APPENDIX I

Reconstruction of Holocene Sedimentary Environments of the St. Jones River Near Delaware Route 10

by

James E. Pizzuto
Department of Geology
University of Delaware
Newark, Delaware 19716
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APPENDIX I

INTRODUCTION

This report presents the results of a study of Holocene sedimentary environments of the St. Jones River near Delaware Route 10 in Kent County, Delaware. This study was designed and undertaken to help interpret archeological data obtained in the area by the University of Delaware Center for Archeological Research.

The present study supplements previous studies at or near this site. Whallon (1989), Pizzuto and Rogers (1992), and Hilgartner and Brush (in preparation) all present data from the same site and each of these authors propose a history of the environments of the area. The present study is based on more radiocarbon dates than were previously available, and the diatom analyses presented here were also not available to previous researchers.

STUDY AREA

The study area is located 4 km southeast of Dover just upstream of where Delaware Route 10 crosses the St. Jones River (Figure 1). The St. Jones River here is a meandering, fresh water tidal river bordered by extensive emergent tidal wetlands. Important plant species of the wetlands include arrow arum (Peltandra virginica), pickerelweed (Pontederia cordata), spatterdock (Nuphar luteum), narrowleaved cattail (Typha augustifolia), bullrush (Scirpus validus), water hemp (Acnida cannabina), and swamp rose (Rosa palustras). (The latter 4 species are also cited by Hilgartner and Brush, in preparation.)

METHODS

This study is primarily based on analyses of seven cores obtained at the site during the summer of 1991 (Figure 1). The cores were obtained using an Eijelkampf peat sampler. This device samples 1-m sections that were described in the field. Colors were determined using the Geological Society of America Rock Color Chart (Rock-Color Chart Committee, 1991). Several of the cores were wrapped in plastic and aluminum foil and placed in half-cylindrical sections of 2 inch O.D. PVC pipe. These preserved cores were returned to the Sedimentology Laboratory at the Geology Department and sampled for diatom analyses and radiocarbon dating. Samples for radiocarbon dating were also obtained from several cores in the field.

The cores and samples were numbered as follows. The prefix SJ indicated the St. Jones River. The year was indicated by adding '91', and then the cores were numbered consecutively in the order in which they were taken. Samples taken from the cores were identified by the depth range, indicated in centimeters, over which the sample was obtained. Thus, 'SJ91-4-105-110' indicates a sample obtained from the depth interval 105-110 cm from core 'SJ91-4'.

The swampy nature of the site precludes normal surveying methods, and thus the surface elevations of the coring sites were not determined directly. Rather, the locations of the coring sites were plotted on 1:600 scale topographic maps obtained from the Delaware Department of Transportation. These maps have a contour interval of 0.30 m (1 foot); these contours were used to estimate the elevations of the coring sites. Data obtained from the National Ocean Survey for the town of Leipsic, Delaware (the closest tidal gage upstream of Delaware Bay to the site) were used to relate map elevations based on the National Geodetic Vertical Datum (1929) to tidal datums (primarily mean high water).

Cores were described in the field using the terminology illustrated in the classification of Figure 2. Loss-on-ignition (LOI) (Ball, 1964) serves as a proxy measurement for organic content of the sediments. Although LOI analyses were not performed during this particular study, many analyses performed by Whallon (1989) from samples obtained at the same site provided a basis for estimating LOI.

Samples were obtained from two cores and sent to Drs. Sherman and Riemer of the Philadelphia Academy for diatom analyses. Drs. Sherman and Riemer provided a list of the species in each sample, in addition to an interpretation of the salinity of the environment of deposition.

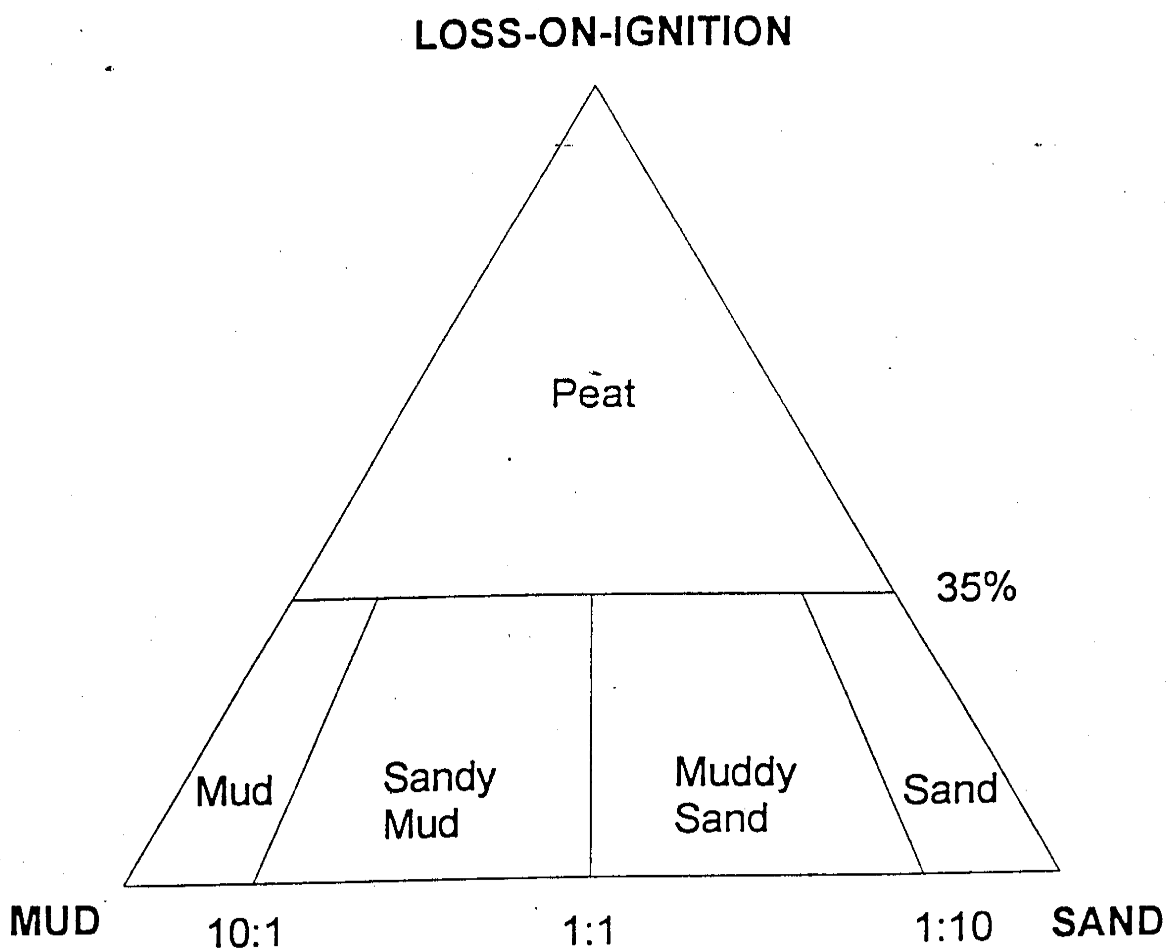

Figure 2. Terminology used to classify sediments of the study area.

Seven peat samples were sent to Beta Analytic, Incorporated, for radiocarbon dating. Beta Analytic uses a half-life of 5568 years in calculating the ^{14}C age of a particular sample. Results were corrected to calendar years using CALIB (Stuiver and Reimer, 1993). In performing the calibration calculations, Dataset I was employed without smoothing using method A (see Stuiver and Reimer, 1993, for further details).

RESULTS

LITHOSTRATIGRAPHY

Three lithofacies were identified in the cores obtained at the site: peat, mud, and mud and sand (Figure 3)

Peat

Peat was encountered in cores 1, 2, 3, 4, 4A, 5, 6, and 7 (see Appendix I for detailed logs of these cores). It typically consists of roots, plant fibres, pieces of wood, and other organic fragments in a matrix of inorganic sediment (usually mud). Peat varies in color from dusky yellowish brown (10 YR 2/2) to moderate brown (5 YR 4/4 to 5 YR 2/2). LOI values for the peat facies average 48%, with a standard deviation of 11%, and minimum and maximum values of 35% and 65% (Table 1).

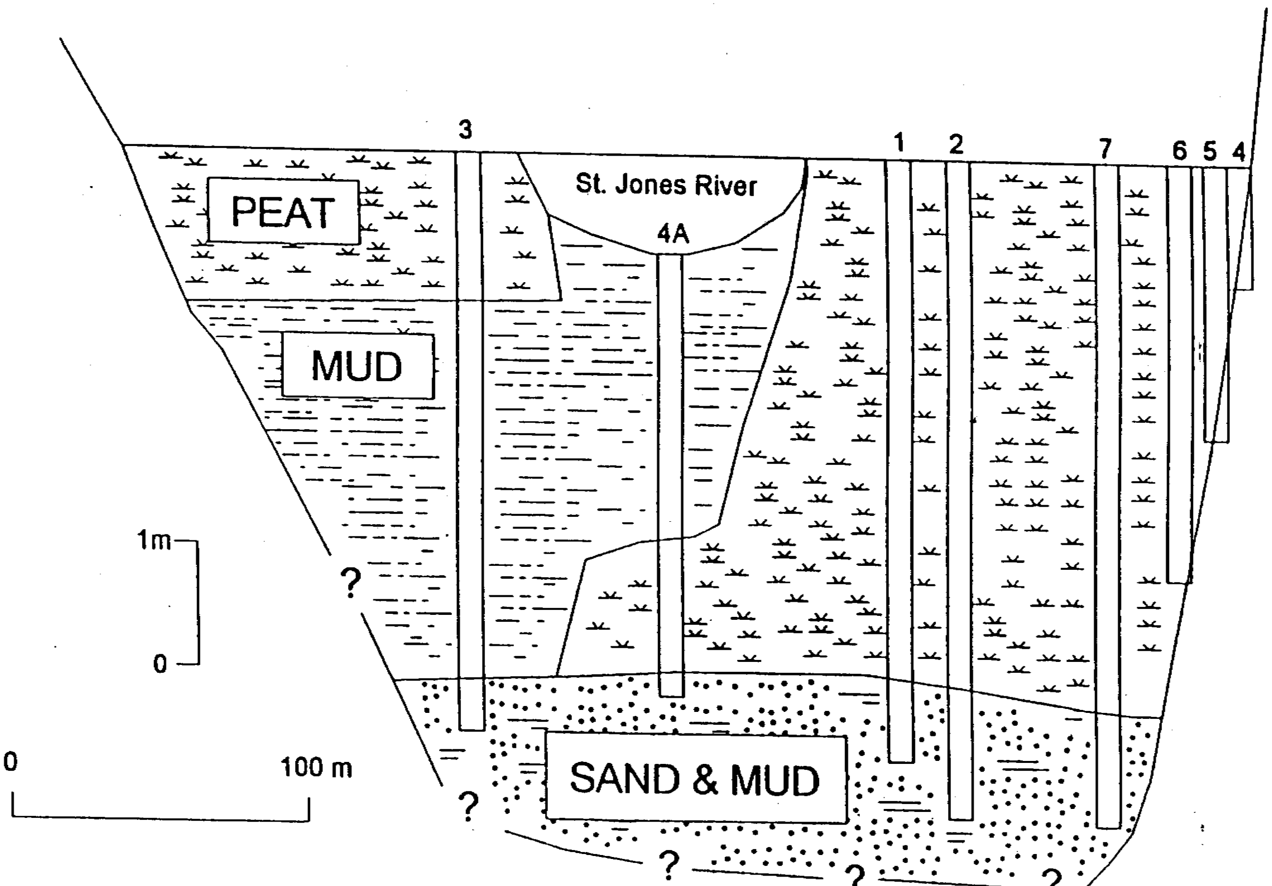

Figure 3. Cross-section of the St. Jones River (the line of section is illustrated in Figure 1).

Mud

Mud was encountered in cores 1, 2, 3, 4A, and 6. It is dusky yellowish brown (10 YR 4/2), dusky brown (5 YR 2/2), olive black (5Y 2/1), or black (N1) in color, and may occasionally contain scattered sand grains and organic material (leaves, twigs, pieces of wood, or plant fibres). LOI values average 17% for the mud facies, with a standard deviation of 7%, and a minimum and maximum of 10% and 38%, respectively.

Table 1 Summary of loss-on-ignition (LOI) data for the St. Jones River lithofacies (from Whallon, 1989)

Lithology	Number of Samples	Mean LOI (%)	Standard Deviation (%)	Minimum LOI (%)	Maximum LOI (%)
Peat	13	48	11	35	65
Mud	34	17	7	10	38
Sandy Mud	10	8	4	5	15
Muddy Sand	1	3	—	—	—
Sand	—	—	—	—	—

Sand and Mud

Mixtures of sand and mud, consisting of sand, muddy, sand, and sandy mud, were found in all of the cores, The sand fraction of these deposits chiefly consists of fine or fine-medium grained sand, light olive brown (5 Y 5/6), light olive gray (5 Y 5/2, 5 Y 6/1), or dusky brown in color. LOI values are typically low (Table 1).

DIATOM ANALYSES

Interpretations of diatom analyses are presented in Table 2. The locations of the samples are illustrated in the detailed core logs of Figures 4 and 5. A complete listing of the raw data is presented in Appendix II.

Table 2. Interpretation of the paleosalinity of sedimentary environments from diatom assemblages.

Sample Number	Interpretation
SJ91-1-147-150	freshwater, slight brackish influence
SJ91-1-247-253	freshwater
SJ91-1-447-450	freshwater
SJ91-3-47-52	freshwater
SJ91-3-213-215	predominantly freshwater, some brackish influence
SJ91-3-405-407	slightly brackish water

The diatom analyses indicate that fresh or slightly brackish conditions prevailed during the deposition of peat and mud facies. The analysis of sample SJ91-3-405-407 is particularly significant, as it indicates slightly brackish conditions at depths of greater than 4 m in core SJ91-3.

SJ-91-1

SURFACE ELEVATION: mean high water (approximately)

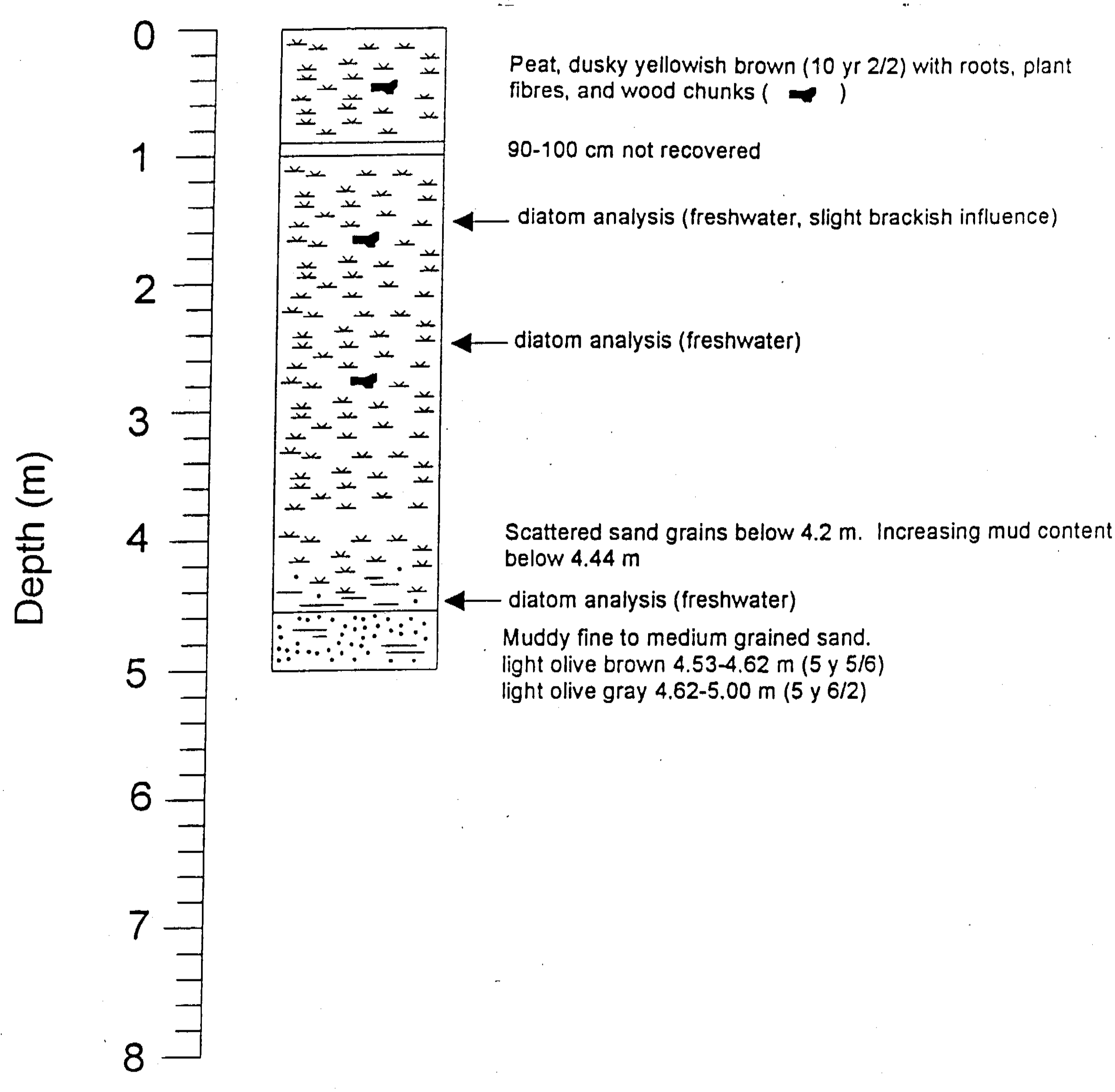

Figure 4. Log of core SJ-91-1 showing distribution of lithogies and diatom analyses.

SJ-91-3

SURFACE ELEVATION: mean high water (approximately)

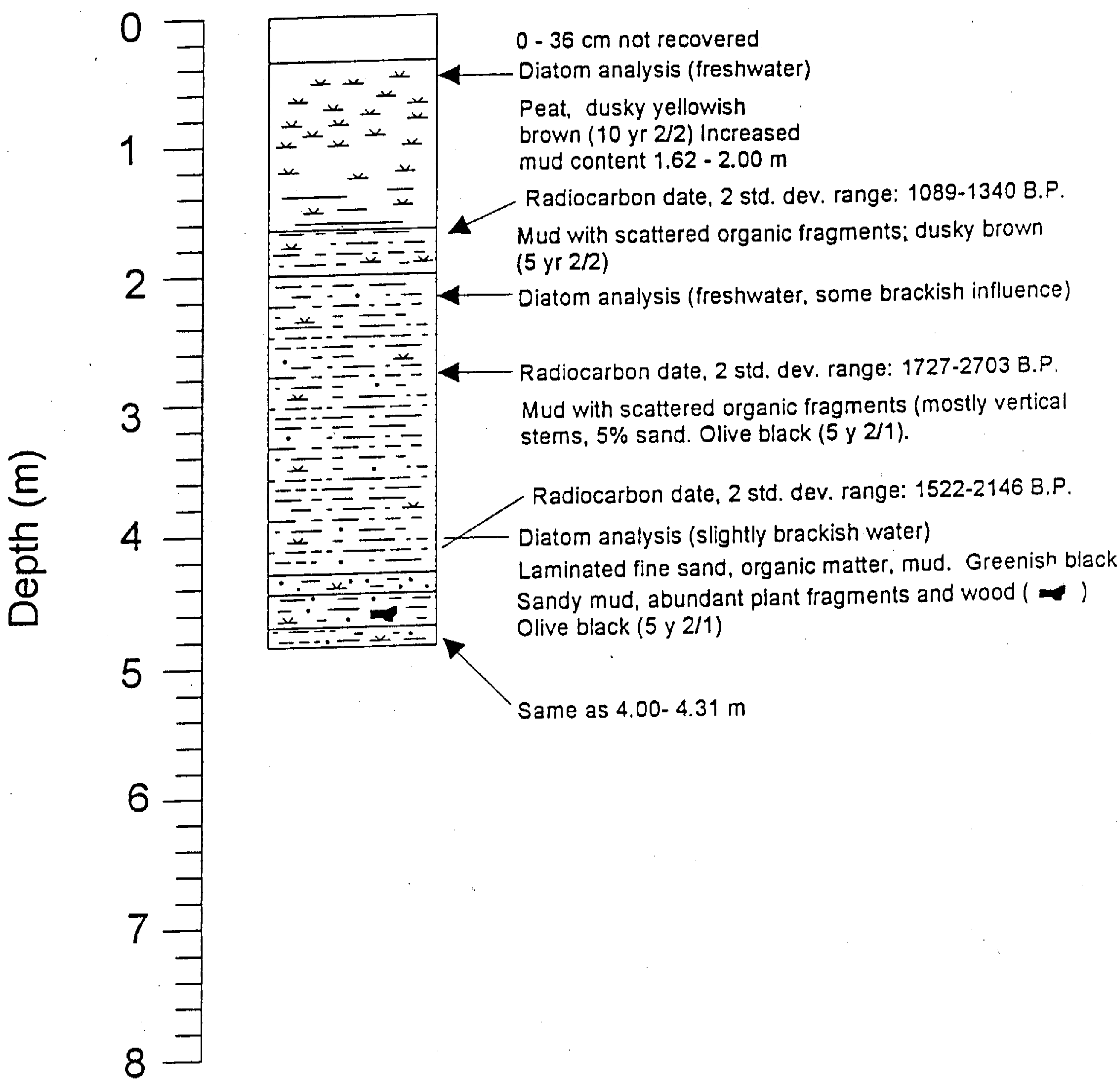

Figure 5. Log of core SJ-91-3 showing distribution of lithologies, diatom analyses, and radiocarbon dates.

RADIOCARBON DATES

Radiocarbon dates from peat samples from the cores vary in age from 350 ±80 to 3430 ± 90 ^{14}C years B.P. (Table 3). The calibrated dates, expressed in ranges of two standard deviations, show even greater variability, and they extend from 0 to 3569 calendar years B.P. (Table 3). This large variability is probably a result of a combination of several factors, including 1) the low sedimentation rate at the site, 2) the wide stratigraphic interval sampled for dating (up to a maximum of 15 cm), and 3) possible contamination by relatively young organic carbon.

Table 3. Radiocarbon dates from peat samples of the St. Jones River Valley

LAB NUMBER	SAMPLE NUMBER	^{14}C Years[a] B.P.	CALENDAR YEARS B.P.[b]
Beta-49223	SJ91-3-168-172	1470 ± 130	1089 - 1340
Beta-49224	SJ91-3-277-285	2150 ± 160	1727 - 2703
Beta-49225	SJ91-3-415-420	1900 ± 140	1522 - 2146
Beta-49226	SJ91-4-105-115	600 ± 70	509 - 622
Beta-49227	SJ91-5-210-218	350 ± 80	0 - 434
Beta-49228	SJ91-6-313-328	1700 ± 80	1503-1690
Beta-49229	SJ91-7B-466-473	3430 ± 90	3465-3569

[a]based on a half-life of 5568 years.
[b]2 σ range obtained from CALIB (Stuiver and Reimer, 1993) using Dataset 1, calculation method A, without smoothing.

The potential for contamination was assessed by plotting the results in age-depth space (Figure 6). A straight-line approximation to Kraft's (1976) sea-level curve (Fletcher et al., 1990) is also plotted in Figure 6 for reference. Two samples SJ91-5-210-218 and SJ91-3-415-420 plot below the sea level curve. As is argued below, these samples were obtained from deposits of tidal environments that could not exist below sea level, and therefore the dates from these two samples are suspect.

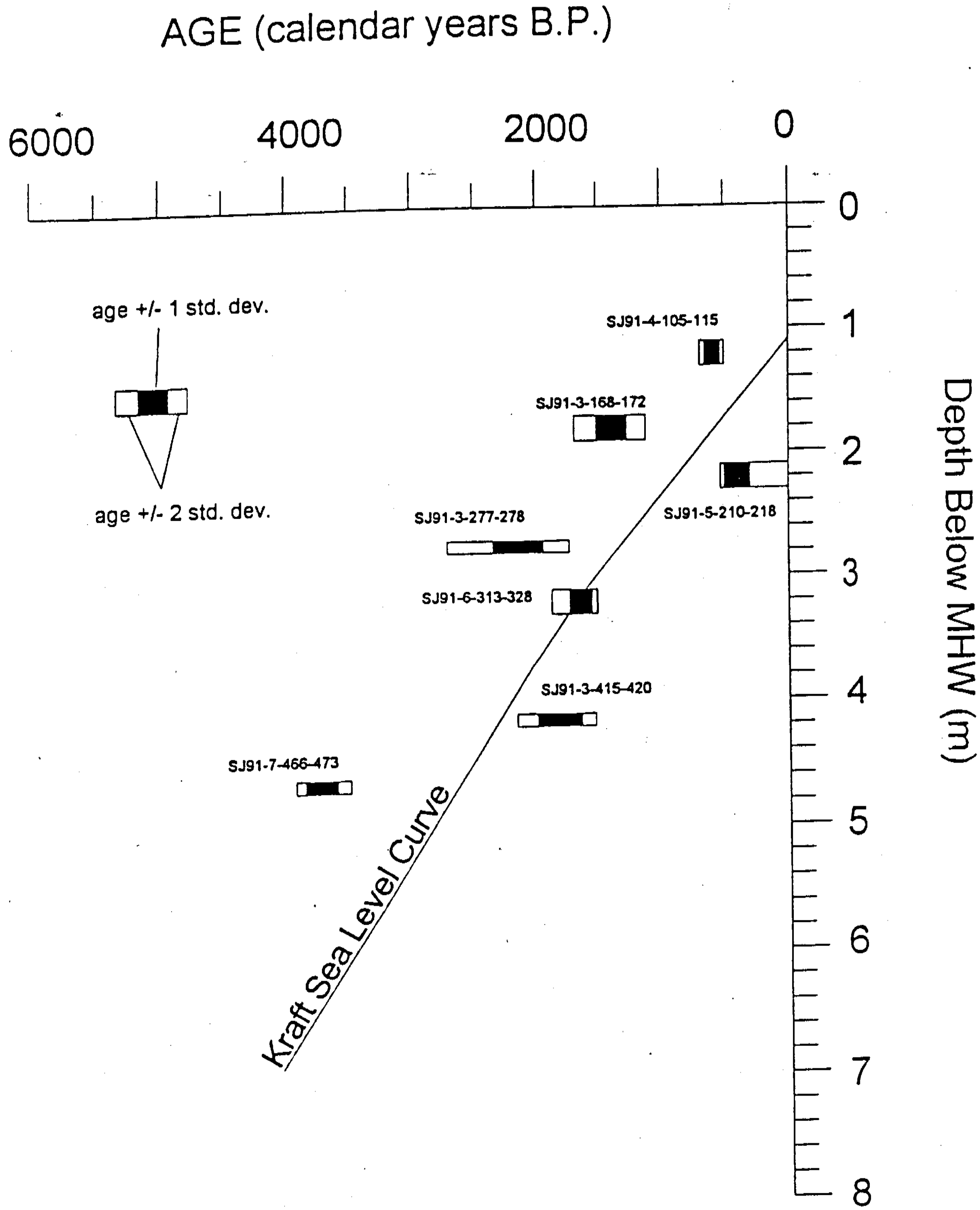

Figure 6. Depth versus age for the 7 radiocarbon dates obtained during this study.

INTERPRETATION

The three sedimentary facies illustrated in Figure 3 are peat, mud, and sand and mud. According to detailed analyses of ancient and modern sedimentary environments of the tidal river valleys of Kent County, Delaware by Whallon (1989), Daniels (1993), Pizzuto and Rogers (1992), and John and Pizzuto (in press), these three facies can be interpreted by their distinctive textures, LOI values, and micro-fossils (in this case, diatoms). Thus, the sand and mud were deposited in a non-tidal fluvial environment of channels and floodplains. The mud represents a broad tidal estuary of slightly brackish salinity or freshwater, while the peat represents a freshwater to slightly brackish emergent tidal wetland.

Table 4. History of depositional environments of the study area.

Age (Calendar Years B.P.)	Environment
(1300-1000) to present	meandering tidal river bordered by emergent freshwater tidal wetlands
(3600-3500) to (1300 - 1000)	freshwater to broad brackish tidal estuary bordered by freshwater to slightly brackish tidal wetlands
>3600	fluvial valley (river channel and floodplain)

A chronology of these environments is presented in Table 4. In developing this chronology, the contaminated radiocarbon dates that plot below the sea level curve (Figure 3) were ignored. The chronology indicates that a freshwater, non-tidal alluvial valley occupied the study area before about 3600 calendar years B.P. Then, the alluvial valley was drowned by rising sea level to create a broad tidal estuary rimmed by tidal wetlands. The diatom analyses indicate that the salinities were fresh to brackish, as would be appropriate for the upper end of a narrow estuary close to abundant freshwater input by rivers. This broad estuary persisted until 1300 to 1000 years B.P., when the present emergent wetland system covered the valley, and the modern meandering tidal St. Jones River was formed.

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Stuiver, M., and Reimer, P.J., 1993, Radiocarbon 35, 215-230.

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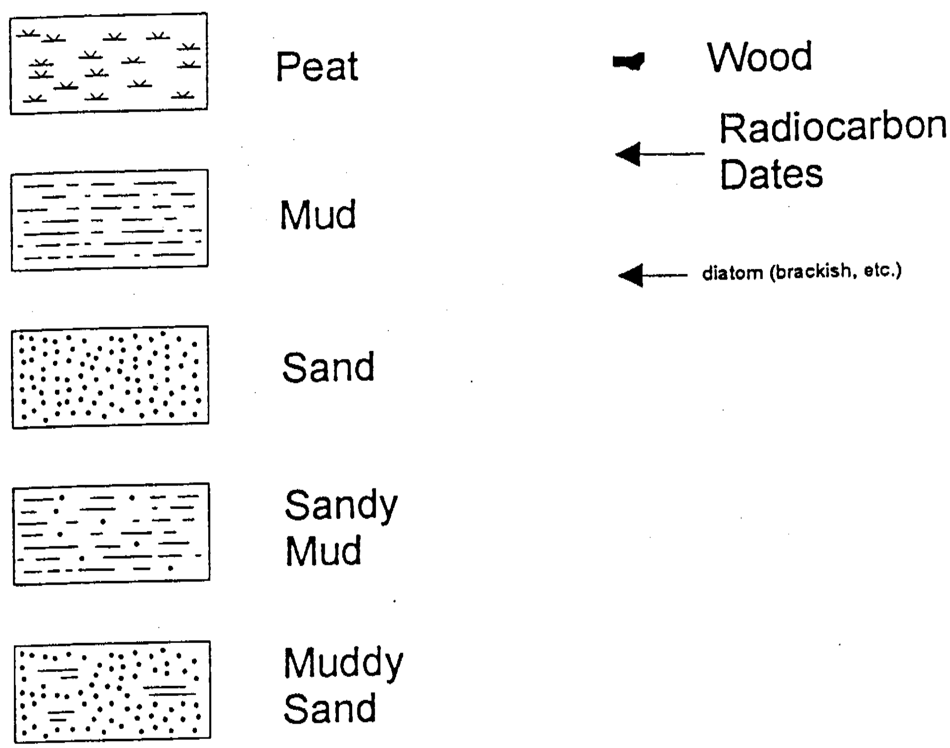
APPENDIX I

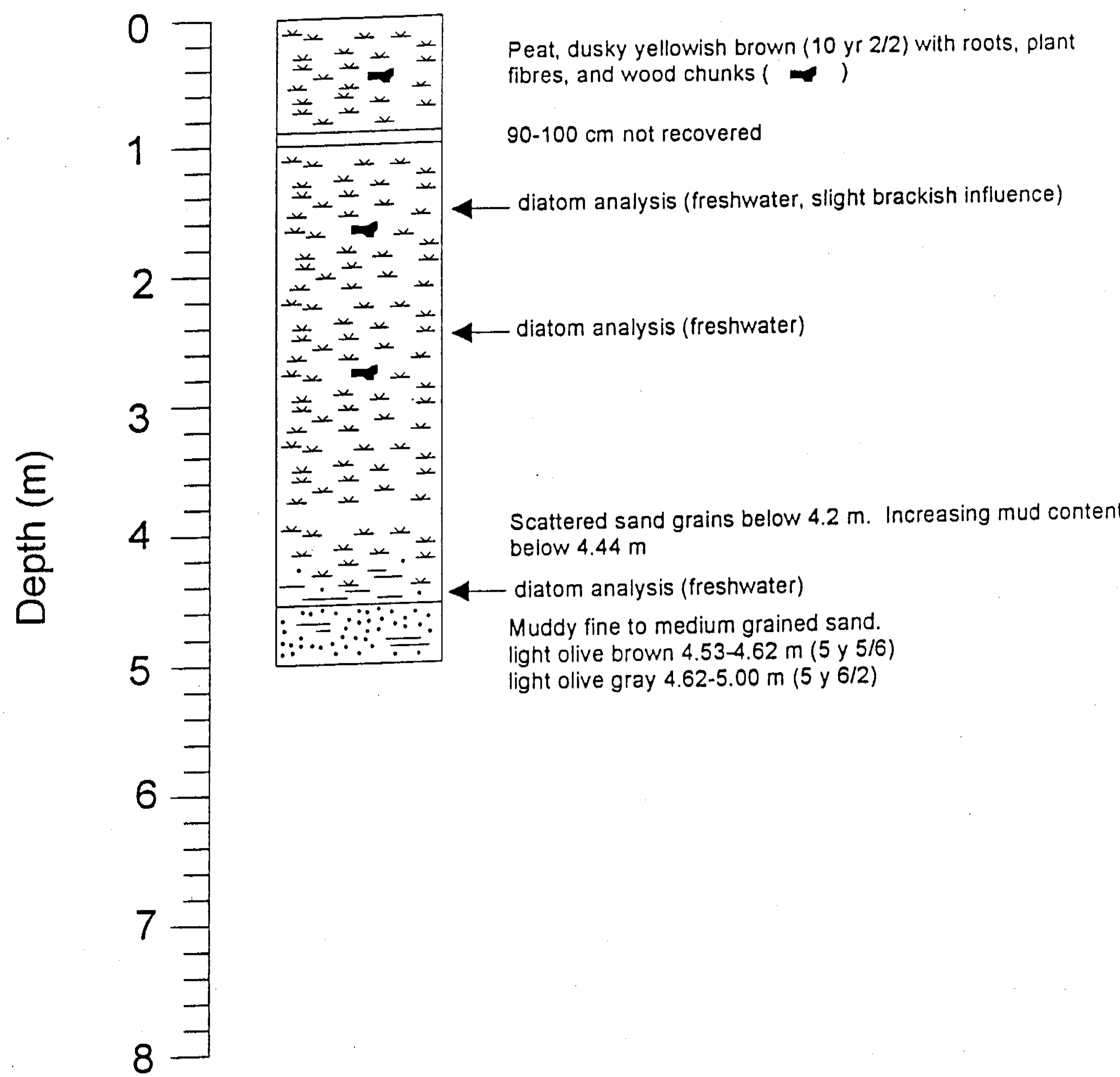
CORE LOGS

LEGEND


Peat
Mud
Sand
Sandy Mud
Muddy Sand
Wood
Radiocarbon Dates
diatom (brackish, etc.)

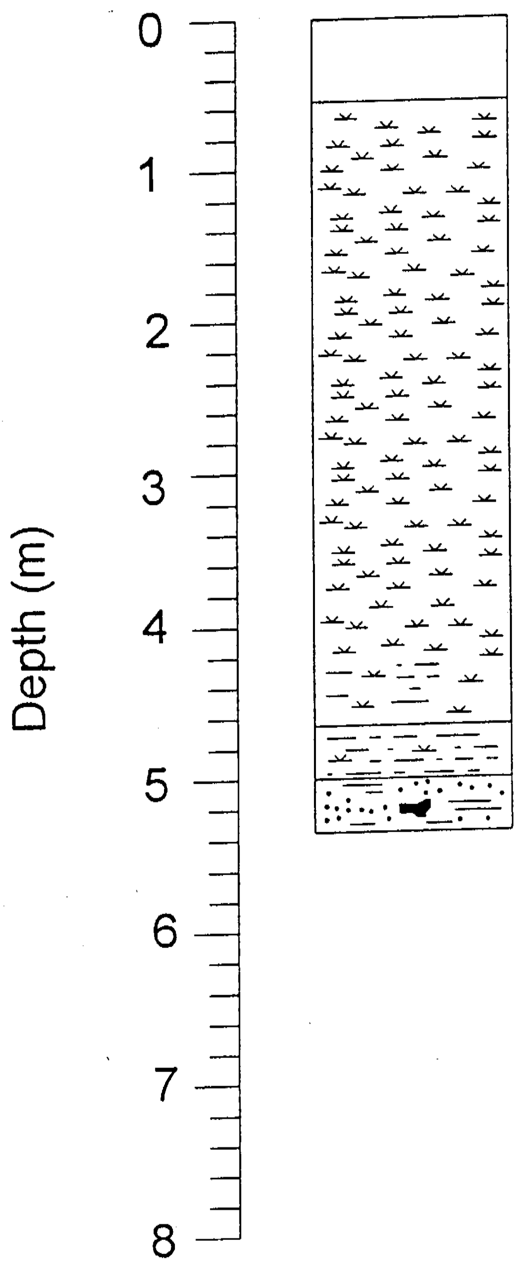
SJ-91-1

SURFACE ELEVATION: mean high water (approximately)



SJ-91-2

SURFACE ELEVATION: mean high water (approximately)



0 - 55 cm not recovered

Peat, moderate brown (5 yr 4/4 - 5 yr 3/4)

Very dense and fibrous near 2.50 m. "Soupy" above and below within this 1 m section.

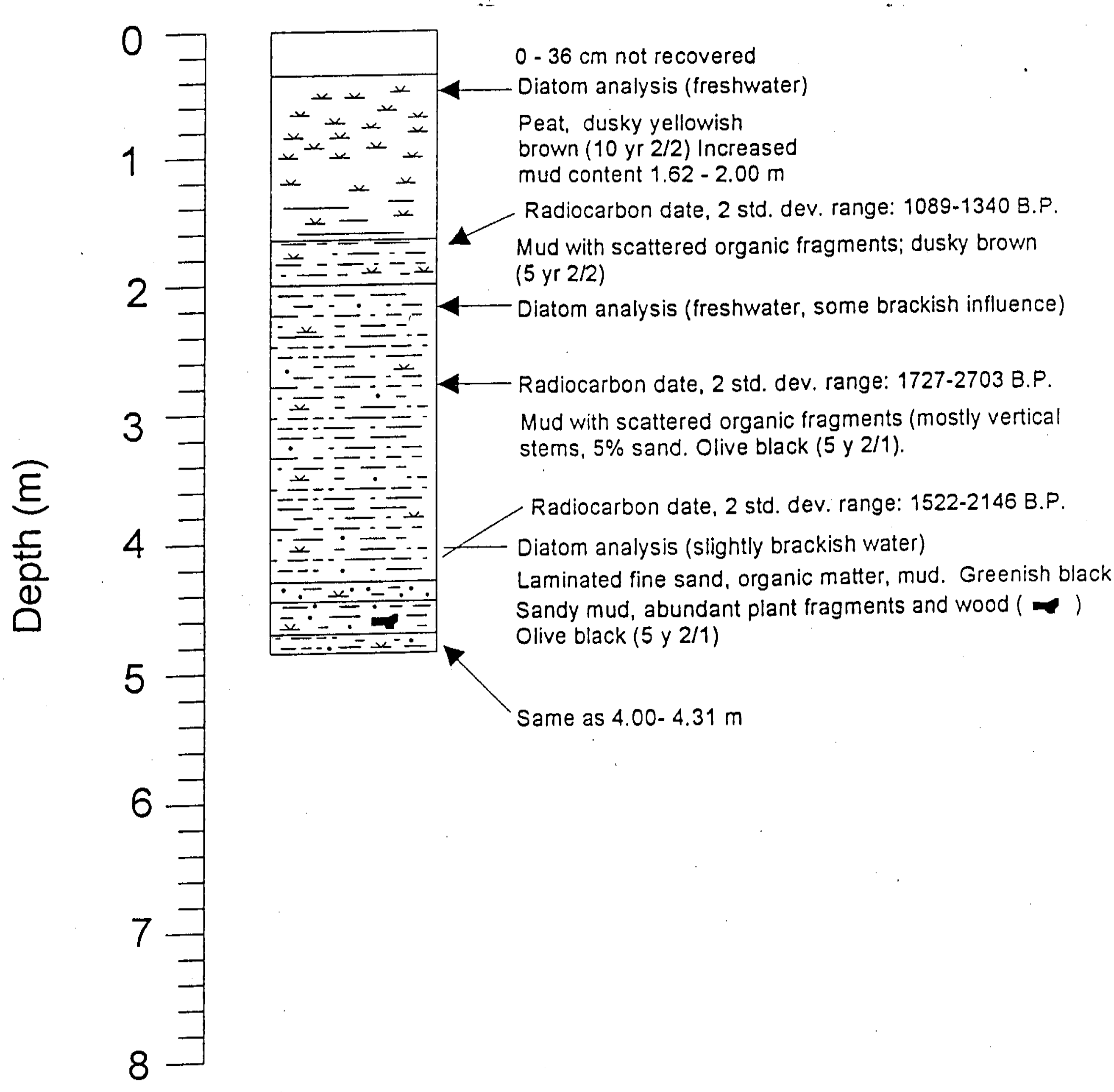
Gradational change from peat to mud from 4.44 m to 4.65 m.

Mud with abundant fibres and other organic matter.

Fine to medium grained muddy sand, sandy mud. Several pieces of wood, including one vertical piece 20 cm long at bottom. Dusky brown (5 yr 3/2) from 5.00 - 5.33 m, grading to olive gray over a 3-5 cm interval at 5.33. Olive gray from 5.33 - 5.51 m (5 y 6/1).

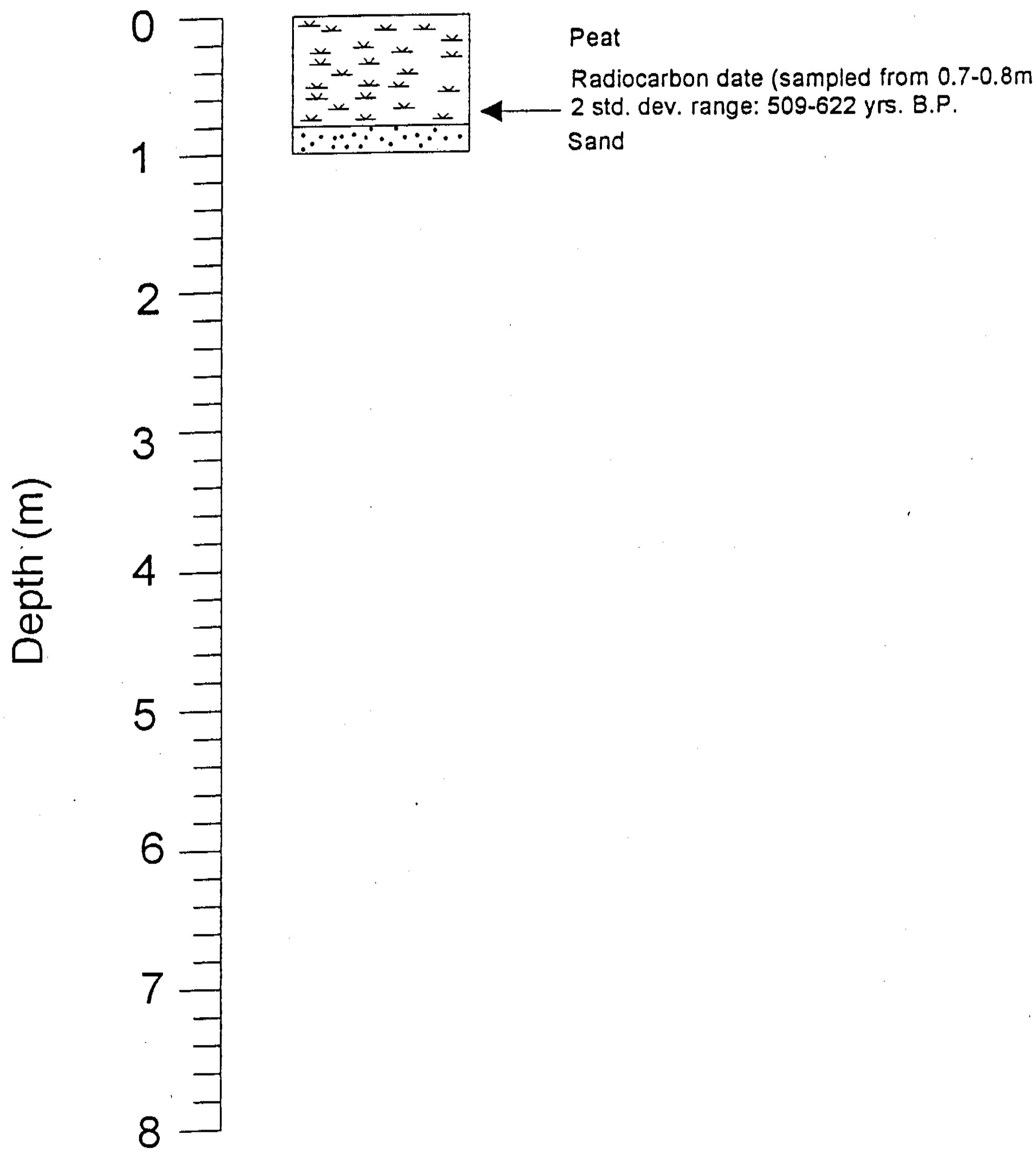
SJ-91-3

SURFACE ELEVATION: mean high water (approximately)



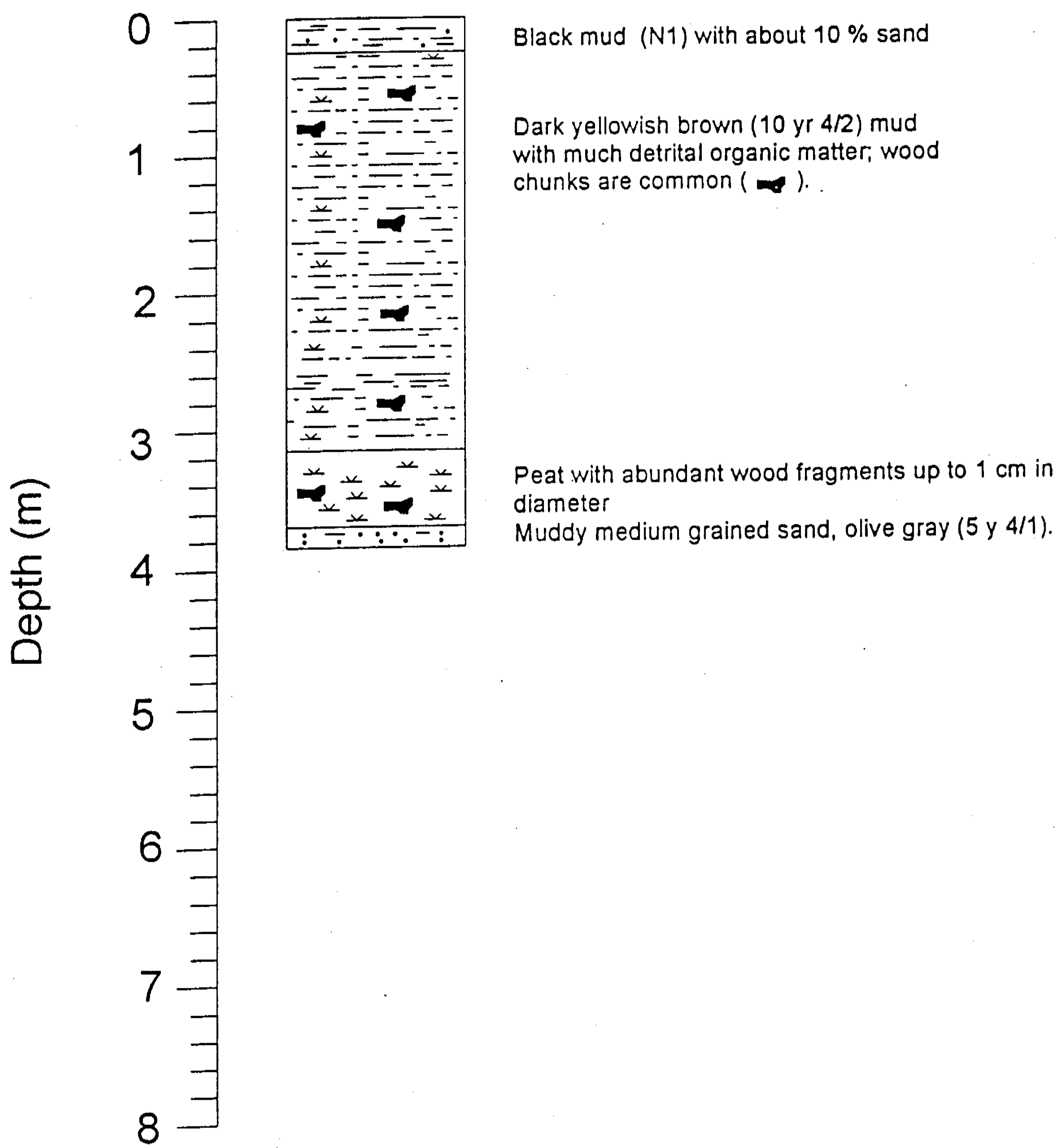
SJ-91-4

SURFACE ELEVATION: mean high water (approximately)



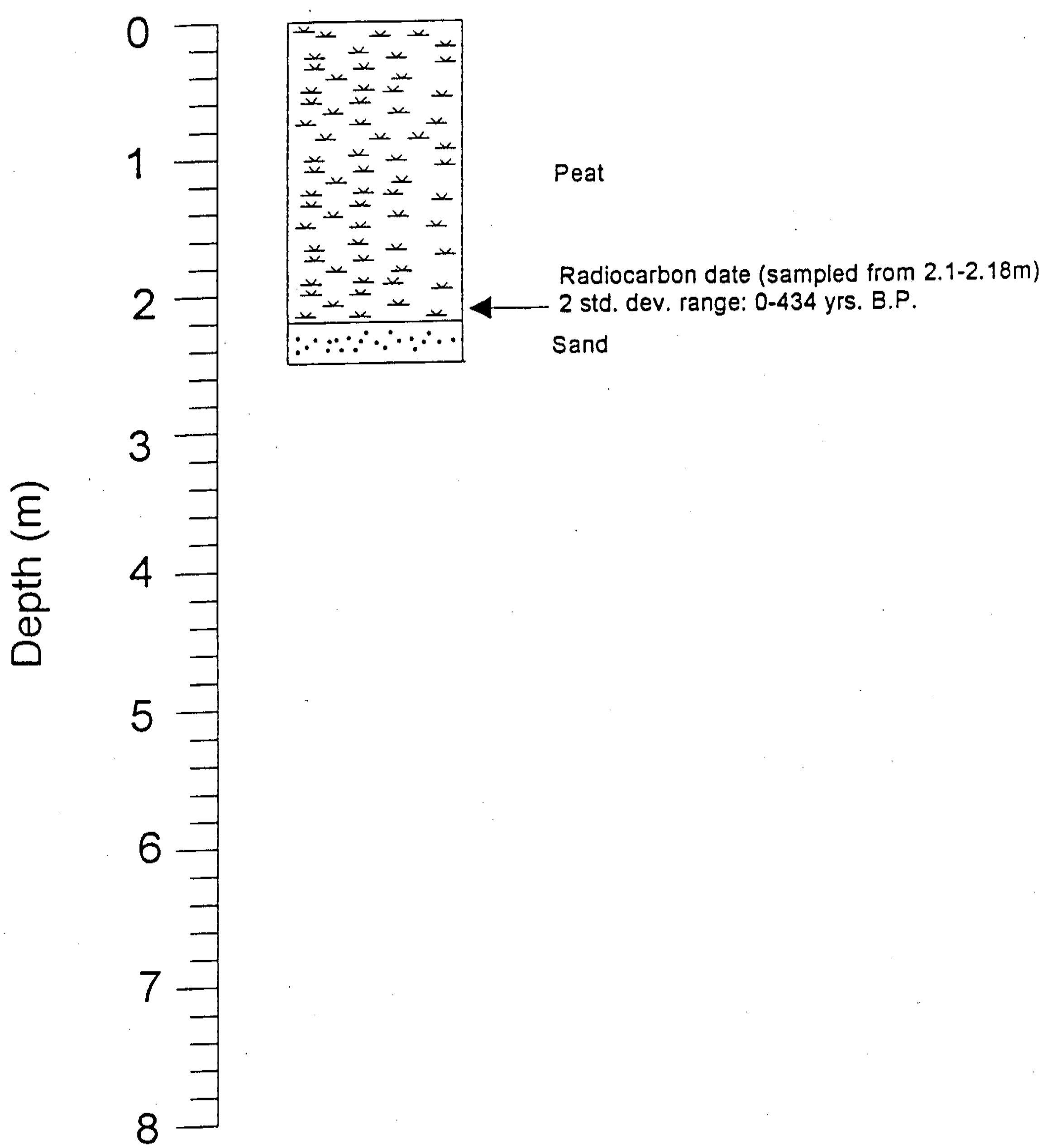
SJ-91-4A

SURFACE ELEVATION: mean high water (approximately)



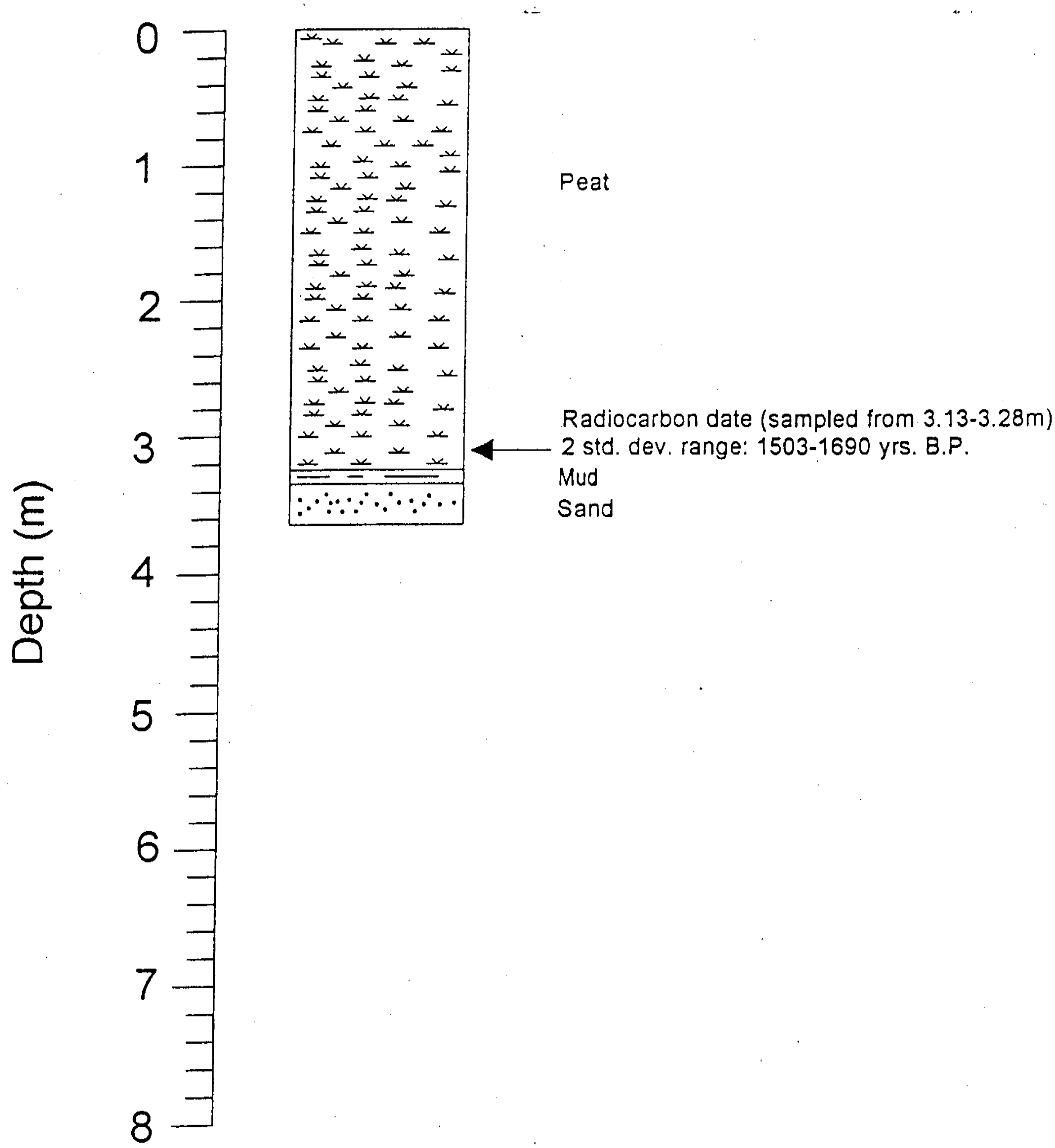
SJ-91-5

SURFACE ELEVATION: mean high water (approximately)



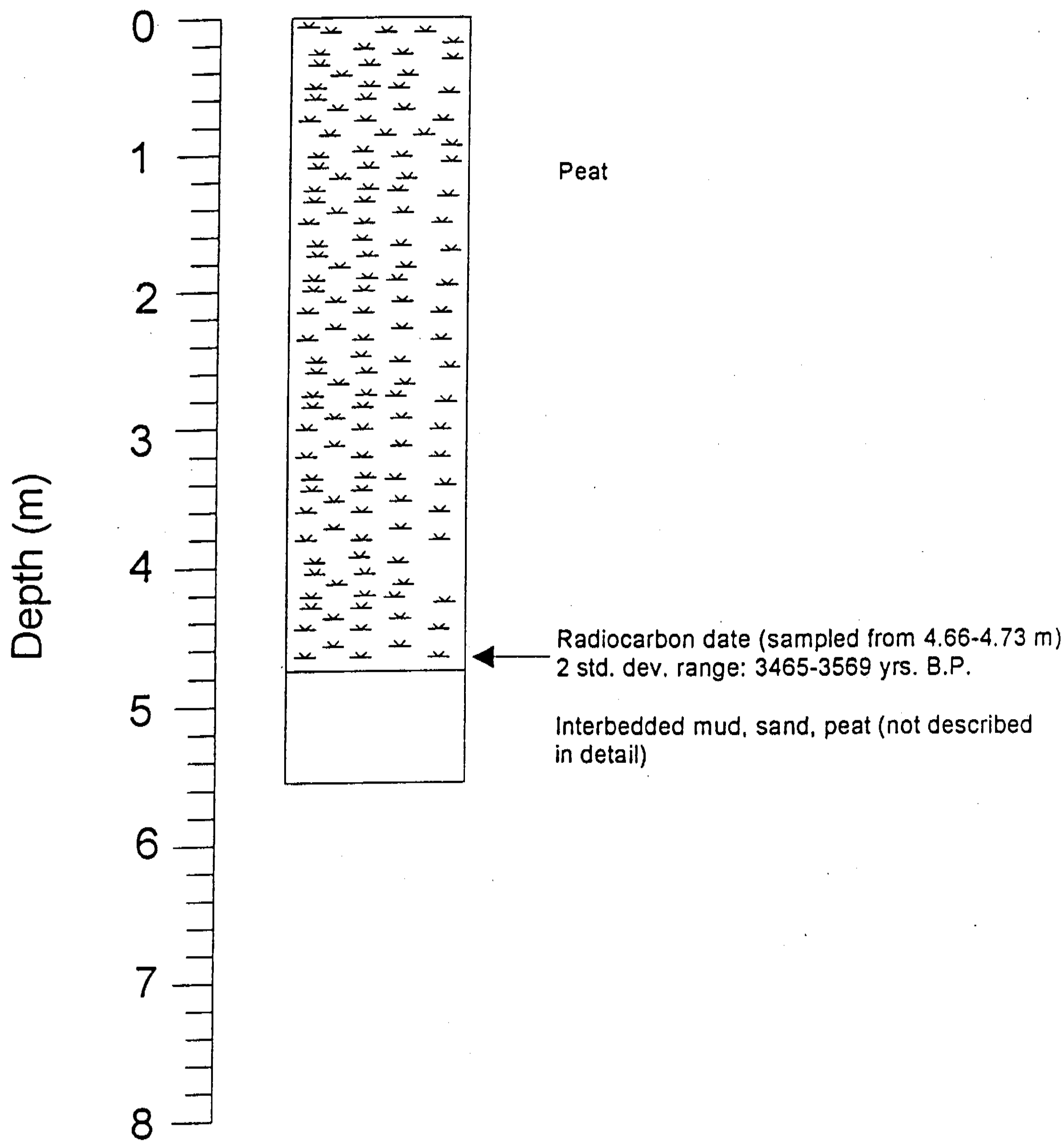
SJ-91-6

SURFACE ELEVATION: mean high water (approximately)



SJ-91-7

SURFACE ELEVATION: mean high water (approximately)



APPENDIX II

DIATOM ANALYSES

SJ 91-1-147-150

~10% diatom material. *Navicula* cf. *placenta*, *Melosira sulcata*, *Coscinodiscus* sp., *Stauroneis* sps., *Frustulia vulgaris*, *Rhopolodia gibberula* type, *Navicula mutica* v. *stigma*, *Eunotia formica*, *Eunotia lunaris* type, *Meridion circulare*, *Fragilaria marginistriata*, *Eunotia* sp., freshwater *Melosira*, *Eunotia pectinalis*.

Environment: predominantly freshwater assemblage with few brackish water forms admixed.

SJ 91-1-247-253

~15% diatom material. Freshwater sponge spicuole, *Eunotia formica* group, *Neidium* sp., *Neidium iridis* v. *subundulatum*, *Eunotia pectinalis*, *Gomphonema* sp., *Cyclotella striata*, *Fragilaria marginestriata*, *Navicula dicephala*, *Pinnularia* sp., *Rhopolodia gibba* type, *Gomphonema* sp., *Actinoptychus* sp.

Environment: Predominantly freshwater assemblage (*Actinoptychus* considered an incidental occurrence).

SJ 91-1-447-450

~5% diatom material. *Navicula mutica*, *Cyclotella striata*, *Pinnularia* sp., *Denticula* sp., *Pinnularia acrospheria*, *Gomphonema turris*, *Cyclotella meneghiniana*, *Navicula bacillum*, *Meridion circulare*, siliceous plant parts belonging to the grasses.

Environment: freshwater, shallow environment, possibly an intermittant pond.

SJ 91-3-47-52

~50% diatom material. Dominance of *Fragilaria construens* in all fields along with a large number of *Melosira* cf. *distans*. *Gomphonema turris*, *Tabellaria* sp., *Stauroneis* sp., *Eunotia* sp., *Fragilaria harrisonii*, *Achnanthes marginulata*, *Neidium* sp., *Anomoeneis* sp.

Environment: Freshwater, shallow lake-like environment, circum-neutral to slightly acid with no brackish water influence.

SJ 91-3-213-215

~40% diatom material. *Navicula halophila, Melosira sulcata, Pinnularia obscura, Rhaphoneis* sp., *Coscinodiscus* sp., *Pinnularia viridis, Diploneis* cf. *bombus, Stauroneis* sp., *Navicula* pygmea group, *Eunotia* sps., *Eunotia formica, Navicula bacillum, Cyclotella striata, Capartogramma* sp.

Environment: Both fresh and brackish water influences with predominance of freshwater forms; freshwater periphyton with brackish water plankton varieties suggests a shallow freshwater pool intermittantly inundated by brackish water.

SJ 91-3-405-407

~30% diatom material. *Nitzschia lorenziana, Cyclotella striata, Cymatosira belgiqua, Nitzschia punctata, Navicula lirata* group, *Stauroneis* sp.

Environment: Strong preponderance of medium conductivity forms with very few true freshwater varieties suggests a relatively stable, slightly brackish water environment.