in Juniper Bay at 25cm. The water table data is missing but the periods before and after this time period were saturated. The dates are 10/8/03-10/16/03. The time 1300 represents afternoon and 100 represents night.

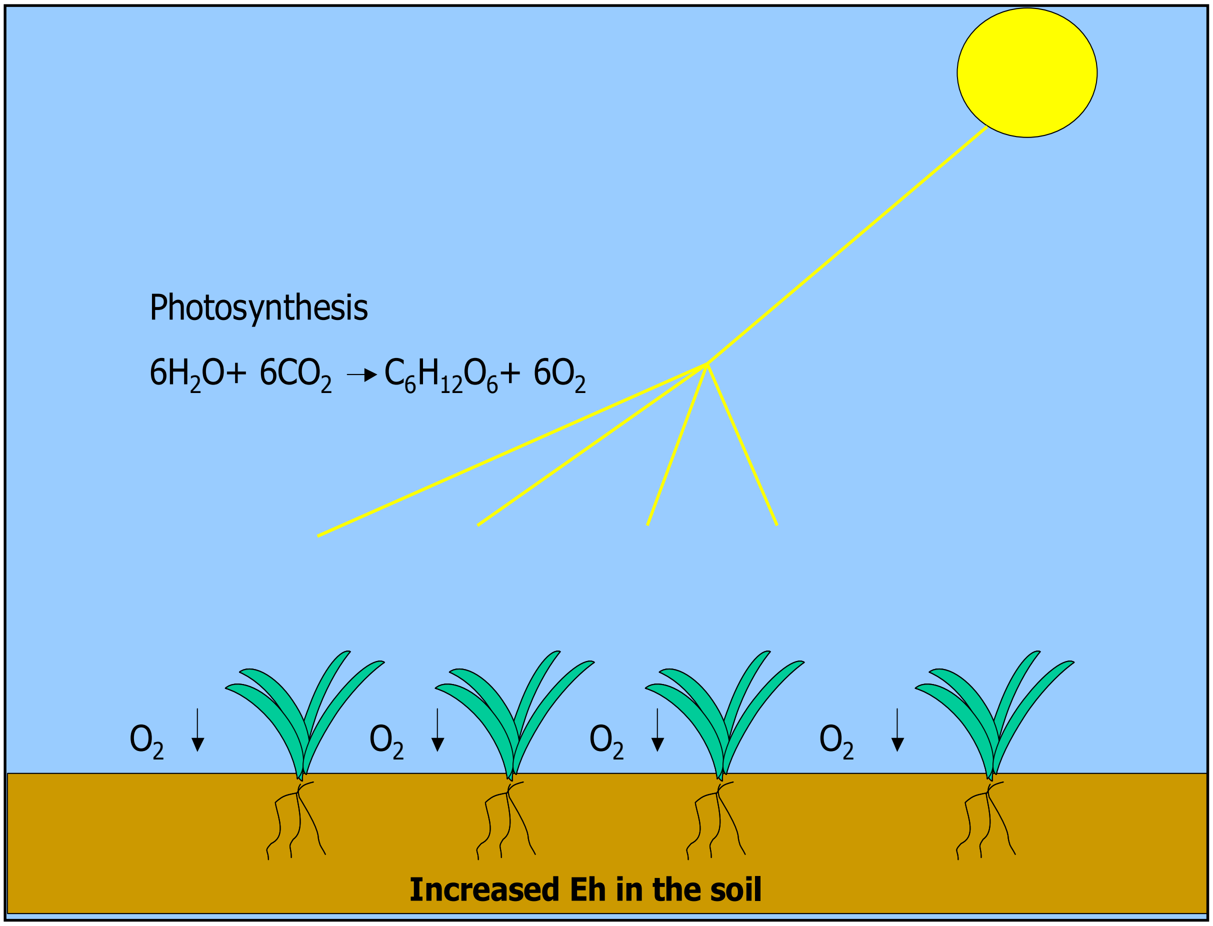


Figure 1.20. Photosynthesis occurred during the day during the growing season and the plants were able to transport O_2 to the roots and oxidize the surrounding soil.

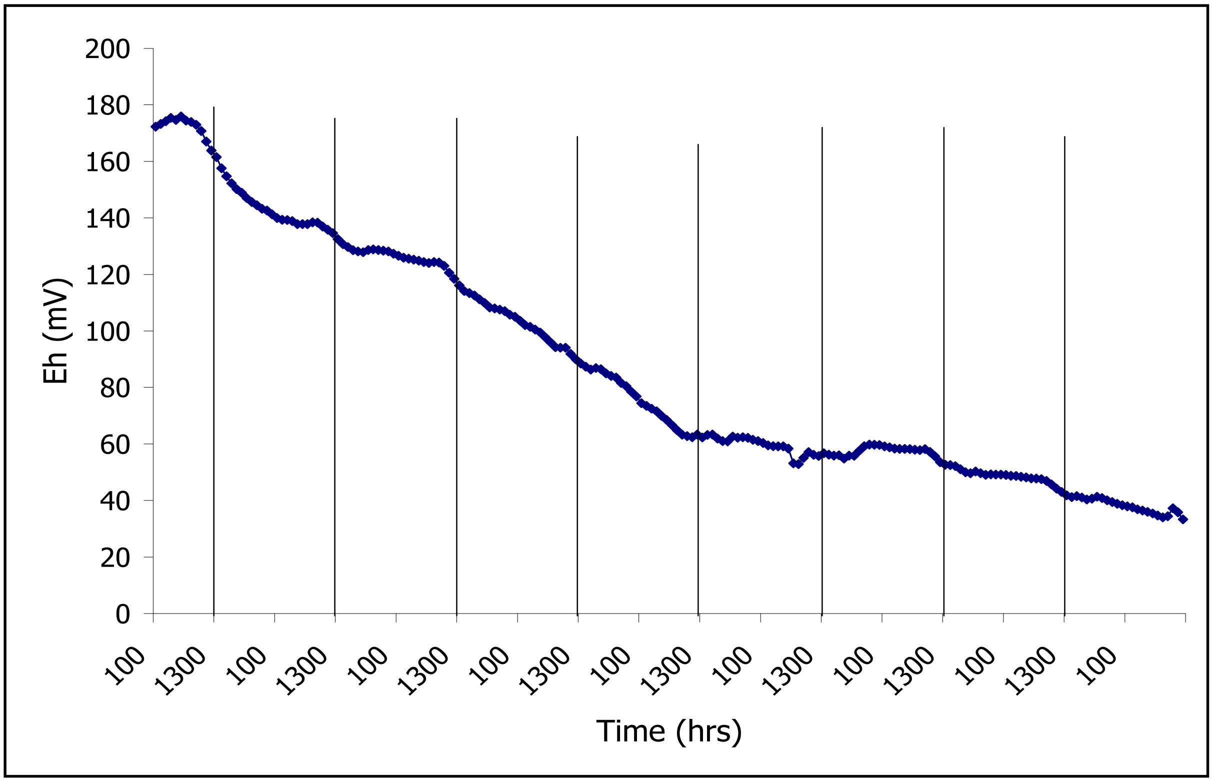


Figure 1.21. Example of diurnal fluctuations not occurring at the end of the growing season. The dates are 11/13/02-11/21/02. The time 1300 represents afternoon and 100 represents night.

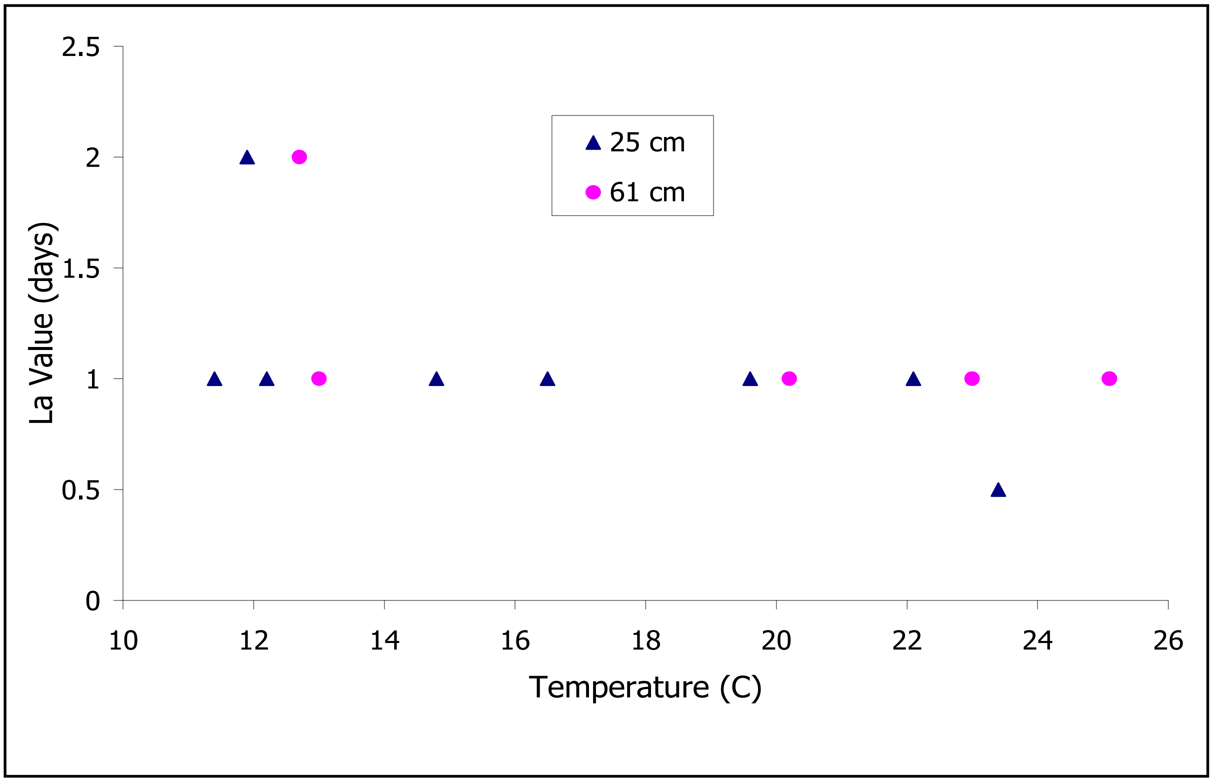


Figure 1.22. Time it took to develop anaerobic conditions as a result of temperature at 25 and 61 cm in an organic soil. Each dot represents an event where anaerobic conditions occurred.

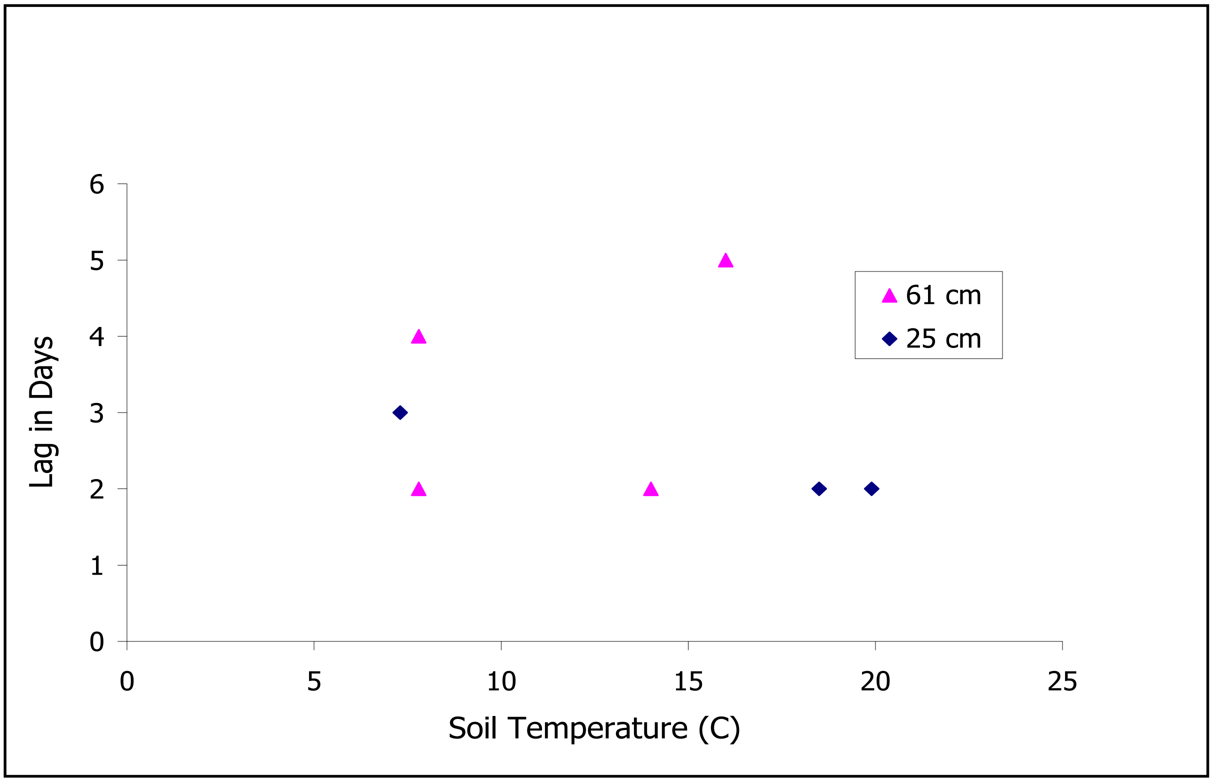


Figure 1.23. Time it took to develop anaerobic conditions as a result of temperature at 25 and 61 cm in a mineral soil. Each dot represents an event where anaerobic conditions occurred.

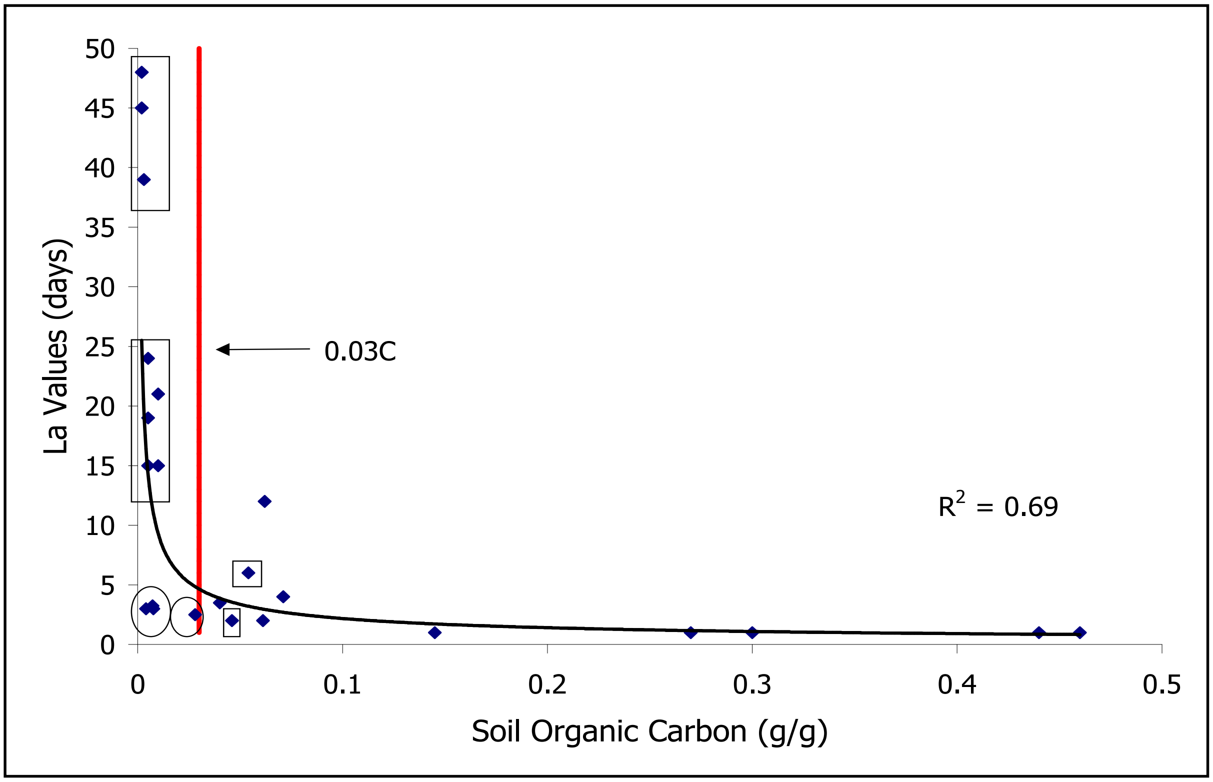


Figure 1.24. Relationship of soil organic carbon at Juniper Bay and two other soils to La values. This applies to areas where the mean annual soil temperature remains greater than 5 C. The points within the rectangles come from He et al. (2003). The circled points have low soil organic carbon and short La values.

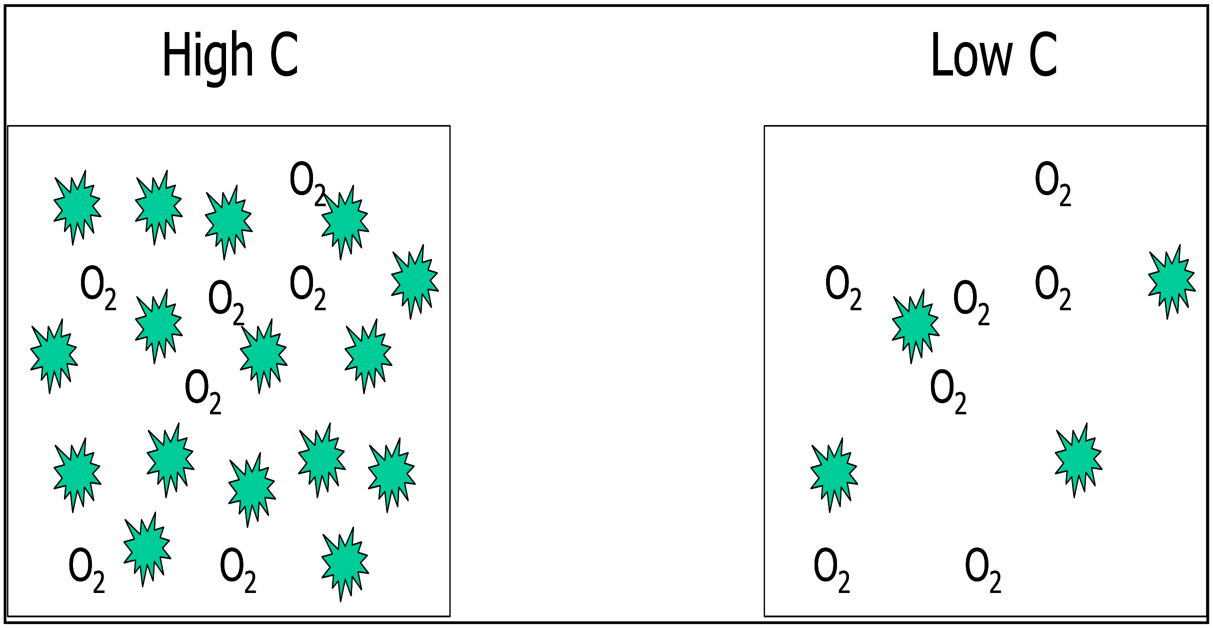


Figure 1.25. The soil with high soil C has a larger number of bacterial colonies (✸) that can quickly consume the O_2 entering the system. The soil with low C has fewer colonies and it requires longer periods for soils to become anaerobic because O_2 must diffuse to bacterial colonies.

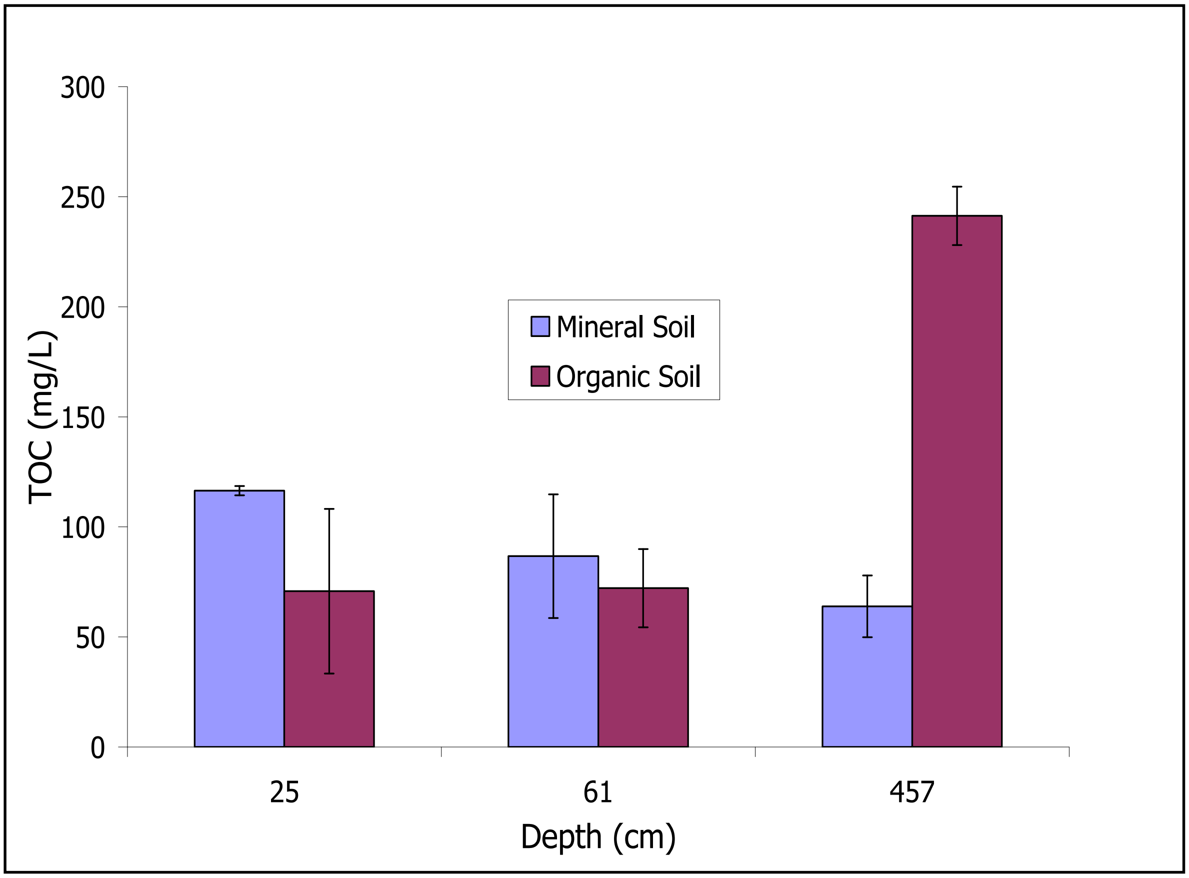


Figure 1.26. The amount of total organic carbon at Juniper Bay. At 457 cm the piezometers were in mineral sediments. The legend shows whether the overlying soil was mineral or organic.

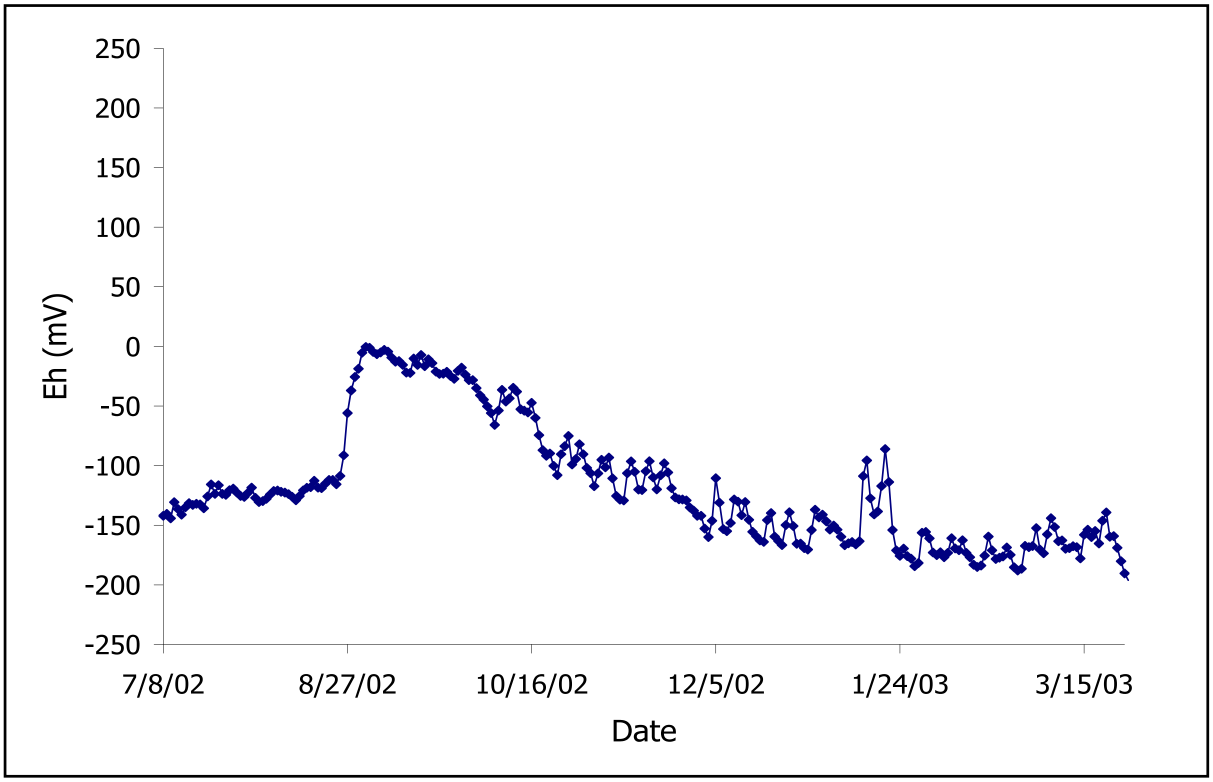


Figure 1.27. The Eh levels at 457cm below an organic soil are consistently anaerobic.

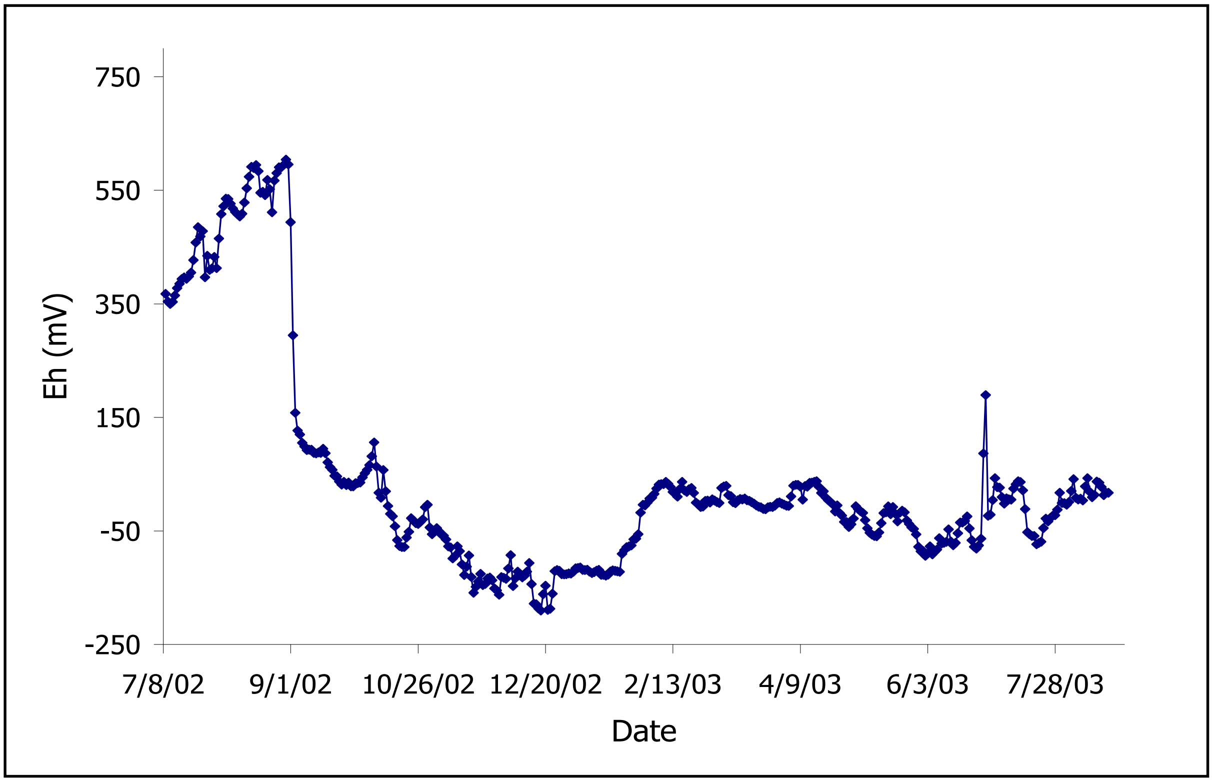


Figure 1.28. The Eh levels at 457cm below a mineral soil, after depletion of O_2 remained anaerobic.

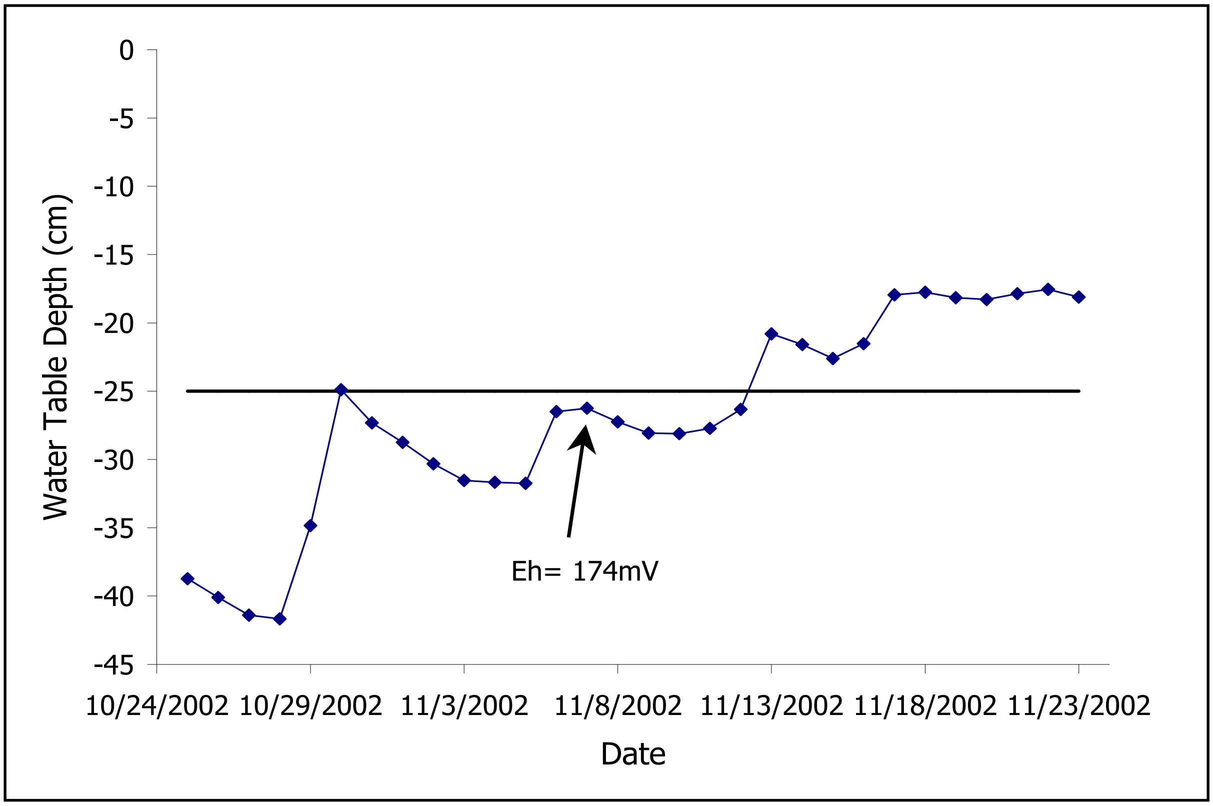


Figure 1.29. An organic soil at 25cm at Causeway where the Eh quickly becomes anaerobic after saturation. The solid horizontal line represents the 25 cm depth. The points above the line are when the soil horizon is saturated. The soil was basically saturated above 25 cm the day of the reading and the soil was already anaerobic.

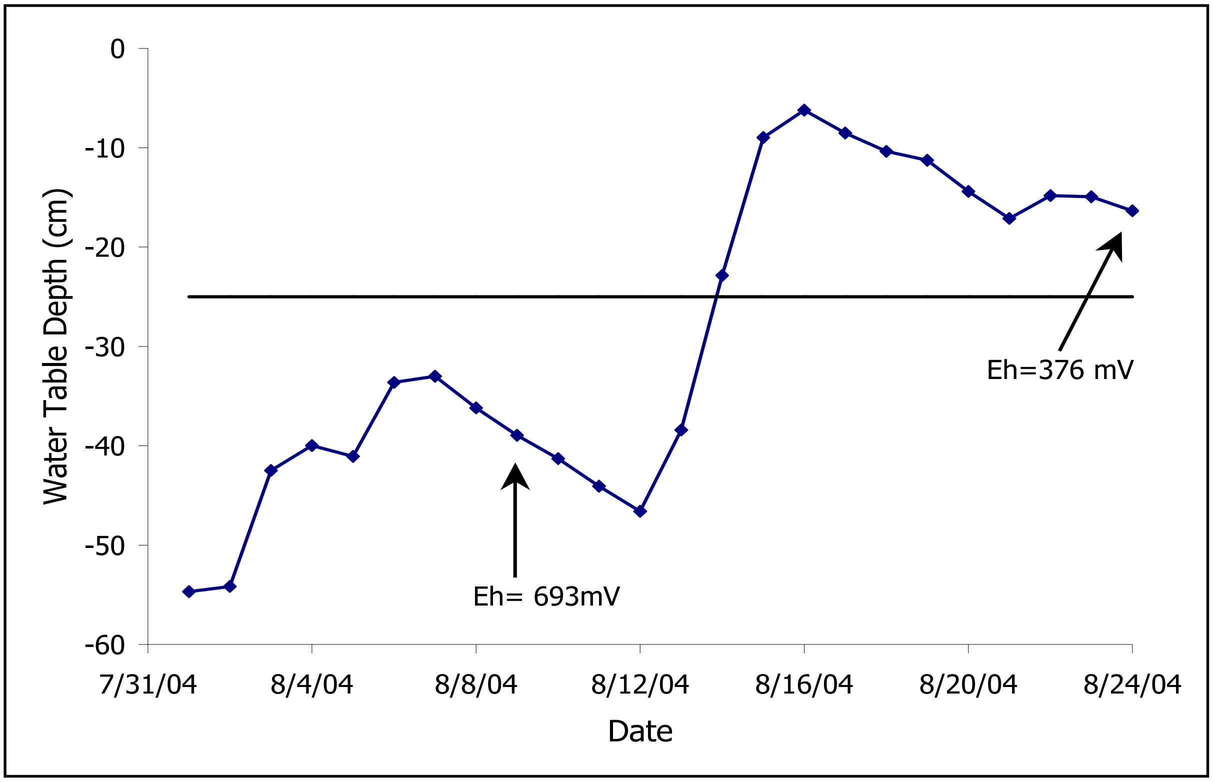


Figure 1.30. An organic soil at Charlie Long, the La value is no greater than 10d. The solid horizontal line represents the 25 cm depth. The points above the line are when the soil horizon is saturated. The soil saturated above 25 cm on 8/13/04 and the next measurement was anaerobic.

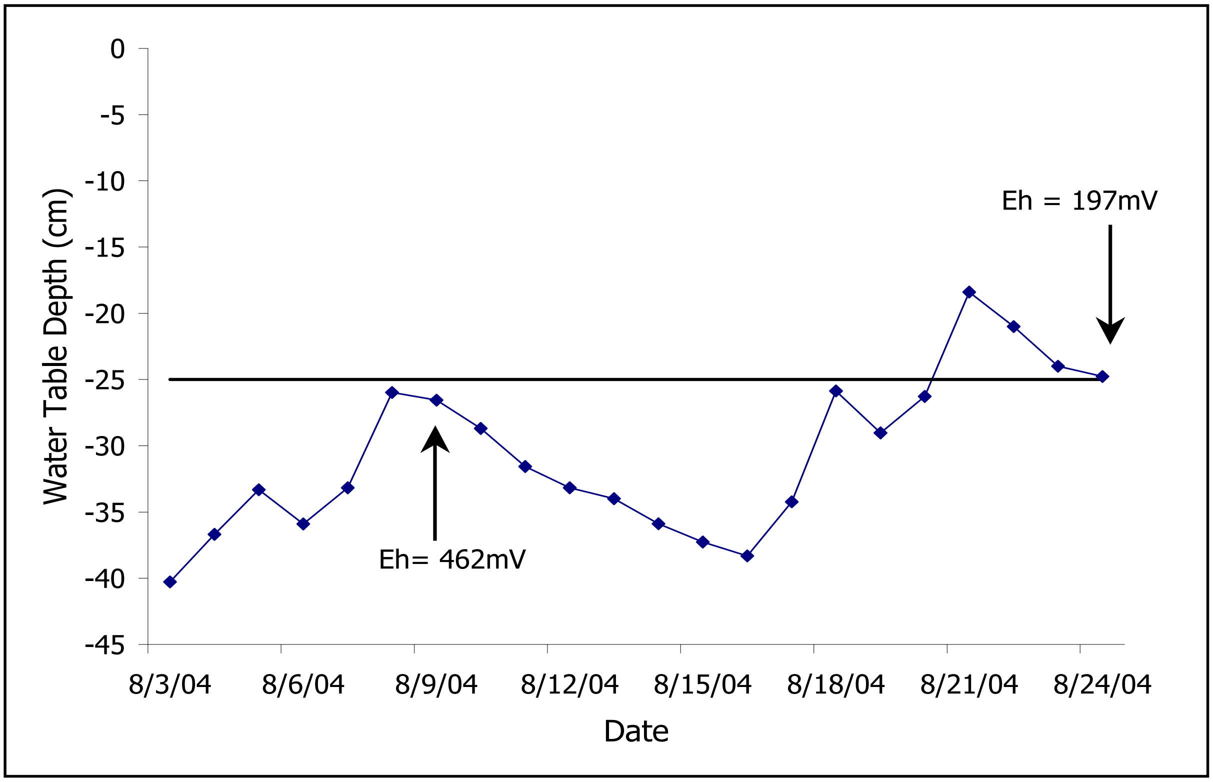


Figure 1.31. A mineral soil at Charlie Long, the La value is no greater than 4d. The solid horizontal line represents the 25 cm depth. The points above the line are when the soil horizon is saturated. The soil saturated above 25 cm on 8/20/04 and the next measurement the soil was anaerobic.

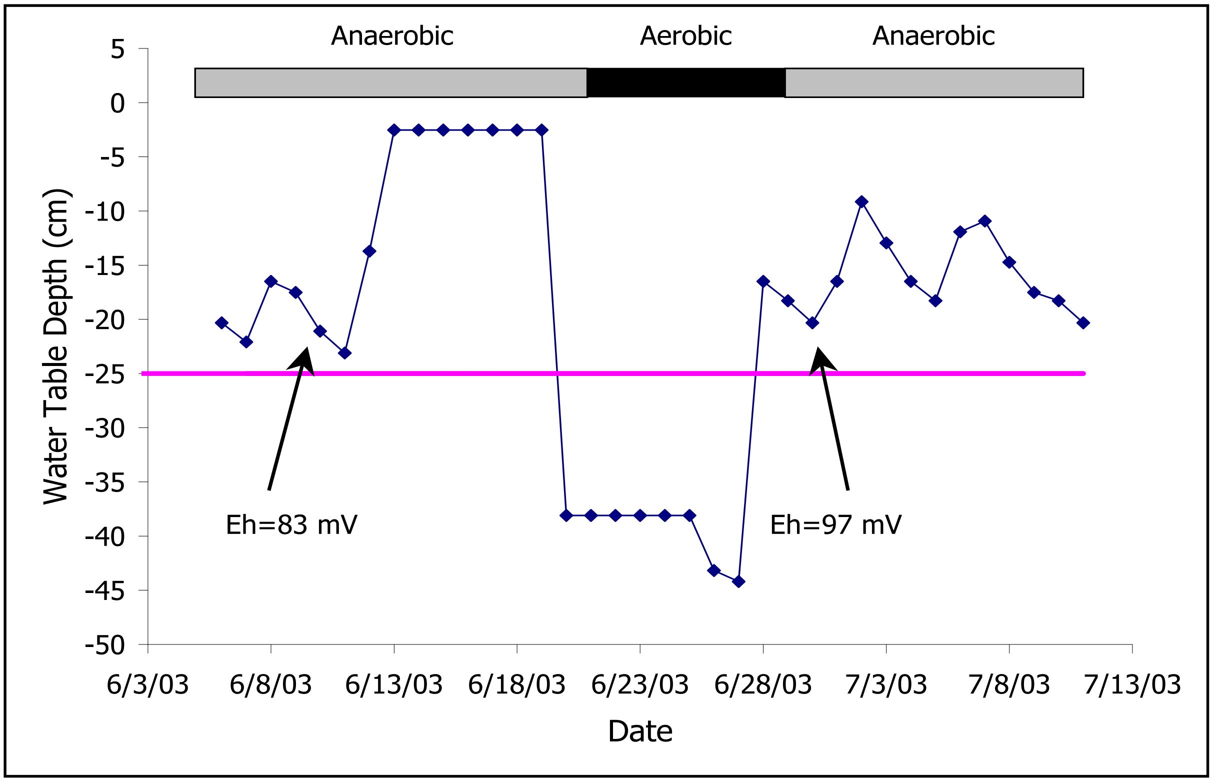


Figure 1.32. A mineral soil at Causeway, the La value is no greater than 3d. The solid horizontal line represents the 25 cm depth. The points above the line are when the soil horizon is saturated. The soil saturated above 25 cm on 6/28/03 and the next measurement was anaerobic.

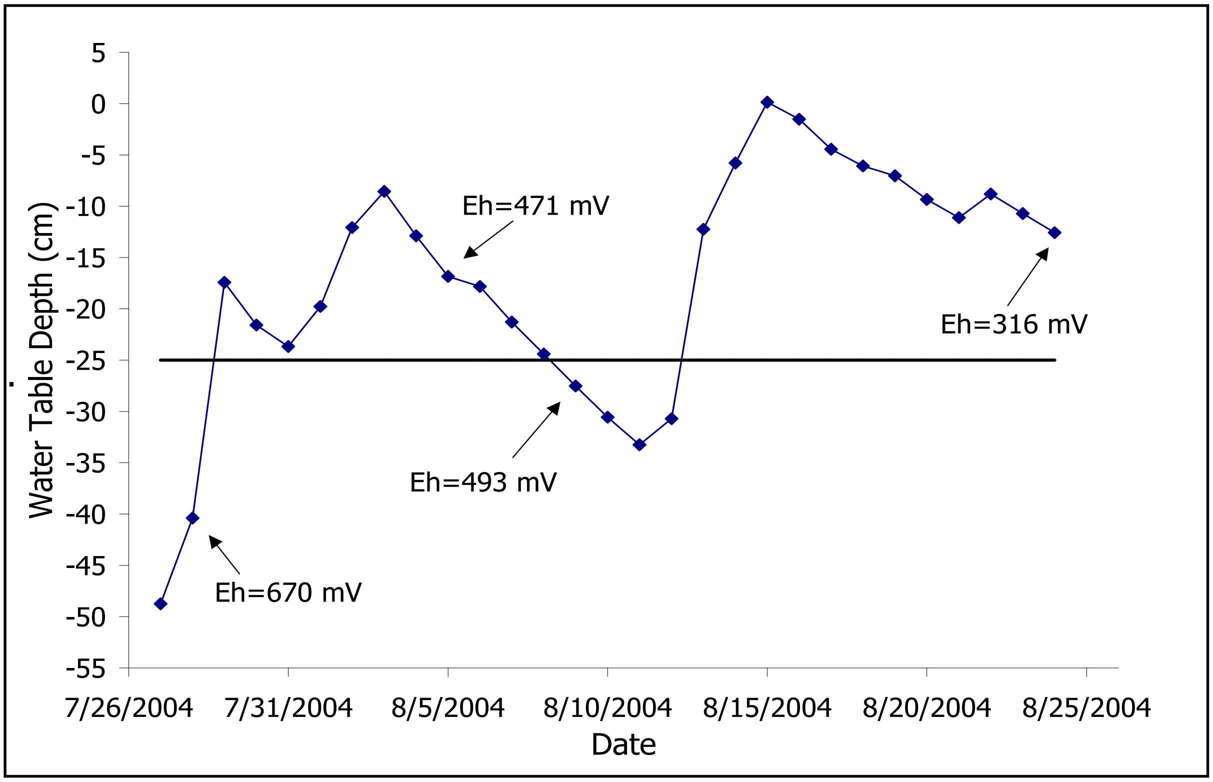


Figure 1.33. A mineral soil at Causeway, the soil has low C and has a variable La value. The solid horizontal line represents the 25 cm depth. The points above the line are when the soil horizon is saturated. The soil saturated above 25 cm on 7/29/04 but the soil did not fall into the anaerobic zone. The soil saturated above 25 cm on 8/24/04 and the next measurement was anaerobic.

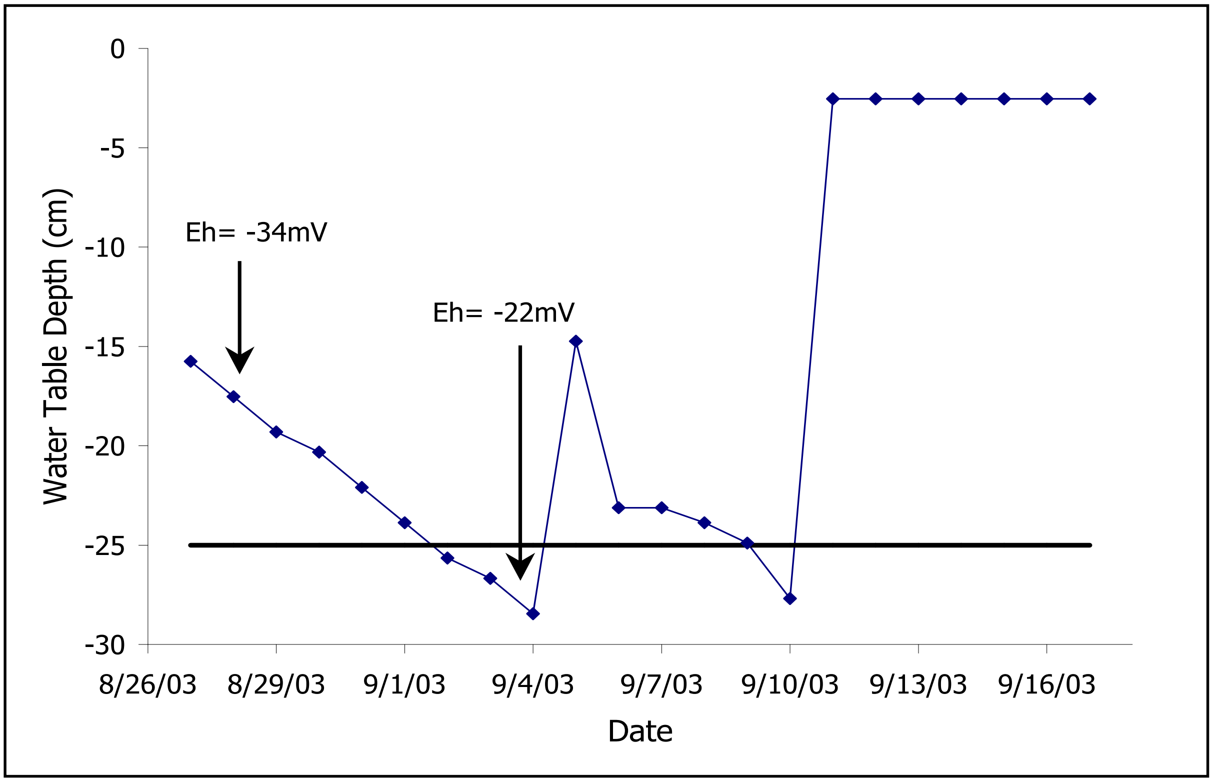


Figure 1.34. A mineral soil at Causeway bay the Ea is at least 3d. The solid horizontal line represents the 25 cm depth. The points above the line are when the soil horizon is saturated. The soil was unsaturated at 25 cm for three days and the measurement was still in the anaerobic zone.

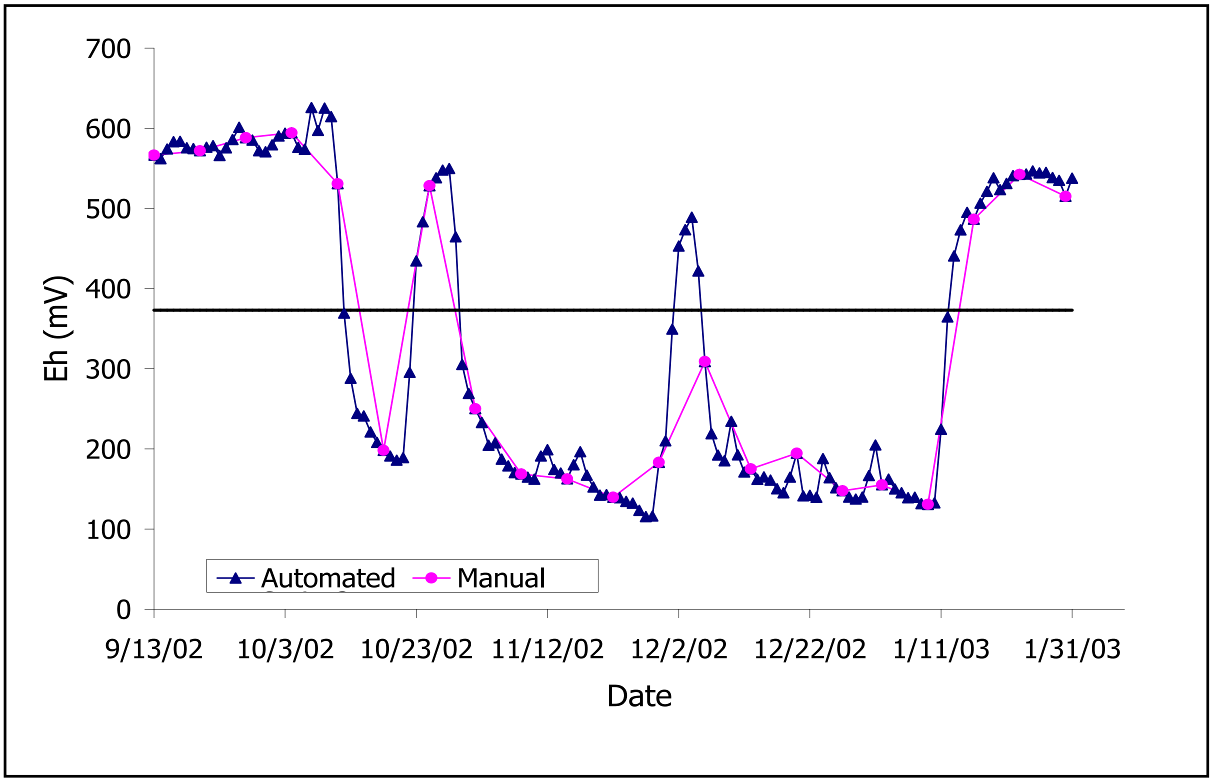


Figure 1.35. A comparison of automated and manual Eh measurements in an organic soil at 61cm. The automated measurements accurately recorded the anaerobic conditions.

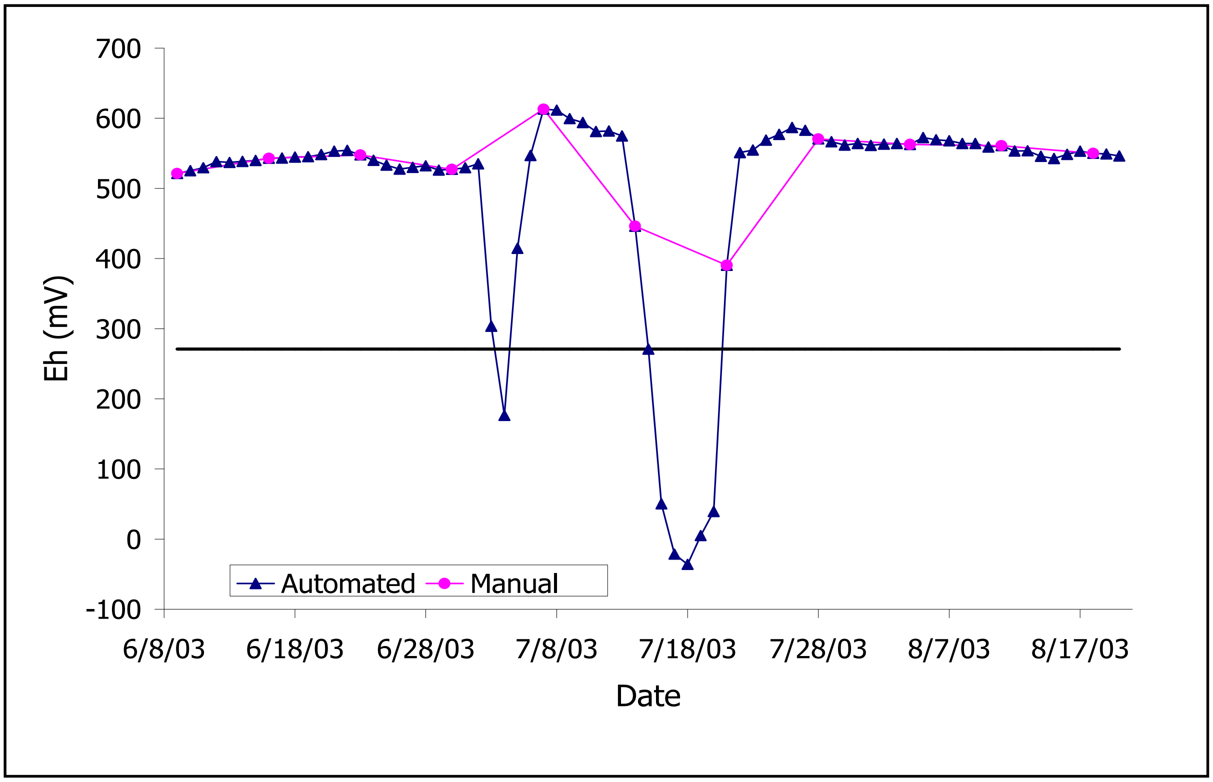


Figure 1.36. A comparison of automated and manual Eh measurements in a mineral soil at 25cm. The automated measurements accurately recorded the anaerobic conditions.

Appendix A

Automated Redox Measurement Setup

Parts needed for automated redox measurements setup

1 thermister with 3 wires

2 Thermocouples with 2 wires each

1 color-coded 4-piece wire for the datalogger to multiplexer connection

1 reference electrode

1 air temperature probe with 4 wires

1 2-piece wire for connection of multiplexer to datalogger

2 1-piece wires for connection of battery to datalogger

1 solar panel with connecting 2-piece wire attached for connection to the battery

3 different color-coded 5-piece wires for electrode connection to the multiplexer
(can use any combination of wires just need as many wires as electrodes and they should be different colors to make clear which wire goes to which electrode)
Assign a colored wire to each electrode and attach to multiplexer.

Datalogger diagram: Thermo represents the two 2-piece thermocouples, Air probe is the air temperature probe, Battery-Data is two separate 1-piece wires connecting the two pieces of equipment, Data-Multi is the 4-piece wire connecting the two pieces of equipment and the bottom block of the diagram is a continuation to the right of the top two blocks.

		7	8		9	10		11	12					
		4			5			6						
G	G	L	H	AG	H	L	AG	H	L	AG	E3	AG	G	G
		Thermo. Blue	Thermo. Red	Nothing	Thermo. Blue	Thermo. Red		Nothing		Nothing	Nothing	Nothing	Nothing	Battery-Data (1 Wire) Black

		1	2		3	4		5	6					
		1			2			3						
G	G	L	H	AG	H	L	AG	H	L	AG	E1	AG	E2	G
		Air Probe Red	Thermister Blue		Data-Multi (2 Wire) Red	Data-Multi (2 Wire) Black	Reference Electrode	Nothing		Thermister Silver	Thermister Black and Air Probe Black	Air Probe Purple	Nothing	Air Probe Silvery White

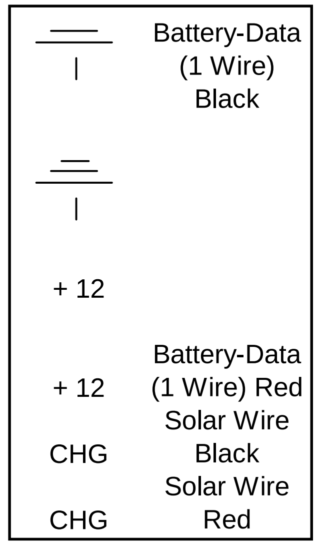
Power In

G	12V

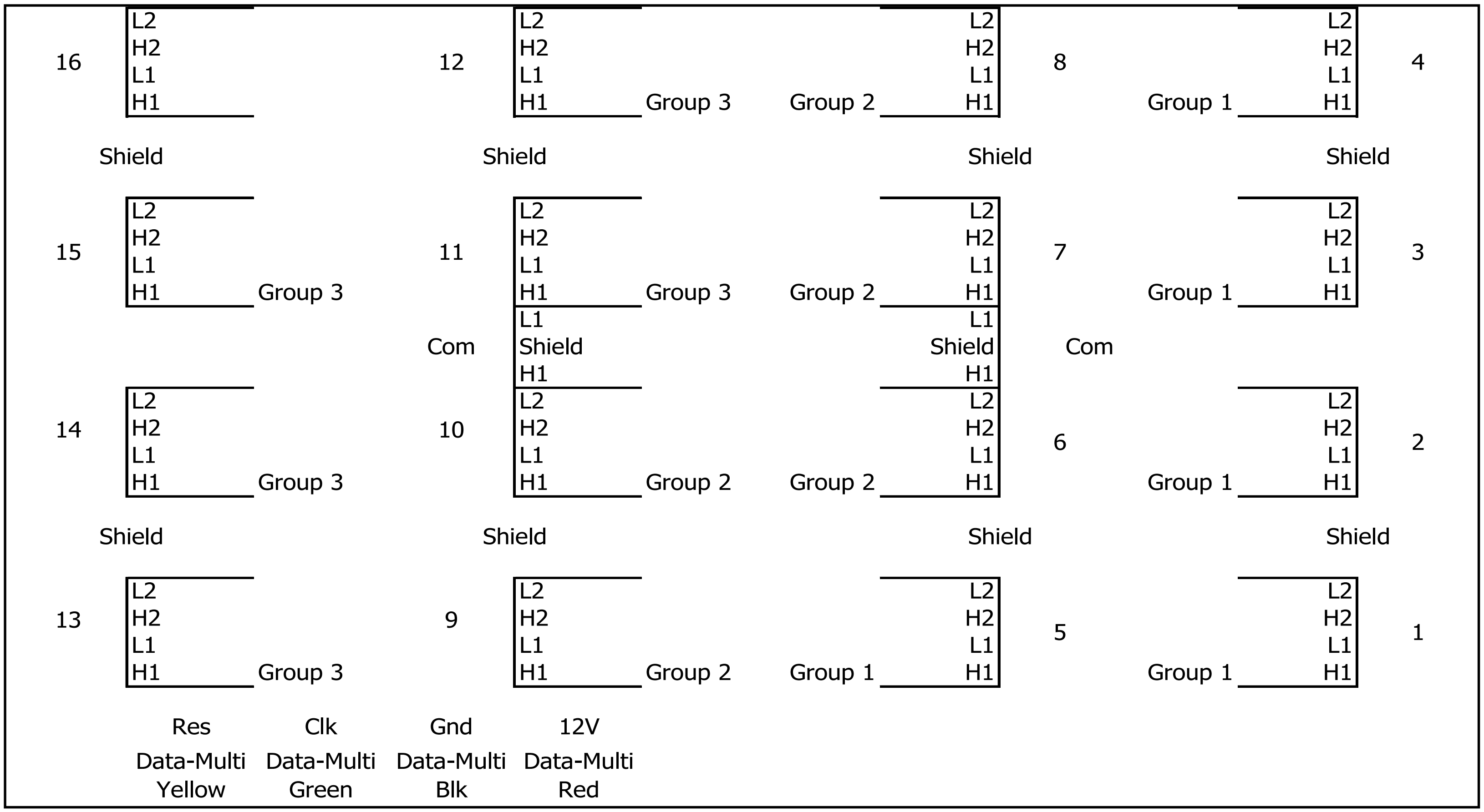
5V	5V	SW 12V CTRL	SW 12V	G
Nothing	Nothing	Nothing	Nothing	Nothing

P1	G	P2	G	C8	C7	C6	C5	C4	C3	C2	C1	G	12V	12V
										Data-Multi (4 Wire) Green	Data-Multi (4 Wire) Yellow	Data-Multi (4 Wire) Black	Data-Multi (4 Wire) Red	Battery-Data (1 Wire) Red

Battery Diagram: Battery-Data is two separate 1-piece wires connecting the two pieces of equipment and Solar represents the wires coming from the solar panel into the battery.



Mulitplexer Diagram (AM 416): Data-Multi is the four piece color-coded wires connecting the datalogger and the multiplexer, Group 1, 2, and 3 represent the15 electrodes in three different groups. The electrode wires go into the odd numbers on the 16/32 multiplexer. Group 1 1-9. Group 2 11-19. Group 3 21-29.



Appendix B

Raw Data-Juniper Bay

pH measurements at Juniper Bay

Core	25cm	61cm
	4	3.75
1	3.72	3.87
	4.44	4.55
3	4.46	4.35
	4.58	3.8
5	3.91	3.62
	3.66	3.56
10	3.91	3.62
	4.03	3.91
11	3.8	3.86
	5.3	4.59
14	5.25	4.47
	5.43	4.76
17	5.08	4.76

Total Organic Carbon Data: Determined using a Total Organic Analyzer

TOC (mg C/L)	Core	Depth (cm)	Soil Type
52	14	457	Mineral
68.7	14	457	Mineral
66.6	14	457	Mineral
68.6	14	457	Mineral
222	10	457	Organic
247	10	457	Organic
252	10	457	Organic
244	10	457	Organic
39.6	17	457	Histic
31.7	3	457	Mineral
42.3	3	457	Mineral
44	3	457	Mineral
42.4	3	457	Mineral
96.7	3	61	Mineral
118	3	61	Mineral
103	3	61	Mineral
82	10	61	Organic
82.9	10	61	Organic
51.6	10	61	Organic
65.4	11	61	Histic
112	11	61	Histic
99.3	11	61	Histic
63.7	17	61	Histic
50.5	17	61	Histic
37.5	17	61	Histic
69.3	14	61	Mineral
103	1	61	Organic
122	1	61	Organic
118	3	25	Mineral
115	3	25	Mineral
31.5	11	25	Histic
106	11	25	Histic
75	11	25	Histic

Average daily redox measurements at Core 10 an organic site

Date	25 cm	61 cm	457 cm	Date	25 cm	61 cm	457 cm
7/8/02	748.44	630.3	-142.16	8/28/02	552.26	461.5	-36.96
7/9/02	743.62	637.24	-140.48	8/29/02	555.32	313.88	-25.562
7/10/02	682.42	598.22	-144.24	8/30/02	353.956	286.3	-18.864
7/11/02	679.48	578.96	-130.64	8/31/02	320.63	264.72	-5.334
7/12/02	752.76	571.94	-136.44	9/1/02	351.42	249.28	-0.372
7/13/02	752.94	574.38	-141.12	9/2/02	547.196	230.08	-1.006
7/14/02	738.46	576.12	-134.9	9/3/02	615.7	220.88	-4.6878
7/15/02	719.48	608.24	-131.54	9/4/02	682.08	214.32	-6.5642
7/16/02	722.96	619.26	-133.02	9/5/02	689.44	208.36	-5.0772
7/17/02	714.78	630.44	-132.06	9/6/02	711.8	199.74	-2.952
7/18/02	713.54	642.42	-132.44	9/7/02	736.96	194.48	-4.438
7/19/02	708.48	647.24	-135.84	9/8/02	748.52	234.16	-9.404
7/20/02	700.54	641.48	-125.88	9/9/02	739.9	329.82	-12.836
7/21/02	699.52	628.44	-115.82	9/10/02	734.52	406.58	-12.391
7/22/02	688.14	621.6	-123.76	9/11/02	735.42	470.78	-15.496
7/23/02	657.14	512.84	-116.42	9/12/02	733.64	518.94	-21.974
7/24/02	687.46	400.42	-123.72	9/13/02	727.72	566.56	-22.226
7/25/02	685.6	457.82	-124.6	9/14/02	721.78	562.1	-10.15
7/26/02	675.7	537.74	-120.62	9/15/02	723.86	574.08	-15.502
7/27/02	677.78	554.96	-119.18	9/16/02	721.76	583.36	-7.2398
7/28/02	676.12	567.1	-122.54	9/17/02	723.96	583.86	-16.602
7/29/02	686.26	580.04	-125.4	9/18/02	717.6	575.64	-10.848
7/30/02	682.52	592.94	-126.18	9/19/02	719.8	574.62	-13.954
7/31/02	659.46	574.28	-122.8	9/20/02	720.04	571.92	-21.106
8/1/02	646.26	560.46	-118.49	9/21/02	722.56	576.44	-23.15
8/2/02	631.28	568.18	-127.01	9/22/02	719.76	578.32	-22.95
8/3/02	678.82	565.18	-130.45	9/23/02	721.44	566.04	-21.304
8/4/02	660.88	563.96	-129.69	9/24/02	720.06	575.66	-24.972
8/5/02	648.2	563	-127.83	9/25/02	720.92	586.08	-27.24
8/6/02	646.58	567.18	-124.2	9/26/02	708.78	601.32	-20.434
8/7/02	647.52	583.54	-121.19	9/27/02	712.2	588.2	-17.732
8/8/02	652.64	586.86	-120.83	9/28/02	704.9	585.16	-23.748
8/9/02	656.7	597.18	-121.87	9/29/02	703.68	571.96	-28.146
8/10/02	661.48	643.92	-122.59	9/30/02	702.64	570.84	-28.176
8/11/02	655.5	663.44	-123.95	10/1/02	701.54	579.28	-34.928
8/12/02	646.76	669.14	-126.03	10/2/02	700.82	590.32	-40.952
8/13/02	630.46	666.86	-129.08	10/3/02	696.9	593.78	-44.543
8/14/02	642.58	667.98	-125.55	10/4/02	693.16	594.42	-50.212
8/15/02	616.18	637.98	-120.71	10/5/02	688.42	576.18	-55.898
8/16/02	614.48	435.22	-118.6	10/6/02	683.04	574.02	-65.719
8/17/02	627.22	345.86	-118.05	10/7/02	682.96	625.84	-53.766
8/18/02	619.66	315.78	-112.67	10/8/02	669.88	597.3	-36.415
8/19/02	641.58	293.16	-118.43	10/9/02	700.58	625.1	-46.28
8/20/02	639.6	408.52	-119	10/10/02	698.6	614.64	-43.678
8/21/02	646.62	530.72	-115.16	10/11/02	620.94	530.76	-34.66
8/22/02	653.02	599.24	-111.95	10/12/02	640.28	369.36	-37.916
8/23/02	639.98	600.2	-111.9	10/13/02	682.16	288.14	-52.686
8/24/02	640.7	597.1	-115.66	10/14/02	687.06	244.16	-53.862
8/25/02	626.36	597.04	-108.69	10/15/02	680.58	241.04	-55.415
8/26/02	637.36	602.5	-91.36	10/16/02	685	221.18	-47.184
8/27/02	624.88	610.16	-55.823	10/17/02	700.7	207.96	-59.962

Date	25 cm	61 cm	457 cm	Date	25 cm	61 cm	457 cm
10/18/02	707.28	198.28	-74.46	12/8/02	733.54	192.32	-154.93
10/19/02	712.1	191.06	-86.98	12/9/02	728.34	185.16	-148.08
10/20/02	711.32	185.8	-91.825	12/10/02	705.56	234.46	-128.38
10/21/02	704.64	189.2	-89.744	12/11/02	693.38	192.594	-130.19
10/22/02	700.14	295.58	-100.17	12/12/02	702.1	171.128	-141.57
10/23/02	711.62	434.56	-107.92	12/13/02	670.42	175.082	-130.51
10/24/02	703.6	483.36	-90.447	12/14/02	633.44	161.89	-145.48
10/25/02	709.72	528.28	-83.652	12/15/02	671.78	164.952	-155.46
10/26/02	706.16	538.18	-75.124	12/16/02	675.38	160.92	-159.32
10/27/02	707.64	547.94	-99.103	12/17/02	664.58	150.08	-162.74
10/28/02	693.12	549.82	-94.403	12/18/02	649.86	145.32	-163.86
10/29/02	652.6	464.58	-81.974	12/19/02	645.8	164.7	-145.8
10/30/02	649.4	305.36	-90.474	12/20/02	638.84	194.42	-139.79
10/31/02	688.52	269.22	-101.87	12/21/02	660.86	141.36	-159.48
11/1/02	698.24	250.04	-106.42	12/22/02	659.4	142.14	-163.24
11/2/02	708.32	232.92	-117.25	12/23/02	661.72	139.5	-166.64
11/3/02	714.68	204.72	-106.46	12/24/02	650.24	187.92	-149.79
11/4/02	711.38	207.58	-95.056	12/25/02	620.32	164.08	-139.09
11/5/02	711.58	187.02	-101.38	12/26/02	652.42	151.46	-150.77
11/6/02	693	178.76	-93.204	12/27/02	688.92	147.72	-165.63
11/7/02	702.12	170.32	-110.66	12/28/02	689.86	139.92	-165.41
11/8/02	708.52	168.54	-125.31	12/29/02	685.22	137.4	-169.22
11/9/02	714.26	164.6	-128.57	12/30/02	688.14	139.84	-170.35
11/10/02	705.24	162.24	-129.22	12/31/02	653.8	166.8	-153.99
11/11/02	666.14	190.98	-106.3	1/1/03	615.68	204.8	-136.92
11/12/02	612.96	198.9	-96.43	1/2/03	606.22	155.24	-143.46
11/13/02	413.52	174.44	-105.18	1/3/03	624.82	162.24	-141.16
11/14/02	553.44	169.9	-120.1	1/4/03	657.6	149.94	-146.71
11/15/02	699.88	162.56	-120.43	1/5/03	693.28	145.16	-153.64
11/16/02	690.26	180.22	-104.63	1/6/03	672.56	139.16	-150.14
11/17/02	471.68	196.5	-96.236	1/7/03	676.62	139.58	-153.6
11/18/02	524.2	167.28	-109.87	1/8/03	689.98	131.64	-159.57
11/19/02	721.12	152.38	-119.83	1/9/03	683.82	130.82	-166.76
11/20/02	738.76	142.26	-108.14	1/10/03	678.26	132.7	-165.13
11/21/02	737.02	142.78	-98.014	1/11/03	703.54	224.64	-164.04
11/22/02	732.28	139.72	-105.61	1/12/03	695.78	364.72	-166.07
11/23/02	740.94	139.16	-118.98	1/13/03	692.78	440.7	-163.52
11/24/02	745.32	134.5	-126.73	1/14/03	667.12	473.32	-108.9
11/25/02	744.46	132.2	-128.26	1/15/03	666.56	495.16	-95.638
11/26/02	742.46	123.38	-128.41	1/16/03	667.94	486.5	-127.29
11/27/02	739	115.5	-129.25	1/17/03	647.6	506.56	-140.99
11/28/02	745.5	116.2	-135.21	1/18/03	661.86	521.36	-138.4
11/29/02	743.6	183.14	-137.8	1/19/03	676.6	538.12	-117.08
11/30/02	742.12	210	-142.02	1/20/03	626.56	523.5	-86.182
12/1/02	744.56	349.28	-142.15	1/21/03	644.74	531.14	-113.71
12/2/02	745.32	453.12	-152.78	1/22/03	677.3	540.9	-153.96
12/3/02	743.3	473.6	-160.02	1/23/03	687.64	542.42	-171.1
12/4/02	729.06	489.08	-146.19	1/24/03	707.54	542.86	-175.76
12/5/02	717.28	421.98	-110.52	1/25/03	704.84	546.94	-169.5
12/6/02	740.38	309.008	-131.07	1/26/03	678.34	544.38	-175.85
12/7/02	742.74	219	-153.1	1/27/03	677.42	544.88	-178.03

Date	25 cm	61 cm	457 cm
1/28/03	674.88	538.46	-184.22
1/29/03	643.04	534.96	-181.58
1/30/03	600.16	515.18	-156.32
1/31/03	634.62	537.78	-155.59
2/1/03	652.92	544.24	-160.97
2/2/03	660.48	544.72	-172.91
2/3/03	662.06	545.62	-175.07
2/4/03	661.36	552.58	-172.64
2/5/03	670.54	565.34	-176.83
2/6/03	666.04	559.76	-173.24
2/7/03	685.12	555.46	-160.78
2/8/03	684.6	534.28	-169.36
2/9/03	639.76	487.76	-170.83
2/10/03	634.46	439.72	-162.57
2/11/03	677.92	355.58	-173.28
2/12/03	671.96	270.76	-176.79
2/13/03	675.1	257.1	-183.16
2/14/03	660.98	248.68	-184.96
2/15/03	654.36	239.96	-183.72
2/16/03	652.06	256.7	-175.51
2/17/03	672.78	292.816	-159.47
2/18/03	691.06	254	-171.07
2/19/03	680.18	224.9	-178.4
2/20/03	670.12	226.04	-177.16
2/21/03	667.18	224.94	-176.2
2/22/03	648.32	258.66	-168.6
2/23/03	651.58	254.34	-174.86
2/24/03	681.7	249.64	-185.22
2/25/03	679.9	280.6	-187.88
2/26/03	679.5	270.84	-186.52
2/27/03	682.04	366.08	-167.24
2/28/03	711.88	325.42	-168.48
3/1/03	702.02	298.2	-167.46
3/2/03	667.3	305.8	-152.29
3/3/03	638.28	294.4	-170.32
3/4/03	628.22	268.28	-173.52
3/5/03	601.94	274.88	-157.62
3/6/03	571.32	313.96	-144.05
3/7/03	261.42	244.38	-151.52
3/8/03	438.92	272.04	-163.38
3/9/03	616.3	350.18	-162.81
3/10/03	688.92	372.48	-169.8
3/11/03	670	374.84	-169.18
3/12/03	659.7	380.34	-167.64
3/13/03	635.7	385.28	-168.38
3/14/03	681.1	398.36	-177.76
3/15/03	620.72	378.2	-157.98
3/16/03	594.18	383.46	-153.62
3/17/03	629.74	396.78	-159.98
3/18/03	619.2	378.84	-154.91
3/19/03	625.7	392.98	-165.24

Date	25 cm	61 cm	457 cm
3/20/03	571.18	350.82	-146.21
3/21/03	234.94	258.7	-139.21
3/22/03	470.16	280.22	-159.68
3/23/03	682.52	354.14	-159.17
3/24/03	670.32	372.44	-168.86
3/25/03	665.04	374.38	-180.14
3/26/03	647.84	379.54	-190.34
3/27/03	630.74	374.38	-196.16
3/28/03	627.42	377.32	-188.32
3/29/03	634	376.9	-159.34
3/30/03	687.34	342.92	-156.09
3/31/03	679.78	341	-164.77
4/1/03	629.36	340.3	-165.74
4/2/03	643.1	328.2	-167.08
4/3/03	625.34	325.72	-181.64
4/4/03	616.16	358.44	-186.86
4/5/03	655.42	344.86	-171.74
4/6/03	698.22	416.06	-155.47
4/7/03	683.08	473.14	-145.2
4/8/03	676.3	325.34	-137.4
4/9/03	586.8	295.9	-124.58
4/10/03	414.56	261.72	-123.44
4/11/03	386.06	222.42	-125.82
4/12/03	583.1	276.28	-124.1
4/13/03	619.66	298.54	-126.42
4/14/03	630.26	311.24	-129.6
4/15/03	613.74	325.8	-129.68
4/16/03	608.74	330.54	-131.8
4/17/03	605.54	307.5	-131
4/18/03	605	296.9	-136
4/19/03	613.34	357.28	-133.46
4/20/03	616.08	484.28	-134.56
4/21/03	606.02	474.08	-127.58
4/22/03	603.2	465.7	-129.64
4/23/03	597.66	508.24	-136.64
4/24/03	600.62	533.62	-134.8
4/25/03	650.68	501.5	-125.2
4/26/03	680.18	465.76	-122.64
4/27/03	633.58	337.36	-127.12
4/28/03	596.72	443.56	-128.68
4/29/03	594.48	501.84	-131.42
4/30/03	589.88	516.22	-133.14
5/1/03	590.94	528.66	-130.58
5/2/03	609.18	530.34	-129.98
5/3/03	666.52	519.14	-129.84
5/4/03	680.6	355.62	-129.02
5/5/03	676.36	289.2	-131.46
5/6/03	606.86	319.74	-122.98
5/7/03	605.32	337.84	-126.04
5/8/03	560.28	331.66	-130.78
5/9/03	513.84	328.22	-129.42

Date	25 cm	61 cm	457 cm	Date	25 cm	61 cm	457 cm
5/10/03	507.74	333.26	-131.42	6/30/03	556.84	472.52	-186.32
5/11/03	502.62	332.08	-132.92	7/1/03	558.26	462.94	-173.38
5/12/03	490.22	343.52	-142.94	7/2/03	403.78	347.62	-155.8
5/13/03	490	462.5	-171.77	7/3/03	145.977	183.46	-159.62
5/14/03	499.2	494.18	-169.77	7/4/03	410.28	200.54	-169.52
5/15/03	503.88	495.26	-162.55	7/5/03	499.24	217.86	-178.15
5/16/03	535.38	495.8	-151.16	7/6/03	494.82	212.56	-174.51
5/17/03	467.44	507.18	-154.27	7/7/03	531.8	216.3	-171.1
5/18/03	491.24	543.94	-157.55	7/8/03	618.38	213.76	-171.52
5/19/03	529.96	540.06	-147.14	7/9/03	557.66	213.202	-175.34
5/20/03	517.96	552	-152.72	7/10/03	518.08	207.814	-178.05
5/21/03	498.22	552.24	-160.36	7/11/03	607.52	212.02	-173.44
5/22/03	504.3	540.24	-135.57	7/12/03	630.86	212.6	-175.84
5/23/03	515.28	454.56	-124.6	7/13/03	584.74	221.2	-175.09
5/24/03	560.18	332.38	-125.9	7/14/03	140.19	184.66	-161.32
5/25/03	588.96	334.14	-124.92	7/15/03	145.513	183.9	-155.96
5/26/03	663.96	332.36	-126.34	7/16/03	423.04	259.96	-168.82
5/27/03	579.68	336.98	-127.56	7/17/03	501.32	266.16	-169.16
5/28/03	538.8	348.52	-134.98	7/18/03	572.98	290.56	-174.08
5/29/03	571.86	376.26	-142.24	7/19/03	539.38	282.76	-174.12
5/30/03	571.76	373.64	-145.02	7/20/03	615.64	303.02	-175.9
5/31/03	545.62	341.02	-144.56	7/21/03	603.74	308.08	-180.78
6/1/03	557.48	318.8	-147.96	7/22/03	601.92	311.92	-186.82
6/2/03	514.16	308.58	-151.46	7/23/03	601.6	300.46	-186.32
6/3/03	518	305.52	-148.48	7/24/03	612.22	303.8	-188.18
6/4/03	544.98	304.52	-143.34	7/25/03	603.54	310.84	-190.5
6/5/03	510.08	324.8	-150.3	7/26/03	603.62	316.62	-187.68
6/6/03	514.56	455.7	-155.28	7/27/03	598.88	318.2	-185.07
6/7/03	544.26	461.94	-156.8	7/28/03	551.76	301.4	-185.32
6/8/03	619.18	435.64	-156.36	7/29/03	517.06	341.68	-193.76
6/9/03	585	445.88	-163.36	7/30/03	595.64	289.78	-185.52
6/10/03	530.6	464.62	-167.44	7/31/03	592.84	314	-188.04
6/11/03	525.1	459.54	-164.5	8/1/03	589.72	327.22	-194.31
6/12/03	586.12	461.48	-163.26	8/2/03	588.98	329.38	-193.5
6/13/03	575.8	499.04	-167.42	8/3/03	592.14	326.78	-185.41
6/14/03	548.68	507.24	-169.12	8/4/03	593.06	335.04	-194.42
6/15/03	549.84	514.74	-170.72	8/5/03	547.18	316.86	-189.55
6/16/03	557.44	500.98	-167.1	8/6/03	525.42	331.5	-187.82
6/17/03	554.58	491.36	-160.44	8/7/03	512.24	312.62	-181.2
6/18/03	551.04	496.28	-163.1	8/8/03	515.12	317.68	-182.3
6/19/03	534.78	464.06	-159.46	8/9/03	515.48	327.5	-188.41
6/20/03	528.3	281.02	-157.8	8/10/03	521.26	310.84	-180.43
6/21/03	652.46	260.96	-165.62	8/11/03	525.4	316.14	-182.73
6/22/03	621.54	255.72	-174.77	8/12/03	522.7	349.52	-183.12
6/23/03	588.36	247.38	-176.45	8/13/03	529.4	364.16	-179.8
6/24/03	544.46	209.62	-175.85	8/14/03	553.68	360.74	-183.02
6/25/03	559.32	215.54	-173.31	8/15/03	621.6	292.6	-184.16
6/26/03	566.82	341.62	-179.78	8/16/03	597.7	305.36	-187.13
6/27/03	574.46	370.2	-184.51	8/17/03	596.28	296.52	-190.58
6/28/03	609.8	425.34	-178.39	8/18/03	601.96	307.62	-193.49
6/29/03	608.66	463.66	-176.91	8/19/03	562.8	340	-189.01

Date	25 cm	61 cm	457 cm	Date	25 cm	61 cm	457 cm
8/20/03	547.38	371.9	-182.65	10/10/03	364.7	183.3	-216.35
8/21/03	571.18	404.7	-184.49	10/11/03	376.1	186.78	-215.23
8/22/03	612.36	414.12	-200.99	10/12/03	376.46	185.3	-212.59
8/23/03	605.24	373.44	-208.79	10/13/03	380.58	182.72	-216.26
8/24/03	609.54	269.9	-190.77	10/14/03	376.9	198.04	-203.6
8/25/03	613.22	290	-194.86	10/15/03	352.28	179.74	-219.6
8/26/03	610.94	330.74	-201.05	10/16/03	386.04	180.78	-217.02
8/27/03	581	378.58	-209.42	10/17/03	391.24	180.98	-214.86
8/28/03	538.74	402.44	-204.45	10/18/03	352.86	178.04	-213.8
8/29/03	527.08	418.44	-197.8	10/19/03	372.66	179.46	-210.6
8/30/03	521.58	413.12	-203.43	10/20/03	391.24	181.06	-207.26
8/31/03	519.72	412.06	-196.06	10/21/03	394.8	178.26	-216.34
9/1/03	521.54	411	-195.4	10/22/03	398.16	180.94	-214.58
9/2/03	540.98	418.14	-202.26	10/23/03	408.72	182.88	-215.74
9/3/03	541.98	423.66	-203.56	10/24/03	409.84	181.62	-222.7
9/4/03	515.28	414.5	-204.76	10/25/03	411	177.68	-224.84
9/5/03	551.48	282.48	-205.08	10/26/03	407.44	173.68	-219.96
9/6/03	540.4	271.96	-214.83	10/27/03	402.86	173.08	-207.82
9/7/03	524.18	276.88	-213.6	10/28/03	386.16	174.48	-204.18
9/8/03	549.98	289.28	-216.59	10/29/03	137	139.9	-209.33
9/9/03	551.88	375.02	-223.2	10/30/03	61.112	116.96	-207.23
9/10/03	530.2	399.14	-218.8	10/31/03	231.82	138.44	-210.58
9/11/03	536.88	424.1	-225.94	11/1/03	365.74	164.78	-212.38
9/12/03	521	421.8	-228.56	11/2/03	423.44	172.42	-212.24
9/13/03	521.28	439.7	-224.17	11/3/03	429.82	172.46	-217.39
9/14/03	526.24	451.48	-209	11/4/03	432.2	178.14	-223.79
9/15/03	518.54	459.88	-214.68	11/5/03	426.94	187.78	-201.86
9/16/03	519.92	470.9	-228.98	11/6/03	421.2	184.48	-199.39
9/17/03	518.52	482.38	-232.5	11/7/03	421.52	178.66	-219.35
9/18/03	452.48	344.9	-207.92	11/8/03	429.88	179.66	-236.4
9/19/03	307.94	222.696	-198.01	11/9/03	436.6	178.14	-240.84
9/20/03	611.38	268.6	-191.72	11/10/03	437.6	173.18	-234.72
9/21/03	630.3	278.4	-200.43	11/11/03	445.74	176.54	-230.66
9/22/03	546.68	260.1	-186.21	11/12/03	442.96	161.78	-235.44
9/23/03	404.92	239.96	-190.5	11/13/03	441.42	157.56	-241.74
9/24/03	553.04	256.22	-199.54	11/14/03	471.26	169.08	-235.54
9/25/03	429.04	163.316	-205.52	11/15/03	458.4	158.7	-248.38
9/26/03	337.306	136.608	-199.44	11/16/03	457.22	165.08	-244.72
9/27/03	337.116	138.156	-195.99	11/17/03	474.48	170.76	-240.88
9/28/03	313.04	139.34	-205.31	11/18/03	481.54	171.22	-244.14
9/29/03	361.058	141.482	-219.5	11/19/03	445.52	167.28	-247.48
9/30/03	372.75	139.628	-214.29	11/20/03	398.64	164.66	-226.9
10/1/03	378.56	139.014	-214.81	11/21/03	410.2	164.84	-224.44
10/2/03	385.966	143.402	-222.83	11/22/03	447.74	167.94	-234.38
10/3/03	391.94	149.732	-218.74	11/23/03	476.3	177.44	-234.76
10/4/03	392.14	156.196	-207.44	11/24/03	478.74	178.28	-234.08
10/5/03	397.68	167.61	-201.52	11/25/03	494.22	172.48	-249.66
10/6/03	398.68	171.68	-201.96	11/26/03	503.72	169.94	-259.7
10/7/03	401.26	173.96	-209.7	11/27/03	499.8	176.58	-255.88
10/8/03	377.12	158.188	-205.19	11/28/03	492.76	175.28	-254.96
10/9/03	338.76	175.38	-215.66	11/29/03	507.78	166.58	-257.52

Date	25 cm	61 cm	457 cm	Date	25 cm	61 cm	457 cm
11/30/03	525.92	169.5	-258.28	1/20/04	600.28	300.96	-103.03
12/1/03	520.9	165.86	-263.42	1/21/04	621.26	304.56	-94.186
12/2/03	531.02	163.64	-264.78	1/22/04	714.02	402.66	-6.474
12/3/03	539.54	176.4	-255.6	1/23/04	609.78	315.66	-96.742
12/4/03	520.18	173.98	-265.4	1/24/04	592.44	311.28	-102.43
12/5/03	511.18	184.64	-255.1	1/25/04	693.82	428.08	-8.87
12/6/03	515.02	186.22	-254.7	1/26/04	550.08	359.66	-83.516
12/7/03	520.94	193.62	-241.5	1/27/04	536.38	324.54	-80.011
12/8/03	554.06	197.08	-247.04	1/28/04	638.5	344.36	-55.46
12/9/03	540.48	213.9	-246.78	1/29/04	699.66	377.26	-8.296
12/10/03	512.7	208.6	-259.78	1/30/04	671.48	362.4	-23.842
12/11/03	470.76	194.12	-257.96	1/31/04	669.84	343.32	-39.78
12/12/03	487.2	203.16	-243.3	2/1/04	706	362.6	-17.744
12/13/03	496.3	206.36	-243	2/2/04	714.78	401.36	4.672
12/14/03	445.62	211.42	-224.16	2/3/04	693.06	388.32	0.026
12/15/03	329.06	185.04	-223.96	2/4/04	706.18	386.88	-6.714
12/16/03	512.2	202.4	-239.18	2/5/04	703.38	390.88	-2.292
12/17/03	511.26	207.56	-241.28	2/6/04	908.24	600.04	195.42
12/18/03	521.32	208.44	-232.28	2/7/04	731.8	429.18	39.218
12/19/03	511.74	210.56	-224.42	2/8/04	646.66	343.02	-47.519
12/20/03	521.14	211.96	-219.76	2/9/04	723.12	427.02	20.5194
12/21/03	574.76	216.1	-228.76	2/10/04	737.84	450.42	45.1696
12/22/03	554.66	208.94	-225.3	2/11/04	696.48	408.8	5.308
12/23/03	531.96	207.46	-254.5	2/12/04	592.78	336.58	-87.403
12/24/03	525.74	201.18	-262.12	2/13/04	673.3	403.16	-4.884
12/25/03	525.16	200.78	-247.48	2/14/04	704.02	438.92	26.8506
12/26/03	555.16	219.66	-237.4	2/15/04	726.98	467.04	68.2748
12/27/03	577.04	238.4	-203.68	2/16/04	651.68	398.46	3.934
12/28/03	632	303.54	-112.11	2/17/04	581.84	327.06	-81.036
12/29/03	659.1	354.9	-25.042	2/18/04	678.06	416.52	23.9756
12/30/03	693.7	390.58	8.448	2/19/04	744.9	450.22	50.8178
12/31/03	646.9	342.78	-48.622	2/20/04	757.52	458.08	58.7614
1/1/04	679.76	375.52	-17.218	2/21/04	756.92	470.02	72.21
1/2/04	656.92	358.66	-32.206	2/22/04	686.42	414.94	15.464
1/3/04	743.32	444.88	49.565	2/23/04	697.94	429.92	31.036
1/4/04	765.62	473.42	78.1588	2/24/04	841.48	559.82	155.66
1/5/04	790.06	504.06	105.448	2/25/04	646.84	369.5	-26.048
1/6/04	621.54	340.72	-53.908	2/26/04	787.76	475.54	72.183
1/7/04	607.8	303.24	-84.802	2/27/04	752.62	458.92	51.8086
1/8/04	628.2	319	-71.282	2/28/04	761.96	467.22	69.393
1/9/04	653.56	373.92	-30.85	2/29/04	735.4	472.48	73.164
1/10/04	614.78	317.54	-69.656	3/1/04	685.16	390.02	-60.691
1/11/04	668.22	336.92	-40.45	3/2/04	519.96	193.4	-302
1/12/04	642.84	335.08	-51.978	3/3/04	522.92	194.42	-300.66
1/13/04	693.04	395.38	-8.4	3/4/04	529.7	195.28	-299.08
1/14/04	649.22	357.74	-48.061	3/5/04	535.96	198.58	-295.08
1/15/04	631.92	343.1	-58.197	3/6/04	533.34	202.74	-297.42
1/16/04	623.74	322.66	-79.184	3/7/04	534.16	208.88	-295.54
1/17/04	643.36	342.22	-64.956	3/8/04	542.54	194.32	-292.16
1/18/04	709.5	435.2	25.042	3/9/04	557.06	207.84	-288.32
1/19/04	633.8	349.5	-60.288	3/10/04	559.3	203.72	-286.62

Date	25 cm	61 cm	457 cm
3/11/04	571.54	219.74	-285.36
3/12/04	555.72	201.9	-296.74
3/13/04	559.52	203.9	-294.5
3/14/04	556.48	217	-292.66
3/15/04	551.12	220.36	-298.58
3/16/04	547.4	229.64	-291.58
3/17/04	550.54	218.44	-290.12
3/18/04	546.7	222.94	-290.24
3/19/04	545.94	229.8	-292.84
3/20/04	545.68	239.12	-293.54
3/21/04	541.32	250.14	-290.32
3/22/04	490.86	251.58	-281.14
3/23/04	569.34	272.04	-273.26
3/24/04	535.18	271.84	-273.96
3/25/04	528.5	257.14	-277.82
3/26/04	540.18	257.22	-286.1
3/27/04	549.36	257.4	-285.12
3/28/04	548.54	251.58	-287.46
3/29/04	552.86	253.88	-285.88
3/30/04	551.26	256.32	-264.72
3/31/04	535.4	241.62	-258.76
4/1/04	536	236.22	-276.08
4/2/04	537.54	239.88	-283.5
4/3/04	506.64	245.14	-287.54
4/4/04	486.6	249.02	-288.18
4/5/04	536.74	253.38	-289.04
4/6/04	553.02	259.18	-291.46
4/7/04	533.22	260.22	-293.24
4/8/04	484.56	266.62	-290.16
4/9/04	482.6	273.38	-289.04
4/10/04	484.86	278.64	-283.88
4/11/04	509.02	283.08	-280.54
4/12/04	460.92	256.48	-258.88
4/13/04	409.42	212.28	-275.46
4/14/04	403.48	178.06	-277.52
4/15/04	424.98	181.38	-283.78
4/16/04	464.88	191.4	-283.08
4/17/04	475.84	189.46	-286.84
4/18/04	478.32	189.88	-289.24
4/19/04	480.68	190.68	-290.04
4/20/04	492.54	193.16	-291.14
4/21/04	491.68	191.06	-288.34
4/22/04	491.26	192.26	-288.9
4/23/04	494.24	205.94	-288.38
4/24/04	494.42	213.5	-289.82
4/25/04	494.7	225.14	-290.02
4/26/04	550.08	253	-275.06

Average daily redox measurements at Core 11 a soil with a histic epipedon

Date	25 cm	61 cm	457 cm	Date	25 cm	61 cm	457 cm
7/10/02	474.06	626.2	-256.54	10/20/02	599.92	564.66	191.8
7/11/02	463.9	618.38	-248.4	10/21/02	498.8	463.06	98.544
7/12/02	474.62	627.9	-238.48	10/22/02	497.38	454.44	75.714
7/13/02	472.12	639.74	-233.36	10/23/02	407.86	328.34	-66.39
7/14/02	462.06	639.7	-234.82	10/24/02	413.94	300.26	-57.394
7/15/02	467.02	638.72	-236.2	10/25/02	412.18	303.82	-66.332
7/16/02	465.4	638.14	-239.74	10/26/02	408.34	296.618	-70.911
7/17/02	461.86	636.48	-238.24	10/27/02	412.02	300.094	-70.874
7/18/02	456.98	635.02	-238.34	10/28/02	431.48	294.66	-69.022
7/19/02	452.94	632.16	-237.24	10/29/02	388.02	278.736	-67.452
7/20/02	447.9	627.08	-234.1	10/30/02	199.25	265.378	-77.42
7/21/02	451.12	612.42	-227.02	10/31/02	128.714	255.402	-79.854
7/22/02	449.84	614.86	-225.64	11/1/02	292.68	256.912	-77.046
7/23/02	475.46	587.5	-227.2	11/2/02	306.78	253.584	-73.186
7/24/02	463.7	592.32	-222.2	11/3/02	292	248.976	-72.778
7/25/02	454.88	591.36	-221.02	11/4/02	299.48	264.498	-71.694
7/26/02	443.72	595.1	-220.4	11/5/02	336.5	258.492	-72.072
7/27/02	441.84	594.42	-216.6	11/6/02	306.46	241.378	-76.728
7/28/02	444.4	595.08	-219.14	11/7/02	286.66	229.578	-74.786
7/29/02	441	596.78	-220.84	11/8/02	272.78	237.954	-73.436
7/30/02	437.84	596.02	-220.26	11/9/02	289.18	232.314	-78.712
7/31/02	437.94	594.88	-222.58	11/10/02	303.14	228.288	-84.056
8/1/02	435.16	601.32	-227.82	11/11/02	323	249.978	-90.358
8/2/02	435.26	609.42	-225.74	11/12/02	297.22	257.892	-88.782
8/3/02	457.24	621.2	-195.5	11/13/02	158.736	224.95	-81.79
8/14/02	645.48	787.24	54.6	11/14/02	68.291	199.866	-74.3
8/15/02	504.38	582.08	-135.49	11/15/02	59.95	184.49	-74.964
8/16/02	422.28	511.6	-227.92	11/16/02	109.752	185.972	-77.039
8/17/02	425.24	485.1	-221.92	11/17/02	116.25	189.92	-80.37
8/18/02	425.44	500.5	-226.38	11/18/02	69.642	164.908	-77.413
8/19/02	428.06	536.22	-232.18	11/19/02	68.646	158.267	-76.712
8/20/02	422.3	539.1	-232.36	11/20/02	73.272	154.002	-77.026
8/21/02	417.88	525.82	-218.8	11/21/02	72.786	148.148	-77.19
8/22/02	414.84	531.88	-211.38	11/22/02	89.23	142.092	-76.796
8/23/02	410.22	550.78	-210.56	11/23/02	187.25	135.424	-78.468
8/24/02	407.74	549.66	-209.58	11/24/02	250.332	146.57	-81.97
8/25/02	415.36	525.26	-203.42	11/25/02	284.568	155.81	-84.454
8/26/02	466.26	545.4	-150.17	11/26/02	313.68	163.528	-84.732
10/7/02	580.04	621.08	143.624	11/27/02	302.76	162.128	-85.23
10/8/02	601.52	638.18	174.176	11/28/02	272.78	137.836	-83.82
10/9/02	835	863.78	393.46	11/29/02	294.2	141.172	-84.234
10/10/02	612.22	644.02	160.6	11/30/02	340.96	162.888	-82.764
10/11/02	408.12	399.1	-83.794	12/1/02	372.3	156.576	-78.518
10/12/02	496	561.78	109.158	12/2/02	371	162.974	-81.804
10/13/02	293.84	467.64	10.246	12/3/02	405.16	186.922	-82.76
10/14/02	541.18	624.24	176.488	12/4/02	440.34	212.352	-74.7
10/15/02	300.14	419.98	-12.89	12/5/02	433.24	233.192	-67.458
10/16/02	178.08	455.32	29.746	12/6/02	346.76	179.834	-80.257
10/17/02	431.64	576	164.012	12/7/02	294.88	150.866	-85.042
10/18/02	577.6	586.58	193.026	12/8/02	351.66	177.462	-87.156
10/19/02	581.24	558.78	182.32	12/9/02	360.76	183.592	-88.89

Date	25 cm	61 cm	457 cm	Date	25 cm	61 cm	457 cm
12/10/02	372.24	203.092	-86.89	1/30/03	443.64	257.44	-85.322
12/11/02	390.22	233.564	-87.172	1/31/03	429.36	254.86	-96.648
12/12/02	320.94	194.334	-89.738	2/1/03	411.34	260.474	-103.63
12/13/02	348.42	209.048	-92.79	2/2/03	411.46	241.018	-103.62
12/14/02	298.976	165.956	-94.43	2/3/03	412.6	269.014	-110.51
12/15/02	229.872	155.776	-95.292	2/4/03	415.38	269.574	-112.35
12/16/02	137.12	139.328	-96.292	2/5/03	409.14	259.014	-100.76
12/17/02	148.228	125.354	-97.468	2/6/03	427.08	271.138	-92.838
12/18/02	247.138	145.786	-98.192	2/7/03	436.4	255.468	-104.55
12/19/02	304.836	186.984	-94.28	2/8/03	415.54	254.748	-107.47
12/20/02	244.416	170.762	-93.872	2/9/03	388.28	240.12	-106.39
12/21/02	155.982	135.73	-94.162	2/10/03	403.92	244.432	-108.88
12/22/02	123.414	131.578	-96.527	2/11/03	377.5	232.682	-109.67
12/23/02	109.956	134.022	-98.762	2/12/03	353.58	240.434	-108.74
12/24/02	168.748	142.096	-102.43	2/13/03	327.44	226.508	-104.83
12/25/02	185.514	143.85	-103.25	2/14/03	332.96	226.77	-105.68
12/26/02	102.664	147.536	-100.16	2/15/03	343.52	247.404	-104.36
12/27/02	91.6802	158.446	-99.2	2/16/03	366.16	247.322	-95.787
12/28/02	148.699	151.15	-97.926	2/17/03	373.38	227.462	-84.925
12/29/02	199.046	137.722	-99.55	2/18/03	343.7	211.556	-99.228
12/30/02	284.022	175.684	-100.19	2/19/03	273.05	187.72	-98.926
12/31/02	307.918	189.97	-99.286	2/20/03	194.588	156.32	-99.174
1/1/03	261.054	181.824	-96.57	2/21/03	113.898	141.92	-98.79
1/2/03	186.93	144.602	-91.702	2/22/03	133.556	142.692	-104.83
1/3/03	135.782	136.58	-91.29	2/23/03	158.258	151.146	-104.78
1/4/03	130.522	139.356	-92.954	2/24/03	124.867	147.544	-112.01
1/5/03	129.874	148.698	-94.048	2/25/03	145.28	134.518	-117.85
1/6/03	161.152	138.002	-97.354	2/26/03	241.002	140.602	-111.07
1/7/03	268.349	173.076	-99.11	2/27/03	253.286	170.174	-107.03
1/8/03	305.736	193.492	-102.63	2/28/03	239.486	156.482	-111.47
1/9/03	326.78	207.722	-101.54	3/1/03	153.84	147.614	-114.53
1/10/03	339.28	219.648	-100.88	3/2/03	161.79	151.728	-113.1
1/11/03	339.4	208.304	-97.496	3/3/03	103.414	131.394	-116.97
1/12/03	350.64	206.884	-98.429	3/4/03	99.71	120.514	-119.86
1/13/03	361.58	218.356	-98.151	3/5/03	122.238	128.172	-113.25
1/14/03	369.84	233.774	-100.04	3/6/03	91.808	156.922	-125.1
1/15/03	380.04	242.558	-98.575	3/7/03	82.6572	160	-110.25
1/16/03	393.46	238.486	-97.784	3/8/03	62.3756	137.528	-115.23
1/17/03	400.98	247.464	-97.436	3/9/03	65.4134	113.78	-120.28
1/18/03	403.34	229.698	-95.41	3/10/03	80.1072	106.074	-122.39
1/19/03	436.66	228.692	-97.378	3/11/03	94.5616	108.274	-118.93
1/20/03	441.54	253.312	-107.47	3/12/03	158.224	101.466	-116.61
1/21/03	428.64	270.73	-105.18	3/13/03	254.335	99.32	-119.62
1/22/03	409.28	255.06	-102.09	3/14/03	269.758	97.7	-125.47
1/23/03	405.96	238.886	-97.544	3/15/03	269.778	135.916	-114.52
1/24/03	420.6	241.396	-94.604	3/16/03	194.86	132.878	-125.12
1/25/03	426.62	253.086	-96.708	3/17/03	108.626	110.832	-130.83
1/26/03	430.1	262.274	-102.77	3/18/03	90.648	125.104	-130.09
1/27/03	428.46	250.01	-98.9	3/19/03	79.188	107.73	-125.77
1/28/03	425.46	254.646	-99.884	3/20/03	73.342	130.556	-123.84
1/29/03	430.5	281.658	-105.74	3/21/03	63.2972	141.354	-118.82

Date	25 cm	61 cm	457 cm	Date	25 cm	61 cm	457 cm
3/22/03	96.23	114.602	-123.5	5/12/03	377.96	225.802	-76.68
3/23/03	113.974	111.428	-125.94	5/13/03	421.4	269.43	-73.035
3/24/03	142.178	110.244	-124.41	5/14/03	438.36	289.38	-67.804
3/25/03	225.924	113.622	-124.61	5/15/03	448.5	312.1	-66.21
3/26/03	250.932	113.608	-126.33	5/16/03	455.14	314.56	-51.99
3/27/03	274.06	123.204	-118.73	5/17/03	462.38	312.12	-63.292
3/28/03	294.9	141.532	-109.44	5/18/03	454.2	310.28	-63.616
3/29/03	309.16	166.81	-97.668	5/19/03	455.3	302.28	-67.018
3/30/03	312.88	176.148	-96.092	5/20/03	449.24	312.42	-81.888
3/31/03	247.844	143.2	-97.57	5/21/03	450.68	317.38	-77.341
4/1/03	248.75	132.19	-100.03	5/22/03	458.8	335	-73.51
4/2/03	280.16	141.19	-101.03	5/23/03	437.24	327.9	-89.518
4/3/03	310.58	161.6	-100.29	5/24/03	318.14	269.18	-88.217
4/4/03	327.2	181.086	-94.328	5/25/03	169.22	247.82	-90.608
4/5/03	367.12	205.666	-93.092	5/26/03	105.507	233.6	-90.234
4/6/03	364.32	207.136	-96.442	5/27/03	102.657	237.6	-87.979
4/7/03	371.86	215.72	-97.482	5/28/03	98.428	231.08	-94.738
4/8/03	335.68	203.506	-97.404	5/29/03	135.942	226.1	-96.566
4/9/03	270.034	170.476	-109.72	5/30/03	302.22	219.18	-86.886
4/10/03	201.182	161.494	-115.27	5/31/03	287.26	214.19	-89.292
4/11/03	106.121	146.208	-104.18	6/1/03	161.424	200.444	-93.072
4/12/03	119.176	124.408	-108	6/2/03	315.58	195.356	-88.622
4/13/03	167.862	112.664	-110.44	6/3/03	326.18	191.918	-87.276
4/14/03	238.463	104.492	-107.84	6/4/03	328.54	184.104	-90.252
4/15/03	269.94	112.224	-104.44	6/5/03	330.48	178.242	-89.83
4/16/03	294.94	126.05	-101.66	6/6/03	357.44	207.24	-82.484
4/17/03	323.64	156.438	-97.382	6/7/03	394.94	235.56	-75.924
4/18/03	346.86	184.014	-90.604	6/8/03	357.44	192.26	-81.536
4/19/03	358.06	186.754	-86.072	6/9/03	328.3	146.536	-82.376
4/20/03	369.3	194.616	-81.604	6/10/03	351.24	175.578	-75.645
4/21/03	403.24	219.342	-80.29	6/11/03	395.94	218.18	-75.796
4/22/03	396.58	213.828	-89.892	6/12/03	439.6	237.1	-78.786
4/23/03	377.34	209.56	-86.074	6/13/03	417.44	235.3	-78.309
4/24/03	390.92	209.448	-83.264	6/14/03	419.94	250.54	-76.66
4/25/03	419.66	251.736	-83.904	6/15/03	467.2	263.68	-75.599
4/26/03	406.4	253.4	-84.412	6/16/03	482.38	272.86	-71.862
4/27/03	351.3	217.734	-87.436	6/17/03	486.52	275.06	-66.058
4/28/03	351.2	224.062	-84.53	6/18/03	488.36	278.56	-62.076
4/29/03	354.14	219.954	-82.25	6/19/03	481.44	268.82	-78.346
4/30/03	363.94	226.716	-83.276	6/20/03	279.86	193.704	-73.348
5/1/03	423.06	288.5	-75.658	6/21/03	112.796	142.322	-80.334
5/2/03	431.84	302.94	-74.902	6/22/03	264.304	127.332	-79.096
5/3/03	422.64	262.06	-81.418	6/23/03	343.06	125.406	-80.02
5/4/03	442.36	263.38	-82.798	6/24/03	399.76	163.272	-73.52
5/5/03	322.44	176.098	-82.028	6/25/03	446.26	212.34	-72.882
5/6/03	249.14	144.912	-83.862	6/26/03	485.92	234.94	-77.297
5/7/03	174.552	134.97	-87.438	6/27/03	475.54	236.22	-75.546
5/8/03	159.766	127.276	-88.534	6/28/03	495.88	222.22	-66.042
5/9/03	314.382	127.472	-86.914	6/29/03	491.42	217.56	-67.454
5/10/03	303.8	130.3	-86.618	6/30/03	491.8	295.38	-69.398
5/11/03	326.82	154.744	-81.578	7/1/03	501.18	335.44	-58.962

Date	25 cm	61 cm	457 cm	Date	25 cm	61 cm	457 cm
7/2/03	510.84	310.16	-82.66	8/22/03	416.18	78.2682	-117.91
7/3/03	213.72	243.14	-80.529	8/23/03	437.4	103.442	-125.37
7/4/03	156.71	223.02	-76.997	8/24/03	447.46	128.07	-111.35
7/5/03	344.004	210.72	-86.633	8/25/03	447.52	128.354	-115.68
7/6/03	356.98	204.756	-87.52	8/26/03	437.14	114.99	-115.92
7/7/03	396.74	196.466	-87.131	8/27/03	425.16	119.99	-117.04
7/8/03	343.306	173.532	-93.664	8/28/03	414.54	142.842	-122.52
7/9/03	412.44	142.038	-96.088	8/29/03	411.3	158.092	-116
7/10/03	440.34	112.144	-92.022	8/30/03	395.82	157.856	-115.8
7/11/03	467.6	155.42	-99.46	8/31/03	401.96	215.512	-111.51
7/12/03	461.84	143.114	-101.56	9/1/03	396.82	232.174	-114.82
7/13/03	458.12	140.476	-108.71	9/2/03	399.72	246.096	-117.58
7/14/03	184.306	133.93	-106.29	9/3/03	372.06	258.966	-120.11
7/15/03	63.9418	117.172	-99.448	9/4/03	346.68	272.4	-121.45
7/16/03	46.5586	78.236	-111.31	9/5/03	395.66	282.38	-139.93
7/17/03	42.02	118.214	-122.62	9/6/03	371.36	281.218	-145.13
7/18/03	35.17	93.856	-112.24	9/7/03	380.14	263.62	-147.36
7/19/03	32.444	90.986	-116.4	9/8/03	396.78	251.612	-150.59
7/20/03	28.742	82.52	-102.91	9/9/03	395.8	232.235	-153.53
7/21/03	39.922	53.59	-101.19	9/10/03	393.62	211.414	-134.55
7/22/03	175.898	44.374	-112.4	9/11/03	394.32	186.375	-141.35
7/23/03	145.912	72.436	-108.5	9/12/03	404.16	179.833	-140.46
7/24/03	162.092	83.342	-105.52	9/13/03	392.64	241.96	-134.65
7/25/03	186.522	56.6	-95.512	9/14/03	392.58	329.596	-113.86
7/26/03	247.662	63.354	-94.61	9/15/03	389.26	347.952	-118.31
7/27/03	315.372	78.166	-97.98	9/16/03	389.02	370.64	-134.42
7/28/03	358.88	96.514	-105.63	9/17/03	388.02	395.9	-143.8
7/29/03	393.5	104.36	-106.24	9/18/03	416.42	362.44	-145.83
7/30/03	309.132	101.32	-102.15	9/19/03	274.82	347.8	-159.61
7/31/03	279.084	67.906	-99.504	9/20/03	89.172	317.62	-145.22
8/1/03	315.15	57.118	-103.06	9/21/03	104.234	309.1	-148.41
8/2/03	353.236	68.07	-102.35	9/22/03	151.418	296.058	-144.98
8/3/03	351.26	73.058	-98.236	9/23/03	74.5	281.928	-153.75
8/4/03	369.72	81.994	-109.33	9/24/03	69.356	272.377	-149.81
8/5/03	274.688	83.788	-112.7	9/25/03	17.484	205.092	-154.53
8/6/03	225.614	46.9846	-118.51	9/26/03	-43.321	-2.15	-156.45
8/7/03	271.03	77.384	-112.83	9/27/03	-42.028	-23.394	-145.18
8/8/03	299.524	81.216	-112.8	9/28/03	-41.834	-23.834	-156.33
8/9/03	325.13	62.3408	-118.89	9/29/03	-38.801	-17.896	-172.77
8/10/03	376.134	91.038	-129.76	9/30/03	-37.906	-1.49	-161.34
8/11/03	364.16	91.744	-118.98	10/1/03	-32.68	5.866	-165.75
8/12/03	365.996	72.2144	-118.35	10/2/03	-20.08	14.202	-178.96
8/13/03	372.99	100.384	-117.33	10/3/03	-18.824	25.552	-173.96
8/14/03	364.23	87.88	-122.54	10/4/03	-14.588	27.7416	-166.98
8/15/03	121.678	72.9256	-122.15	10/5/03	-7.008	31.666	-162.17
8/16/03	223.446	47.002	-125.77	10/6/03	21.54	44.454	-161.82
8/17/03	233.67	48.3892	-130.13	10/7/03	64.37	65.662	-178.26
8/18/03	292.777	35.9088	-139.42	10/8/03	60.548	71.1196	-157.32
8/19/03	333.61	61.8638	-117.72	10/9/03	-13.328	41.476	-185.14
8/20/03	345.214	66.87	-111.62	10/10/03	-25.218	36.608	-178.34
8/21/03	389.72	74.6372	-115.66	10/11/03	-30.324	32.32	-185.13

Date	25 cm	61 cm	457 cm	Date	25 cm	61 cm	457 cm
10/12/03	-26.908	27.052	-187.99	12/2/03	228.396	86.846	-225.9
10/13/03	-9.066	24.18	-180.41	12/3/03	248.172	92.878	-207.69
10/14/03	-27.17	32.62	-188.76	12/4/03	236.512	86.64	-214.04
10/15/03	-34.438	30.534	-197.16	12/5/03	183.882	68.63	-224.26
10/16/03	-12.498	25.284	-189.86	12/6/03	139.9	46.3868	-229.23
10/17/03	-6.62	27.086	-188.19	12/7/03	141.68	27.402	-226.97
10/18/03	-26.39	29.498	-190.51	12/8/03	177.874	39.2922	-210.13
10/19/03	-24.868	29.622	-184.52	12/9/03	181.14	30.014	-222.78
10/20/03	0.754	30.114	-187.08	12/10/03	182.72	50.265	-214.9
10/21/03	5.444	23.79	-193.2	12/11/03	162.994	45.03	-222.7
10/22/03	26.592	18.052	-200.19	12/12/03	122.872	36.3456	-215.57
10/23/03	63.038	23.418	-195.81	12/13/03	53.994	33.062	-214.94
10/24/03	100.24	30.81	-194.2	12/14/03	43.814	45.152	-202.07
10/25/03	148.84	78.856	-199.06	12/15/03	37.168	40.802	-219.38
10/26/03	159.54	84.866	-186.6	2/15/04	190.12	193.32	-231
10/27/03	162.26	88.378	-189.09	2/16/04	169.834	185.12	-232.78
10/28/03	156.88	88.452	-190.52	2/17/04	152.624	172.72	-219.2
10/29/03	51.08	57.74	-206.93	2/18/04	132.446	163.08	-226.08
10/30/03	9.648	34.978	-198.23	2/19/04	112.93	164.92	-233.66
10/31/03	-2.18	31.342	-195.57	2/20/04	48.0064	143.62	-240.5
11/1/03	-11.232	26.898	-197.98	2/21/04	8.03	136.8	-240
11/2/03	-15.902	23.056	-199.88	2/22/04	13.014	146.78	-230.76
11/3/03	-21.53	16.886	-203.99	2/23/04	27.418	141.2	-223.1
11/4/03	-25.642	5.0334	-213.7	2/24/04	79.98	135.92	-229.83
11/5/03	-17.924	3.926	-193.48	2/25/04	129.786	136.58	-227.18
11/6/03	-7.634	2.7204	-193.91	2/26/04	159.208	142.66	-223.74
11/7/03	8.136	-4.9062	-210.41	2/27/04	146.56	136.44	-223.12
11/8/03	17.8802	-2.316	-211.22	2/28/04	128.774	138.14	-229.58
11/9/03	47.606	9.138	-203.09	2/29/04	110.034	128.302	-230.04
11/10/03	80.132	2.184	-207.51	3/1/04	79.066	112.434	-233.96
11/11/03	113.94	-0.746	-199.6	3/2/04	58.064	140.42	-212.18
11/12/03	122.576	1.702	-220.66	3/3/04	59.3	148.22	-201.08
11/13/03	135.524	0.326	-213.26	3/4/04	58.984	147.64	-201.11
11/14/03	179.32	38.3524	-211.36	3/5/04	59.55	145.712	-196.42
11/15/03	186.02	50.1796	-209.23	3/6/04	67.326	143.81	-188.08
11/16/03	191.254	54.0862	-213.94	3/7/04	138.378	141.096	-170
11/17/03	193.622	57.546	-210.58	3/8/04	235.226	143.616	-185.22
11/18/03	201.044	55.26	-205.4	3/9/04	255.44	144.624	-144.9
11/19/03	192.746	54.97	-214.08	3/10/04	255.68	146.67	-150.26
11/20/03	115.54	28.3246	-224.1	3/11/04	294.46	153.91	-146.12
11/21/03	20.082	16.05	-220.34	3/12/04	347.28	165.18	-150.58
11/22/03	13.936	10.108	-221.7	3/13/04	354.92	178.96	-148.73
11/23/03	43.43	5.976	-222.11	3/14/04	355.34	177.02	-144.98
11/24/03	53.616	0.93	-225.26	3/15/04	372.22	178.88	-166.29
11/25/03	127.482	6.442	-224.83	3/16/04	373.72	178.94	-132.66
11/26/03	136.9	5.68	-223.39	3/17/04	379.12	192.66	-136.62
11/27/03	142.544	5.22	-210.22	3/18/04	378.12	217.26	-141.61
11/28/03	147.404	15.826	-226.31	3/19/04	378.78	236.98	-139.68
11/29/03	169.392	17.358	-225.04	3/20/04	372.16	246.42	-144.39
11/30/03	180.294	24.056	-221.2	3/21/04	352.42	257.06	-131.36
12/1/03	206.212	68.466	-232.79	3/22/04	349.98	298.72	-138.73

Date	25 cm	61 cm	457 cm
3/23/04	354.7	314.54	-130.14
3/24/04	358.7	309.44	-129.84
3/25/04	360.82	315.1	-139.8
3/26/04	361.88	319.38	-140.83
3/27/04	361.74	320.74	-132.28
3/28/04	361.7	333.84	-137.34
3/29/04	388.74	361.54	-141.72
3/30/04	373.38	377.98	-130.1
3/31/04	377.26	379.14	-129.82
4/1/04	362.68	380.62	-138.02
4/2/04	353.6	391.28	-141.81
4/3/04	354.84	391.18	-141.05
4/4/04	357	389.8	-136.23
4/5/04	355.42	393.52	-136.73
4/6/04	354.58	396.16	-141.8
4/7/04	354	389.7	-145.1
4/8/04	358.6	395.76	-143.2
4/9/04	370.7	393.26	-142.05
4/10/04	370.34	382.9	-140.75
4/11/04	370.42	384.38	-146.81
4/12/04	391.96	376.96	-126.55
4/13/04	356.517	365.92	-137.89
4/14/04	284.424	357.32	-151.27
4/15/04	225.018	337.28	-158.71
4/16/04	212.67	323.06	-159.74
4/17/04	231.624	313.32	-164.77
4/18/04	256.382	308.76	-170.7
4/19/04	288.738	319.3	-173.2
4/20/04	322.22	332.16	-174.69
4/21/04	338.82	336.52	-173.7
4/22/04	341.9	335.9	-173.79
4/23/04	347.76	335.76	-165.19
4/24/04	351.02	332.18	-170.75
4/25/04	371.56	337.18	-172.38
4/26/04	383.08	344.52	-144.41
4/27/04	363.74	370.3	-157.32
4/28/04	355.52	382.62	-165.92
4/29/04	362.08	380.16	-166.04
4/30/04	359.28	377.82	-159.15
5/1/04	371.34	365.54	-128.54
5/2/04	385.22	364.3	-125.84
5/3/04	343.792	368.58	-153.16
5/4/04	235.74	367.74	-169.9
5/5/04	128.48	353.82	-179
5/6/04	144.408	345.7	-182.28
5/7/04	198.992	342.54	-183.84
5/8/04	220.012	340.16	-179.22
5/9/04	274.608	350.8	-178.05
5/10/04	307.916	358.86	-181.41
5/11/04	338.38	357.96	-170.95
5/12/04	372.54	354.22	-151.26
5/13/04	373.18	352.18	-157.27
5/14/04	354.42	354.5	-160.53
5/15/04	358.04	361.26	-161.42
5/16/04	360.08	366.9	-162.82
5/17/04	362.76	375.96	-161.06
5/18/04	366.74	382.56	-158.23
5/19/04	368.76	393.24	-167.63
5/20/04	372.74	397.5	-167.06
5/21/04	372.06	398.04	-168.05
5/22/04	368.3	394.96	-166.44
5/23/04	391.78	386.28	-158.64
5/24/04	387.36	395.78	-157.86
5/25/04	365.6	393.82	-168.11
5/26/04	360.66	394.4	-169.15
5/27/04	357.34	401.78	-168.39
5/28/04	355.8	403.72	-169.76
5/29/04	357.26	412.58	-165.45
5/30/04	376.56	408.68	-158.91
5/31/04	357.84	430.06	-169.25
6/1/04	339.58	435.68	-168.46
6/2/04	340.16	440.98	-165.67
6/3/04	357.22	445.1	-154.05
6/4/04	342.72	445.12	-155.15
6/5/04	172.914	437.46	-164.88
6/6/04	110.332	426.52	-160.73
6/7/04	109.94	422.9	-160.37
6/8/04	118.87	419.7	-158.94
6/9/04	116.33	442.28	-138.55
6/10/04	131.455	446.86	-125.89
6/11/04	140.785	434.12	-135.26
6/12/04	151.704	430.16	-135.3
6/13/04	149.114	424.4	-133.32
6/14/04	150.276	418.44	-137.3
6/15/04	142.867	413.54	-128.32
6/16/04	145.76	402.46	-126.32
6/17/04	155.972	385.78	-125.66
6/18/04	138.516	359.46	-124.58
6/19/04	127.957	332.42	-112.12
6/20/04	138.268	305.64	-127.34
6/21/04	136.52	285.78	-119.59
6/22/04	138.892	273.038	-129.97
6/23/04	136.17	265.112	-128.76
6/24/04	101.226	256.384	-115.01
6/25/04	111.288	238.96	-114.29
6/26/04	123.876	242.926	-111.21
6/27/04	127.788	218.86	-105.28
6/28/04	111.614	199.246	-109.32
6/29/04	118.764	175.516	-120.65
6/30/04	161.594	152.184	-104.96
7/1/04	192.982	137.72	-108.73
7/2/04	219.078	131.968	-104.07

Appendix C

Raw Data- Reference Bays

Manual redox measurements (mV) at Causeway Bay

	Mineral		Histic		Deep Organic	
Date	25 cm	61 cm	25 cm	61 cm	25 cm	61 cm
11/7/2002	573.4	168.4	174.2	-54.4	226.8	24.8
1/14/2003	195.6	56.4	93	-105.6	146.6	27.4
1/28/2003	179.6	26.2	137.2	-74	187.4	77.8
2/19/2003	215.4	159.4	153.6	-38.4	239.6	66.8
2/25/2003	102.8	4.6	48	-104.6	107.4	-28.6
3/17/2003	87.6	16	-6.8	-163.6	97.4	12.8
3/25/2003	167	123.4	69	-75.8	157.8	45.2
4/1/2003	64.2	48.4	-41.8	-83	71	-4.4
4/15/2003	74.4	67.8	-13.4	-77.6	-26.4	-74
5/13/2003	136.6	46	-26	-66.8	39.4	-14.6
6/10/2003	83.8	27.2	-30.2	-60.2	54.4	-127.6
6/30/2003	97.4	49.6	-96.6	-98.2	38.6	7.8
7/8/2003	14.6	51	-59	-71	-10.8	-40.4
8/6/2003	21	72.4	-1	-40	79.2	3.8
8/28/2003	-34	-16.2	-124.8	-165.8	3	-0.4
9/4/2003	-22	-8	-102.7	-155.1	25.9	-2.7
9/10/2003	143.4	13.6	-78	-146	77.2	-6.6
10/2/2003	-15.4	-17.2	-77.4	-165.4	55.8	12
11/20/2003	-14.6	87.4	-12.2	-159	160.2	91
12/4/2003	9.8	-24.4	-99	-155.2	250	76.6
1/7/2004	1.6	-22.4	-49.4	164.4	58	34.4
1/30/2004	-3.2	-33.4	-22.8	-133.6	92.2	-17
2/6/2004	10.4	-19.8	31.4	-44.4	26.2	-21.6
2/13/2004	2	31	-124.6	-45	146	22.2
2/20/2004	-159.6	-17.6	-190.6	-161	101.2	-29.6
3/5/2004	-0.4	-23	-100.8	-124.6	68	-35.6
3/19/2004	-17.8	-45	-123.2	-172.4	122.6	-14.4
3/26/2004	7.2	-31.6	-112.2	-151.4	106.6	-29
4/5/2004	-11.4	-57.6	-110.6	-148.6	89.8	-27.6
4/16/2004	-42.8	-27.2	-88	-146	82.6	-27.8
5/10/2004	22	-4	-82.6	-130.2	74	1
5/28/2004	98.4	-56.2	-118.2	-158.6	31	13.2
6/7/2004	146.6	-29.2	-115	-162.4	8.8	-10.4
6/15/2004	219	44.6	-144	-181.2	54.2	1
7/22/2004	621	254.6	54.6	60.6	218.4	208.8
7/28/2004	670.2	218.4	64	109.8	278.6	211.6
8/5/2004	471.06	311.6	91.6	98.6	199.8	194.4
8/9/2004	493	203.8	80.2	83.6	257.2	171.8
8/24/2004	316.75	202.8	391.6	235.2	246	305.4

Manual redox measurements (mV) at Charlie Long Millpond

	Mineral		Histic		Deep Organic	
Date	25 cm	61 cm	25 cm	61 cm	25 cm	61 cm
11/7/2002	675.8	-82.2	395.2	-71	-62	152.4
1/14/2003	199.8	37.2	269	-101.4	276.6	186.2
1/28/2003	216.6	99.8	296.8	-72	371.2	212.8
2/19/2003	269.4	63.2	278.8	-29	395.8	260.2
2/25/2003	232	70	277.4	-34.6	321.6	227.6
3/17/2003	139.2	-49	103.2	-103.6	271.2	258.2
3/25/2003	147.4	-48.4	109.6	-76.2	186.8	148.6
4/1/2003	94.6	-13	61.8	-13.6	160	92.8
4/15/2003	84	2	42.4	-62.4	10.2	72.8
5/13/2003	152.6	22.4	71.2	-41.2	119.6	116.2
6/10/2003	19.8	-95	69.8	-89	123	157.8
6/30/2003	85.6	15.8	55.8	-22.8	97.8	102
7/8/2003	75.4	19	77.4	24.4	116.6	129.4
8/6/2003	64	38	44.4	7	40.8	109.4
9/4/2003	32.4	14.3	36.8	15.5	16.9	99.9
9/10/2003	-25.8	-45	29.2	-110	-29.8	33.8
10/2/2003	-15.4	-17.2	-77.4	-165.4	55.8	12
11/20/2003	-28.2	-16.6	30.4	-8.2	-10	124
12/4/2003	-1	32	2.2	-6.4	-2.4	87.8
1/7/2004	-36.2	-27	-26.6	-135	11	37.6
1/30/2004	-14	-35.8	-14.2	-130.2	64.8	49.8
2/6/2004	11.4	-23.4	-22.6	-131	35.6	49
2/13/2004	-19	-9.6	55.6	107.8	11.4	-64.2
2/20/2004	-7.4	-32.4	-47.6	-162.4	42.2	36.8
3/5/2004	-5.2	-72.2	-16.8	-145	70.2	28.6
3/19/2004	-26.8	-44.2	-51	-157.4	28.8	39.4
3/26/2004	-45	-51.8	-32.2	-138.2	27.2	37.2
4/5/2004	-37.6	-61.2	-45.6	-169	3.8	34
4/16/2004	-30.4	-49.6	-4.4	-147.2	95	23.4
5/10/2004	-4.6	-27.6	41	21.2	226.2	334.2
5/28/2004	-26	-81.2	76.6	-137.2	-1.6	19.6
6/7/2004	-13	-63	6.4	-143	40.8	28.2
6/15/2004	-28.6	-62.4	105.6	-146.8	69	19.2
7/22/2004	537	137.6	449	80.2	693.8	321.4
7/28/2004	499.6	150.4	469.6	74	719	290.2
8/5/2004	555.6	132.4	440.2	68.4	698.6	289
8/9/2004	462.2	133	453.2	51	693.8	276.6
8/24/2004	197.6	281	334.6	53.2	376.2	269

Manual redox measurements (mV) at Tatum Millpond

	Mineral		Histic		Deep Organic	
Date	25 cm	61 cm	25 cm	61 cm	25 cm	61 cm
11/7/2002	365.2	228.4	53	198.6	126.6	232.8
1/14/2003	224.6	38	-22.4	-1.2	23	103.8
1/28/2003	362.6	86.2	-7.4	19.6	56.2	14.2
2/19/2003	230	105.6	27.6	28.6	97	168.6
2/25/2003	196.8	195.2	-69.4	-75	-7	197.4
3/17/2003	106.8	200	-113.6	-75.4	-30	45.2
3/25/2003	133.2	29.8	-15.2	-6.6	-13.6	55.8
4/1/2003	-64.2	-84.6	9.4	61.6	80.4	29.6
4/15/2003	64.4	-6	-77.8	97.8	-50.2	49.2
5/13/2003	100.4	200	-40.8	-77.4	-16.6	-46.2
6/10/2003	75.6	200	-79.6	-94.4	-20.8	-39
6/30/2003	76.2	-28.2	-23.2	-82.4	-14.4	-18.2
7/8/2003	24	-58.4	-37.2	-62.8		
8/6/2003	-5.4	-53	-24.8	-76.4	-57.8	-47.6
8/28/2003	-58.6	-133.8	-173.4	-136.2		
9/4/2003	-62.5	-154.8	-187.4	-132.9		
9/10/2003	-37	-94.4	-54	-115	-76.2	-68
10/2/2003	-47	-120	-64.8	-1.6		
11/14/2003	-10	-70	20.4	-115.8	-72.8	-89.4
11/20/2003	-15.4	-59	-72	78	-48.4	-9
12/4/2003	-5.4	-52.2	26.6	-102		
1/7/2004	62.8	-44.6	-77.3	-109.2	175.4	-86
1/30/2004	74.2	-42.2	13.5	-24.6		
2/6/2004	75.4	-4.4	-67.3	-105.8		
2/13/2004	-14	-75.6	58.6	-14.4	88.4	-35.2
2/20/2004	5.6	-93	-61.3	-104.4		
3/5/2004	37	-54.2	-102.5	-119		
3/19/2004	71.6	-5.4	-62.8	-117		
3/26/2004	42.8	-26.6	-64	-109.8	50	-84.6
4/5/2004	31.8	-24.8	-84.5	-109		
4/16/2004	37.8	-24	-105.3	-135.8	-4	-83.6
5/10/2004	48.6	-10.6	-78.4	-102.8		
5/28/2004	-5.2	-77.8	-61.6	-109		
6/7/2004	-35	-118	-66.75	-84.4		
6/15/2004	44.8	-68.2	-119.6	-133.8	-33.6	-108.2
7/22/2004	269	148.2	188.75	89.8	209.2	186.8
7/28/2004	234	134.2	73.75	78.6	136.8	104.2