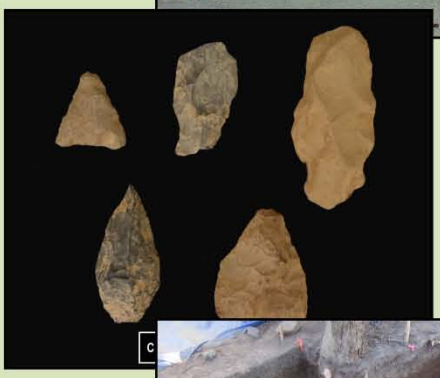


Data Recovery Archaeological Investigation Reeders Creek West Site (28Me360)

I-95 Scudder Falls Bridge Improvement Project Ewing Township Mercer County, New Jersey

Volume II

Prepared For

Delaware River Joint Toll Bridge Commission
Executive Offices
2492 River Road
New Hope, Pennsylvania 18938-9519

Prepared By

AECOM Transportation
516 East State Street
Trenton, New Jersey 08609

July 2012

Delaware River Joint Toll Bridge Commission

AECOM

Data Recovery
Archaeological Investigation
Reeders Creek West Site (28Me360)

I-95
Scudder Falls Bridge Improvement Project
Ewing Township, Mercer County, New Jersey

Volume II

Prepared for

Delaware River Joint Toll Bridge Commission
Executive Offices
2492 River Road
New Hope, Pennsylvania 18938-9519

Prepared by

Frank G Mikolic, Archaeologist
Brian M. Albright, Archaeologist

AECOM Transportation
516 East State Street
Trenton, New Jersey 08609

July 2012

Appendix A: List of Preparers

LIST OF PREPARERS

Frank G. Mikolic, RPA, Principal Investigator: over 13 years experience in archaeology throughout the eastern United States. In his capacity as Principal Investigator, he has conducted, directed, and managed more than 40 archeological field projects in Maryland, Delaware, New Jersey, Pennsylvania, Virginia, Rhode Island, and New York. These projects have ranged from initial scoping efforts to monitoring projects, to large-scale archeological data recovery excavations of multi-component prehistoric and historic sites. As Principal Investigator, he has developed, implemented, and coordinated field, laboratory, research, technical report, and public involvement methods. Also has knowledge of prehistoric and historic artifact types. Clarion University of Pennsylvania, 1999, BA, Anthropology; Pennsylvania State University, MA, American Studies.

Brian M. Albright, Field Director and GIS Analyst*:* has participated in and supervised archaeological and historical investigations in Alabama, Georgia, Maryland, Massachusetts, Michigan, New Jersey, New York, Pennsylvania, Virginia and in Mexico. He is an expert in GIS modeling of prehistoric and historic land uses. Mr. Albright has acted as archaeological Field Director on numerous studies, assisting the Senior Archaeologist and Senior Architectural Historian with field reconnaissance, Phase I testing, Phase II evaluation, Phase III data recoveries, and historic structures surveys. In addition, he provides GIS- and GPS-based mapping, analysis, planning, and map production services.

Mr. Albright has performed numerous surveys, including transportation resources (railroads and bridges), industrial properties (coal mines and coke works), agricultural properties (farmsteads, plantations and tenant farmer houses) and prehistoric archaeological sites. He has also coauthored numerous Section 106 documents, including Phase I, II and III (Data Recovery) Reports and Predictive Model Reports and is experienced in all portions of the Section 106 Review process. Pennsylvania State University, 1995, BA, Anthropology.

Appendix B: Project Documents

PROGRAMMATIC AGREEMENT (PA) AMONG THE FEDERAL HIGHWAY ADMINISTRATION (FHWA), THE PENNSYLVANIA STATE HISTORIC PRESERVATION OFFICER (PASHPO), AND THE NEW JERSEY STATE HISTORIC PRESERVATION OFFICER (NJSHPO) PURSUANT TO 36 CFR SECTION 800.6(b)(1) REGARDING THE I-95/SCUDDER FALLS BRIDGE IMPROVEMENT PROJECT LOWER MAKEFIELD TOWNSHIP, BUCKS COUNTY, PENNSYLVANIA AND EWING TOWNSHIP, MERCER COUNTY, NEW JERSEY

WHEREAS, the Delaware River Joint Toll Bridge Commission (DRJTBC) is proposing to construct the I-95/Scudder Falls Bridge Improvement Project (Project) in Lower Makefield Township, Bucks County, Pennsylvania and Ewing Township, Mercer County, New Jersey, described as the Proposed Action in Chapter III, Section D of the Environmental Assessment (EA) entitled "I-95/Scudder Falls Bridge Improvement Project Environmental Assessment" and dated October 2009; and

WHEREAS, the DRJTBC is the Project sponsor and the Federal Highway Administration (FHWA) is serving as the Project lead federal agency pursuant to the National Environmental Policy Act (NEPA, codified as 42 USC 4321 *et seq.*), and is the federal agency responsible for compliance with Section 106 of the National Historic Preservation Act (codified at 16 USC § 470f, and herein "Section 106"); and

WHEREAS the FHWA and the DRJTBC have established the Project's area of potential effect (APE), as defined at 36 CFR Part 800.16(d), as shown in Figure II-4 of the EA (Attachment 1); and

WHEREAS, the FHWA and the DRJTBC, pursuant to 36 CFR Part 800.4(c), have determined in consultation with the PASHPO that the following properties in Pennsylvania are eligible for the National Register of Historic Places (NRHP): Elm Lowne, as described in the Determination of Effect Report, dated September 2008, and the archaeological site 36Bu379, as described in the Phase I Archaeology Report, dated January 2008; and

WHEREAS, the FHWA and the DRJTBC, pursuant to 36 CFR Part 800.4(c), have determined in consultation with the PASHPO that the following property in Pennsylvania is a National Historic Landmark (NHL): the Delaware Canal, as described in the Determination of Effect Report, dated September 2008; and

WHEREAS, pursuant to 36 CFR Part 800.5(a) the FHWA and the DRJTBC have determined in consultation with the PASHPO that the Project will have no adverse effect on Elm Lowne and a conditional no adverse effect on the Delaware Canal, contingent on a review of related Project plans, photographs, architectural drawings, and specifications and their conformance with the Secretary of the Interior's Standards for the Treatment of Historic Properties; and

WHEREAS, pursuant to 36 CFR Part 800.5(a), as a result of Phase I studies conducted for the project, the FHWA and the DRJTBC have determined in consultation with the PASHPO that there is an eligible site, 36Bu379, a Phase III data recovery plan will be conducted at Site 36Bu379; and

WHEREAS, pursuant to 36 CFR Part 800.5(a), the FHWA and the DRJTBC in consultation with the PASHPO have determined that archaeological survey will occur in the area of causeway construction across the southern portion of Park Island in the Delaware River to determine the presence of intact cultural resources and the NRHP eligibility of any such resources. If resources are present and are deemed potentially eligible, a Phase III data recovery plan will be implemented at this location if the resources cannot be avoided or preserved in place; and

WHEREAS, the FHWA and the DRJTBC, pursuant to 36 CFR Part 800.4(c), have determined in consultation with the NJSHPO that the following properties in New Jersey are eligible for the NRHP: the Charles S. Maddock House; and the New Jersey State Police Headquarters Historic District (NJSPHQ), as described in the Historic Structures Survey, Determination of Eligibility and Determination of Effect Report, dated September 2008; and

WHEREAS, the FHWA and the DRJTBC, pursuant to 36 CFR Part 800.4(c), have determined in consultation with the NJSHPO that archaeological site 28Me360, as described in the Phase I Archaeology Report, dated January 2008, requires further testing to assess significance of the site; and

WHEREAS, the FHWA and the DRJTBC, pursuant to 36 CFR Part 800.4(c), have determined in consultation with the NJSHPO that the following property in New Jersey was listed in the NRHP on May 11, 1973: the Delaware and Raritan Canal; and

WHEREAS, pursuant to 36 CFR Part 800.5(a) the FHWA and the DRJTBC have determined in consultation with the NJSHPO that the Project will have no adverse effect on the Charles S. Maddock House and the New Jersey State Police Headquarters Historic District (NJSPHQ); and

WHEREAS, pursuant to 36 CFR Part 800.5(a), the FHWA and the DRJTBC have determined in consultation with the NJSHPO that the Project will have an adverse effect on the Delaware and Raritan Canal; and

WHEREAS, pursuant to 36 CFR Part 800.5(a), the FHWA and the DRJTBC in consultation with the NJSHPO have determined that for areas previously inaccessible for archaeological testing that will be affected by the project, including any detention or retention basin(s) is to be located in the southern loop of the NJ Route 29 interchange with I-95, preliminary archaeological investigations will be conducted to determine the presence or absence of intact cultural resources and the NRHP eligibility of any such resources. If resources are present and deemed eligible, a Phase III data recovery plan will be implemented at this location. Further, if piers are placed within or in the immediate vicinity of the Trenton Water Power Channel, preliminary archaeological investigations will be conducted to expose and record construction features including channel profile; and

WHEREAS, pursuant to 36 CFR Part 800.6(a), the FHWA and the DRJTBC have consulted with the NJSHPO to resolve the adverse effect of the Project on historic properties; and

WHEREAS, pursuant to 36 CFR Part 800.6(a), the FHWA and the DRJTBC have determined in consultation with the PASHPO and the NJSHPO that it is necessary to develop protection measures to protect the Delaware Canal and the Delaware and Raritan Canal, respectively during construction activities; and

WHEREAS, pursuant to 36 CFR Part 800.6(a), the FHWA has invited the Advisory Council on Historic Preservation (ACHP) to participate in the Section 106 process for the I-95/Scudder Falls Bridge Improvement Project; and in a response letter dated July 29, 2009, the ACHP has declined to be a signatory to this PA; and

WHEREAS, pursuant to 36 CFR Part 800.6(a), the FHWA has consulted with the PASHPO, NJSHPO, U.S. Army Corps of Engineers (USACE) – Philadelphia District, the Delaware Canal State Park, the Friends of the Delaware Canal, the Elm Lowne Preservation Committee, the Society for Pennsylvania Archaeology, the Lower Makefield Township Board of Supervisors, State Representative Honorable David J. Steil, and the Pennsylvania Archaeological Council in Pennsylvania; and Ewing Township, the Delaware and Raritan Canal Commission (D&RCC), Mercer County, New Jersey Green Acres Program and the Division of Parks and Forestry in New Jersey to resolve the adverse effects of the Project on historic properties; and

WHEREAS, pursuant to 36 CFR Part 800.6(c), the FHWA has also invited the PASHPO, NJSHPO, DRJTBC, the Pennsylvania Department of Transportation (PennDOT), the New Jersey Department of Transportation (NJDOT), and federally recognized Indian Tribes (Tribes) that may attach religious and/or cultural significance to any affected property within the APE pursuant to 36 CFR Part 800.3(f)(2), namely the Absentee-Shawnee Tribe of Oklahoma, the Delaware Nation, and the Shawnee Tribe, to participate in the consultation and to concur in this PA; and

WHEREAS, pursuant to 36 CFR Part 800.6(c), the DRJTBC, PennDOT, and NJDOT have agreed to be concurring parties in this PA; and

WHEREAS, the FHWA has involved, and will continue to involve the public, the Tribes, and historic interest groups, as stipulated under the NEPA of 1969, as amended, and the National Historic Preservation Act (NHPA) as amended [16 U.S.C. § 470], and its implementing regulations (36 CFR Part 800) in a manner consistent with PennDOT's and NJDOT's Public Involvement Procedures and PennDOT's procedures for Native American Coordination and Consultation;

NOW, THEREFORE, the FHWA, the PASHPO, and the NJSHPO agree that upon FHWA's decision to proceed with the Project, FHWA shall ensure that the following stipulations are implemented in order to take into account the adverse effect of the undertaking on historic properties.

STIPULATIONS

All parties to this PA have reviewed the Project with regard to historic resource mitigation, interpretation and acquisition issues, and as a consequence of the same, the DRJTBC agrees to the following stipulations. The FHWA shall ensure that the following stipulations are implemented by the DRJTBC.

I. Archaeological Resources

A. The DRJTBC will undertake geoarchaeological assessment investigations at the southern loop of the NJ Route 29 interchange with I-95 if a detention or retention basin is placed in this loop. Such investigations will be followed by archaeological investigations and/or data recovery investigations if the geoarchaeological assessment indicates such approaches are warranted.

B. The DRJTBC will conduct a geomorphological assessment of the area of the causeway construction across the southern end of Park Island in the Delaware River followed by Phase I archaeological testing if warranted. If archaeological resources are identified in this area, Phase II testing will be conducted to evaluate these resources and determine if they are eligible for listing in the NHRP. If eligible archaeological resources are present and cannot be avoided by construction or preserved in place, Phase III data recovery will be conducted.

C. The DRJTBC will implement Phase I archaeological testing in an area of high potential in the T2 Terrace in Pennsylvania that is adjacent to and possibly associated with 36Bu379 (see Stipulation I.G) and has not yet been surveyed because access to the property has been limited. If archaeological resources are identified in this area, Phase II testing will be conducted to evaluate these resources and determine if they are eligible for listing in the NRHP. If these resources are determined to be eligible for the NRHP, a Data Recovery Workplan will be prepared. The workplan will include research, fieldwork, analysis, report preparation, and public outreach. The Data Recovery Workplan will be developed by the FHWA and the DRJTBC in consultation with the PASHPO.

D. The DRJTBC will implement a Phase II excavation at 28Me360 with the purpose of assessing the NRHP eligibility of the site. If the site is determined eligible and if the FHWA and the DRJTBC in consultation with the NJSHPO determine that a sufficient portion of the site remains to warrant further excavation, a Data Recovery Workplan will be prepared. The workplan will include research, fieldwork, analysis, report preparation, and public outreach. The Data Recovery Workplan will be developed by the FHWA and the DRJTBC in consultation with the NJSHPO.

E. If, during final design, the NJDOT, in consultation with the NJHPO, determines that the Trenton Water Power Channel will be impacted by the project, FHWA and the DRJTBC will develop a plan for the archaeological recordation of construction features related to the Trenton Water Power Channel. This plan shall be submitted to the NJHPO for review and approval. Such approval will not be unreasonably withheld.

F. The DRJTBC will undertake preliminary archaeological investigations to record construction features including the channel profile related to the Trenton Water Power Channel under the Scudder Falls Bridge in New Jersey in accordance with the approved plan for archaeological recordation referenced above, if it is determined by the NJHPO during final design that the proposed bridge pier construction will impact the location of the channel.

G. The DRJTBC will implement a Data Recovery Workplan for 36Bu379 including research, fieldwork, analysis, report preparation, and public outreach, or an alternative mitigation program. The Data Recovery Workplan or alternative mitigation program will be developed by the FHWA and the DRJTBC in consultation with the PASHPO.

H. If any human remains and grave-associated artifacts are encountered during the archaeological investigations, FHWA will bring this to the attention of the PASHPO and NJSHPO, as appropriate, and any federally recognized Tribes that may attach religious and/or cultural significance to the affected property within 24 hours of the discovery. No activities that might disturb or damage the remains will be conducted until all parties have determined whether excavation is necessary and or/desirable. All procedures will follow the guidance outlined in the National Park Service Publication *National Register Bulletin 41: Guidelines for Evaluating and Registering Cemeteries and Burial Places,* the Native American Graves Protection and Repatriation Act of 1990 (PL 101-601), as appropriate, and the PASHPO's *Policy for the Treatment of Burials and Human Remains* (1993) and/or NJSHPO's Archaeology and Ethnology Guidelines (2005), as appropriate.

I. The DRJTBC or their consultant will prepare reports on the data recovery excavations for review and comment by the FHWA, the PASHPO, and NJSHPO, as appropriate, and any interested federally recognized Tribes. The report shall meet professional standards set forth by the Department of the Interior's *Format Standards for Final Reports of Data Recovery Program* (42 FR 5377-79) and will be consistent with the Bureau for Historic Preservation/Pennsylvania Historical and Museum Commission's *Cultural Resource Management in Pennsylvania: Guidelines for Archaeological Investigations* (July 1991) for reports prepared for the PASHPO. Reports prepared for the NJSHPO will be consistent with *Guidelines for Phase I Archaeological Investigations: Identification of Archaeological Resources*, *Guidelines for Preparing Cultural Resources Management Archaeological Report Submitted to the Historic Preservation Office,* and the Secretary of the Interior's *Standards and Guidelines for Archeology and Historic Preservation,* September 29, 1983. A draft report will be completed within one year of the conclusion of fieldwork. Any comments provided by the PASHPO and NJSHPO, as appropriate, or

other consulting parties will be considered in the preparation of the final report. A final report will be completed and submitted within one year of the close of the comment period.

J. All records and materials resulting from the archaeological investigations that are not privately owned will be curated in accordance with 36 CFR § 79 and the curation guidelines developed by the PASHPO (June 2003) or NJSHPO's Archaeology and Ethnology Guidelines (2005), as appropriate. If the DRJTBC has not purchased the Right-of-Way at the time of the Data Recovery excavations, the DRJTBC shall request that the property owner sign a gift agreement donating the artifacts to the State Museum of Pennsylvania or the New Jersey State Museum, as appropriate. In Pennsylvania, all records and all artifacts not privately owned will be curated by the DRJTBC at the PASHPO in Harrisburg, or its designee, following the policies of that institution. The DRJTBC will be responsible for the curation fee of three hundred-fifty dollars ($350) per cubic foot. In New Jersey, if the site is determined by the NJSHPO to have statewide or national significance, the DRJTBC will curate all records and all artifacts not privately owned to the NJ State Museum, or if the site is determined to have local significance, to an undetermined designee selected in consultation with the NJSHPO, following the policies of the selected institution. The DRJTBC will be responsible for any related fees at the selected institution. If the final repository of the artifacts recovered in New Jersey is determined to be the NJ State Museum, then the DRJTBC will be responsible for the curation fee of three hundred-fifty dollars ($350) per Hollinger storage box.

II. Historic Structures

A. The Delaware and Raritan Canal and the Delaware Canal

DRJTBC, in consultation with consulting parties, shall develop an appropriate and compatible design for the replacement structure that is sensitive to historic properties in the immediate vicinity, as per the measures outlined in Stipulations II.A.1, II.B, and II.C.

1. Minimization through Design

a) To minimize visual impacts to the Delaware and Raritan Canal, the DRJTBC will design the piers of the I-95/Scudder Falls Bridge and NJ Route 29 interchange bridges to be the smallest size allowed by engineering design. The piers will be treated with an aesthetic finish to be agreed upon in consultation with the NJSHPO and consulting parties during the final design phase of the Project. Guidelines for the appearance of the aesthetic finish, including any available photographs and specifications, will be provided to the DRJTBC in advance of the preparation of test panel(s). Test panels will be constructed by the contractor, as many times as are reasonable and necessary, for review and approval by representatives of the NJSHPO, D&RCC, and Delaware and Raritan Canal State Park. Such approval will not be unreasonably withheld.

b) To preserve openness along the Delaware and Raritan Canal under the bridges, the DRJTBC will use pier configurations that will accommodate concerns of openness and are consistent with FHWA and NJDOT design standards.

c) To minimize impacts to the earthen embankment adjacent to the Delaware and Raritan Canal along Upper River Road beneath the proposed I-95/Scudder Falls Bridge, the DRJTBC will design the Project to consider methods to reduce erosion of the embankment.

d) To minimize runoff of water into the Delaware and Raritan Canal, the DRJTBC will design the drainage system for the new roadways to divert water flow away from the canal prism to the maximum extent possible.

e) To minimize effects on the Delaware and Raritan Canal, the proposed action will eliminate public use of the existing ramp from River Road (NJ Route 175) to I-95 northbound. The ramp will be gated for use by the NJ State Police.

2. Interpretation and Acquisitions

To mitigate for adverse effects of the project on the Delaware and Raritan Canal Historic District, including the acquisition of a portion of the National Register listed property, DRJTBC shall deposit $2 million to a mitigation fund established in the New Jersey Historic Preservation Office to be used to construct an interpretive swing bridge and/or for other interpretation of the Delaware and Raritan Canal. The $2 million includes the compensation for the acquisition of State Park property, subject to the approval of the State House Commission. The funds shall be deposited prior to the start of construction within the Delaware and Raritan Canal Historic District. The DRJTBC has completed consultation with the NJHPO, the Delaware and Raritan Canal State Park, and Green Acres, and other than as a consequence of unanticipated discoveries as set forth in Section III(B) of the PA, no additional monies shall be required from DRJTBC.

B. Consultation Relative to Design Elements

The DRJTBC will consult with the NJSHPO, PASHPO, D&RCC, Delaware Canal State Park, and the Delaware and Raritan Canal State Park, as applicable, concerning the design of the bridge, noise walls, and pedestrian/bicycle facility along the Delaware Canal in Pennsylvania and the Delaware and Raritan Canal in New Jersey.

C. Construction Protection Plan

To avoid project-related construction damage, the DRJTBC, in consultation with FHWA, the PASHPO, the NJSHPO, the D&RCC, the Delaware Canal State Park and the Delaware and Raritan Canal State Park, will develop for the approval of the PASHPO, NJSHPO, the D&RCC, and the Delaware Canal State Park a construction protection plan for work along the Delaware Canal in Pennsylvania and the Delaware and Raritan Canal in New Jersey prior to any destructive construction activity in the immediate vicinity of the canals. The plan will set forth specific measures that will protect the canal prisms, towpaths, and any related features during the construction period. The construction protection plan will include measures to protect the dry-laid stone wall along the eastern side of the Delaware Canal prism and towpath, immediately north of the existing I-95/Scudder Falls Bridge. The protection plan will provide measures for minimizing direct impacts to the canal prisms and towpaths during the removal of the piers of the existing I-95/Scudder Falls Bridge. In addition, to the extent possible, the plan will indicate that construction areas will be located outside the canal prism and towpath features and will be separated for the safety of towpath users. All areas of known archaeological sensitivity shall be marked on/or referenced in the plans and specifications.

III. Administrative Stipulations

A. Personnel Qualifications

All archaeological work carried out pursuant to this agreement will be by or under the direct supervision of a person or persons meeting at a minimum the *Secretary of the Interior's Professional Qualification Standards for Archaeology* and Historic Preservation and all historic preservation work carried out pursuant to this agreement will be by or under the direct supervision of a person or persons meeting at a minimum the *Secretary of the Interior's Professional Qualification Standards* (61 CFR Appendix A).. All work shall conform with the *Secretary of Interior's Standards and Guidelines for Archaeology and Historic Preservation*, and the New Jersey Historic Preservation Office Guidelines and Pennsylvania guidelines.

B. Late Discoveries

If any unanticipated discoveries of archaeological sites or historic properties are encountered during the implementation of this undertaking, DRJTBC shall suspend work in the area of the discovery, and FHWA shall comply with 36 CFR Part 800.13 by consulting with the PASHPO or NJSHPO, as appropriate, and, if applicable, federally recognized Tribes that attach religious and/or cultural significance to the affected property. The FHWA will notify the PASHPO or NJSHPO, as appropriate, and, if applicable, any such federally recognized Tribes within one working day of the

discovery. The FHWA, DRJTBC, the PASHPO or NJSHPO, as appropriate, and, if applicable, any such federally recognized Tribes will meet at the location of the discovery within seventy-two (72) hours of the initial notification to determine appropriate treatment of the discovery prior to the resumption of construction activities within the area of discovery.

C. Review Periods

The review period for all submissions will be thirty (30) calendar days from receipt of submission for review. The review of test panels will be accomplished within an immediate and reasonable response time, not to exceed seven (7) days from the date of notification for review.

D. Amendments

Any party to this PA may propose to FHWA that this agreement be amended, whereupon FHWA shall consult with the other parties to this PA to consider such an amendment. 36 CFR Part 800.6(c)(7) shall govern the execution of any such amendment.

E. Resolving Objections

1. Should any party to this PA object in writing to FHWA regarding any action carried out or proposed with respect to the Project or implementation of this PA, FHWA shall consult with the objecting party to resolve the objection. If after initiating such consultation FHWA determines that the objection cannot be resolved through consultation, FHWA shall forward all documentation relevant to the objection to the ACHP, including FHWA's proposed response to the objection. Within thirty (30) days after receipt of all pertinent documentation, the ACHP shall exercise one of the following options:

   a) Advise FHWA that the ACHP concurs in FHWA's proposed response to the objection, whereupon FHWA shall respond to the objection accordingly;

   b) Provide FHWA with recommendations, which FHWA shall take into account in reaching a final decision regarding its response to the objection; or

   c) Notify FHWA that the objection will be referred to comment pursuant to 36 CFR Part 800.7, and proceed to refer the objection and comment. The resulting comment shall be taken into account by FHWA in accordance with 36 CFR Part 800.7(c) (4) and Part 110(1) of NHPA.

2. Should the ACHP not exercise one of the above options within thirty (30) days after receipt of all pertinent documentation, FHWA may assume the ACHP's concurrence in its proposed response to the objection.

3. FHWA shall take into account any ACHP recommendation or comment provided in accordance with this stipulation with reference only to the subject of the objection; FHWA's responsibility to carry out all actions under this PA that are not the subjects of the objection shall remain unchanged.

F. Objection Resolution Provision

If the DRJTBC, NJSHPO, and PASHPO or any invited signatory to this PA should object in writing to any measures or their manner of implementation, then FHWA shall notify the parties of this PA and take the objection into account, consulting with the objector and, should the objector so request, with any of the parties to this PA to resolve the objection.

G. Review of Implementation

If the stipulations have not been initiated within five (5) years after the execution of this PA, the parties to this agreement shall review the PA to determine whether revisions are needed. If revisions are needed, the parties to this PA shall consult in accordance with 36 CFR Part 800 to make such revisions.

H. Sunsetting Duration

If the terms of this PA have not been implemented by ten (10) years from the date of the signed PA, this PA shall be considered null and void. In such event, FHWA shall notify the parties to this PA, and if FHWA chooses to continue with the Project, shall re-initiate review of the Project in accordance with 36 CFR Part 800.

I. Termination

1. If FHWA determines that it cannot implement the terms of this PA, or the PASHPO or NJSHPO, as appropriate, or the ACHP determines that the PA is not being properly implemented, FHWA or the PASHPO or NJSHPO, as appropriate, or the ACHP may propose to the other parties to this PA that it be terminated.

2. The party proposing to terminate this PA shall so notify all parties to this PA, explaining the reasons for termination and affording them at least thirty (30) days to consult and seek alternatives to termination. The parties shall then consult.

3. Should such consultation fail, FHWA or the ACHP, or the PASHPO or NJSHPO, as appropriate, may terminate the PA by so notifying all parties in writing.

4. Should this PA be terminated, FHWA shall either:

   a) Consult in accordance with 36 CFR Part 800.6(a)(1) to develop a new PA; or

b) Request the comments of the ACHP pursuant to 36 CFR Part 800.7(a)(1). The ACHP shall have forty-five (45) days to respond with comments.

5. FHWA and the ACHP may conclude the Section 106 process with a PA between them if either the PASHPO or NJSHPO, as appropriate, terminates consultation in accordance with 36 CFR Part 800.7(a)(2).

J. Entire Agreement

This PA represents the entire agreement between the signatories and concurring parties to this PA. Other than the occurrence of unanticipated discoveries as referenced in section III(B) of this PA, all known obligations of the DRJTBC and other signatories and concurring parties concerning historic preservation, mitigation, interpretation and acquisition are set forth in this PA.

Execution of this PA by FHWA, the PASHPO and the NJSHPO, and the implementation of its terms, will be evidence that FHWA has taken into account the effects of the Project on historic properties.

By: _____ Date: 12-30-10
FEDERAL HIGHWAY ADMINISTRATION

By: _____ Date:
PENNSYLVANIA STATE HISTORIC PRESERVATION OFFICER

By: _____ Date:
NEW JERSEY STATE HISTORIC PRESERVATION OFFICER

b) Request the comments of the ACHP pursuant to 36 CFR Part 800.7(a)(1). The ACHP shall have forty-five (45) days to respond with comments.

5. FHWA and the ACHP may conclude the Section 106 process with a PA between them if either the PASHPO or NJSHPO, as appropriate, terminates consultation in accordance with 36 CFR Part 800.7(a)(2).

J. Entire Agreement

This PA represents the entire agreement between the signatories and concurring parties to this PA. Other than the occurrence of unanticipated discoveries as referenced in section III(B) of this PA, all known obligations of the DRJTBC and other signatories and concurring parties concerning historic preservation, mitigation, interpretation and acquisition are set forth in this PA.

Execution of this PA by FHWA, the PASHPO and the NJSHPO, and the implementation of its terms, will be evidence that FHWA has taken into account the effects of the Project on historic properties.

By: _____ Date:
FEDERAL HIGHWAY ADMINISTRATION

By: Kim H Cutler Date: 10/18/2010
PENNSYLVANIA STATE HISTORIC PRESERVATION OFFICER

By: _____ Date:
NEW JERSEY STATE HISTORIC PRESERVATION OFFICER

b) Request the comments of the ACHP pursuant to 36 CFR Part 800.7(a)(1). The ACHP shall have forty-five (45) days to respond with comments.

5. FHWA and the ACHP may conclude the Section 106 process with a PA between them if either the PASHPO or NJSHPO, as appropriate, terminates consultation in accordance with 36 CFR Part 800.7(a)(2).

J. Entire Agreement

This PA represents the entire agreement between the signatories and concurring parties to this PA. Other than the occurrence of unanticipated discoveries as referenced in section III(B) of this PA, all known obligations of the DRJTBC and other signatories and concurring parties concerning historic preservation, mitigation, interpretation and acquisition are set forth in this PA.

Execution of this PA by FHWA, the PASHPO and the NJSHPO, and the implementation of its terms, will be evidence that FHWA has taken into account the effects of the Project on historic properties.

By: _____ Date:
FEDERAL HIGHWAY ADMINISTRATION

By: _____ Date:
PENNSYLVANIA STATE HISTORIC PRESERVATION OFFICER

By: _____ Date: 10/5/10
NEW JERSEY STATE HISTORIC PRESERVATION OFFICER (DEPUTY)

CONCUR:

By: _____ Date: 11-4-10
DELAWARE RIVER JOINT TOLL BRIDGE COMMISSION

By: _____ Date:
NEW JERSEY DEPARTMENT OF TRANSPORTATION

By: _____ Date:
PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

CONCUR:

By: _____ Date:
DELAWARE RIVER JOINT TOLL BRIDGE COMMISSION

By: _____ Date: 10-15-10
NEW JERSEY DEPARTMENT OF TRANSPORTATION

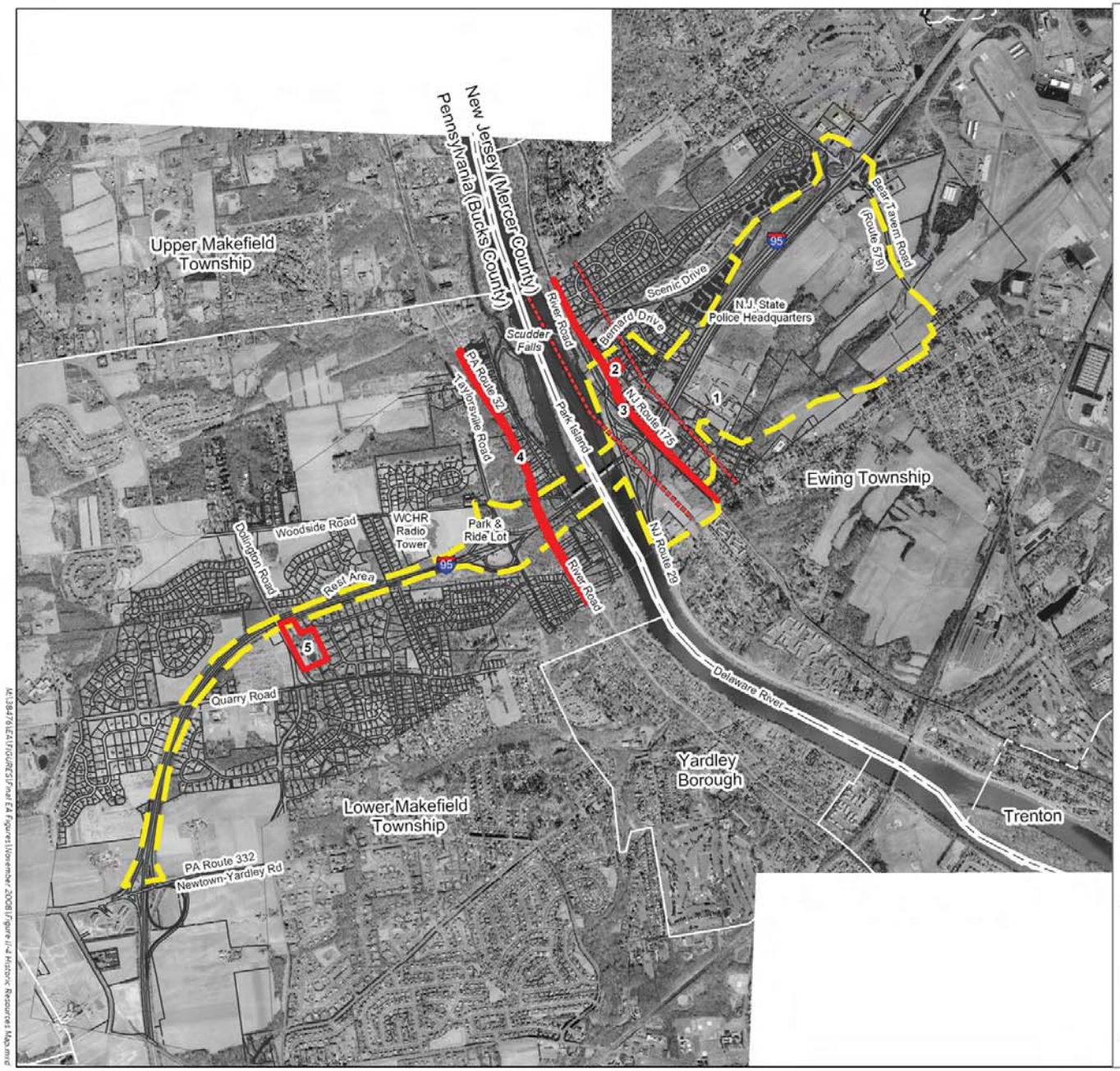
By: _____ Date:
PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

CONCUR:

By: _____ Date:
DELAWARE RIVER JOINT TOLL BRIDGE COMMISSION

By: _____ Date:
NEW JERSEY DEPARTMENT OF TRANSPORTATION

By: _____ Date: 10/18/10
PENNSYLVANIA DEPARTMENT OF TRANSPORTATION



Legend

- Area of Potential Effect (APE)
- National Register of Historic Places Listed or Eligible Historic Resources
- Delaware and Raritan Canal District

1. N.J. State Police Headquarters
2. Charles S. Maddock House
3. Delaware and Raritan Canal
4. Delaware Canal
5. Elm Lowne House

0 1,250 2,500 5,000 7,500 10,000 Feet

I-95/Scudder Falls Bridge Improvement Project Environmental Assessment Historic Resources Map Figure II-4

M:\38476\EA\FIGURES\Final EA Figures\November 2008\Figure II-4 Historic Resources Map.mxd

HPO Project # 04-0137-26
HPO-F2012-108

State of New Jersey

MAIL CODE 501-04B
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NATURAL & HISTORIC RESOURCES
HISTORIC PRESERVATION OFFICE
P.O. Box 420
Trenton, NJ 08625-0420
TEL. (609) 984-0176 FAX (609) 984-0578

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

June 13, 2012

George Alexandridis, Chief Engineer
Delaware River Joint Toll Bridge Commission
110 Wood and Grove Streets
Morrisville, PA 19067

Re: Mercer County, Ewing Township, I-95 Scudder Falls Bridge Replacement project
Archaeological Data Recovery at the Reeder's Creek West Locus of 28-ME-360

Dear Mr. Alexandridis:

The Historic Preservation Office (HPO) has received a copy of the following archaeological data recovery report for review and comment in partial fulfillment of Stipulation I.I of the Programmatic Agreement for the above-referenced project:

Mikolic, Frank G. and Brian M. Albright
April 2012 *Data Recovery Archaeological Investigation Reeders Creek West Site (28Me360) I-95 Scudder Falls Bridge Improvement Project Ewing Township, Mercer County, New Jersey.* AECOM Transportation, Trenton, NJ. Prepared for Delaware River Joint Toll Bridge Commission Morrisville, PA.

The above-referenced report documents the results of archaeological data recovery conducted at the Reeders Creek West Site (28Me360), along the Delaware River in Ewing Township, Mercer County, New Jersey. The data recovery work is responsive to the archaeological data recovery plan approved by the Historic Preservation Office on September 30, 2010 with appropriate justification for the deviations from the originally proposed methodology and sampling design. Subsurface investigations conducted as part of the archaeological data recovery provided information about Native American life in the Middle Delaware River Valley region during the Late Archaic, Early/Middle Woodland and Late Woodland time periods and contributes to the understanding of settlement patterns and subsistence strategies during these time periods.

Report Comments

This report is an excellent example of pre-Contact period research in the Middle Atlantic region. The scope and depth of analysis have significantly contributed to the study of settlement patterns, subsistence strategies and lifeways of Native Americans in the Middle Delaware River Valley, and will be valuable to future researchers.

The HPO does have a few minor comments about the report that should be addressed in the final report that will be prepared and submitted to the HPO. These are:

1. In Volume I, page 7-21, Table 7-7, there is a typographical error in the site number on the last line. Site 38ME0360 should be 28ME0360.
2. Page 8-4, line 2 sentence should read "along with other species native to the Delaware Valley".
3. In Volume II, Appendix F, page 1 of the FTIR report is missing.

In addition to the above, we look forward to updates on the progress of public outreach activities as outlined in the Data Recovery Plan.

Thank you for providing the opportunity to review and comment on the above-referenced report. Please do not hesitate to contact Kate Marcopul of my staff at (609) 984-5816 with any questions regarding archaeology.

Sincerely,

Daniel D. Saunders
Deputy State Historic
Preservation Officer

CC: Frank Mikolic, AECOM
Janet Fittipaldi, NJDOT

Appendix C: Geomorphology Report

Geo-Sci Consultants LLC

4410 Van Buren Street, University Park, Maryland 20782
tel: 301 277 3731 fax: 301 277 2147

GEOARCHAEOLOGY

OF SITES 28ME360 AND 36BU379

AT THE SCUDDERS FALLS I-95 BRIDGE

ACROSS THE DELAWARE RIVER

IN BUCKS COUNTY, PENNSYLVANIA

AND MERCER COUNTY, NEW JERSEY

Submitted to
AECOM

By

Daniel P. Wagner, Ph.D.
Pedologist

December 15, 2011

Introduction

The following discusses pedological and geomorphological interpretations of terrace soils and landscapes on opposing sides of the Delaware River near where it is crossed by the Scudders Falls Bridge for the Interstate 95 highway. Both sides of the river were subjected to intense archaeological investigations that were respectively divided between the Reeder's Creek Site (28ME360) on the Mercer County, New Jersey side and the River Road Site (36BU379) on the Bucks County, Pennsylvanian side. Geoarchaeological investigations were intended as support studies focused principally on elucidation of site formations histories. These were to address both internal autogenic processes for each of the site areas as well as comparative assessments relating differences and/or similarities between the two.

Methods

Methods of investigations entailed both field and laboratory efforts. Field investigations were distributed over multiple site visits concentrating first on the Reeder's Creek Site and then the River Road Site. Field visits to Reeder's Creek were made on December 1, 2009, October 25 and 26, 2110, and December 14, 2010. Those to River Road were made on May 11, 2011 and July 7, 2011. During each of these visits soil examinations of profiles were made mainly by means of available archaeological test unit and block exposures, but in some circumstances supplemental hand auger borings were also made, typically extending below a test unit floor. Examined soil profiles were described in accordance with standard pedological techniques and nomenclature for the field description of soils (Schoeneberger, et al. 1998), and the compiled descriptions are contained in Appendix A.

Laboratory analyses involved determinations of both physical and chemical properties of site soils. Physical analyses consisted of particle size analyses of samples collected from representative deep columns at each of the sites. These analyses consisted of determinations of silt and clay by the hydrometer method (Gee and Bauder, 1986), and measurements of sand by sieve fractionation. Soil particle size data are provided in Appendix B.

A suite of soil chemical analyses was also made on selected samples from the River Road Site as a means of characterizing chemical signatures likely attributable to human activity. Samples were collected both from point-specific subsurface cultural features as well as from a more widespread buried surface horizon. The buried surface was sampled at several locations in an effort to identify areas that may have been the most intensively utilized. Soil chemical analyses were determined by the University of Delaware Soil Test Laboratory, and the data are contained in Appendix C.

Physiology and Regional Terraces

The study location is situated within the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province. Also known as the Triassic Lowland this section is typically characterized by gently to moderately sloping uplands composed mainly of reddish shales interbedded with or situated adjacent to lesser amounts of other sedimentary rocks. Among these other are more buff colored rocks such as the Stockton Sandstone that comprises the local uplands near the study location, as well as the dark gray argillite of the Lockaton Formation occurring just upstream of the study area. However, since both site areas are contained on alluvial landforms, the primary significance of bedrock compositions is the extent to which they are represented as sources of transported sediment. Recognizing that relative to the Stockton and Lockaton rocks an even a larger portion of the Delaware River watershed farther upstream of the study location is dominated by the reddish shale, siltstone and mudstone of the Brunswick Formation, much of the alluvium delivered to the river by tributaries within this outcrop belt would tend to exhibit reddish hues (7.5YR and 5YR) inherited from the more prevalent Triassic rocks. Also, of course, alluvium derived from much greater distances well to the north would be a significant component in any alluvial landforms built by the river; and thus to some extent the reddish hues common to the closer sources of Triassic-derived alluvium would be effectively diminished in blending with materials originating from other physiographic provinces. Additionally, the deepest basal layers of gravel that commonly underlie many of river's terraces often consist of lag or reworked outwash train deposits carried to the region by glacial meltwater late in the Pleistocene.

Perhaps of more significance than the physiographic province in which the project area is situated, is the segment of the Delaware River system in which it is contained, and thus where the site landforms likely fall within regional terrace schemes. Models for discriminating separate terrace formations have been suggested for both the Susquehanna and Delaware Rivers. For the Susquehanna River, Vento and Rollins (1989) formulated a classically stepped sequence of four late Pleistocene through Holocene terrace levels distinguished on the bases of height, age and stratigraphy. The designated terrace levels include the 9.5 to 13.5-m high Binghamton and Olean terraces of Pleistocene glaciofluvial origin, the 7-m high Valley Heads terrace of late Pleistocene to early Holocene age, and the 4-m high Port Huron terrace of Holocene age. With respect to the Delaware River, Stewart (1990) in a review of the upper and particularly middle valley stretches of the river, considered the Vento and Rollins Susquehanna model sufficiently workable to recognize terraces correlative to the Valley Heads and Port Huron. Similarly, Wagner and Benedict (1994) recognized Holocene alluvium distributed over three terrace levels reaching as high as 9.5 m above the Delaware River at the Depew Recreation Area about 20 km above the Delaware Water Gap. The respective 6-m and 4.5-m heights of the Reeder's Creek and River Road Sites most closely correspond to the Port Huron Terrace, but the higher of the two also approaches the level of the older Valley heads Terrace.

Schuldenrein (1994) has also recognized multiple terrace levels along the Delaware River, and has generally grouped them within sedimentation zones more or less

corresponding to a commonly accepted partitioning of the Delaware Valley into upper, middle and lower segments respectively demarcated by the Delaware River Gap upriver and the head of tide below Trenton. Located just above Trenton, the project area is thus within the lowest portion of the middle valley segment. Within Schuldenrein's system such a near boundary location would be transitional between two zones of sedimentation, falling just within the zone of overall sediment transfer but likely also reflecting to some extent the immediate downriver zone of deposition. Archaeological sites cited by Schuldenrein as situated on terraces which appear to be similar to those of the project area include the Sandts Eddy Site about 90 km upriver and lying between 4 to 6 m above the river, and the Lower Black's Eddy Site only about 30 km away and rising to about 4 m above the river.

All of the above studies also noted differences in stratigraphy, soil horizonation, and age that, complimentary to height, served to distinguish separate terrace formations. In a somewhat similar vein, Thieme (2003) proposed the Wyoming Valley Formation to identify deposits of mostly Holocene origin along the North Branch of the Susquehanna River. However, the allostratigraphic approach employed in his study was not precise in recognizing the age and genesis of deposits; and even though four morphological facies of the formation were described, the utility for archeological applications was accordingly limited. As with Vento and Rollins, Thieme also suggested models of climate change to account for varying sedimentation rates and terrace construction during the Holocene, and Stewart (1990) as well as Schuldenrein (1994) have provided summaries of archeological deposits typical of each of the Delaware River terraces. Schuldenrein's system suggests that deposits appreciably older than Late Archaic would not generally be expected in the transitional zone of the study location.

Reeder's Creek (28ME360)

Over the course of field investigations this site was visited on four occasions. During the initial visit both western and northeastern portions of the site were examined, and soil profile descriptions were made in each area. The description in the western portion was at that time originally identified as Test Unit 1, a location now approximately corresponding to the location of Test Unit J16 in the coordinate system employed for later investigations. The description in the northeastern area was made at the location of Test Unit 7. This location was never revisited during ensuing investigations, and hence is not included in the discussion of the site, which concentrates solely on the western portion. The compiled Test Unit 7 description is, however, attached at the end of the Reeder's Creek descriptions log.

The Reeder's Creek Site occupies a terrace of the Delaware River that is of a riverside type not particularly common for the lower Middle Valley. Rising some 6 m above the river, it is considerably higher than the normal 4-m or so height otherwise prevalent is this segment of the valley. An even higher terrace level is present both landward and downriver of the site terrace. Although not directly examined, this terrace's 2 to 3-m greater height likely signals a Pleistocene landform of glacial outwash origin. A

gravelly phase of the Birdsboro soil recognized (Jablonski, 1972) across portions of this higher terrain just downriver of the site is also suggestive of such a Pleistocene origin, and based on the presence of surface cobbles on a similarly high terrace in the nearby town of Yardley on the Pennsylvania side of the river this investigator (Wagner, 2009) similarly identified an outwash terrace abutting the distal margin of the river terrace.

Although as much as 200 m removed from the site location, the higher Pleistocene terrace could still have influenced the site formation process. Downriver of the site the edge of the higher terrace is approximately defined by the 40-ft contour line on the USGS 7.5' topographic quadrangle (Figure 1). Roughly corresponding to a location just beyond the original confluence of Reeder's Creek with the Delaware River, such a preexisting higher terrace ranging almost to contact with the river could have been a factor contributing to the rather unusual height of the site landscape. By partially obstructing flow along the New Jersey side of the river during flood events and thereby retarding the flow rate, sediment transport competence would also diminish and hence result in increased upriver sedimentation. Similarly, a disruption in the flow pattern would also mitigate destructive scour events and enhance preservation of deposits.

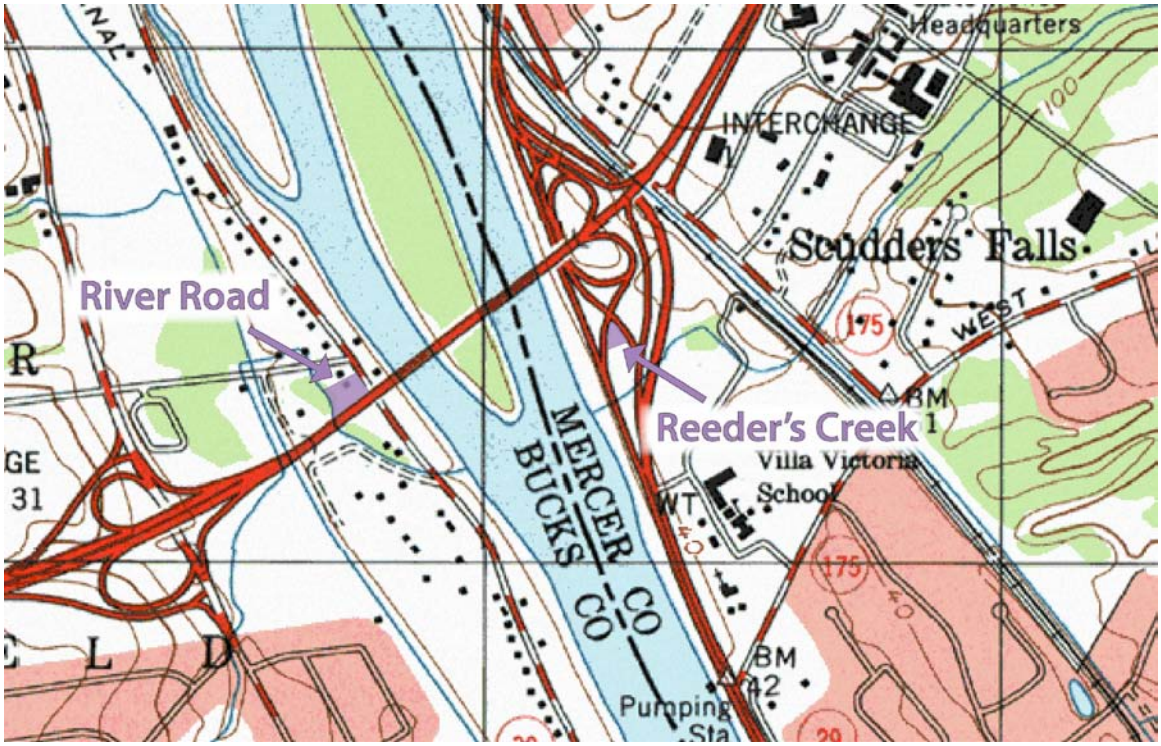


Figure 1. Locations of Reeder's Creek and River Road Sites. The 40-ft contour line near Reeder's Creek is interpreted as the demarcation of a higher, probable outwash terrace.

Except for its somewhat uncharacteristic height for the region, the site landform otherwise exhibits a topographic form common to river terraces. From its greatest height along its proximal side nearest the Delaware River the surface of the terrace undergoes a discernible landward decline of about 3% slope. The landward decline is less evident at the southern end of the site, which is probably due to modern disturbances and filling. Other modifications have resulted in altered topography as well, and prior to construction of the road the rise toward the river is likely to have continued farther to culminate in a levee crest fronting the river.

Along the terrace's north-south axis parallel with the Delaware River the modern surface is nearly level and varies by little more than 10 or 15 cm difference in height over a distance of nearly 50 m, with most existing surface irregularities simply again attributable to modern grading disturbances. However, across most of the site there is a surface horizon sequence consisting of two stacked plow zones of varying thicknesses. The lowermost (Ap2) is reflective of an earlier history of tillage and represents the original surface. The upper (Ap1) is formed in graded, albeit locally derived, fill related to road construction. This upper layer of disturbance fill generally thickens to the south, and in restoring the original grade by its removal, it is apparent that along the length of the site the surface declined roughly 40 cm in height to slope gently (1%) southward toward the valley of Reeder's Creek.

Not unexpectedly given the relatively limited size of the site area, soils across the terrace are quite similar. They are formed in fine-sandy to loamy alluvium typical of terrace columns built primarily by overbank sedimentation. As revealed in two of the deeper examinations (Test Units J16 and L18) the site soils are multisequal with as many as five different episodes of comparative landscape stasis and soil formation apparent. The uppermost sequum is present throughout the site and beneath the stacked plow zones typically consists of a combination of weakly formed subsoil cambic (Bw) horizons of very fine sandy loam texture and relatively uniform brownish color (7.5YR 4/3 or 4/4) atop a less homogenous zone comprised of dark yellowish brown (10YR 3/4) fine sand and variably expressed pedogenic lamellae generally of very fine sandy loam texture and reddish brown (5YR 3/4) color. Figure 2 showing the profile of Test Unit E10 offers a good example of the upper soil sequum. Discounting the variable mantle of disturbed surface material, this uppermost sequum is generally about 1.5 m thick beneath, and in most of the test units was the only one exposed.

Figure 2. The profile of Test Unit E10 is typical of upper soil horizonation throughout the site, consisting of cambic horizons and an underlying zone of lamellae.

The deepest soil examination made was that of Test Unit L18. The multiple sequa described in this profile matched stratigraphically with four sequa in the nearby profile of J16, but in extending another 116 cm deeper to contact with basal gravel at the depth of 456 cm, a lower fifth sequum was also identified. As this profile provided exposure of the entire soil column, in addition to being described in the field it was also sampled for determinations of soil particle size fractions. These data are graphically depicted in Figure 3, which shows that the predominant sediments are of a fine-sandy composition typical of essentially all Holocene terraces throughout both the middle and upper segments of the Delaware Valley. The single biggest stratigraphic shift occurs at the depth of 300 cm where three overlying sequa formed in the fine-sandy deposits yield to a considerably more silty and mottled sequum marked by a buried surface horizon (4Ab). These silty and regionally less common deposits are distributed between two sequa, with another buried surface (5BAb) occurring at the depth of 394 cm. The buried surface here is less discrete than the 4Ab, and partially welded to the overlying sequum (hence the BA designation), it does not mark a similarly abrupt shift in sedimentation. A sharp change in composition does, however, occur at the depth of 440 cm where a relatively thin horizon (6BCb) of increasing sand content signals transition to underlying gravel at the depth of 456 cm.

When coupled with available age determinations, the soil horizonation and particle size data allow for a general scheme of site formation. Most of the dates shown in Figure 2 are drawn form other test units with comparable horizonation, and these are clustered in upper soil levels where most cultural materials and features occur. Only the lowest date for the 4Ab horizon is actually from the profile of Test Unit L18. Nonetheless, with but a few exceptions the dates for comparable horizons throughout the site are in reasonably close agreement, and the ordered progression shown in Figure 2 should represent a close facsimile of the major stages of sedimentation responsible for construction of the site landform.

Among the major traits demonstrated by the combined data is relative stability in the Late Holocene. Indeed, there even appears to be little or no historic sedimentation, which is rather uncommon. It is possible that some historic alluvium is contained within the Ap1 horizon, but as previously discussed this horizon is considered to be largely the product of grading and other disturbance activities related to road construction. Below this disturbed zone is a fairly compressed chronological sequence culminating in the upper lamellae zone (C/Bb) with an age of 3180 – 3150 B.C. by the depth of only about 100 cm beneath the original surface (Ap2). This age is readily consistent with the exhibited degree of subsoil formation, particularly for what was identified in the field as the Bw2 horizon. Based on the particle size data and the increase in clay content within this horizon it actually qualifies as a weak argillic horizon (Bt), which typically can form within a soil weathering period spanning about 4,000 to 5,000 years. This soil development together with the compressed age sequence demonstrates fundamental terrace stability in the latter part of the Holocene during which time only very slow sedimentation (2 cm/100 years) was operative.

The chronology of underlying deposits is somewhat more problematic. Beneath the upper sequum are two additional soil sequences (2Bwb, 3Bwb) that exhibit similar degrees of soil development evincing both separate intervals of rejuvenated sedimentation as well as periods of relative stasis to allow for subsoil formation. They are somewhat less developed soils than the uppermost sequum, and lying at lower heights above the Delaware River, the fine-sandy deposits in which they are formed were presumably amassed under slightly more rapid rates of sedimentation. Following this reasoning each of the two underlying sequa should account for time intervals approaching but probably less than that of the upper sequum. Accordingly, by the base of the third sequum a combined age of another 6,000 or 7,000 years added to the age of the upper sequum would place the origin of strata beneath the third sequum before about 11,000 years ago or so. Other age approximations can be made by employing sedimentation rates independent of apparent degree of soil development. By extending the same 2 cm/100 years rate of the upper sequum throughout the nearly 280 cm span (discounts Ap1) to the base of the third sequum, a minimum age for deep strata underlying the third sequum would be roughly 14,000 years. More conservatively increasing the rate to 3 cm/100 years would yield a calculated age of 11,200 years which is similar to the estimate based

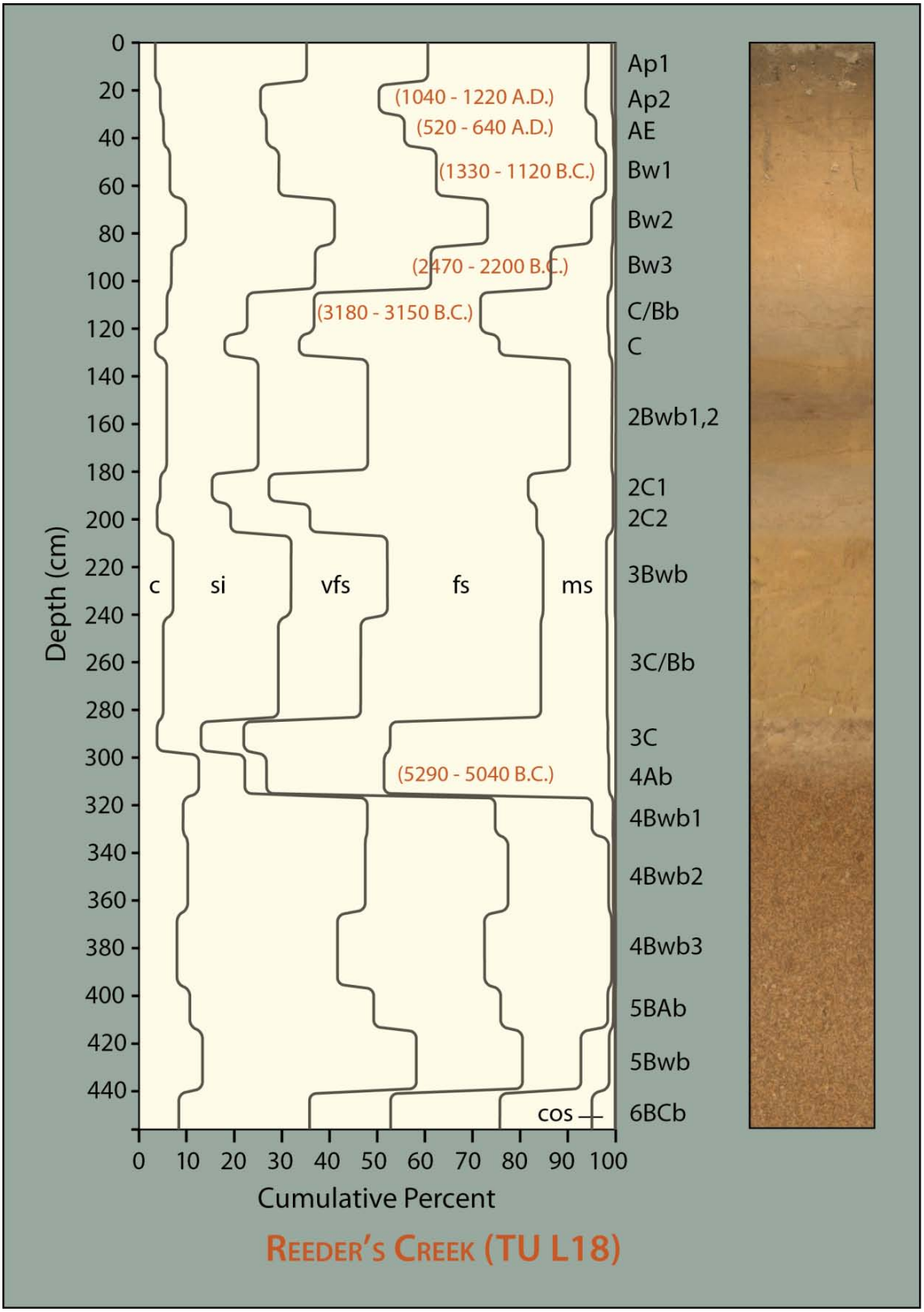


Figure 3. Fine-sandy deposits in the upper 3 m are typical of Delaware River overbank alluvium. Deeper more silty deposits are less common. Upper dates are from comparable horizons elsewhere on the site.

on soil development. However, none of these approaches are in accord with the C^{14} 5290 – 5040 B.C. age determination made at this level for a bulk soil sample obtained from the buried surface (4Ab) between the depths of 298 and 316 cm. It is therefore apparent that either the determined age is for some reason not particularly reliable, or that for the second and third sequa the rates for both soil development and sedimentation (increase to 9 cm/100 years needed) were considerably greater than those accounting for the uppermost sequum. Interestingly, even accepting the youngest age, the terrace still stands out as an oddity. As summarized by Schuldenrein (1994) terrace formations along this section of the Delaware Valley do not typically predate the Middle Holocene, and have been built under aggradation rates of as much as 4 cm/100 years.

There are several reasons to suspect the reliability of the measured C^{14} age. Chief among these is the abrupt shift in soil composition atop the deeply buried surface. A very similar shift from a mottled silty soil to overlying fine sands also occurs in the Shawnee Minisink terrace at a time well documented (Gingerich, 2007) to correspond with the end of the Clovis culture and the onset of the Younger Dryas cold reversal period. While it is not necessary to invoke such a severe climatic event in every circumstance where a dramatic change in deposit type occurs, the fact is that the Younger Dryas did have a major impact on the Delaware Valley, and its effects should be discernible if deposits are of sufficient antiquity. Since age summations based on soil development of the multiple sequa as well as likely sedimentation rates also point to a similar window in time, serious consideration should be given to the possibility of such antiquity.

Possible origins for the silty deposits beneath the 4Ab horizon should also be considered. If of alluvial origin, the finer textural composition would infer a lower energy depositional environment supporting a sedimentation rate likely to be considerably slower than those for the overlying sands. Hence, even if the determined C^{14} age at the top of these deposits is reasonably accurate, underlying levels ranging to about 1.5 m deeper could still encompass enough time to reach the Pleistocene. If the determined age is too young as suggested by other soil and sedimentation indicators, then the origin of these deposits could reach even farther into the Pleistocene. In that regard another potential mode of origin for the silts is loessial (wind blown). This possibility has been suggested for the similar silty deposits at Shawnee Minisink (Foss, 1977), and might even be more applicable to Reeder's Creek. Since loess deposits are often derived from eolian reworking of train deposits carried by meltwater to areas well below glacial boundaries, the much lower watershed location of Reeder's Creek might better fit the typical loess model. With prevailing westerly winds, it is also on the windward side of the Delaware River.

In summary, Reeder's Creek occupies a terrace of the Delaware River built mostly by overbank accretion of fine sands during the Holocene, but very possibly also containing a deep Pleistocene component in the form of a silty stratum that comprises the first 1.5 m above basal gravel. Rising to a height of 6 m above the river, the terrace is of multisequal construction with three separate soil sequa represented in the sandy deposits and two in the deep silts. These sequa are indicative of episodic terrace building in which periods of rejuvenated sedimentation were followed by intervals of relative stasis that allowed for the advancement of soil development. Based on measured dates within the

upper meter or so as well as the degree of soil development, the terrace has been subject to only very slow rates of sediment accretion for about the last 5,000 years. Prior to this the average sedimentation rates are likely to have been somewhat more rapid, although a good deal of question remains about the precise ages of deeper strata, particularly those below the depth of 3 m. A measured date at this depth on the order of 7200 B.P. could be too young, but even if accurate places the underlying strata of this unusual terrace within an age bracket much older than that typical for this stretch of the river.

River Road (36BU379)

The River Road Site is located on the edge of a broad river terrace that extends some 500 m landward to where the Pennsylvania Canal appears to mark the toe of another higher terrace. In most respects the site terrace is typical of those along the lower middle segment of the Delaware Valley, but its topographic construction does contain fairly unique autogenic components reflective of local conditions, a principal element of which is an unnamed stream along the site's distal margin. The highest surfaces within the site area are for the most part on its opposing eastern and western margins where they are situated at the regionally common height of about 4 m above the Delaware River. Within the central portion of the site, however, the original pre-Contact surface dipped to a level of more than half a meter lower. To some extent this central declivity is still discernible in the modern topography, but owing to a variably thick veneer of historic deposits that covers almost all of the site, and that is significantly thicker in the central portion, expression of the central low is now more subdued than in the past. Whereas historic deposits on the high margins vary in thickness from essentially none on the east side to about 20 cm on the west, modern deposits of as much as 57 cm in thickness (Figure 4) have filled the more central location.

Without the mantle of modern deposits, the original site topography was somewhat saddle-like in shape. From the lower lying middle portion of the site the pre-Contact surface rose eastward toward the Delaware River where, absent disturbances related to the construction of River Road, it likely reached a distinct levee crest. West of the central low the original surface rose to a similar high also suggestive of a levee position, but if so, one associated with the stream rather than the river. Hence, in topographic form the site terrace appears to consist of two opposing levees separated by an intervening low area. The varying relief is, however, unlikely to be entirely the product of levees simply building to heights above the central low. As will be subsequently discussed, Late Holocene sedimentation data do not support this interpretation, and relative stabilities of the different landscape positions could also well be a factor. Compared to the higher terrain along the eastern and western margins, the lower height of the middle section renders this position more susceptible to flood events. Accordingly, while the latest status of the central low tends to be that of a sediment sink in which there is a net gain of deposits, earlier in its flood history the position may have been more subject to carving by scour events during which the predominant action was erosional loss of material.

Like nearly all terraces along the Delaware River, the principal deposit type present is overbank alluvium of fine-sandy to loamy textures. The textural composition of the terrace alluvium is shown in Figure 4. In this deepest excavation made on the site (Block 7X7), the overbank sediments extend to contact with basal gravel at the depth of 367 cm, which translates to a height of only about a half meter above the nominal level of the river. As is also typical for river terraces, soil development within this nearly 4-m column is multisequal, with as many as three sequa having subsoil expressions mainly as either cambic horizons (Bw) or lamellae zones (C/B). Common properties for cambic horizons are dark brown (7.5YR 3/4) to brown (7.5YR 4/4) colors and textures of either fine sandy loam or loam. Lamellae zones are predominantly brown (10YR 4/3) loamy fine sand banded with fine sandy loam lamellae typically 1- 2 cm thick and dark reddish brown (5YR 3/4) in color.

The multiple soil sequa evince a history of terrace construction entailing alternating intervals of rejuvenated sedimentation followed by periods of relative stasis to allow for subsoil formation. As with the Reeder's Creek terrace on the opposite side of the Delaware River, Late Archaic cultural material recovered within the upper 75 cm on one of the higher landscape positions is indicative of mostly slow Late Holocene sedimentation across much of the terrace. Although no measured dates for deep strata were determined in the study, the tendencies for coarser textures and lamellae banding for the lower half of the column suggest that lower deposits were laid down more rapidly than higher ones, and it is likely that most of the terrace was amassed after the Early Holocene.

In contrast to the relative stasis of the higher margin positions late in the Holocene, a significant part of the site was not at all stable during the same period. As previously discussed, the central low portion of the site has in modern time undergone increased sedimentation relative to that on the rises to the east and west. As demonstrated both by soil horizonation as well as measured dates, the disparity in sedimentation was also well underway even before the advent of European settlement. These central deposits were probably derived from both direct alluvial additions during flood events as well as local slope wash contributions from the adjacent higher positions. While not evenly documented in all exposures probably as a function of frequent shifting and readjustment of microtopography within this comparatively more dynamic local landscape position, Late Holocene deposits are amply expressed by a sequence of consecutive surface horizons beneath the veneer of modern deposits (Figure 5). Whereas historic deposits are typically contained within one or two plow zones, including horizons that were subject to local grading but not necessarily tillage, at some locations such as Block R the underlying Late Holocene deposits continue as a further stacking of multiple surface horizons. Indeed, in the Block R profile the upper portion of the pre-Contact profile consists of four (2Apb, 2Ab1, 2Ab2, and 2ABb) surface horizons comprising the upper 58 cm of the original profile. Below this sequence only a weakly formed 22-cm thick cambic horizon (2Bwb) disrupts the surface horizon stacking through to another buried surface (3BAb) extending to the depth of nearly 1 m below the original surface.

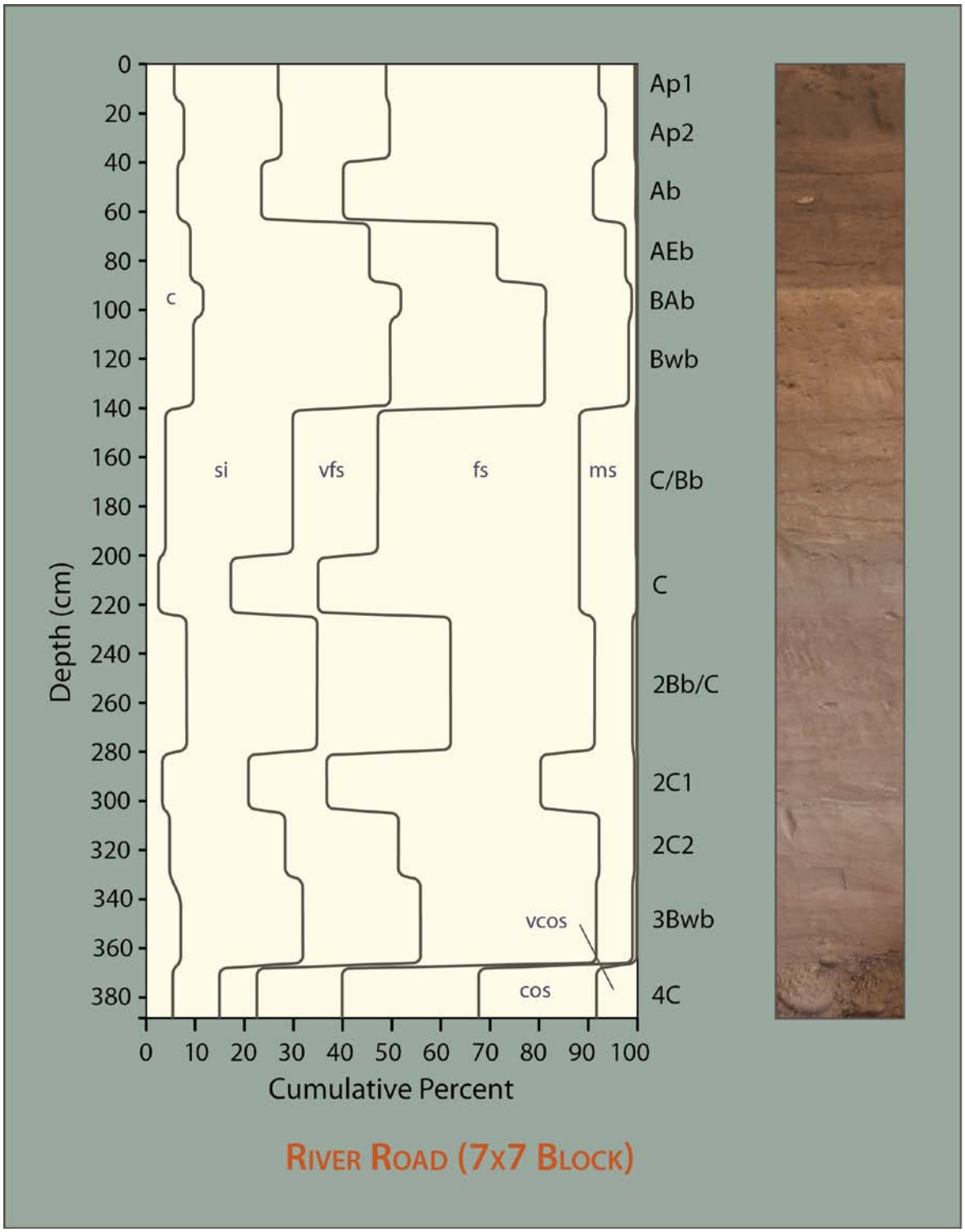


Figure 4. The fine-sandy terrace soil is multisequal with subsoil development occurring as either cambic horizons (Bw) or lamellae zones (C/B). The 4C horizon is in basal gravel.

Figure 5. Modern deposits extend to the depth of 57 cm (nail and knife hilt) in this Block R profile. Underlying A horizons document infilling of the low position even before European settlement.

Although a continuous series of vertical age measurements with depth was not determined for any single profile within the central low position, similar horizon sequences occurring throughout the site allow for correlative linkages to provide a generalized composite ordering of upper soil chronology. Determined dates from three locations were thereby translated to the profile of Block R presented in Figure 6. One date actually determined for the Block R profile at the level of the 2ABb horizon is not shown since it fell within the last half century, and inconsistent both with soil horizonation as well as other dates from around the site, must be considered one of modern contamination. The other shown dates are, however, highly informative. Ranging from about 1600 A.D. in the buried original surface (2Apb) to about 1200 A.D. by the 2ABb horizon, these data demonstrate that the upper 60 cm of deposits beneath the

historic mantle was laid down over a period of only about 400 years under a fairly rapid sedimentation rate of 14.5 cm/100 years. Similar rates of accretion may also have been in play for even deeper levels since similar loam-textured deposits extend through the 3ABb horizon to the depth of nearly 1 m below the pre-Contact surface. If so the deposits at this depth would date to roughly 925 A.D., and the relative stratigraphic position indicates that prior to that time the local relief between the central low position and higher margins was much more pronounced, probably by as much as 1.5 m.

Unlike those within the central low area, upper soil levels of the bordering rises along the site margins have been considerably more stable during the Late Holocene. Subsoil development actually achieves that of a weakly formed argillic horizon (2Btb) at the depth of 75 cm in the Block K profile of the riverside levee. Although the absence of an overlying surface horizon directly associated with the argillic horizon is possibly suggestive of a minor truncation event, the argillic horizon in and of itself indicates that a period of mostly stable landscape conditions has prevailed over a span of about the last 4,500 years or so. Similarly, even though subsoil development is limited to cambic horizon (Bw) formation in Block A of the western rise, a dated (2470-2290 B.C.) hearth feature here at the depth of 65-73 cm demonstrates comparatively slow sedimentation within about the same time frame. The sedimentation rate of 2.7 cm/100 years calculated for this upper level along the western rise is therefore probably reasonably representative of the rate for the eastern levee as well. A similar rate may even have typified the central low area at the time, with accelerated deposition only occurring over the last 1,000 or 1,200 years.

To summarize the topography and stucture, the River Road Site is contained on a river terrace that in some respects is typical of those along this segment of the Delaware River. Its maximum height of about 4 m is compatible with the regionally prevalent norm, and as with most terraces it contains multisequal soil profiles formed in fine-sandy to loamy overbank alluvium. More unique features include a stream along the site's landward margin as well as a saddle-like site topography in which both the eastern and western margins of the site rise above a lower lying central position. To some extent these rises are probably reflective of levee building related to both the river and stream, but flood scouring through the central portion of the site may also have contributed to the peculiar saddle-like topography.

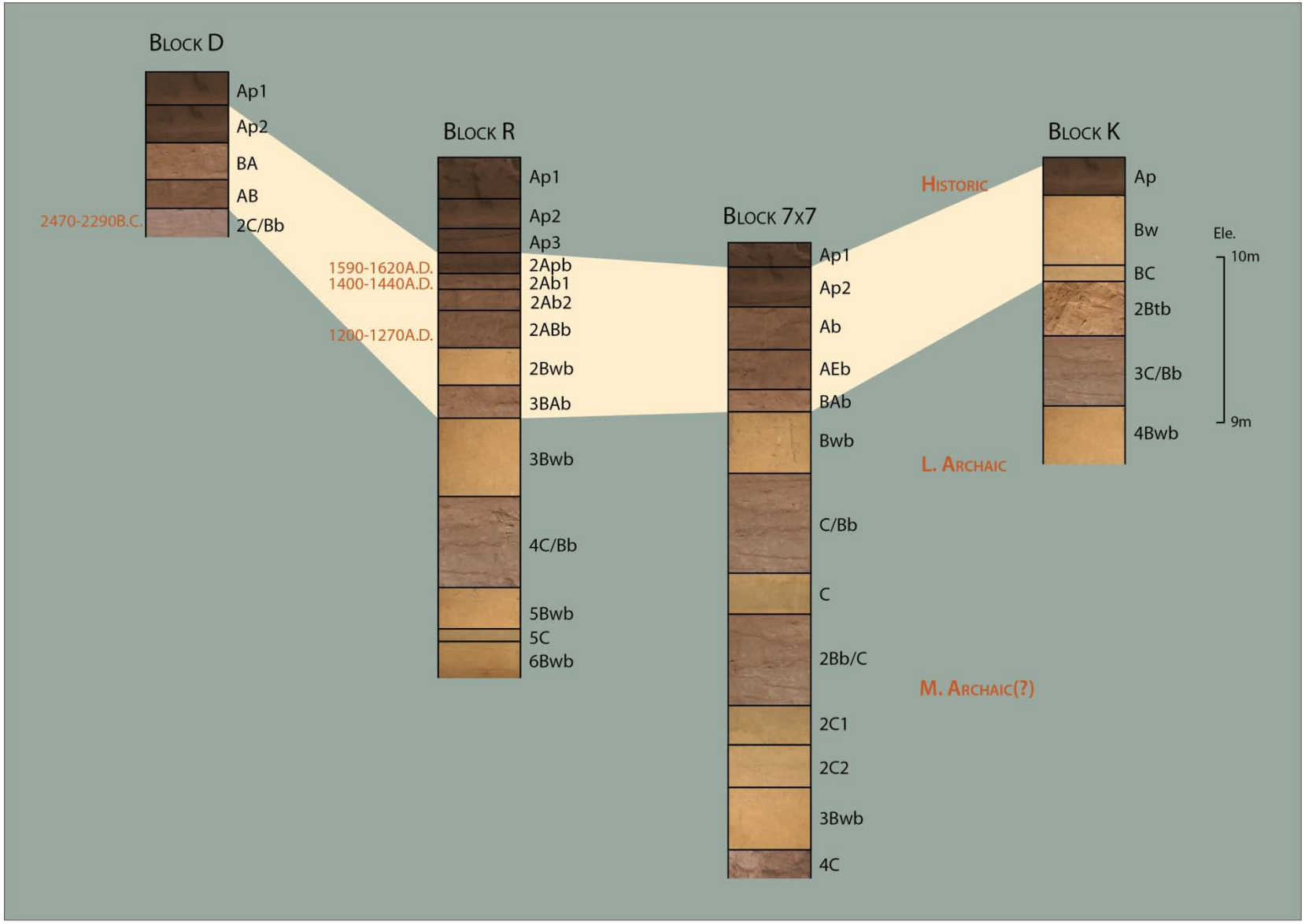


Figure 6 The central portion of the site represented by Blocks R and 7x7 has served as a sink for both modern and Late Holocene

Relative to the higher site margins, the central low has undergone much more rapid sedimentation both in historic as well as late prehistoric time. As a result thicker historic deposits in the low position have tended to smooth modern surface contours to a more level grade. Even prior to the modern era, however, the low position was much more dynamic, and over about the preceding 1,100 years had accrued as much 1 m of sediments. In contrast, the eastern and western margins received 60 cm or less over the last 4,500 years, so that along these higher positions Late Archaic levels are no more than a half meter or so below the pre-Contact surface. Any strata of comparable antiquity in the central low position are at least 1 m deeper, and it is quite possible that strata below this depth could be considerably older. If flood scouring did indeed have some role in carving out the lower area, some deposits predating the Woodland period may well have been removed during the terrace dissection. Along with this speculation is the possibility that sediments rapidly amassed very late in the Holocene could be resting unconformably atop terrace deposits thousands of years older.

Soil Chemistry

In an effort to discern or more sharply define loci of potentially more focused human activity, chemical analyses were determined for soil samples collected from across the River Road Site. Most samples (14) were from original surfaces typically identified as 2ABb, 2Ab or Ab horizons. Additionally, samples were also collected from a subsurface feature (Feature 11) as well as material at the same level but outside of the feature to serve as a control against which the feature chemistry could be compared. Results of all chemical analyses are given in Appendix C, and the principle conclusions to be drawn from the data are discussed in this section.

Variations in soil chemistry across a landscape can be related to both natural and man-influenced factors. Natural variations arise from such factors as shifts in parent material composition, varying pedogenic histories for different portions of a site, and depth-function trends normal within all soil profiles. Cultural influences normally stand out as enhancements of chemical constituents above what would be expected as normal for a given soil. Among the most obvious and important examples of this are historic fertilizer or other amendment types, which even in settings no longer cultivated or occupied can still greatly skew the chemical signatures not only of surface horizons but even some subsoil layers. Such historic overprints may mask the often more subtle contributions of prehistoric people, particularly on a landscape-wide basis; and while this concern must be weighed for all but the most deeply buried prehistoric sites, it is possible that River Road has been only minimally affected. Most of the historically altered chemistry is likely contained within the nearly ubiquitous mantle of modern alluvium, which in providing a degree of separation to underlying original surfaces should allow for more favorable prospects of isolating prehistoric inputs.

Analyses of soil chemical properties have long been used both as broad markers of human presence as well as more specific indicators of concentrated activity areas and possible functional aspects of individual features. The utility of soil chemical analyses arises from the general rule that a significant human presence on a landscape normally results in elevated concentrations of one or more major elements associated with living organisms. Originating from such sources as human waste, residues from the decomposition of refuse, or the ash

remains of burned materials, the major elements most commonly derived from anthropogenic sources and retained in soil include carbon (C), phosphorus (P), calcium (Ca), potassium (K), and magnesium (Mg). Trace elements such as barium (Ba) and strontium (Sr) or heavy metals such as zinc (Zn) have also been recognized as indicators of human influence (Lewis, et al., 1992; Lutz, 1951). Additionally, with sufficient increases in the principal base elements such as Ca, pH also tends to rise.

Of all the major elements P has received the greatest attention in soil chemical examinations of archaeological sites. The reasons for this are twofold. Not only does P often occur in elevated concentrations that can be clearly associated with human occupation, but its tendency to remain largely stationary in most soils also equips P as a better stratigraphic marker than other more mobile elements such as Ca and K. Scrutinized as early as the mid 1900's (Hrdlicka, 1937), soil P has been the focus of numerous studies dealing both with amounts as well as chemical forms present. Even in disciplines not directly concerned with archaeology the association of high P levels with human activity is recognized. In the field of pedology, surface horizons with P concentrations in excess of 1500 mg/kg are considered to have been strongly influenced by human occupation, and are uniquely identified as anthropic epipedons (Soil Survey Staff, 1999). The relationship between extractable and total-P is also worth noting. Unlike many other common elements, phosphorus does not as readily move in the soil due to adsorption with insoluble iron oxides or organic compounds. Adsorbed phosphorus is, however, not recovered by standard weak-acid extraction, and is best detected by means of strong acid digestion for total elemental analysis.

As an overall summary of major soil chemical properties, the original surfaces of the site can be characterized as having low to moderate concentrations of most elements. Such relatively low fertility supports the likelihood of only minimal modern contamination, and the measured chemistries are probably well representative of the pre-Contact condition. However, the data also indicate relatively low intensities of site usage, probably entailing intermittent, short-term visits by only a few individuals at a time. For instance, compared to extractable-P concentrations of 30 to 40 mg/kg and total-P of 200 to 300 mg/kg in the River Road surfaces, respective concentrations determined by this investigator for the buried surfaces at a Saladoid village site (200 B.C to 1200 A.D.) on the north coast of Puerto Rico were on the order of 100 to 400 mg/kg and 1000 to 2000 mg/kg. Marked differences in soil parent material types undoubtedly account for some of the disparity, but since the vast majority of soil phosphorus is derived as additions from outside sources, the meager amounts present at River Road likely demonstrate mostly transient activity at the site.

Table 1 provides a comparative summary of the principal chemical parameters for each of the collected samples. While absolute data are given in Appendix C, this table shows how each sample compares against the mean value for all samples. Values are ranked as degrees of enhancement. Levels of less than 25% above the mean are considered to be within a normal range of variation that would occur across any area of soil even without human inputs. Above this and with increasing amounts of enhancement there is a greater likelihood of human influences on soil chemistry. Samples RR1 and RR2 representing Feature 11 fill and a nearby control can be compared directly against each other. Elsewhere where appreciable enhancements above the mean are present, the values can be interpreted to mark potential locations of more concentrated activity.

The chemistries of Feature 11 and the nearby control do not exhibit any appreciable differences either in the summarized comparative data of Table 1 or in the full suite of measurements given in Appendix C. Indeed, the control is actually slightly higher in extractable-P than the feature. Similarities between the feature fill and control could to some extent be reflective of the feature's age and a tendency for some elements to diffuse over time. However, if it is a former refuse pit, hearth, or even long degraded burial, then elevated concentrations in most if not all of the Table 1 elements should exist. One possible interpretation to be drawn from the chemical data is that the feature represents an abandoned storage pit in which nothing was left and that eventually was naturally refilled by the wash in of adjacent soil materials to thus produce similar chemical signatures.

With respect to areal patterning of soil chemistry, a few observations can be made from the data of Table 1. As previously noted in the discussion of overall site chemistry, none of the sampled areas exhibits strikingly pronounced concentrations of any elements. Modest enhancements at best can be identified in the buried pre-Contact surface over an area encompassing the 7x7, S and R Blocks. Test Units AO31 and AS29 of the 7x7 Block as well as AO20 of the R Block are particular standouts, and some data not shown in Table 1 should also be noted. Specifically, concentrations of Zn in the test units of the 7x7 Block are well above the norm for the site. Even with these observations it should again be stressed that the relatively modest elemental increases at the three test unit locations are not consistent with intensive utilization. They probably do, however, indicate a higher level than elsewhere within the site area.

Table 1. Chemistries of River Road soil strata.

Sample	pH	OM	K	Ca	Mg	P	P	Ba	Sr	Provenience and Soil Horizon
			-- Extractable --				-- Total --			
RR1	0	0	0	0	0	+	0	0	0	Block A, Feature 11
RR2	0	0	0	0	0	++	0	0	0	Block A, Control
RR3	0	0	0	0	0	0	0	0	0	Block M, 2Apb
RR4	0	0	++	0	0	0	0	0	0	Block P, 2Apb
RR5	0	0	0	0	0	0	0	0	0	Block R, TU AK20, 2AB1
RR6	0	0	0	0	0	+	+	0	0	Block R, TU AM20, 2AB1
RR7	0	++	0	+	0	++	++	+	0	Block R, TU AO20, 2AB1
RR8	0	0	0	0	0	0	0	0	0	Block S, TU AM24, 2Ab1
RR9	0	0	0	0	0	+	0	+	0	Block S, TU AK24, 2Ab1
RR10	0	+	0	0	0	+	0	+	0	Block S, TU AO24, 2Ab1
RR16	0	+	0	0	0	0	0	0	0	Block U, 2Apb
RR11	0	0	0	0	0	0	+	+	0	Block V, Ap2
RR12	0	+++	0	+	0	0	0	0	0	Block 7x7, TU AO29, Ab
RR13	0	++	++	+	0	0	+	+	++	Block 7x7, TU AO31, Ab
RR14	0	+	++	0	0	+	+	+	+	Block 7x7, TU AS29, Ab
RR15	0	0	++	0	0	0	0	0	+	Block 7x7, TU AU29, Ab

Enhancement above mean:
- 0 none (<25%)
- + slight (25-50%)
- ++ moderate (50-75%)
- +++ high (>75%)

Site Comparisons

The two site landscapes share some similarities but also differ in such significant respects that even though they lie directly across from each other on opposing sides of the Delaware River they can not be considered a paired set. As with essentially all river terraces, both site landforms consist principally of vertically amassed, fine-sandy to loamy overbank deposits in which soil development is multisequal. The multiple buried soils are expressed mainly as cambic horizons or zones of pedogenic lamellae typically separated by intervening strata of more sandy deposits, a pattern testifying to intervals of relative landscape stability that allowed for soil formation interspersed with less stable periods of increased sedimentation. As many as five separate soil sequa comprise the 6-m Reeder's Creek terrace, whereas only three occur in the 4-m River Road terrace. This difference is principally a function of the greater thickness and age of the Reeder's Creek terrace.

Important information offered by both terraces is evidence for a comparatively stable period in the Delaware Valley that spanned about the last 4,500 years or so. This is demonstrated both by dated cultural material as well as the degree of subsoil development exhibited by the uppermost sola across nearly the entirety of the Reeder's Creek Site and also along the higher margins of the River Road Site. Atop these positions only minor sedimentation has occurred during this period with sediments accumulating at about the rate of 2 cm/100 years at Reeder's Creek and at only a slightly faster rate of 2.7 cm/100 years on the lower lying River Road. The similar sedimentation indicates that not only were major flood events fairly rare during the Late Holocene, but that when they did occur they generally achieved levels sufficiently high to inundate both terraces. In contrast, modern flood events have disproportionately affected River Road. Whereas historic alluvium forms a nearly ubiquitous mantle on the order of 20 to over 50 cm thickness at River Road, modern alluvium has a scant presence if any at Reeder's Creek.

Unlike the evidence for Late Holocene stability discussed above, a significant portion of the River Road Site documents more dynamic conditions for about the latter third of the same period. The increased activity is, however, attributable to local topography rather than valley wide influences. During this time sediments accumulated at rates of as much as 14.5 cm/100 years within what was a central low area. The much more rapid sedimentation here compared to that on the higher margin positions can possibly be credited to greater susceptibility to flooding, but perhaps more significantly to a favorable configuration for sediment retention. How the low position developed is a matter of speculation, but a scouring episode may have preceded the period of rapid sedimentation.

The Reeder's Creek landform has its own local peculiarities. It is both higher and older than is the norm for other terraces along this stretch of the Delaware Valley. Essentially cradled by another higher terrace of probable glacial outwash construction, the terrace is likely the product of a unique flow pattern that provided for enhanced preservation of alluvial deposits possibly beginning as early as the Late Pleistocene. Indeed, whereas even the deepest overbank alluvium at the River Road Site is likely to postdate the Early Holocene, the possibility that deep deposits at the Reeder's Creek Site were available to Paleoindians can not be ruled out.

References Cited

Foss, J. E. 1977. The pedological record at several Paleoindian sites in the Northeast. Annals of the New York Academy of Sciences. 288: 234-244.

Gee, G.W., and J.W. Bauder. 1986. Particle-size analysis. *In* Klute, A. (ed.) Methods of Soil Analysis Part 1 – Physical and Mineralogical Methods Second Edition. SSSA Book Series 5, No. 9: 383-411.

Gingerich, A.M. 2007. Shawnee Minisink revisited: Re-evaluating the Paleoindian occupation. Masters Thesis. University of Wyoming. Laramie, Wyoming

Hrdlicka, A. 1937. Man and plants in Alaska. Science 86: 559-560.

Jablonski, C.F. 1972. Soil Survey of Mercer County, New Jersey, USDA, Soil Conservation Service.

Lewis, R.J., J.E. Foss, W.M. Morris, M.E. Timpson, and C.A. Stiles. 1993. Trace element analysis in pedo-archaeology studies. *In* J.E. Foss, M.E. Timpson, and W.M. Morris (eds.) Proceedings of the First International Conference on Pedo-Archaeology Spec. Pub. 93-03: 81-88.

Lutz, H.J. 1951. The concentration of certain chemical elements in the soils of Alaskan archaeological sites. Am. J. Sci. 249: 925-928

Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and W.D. Broderson. 1998. Field book for describing and sampling soils. NRCS, USDA, National Soil Survey Center, Lincoln, NE.

Schuldenrein, J. 1994. Alluvial site geoarcheology of the middle Delaware Valley: A fluvial systems paradigm. Journal of Middle Atlantic Archaeology 10: 1-21.

Stewart, R.M. 1990. Archaeology, sedimentary sequences, and environmental change in the Delaware River basin. In F. Vento and H. Rollins (eds.) Genetic stratigraphy, climate change, and the burial of archaeological sites within the Susquehanna, Delaware, and Ohio River drainage basins. Report prepared for the Pennsylvania Historical and Museum Commission, Harrisburg, PA.

Thieme, D.M. 2003. A stratigraphic and chronometric investigation of the alluvial deposits of the North Branch of the Susquehanna River, Ph.D. Dissertation, University of Georgia.

Vento, F. J. and H. B. Rollins. 1989. Development of a late Pleistocene-Holocene genetic stratigraphic framework as it relates to atmospheric circulation and climate change in the upper and central Susquehanna River Drainage basin. Ms., Bureau for Historic Preservation, Pennsylvania Historical and Museum Commission, Harrisburg, PA.

Wagner, D.P. and T.L. Benedict. 1994. A Geomorphological/pedological survey and archeological monitoring of the Depew Recreation Area, Delaware Water Gap National Recreation area, New Jersey Section. In P. Inashima (ed.) Geomorphology, remote sensing, and

archeological monitoring at Depew Recreation Area. National Park Service, Denver Service Center, Eastern Applied Archeology, Silver Spring, MD. pp. 1-35.

Wagner, D.P. 2009. Pedology and geomorphology in the area of the Delaware Canal Aqueduct over Brock Creek in Yardley, Pennsylvania. Report submitted to A.D. Marble & Company, Inc.

APPENDIX A

Soil Profile Descriptions

Reeder's Creek Site
Soil Profile Descriptions

Test Unit L18, Block B

Horizon	Depth (cm)	Properties
Ap1	0-17	Very dark gray (7.5YR 3/1) to dark brown (7.5YR 3/2) very fine sandy loam; weak, medium granular structure; very friable consistence; horizon attributable to late historic grading rather than plowing; clear, smooth boundary
Ap2	17-30	Dark brown (7.5YR 3/2) very fine sandy loam; structureless, massive; very friable consistence; weakly expressed plow zone; clear, smooth boundary
AE	30-44	Dark brown (7.5YR 3/2-3/3) and brown (10YR 4/3) very fine sandy loam; structureless, massive; very friable consistence; clear, wavy boundary
Bw1	44-65	Dark brown (7.5YR 3/4) very fine sandy loam; weak, very coarse subangular blocky structure; very friable consistence; clear, smooth boundary
Bw2	65-85	Brown (7.5YR 4/4) loam; weak, coarse subangular blocky structure; friable consistence; clear, smooth boundary
Bw3	85-104	Brown (7.5YR 4/4-4/3) very fine sandy loam; weak, coarse subangular blocky structure; friable consistence; clear, wavy boundary
C/Bb	104-122	Dark yellowish brown (10YR 3/4) loamy very fine sand to fine sand; structureless, single grain; loose consistence; three wavy lamellae, dark brown (7.5YR 3/4) to dark reddish brown (5YR 3/4) very fine sandy loam, 5-12 cm thick; structureless, massive; friable consistence; clear, wavy boundary
C	122-132	Dark yellowish brown (10YR 3/4) loamy fine sand to fine sand; structureless, single grain; loose consistence; clear, smooth boundary
2Bwb1	132-146	Dark brown (7.5YR 4/4-3/4) loamy fine sand; weak, very coarse subangular blocky structure; friable consistence; clear, smooth boundary

2Bwb2	146-180	Dark brown (7.5YR 3/4) very fine sandy loam; weak, coarse subangular blocky structure; friable consistence
2C1	180-193	Dark yellowish brown (10YR 3/4) fine sand; loose consistence
2C2	193-206	Dark brown (7.5YR 3/4) fine sand; loose consistence
3Bwb	206-241	Dark yellowish brown (10YR 3/4) very fine sandy loam; very friable consistence
3C/Bb	241-284	Dark yellowish brown (10YR 3/4) fine sand; loose consistence; two thin lamellae, dark brown (7.5YR 3/4) very fine sandy loam; very friable consistence; few pebbles at ~265 cm
3C	284-298	Dark yellowish brown (10YR 3/4) fine sand; loose consistence
4Ab	298-316	Dark brown (7.5YR 3/4) to dark reddish brown (5YR 3/4) fine sandy loam; abrupt upper contact; friable consistence
4Bwb1	316-333	Brown (7.5YR 4/3) loam; common, medium distinct mottles of brown (7.5YR 5/3); friable consistence
4Bwb2	333-365	Brown (7.5YR 4/3) and dark brown (7.5YR 3/4) loam; many, medium distinct mottles of brown (7.5YR 5/3 and 5/2); friable consistence
4Bwb3	365-394	Brown (7.5YR 4/4-4/3) loam to very fine sandy loam; common, coarse distinct mottles of brown (7.5YR 5/3); friable consistence
5BAb	394-414	Reddish brown (5YR 4/3) to dark reddish brown (5YR 3/3) silt loam; common, medium distinct mottles of brown (7.5YR 5/2); friable consistence
5Bwb	414-440	Dark yellowish brown (105YR 4/4 and 4/6) loam to silt loam; common, coarse distinct mottles of brown (7.5YR 5/2); friable consistence
6BCb	440-456	Dark yellowish brown (105YR 3/6) fine sandy loam; common, medium distinct mottles of gray (2.5Y 5/1) and dark yellowish brown (10YR 4/6); friable consistence

Other comments: River terrace, 6 m above river; Ap2 horizon is original surface; particle size data indicate Bw2 horizon is actually weakly argillic (Bt); examination by hand auger below 170 cm; auger refusal at 456 cm, probably on basal Pleistocene gravel; description D.P. Wagner, 10/25-26/10

Test Unit 1 (Revised to Test Unit J16)

Horizon	Depth (cm)	Properties
Ap1	0-6	Very dark gray (7.5YR 3/1) very fine sandy loam; weak, medium granular structure; graded horizon; very friable consistence; abrupt, smooth boundary
Ap2	6-16	Dark brown (7.5YR 3/2) very fine sandy loam; structureless, massive; very friable consistence; abrupt, smooth boundary
AE	16-49	Dark brown (7.5YR 3/4) loamy very fine sand; structureless, massive; very friable consistence; clear, wavy boundary
Bw1	49-72	Brown (7.5YR 4/3) very fine sandy loam; weak, very coarse subangular blocky structure; very friable to friable consistence; clear, smooth boundary
Bw2	72-128	Brown (7.5YR 4/3-4/4) very fine sandy loam to loam; weak, coarse subangular blocky structure; friable to very friable consistence
BC	128-142	Brown (7.5YR 4/3) loamy fine sand; very friable consistence
C	142-154	Dark yellowish brown (10YR 3/4) fine sand to loamy fine sand; loose consistence
2Bwb1	154-174	Dark brown (7.5YR 3/4-4/4) very fine sandy loam; very friable consistence
2Bwb2	174-190	Brown (7.5YR 4/3) very fine sandy loam; common, medium faint mottles of brown (7.5YR 5/3); very friable consistence
2C/Bb	190-220	Brown (7.5YR 4/3) fine sand with thin, loamy very fine sand lamellae of dark brown (7.5YR 3/4); loose consistence
3Bwb1	220-266	Dark reddish brown (5YR 3/4) fine sandy loam; common medium distinct mottles of brown (7.5YR 5/3); friable to very friable consistence
3Bwb2	266-305	Dark reddish brown (5YR 3/4) and brown (7.5YR 5/3) sandy loam; friable to very friable consistence

3Bwb3	305-324	Dark reddish brown (5YR 3/4) sandy loam; friable to very friable consistence
4Bwb	324-340+	Brown (7.5YR 4/3) loam to silt loam; common, medium distinct mottles of brown (7.5YR 5/2); friable consistence

Other comments: Ap2 horizon is original surface; examination by hand auger below 90 cm; mottling below 174 cm is not interpreted to be due to drainage except for that in the 4Bwb horizon; stone line at 283 cm; description D.P. Wagner, 12/1/09

Test Unit E 10

Horizon	Depth (cm)	Properties
Ap	0-16	Very dark gray (7.5YR 3/1) very fine sandy loam; weak, medium granular structure; very friable consistence; clear wavy, boundary
AE	16-26	Dark brown (7.5YR 3/3) and dark yellowish brown (10YR 4/4) very fine sandy loam; structureless, massive; very friable consistence; clear, wavy boundary
E	26-42	Dark yellowish brown (10YR 4/4) very fine sandy loam; weak, coarse platy structure; very friable consistence; clear, smooth boundary
Bw1	42-57	Brown (7.5YR 4/4) very fine sandy loam; weak, coarse subangular blocky structure; friable consistence; clear, smooth boundary
Bw2	57-72	Brown (7.5YR 4/4) loam; weak, medium subangular blocky structure; friable consistence; clear, wavy boundary
2C/Bb	72-130+	Brown (10YR 4/3) fine sand; structureless, single grain, and lamellae of reddish brown (5YR 4/4) to dark reddish brown (5YR 3/4) very fine sandy loam; structureless, massive; very friable and loose consistence

Other comments: Ap horizon is disturbed; 2C/Bb horizon correlates with 2Bb/C and 2C/Bb horizons of Test Unit M-N 47; description D.P. Wagner, 12/14/10

Test Unit M 29

Horizon	Depth (cm)	Properties
Ap1	0-15	Very dark gray (7.5YR 3/1) very fine sandy loam; weak, medium granular structure; very friable consistence; graded horizon; clear wavy, boundary
Ap2	15-32	Dark brown (7.5YR 3/2) very fine sandy loam; structureless, massive; very friable consistence; clear, smooth boundary
AE	32-41	Dark brown (7.5YR 3/3) and dark yellowish brown (10YR 4/4) very fine sandy loam; structureless, massive; very friable consistence; clear, wavy boundary
E	41-51	Dark yellowish brown (10YR 4/4) very fine sandy loam; weak, coarse platy structure; very friable consistence; clear, smooth boundary
Bw1	51-64	Brown (7.5YR 4/4) very fine sandy loam; weak, coarse subangular blocky structure; friable consistence; clear, smooth boundary
Bw2	64-84	Brown (7.5YR 4/4) loam; weak, medium subangular blocky structure; friable consistence; clear, wavy boundary
2C/Bb	84-168+	Brown (10YR 4/3) fine sand; structureless, single grain, and lamellae of reddish brown (5YR 4/4) to dark reddish brown (5YR 3/4) very fine sandy loam; structureless, massive; very friable and loose consistence

Other comments: 2C/Bb horizon correlates with similar lamellae zones in other test units; lamellae up to 2 cm thickness; description D.P. Wagner, 12/14/10

Test Unit U 34

Horizon	Depth (cm)	Properties
Ap1	0-19	Very dark gray (7.5YR 3/1) very fine sandy loam; weak, medium granular structure; very friable consistence; graded horizon; clear wavy, boundary
Ap2	19-39	Dark brown (7.5YR 3/2) very fine sandy loam; structureless, massive; very friable consistence; clear, smooth boundary
AE	39-49	Dark brown (7.5YR 3/3) and dark yellowish brown (10YR 4/4) very fine sandy loam; structureless, massive; very friable consistence; clear, wavy boundary
BE	49-65	Dark yellowish brown (10YR 4/4) to brown (7.5YR 4/4) very fine sandy loam; weak, coarse subangular blocky structure; very friable consistence; clear, smooth boundary
Bw1	65-83	Brown (7.5YR 4/4) very fine sandy loam; weak, coarse subangular blocky structure; friable consistence; clear, smooth boundary
Bw2	83-105	Brown (7.5YR 4/4) loam; weak, medium subangular blocky structure; friable consistence; gradual, wavy boundary
2C/Bb	105-180+	Brown (10YR 4/3) fine sand; structureless, single grain, and lamellae of reddish brown (5YR 4/4) to dark reddish brown (5YR 3/4) very fine sandy loam; structureless, massive; very friable and loose consistence

Other comments: 2C/Bb horizon correlates with similar lamellae zones in other test units; description D.P. Wagner, 12/14/10

Test Unit M-N 47

Horizon	Depth (cm)	Properties
Ap1	0-16	Very dark gray (7.5YR 3/1) very fine sandy loam; weak, medium granular structure; very friable consistence; graded horizon; abrupt wavy, boundary
Ap2	16-30	Dark brown (7.5YR 3/2) very fine sandy loam; structureless, massive; very friable consistence; abrupt, smooth boundary
Ap3	30-40	Dark brown (7.5YR 3/2-3/3) very fine sandy loam; structureless, massive; very friable consistence; clear, wavy boundary
AE	40-51	Dark brown (7.5YR 3/3) and dark yellowish brown (10YR 4/4) very fine sandy loam; structureless, massive; very friable consistence; clear, wavy boundary
E	51-67	Dark yellowish brown (10YR 4/4) very fine sandy loam; weak, coarse platy structure; very friable consistence; clear, smooth boundary
Bw1	67-81	Brown (7.5YR 4/4) very fine sandy loam; weak, coarse subangular blocky structure; friable consistence; clear, smooth boundary
Bw2	81-95	Brown (7.5YR 4/4) loam; weak, medium subangular blocky structure; friable consistence; clear, smooth boundary
2Bb/C	95-139	Braided lamellae of reddish brown (5YR 4/4) to dark reddish brown (5YR 3/4) very fine sandy loam, and interlamellae of brown (7.5YR 4/4) to dark yellowish brown (10YR 4/4) loamy very fine sand; structureless, massive; very friable consistence; gradual, wavy boundary
2C/Bb	139-168+	Brown (10YR 4/3) fine sand; structureless, single grain, and lamellae of reddish brown (5YR 4/4) to dark reddish brown (5YR 3/4) very fine sandy loam; structureless, massive; very friable and loose consistence

Other comments: Description D.P. Wagner, 12/14/10

Test Unit 7 (Soil Boring Examination)

Horizon	Depth (cm)	Properties
Ap	0-29	Very dark grayish brown (10YR 3/2) silt loam; friable consistence
AC	29-52	Dark yellowish brown (10YR 3/4) silt loam; friable consistence
2Apb	52-67	Dark brown (7.5YR 3/3) silt loam; friable consistence
2Bwb1	67-98	Brown (7.5YR 4/3) very fine sandy loam to loam; friable consistence
2Bwb2	98-125	Brown (7.5YR 4/4) fine sandy loam to loam; friable consistence
3Ab	125-142	Brown (7.5YR 4/3) to dark brown (7.5YR 3/3) sandy loam; friable consistence
3BAb	142-157	Dark brown (7.5YR 3/4) fine sandy loam; friable consistence
2Btb	157-185+	Brown (7.5YR 4/4) heavy fine sandy loam to loam; common, medium faint mottles of brown (7.5YR 5/); friable consistence

Other comments: River terrace; examination by hand auger; 2Apb horizon is original surface; overlying material is a mix of fill and slope wash; description D.P. Wagner, 12/1/09

River Road Site
Soil Profile Descriptions

Block K (west wall)

Horizon	Depth (cm)	Properties
Ap	0-22	Dark brown (7.5YR 3/3) fine sandy loam; structureless, massive; friable to very friable consistence; abrupt, smooth boundary
Bw1	22-56	Brown (7.5YR 4/3) loam; weak, medium subangular blocky structure; friable consistence; clear, smooth boundary
Bw2	56-69	Brown (7.5YR 4/3) loam to fine sandy loam; weak, medium subangular blocky structure; few very patchy clay films; friable consistence; clear, smooth boundary
BC	69-75	Brown (10YR 4/3) fine sandy loam; weak, medium platy structure; friable consistence; clear, smooth boundary
2Btb	75-107	Dark reddish brown (5YR 3/4) to dark brown (7.5YR 3/4) fine sandy loam to loam; weak, coarse prismatic breaking to moderate, medium subangular blocky structure; patchy clay films; friable consistence; abrupt, smooth boundary
3C/Bb	107-150	Brown (10YR 4/3) loamy fine sand, and lamellae of dark reddish brown (5YR 3/4) fine sandy loam; structureless, massive; very friable consistence; abrupt, smooth boundary
4Bwb	150-179	Dark reddish brown (5YR 3/4) loam; weak medium platy breaking to weak, medium subangular blocky structure; friable consistence; clear, smooth boundary
4BCb	179-185+	Banded brown (10YR 4/3) and dark reddish brown (5YR 3/4) fine sandy loam; structureless, massive; friable consistence

Other comments: River terrace, levee; 4 m above Delaware River; minor historic component likely mixed with Ap horizon; 2Bt horizon is weakly argillic, at most; banding in 4BCb horizon is not pedogenetic; description D.P. Wagner, 5/11/11

Block 7X7 (north walls and center)

Horizon	Depth (cm)	Properties
Ap1	0-15	Dark brown (7.5YR 3/2) fine sandy loam; structureless, massive; friable to very friable consistence; abrupt, smooth boundary
Ap2	15-39	Very dark grayish brown (10YR 3/2) to dark brown (10YR 3/3) fine sandy loam to loamy fine sand; structureless, massive; very friable consistence; clear, smooth boundary
Ab	39-64	Dark brown (7.5YR 3/2) fine sandy loam; structureless, massive; very friable consistence; clear, wavy boundary
AEb	64-89	Dark brown (7.5YR 3/3) and dark yellowish brown (10YR 4/4) loam to fine sandy loam; structureless, massive; friable to very friable consistence; clear, smooth boundary
BAb	89-103	Dark brown (7.5YR 3/4 and 3/3) loam; weak, medium subangular blocky structure; friable consistence; clear, smooth boundary
Bwb	103-140	Dark brown (7.5YR 3/4) loam to fine sandy loam; weak, medium subangular blocky structure; very friable to friable consistence
C/Bb	140-200	Dark yellowish brown (10YR 3/4) to brown (10YR 4/3) loamy fine sand, and three lamellae 1 to 2 cm thick of f dark reddish brown (5YR 3/4) fine sandy loam; structureless, massive; very friable consistence
C	200-225	Brown (10YR 4/3) loamy fine sand to fine sand; structureless, massive; very friable consistence; abrupt, smooth boundary
2Bb/C	225-280	Dark reddish brown (5YR 3/4) loam banded with brown (10YR 4/3) fine sandy loam; weak, coarse subangular blocky structure; friable consistence; abrupt, smooth boundary
2C1	280-304	Brown (10YR 4/3) loamy fine sand to fine sand, structureless, massive; very friable consistence; clear, wavy boundary
2C2	304-331	Brown (7.5YR 4/3) fine sandy loam; structureless, massive; very friable consistence; abrupt, smooth boundary
3Bwb	331-367	Dark reddish brown (5YR 3/4) fine sandy loam to loamy; weak, coarse subangular blocky structure; friable consistence; clear, wavy boundary
4C	367-388+	Brown (7.5YR 4/3) very cobbly loamy fine sand; structureless, massive; very friable consistence

Other comments: River terrace, levee toeslope; Ab horizon is original surface and may have been plowed; 2C/Bb horizon rises toward river at ~6% slope; C horizon thickens southward to the depth of 232 cm; faint lamellae occur near the base of the 2C1 horizon; description D.P. Wagner, 7/6/11

Block R (southeast corner)

Horizon	Depth (cm)	Properties
Ap1	0-25	Dark brown (7.5YR 3/3) fine sandy loam; structureless, massive; very friable consistence; clear, smooth boundary
Ap2	25-46	Dark brown (7.5YR 3/2) fine sandy loam to loamy fine sand; structureless, massive; very friable consistence; clear, smooth boundary
Ap3	46-57	Dark brown (7.5YR 3/3) fine sandy loam to loamy fine sand; structureless, massive; very friable consistence; gradual, smooth boundary
2Apb	57-70	Very dark gray (7.5YR 3/1) fine sandy loam to loam; structureless, massive; very friable consistence; abrupt, smooth boundary
2Ab1	70-80	Dark reddish brown (5YR 3/2) loam to fine sandy loam; structureless, massive; very friable consistence; clear, smooth boundary
2Ab2	80-93	Dark reddish brown (5YR 3/2) loam; structureless, massive; very friable consistence; abrupt, smooth boundary
2ABb	93-115	Dark brown (7.5YR 3/4) loam; weak, medium subangular blocky structure; very friable to friable consistence; abrupt, smooth boundary
2Bwb	115-137	Dark brown (7.5YR 3/4) to brown (7.5YR 4/4) loam to fine sandy loam; weak, medium subangular blocky structure; very friable to friable consistence
3BAb	137-156	Dark brown (7.5YR 3/3-3/4) silt loam; friable consistence
3Bwb1	156-183	Dark brown (7.5YR 3/4) to brown (7.5YR 4/4) silt loam to loam; friable to very friable consistence
3Bwb2	183-203	Dark reddish brown (5YR 3/4) loam to silt loam; friable consistence
4C/Bb	203-260	Brown (10YR 4/3) loamy fine sand, and several thin lamellae of dark reddish brown (5YR 3/4) fine sandy loam; very friable consistence

5Bwb	260-284	Dark reddish brown (5YR 3/4) fine sandy loam; friable consistence
5C	284-293	Brown (7.5YR 4/3) fine sandy loam to loamy fine sand; very friable consistence
6Bwb	293-315+	Dark reddish brown (5YR 3/4) fine sandy loam to loam; friable consistence

Other comments: River terrace, levee toeslope; examination by hand auger below 122 cm; 2Apb horizon is original surface but is partially mixed with overlying deposits; description D.P. Wagner, 5/11/11

Block D (east wall)

Horizon	Depth (cm)	Properties
Ap1	0-20	Dark brown (7.5YR 3/2) fine sandy loam; structureless, massive; very friable consistence; clear, smooth boundary
Ap2	20-43	Dark brown (7.5YR 3/3) fine sandy loam; structureless, massive; very friable consistence; clear, smooth boundary
BA	43-66	Dark brown (7.5YR 3/4) loam to fine sandy loam; weak, medium subangular blocky structure; friable to very friable consistence; clear, smooth boundary
AB	66-82	Dark brown (7.5YR 3/4-3/3) fine sandy loam; weak, medium subangular blocky structure; very friable consistence; clear, smooth boundary
2C/Bb	82-148	Brown (10YR 4/3) fine sand, and nine lamellae of dark reddish brown (5YR 3/4) fine sandy loam; structureless, single grain, and structureless, massive; loose and very friable consistence

Other comments: River terrace, landward levee along tributary stream; Ap2 horizon is original surface; description D.P. Wagner, 5/11/11

APPENDIX B

Soil Particle Size Analyses

Soil Particle Size Analyses

Reeder's Creek (TU L18)

Horizon	Depth (cm)	Sand (2-0.05 mm) vcos	co	ms	fs	vfs	Total (<2 mm) sand	silt	Clay
		- - - - - - - - - - - - % - - - - - - - - - - - - - -							
Ap1	0-17	0.1	0.5	5.2	33.6	25.4	64.8	31.7	3.5
Ap2	17-30	0.1	0.4	5.7	43.4	25.0	74.6	20.9	4.5
AE	30-44	0	0.3	3.8	40.3	28.9	73.3	21.5	5.2
Bw1	44-65	0	0.2	2.0	35.4	33.0	70.6	22.9	6.5
Bw2	65-85	0	0.4	4.6	21.8	32.2	59.0	31.2	9.8
Bw3	85-104	0	0.9	12.7	25.1	24.3	63.0	30.2	6.8
C/Bb	104-122	0	1.6	26.7	35.0	14.0	77.3	16.9	5.8
C	122-132	0	1.4	23.0	42.0	15.6	82.0	14.6	3.4
2Bwb1,2	132-180	0	0.6	9.0	42.4	23.0	75.0	19.2	5.8
2C1	180-193	0	0.4	16.2	47.6	16.5	80.0	15.5	3.8
2C2	193-206	0	0.4	17.9	54.4	11.9	84.6	10.9	4.5
3Bwb2	206-241	0	2.0	13.2	32.7	20.2	68.1	24.7	7.2
3C/Bb	241-284	0.2	1.6	13.8	37.9	17.2	70.7	24.2	5.1
3C	284-298	0	1.6	45.7	30.7	9.0	87.0	9.2	3.8
4ABb	298-316	0	1.4	47.2	24.7	4.5	77.8	9.7	12.5
4Bwb1	316-333	0.1	0.4	4.4	20.5	26.7	52.1	38.5	9.4
4Bwb2	333-365	0.1	0.3	1.1	21.1	29.9	52.5	37.2	10.3
4Bwb3	365-394	0	0.2	0.6	26.7	30.9	58.4	33.6	8.0
5BAb	394-414	0.1	0.2	1.3	22.5	26.7	50.8	38.5	10.7
5Bwb	414-440	0.1	1.3	5.9	12.3	22.2	41.8	44.9	13.3
6BCb	440-456	0.2	4.8	19.2	23.0	17.1	64.3	27.2	8.5

vcos = 2-1 mm, cos = 1-0.5 mm, ms = 0.5-0.25 mm, fs = 0.25-0.1 mm, vfs = 0.1-0.05 mm, silt = 0.05-0.002 mm, clay = <0.002 mm

River Road (7X7 Block)

Horizon	Depth (cm)	Sand (2-0.05 mm) vcos	co	ms	fs	vfs	Total (<2 mm) sand	silt	Clay
		- - - - - - - - - - - - % - - - - - - - - - - - - - -							
Ap1	0-15	0.1	0.4	7.4	43.2	22.0	73.1	21.1	5.8
Ap2	15-39	0.1	0.4	5.9	44.0	22.1	72.5	19.7	7.8
Ab	36-64	0	0.2	8.8	50.9	16.7	76.6	16.9	6.5
AEb	64-89	0	0.1	2.3	26.1	26.1	54.6	36.1	9.0
BAb	89-103	0	0.2	1.0	17.3	29.6	48.1	40.2	11.7
Bwb	103-140	0	0.2	1.6	17.0	31.4	50.2	40.1	9.7
C/Bb	140-200	0	0.3	11.5	41.0	17.3	70.1	25.9	4.0
C	200-225	0	0.2	11.6	53.3	17.7	82.2	15.2	2.6
2Bb/C	225-280	0.1	1.0	7.6	29.3	27.2	65.2	26.5	8.3
2C1	280-304	0	0.5	19.2	43.5	16.0	79.0	17.6	3.4
2C2	304-331	0	0.4	7.4	40.8	23.1	71.7	23.5	4.8
3Bwb	331-367	0.1	0.9	7.3	35.9	23.9	68.1	24.8	7.1
4C	367-388	7.3	25.0	27.8	17.4	7.6	85.1	9.5	5.4

vcos = 2-1 mm, cos = 1-0.5 mm, ms = 0.5-0.25 mm, fs = 0.25-0.1 mm, vfs = 0.1-0.05 mm, silt = 0.05-0.002 mm, clay = <0.002 mm

APPENDIX C

Soil Chemical Data

University of Delaware Soil Testing Program
Analysis Report for Data Set: 12GEO001
11/11/2011
p1

Sample ID	pH	Buffer pH	OM (%) by LOI	M3-P (mg/kg)	M3-K (mg/kg)	M3-Ca (mg/kg)	M3-Mg (mg/kg)
RR1	5.5	7.75	0.4	37.99	28.57	490.35	72.49
RR2	5.5	7.73	0.3	42.04	24.05	493.47	84.25
RR3	5.5	7.74	0.5	20.66	14.94	456.99	75.88
RR4	5.2	7.67	0.4	15.74	46.39	380.44	67.76
RR5	4.7	7.60	0.5	36.83	19.58	263.82	64.06
RR6	4.9	7.59	0.6	37.46	23.61	426.60	57.99
RR7	5.3	7.59	1.0	44.31	25.80	630.57	80.25
RR8	5.1	7.68	0.5	14.95	37.85	330.37	60.71
RR9	5.1	7.58	0.8	35.54	26.96	468.35	68.62
RR10	5.2	7.58	0.9	34.00	27.43	545.78	76.81
RR11	5.2	7.60	0.4	15.48	24.83	398.79	71.99
RR12	5.1	7.51	1.2	31.59	32.72	653.77	82.36
RR13	5.5	7.57	1.0	31.57	45.80	596.10	78.22
RR14	5.3	7.67	0.8	32.65	45.46	505.25	73.74
RR15	5.4	7.71	0.6	28.17	51.26	541.28	78.98
RR16	5.3	7.65	0.9	12.54	23.22	527.20	82.82

University of Delaware Soil Testing Program
Analysis Report for Data Set: 12GEO001
11/11/2011
p2

Sample ID	M3-Mn (mg/kg)	M3-Zn (mg/kg)	M3-Cu (mg/kg)	M3-Fe (mg/kg)	M3-B (mg/kg)	M3-S (mg/kg)	M3-Al (mg/kg)
RR1	73.63	1.11	1.39	251.72	0.43	12.77	568.72
RR2	40.66	0.96	0.82	286.11	0.35	18.57	672.15
RR3	37.33	2.70	1.93	195.52	0.35	12.92	581.08
RR4	52.79	5.88	1.95	215.17	0.28	15.52	681.09
RR5	55.21	14.93	1.75	243.17	0.22	22.04	706.47
RR6	38.46	6.99	1.71	247.82	0.29	23.98	710.45
RR7	36.90	0.94	1.70	219.20	0.38	16.04	752.23
RR8	48.57	1.16	1.29	197.69	0.29	22.04	663.98
RR9	66.74	1.04	1.28	225.99	0.35	11.84	535.74
RR10	55.14	0.75	1.76	248.54	0.26	17.12	798.28
RR11	51.00	2.96	1.91	209.98	0.29	17.40	709.83
RR12	29.77	3.78	2.40	205.96	0.36	13.26	814.33
RR13	89.57	3.52	2.17	248.84	0.33	10.44	836.37
RR14	50.51	14.73	2.09	215.88	0.41	15.72	660.76
RR15	36.98	10.50	1.97	206.36	0.39	22.78	620.83
RR16	41.87	4.61	2.13	196.33	0.46	18.50	650.13

University of Delaware Soil Testing Program
Analysis Report for Data Set: 12GEO001
11/11/2011
p3

Sample ID	Est. CEC (meq/100g)	Base Sat. (%)	P Sat. Ratio	WB-OM (%)	Total P (ppm)	Total Ba (ppm)	Total Sr (ppm)
RR1	5.1	61.0	15.9	0.60	227.97	70.7	4.13
RR2	5.4	59.9	15.3	0.30	265.18	44.0	3.68
RR3	5.0	58.7	10.9	0.66	249.08	94.1	3.72
RR4	5.2	49.5	8.7	0.48	223.33	88.7	3.08
RR5	5.1	37.3	13.8	0.68	268.34	96.5	3.02
RR6	6.0	44.9	13.9	0.66	299.62	114.9	4.23
RR7	7.2	54.2	15.2	0.40	390.64	135.4	4.18
RR8	4.8	46.8	8.6	0.54	208.34	89.3	2.96
RR9	6.3	47.0	16.0	0.77	285.59	132.6	3.13
RR10	6.8	50.6	12.2	0.70	368.86	139.9	4.01
RR11	5.9	45.4	8.5	0.64	254.47	105.2	3.99
RR12	8.0	50.7	11.7	1.27	400.20	151.4	5.80
RR13	7.2	52.2	11.4	0.75	371.72	135.2	5.33
RR14	5.9	55.2	13.4	0.78	295.02	116.0	5.29
RR15	5.8	60.1	12.6	0.52	284.78	100.2	4.86
RR16	6.2	54.7	8.0	0.68	256.69	119.0	4.56

Appendix D: Phase III Excavation Log

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
A	G10	Ap1	1	9	18	10YR3/2	Silt Loam	Not Screened	***Datum 8 cmabgs**
		Ap2	2	18	28	10YR3/2	Silt Loam		
		AE	3	28	38	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	4	38	48	10YR4/3	Sandy Loam		
		E	5	48	58	10YR4/3	Sandy Loam		
		E	6	58	62	10YR4/3	Sandy Loam		
		Bw1	7	62	72	10YR4/4	Sandy Loam	Compact	
		Bw1	8	72	82	10YR4/4	Sandy Loam	Compact	
		Bw1	9	82	92	10YR4/4	Sandy Loam	Compact	
		Bw2	10	92	102	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	11	102	112	10YR4/6 mottled w/10YR6/3	Sandy Loam	Compact	
		C/B	12	112	122	10YR4/6	Sandy Loam	Lamellae	
		C/B	13	122	132	10YR4/6	Sandy Loam	Lamellae	
A	H10	Ap1	1	11	20	10YR3/2	Silt Loam	Not Screened	***Datum 8 cmabgs**
		Ap2	2	20	28	10YR3/2	Silt Loam		
		AE	3	28	38	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	4	38	54	10YR4/3	Sandy Loam		
		E	5	54	58	10YR4/3	Sandy Loam		
		E	6	58	62	10YR4/3	Sandy Loam		
		Bw1	7	62	72	10YR4/4	Sandy Loam	Compact	
		Bw1	8	72	82	10YR4/4	Sandy Loam	Compact	
		Bw1	9	82	92	10YR4/4	Sandy Loam	Compact	
		Bw2	10	92	102	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	11	102	112	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		C/B	12	112	122	10YR4/6	Sandy Loam		
		C/B	13	122	132	10YR4/6	Sandy Loam	Lamellae	
A	G11	Ap1	1	8	17	10YR3/2	Silt Loam	Not Screened	***Datum 8 cmabgs**
		Ap2	2	17	28	10YR3/2	Silt Loam		
		AE	3	28	38	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	4	38	48	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	5	48	58	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		Bw1	6	58	62	10YR4/3	Sandy Loam	Compact	
		Bw1	7	62	72	10YR4/4	Sandy Loam	Compact	
		Bw1	8	72	82	10YR4/4	Sandy Loam	Compact	
		Bw1	9	82	92	10YR4/4	Sandy Loam	Compact	
		Bw2	10	92	102	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	11	102	112	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		C/B	12	112	123	10YR4/6	Sandy Loam		
		C/B	13	123	132	10YR4/6	Sandy Loam	Lamellae	
A	H11	Ap1	1	9	18	10YR3/2	Silt Loam	Not Screened	***Datum 8 cmabgs**
		Ap2	2	18	28	10YR3/2	Silt Loam		
		AE	3	28	38	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	4	38	48	10YR4/3	Sandy Loam		
		E	5	48	58	10YR4/3	Sandy Loam		
		Bw1	6	58	62	10YR4/4	Sandy Loam		
		Bw1	7	62	72	10YR4/4	Sandy Loam	Compact	
		Bw1	8	72	82	10YR4/4	Sandy Loam	Compact	
		Bw1	9	82	92	10YR4/4	Sandy Loam	Compact	
		Bw2	10	92	102	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	11	102	112	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		C/B	12	112	122	10YR4/6	Sandy Loam		
		C/B	13	122	132	10YR4/6	Sandy Loam	Lamellae	
B	L18	Ap1/Fill	1	28.5	37	7.5YR3/1	Sandy Loam	Not Screened	***Datum 20 cmabgs**
		Ap2	2	37	45	7.5YR3/2	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		Ap2	3	45	55	7.5YR3/2	Sandy Loam		
B	L18 (con't)	AE	4	55	66	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	66	69	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		Bw1	6	69	83	7.5YR3/4	Sandy Loam		
		Bw1	7	83	86	7.5YR3/4	Sandy Loam		
		Bw2	8	86	97	7.5YR4/4	Loam	Compact	
		Bw2	9	97	107	7.5YR4/4	Loam	Compact	
		Bw3	10	107	117	7.5YR4/3	Sandy Loam	Compact	
		Bw3	11	117	127	7.5YR4/3	Sandy Loam	Compact	
		C/B	12	127	138.5	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C	13	138.5	147	10YR3/4	Sandy Loam		
		C	14	147	157	10YR3/4	Sandy Loam		
		2Bwb1	15	157	167	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb1	16	167	177	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb2	17	177	187	7.5YR3/4	Sandy Loam	Lamellae	
		2Bwb2	18	187	197	7.5YR3/4	Sandy Loam	Lamellae	
B	L19	Ap1/Fill	1	22	32.5	7.5YR3/1	Sandy Loam	Not Screened	***Datum 20 cmabgs**
		Ap2	2	32.5	44.5	7.5YR3/2	Sandy Loam		
		Ap2	3	44.5	55	7.5YR3/2	Sandy Loam		
		AE	4	55	65	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	65	68	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		Bw1	6	68	79	7.5YR3/4	Sandy Loam		
		Bw1	7	79	83	7.5YR3/4	Sandy Loam		
		Bw1	8	83	86	7.5YR3/4	Sandy Loam		
		Bw2	9	86	97	7.5YR4/4	Loam	Compact	
		Bw2	10	97	107	7.5YR4/4	Loam	Compact	
		Bw3	11	107	110	7.5YR4/3	Sandy Loam	Compact	
		Bw3	12	110	120	7.5YR4/3	Sandy Loam	Compact	
		Bw3	13	120	126	7.5YR4/3	Sandy Loam	Compact	
		C/B	14	126	137	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C	15	137	147	10YR3/4	Sandy Loam		
		C	16	147	157	10YR3/4	Sandy Loam		
		2Bwb1	17	157	167	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb1	18	167	177	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb2	19	177	187	7.5YR3/4	Sandy Loam	Lamellae	
		2Bwb2	20	187	197	7.5YR3/4	Sandy Loam	Lamellae	
B	M18	Ap1/Fill	1	31	39	7.5YR3/1	Sandy Loam	Not Screened	***Datum 20 cmabgs**
		Ap2	2	39	44	7.5YR3/2	Sandy Loam		
		Ap2	3	44	55	7.5YR3/2	Sandy Loam		
		AE	4	55	65	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		Bw1	5	65	71	7.5YR3/4	Sandy Loam		
		Bw1	6	71	83	7.5YR3/4	Sandy Loam		
		Bw2	7	83	86	7.5YR4/4	Loam	Compact	
		Bw2	8	86	97	7.5YR4/4	Loam	Compact	
		Bw2	9	97	107	7.5YR4/4	Loam	Compact	
		Bw3	10	107	117	7.5YR4/3	Sandy Loam	Compact	
		Bw3	11	117	127	7.5YR4/3	Sandy Loam	Compact	
		C/B	12	127	137	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C	13	137	147	10YR3/4	Sandy Loam		
		C	14	147	157	10YR3/4	Sandy Loam		
B	M19	Ap1/Fill	1	-	-	7.5YR3/1	Sandy Loam	Not Screened	***Datum 20 cmabgs**
		Ap2	2	38	44	7.5YR3/2	Sandy Loam		
		Ap2	3	44	54	7.5YR3/2	Sandy Loam		
		AE	4	54	65	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		Bw1	5	65	73	7.5YR3/4	Sandy Loam		
		Bw1	6	73	83	7.5YR3/4	Sandy Loam		
		Bw2	7	83	87	7.5YR4/4	Loam	Compact	
		Bw2	8	87	97	7.5YR4/4	Loam	Compact	
		Bw2	9	97	107	7.5YR4/4	Loam	Compact	
		Bw3	10	107	117	7.5YR4/3	Sandy Loam	Compact	
		Bw3	11	117	127	7.5YR4/3	Sandy Loam	Compact	
		C/B	12	127	137	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C	13	137	147	10YR3/4	Sandy Loam		
		C	14	147	157	10YR3/4	Sandy Loam		
C	L14	Ap1	1	6	16	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	16	24	7.5YR3/1	Sandy Loam	Not Screened	
		Ap2	3	24	40	7.5YR3/2	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
C	L14 (con't)	AE	5	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	60	70	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		Bw1	7	70	80	7.5YR3/4	Sandy Loam		
		Bw1	8	80	90	7.5YR3/4	Sandy Loam		
		Bw2	9	90	100	7.5YR4/4	Loam	Compact	
		Bw2	10	100	114	7.5YR4/4	Loam	Compact	
		Bw3	11	114	124	7.5YR4/3	Sandy Loam	Compact	
		Bw3	12	124	130	7.5YR4/3	Sandy Loam	Compact	
		C/B	13	130	140	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
C	L15	Ap1	1	6	15	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	15	25	7.5YR3/1	Sandy Loam	Not Screened	
		Ap2	3	25	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
		AE	5	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	60	70	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		Bw1	7	70	80	7.5YR3/4	Sandy Loam		
		Bw1	8	80	90	7.5YR3/4	Sandy Loam		
		Bw2	9	90	100	7.5YR4/4	Loam	Compact	
		Bw2	10	100	112	7.5YR4/4	Loam	Compact	
		Bw3	11	112	126	7.5YR4/3	Sandy Loam	Compact	
		Bw3	12	126	130	7.5YR4/3	Sandy Loam	Compact	
		C/B	13	130	140	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
C	M14	Ap1	1	9	19	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	19	29	7.5YR3/1	Sandy Loam	Not Screened	
		Ap2	3	29	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
		AE	5	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	60	70	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		Bw1	7	70	80	7.5YR3/4	Sandy Loam		
		Bw1	8	80	90	7.5YR3/4	Sandy Loam		
		Bw2	9	90	100	7.5YR4/4	Loam	Compact	
		Bw2	10	100	110	7.5YR4/4	Loam	Compact	
		Bw3	11	110	120	7.5YR4/3	Sandy Loam	Compact	
		Bw3	12	120	130	7.5YR4/3	Sandy Loam	Compact	
		C/B	13	130	140	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	14	140	148.5	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	148.5	158.5	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C	16	158.5	168.5	10YR3/4	Sandy Loam		
		C	17	168.5	178.5	10YR3/4	Sandy Loam		
C	M15	Ap1	1	6	17	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	17	25	7.5YR3/1	Sandy Loam	Not Screened	
		Ap2	3	25	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
		AE	5	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	60	70	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		Bw1	7	70	80	7.5YR3/4	Sandy Loam		
		Bw1	8	80	90	7.5YR3/4	Sandy Loam		
		Bw2	9	90	100	7.5YR4/4	Loam	Compact	
		Bw2	10	100	110	7.5YR4/4	Loam	Compact	
		Bw3	11	110	124	7.5YR4/3	Sandy Loam	Compact	
		Bw3	12	124	130	7.5YR4/3	Sandy Loam	Compact	
		C/B	13	130	140	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
D	K47	Ap1	1	8	16	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	16	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
		Ap3	5	50	60	7.5YR3/3	Sandy Loam		
		AE	-	60	70	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		AE	6	70	80	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
D	K47 (con't)	E	7	80	90	10YR4/4	Sandy Loam		
		Bw1	8	90	100	7.5YR4/4	Sandy Loam		
		Bw1	9	100	110	7.5YR4/4	Sandy Loam		
		Bw2	10	110	120	7.5YR4/4	Loam		
		Bw2	11	120	130	7.5YR4/4	Loam		
		B/C	12	130	140	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	13	140	150	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	14	150	155	5YR4/4 mottled w/10YR4/3	Sandy Loam		
D	K48	Ap1	1	11	19	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	19	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
		Ap3	5	50	60	7.5YR3/3	Sandy Loam		
		AE	-	60	70	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		AE	6	70	80	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		E	7	80	90	10YR4/4	Sandy Loam		
		Bw1	8	90	100	7.5YR4/4	Sandy Loam		
		Bw1	9	100	110	7.5YR4/4	Sandy Loam		
		Bw2	10	110	120	7.5YR4/4	Loam		
		Bw2	11	120	130	7.5YR4/4	Loam		
		B/C	12	130	140	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	13	140	150	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	14	150	155	5YR4/4 mottled w/10YR4/3	Sandy Loam		
D	L47	Ap1	1	13	21	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	21	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
		Ap3	5	50	60	7.5YR3/3	Sandy Loam		
		AE	-	60	70	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		AE	6	70	80	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		E	7	80	90	10YR4/4	Sandy Loam		
		Bw1	8	90	100	7.5YR4/4	Sandy Loam		
		Bw1	9	100	110	7.5YR4/4	Sandy Loam		
		Bw2	10	110	120	7.5YR4/4	Loam		
		Bw2	11	120	130	7.5YR4/4	Loam		
		B/C	12	130	140	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	13	140	150	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	14	150	155	5YR4/4 mottled w/10YR4/3	Sandy Loam		
D	L48	Ap1	1	16	25	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	25	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
		Ap3	5	50	61	7.5YR3/3	Sandy Loam		
		AE	-	61	70	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		AE	6	70	80	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		E	7	80	90	10YR4/4	Sandy Loam		
		Bw1	8	90	100	7.5YR4/4	Sandy Loam		
		Bw1	9	100	110	7.5YR4/4	Sandy Loam		
		Bw2	10	110	120	7.5YR4/4	Loam		
		Bw2	11	120	130	7.5YR4/4	Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		B/C	12	130	140	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	13	140	150	5YR4/4 mottled w/10YR4/3	Sandy Loam		
D	L48 (con't)	B/C	14	150	155	5YR4/4 mottled w/10YR4/3	Sandy Loam		
E	E10	Fill/Ap2	1	10	30	10YR3/2	Silt Loam	Not Screened	***Datum 10 cmabgs**
		AE	2	30	40	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	3	40	45	10YR4/3	Sandy Loam		
		E	4	45	55	10YR4/3	Sandy Loam		
		E	5	55	60	10YR4/3	Sandy Loam		
		Bw1	6	60	70	10YR4/4	Sandy Loam		
		Bw1	7	70	80	10YR4/4	Sandy Loam		
		Bw2	8	80	90	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	9	90	100	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		C/B	10	100	110	10YR4/3	Sandy Loam		
		C/B	11	110	120	10YR4/3	Sandy Loam		
		C/B	12	120	122	10YR4/3	Sandy Loam		
		C/B	13	122	130	10YR4/3	Sandy Loam		
		C/B	14	130	140	10YR4/3	Sandy Loam		
		C/B	15	140	150	10YR4/3	Sandy Loam		
		C/B	16	150	160	10YR4/3	Sandy Loam		
E	F10	Fill/Ap2	1	7	20	10YR3/2	Silt Loam	Not Screened	***Datum 8 cmabgs**
		AE	2	20	30	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	3	30	40	10YR4/3	Sandy Loam		
		E	4	40	48	10YR4/3	Sandy Loam		
		E	5	48	58	10YR4/3	Sandy Loam		
		Bw1	6	58	68	10YR4/4	Sandy Loam		
		Bw1	7	68	78	10YR4/4	Sandy Loam		
		Bw2	8	78	88	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	9	88	90	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	10	90	100	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		C/B	11	100	102	10YR4/3	Sandy Loam		
		C/B	12	102	112	10YR4/3	Sandy Loam		
		C/B	13	112	122	10YR4/3	Sandy Loam		
		C/B	14	122	132	10YR4/3	Sandy Loam		
E	E11	Fill/Ap2	1	20	30	10YR3/2	Silt Loam	Not Screened	***Datum 10 cmabgs**
		AE	2	30	40	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	3	40	43	10YR4/3	Sandy Loam		
		E	4	43	58	10YR4/3	Sandy Loam		
		E	5	58	60	10YR4/3	Sandy Loam		
		Bw1	6	60	70	10YR4/4	Sandy Loam		
		Bw1	7	70	80	10YR4/4	Sandy Loam		
		Bw2	8	80	90	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	9	90	100	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		C/B	10	100	110	10YR4/3	Sandy Loam		
		C/B	11	110	120	10YR4/3	Sandy Loam		
		C/B	12	120	122	10YR4/3	Sandy Loam		
		C/B	13	122	130	10YR4/3	Sandy Loam		
		C/B	14	130	140	10YR4/3	Sandy Loam		
		C/B	15	140	150	10YR4/3	Sandy Loam		
		C/B	16	150	160	10YR4/3	Sandy Loam		
E	F11	Fill/Ap2	1	7	20	10YR3/2	Silt Loam	Not Screened	***Datum 8 cmabgs**
		AE	2	20	30	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	3	30	40	10YR4/3	Sandy Loam		
		E	4	40	48	10YR4/3	Sandy Loam		
		E	5	48	58	10YR4/3	Sandy Loam		
		Bw1	6	58	68	10YR4/4	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		Bw1	7	68	78	10YR4/4	Sandy Loam		
		Bw2	8	78	88	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	9	88	90	10YR5/6 mottled w/10YR6/4	Sandy Loam		
E	F11 (con't)	Bw2	10	90	100	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		C/B	11	100	102	10YR4/3	Sandy Loam		
		C/B	12	102	112	10YR4/3	Sandy Loam		
		C/B	13	112	122	10YR4/3	Sandy Loam		
		C/B	14	122	132	10YR4/3	Sandy Loam		
F	J47	Fill I/Ap1	1	9	19	Mixed Fill	-	Not Screened	***Datum 20 cmabgs**
		Fill I/Ap1	2	19	30	Mixed Fill	-		
		Fill I/Ap1	3	30	33	Mixed Fill	-		
		Fill I/Ap1	4	33	40	Mixed Fill	-		
		Fill II/Ap2	5	40	50	Mixed Fill	-		
		Fill II/Ap2	6	50	54	Mixed Fill	-		
		Ap3	7	54	60	7.5YR3/3	Sandy Loam		
		Ap3	8	60	70	7.5YR3/3	Sandy Loam		
		AE	9	70	80	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		E	10	80	90	10YR4/4	Sandy Loam		
		Bw1	11	90	100	7.5YR4/4	Sandy Loam		
		Bw1	12	100	110	7.5YR4/4	Sandy Loam		
		Bw2	13	110	120	7.5YR4/4	Loam		
		Bw2	14	120	130	7.5YR4/4	Loam		
		B/C	15	130	140	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	16	140	150	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	17	150	155	5YR4/4 mottled w/10YR4/3	Sandy Loam		
F	J48	Fill I/Ap1	1	8	18	Mixed Fill	-	Not Screened	***Datum 20 cmabgs**
		Fill I/Ap1	2	18	30	Mixed Fill	-		
		Fill I/Ap1	3	30	33	Mixed Fill	-		
		Fill I/Ap1	4	33	40	Mixed Fill	-		
		Fill II/Ap2	5	40	50	Mixed Fill	-		
		Fill II/Ap2	6	50	60	Mixed Fill	-		
		Ap3	7	60	70	7.5YR3/3	Sandy Loam		
		AE	8	70	80	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		E	9	80	90	10YR4/4	Sandy Loam		
		Bw1	10	90	100	7.5YR4/4	Sandy Loam		
		Bw1	11	100	110	7.5YR4/4	Sandy Loam		
		Bw2	12	110	120	7.5YR4/4	Loam		
		Bw2	13	120	130	7.5YR4/4	Loam		
		B/C	14	130	140	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	15	140	150	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	16	150	155	5YR4/4 mottled w/10YR4/3	Sandy Loam		
G	M47	Ap1	1	14	20	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	20	27	7.5YR3/1	Sandy Loam		
		Ap2	3	27	35	7.5YR3/2	Sandy Loam		
		Ap2	4	35	45	7.5YR3/2	Sandy Loam		
		Ap3	5	45	50	7.5YR3/3	Sandy Loam		
		AE	6	50	60	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		E	7	60	70	10YR4/4	Sandy Loam		
		E	8	70	80	10YR4/4	Sandy Loam		
		Bw1	9	80	90	7.5YR4/4	Sandy Loam		
		Bw2	10	90	100	7.5YR4/4	Loam		
		Bw2	11	100	110	7.5YR4/4	Loam		
		B/C	12	110	120	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	13	120	130	5YR4/4 mottled w/10YR4/3	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		B/C	14	130	140	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	15	140	150	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	16	150	160	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		C/B	17	160	170	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
G	M47 (con't)	C/B	18	170	180	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
G	M48	Ap1	1	9	19	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	19	26	7.5YR3/1	Sandy Loam		
		Ap2	3	26	35	7.5YR3/2	Sandy Loam		
		Ap2	4	35	45	7.5YR3/2	Sandy Loam		
		Ap3	5	45	50	7.5YR3/3	Sandy Loam		
		AE	6	50	60	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		E	7	60	70	10YR4/4	Sandy Loam		
		Bw1	8	70	80	7.5YR4/4	Sandy Loam		
		Bw1	9	80	90	7.5YR4/4	Sandy Loam		
		Bw2	10	90	100	7.5YR4/4	Loam		
		Bw2	11	100	110	7.5YR4/4	Loam		
		B/C	12	110	120	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	13	120	130	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	14	130	140	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		C/B	15	140	150	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	16	150	160	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	17	160	170	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	18	170	180	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
G	N47	Ap1	1	12	14	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	14	25	7.5YR3/1	Sandy Loam		
		Ap2	3	25	35	7.5YR3/2	Sandy Loam		
		Ap2	4	35	45	7.5YR3/2	Sandy Loam		
		Ap3	5	45	50	7.5YR3/3	Sandy Loam		
		AE	6	50	60	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		E	7	60	70	10YR4/4	Sandy Loam		
		Bw1	8	70	80	7.5YR4/4	Sandy Loam		
		Bw2	9	80	90	7.5YR4/4	Loam		
		Bw2	10	90	100	7.5YR4/4	Loam		
		B/C	11	100	110	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	12	110	120	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	13	120	130	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	14	130	140	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	15	140	150	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		C/B	16	150	160	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	17	160	170	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	18	170	180	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
G	N48	Ap1	1	14	19	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	19	28	7.5YR3/1	Sandy Loam		
		Ap2	3	28	35	7.5YR3/2	Sandy Loam		
		Ap2	4	35	45	7.5YR3/2	Sandy Loam		
		Ap3	5	45	50	7.5YR3/3	Sandy Loam		
		AE	6	50	60	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		E	7	60	70	10YR4/4	Sandy Loam		
		Bw1	8	70	80	7.5YR4/4	Sandy Loam		
		Bw1	9	80	90	7.5YR4/4	Sandy Loam		
		Bw2	10	90	100	7.5YR4/4	Loam		
		Bw2	11	100	110	7.5YR4/4	Loam		
		B/C	12	110	120	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		B/C	13	120	130	5YR4/4 mottled w/10YR4/3	Sandy Loam		
G	N48 (con't)	B/C	14	130	140	5YR4/4 mottled w/10YR4/3	Sandy Loam		
		C/B	15	140	150	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	16	150	160	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	17	160	170	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	18	170	180	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
H	E12	Ap2	1	22	30	10YR3/2	Silt Loam	Not Screened	***Datum 10 cmabgs**
		AE	2	30	40	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	3	40	50	10YR4/3	Sandy Loam		
		E	4	50	60	10YR4/3	Sandy Loam		
		Bw1	5	60	70	10YR4/4	Sandy Loam		
		Bw2	6	70	80	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		C/B	7	80	90	10YR4/3	Sandy Loam		
		C/B	8	90	100	10YR4/3	Sandy Loam		
		C/B	9	100	105	10YR4/3	Sandy Loam		
		C/B	10	105	115	10YR4/3	Sandy Loam		
		C/B	11	115	120	10YR4/3	Sandy Loam		
H	E13	Ap2	1	18	30	10YR3/2	Silt Loam	Not Screened	***Datum 10 cmabgs**
		AE	2	30	40	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	3	40	47	10YR4/3	Sandy Loam		
		E	4	47	60	10YR4/3	Sandy Loam		
		Bw1	5	60	70	10YR4/4	Sandy Loam		
		Bw2	6	70	80	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		C/B	7	80	90	10YR4/3	Sandy Loam		
		C/B	8	90	100	10YR4/3	Sandy Loam		
		C/B	9	100	105	10YR4/3	Sandy Loam		
		C/B	10	105	115	10YR4/3	Sandy Loam		
		C/B	11	115	120	10YR4/3	Sandy Loam		
I	D10	Ap2	1	21	24	10YR3/2	Silt Loam	Not Screened	***Datum 10 cmabgs**
		AE	2	24	34	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	3	34	40	10YR4/3	Sandy Loam		
		E	4	40	48	10YR4/3	Sandy Loam		
		Bw1	5	48	58	10YR4/4	Sandy Loam		
		Bw1	6	58	60	10YR4/4	Sandy Loam		
		Bw2	7	60	70	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	8	70	80	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		C/B	9	80	90	10YR4/3	Sandy Loam		
		C/B	10	90	100	10YR4/3	Sandy Loam		
		C/B	11	100	110	10YR4/3	Sandy Loam		
		C/B	12	110	120	10YR4/3	Sandy Loam		
		C/B	13	120	120	10YR4/3	Sandy Loam		
		C/B	14	120	130	10YR4/3	Sandy Loam		
		C/B	15	130	140	10YR4/3	Sandy Loam		
		C/B	16	140	150	10YR4/3	Sandy Loam		
		C/B	17	150	160	10YR4/3	Sandy Loam		
I	D11	Ap2	1	10	25	10YR3/2	Silt Loam	Not Screened	***Datum 10 cmabgs**
		AE	2	25	35	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	3	35	43	10YR4/3	Sandy Loam		
		E	4	43	53	10YR4/3	Sandy Loam		
		Bw1	5	53	60	10YR4/4	Sandy Loam		
		Bw1	6	60	70	10YR4/4	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		Bw2	7	70	80	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	8	80	90	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		C/B	9	90	100	10YR4/3	Sandy Loam		
		C/B	10	100	110	10YR4/3	Sandy Loam		
		C/B	11	110	120	10YR4/3	Sandy Loam		
		C/B	12	120	120	10YR4/3	Sandy Loam		
		C/B	13	120	130	10YR4/3	Sandy Loam		
		C/B	14	130	140	10YR4/3	Sandy Loam		
		C/B	15	140	150	10YR4/3	Sandy Loam		
I	D11 (con't)	C/B	16	150	160	10YR4/3	Sandy Loam		
J	D12	Ap2	1	22	25	10YR3/2	Silt Loam	Not Screened	***Datum 10 cmabgs**
		AE	2	25	35	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	3	35	43	10YR4/3	Sandy Loam		
		E	4	43	53	10YR4/3	Sandy Loam		
		Bw1	5	53	60	10YR4/4	Sandy Loam		
		Bw1	6	60	70	10YR4/4	Sandy Loam		
		Bw2	7	70	80	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	8	80	90	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		C/B	9	90	100	10YR4/3	Sandy Loam		
		C/B	10	100	105	10YR4/3	Sandy Loam		
		C/B	11	105	120	10YR4/3	Sandy Loam		
J	D13	Ap2	1	15	24	10YR3/2	Silt Loam	Not Screened	***Datum 10 cmabgs**
		AE	2	24	35	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	3	35	45	10YR4/3	Sandy Loam		
		E	4	45	55	10YR4/3	Sandy Loam		
		Bw1	5	55	60	10YR4/4	Sandy Loam		
		Bw1	6	60	70	10YR4/4	Sandy Loam		
		Bw2	7	70	80	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	8	80	90	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		C/B	9	90	100	10YR4/3	Sandy Loam		
		C/B	10	100	105	10YR4/3	Sandy Loam		
		C/B	11	105	120	10YR4/3	Sandy Loam		
K	L22	Ap1	1	17	27	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap2	2	27	33	7.5YR3/2	Sandy Loam		
		AE	3	33	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	4	50	56	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	56	66	7.5YR4/3	Sandy Loam		
		E	6	66	76	7.5YR4/3	Sandy Loam		
		Bw1	7	76	87	7.5YR3/4	Sandy Loam		
		Bw1	8	87	96	7.5YR3/4	Sandy Loam		
		Bw2	9	96	101	7.5YR4/4	Loam		
		Bw2	10	101	111	7.5YR4/4	Loam		
		Bw2	11	111	121	7.5YR4/4	Loam		
K	L23	Ap1	1	10	27	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap2	2	27	33	7.5YR3/2	Sandy Loam		
		AE	3	33	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	4	50	56	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		Bw1	5	56	66	7.5YR3/4	Sandy Loam		
		Bw1	6	66	76	7.5YR3/4	Sandy Loam		
		Bw1	7	76	86	7.5YR3/4	Sandy Loam		
		Bw2	8	86	96	7.5YR4/4	Loam		
		Bw2	9	96	102	7.5YR4/4	Loam		
		C/B	10	102	111	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	11	111	121	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	12	121	131	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
K	M22	Ap1	1	17	32	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap2	2	32	41	7.5YR3/2	Sandy Loam		
		AE	3	41	51	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	4	51	56	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	56	66	7.5YR4/3	Sandy Loam		
		E	6	66	76	7.5YR4/3	Sandy Loam		
		Bw1	7	76	86	7.5YR3/4	Sandy Loam		
		Bw1	8	86	96	7.5YR3/4	Sandy Loam		
		Bw2	9	96	101	7.5YR4/4	Loam		
		Bw2	10	101	111	7.5YR4/4	Loam		
		Bw2	11	111	121	7.5YR4/4	Loam		
K	M23	Ap1	1	14	30	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap2	2	30	42	7.5YR3/2	Sandy Loam		
		AE	3	42	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	4	50	56	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	56	66	7.5YR4/3	Sandy Loam		
		E	6	66	76	7.5YR4/3	Sandy Loam		
		Bw1	7	76	86	7.5YR3/4	Sandy Loam		
		Bw1	8	86	96	7.5YR3/4	Sandy Loam		
		Bw2	9	96	101	7.5YR4/4	Loam		
		Bw2	10	101	111	7.5YR4/4	Loam		
		Bw2	11	111	121	7.5YR4/4	Loam		
L	L26	Ap1	1	10	30	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	30	34	7.5YR3/1	Sandy Loam		
		Ap2	3	34	42	7.5YR3/2	Sandy Loam		
		AE	4	42	52	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	52	62	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	62	72	7.5YR4/3	Sandy Loam		
		E	7	72	82	7.5YR4/3	Sandy Loam		
		Bw1	8	82	92	7.5YR3/4	Sandy Loam		
		Bw1	9	92	102	7.5YR3/4	Sandy Loam		
		Bw2	10	102	112	7.5YR4/4	Loam		
		Bw2	11	112	122	7.5YR4/4	Loam		
		Bw2	12	122	135	7.5YR4/4	Loam		
		Bw2	13	135	145	7.5YR4/4	Loam		
		C/B	14	145	155	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	155	166	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
L	L27	Ap1	1	13	30	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	30	38	7.5YR3/1	Sandy Loam		
		Ap2	3	38	42	7.5YR3/2	Sandy Loam		
		AE	4	42	52	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	52	62	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	62	72	7.5YR4/3	Sandy Loam		
		E	7	72	82	7.5YR4/3	Sandy Loam		
		Bw1	8	82	92	7.5YR3/4	Sandy Loam		
		Bw1	9	92	102	7.5YR3/4	Sandy Loam		
		Bw2	10	102	112	7.5YR4/4	Loam		
		Bw2	11	112	122	7.5YR4/4	Loam		
		Bw2	12	122	135	7.5YR4/4	Loam		
		Bw2	13	135	145	7.5YR4/4	Loam		
		C/B	14	145	155	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	155	170	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
L	M26	Ap1	1	15	32	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	32	40	7.5YR3/1	Sandy Loam		
		Ap2	3	40	42	7.5YR3/2	Sandy Loam		
		AE	4	42	52	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	52	62	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	62	72	7.5YR4/3	Sandy Loam		
		E	7	72	82	7.5YR4/3	Sandy Loam		
		Bw1	8	82	92	7.5YR3/4	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		Bw1	9	92	102	7.5YR3/4	Sandy Loam		
		Bw2	10	102	112	7.5YR4/4	Loam		
		Bw2	11	112	122	7.5YR4/4	Loam		
		Bw2	12	122	135	7.5YR4/4	Loam		
		Bw2	13	135	145	7.5YR4/4	Loam		
		C/B	14	145	155	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	155	172	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
L	M27	Ap1	1	10	30	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	30	39	7.5YR3/1	Sandy Loam		
		Ap2	3	39	42	7.5YR3/2	Sandy Loam		
		AE	4	42	52	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
L	M27 (con't)	AE	5	52	62	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	62	72	7.5YR4/3	Sandy Loam		
		E	7	72	82	7.5YR4/3	Sandy Loam		
		Bw1	8	82	92	7.5YR3/4	Sandy Loam		
		Bw1	9	92	102	7.5YR3/4	Sandy Loam		
		Bw2	10	102	106	7.5YR4/4	Loam		
		Bw2	11	106	116	7.5YR4/4	Loam		
		Bw2	12	116	126	7.5YR4/4	Loam		
		Bw2	13	126	135	7.5YR4/4	Loam		
		Bw2	14	135	145	7.5YR4/4	Loam		
		Bw2	15	145	155	7.5YR4/4	Loam		
		C/B	16	155	170	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
M	L29	Ap1	1	5	10	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	10	22	7.5YR3/1	Sandy Loam		
		Ap2	3	22	34	7.5YR3/2	Sandy Loam		
		AE	4	34	44	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	44	48	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	48	58	7.5YR4/3	Sandy Loam		
		E	7	58	68	7.5YR4/3	Sandy Loam		
		Bw1	8	68	75	7.5YR3/4	Sandy Loam		
		Bw1	9	75	85	7.5YR3/4	Sandy Loam		
		Bw1	10	85	95	7.5YR3/4	Sandy Loam		
		Bw2	11	95	105	7.5YR4/4	Loam		
		Bw2	12	105	115	7.5YR4/4	Loam		
		Bw2	13	115	125	7.5YR4/4	Loam		
		Bw2	14	125	135	7.5YR4/4	Loam		
M	L30	Ap1	1	12	17	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	17	27	7.5YR3/1	Sandy Loam		
		Ap2	3	27	34	7.5YR3/2	Sandy Loam		
		AE	4	34	44	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	44	48	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	48	58	7.5YR4/3	Sandy Loam		
		E	7	58	68	7.5YR4/3	Sandy Loam		
		Bw1	8	68	75	7.5YR3/4	Sandy Loam		
		Bw1	9	75	85	7.5YR3/4	Sandy Loam		
		Bw1	10	85	95	7.5YR3/4	Sandy Loam		
		Bw2	11	97	105	7.5YR4/4	Loam		
		Bw2	12	105	115	7.5YR4/4	Loam		
		Bw2	13	115	125	7.5YR4/4	Loam		
		Bw2	14	125	135	7.5YR4/4	Loam		
M	M29	Ap1	1	15	20	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	20	25	7.5YR3/1	Sandy Loam		
		Ap2	3	25	34	7.5YR3/2	Sandy Loam		
		AE	4	34	44	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	44	48	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	48	58	7.5YR4/3	Sandy Loam		
		E	7	58	68	7.5YR4/3	Sandy Loam		
		Bw1	8	68	78	7.5YR3/4	Sandy Loam		
		Bw1	9	78	88	7.5YR3/4	Sandy Loam		
		Bw1	10	88	98	7.5YR3/4	Sandy Loam		
		Bw2	11	98	108	7.5YR4/4	Loam		
		Bw2	12	108	118	7.5YR4/4	Loam		
		Bw2	13	118	125	7.5YR4/4	Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		Bw2	14	125	136	7.5YR4/4	Loam		
		Bw2	15	136	145	7.5YR4/4	Loam		
		Bw2	16	145	155	7.5YR4/4	Loam		
		Bw2	17	155	165	7.5YR4/4	Loam		
		C/B	18	165	175	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	19	175	185	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
M	M30	Ap1	1	12	17	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	17	27	7.5YR3/1	Sandy Loam		
		Ap2	3	27	34	7.5YR3/2	Sandy Loam		
		AE	4	34	44	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	44	48	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
M	M30 (con't)	E	6	48	58	7.5YR4/3	Sandy Loam		
		E	7	58	68	7.5YR4/3	Sandy Loam		
		Bw1	8	68	78	7.5YR3/4	Sandy Loam		
		Bw1	9	78	88	7.5YR3/4	Sandy Loam		
		Bw1	10	88	98	7.5YR3/4	Sandy Loam		
		Bw2	11	98	108	7.5YR4/4	Loam		
		Bw2	12	108	118	7.5YR4/4	Loam		
		Bw2	13	118	125	7.5YR4/4	Loam		
		Bw2	14	125	135	7.5YR4/4	Loam		
		Bw2	15	135	145	7.5YR4/4	Loam		
		Bw2	16	145	155	7.5YR4/4	Loam		
		Bw2	17	155	165	7.5YR4/4	Loam		
		C/B	18	165	175	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	19	175	185	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
N	L33	Ap1	1	9	15	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	15	27	7.5YR3/1	Sandy Loam		
		Ap2	3	27	36	7.5YR3/2	Sandy Loam		
		AE	4	36	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	60	70	7.5YR4/3	Sandy Loam		
		E	7	70	80	7.5YR4/3	Sandy Loam		
		BE	8	80	90	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	9	90	105	7.5YR3/4	Sandy Loam		
		Bw1	10	105	110	7.5YR3/4	Sandy Loam		
		Bw2	11	110	120	7.5YR4/4	Loam		
		Bw2	12	120	135	7.5YR4/4	Loam		
		Bw2	13	135	150	7.5YR4/4	Loam		
		Bw2	14	150	160	7.5YR4/4	Loam		
		Bw2	15	160	170	7.5YR4/4	Loam		
		Bw2	16	170	188	7.5YR4/4	Loam		
N	M33	Ap1	1	10	11	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	11	20	7.5YR3/1	Sandy Loam		
		Ap2	3	20	36	7.5YR3/2	Sandy Loam		
		AE	4	36	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	60	70	7.5YR4/3	Sandy Loam		
		E	7	70	80	7.5YR4/3	Sandy Loam		
		BE	8	80	90	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	9	90	105	7.5YR3/4	Sandy Loam		
		Bw1	10	105	110	7.5YR3/4	Sandy Loam		
		Bw2	11	110	120	7.5YR4/4	Loam		
		Bw2	12	120	130	7.5YR4/4	Loam		
		Bw2	13	130	150	7.5YR4/4	Loam		
		Bw2	14	150	160	7.5YR4/4	Loam		
N	L34	Ap1	1	9	15	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	15	25	7.5YR3/1	Sandy Loam		
		Ap2	3	25	35	7.5YR3/2	Sandy Loam		
		AE	4	35	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		AE	5	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	60	70	7.5YR4/3	Sandy Loam		
		E	7	70	80	7.5YR4/3	Sandy Loam		
		BE	8	80	90	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	9	90	100	7.5YR3/4	Sandy Loam		
		Bw1	10	100	110	7.5YR3/4	Sandy Loam		
		Bw2	11	110	120	7.5YR4/4	Loam		
		Bw2	12	120	130	7.5YR4/4	Loam		
		Bw2	13	130	140	7.5YR4/4	Loam		
		Bw2	14	140	150	7.5YR4/4	Loam		
		Bw2	15	150	160	7.5YR4/4	Loam		
N	M34	Ap1	1	9	14	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	14	25	7.5YR3/1	Sandy Loam		
		Ap2	3	25	36	7.5YR3/2	Sandy Loam		
		AE	4	36	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
N	M34 (con't)	AE	5	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	60	70	7.5YR4/3	Sandy Loam		
		E	7	70	80	7.5YR4/3	Sandy Loam		
		BE	8	80	90	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	9	90	100	7.5YR3/4	Sandy Loam		
		Bw1	10	100	110	7.5YR3/4	Sandy Loam		
		Bw2	11	110	120	7.5YR4/4	Loam		
		Bw2	12	120	130	7.5YR4/4	Loam		
		Bw2	13	130	140	7.5YR4/4	Loam		
		Bw2	14	140	150	7.5YR4/4	Loam		
		Bw2	15	150	160	7.5YR4/4	Loam		
O	L41	Ap1	1	15	20	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	20	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	47	7.5YR3/2	Sandy Loam		
		AE	5	47	59	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	59	69	7.5YR4/3	Sandy Loam		
		BE	7	69	79	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	8	79	89	7.5YR3/4	Sandy Loam		
		Bw2	9	89	99	7.5YR4/4	Loam		
		Bw2	10	99	109	7.5YR4/4	Loam		
		C/B	11	109	119	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	12	119	129	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C	13	129	139	7.5YR3/4	Sandy Loam		
		2Bwb1	14	139	153	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb1	15	153	163	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb1	16	163	173	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb1	17	173	183	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb2	18	183	196	7.5YR3/4	Sandy Loam	Lamellae	
		2Bwb2	19	196	212	7.5YR3/4	Sandy Loam	Lamellae	
O	M41	Ap1	1	15	20	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	20	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	59	7.5YR3/2	Sandy Loam		
		AE	5	59	69	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	69	77	7.5YR4/3	Sandy Loam		
		BE	7	77	87	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	8	87	90	7.5YR3/4	Sandy Loam		
		Bw2	9	90	99	7.5YR4/4	Loam		
		Bw2	10	99	109	7.5YR4/4	Loam		
		C/B	11	109	119	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	12	119	129	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C	13	129	139	7.5YR3/4	Sandy Loam		
		2Bwb1	14	139	153	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb1	15	153	163	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb1	16	163	174	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb1	17	174	184	7.5YR4/4	Sandy Loam	Lamellae	

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
O	L42	Ap1	1	10	15	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	15	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	49	7.5YR3/2	Sandy Loam		
		AE	5	49	59	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	59	69	7.5YR4/3	Sandy Loam		
		BE	7	69	79	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	8	79	89	7.5YR3/4	Sandy Loam		
		Bw2	9	89	99	7.5YR4/4	Loam		
		Bw2	10	99	109	7.5YR4/4	Loam		
		C/B	11	109	119	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	12	119	130	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C	13	130	140	7.5YR3/4	Sandy Loam		
		2Bwb1	14	140	150	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb1	15	150	160	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb1	16	160	170	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb1	17	170	180	7.5YR4/4	Sandy Loam	Lamellae	
O	L42 (con't)	2Bwb2	18	180	192	7.5YR3/4	Sandy Loam	Lamellae	
O	M42	Ap1	1	10	19	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	19	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	48	7.5YR3/2	Sandy Loam		
		AE	5	48	59	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	59	69	7.5YR4/3	Sandy Loam		
		BE	7	69	79	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	8	79	89	7.5YR3/4	Sandy Loam		
		Bw2	9	89	99	7.5YR4/4	Loam		
		Bw2	10	99	109	7.5YR4/4	Loam		
		C/B	11	109	120	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	12	120	130	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C	13	130	140	7.5YR3/4	Sandy Loam		
		2Bwb1	14	140	150	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb1	15	150	160	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb1	16	160	170	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb1	17	170	180	7.5YR4/4	Sandy Loam	Lamellae	
		2Bwb2	18	180	185	7.5YR3/4	Sandy Loam	Lamellae	
P	P33	Ap1	1	17	24	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	24	35	7.5YR3/1	Sandy Loam		
		Ap2	3	35	44	7.5YR3/2	Sandy Loam		
		AE	4	44	53	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	53	65	7.5YR4/3	Sandy Loam		
		E	6	65	75	7.5YR4/3	Sandy Loam		
		E	7	75	85	7.5YR4/3	Sandy Loam		
		BE	8	85	95	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	9	95	105	7.5YR3/4	Sandy Loam		
		Bw1	10	105	115	7.5YR3/4	Sandy Loam		
		Bw2	11	115	125	7.5YR4/4	Loam		
		Bw2	12	125	135	7.5YR4/4	Loam		
		Bw2	13	135	145	7.5YR4/4	Loam		
P	Q33	Ap1	1	17	24	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	24	33	7.5YR3/1	Sandy Loam		
		Ap2	3	33	45	7.5YR3/2	Sandy Loam		
		AE	4	45	55	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	55	65	7.5YR4/3	Sandy Loam		
		E	6	65	75	7.5YR4/3	Sandy Loam		
		E	7	75	85	7.5YR4/3	Sandy Loam		
		BE	8	85	95	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	9	95	105	7.5YR3/4	Sandy Loam		
		Bw1	10	105	115	7.5YR3/4	Sandy Loam		
		Bw2	11	115	125	7.5YR4/4	Loam		
		Bw2	12	125	135	7.5YR4/4	Loam		
		Bw2	13	135	145	7.5YR4/4	Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
P	P34	Ap1	1	12	24	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	24	33	7.5YR3/1	Sandy Loam		
		Ap2	3	33	44	7.5YR3/2	Sandy Loam		
		AE	4	44	53	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	53	65	7.5YR4/3	Sandy Loam		
		E	6	65	75	7.5YR4/3	Sandy Loam		
		E	7	75	85	7.5YR4/3	Sandy Loam		
		BE	8	85	95	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	9	95	105	7.5YR3/4	Sandy Loam		
		Bw1	10	105	110	7.5YR3/4	Sandy Loam		
		Bw2	11	110	125	7.5YR4/4	Loam		
		Bw2	12	125	135	7.5YR4/4	Loam		
		Bw2	13	135	145	7.5YR4/4	Loam		
P	Q34	Ap1	1	12	24	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	24	34	7.5YR3/1	Sandy Loam		
		Ap2	3	34	44	7.5YR3/2	Sandy Loam		
		AE	4	44	53	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	53	65	7.5YR4/3	Sandy Loam		
		E	6	65	75	7.5YR4/3	Sandy Loam		
P	Q34 (con't)	E	7	75	85	7.5YR4/3	Sandy Loam		
		BE	8	85	95	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	9	95	105	7.5YR3/4	Sandy Loam		
		Bw1	10	105	110	7.5YR3/4	Sandy Loam		
		Bw2	11	110	125	7.5YR4/4	Loam		
		Bw2	12	125	135	7.5YR4/4	Loam		
		Bw2	13	135	145	7.5YR4/4	Loam		
Q	J39	Ap1	1	11	16	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	16	24	7.5YR3/1	Sandy Loam		
		Ap2	3	24	34	7.5YR3/2	Sandy Loam		
		Ap2	4	34	44	7.5YR3/2	Sandy Loam		
		AE	5	44	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	7	60	70	7.5YR4/3	Sandy Loam		
		E	8	70	80	7.5YR4/3	Sandy Loam		
		BE	9	80	90	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	10	90	100	7.5YR3/4	Sandy Loam		
		Bw2	11	100	110	7.5YR4/4	Loam		
		Bw2	12	110	120	7.5YR4/4	Loam		
		C/B	13	120	130	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	14	130	140	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	140	150	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C	16	150	160	7.5YR3/4	Sandy Loam		
Q	K39	Ap1	1	11	16	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	16	24	7.5YR3/1	Sandy Loam		
		Ap2	3	24	34	7.5YR3/2	Sandy Loam		
		Ap2	4	34	44	7.5YR3/2	Sandy Loam		
		AE	5	44	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	7	60	70	7.5YR4/3	Sandy Loam		
		E	8	70	80	7.5YR4/3	Sandy Loam		
		BE	9	80	90	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	10	90	100	7.5YR3/4	Sandy Loam		
		Bw2	11	100	110	7.5YR4/4	Loam		
		Bw2	12	110	120	7.5YR4/4	Loam		
		C/B	13	120	130	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	14	130	140	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	140	150	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C	16	150	160	7.5YR3/4	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
Q	J40	Ap1	1	9	14	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	14	24	7.5YR3/1	Sandy Loam		
		Ap2	3	24	34	7.5YR3/2	Sandy Loam		
		Ap2	4	34	44	7.5YR3/2	Sandy Loam		
		AE	5	44	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	7	60	70	7.5YR4/3	Sandy Loam		
		E	8	70	80	7.5YR4/3	Sandy Loam		
		BE	9	80	90	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	10	90	100	7.5YR3/4	Sandy Loam		
		Bw2	11	100	110	7.5YR4/4	Loam		
		Bw2	12	110	120	7.5YR4/4	Loam		
		C/B	13	120	130	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	14	130	140	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	140	150	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
Q	K40	Ap1	1	13	18	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	18	24	7.5YR3/1	Sandy Loam		
Q	K40 (con't)	Ap2	3	24	34	7.5YR3/2	Sandy Loam		
		Ap2	4	34	44	7.5YR3/2	Sandy Loam		
		AE	5	44	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	7	60	70	7.5YR4/3	Sandy Loam		
		E	8	70	80	7.5YR4/3	Sandy Loam		
		BE	9	80	90	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	10	90	100	7.5YR3/4	Sandy Loam		
		Bw2	11	100	110	7.5YR4/4	Loam		
		Bw2	12	110	120	7.5YR4/4	Loam		
		C/B	13	120	130	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	14	130	140	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	140	150	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C	16	150	160	7.5YR3/4	Sandy Loam		
R	T33	Ap1	1	5	18	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	18	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
		AE	5	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		BE	6	60	70	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	7	70	80	7.5YR3/4	Sandy Loam		
		Bw1	8	80	90	7.5YR3/4	Sandy Loam		
		Bw1	9	90	100	7.5YR3/4	Sandy Loam		
		Bw2	10	100	110	7.5YR4/4	Loam		
		Bw2	11	110	120	7.5YR4/4	Loam		
		Bw2	12	120	130	7.5YR4/4	Loam		
		Bw2	13	130	140	7.5YR4/4	Loam		
		Bw2	14	140	150	7.5YR4/4	Loam		
		Bw2	15	150	160	7.5YR4/4	Loam		
		C/B	16	160	170	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
R	U33	Ap1	1	7	18	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	18	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
		AE	5	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		BE	6	60	70	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	7	70	80	7.5YR3/4	Sandy Loam		
		Bw1	8	80	90	7.5YR3/4	Sandy Loam		
		Bw1	9	90	100	7.5YR3/4	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		Bw2	10	100	110	7.5YR4/4	Loam		
		Bw2	11	110	120	7.5YR4/4	Loam		
		Bw2	12	120	132	7.5YR4/4	Loam		
		Bw2	13	132	142	7.5YR4/4	Loam		
		Bw2	14	142	150	7.5YR4/4	Loam		
		Bw2	15	150	160	7.5YR4/4	Loam		
		C/B	16	160	170	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
R	T34	Ap1	1	8	18	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	18	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
		AE	5	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		BE	6	60	75	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	7	75	80	7.5YR3/4	Sandy Loam		
		Bw1	8	80	90	7.5YR3/4	Sandy Loam		
		Bw1	9	90	100	7.5YR3/4	Sandy Loam		
		Bw2	10	100	110	7.5YR4/4	Loam		
		Bw2	11	110	120	7.5YR4/4	Loam		
		Bw2	12	120	130	7.5YR4/4	Loam		
		Bw2	13	130	140	7.5YR4/4	Loam		
		Bw2	14	140	150	7.5YR4/4	Loam		
		Bw2	15	150	160	7.5YR4/4	Loam		
		C/B	16	160	170	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
R	U34	Ap1	1	9	18	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	18	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
		AE	5	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		BE	6	60	70	7.5YR4/3 mottled w/7.5YR3/4	Sandy Loam		
		Bw1	7	70	85	7.5YR3/4	Sandy Loam		
		Bw1	8	85	90	7.5YR3/4	Sandy Loam		
		Bw1	9	90	100	7.5YR3/4	Sandy Loam		
		Bw2	10	100	110	7.5YR4/4	Loam		
		Bw2	11	110	120	7.5YR4/4	Loam		
		Bw2	12	120	133	7.5YR4/4	Loam		
		Bw2	13	133	144	7.5YR4/4	Loam		
		Bw2	14	144	150	7.5YR4/4	Loam		
		Bw2	15	150	160	7.5YR4/4	Loam		
		C/B	16	160	170	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	17	170	193	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
S	L10	Ap1	1	20	26	10YR3/2	Silt Loam	Not Screened	***Datum 20 cmabgs**
		Ap1	2	26	36	10YR3/2	Silt Loam		
		Ap2	3	36	44	10YR3/2	Silt Loam		
		Ap2	4	44	59	10YR3/2	Silt Loam		
		AE	5	59	69	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	6	69	79	10YR4/3	Sandy Loam		
		Bw1	7	79	89	10YR4/4	Sandy Loam	Compact	
		Bw1	8	89	97	10YR4/4	Sandy Loam	Compact	
		Bw2	9	97	107	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	10	107	111	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	11	134	145	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	12	145	151	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		C/B	13	151	162	10YR4/6	Sandy Loam	Lamellae	
		C/B	14	162	173	10YR4/6	Sandy Loam	Lamellae	
S	M10	Ap1	1	35	41	10YR3/2	Silt Loam	Not Screened	***Datum 20 cmabgs**
		Ap1	2	41	43	10YR3/2	Silt Loam		
		Ap2	3	43	49	10YR3/2	Silt Loam		
		Ap2	4	49	59	10YR3/2	Silt Loam		
		AE	5	59	69	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	6	69	79	10YR4/3	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		Bw1	7	79	89	10YR4/4	Sandy Loam	Compact	
		Bw1	8	89	99	10YR4/4	Sandy Loam	Compact	
		Bw1	9	99	112	10YR4/4	Sandy Loam	Compact	
		Bw2	10	112	122	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	11	122	134	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	12	134	145	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		C/B	13	145	163	10YR4/6	Sandy Loam	Lamellae	
S	L11	Ap1	1	15	20	10YR3/2	Silt Loam	Not Screened	***Datum 20 cmabgs**
		Ap1	2	20	32	10YR3/2	Silt Loam		
		Ap2	3	32	43	10YR3/2	Silt Loam		
		Ap2	4	43	56	10YR3/2	Silt Loam		
		AE	5	56	59	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	6	59	69	10YR4/3	Sandy Loam		
		Bw1	7	69	79	10YR4/4	Sandy Loam	Compact	
		Bw1	8	79	89	10YR4/4	Sandy Loam	Compact	
		Bw1	9	89	95	10YR4/4	Sandy Loam	Compact	
		Bw2	10	95	97	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	11	97	122	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
S	L11 (con't)	Bw2	12	122	132	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		C/B	13	132	142	10YR4/6	Sandy Loam	Lamellae	
S	M11	Ap1	1	28	33	10YR3/2	Silt Loam	Not Screened	***Datum 20 cmabgs**
		Ap1	2	33	39	10YR3/2	Silt Loam		
		Ap2	3	39	46	10YR3/2	Silt Loam		
		Ap2	4	46	59	10YR3/2	Silt Loam		
		Ap2	5	59	69	10YR3/2	Silt Loam		
		AE	6	69	79	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	7	79	89	10YR4/3	Sandy Loam		
		Bw1	8	89	98	10YR4/4	Sandy Loam	Compact	
		Bw1	9	98	103	10YR4/4	Sandy Loam	Compact	
		Bw2	10	103	110	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	11	110	122	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	12	122	135	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		C/B	13	135	145	10YR4/6	Sandy Loam	Lamellae	
		C/B	14	145	152	10YR4/6	Sandy Loam	Lamellae	
		C/B	15	152	162	10YR4/6	Sandy Loam	Lamellae	
		C/B	16	162	172	10YR4/6	Sandy Loam	Lamellae	
T	L9	Ap1	1	14	22	10YR3/2	Silt Loam	Not Screened	***Datum 20 cmabgs**
		Ap1	2	22	40	10YR3/2	Silt Loam		
		Ap2	3	40	50	10YR3/2	Silt Loam		
		Ap2	4	50	60	10YR3/2	Silt Loam		
		AE	5	60	70	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	6	70	80	10YR4/3	Sandy Loam		
		Bw1	7	80	90	10YR4/4	Sandy Loam	Compact	
		Bw1	8	90	100	10YR4/4	Sandy Loam	Compact	
T	M9	Ap1	1	19	29	10YR3/2	Silt Loam	Not Screened	***Datum 20 cmabgs**
		Ap1	2	29	40	10YR3/2	Silt Loam		
		Ap2	3	40	50	10YR3/2	Silt Loam		
		Ap2	4	50	60	10YR3/2	Silt Loam		
		AE	5	60	70	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	6	70	80	10YR4/3	Sandy Loam		
		Bw1	7	80	90	10YR4/4	Sandy Loam	Compact	
		Bw1	8	90	-	10YR4/4	Sandy Loam	Compact	
U	W46	Ap1	1	16	19	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	19	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		AE	5	50	60	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		E	6	60	70	10YR4/4	Sandy Loam		
		E	7	70	80	10YR4/4	Sandy Loam		
		E	8	80	90	10YR4/4	Sandy Loam		
		Bw1	9	90	100	7.5YR4/4	Sandy Loam		
		Bw1	10	100	110	7.5YR4/4	Sandy Loam		
		Bw1	11	110	120	7.5YR4/4	Sandy Loam		
U	X46	Ap1	1	18	23	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	23	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
		AE	5	50	60	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		E	6	60	70	10YR4/4	Sandy Loam		
		E	7	70	80	10YR4/4	Sandy Loam		
		E	8	80	90	10YR4/4	Sandy Loam		
		Bw1	9	90	100	7.5YR4/4	Sandy Loam		
		Bw1	10	100	110	7.5YR4/4	Sandy Loam		
U	W47	Ap1	1	10	17	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	17	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
		AE	5	50	60	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		E	6	60	70	10YR4/4	Sandy Loam		
		E	7	70	80	10YR4/4	Sandy Loam		
		E	8	80	90	10YR4/4	Sandy Loam		
U	W47 (con't)	Bw1	9	90	100	7.5YR4/4	Sandy Loam		
		Bw1	10	100	110	7.5YR4/4	Sandy Loam		
U	X47	Ap1	1	19	25	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	25	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		Ap2	4	40	50	7.5YR3/2	Sandy Loam		
		AE	5	50	60	7.5YR3/3 mottled w/10YR4/4	Sandy Loam		
		E	6	60	70	10YR4/4	Sandy Loam		
		E	7	70	80	10YR4/4	Sandy Loam		
		E	8	80	90	10YR4/4	Sandy Loam		
		Bw1	9	90	100	7.5YR4/4	Sandy Loam		
		Bw1	10	100	110	7.5YR4/4	Sandy Loam		
V	H33	Ap1	1	9	24	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	24	34	7.5YR3/1	Sandy Loam		
		Ap2	3	34	44	7.5YR3/2	Sandy Loam		
		Ap2	4	44	54	7.5YR3/2	Sandy Loam		
		AE	5	54	64	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	64	74	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	7	74	82	7.5YR4/3	Sandy Loam		
		E	8	82	92	7.5YR4/3	Sandy Loam		
		Bw1	9	92	102	7.5YR3/4	Sandy Loam		
		Bw2	10	102	112	7.5YR4/4	Loam		
		Bw2	11	112	122	7.5YR4/4	Loam		
		C/B	12	122	132	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	13	132	142	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	14	142	152	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	152	162	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	16	162	172	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
V	I33	Ap1	1	14	24	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	24	34	7.5YR3/1	Sandy Loam		
		Ap2	3	34	44	7.5YR3/2	Sandy Loam		
		Ap2	4	44	56	7.5YR3/2	Sandy Loam		
		AE	5	56	64	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	64	72	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	7	72	82	7.5YR4/3	Sandy Loam		
		E	8	82	92	7.5YR4/3	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		Bw1	9	92	102	7.5YR3/4	Sandy Loam		
		Bw2	10	102	112	7.5YR4/4	Loam		
		Bw2	11	112	122	7.5YR4/4	Loam		
		C/B	12	122	132	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	13	132	142	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	14	142	152	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	152	162	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
V	H34	Ap1	1	10	22	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	22	34	7.5YR3/1	Sandy Loam		
		Ap2	3	34	44	7.5YR3/2	Sandy Loam		
		Ap2	4	44	54	7.5YR3/2	Sandy Loam		
		AE	5	54	64	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	64	72	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	7	72	82	7.5YR4/3	Sandy Loam		
		E	8	82	92	7.5YR4/3	Sandy Loam		
		Bw1	9	92	102	7.5YR3/4	Sandy Loam		
		Bw2	10	102	112	7.5YR4/4	Loam		
		Bw2	11	112	122	7.5YR4/4	Loam		
		Bw2	12	122	132	7.5YR4/4	Loam		
		Bw2	13	132	142	7.5YR4/4	Loam		
		C/B	14	142	152	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	152	162	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	16	162	172	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
V	I34	Ap1	1	14	24	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	24	34	7.5YR3/1	Sandy Loam		
		Ap2	3	34	44	7.5YR3/2	Sandy Loam		
		Ap2	4	44	57	7.5YR3/2	Sandy Loam		
		AE	5	57	64	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	64	72	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	7	72	82	7.5YR4/3	Sandy Loam		
		E	8	82	92	7.5YR4/3	Sandy Loam		
		Bw1	9	92	102	7.5YR3/4	Sandy Loam		
		Bw2	10	102	112	7.5YR4/4	Loam		
		Bw2	11	112	122	7.5YR4/4	Loam		
		Bw2	12	122	132	7.5YR4/4	Loam		
		Bw2	13	132	142	7.5YR4/4	Loam		
		C/B	14	142	152	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	152	162	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	16	162	172	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
W	J10	Ap1/Ap2	1	12	18	10YR3/2	Silt Loam	Not Screened	***Datum 15 cmabgs**
		Ap1/Ap2	2	18	30	10YR3/2	Silt Loam		
		Ap1/Ap2	3	30	38	10YR3/2	Silt Loam		
		AE	4	38	50	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		AE	5	50	60	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	6	60	70	10YR4/3	Sandy Loam		
		E	7	70	80	10YR4/3	Sandy Loam		
		Bw1	8	80	90	10YR4/4	Sandy Loam	Compact	
		Bw1	9	90	100	10YR4/4	Sandy Loam	Compact	
		Bw1	10	100	102	10YR4/4	Sandy Loam	Compact	
		Bw2	11	102	115	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	12	115	125	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	13	125	135	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	14	135	145	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		C/B	15	145	157	10YR4/6	Sandy Loam	Lamellae	
		C/B	16	157	173	10YR4/6	Sandy Loam	Lamellae	

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		C/B	17	173	195	10YR4/6	Sandy Loam	Lamellae	
W	K10	Ap1	1	21	25	10YR3/2	Silt Loam	Not Screened	***Datum 15 cmabgs**
		Ap1	2	25	36	10YR3/2	Silt Loam		
		Ap2	3	36	46	10YR3/2	Silt Loam		
		Ap2	4	46	56	10YR3/2	Silt Loam		
		E	5	56	66	10YR4/3	Sandy Loam		
		Bw1	6	66	76	10YR4/4	Sandy Loam	Compact	
		Bw1	7	76	86	10YR4/4	Sandy Loam	Compact	
		Bw1	8	86	96	10YR4/4	Sandy Loam	Compact	
		Bw1	9	96	105	10YR4/4	Sandy Loam	Compact	
		Bw2	10	105	120	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	11	120	133	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	12	133	145	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		C/B	13	145	157	10YR4/6	Sandy Loam	Lamellae	
		C/B	14	157	173	10YR4/6	Sandy Loam	Lamellae	
		C/B	15	173	190	10YR4/6	Sandy Loam	Lamellae	
W	J11	Ap1/Ap2	1	9	17	10YR3/2	Silt Loam	Not Screened	***Datum 15 cmabgs**
		Ap1/Ap2	2	17	30	10YR3/2	Silt Loam		
		Ap1/Ap2	3	30	37	10YR3/2	Silt Loam		
		Ap1/Ap2	4	37	50	10YR3/2	Silt Loam		
		E	5	50	60	10YR4/3	Sandy Loam		
		E	6	60	70	10YR4/3	Sandy Loam		
		E	7	70	80	10YR4/3	Sandy Loam		
		Bw1	8	80	90	10YR4/4	Sandy Loam	Compact	
		Bw1	9	90	100	10YR4/4	Sandy Loam	Compact	
		Bw1	10	100	102	10YR4/4	Sandy Loam	Compact	
		Bw1	11	90	115	10YR4/4	Sandy Loam	Compact	
W	J11 (con't)	Bw2	12	115	125	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	13	125	135	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	14	135	145	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		C/B	15	145	157	10YR4/6	Sandy Loam	Lamellae	
		C/B	16	157	173	10YR4/6	Sandy Loam	Lamellae	
W	K11	Ap1/Ap2	1	17	22	10YR3/2	Silt Loam	Not Screened	***Datum 15 cmabgs**
		Ap1/Ap2	2	22	36	10YR3/2	Silt Loam		
		Ap1/Ap2	3	36	46	10YR3/2	Silt Loam		
		AE	4	46	56	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	5	56	66	10YR4/3	Sandy Loam		
		E	6	66	76	10YR4/3	Sandy Loam		
		E	7	76	86	10YR4/3	Sandy Loam		
		Bw1	8	86	88	10YR4/4	Sandy Loam	Compact	
		Bw1	9	88	99	10YR4/4	Sandy Loam	Compact	
		Bw1	10	99	103	10YR4/4	Sandy Loam	Compact	
		Bw2	11	103	113	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	12	113	124	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	13	124	137	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		C/B	14	137	147	10YR4/6	Sandy Loam	Lamellae	
		C/B	15	147	159	10YR4/6	Sandy Loam	Lamellae	
X	L12	Ap1	1	8	14	10YR3/2	Silt Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	14	27	10YR3/2	Silt Loam		
		Ap2	3	27	37	10YR3/2	Silt Loam		
		Ap2	4	37	47	10YR3/2	Silt Loam		
		AE	5	47	57	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	6	57	67	10YR4/3	Sandy Loam		
		Bw1	7	67	77	10YR4/4	Sandy Loam	Compact	
		Bw1	8	77	87	10YR4/4	Sandy Loam	Compact	
		Bw2	9	87	97	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	10	90	90	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		Bw2	11	90	105	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	12	90	105	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
X	M12	Ap1	1	17	21	10YR3/2	Silt Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	21	27	10YR3/2	Silt Loam		
		Ap2	3	27	37	10YR3/2	Silt Loam		
		Ap2	4	37	47	10YR3/2	Silt Loam		
		AE	5	47	57	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	6	57	67	10YR4/3	Sandy Loam		
		Bw1	7	67	77	10YR4/4	Sandy Loam	Compact	
		Bw1	8	77	87	10YR4/4	Sandy Loam	Compact	
		Bw2	9	87	97	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	10	97	107	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	11	107	107	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
		Bw2	12	107	114	10YR5/6 mottled w/10YR6/4	Sandy Loam	Compact	
Y	P22	Ap1	1	10	15	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	15	25	7.5YR3/1	Sandy Loam		
		Ap2	3	25	35	7.5YR3/2	Sandy Loam		
		Ap2	4	35	45	7.5YR3/2	Sandy Loam		
		AE	5	45	55	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
Y	P22 (con't)	AE	6	55	65	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		Bw1	7	65	75	7.5YR3/4	Sandy Loam		
		Bw1	8	75	85	7.5YR3/4	Sandy Loam		
		Bw1	9	85	95	7.5YR3/4	Sandy Loam		
		Bw2	10	95	105	7.5YR4/4	Loam		
		Bw2	11	105	115	7.5YR4/4	Loam		
		Bw2	12	115	125	7.5YR4/4	Loam		
		Bw2	13	125	135	7.5YR4/4	Loam		
		Bw2	14	135	145	7.5YR4/4	Loam		
		Bw2	15	145	157	7.5YR4/4	Loam		
		C/B	16	157	165	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
Y	Q22	Ap1	1	13	18	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	18	25	7.5YR3/1	Sandy Loam		
		Ap2	3	25	35	7.5YR3/2	Sandy Loam		
		Ap2	4	35	45	7.5YR3/2	Sandy Loam		
		AE	5	45	55	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	55	65	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		Bw1	7	65	75	7.5YR3/4	Sandy Loam		
		Bw1	8	75	85	7.5YR3/4	Sandy Loam		
		Bw1	9	85	95	7.5YR3/4	Sandy Loam		
		Bw2	10	95	105	7.5YR4/4	Loam		
		Bw2	11	105	115	7.5YR4/4	Loam		
		Bw2	12	115	125	7.5YR4/4	Loam		
		Bw2	13	125	135	7.5YR4/4	Loam		
		Bw2	14	135	145	7.5YR4/4	Loam		
		Bw2	15	145	155	7.5YR4/4	Loam		
Y	P23	Ap1	1	10	15	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	15	25	7.5YR3/1	Sandy Loam		
		Ap2	3	25	35	7.5YR3/2	Sandy Loam		
		Ap2	4	35	45	7.5YR3/2	Sandy Loam		
		AE	5	45	55	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	55	65	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		Bw1	7	65	75	7.5YR3/4	Sandy Loam		
		Bw1	8	75	85	7.5YR3/4	Sandy Loam		
		Bw1	9	85	95	7.5YR3/4	Sandy Loam		
		Bw2	10	95	105	7.5YR4/4	Loam		
		Bw2	11	105	115	7.5YR4/4	Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		Bw2	12	115	125	7.5YR4/4	Loam		
		Bw2	13	125	135	7.5YR4/4	Loam		
		Bw2	14	135	145	7.5YR4/4	Loam		
		Bw2	15	145	157	7.5YR4/4	Loam		
		C/B	16	157	165	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
Y	Q23	Ap1	1	11	16	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	16	25	7.5YR3/1	Sandy Loam		
		Ap2	3	25	35	7.5YR3/2	Sandy Loam		
		Ap2	4	35	45	7.5YR3/2	Sandy Loam		
		AE	5	45	55	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	6	55	65	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		Bw1	7	65	75	7.5YR3/4	Sandy Loam		
		Bw1	8	75	85	7.5YR3/4	Sandy Loam		
		Bw1	9	85	95	7.5YR3/4	Sandy Loam		
		Bw2	10	95	105	7.5YR4/4	Loam		
		Bw2	11	105	115	7.5YR4/4	Loam		
		Bw2	12	115	125	7.5YR4/4	Loam		
		Bw2	13	125	135	7.5YR4/4	Loam		
		Bw2	14	135	145	7.5YR4/4	Loam		
		Bw2	15	145	155	7.5YR4/4	Loam		
		C/B	16	155	165	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
Z	H26	Ap1	1	21	30	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap2	2	30	40	7.5YR3/2	Sandy Loam		
		Ap2	3	40	50	7.5YR3/2	Sandy Loam		
		AE	4	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	60	70	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	70	80	7.5YR4/3	Sandy Loam		
Z	H26 (con't)	Bw1	7	80	90	7.5YR3/4	Sandy Loam		
		Bw1	8	90	100	7.5YR3/4	Sandy Loam		
		Bw1	9	100	110	7.5YR3/4	Sandy Loam		
		Bw1	10	110	120	7.5YR3/4	Sandy Loam		
		Bw2	11	120	130	7.5YR4/4	Loam		
		Bw2	12	130	140	7.5YR4/4	Loam		
Z	I26	Ap1	1	21	30	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap2	2	30	40	7.5YR3/2	Sandy Loam		
		Ap2	3	40	50	7.5YR3/2	Sandy Loam		
		AE	4	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	60	70	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	70	80	7.5YR4/3	Sandy Loam		
		Bw1	7	80	90	7.5YR3/4	Sandy Loam		
		Bw1	8	90	100	7.5YR3/4	Sandy Loam		
		Bw1	9	100	110	7.5YR3/4	Sandy Loam		
		Bw1	10	110	120	7.5YR3/4	Sandy Loam		
		Bw2	11	120	130	7.5YR4/4	Loam		
		Bw2	12	130	140	7.5YR4/4	Loam		
		Bw2	13	140	150	7.5YR4/4	Loam		
		Bw2	14	150	160	7.5YR4/4	Loam		
		Bw2	15	160	170	7.5YR4/4	Loam		
		Bw2	16	170	180	7.5YR4/4	Loam		
		C/B	17	180	190	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
Z	H27	Ap1	1	18	30	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap2	2	30	40	7.5YR3/2	Sandy Loam		
		Ap2	3	40	50	7.5YR3/2	Sandy Loam		
		AE	4	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	60	70	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	70	80	7.5YR4/3	Sandy Loam		
		Bw1	7	80	90	7.5YR3/4	Sandy Loam		
		Bw1	8	90	100	7.5YR3/4	Sandy Loam		
		Bw1	9	100	110	7.5YR3/4	Sandy Loam		
		Bw1	10	110	120	7.5YR3/4	Sandy Loam		
		Bw2	11	120	130	7.5YR4/4	Loam		
		Bw2	12	130	140	7.5YR4/4	Loam		
		Bw2	13	140	150	7.5YR4/4	Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
Z	I27	Ap1	1	21	30	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap2	2	30	40	7.5YR3/2	Sandy Loam		
		Ap2	3	40	50	7.5YR3/2	Sandy Loam		
		AE	4	50	60	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		AE	5	60	70	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	6	70	80	7.5YR4/3	Sandy Loam		
		Bw1	7	80	90	7.5YR3/4	Sandy Loam		
		Bw1	8	90	100	7.5YR3/4	Sandy Loam		
		Bw1	9	100	110	7.5YR3/4	Sandy Loam		
		Bw1	10	110	120	7.5YR3/4	Sandy Loam		
		Bw2	11	120	130	7.5YR4/4	Loam		
		Bw2	12	130	140	7.5YR4/4	Loam		
		Bw2	13	140	150	7.5YR4/4	Loam		
		Bw2	14	150	160	7.5YR4/4	Loam		
		Bw2	15	160	170	7.5YR4/4	Loam		
		Bw2	16	170	180	7.5YR4/4	Loam		
		C/B	17	180	190	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
AA	D5	Ap2	1	10	20	10YR3/2	Silt Loam	Not Screened	***Datum 10 cmabgs**
		Ap2	2	20	30	10YR3/2	Silt Loam		
		AE	3	30	40	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	4	40	50	10YR4/3	Sandy Loam		
		Bw1	5	50	60	10YR4/4	Sandy Loam		
		Bw1	6	60	70	10YR4/4	Sandy Loam		
		Bw2	7	70	80	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	8	80	90	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	9	90	100	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		C/B	10	100	110	10YR4/3	Sandy Loam		
AA	D5 (con't)	C/B	11	110	120	10YR4/3	Sandy Loam		
		C/B	12	120	130	10YR4/3	Sandy Loam		
		C/B	13	130	140	10YR4/3	Sandy Loam		
		C/B	14	140	150	10YR4/3	Sandy Loam		
		C/B	15	150	165	10YR4/3	Sandy Loam		
AA	E5	Ap2	1	20	30	10YR3/2	Silt Loam	Not Screened	***Datum 10 cmabgs**
		Ap2	2	30	32	10YR3/2	Silt Loam		
		AE	3	32	40	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	4	40	50	10YR4/3	Sandy Loam		
		Bw1	5	50	60	10YR4/4	Sandy Loam		
		Bw1	6	60	70	10YR4/4	Sandy Loam		
		Bw2	7	70	80	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	8	80	90	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	9	90	100	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		C/B	10	100	110	10YR4/3	Sandy Loam		
		C/B	11	110	120	10YR4/3	Sandy Loam		
		C/B	12	120	130	10YR4/3	Sandy Loam		
		C/B	13	130	140	10YR4/3	Sandy Loam		
		C/B	14	140	150	10YR4/3	Sandy Loam		
		C/B	15	150	165	10YR4/3	Sandy Loam		
AA	D6	Ap2	1	10	20	10YR3/2	Silt Loam	Not Screened	***Datum 10 cmabgs**
		Ap2	2	20	30	10YR3/2	Silt Loam		
		AE	3	30	40	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	4	40	50	10YR4/3	Sandy Loam		
		Bw1	5	50	60	10YR4/4	Sandy Loam		
		Bw1	6	60	70	10YR4/4	Sandy Loam		
		Bw2	7	70	80	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	8	80	90	10YR5/6 mottled w/10YR6/4	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		Bw2	9	90	100	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		C/B	10	100	110	10YR4/3	Sandy Loam		
		C/B	11	110	120	10YR4/3	Sandy Loam		
		C/B	12	120	130	10YR4/3	Sandy Loam		
		C/B	13	130	140	10YR4/3	Sandy Loam		
		C/B	14	140	150	10YR4/3	Sandy Loam		
		C/B	15	150	165	10YR4/3	Sandy Loam		
AA	E6	Ap2	1	16	26	10YR3/2	Silt Loam	Not Screened	***Datum 10 cmabgs**
		Ap2	2	26	30	10YR3/2	Silt Loam		
		AE	3	30	40	10YR3/2 mottled w/10YR4/3	Sandy Loam		
		E	4	40	50	10YR4/3	Sandy Loam		
		Bw1	5	50	60	10YR4/4	Sandy Loam		
		Bw1	6	60	70	10YR4/4	Sandy Loam		
		Bw2	7	70	80	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	8	80	90	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		Bw2	9	90	100	10YR5/6 mottled w/10YR6/4	Sandy Loam		
		C/B	10	100	110	10YR4/3	Sandy Loam		
		C/B	11	110	120	10YR4/3	Sandy Loam		
		C/B	12	120	130	10YR4/3	Sandy Loam		
		C/B	13	130	140	10YR4/3	Sandy Loam		
		C/B	14	140	150	10YR4/3	Sandy Loam		
		C/B	15	150	165	10YR4/3	Sandy Loam		
BB	W40	Ap1	1	9	22	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	22	32	7.5YR3/1	Sandy Loam		
		Ap2	3	32	42	7.5YR3/2	Sandy Loam		
		AE	4	42	52	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	52	62	7.5YR4/3	Sandy Loam		
		Bw1	6	62	72	7.5YR3/4	Sandy Loam		
		Bw2	7	72	82	7.5YR4/4	Loam		
		Bw2	8	82	92	7.5YR4/4	Loam		
		Bw2	9	92	102	7.5YR4/4	Loam		
BB	W40 (con't)	Bw2	10	102	112	7.5YR4/4	Loam		
		Bw2	11	112	122	7.5YR4/4	Loam		
		Bw2	12	122	132	7.5YR4/4	Loam		
		C/B	13	132	142	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	14	142	152	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	152	162	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	16	162	172	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
BB	X40	Ap1	1	13	22	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	22	32	7.5YR3/1	Sandy Loam		
		Ap2	3	32	42	7.5YR3/2	Sandy Loam		
		AE	4	42	52	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	52	62	7.5YR4/3	Sandy Loam		
		Bw1	6	62	72	7.5YR3/4	Sandy Loam		
		Bw2	7	72	82	7.5YR4/4	Loam		
		Bw2	8	82	92	7.5YR4/4	Loam		
		Bw2	9	92	102	7.5YR4/4	Loam		
		Bw2	10	102	112	7.5YR4/4	Loam		
		Bw2	11	112	122	7.5YR4/4	Loam		
		Bw2	12	122	132	7.5YR4/4	Loam		
		C/B	13	132	142	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	14	142	152	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	152	162	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	16	162	172	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
BB	W41	Ap1	1	9	22	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	22	32	7.5YR3/1	Sandy Loam		
		Ap2	3	32	42	7.5YR3/2	Sandy Loam		
		AE	4	42	52	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	52	62	7.5YR4/3	Sandy Loam		

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
		Bw1	6	62	72	7.5YR3/4	Sandy Loam		
		Bw2	7	72	82	7.5YR4/4	Loam		
		Bw2	8	82	92	7.5YR4/4	Loam		
		Bw2	9	92	102	7.5YR4/4	Loam		
		Bw2	10	102	112	7.5YR4/4	Loam		
		Bw2	11	112	122	7.5YR4/4	Loam		
BB	X41	Ap1	1	9	22	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	22	32	7.5YR3/1	Sandy Loam		
		Ap2	3	32	42	7.5YR3/2	Sandy Loam		
		AE	4	42	52	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	52	62	7.5YR4/3	Sandy Loam		
		Bw1	6	62	72	7.5YR3/4	Sandy Loam		
		Bw2	7	72	82	7.5YR4/4	Loam		
		Bw2	8	82	92	7.5YR4/4	Loam		
		Bw2	9	92	102	7.5YR4/4	Loam		
		Bw2	10	102	112	7.5YR4/4	Loam		
		Bw2	11	112	122	7.5YR4/4	Loam		
		Bw2	12	122	132	7.5YR4/4	Loam		
		C/B	13	132	142	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	14	142	152	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	15	152	162	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
CC	E18	Ap1	1	9	20	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	20	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		AE	4	40	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	50	60	7.5YR4/3	Sandy Loam		
		Bw1	6	60	70	7.5YR3/4	Sandy Loam		
		Bw2	7	70	80	7.5YR4/4	Loam		
		Bw2	8	80	90	7.5YR4/4	Loam		
		Bw2	9	90	100	7.5YR4/4	Loam		
		Bw2	10	100	110	7.5YR4/4	Loam		
		C/B	11	110	120	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	12	120	130	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	13	130	140	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	

Appendix D
Reeders Creek West Excavation Log

Block	TU	Soil Horizon	Level	Opening	Closing	Munsell	Texture	Comments	Datum
CC	F18	Ap1	1	9	20	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	20	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		AE	4	40	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	50	60	7.5YR4/3	Sandy Loam		
		Bw1	6	60	70	7.5YR3/4	Sandy Loam		
		Bw2	7	70	80	7.5YR4/4	Loam		
		Bw2	8	80	90	7.5YR4/4	Loam		
		Bw2	9	90	100	7.5YR4/4	Loam		
		Bw2	10	100	110	7.5YR4/4	Loam		
		C/B	11	110	120	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	12	120	130	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
CC	E19	Ap1	1	11	20	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	20	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		AE	4	40	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	50	60	7.5YR4/3	Sandy Loam		
		Bw1	6	60	70	7.5YR3/4	Sandy Loam		
		Bw2	7	70	80	7.5YR4/4	Loam		
		Bw2	8	80	90	7.5YR4/4	Loam		
		Bw2	9	90	100	7.5YR4/4	Loam		
		Bw2	10	100	110	7.5YR4/4	Loam		
		C/B	11	110	120	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	12	120	130	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	13	130	140	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
CC	F19	Ap1	1	11	20	7.5YR3/1	Sandy Loam	Not Screened	***Datum 10 cmabgs**
		Ap1	2	20	30	7.5YR3/1	Sandy Loam		
		Ap2	3	30	40	7.5YR3/2	Sandy Loam		
		AE	4	40	50	7.5YR3/3 mottled w/10YR4/3	Sandy Loam		
		E	5	50	60	7.5YR4/3	Sandy Loam		
		Bw1	6	60	70	7.5YR3/4	Sandy Loam		
		Bw2	7	70	80	7.5YR4/4	Loam		
		Bw2	8	80	90	7.5YR4/4	Loam		
		Bw2	9	90	100	7.5YR4/4	Loam		
		Bw2	10	100	110	7.5YR4/4	Loam		
		C/B	11	110	120	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	
		C/B	12	120	130	10YR3/4 w/7.5YR3/4	Sandy Loam	Lamellae	

Appendix E: Floral Analysis Report

ANALYSIS OF ARCHAEOBOTANICAL SEED ASSEMBLAGES FROM SCUDDER FALLS BRIDGE: PENNSYLVANIA (36BU0379) AND NEW JERSEY (28Me360) SITES

William Hilgartner, PhD

The Johns Hopkins University
& Friends School, Baltimore, MD

28 December 2011

Prepared for
AECOM, Trenton, NJ

ABSTRACT

Twenty-two flotation samples of seeds plus 52 “additional” samples (primarily of carbonized hickory nut fragments) from the Pennsylvania site (36BU0379), and 28 flotation samples from the New Jersey Site (28Me360) were examined for identification and analysis. Attempts were made to identify all seeds to the species level; in some cases seeds could only be identified to a genus or type. Analysis of the species composition included determination of native versus non-native status, habitat preference and possible cultural use. The Pennsylvania samples contained 891 seeds of 20 species and a significant number of introduced, non-native species in each sample indicating a post-settlement age (ca. A.D. 1700 or more recent) of the samples, assuming no contamination from upper stratigraphic layers. The dominant species was lambs quarters (*Chenopodium album*), a native of Europe and Asia and was introduced during the colonial period. “Large *Chenopodium*” seeds were present in one sample; this is a species believed to be a Native American cultivar. Carbonized pignut hickory nut fragments (*Carya glabra*), both in association with *C. album,* indicate an early transition age perhaps A.D. 1650-1700. The “Additional Samples” from PA contained numerous carbonized *Carya glabra* nut fragments indicating cultural use of this species. Associated native species with the hickory material and absence of non-native species indicates a pre-settlement age for these additional samples.

A total of 441 seeds of a minimum of 11 species or taxa were identified from the New Jersey site. Seed origins (native vs. non-native) indicate that samples labeled NJ 1-4 and NJ 20 are post-settlement (post A.D. 1700), as represented by the presence of the introduced European species lambs quarters (*Chenopodium album*). *Chenopodium* does not occur in the other samples and this along with native species suggests that these levels are pre-contact or at least pre- A.D. 1700. The most abundant seed is blackberry in genus *Rubus* (*Rubus allegheniensis* type). The high abundance of this species throughout the series of samples, but particularly in post-contact levels suggests an important food source for local native populations as well as for Euro-Americans during the settlement period. Carbonized shells of pignut hickory (*Carya glabra*) occur in the lowest three levels, while uncarbonized shells of this species were important throughout the series of samples. Other important species that occur throughout pre- and post-settlement periods are wild grape (*Vitis aestivalis/labrusca*), pokeweed (*Phytolacca americana*) and an unknown mustard (*Brassica rapa* type). Seed determined dates (pre- or post-1700 AD) were compared to ^{14}C dates established for the sediment samples. Arboreal species other than *Carya* in PA and NJ samples represent nearby dispersal sources.

METHODS

Seeds isolated from sediment by AECOM were identified using a 20X-40X dissecting scope. Identifications were aided by the seed reference collection of William Hilgartner (210 species, 280 specimens) and various botanical and seed identification references (U of Illinois 1954; Martin and Barkley 1961; Musil 1963; Reed 1970; Renfrew 1973; Montgomery 1977). Seeds identified and counted from samples were placed back in original plastic bags to be returned to AECOM upon request.

Most of the seed identifications are diagnostic and are assigned with a high level of confidence. In cases where the seed resembles most closely the shape, structure and/or size of a species but where there is still uncertainty in the identification, the species is labeled as “type”, as in *Brassica rapa* type or *Rubus allegheniensis* type, and *genus* sp.

if the seed can be assigned to a genus but not species, for example *Viola* sp. (a violet species). Terminology follows Gleason and Cronquist (1991) except where indicated. Four tables summarizing species identified and seed numbers were constructed for this report. No attempt was made to place the abundances of these species in graph form without a full knowledge of chronological arrangement of the samples.

NOTES ON IMPORTANT SPECIES IN SAMPLES

Non-native Species - Indicators of post-settlement dates (post-1700 AD)

Chenopodium album – Lambsquarters or goosefoot has a distinctive round, black seed measuring 1.0-1.2 mm in diameter (W. Hilgartner Seed Collection; Montgomery 1977; Reed 1970). It is listed as Eurasian in origin and therefore a species introduced during the colonial or post-settlement period (Gleason and Cronquist 1991; USDA Plant Data Base; Crockett 1977). There are no records of when *Chenopodium* was introduced into the eastern US, or specifically the NJ/PA region. However, pollen and seed records from the Chesapeake Bay area and southern PA (Hilgartner and Brush 2006; Brush 1986) indicate a sudden rise in ragweed and other agricultural species where *Chenopodium* is most commonly found, at around 1730, ± 20 years. Thus it is suggested here that the first appearance of *Chenopodium album* in a stratigraphic sequence represents the date of A.D.1700 and samples containing this species would be post-1700.

Mollugo verticillata – Carpetweed has a tiny, round seed 0.6 mm with distinctive ridges. It is native to tropical America and is believed to have been introduced into temperate North America (Gleason and Cronquist 1991). Therefore it's presence in sediments indicates a post-settlement age.

The *Brassica rapa* type seed matches the size of *Lepidium campestre,* a mustard but the reticulate or honeycomb surface markings are much finer in the fossil seed. These reticulations resemble closely *Brassica rapa* but the *Brassica* seed is considerably larger. This seed is most likely assigned to a species of mustard but awaits further discovery of identification. This species is probably a non-native weed because it consistently co-occurs with *Chenopodium album* and is absent in deeper stratigraphic levels.

Cultivars and Native Species Utilized

Carya glabra – The carbonized and non-carbonized nut fragments in these samples are consistent with pignut hickory in seed morphology and thickness. They differ considerably from other hickory nut morphologies so the identification of *Carya glabra* is with a high degree of confidence.

Large *Chenopodium* – is a glossy black, chenopod seed 1.7 to 2.2 mm in length, considerably larger than *Chenopodium album* (1.2 mm). Several large-seeded Chenopods have been described as cultivars from prehistoric sites in North America. One species, *Chenopodium bushianum* var. *jonesianum* is found in eastern woodlands and is believed to be an extinct cultivar (DeFant 1997; Smith 1989). Without comparative material other then similar seeds from samples from other archaeological sites (Hilgartner 1999a; 2000; 2008) this cultivar identity is tentative but remains a strong possibility.

Rubus allegheniensis type can refer to several species of *Rubus* that exist which have similar seed morphologies. This seed is tentatively assigned to *R. allegheniensis* because of size, general morphologic similarity and probability of occurrence.

Vitus aestivalis/labrusca – The seed morphology and size (5.0 mm) is consistent with both species, *V. aestivalis* or summer grape and *V. labrusca* or fox grape. It is established that these species were used by prehistoric populations throughout the northeast (Crockett 1977).

Portulaca oleracea – Purslane seeds have a distinctive tapered and ridged seed 0.8 mm in length. This species is listed in most texts as a non-native being Eurasian in origin, but fossil evidence indicates that this species is native at least since the early 15th century (Byrne and McAndrews 1975). Hence, its presence along with *Chenopodium* and *Mollugo* indicates an open, field environment but should not be used as an indicator of post-settlement age.

RESULTS

Pennsylvania Site (36BU0379)

The Pennsylvania samples (PA1-PA16) contained a total of 845 identified seeds of 18 species and a significant number of introduced, non-native species in each sample (TABLE 1). These indicate a post-settlement age (ca. A.D. 1700 or more recent) of the samples, assuming no contamination from upper layers (see further discussion of contamination under the heading Problem with Chronostratigraphy below). The dominant species lambs quarters (*Chenopodium album*) with 618 seeds or 73% of total seeds is native to Europe and was introduced during the colonial period. This species though a weedy plant, has been used by Europeans in archaeological sites for a source of gruel for centuries (Renfrew 1973). It was a common constituent of the stomach contents of 2000 year old bog bodies (Crockett 1977). There is evidence that this species was an important camp-follower for Northeastern U.S. Indian tribes during the early contact period in the 17th and 18th centuries (Feest 1978; Smith 1992; DeFant 1997). The presence of seeds of *Chenopodium* in these samples suggests that the calcium oxalates reported to AECOM by Logan et al. (2011) are derived from this species. *Chenopodium* is one of the species listed as a possible source of the calcium oxalate.

The abundance of other non-native species in PA1-PA16 further suggests a post-settlement date for these samples. However, wild grape (*Vitis aestivalis/labrusca*) is in high enough numbers (4.3% of total seeds) to have been utilized as a source of food either by Native Americans or early European colonists. In non-cultural sediments only single seeds of *Vitis* are generally encountered (Hilgartner, pers. obs.). The presence of tulip tree (*Liriodendron tulipifera)* seeds in these samples is not unexpected since this species produces abundant widely-dispersed seeds which occur in many regional sedimentary deposits (Hilgartner pers. obs.). The source trees could have been located 50 meters or more away from the archaeological site.

The 2nd set of samples from PA (PA17-PA22) contained an additional 46 seeds of 9 species with *Chenopodium album* representing 28.3% of all seeds (TABLE 2). One sample (PA20) contained 3 “Large *Chenopodium*” seeds, a species believed to be a Native American cultivar, and carbonized pignut hickory nut fragments (*Carya glabra*),

both in association with *C. album,* indicating an early transition age perhaps A.D. 1650-1700. The addition of a high number of carpetweed *Mollugo verticillata* (19.6% of seeds) further supports a post-contact age for these samples. The addition of Purslane (*Portulaca oleracea)* provides support that this environment was an open, agricultural or weedy environment.

The "Additional Samples" from Pennsylvania contained numerous carbonized *Carya glabra* nut fragments indicating cultural use of this species and a pre-settlement (pre-1700) date (TABLE 3). The associated native species wild grape and pokeweed and absence of *Chenopodium* and other non-native species further indicate a pre-settlement age for these additional samples.

New Jersey Site (28Me360)

A total of 441 seeds of a minimum of 11 species or taxa were identified from the New Jersey site (TABLE 4; FIGURES 1&2). Seed origins (native vs. non-native) indicate that samples labeled NJ 1-4 and NJ 20 are post-settlement (post A.D. 1700), as represented by the presence of the introduced European species lambs quarters or goosefoot (*Chenopodium album*). *Chenopodium* does not occur in the other samples and this along with associated native species suggests that these levels are pre-settlement (pre-A.D. 1700). The most abundant seed (221 seeds or 50% of all seeds) is that of blackberry or black raspberry in genus *Rubus* (*Rubus allegheniensis* type). The high abundance of this genus throughout the series of samples as well as in post-contact levels, suggests an important food source for both local native populations and Euro-Americans during the settlement period. Indian populations throughout the northeast used blackberry as a food and Peter Kalm reported in the 18th c., that "They grow about the fields…abundantly, and have a very agreeable taste" (Crockett 1977). Carbonized shells of pignut hickory (*Carya glabra*) occur in the lowest three levels, while uncarbonized shells of this species were important throughout the series of samples. Other important species that occur throughout pre- and post-settlement periods are wild grape (*Vitis aestivalis/labrusca*), pokeweed (*Phytolacca americana*) and the unknown mustard (*Brassica rapa* type).
This summary is an update from an earlier preliminary report on the NJ material submitted to AECOM on 9 October 2011.

Problem With Chronostratigraphy

Seed-determined dates (pre- or post-1700 AD) were compared to ^{14}C dates established for the sediment samples by AECOM (TABLE 4). Discrepancies occur in NJ1- NJ4 and NJ20, in which the presence of *Chenopodium album* a post-1700 non-native species, occurs in sediments that have radiocarbon dates of A.D. 520-640 for NJ1-NJ3, 320-210 BC for NJ4 and A.D. 1040-1220 for NJ20 (FIGURE 2). Possible explanations for these dating discrepancies are 1). There has been some contamination from modern, surface samples, into lower stratigraphic layers, 2). The ^{14}C dates are in error because of sampling mistakes or are possibly too recent for accurate dating,or 3). *Chenopodium album* is not a new introduction into the New World since settlement but rather has been a native species, contrary to all published reports. The science and taxonomy surrounding *Chenopodium* in North America has been somewhat confused by the persistence of several varieties which might be separate species, interacting crop and weed populations in which the crop species produce larger, thinner seeds, and possibly extinct cultivated varieties (DeFant 1997; Gremillion 1993; Smith 1989). Certainly dating

the seeds themselves using AMS dates would address the age of the seeds and help clarify this discrepancy. If this isn't possible the samples named here (NJ1-4, NJ20) might have to be disregarded in the final analysis of the project report.

DISCUSSION/INTERPRETATION

Seeds from the PA and NJ sites represent primarily weedy species typical of agricultural fields and disturbed sites, but contain important cultural species, i.e. pignut hickory, blackberry or raspberry, wild grape, and possibly a cultivated *Chenopodium*. The hickory nuts are mostly carbonized while the other species were used without cooking. Hickory, blackberry and grape would all have been gathered in a near by woodland. Weedy species typical of fields and waste places include lambs quarters, a mustard (*Brassica rapa type)*, purslane, carpetweed, poke weed, and a *Polygonum*. *Rubus* is a small shrub which can occur along fence rows and wood edges as well as open areas and produces fruit in mid-summer. *Chenopodium* seeds and hickory nuts are produced in late summer/early fall while *Brassica (*mustard*)* seeds are produced in spring, so no seasonal preference for use or occupation is indicated. Seeds of *Liriodendron* and sycamore (*Platanus occidentalis)* are widely dispersed from their source and their occurrence in these samples represents a more distant location from a nearby woodland and riparian site. Most of the weedy species in these samples are generally dropped within a few meters of the source plants (Hilgartner, unpublished data) and represent local populations. The exception would be *Rubus* which undoubtably was gathered by human populations, since as many as 59 seeds occurred in one sample (NJ-3). This author (Hilgartner) has never seen more than 2-3 seeds of *Rubus* in any one sample as a result of natural dispersal. Likewise, the presence of so many hickory nuts (*Carya glabra*), including carbonized shells indicate prehistoric human use of this species.

It is notable that most of the dominant species at Scudder Falls are among the dominant species at other prehistoric and post-settlement sites in Pennsylvania (Reports to A.D. Marble and Company, Hilgartner 1999a; 1999b; 2000; 2008). As mentioned in these previous reports, the persistent occurrence of these species in each of these sites and their occurrence in many other prehistoric sites in Eastern North America provide the best interpretation that these are culturally associated. Obtaining AMS dates on the seeds of weedy species, particularly *Chenopodium album*, would be an important step in establishing the native/non-native status of these species and the reliability of their use as a chronostratigraphic tool.

REFERENCES

Brush, G.S. 1986. Geology and paleoecology of Chesapeake Bay: a long-term monitoring tool for management. Journal of Washington Academy of Sciences 76:146-160.

Byrne, R. and J. McAndrews. 1975.Pre-Columbian purslane (*Portulaca oleracea* L) in the New World. Nature 253:726-727.

Crockett. L. 1977. Wildly Successful Plants: A Handbook of North American Weeds. Macmillan co., Inc. 268 pages.

DeFant, D.G. 1997. New World domesticates of the genus *Chenopodium*. Southern Illinois University Carbondale Ethnobotanical Leaflets: http://www.siu.edu/~ebl/

Feest, C.F. 1978. North Carolina Algonquians, pages 271-289 *in* Handbook of North American Indians, Northeast, W.C. Sturtevant, ed. Smithsonian Institution, Washington, D.C.

Gleason, H. and A. Cronquist. 1991. Manual of Vascular Plants, 2nd Edition. The New York Botanical Garden. 993 pages.

Gremillion, K. 1993. Crop and weed in prehistoric eastern North America: The *Chenopodium* example. American Antiquity 58(3):496-509.

Hilgartner, W.B. 2008. Report to A.D. Marble on archaeobotanical seed assemblage from the Neshaminy Creek Site.

Hilgartner, W.B. 2000. Report to A.D. Marble on archaeobotanical seed assemblage from the Middle Creek Bridge Site.

Hilgartner, W.B. 1999a. Report to A.D. Marble on identification of macrofossils from Bieber Field Site, PA

Hilgartner, W.B. 1999b. Report to A.D. Marble on archaeobotanical seed assemblage from the Athens Bridge Site.

Hilgartner, W.B. and Brush G.S. 2006. Prehistoric habitat stability and post-settlement habitat change in a Chesapeake Bay freshwater tidal wetland, USA.The Holocene 16(4):479-494.

Logan, M., C. Yost, R. Varney and M. Murphy. 2011. Phytolith, starch, and organic residue (FTIR) analysis of samples from the River Road Site (36BU0379), Bucks County, Yardley, Pennsylvania. PaleoResearch Institute Technical Report 11-18.

Martin, A.C. and W.D.Barkley 1961. Seed identification manual. U. of California Press.

Montgomery, F.H. 1977. Seeds and fruits of plants of eastern Canada and northeastern U.S. U. of Toronto press.

Musil, A.F. 1963. Identification of crop and weed seeds. U.S. Dept. of Agriculture Handbook No.219.

Reed, C. 1970. Common Weeds of the United States. Dover Pub.

Smith, B. 1992. Prehistoric plant husbandry in Eastern North America, pages 101-119 *in* The Origins of Agriculture: An International Perspective, C.W. Cowan and P.J. Watson, eds. Smithsonian Institution, Washington, D.C. 224 pages.

Smith, B. 1989. Origins of agriculture in Eastern North America. Science, 246:1566-1571.

Renfrew, J.M. 1973. Paleoethnobotany: The prehistoric food plants of the Near East and Europe. Columbia University Press.

University of Illinois. 1954. Weeds of the North Central States. North central regional publication No. 36, circular 718 of the U. of Illinois.

TABLE LEGENDS

TABLE 1. Seed numbers of species identified plus non-seed and unidentified material from Samples PA1 to PA16.

TABLE 2. Seed numbers of species identified from Samples PA17 to PA22. Plus sign means seed fragments of additional seeds are present. * Purslane is listed in most references as a non-native but fossil evidence provides a Pre-Columbian date for its occurrence (see text).

TABLE 3. Fragment samples from Additional Floral Samples.

TABLE 4. Seed numbers of species identified plus non-seed and unidentified material from Samples NJ1 to NJ28.

FIGURE LEGENDS

FIGURE 1. Seed numbers through time of four dominant native species in the New Jersey Site. Radiocarbon dates (^{14}C dates supplied by AECOM) on the Y-axis, raw seed numbers summed for samples within the time period (data in TABLE 4) on the X-axis. *Carya, Rubus* and *Vitis* are culturally associated. *Phytolacca* is a native species that may have been of some importance to native populations.

FIGURE 2. Seed numbers through time of two dominant introduced species in the New Jersey Site. Radiocarbon dates (^{14}C dates supplied by AECOM) on the Y-axis, raw seed numbers summed for samples within the time period (data in TABLE 4) on the X-axis. *Chenopodium* and *Brassica* are introduced species that indicate a post-settlement (post-1700 AD) date, revealing a discrepancy between seed dates and ^{14}C dates where these two species occur. Note abundance of these species in the A.D. 520-640 date. See text for further discussion of this discrepancy.

		TABLE 3															
		Scudder Falls															
		Additional Floral Samples															Totals
			Catalog/Sample	228	234	242	263	272	273	277	575.1	575.11	575.15	575.19	575.21	576.27	
		Carbonized Carya glabra	Pignut Hickory				2				1	1	1	1	1	1	8
		Vitus aestivalis	Wild Grape	3		2		1									6
		Phytolacca americana	Poke weed		1				2	1							4
		Unknown		1													1
			Catalog/Sample	576.28	576.31	576.32	576.36	576.38	576.41	576.43	576.45	576.48	576.49	576.5	576.51	576.52	
		Carbonized Carya glabra	Pignut Hickory	1	1	1	1	1	1		1	1	1	1	1	1	12
		Vitus aestivalis	Wild Grape														
		Phytolacca americana	Poke weed														
		Unknown								1							1
			Catalog/Sample	576.53	576.55	576.57	576.59	576.6	576.63	576.68	576.69	576.73	577.106	578.137	578.141	578.148	
		Carbonized Carya glabra	Pignut Hickory	1	1	1	1	1	1	1	1	1	1	1	1	1	13
		Vitus aestivalis	Wild Grape														
		Phytolacca americana	Poke weed														
		Unknown															
			Catalog/Sample	578.149	578.153	579.169	579.179	580.192	580.193	580.202	580.203	580.209	601	602	603	605	
		Carbonized Carya glabra	Pignut Hickory	1	1	1	1	1	1	1	1	1	1	1	2	1	14
		Vitus aestivalis	Wild Grape														
		Phytolacca americana	Poke weed														
		Unknown															

		TABLE 4																				
								Early														
		Scudder Falls Seeds	Periods AECOM		Mid Woodland			Woodland	Late Archaic			Late Archaic										
		New Jersey	C14 Dates AECOM		520-640 AD			320-210 BC	1880-1690 BC			1330-1120 BC										
			Date Indicated by Seed		**post - 1730 AD**			**Post-1730**	**Pre-1730 AD**			**Pre-1730 AD**										
		Level			4	5	4	7	8	9	9	10	10	12	11	12	7	11	10	11	11	12
		Sample #			NJ 1	NJ 2	NJ 3	NJ 4	NJ 5	NJ 6	NJ 7	NJ 8	NJ 9	NJ 10	NJ 11	NJ 12	NJ 13	NJ 14	NJ 15	NJ 16	NJ 17	NJ 18
		Species		Native/Nonnative Status																		
		Rubus allegheniensis type	blackberry	native	47	12	59	50	1	3				1				3	1	1	5	
		Brassica rapa type	mustard	uncertain		4	45	5												1	1	
		Chenopodium album	lambs quarters	nonnative		1	27	7														
		carbonized Chenopodium		nonnative		1	7															
		Phytolacca americana	pokeweed	native		1	3	1	1		1	1				3						1
		Vitis aestivalis/labrusca	wild grape	native				3			1	3	2	2	1	4	1	6		2	1	6
		Persicaria pennsylvanica	PA knotweed	native			1															
		Lg. Trig. Polygonum																				
		Scirpus sp.	sedge	native							1											
		Sambucus canadensis	elderberry	native	2																	
		Liriodendron tulipifera	tulip tree	native				7	1												1	
		Carya glabra	pignut hickory	native				2	1	3	1				3		1		1		1	
		charred Carya glabra	pignut hickory	native																		
		Robinia pseudoacacia	black locust	native		1																
		charred seed								1												1
		unknown						2	1											1	2	
					49	20	142	77	5	7	4	4	2	3	4	7	2	9	2	5	11	8
		Total Seeds			49	20	142	77	5	7	4	4	2	3	4	7	2	9	2	5	11	8
		Other Organic Material																				
		invertebrate/insect egg case					5	8														
		beetle wing (elytra)																				
		fungal cases?																				
		antheads					92															
		Charcoal																				
		Bone?																				

		TABLE 4 CONTINUED							Late								
					Late Woodland				Woodland		Late Archaic						
					1040-1220 AD				1390-1430 AD		3180-3150 BC						
						Post-1730			**Pre-1730**		**Pre-1730**			**Pre-1730**			
		Level			4	5	6	7	4	4	12	13	14	5	Total	Percent	
		Sample #			NJ 19	NJ 20	NJ 21	NJ 22	NJ 23	NJ 24	NJ 25	NJ 26	NJ 27	NJ 28	Seeds	of Seeds	**Species**
		Species		Native/Nonnative Status													
		Rubus allegheniensis type	blackberry	native	3	9	11	6		3				6	183	51.3	*Rubus allegheniensis type*
		Brassica rapa type	mustard	uncertain		3	4			2				3	56	15.8	*Brassica rapa type*
		Chenopodium album	lambs quarters	nonnative		4									35	9	*Chenopodium album*
		carbonized Chenopodium		nonnative											8	1.9	*carbonized Chenopodium*
		Phytolacca americana	pokeweed	native	2	1	2	1							12	4.2	*Phytolacca americana*
		Vitis aestivalis/labrusca	wild grape	native	3		1	1		1					32	8.8	*Vitis aestivalis/labrusca*
		Persicaria pennsylvanica	PA knotweed	native											1	0.2	*Persicaria pennsylvanica*
		Lg. Trig. Polygonum				1									0	0.2	*Lg. Trig. Polygonum*
		Scirpus sp.	sedge	native											1	0.2	*Scirpus sp.*
		Sambucus canadensis	elderberry	native											2	0.4	*Sambucus canadensis*
		Liriodendron tulipifera	tulip tree	native											9	2.1	*Liriodendron tulipifera*
		Carya glabra	pignut hickory	native	2	2	1								13	4.1	*Carya glabra*
		charred Carya glabra	pignut hickory	native							2	2	2		0	1.4	*charred hickory*
		Robinia pseudoacacia	black locust	native											1	0.2	*Robinia pseudoacacia*
															353		
		charred seed				2?			1								charred seed
		unknown						2	1					2			unknown
					10	20	19	10	2	6	2	2	2	11			
		Total Seeds			10	20	19	10	2	6	2	2	2	11			
		Other Organic Material															
		invertebrate/insect egg case			4	4	6	1						2			invertebrate/insect egg case
		beetle wing (elytra)															beetle wing (elytra)
		fungal cases?												3			fungal cases?
		antheads															antheads
		Charcoal							1								Charcoal
		Bone?							2								Bone?

FIGURE 1

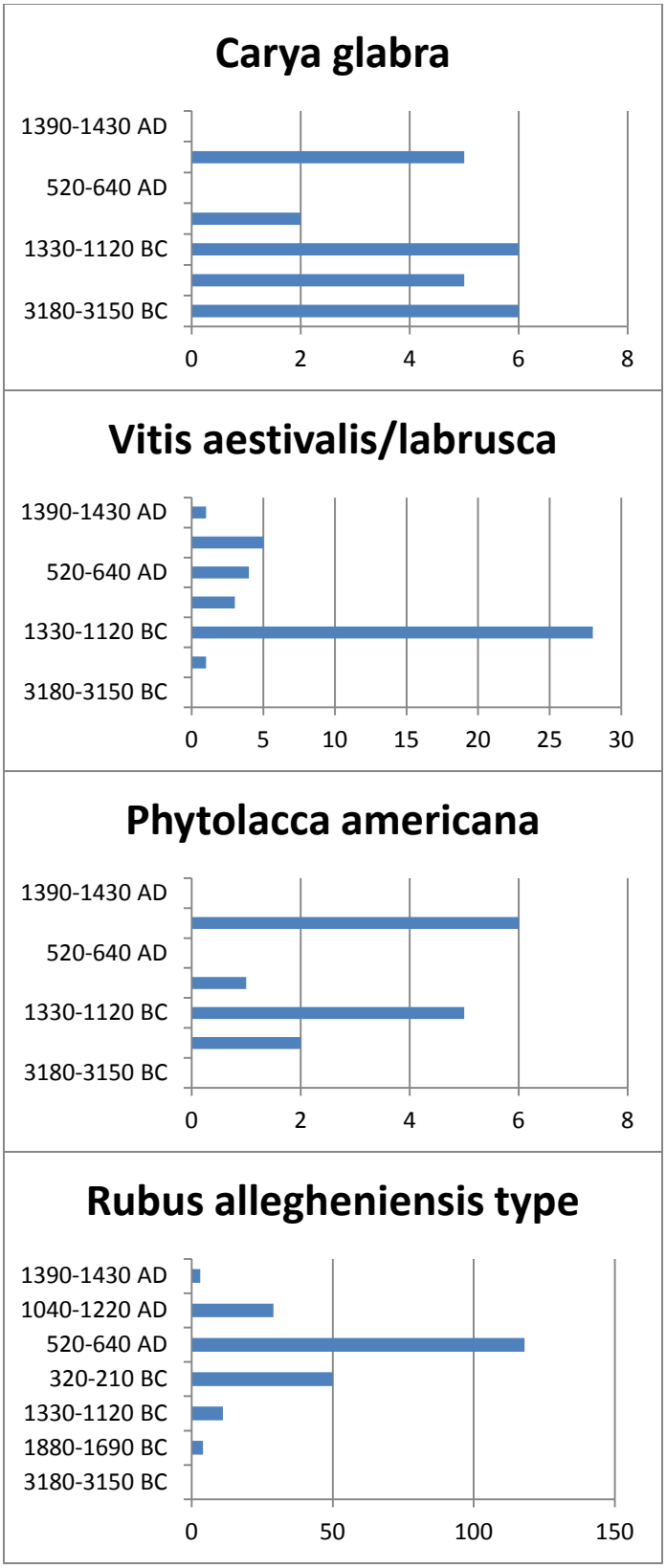
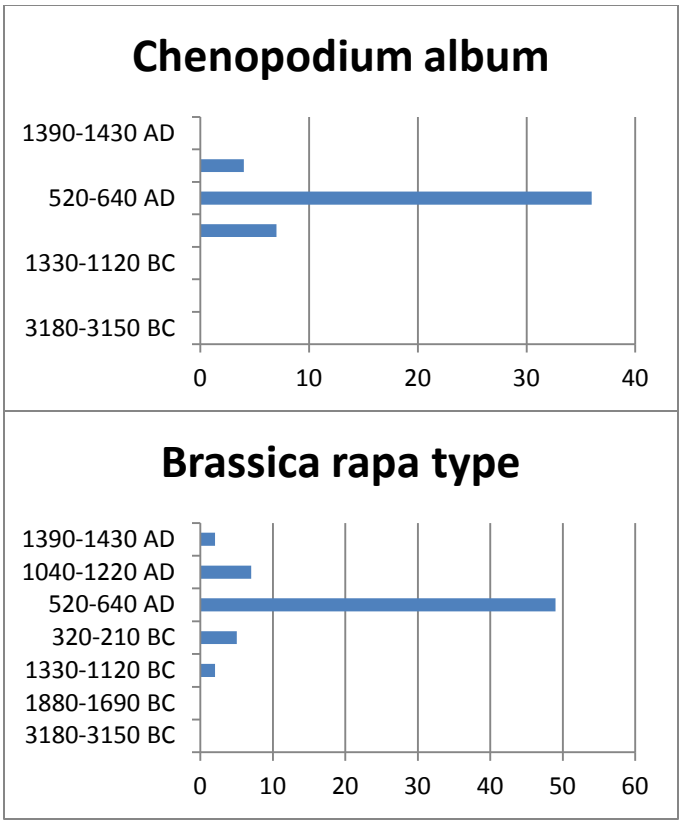

Carya glabra
1390-1430 AD
520-640 AD
1330-1120 BC
3180-3150 BC
0
2
4
6
8
Vitis aestivalis/labrusca
1390-1430 AD
520-640 AD
1330-1120 BC
3180-3150 BC
0
5
10
15
20
25
30
Phytolacca americana
1390-1430 AD
520-640 AD
1330-1120 BC
3180-3150 BC
0
2
4
6
8
Rubus allegheniensis type
1390-1430 AD
1040-1220 AD
520-640 AD
320-210 BC
1330-1120 BC
1880-1690 BC
3180-3150 BC
0
50
100
150

FIGURE 2


Chenopodium album
1390-1430 AD
520-640 AD
1330-1120 BC
3180-3150 BC
0
10
20
30
40
Brassica rapa type
1390-1430 AD
1040-1220 AD
520-640 AD
320-210 BC
1330-1120 BC
1880-1690 BC
3180-3150 BC
0
10
20
30
40
50
60

Appendix F: PaleoResearch FTIR, Protein Residue, and Pollen Analysis Reports

ORGANIC RESIDUE (FTIR) ANALYSIS OF CERAMIC SHERDS AND PROTEIN RESIDUE ANALYSIS OF LITHIC TOOLS FROM THE REEDERS CREEK WEST SITE (28ME360), MERCER COUNTY, NEW JERSEY

By

Melissa K. Logan
and
Chad Yost

With assistance from
R. A. Varney,
Mikaela Murphy,
and
Janet C. Niessner

PaleoResearch Institute
Golden, Colorado

PaleoResearch Institute Technical Report 11-041

Prepared for

AECOM
Trenton, New Jersey

October 2011

INTRODUCTION

Three ceramic sherds and four lithic tools from the Reeders Creek West site (28ME360) in Mercer County, New Jersey, were submitted for organic and protein residue analysis. The samples were tested for organic residues using Fourier Transfer Infrared Spectroscopy (FTIR). Protein residue analysis was conducted using cross-over immunoelectrophoresis (CIEP). Organic residue analysis was used to identify foods cooked in the vessels represented by these sherds. Protein residue analysis was used to identify animal resources that may have been processed using the lithic tools submitted for analysis.

METHODS

Protein Residue

The artifacts submitted for protein residue analysis were tested using an immunologically-based technique referred to as cross-over immunoelectrophoresis (CIEP). This method is based on an antigen-antibody reaction, where a known antibody (immunoglobulin) is used to detect an unknown antigen (Bog-Hansen 1990). Antigens are usually proteins or polysaccharides. The method for CIEP is based on forensic work by Culliford (1964; 1971) with changes made by Newman (1989) following the procedure used by the Royal Canadian Mounted Police Serology Laboratory in Ottawa, and the Centre of Forensic Sciences in Toronto. Further changes were made at the PaleoResearch Institute following the advice of Dr. Richard Marlar of the Thrombosis Research Laboratory at the Denver VA Medical Center and the University of Colorado Health Sciences Center. Although several different protein detection methods have been employed in archaeological analyses, including enzyme-linked immunosorbant assay (ELISA) and radioimmune assay (RIA), the CIEP test has been found to be extremely sensitive, with the detection of 10^{-8} g of protein possible (Culliford 1964:1092). The specificity of CIEP is further strengthened by testing unknowns against non-immunized animal serum and the use of soil controls to eliminate the possibility of false positives due to non-specific protein interactions.

Ancient protein residues are sometimes preserved and have been detected on stone tools of considerable age using CIEP (Gerlach et al. 1996; Hogberg et al. 2009; Kooyman et al. 2001; Seeman et al. 2008; Yost and Cummings 2008). In one of the largest samples of reactive protein residues from an archaeological site, Gerlach et al. (1996) report a total of 45 positive reactions obtained on 40 of the 130 stone tools tested from an early North American Paleoindian site (ca. 11,200-10,800 years BP).

In an archaeological context, an antigen is the unknown protein adhering to an artifact after its use. Ancient proteins undoubtedly break down into small fragments over time; however, antibodies can recognize small regions of antigens (Marlar et al. 1995). Studies by Loy (1983) and Gurfinkel and Franklin (1988) suggest that hemoglobin and other proteins bind to soil and clay particles through electrostatic interactions, and these interactions protect the proteins from microbial attack and removal by groundwater. Sensabaugh (1971) reported that dried blood proteins "covalently cross-linked to form a single proteinaceous mass with a high molecular weight, resulting in decreased solubility." Hyland et al. (1990:105) suggest that protein molecules may be conjoined with fatty tissues, resulting in an insoluble complex that is

secure against dissolution by water. These studies may explain, in part, mechanisms for prolonged protein preservation and adherence to stone surfaces; however, they also illustrate the challenges of recovery from artifact surfaces.

The artifacts were washed using 1-2 ml of a solution of 0.02M Tris hydrochloride, 0.5M sodium chloride, and 0.5% Triton X-100. The artifacts were placed in an ultrasonic bath for 30 minutes, on a rotating mixer for 30 minutes, then in the ultrasonic bath for an additional 30 minutes. Because soils contain compounds such as bacteria and animal feces that can cause false positive results for artifacts buried in the soil, control samples also were tested. One gram of soil associated with each artifact was added to 1 mL of the Tris/NaCl/Triton solution, then refrigerated for several days prior to testing.

The residues extracted from the artifacts and the soil controls first were tested against pre-immune goat serum (serum from a non-immunized animal) to detect non-specific binding of proteins. Samples testing negative against pre-immune serum were then tested against prepared animal antisera obtained from ICN Pharmaceuticals, Inc. and Sigma Chemical Company, and against antisera raised under the direction of Robert Sargeant in Lompoc, California, and of Dr. Richard Marlar. Appropriate positive and negative controls were run for each antiserum. A positive control consists of the blood of an animal for which the antiserum is known to test positively, and a negative control consists of the serum/blood of the animal in which the antiserum was raised, either rabbit or goat.

CIEP was performed using agarose gel as the medium. Two holes were punched in the gel about 5 mm apart. The protein extract from each artifact was placed in the cathodic well and the antiserum was placed in the anodic well. The sample was electrophoresed in Barbital buffer (pH 8.6) for 45 minutes at a voltage of 130v to drive the antigens and antibodies towards each other. Positive reactions appeared as a line of precipitation between the two wells. The gels were stained with Coomassie Blue to make the precipitate line easier to see. Samples with initial positive reactions were re-tested with dilute antisera, usually 1:10 or 1:20, to distinguish between true and false positives, to increase specificity, and to replicate the initial positive reaction. Positive reactions obtained after this second test then were reported.

Identification of animals represented by positive results is usually made to the family level. All mammalian species have serum protein antigenic determinations in common; therefore, some cross-reactions will occur between closely and sometimes distantly related animals (Gaensslen 1983:241). For example, bovine antiserum will react with bison blood, and deer antiserum will react with other members of the Cervidae (deer) family, such as elk and moose.

FTIR (Fourier Transform Infrared Spectroscopy)

A mixture of chloroform and methanol (CHM) was used as a solvent to remove lipids and other organic substances that had soaked into the surface of the ceramic. This mixture is represented in the FTIR graphics as CHM. The CHM solvent and sample were placed in a glass container, and allowed to sit, covered, for several hours. After this period of time, the solvent was pipetted into an aluminum evaporation dish, where the CHM was allowed to evaporate. This process leaves the residue of any absorbed chemicals in the aluminum dishes. The residue remaining in the aluminum dishes was then placed on the FTIR crystal and the spectra were collected. The aluminum dishes were tilted during the process of evaporation to

separate the lighter from the heavier fraction of the residue. The lighter and heavier fractions are designated upper and lower, respectively, in the subsequent analysis.

FTIR is performed using a Nicolet 6700 optical bench with an ATR and a diamond crystal. The sample is placed in the path of a specially encoded infrared beam, which passes through the sample and produces a signal called an “inferogram.” The inferogram contains information about the frequencies of infrared that are absorbed and the strength of the absorptions, which is determined by the sample’s chemical make-up. A computer reads the inferogram and uses Fourier transformation to decode the intensity information for each frequency (expressed as wave numbers) and presents a spectrum.

FTIR (FOURIER TRANSFORM INFRARED SPECTROSCOPY) REVIEW

Infrared spectroscopy (IR) is the study of how molecules absorb infrared radiation and ultimately convert it to heat, revealing how the infrared energy is absorbed, as well as the structure of specific organic molecules. Infrared spectroscopy has been experiencing a renaissance for identifying organic substances during the past few decades. It is currently considered one of the more powerful tools in organic and analytical chemistry. One of the primary advantages to FTIR is that it measures all wave lengths simultaneously. It has a relatively high signal-to-noise ratio and a short measurement time. Each peak in the spectrum represents either a chemical bond or a functional group.

Since molecular structures absorb the vibrational frequencies or wavelengths of infrared radiation, the bands of absorbance can then be used to identify the composition of the materials under study. In the case of the current research, the portion of the electromagnetic spectrum between 4000 and 400 wave numbers is used for identifying organic materials. Carbohydrates, lipids, proteins, and other organic molecules are associated with specific wave number bands (Isaksson 1999:36-39).

The infrared spectrum can be divided into two regions: the functional group region and the fingerprint region. These two groups are recognized by the effect that infrared radiation has on the respective molecules of these groups. The functional group region is located between 4000 and approximately 1500 wave numbers. The molecular bonds display specific characteristic vibrations that identify fats, lipids, waxes, lignins, proteins, carbohydrates, etc. The fingerprint region, located below 1500 wave numbers, is influenced by bending motions, which further identify the molecules present.

Using FTIR, it is possible to identify different types of organic compounds and eventually recognize different types of materials such as plant or animal fats or lipids, plant waxes, esters, proteins, carbohydrates, and more. Specific regions of the spectrum are important in identifying these compounds.

The results of the identification of specific wavelengths can be compared with commercial or laboratory-created analytical standards to identify the specific types of bonds present in different materials. By combining the results of the analysis of individual samples with all of the reference materials in the PaleoResearch Institute (PRI) library, the percent match with individual reference items can be displayed. For instance, plant lipids or fats are

identifiable between 3000 and 2800 wave numbers. A match might be obtained on this portion of the spectrum with nuts such as hickory, walnut, or acorn, or with animal fats or corn oil. Recovery of high-level matches with several types of nuts (in this example) indicates that nuts were processed. If the match with the PRI library is with meats, then the fats matched are more consistent with those produced by meat than plant parts, such as nuts.

Samples containing many compounds are more difficult to identify, and many archaeological samples are complex mixtures. Multi-purpose artifacts, such as groundstone, which could have been used to crush or grind a variety of foodstuffs, or ceramic cooking vessels, which are expected to have been used to cook many different foods, might present a mixture problem. Mixtures sometimes have many absorption bands that overlap, yielding only broad envelopes of absorption and few distinctive features. FTIR analysis is expected to be particularly valuable in examining fire-cracked rock (FCR), for which few other means of analysis exist, since the fats, lipids, waxes, and other organic molecules contained in liquids that seep out of the food being processed become deposited on the rocks during the baking process. Once again, these rocks might have been present in more than one cooking episode, thus having the potential to yield a complex signature. The PRI extraction method gently removes these organic molecules from the groundstone, ceramics, and/or rocks so that they can be measured with FTIR and subsequently identified.

Organic molecules from sediments can be extracted and the sediments then characterized. This has the potential to be very useful in identifying signatures of the remains responsible for a dark horizon. For instance, if the dark horizons are the result of decaying organic matter (plant or animal), FTIR will yield a signature of decaying organic remains. If the dark horizons are the result of blowing ash from cultural features, the FTIR signature will be considerably different. This is an affordable technique for making distinctions between horizons and identifying cultural horizons.

Carbohydrates

Carbohydrates are a product of photosynthesis in green plants. This group of compounds is the most abundant found on earth. The term carbohydrates encompasses three main groups of compounds: 1) sugars, 2) starches, and 3) fibers. To elaborate, sugars include the simple carbohydrates found in table sugar, honey, natural fruit sugars, and molasses. Starches and complex carbohydrates are present in legumes, grains, vegetables, and fruits. Fibers, including cellulose, hemicellulose, and pectin, are present in whole grains, legumes, vegetables, and fruits (Garrison and Somer 1985:13). Dietary carbohydrates provide energy for bodily functions, including our ability to digest and absorb other foods. They are the body's preferred source of energy, although proteins and lipids also may be converted to energy. Carbohydrates are so important that an inadequate intake may result in nutritional deficiencies such as ketosis, energy loss, depression, and even loss of essential body protein. On the other hand, excess intake of carbohydrates causes obesity and dental decay.

To understand carbohydrates and their detection with FTIR, it is important to know that they are formed of carbon atoms coupled to hydrates, such as water, resulting in empirical formulas of $C_nH_{2n}O_n$ where "n" represents the number of atoms for C, H, and O, respectively. "Biochemically, carbohydrates are polyhydroxy alcohols with aldehyde or ketone groups that are potentially active" (Garrison and Somer 1985:13). Since carbohydrates are classified according

to their structure and FTIR detects the bonds between molecules, we will review the simple sugars (monosaccharides), multiple sugars (oligosaccharides), and complex molecules (polysaccharides) that are made up of simple sugars.

Polysaccharides

These complex starchy compounds follow the empirical formula $C_6H_{10}O_5$. They are not sweet, do not crystallize, and are not water soluble. Simply defined, polysaccharides are complex carbohydrates found in plants as starch and cellulose, and in animals as glycogen. Because FTIR detects the bonds between atoms in molecules, it is important to know that polysaccharides are formed of repeating units of mono- or disaccharides that are joined together by glycosidic bonds. Polysaccharides are often heterogeneous. The slight modifications of the repeating unit results in slightly different FTIR wave number signatures. Types of polysaccharides are descriptive and include storage (starches and glycogen), structural (cellulose and chitin), acidic (containing carboxyl groups, phosphate groups, and/or sulfuric ester groups), neutral (presumably without the acid features), bacterial (macromolecules that include peptidoglycan, lipipolysaccharides, capsules and exopolysaccharides), and more. The study of polysaccharides is an ever-growing field and industry, since polysaccharides are important to proper immune function, bowel health, and a host of other factors that are important in human health. At present there is no comprehensive study of which plants and animal parts contain which polysaccharides. Research into this field is currently growing at a rapid pace. Some highlights for the purpose of our discussions are presented below.

Storage Polysaccharides

Storage polysaccharides are digestible polysaccharides. Starch and glycogen are the two primary groups of these polysaccharides (Wardlaw and Insel 1996:80-81).

Starch

Starch is the primary digestible polysaccharide in the human diet, and the most important carbohydrate food source (Murray et al. 2000:155; Wardlaw and Insel 1996:80). Starch is composed of long chains of glucose units. “Cooking increases the digestibility of...starches...making them more soluble in water and thus more available for attack by digestive enzymes” (Wardlaw and Insel 1996:80). Amorphous starch granules encased in cell walls burst free when cooked because the granules absorb water and expand. The two primary constituents of starch are amylose and amylopectin, both of which are a source of energy for plants and animals (Murray, et al. 2000:155; Wardlaw and Insel 1996:80). When the glucose chains are long and straight, the starch is labeled amylose. If the chains are short and branched, they are amylopectin. Shorter chains of glucose (dextrin) are the intermediate product of the hydrolysis of starch. Glucan, which is often found in association with pectin, resides in the cell walls of plants and trees and many forms of bacteria and fungi (Stephen et al. 2006). Beta glucans are a diverse group of molecules that occur commonly in the cellulose of plants, bran of cereals, cell walls of baker’s yeast, and certain fungi, mushrooms, and bacteria. Some beta glucans may be useful as texturing agents and soluble fiber supplements. Beta glucans derived from yeast and medicinal mushrooms have been used for their ability to modulate the immune system.

Cellulose

Cellulose comprises a long linear chain of glucose, whereas hemicellulose consists of shorter branched chains of simple sugars in addition to glucose, including especially xylose, but also mannose, galactose, rhamnose, and arabinose (Crawford 1981; Updegraff 1969). Pectin, however, may be found in either a linear or branched form of simple sugars that is primarily composed of rhamnose.

Pectin, Gums, and Mucilages

Pectin, gums, and mucilages are soluble fibers found inside and around plant cells that help "glue" them together (Wardlaw and Insel 1996:82). Pectin is a structural heteropolysaccharide and common substance found in many plants (apples, plums, gooseberries, and citrus) often used for its gelling or thickening action. Plant derived gums and mucilages such as gum arabic, guar gum, and locus bean gum are also used for this same purpose. Arabinan, arabinogalactan, arabinoglucuronoxylan, and rhamnogalacturonan are some examples of these types of polysaccharides (Wilkie 1985).

Esters

Esters are an important functional group because they are present as flavoring agents in food and are components of biological compounds such as fats, oils, and lipids. In an ester, the basic unit of the molecule is known as a carbonyl. The presence of the double peak between 3000 and 2800 wave numbers identifies the presence of the aldehyde functional group, which is present in fats, oils, lipids, and waxes.

There are two important groups of esters: saturated esters and aromatic esters. Aromatic esters take their name from their ability to produce distinctive odors and are present as flavoring agents in food. In contrast, saturated esters do not produce distinctive odors. Esters are expressed in the FTIR spectrum by three distinct peaks ("the rule of three") located at approximately 1700, 1200, and 1100 wave numbers, plus a fourth peak in the region between 750 and 700 wave numbers, which represents the CH_2 bend associated with aromatic esters. The first peak for saturated esters falls in the 1750–1735 range, the second peak lies between 1210 and 1160, and the third peak sits between 1100 and 1030. Saturated esters have a unique peak for acetates at 1240. This band can be very strong in the signature. The first peak for aromatic esters falls in the range between 1730 and 1715, the second peak between 1310 and 1250, and the third peak between 1130 and 1100 (Smith 1999:110-112). Distinguishing between saturated and aromatic esters, which are both components of foods, is easy if all three bands are present, since they occupy different wave number regions.

Lipids

Lipids that are solid at room temperature are called fats, and those that are liquid at room temperature are referred to as oils (Wardlaw and Insel 1996:108). Both forms of lipids can be detrimental, as well as beneficial, to human health. Consumption of certain animal fats rich in saturated fatty acids can lead to heart disease, while ingesting omega-3 fatty acids such as

EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid), found in fish and other plant sources, is essential to good health.

Fatty Acids

Fatty acids are found in most lipids in human and animal bodies, as well as in the lipids in foods (Wardlaw and Insel 1996:108). Long chains of carbons bonded together which are then bonded to hydrogens define the structure of fatty acids (Wardlaw and Insel 1996:109). A fatty acid is considered saturated if the carbons are connected by single bonds. Saturated fatty acids occur in high proportions in animal fats. If the carbon chain has one double bond between two of the carbons, then the fatty acid is monounsaturated. If there are two or more double bonds between carbons, then the fatty acid is polyunsaturated.

Essential Fatty Acids

Essential fatty acids are those lipids critical to human health, such as omega-3 and omega-6 fatty acids, alpha-lineolic acid, and linoleic acid, that cannot be created within the body and must be obtained from dietary sources (Wardlaw and Insel 1996:110-111). These essential fatty acids are part of "vital body structures, perform vital roles in immune system function and vision, help form cell membranes, and produce hormone like compounds" (Wardlaw and Insel 1996:111). Diets high in essential fatty acids, such as omega-3 and omega-6, reduce the risk of heart attacks because they minimize the tendency for blood to clot (Wardlaw and Insel 1996:112). Fish oils contain high concentrations of omega-3 and omega-6 fatty acids and may be administered as a dietary supplement.

Proteins

The human body uses protein from dietary plant and animal sources to form body structures and other constituents (Wardlaw and Insel 1996:152). "Proteins contribute to key body functions, including blood clotting, fluid balance, production of hormones and enzymes, vision, and cell growth and repair" (Wardlaw and Insel 1996:152). This constant regulation and maintenance of the body requires thousands of different types of proteins that are not all available within the body (Wardlaw and Insel 1996:152). The majority of the building blocks for these proteins, which are also known as amino acids, are produced by plants.

Amino Acids

Within the body, amino acids are linked to form the necessary proteins, making them not only essential for life, but key to nutrition. Amino acids can be combined in a multitude of ways to create a vast variety of proteins. These proteins are distinguished by the unique arrangements of amino acids. Proteins are created through a process called translation, in which amino acids are added, one by one, to form short polymer chains called peptides, or longer chains called polypeptides or proteins (Rodnina 2007). The order in which the amino acids are added is determined by the genetic code of the mRNA template, which is a copy of an organism's genes (Creighton 1993). Amino acids are divided into standard and non-standard types.

Standard Amino Acids

There are twenty naturally occurring amino acids on earth, called standard amino acids (Creighton 1993). These amino acids are encoded by the standard genetic code and are found in all forms of life (Creighton 1993). The standard amino acids are broken down into two different types: essential and nonessential.

Nonessential Amino Acids

The majority of the standard amino acids are considered "nonessential," meaning that under normal circumstances these amino acids can be manufactured by the human body and are not required in the diet. However, some amino acids that are normally nonessential may become an essential part of the diet for a person whose health has been compromised (Wardlaw and Insel 1996:155). Nonessential amino acids include alanine, arginine, asparagine, aspartate (aspartic acid), cysteine, glutamate (glutamic acid), glutamine, glycine, proline, serine, and tyrosine (Furst and Stehle 2004; Reeds 2000; Wardlaw and Insel 1996:154).

Serine. Serine is important in metabolic function (Nelson and Cox 2005). It serves as a neuronal signal by activating N-methyl-D-aspartate (NMDA) receptors in the brain and helps to build muscle tissue (Mothet et al. 2000). Common sources of serine in the diet are beef, eggs, nuts and seeds, legumes, and milk.

ETHNOBOTANIC REVIEW

It is a commonly accepted practice in archaeological studies to reference ethnographically documented plant uses as indicators of possible or even probable plant uses in prehistoric times. The ethnobotanic literature provides evidence for the exploitation of numerous plants in historic times, both by broad categories and by specific example. Evidence for exploitation from numerous sources can suggest widespread utilization and strengthens the possibility that the same or similar resources were used in prehistoric times. Ethnographic sources outside the study area have been consulted to permit a more exhaustive review of potential uses for each plant. Ethnographic sources document that with some plants, the historic use was developed and carried from the past. A plant with medicinal qualities very likely was discovered in prehistoric times and the usage persisted into historic times. There is, however, likely to have been a loss of knowledge concerning the utilization of plant resources as cultures moved from subsistence to agricultural economies and/or were introduced to European foods during the historic period. The ethnobotanic literature serves only as a guide indicating that the potential for utilization existed in prehistoric times—not as conclusive evidence that the resources were used. Pollen and macrofloral remains, when compared with the material culture (artifacts and features) recovered by the archaeologists, can become indicators of use. Plants represented by organic residues will be discussed in the following paragraphs in order to provide an ethnobotanic background for discussing the remains.

Native Plants

Typha (Cattail)

Typha (cattail) are perennial marsh or aquatic plants with creeping rhizomes. This plant is a rich source of nutrients and is one of the most important and common wild foods. Cattails were a staple for many Native American groups. Various parts of the cattail plant could be used throughout the year. In the spring, young shoots could be peeled and the white inner core eaten raw or cooked like asparagus. Cattail shoots provide beta carotene, niacin, riboflavin, thiamin, potassium, phosphorus, and vitamin C. During the summer, young flower stalks were taken out of their sheaths and cooked. The male portions of the immature, green flower head can be steamed or simmered and eaten like corn. Flowers were eaten alone or added as a flavoring or thickening for other foods. Pollen-producing flowers and the pollen itself were collected and used as flour, either alone or mixed with other meal. In the fall, the rootstalks were collected, the outer peel removed, and the white inner cores of almost pure starch were eaten raw, boiled, baked, or dried and ground into flour. Cattail roots are richer in starch during the fall. Cattail starch flour is noted to be similar in quantities of fats, proteins, and carbohydrates to flour from rice and corn. The seed-like fruits also were collected and eaten in the fall. Indian groups are noted to process these “seeds” by burning off the bristles. The seeds were then parched and could be more easily rubbed off the spike. The slightly astringent flower heads were sometimes used to relieve diarrhea and other digestive disorders. The “jelly” from between the young leaves and from pounded roots was applied to wounds, sores, carbuncles, boils, external inflammations, burns, scalds, and to soothe pain. Cattail down was used as dressing for wounds and padding in cradleboards and moccasins. Leaves and stems were used for weaving mats and baskets, to make toys, and to thatch roofs. Cattails form dense stands in marshes, swamps, ponds, sloughs, ditches, shallow stagnant water, and edges of streams (Brill and Dean 1994:67-71; Foster and Duke 1990:312; Medsger 1966:196; Niering 1985:431-432; Peterson 1977:158).

DISCUSSION

The Reeders Creek West site (28Me360) is a prehistoric camp located along the Delaware River in Mercer County, north of Trenton, New Jersey (Frank Mikolic, personal communication, March 7, 2011). The site is associated with a Woodland period occupation, but it also has a deeper Archaic component. The local vegetation is dominated by *Liquidambar styriciflua* (sweetgum), *Pinus strobus* (eastern white pine), *Robinia pseudoacacia* (black locust), and *Rosa multiflora* (multiflora rose), but also includes *Acer rubrum* var. *trilobum* (Trident red maple), *Fraxinus pennsylvanica* (green ash), *Ulmus americana* (American elm), *Toxicodendron radicans* (poison ivy), *Vitis labrusa* (fox grape), *Alliaria officinalis* (garlic mustard), and *Allium canadense* (meadow onion). Ceramic sherds from three hearths dating from the Terminal to the Early Woodland periods were tested for organic residues using Fourier Transform Infrared Spectroscopy (FTIR) (Table 1). In addition to the sherds, four lithic tools were submitted for protein residue analysis using cross-over immunoelectrophoresis (CIEP). Organic residue analysis focuses on identification of plant and animal processing that includes cooking, represented by ceramics, which provides information regarding diet. Protein residue analysis focuses on the identification of animal proteins that may be present on the working surfaces of

the four lithic tools submitted. The results from these analysis are organized and discussed by analysis type and feature.

Organic Residue (FTIR) Analysis

Feature 67

Feature 67 is identified as a possible hearth. This feature is associated with a radiocarbon age of AD 1040-1220 (Frank Mikolic, personal communication, April 7, 2011). Organic residue analysis of a ceramic sherd (sample 2) recovered from the hearth yielded peaks representing major categories (functional groups) of compounds (4000-1500 wave number), as well as specific compounds noted in the fingerprint region (1500-400 wave numbers) of the spectrum. The functional group peaks indicate the presence of absorbed water and fats/oils/lipids and/or plant waxes (Table 2). Peaks within the fingerprint region represent the presence of protein, cellulose, and carbohydrates.

The best matches for these peaks were made with deteriorated cellulose in portions of the spectrum representing cellulose and carbohydrates (Table 3). Deteriorated cellulose in the samples probably is attributable to the environmental signal and the natural breakdown of plant matter in the sediments at the site. However, matches with cellulose also might suggest processing plants that have deteriorated to the point they are no longer visible beyond their general cellulose signature.

Feature 73

Feature 73 also is identified as a possible hearth. A radiocarbon age of 2040-1880 BC is associated with the hearth (Frank Mikolic, personal communication, April 7, 2011). A ceramic sherd (sample 3) recovered from this feature was tested for organic residues. Sample 3 yielded no peaks in the functional group portion of the spectrum. Peaks in the fingerprint region represent pectin, cellulose, and carbohydrates.

The signature from this ceramic sherd also matched well with deteriorated cellulose for peaks at 1163, 1000, and 796 wave numbers, representing cellulose and carbohydrates. Just as for sample 2, cellulose in sample 3 might have resulted from the local environment or perhaps plant processing using this ceramic vessel.

Feature 64

A large platform hearth is identified as Feature 64. The hearth is associated with a radiocarbon age of 1330-1120 BC (Frank Mikolic, personal communication, April 7, 2011). FTIR analysis of a ceramic sherd (sample 1) from this feature yielded peaks representing functional group compounds including absorbed water and fats/oils/lipids and/or plant waxes. Other peaks identified in the fingerprint range indicate the presence of aromatic rings; aromatic and saturated esters; protein; the amino acid serine; calcium oxalates; pectin; starch; humates; and cellulose.

Typha (cattail) root was matched with several portions of the spectrum representing protein, alcohol, and saturated esters. These matches suggest that cattail might have been processed in the vessel represented by this sherd. Other matches with deteriorated cellulose also were made with cellulose peaks at 1162 and 795 wave numbers. Cellulose in the sample might be attributable to the natural breakdown of plant matter, or perhaps processing plants that have decomposed to the point they are only visible by their cellulose signature.

Several peaks between 1350 and 1250 wave numbers indicate the presence of the amino acid serine. None of these peaks were matched with any references in the PaleoResearch libraries. The presence of serine indicates nuts, seeds, and/or meat are contributing to the signature. Serine in the sample could be attributable to plant and/or animal processing; however, it is more likely this compound represents the natural decay of floral and faunal materials in the sediments from which the sherd was recovered.

No matches were made with calcium oxalate peaks at 1311 and 777 wave numbers. Calcium oxalates are present in many plant parts, often in the form of crystals, particularly in various plants in the Chenopodiaceae such as *Chenopodium* (goosefoot) and others. Some edible plants that contain calcium oxalates include legumes (leaves and pods) and goosefoot (and spinach) greens (leaves). Recovery of calcium oxalate peaks might represent processing locally available members of the Chenopodiaceae such as goosefoot; however, it also is possible this compound reflects the deterioration of plant matter from local vegetation.

Protein Residue Analysis

Four lithic tools were submitted for protein residue analysis from site 28ME360 (Table 1). No cultural affiliation was reported for these tools. The site is stratified, with Middle Archaic (6,000–2,500 B.C.) to Late Woodland (A.D. 900–1600) components. Three of the tools were recovered from possible living surfaces (samples 1, 3, and 4). One of the tools (sample 2) was recovered from a possible hearth feature (Feature 52).

The lithic tools were tested against the antisera listed in Table 4, yielding positive results on one of them (Table 5). Samples 1, 2, and 3 all tested negative. It is possible that these tools were not used for processing animal resources, that they had not been used since their last edge shaping/resharpening episode, that they were used to process animals other than those represented by the available antisera, or that insufficient amounts of protein residues were retained on the tool surfaces. Sample 4, an argillite biface from within a possible living surface, tested positive to both bear and deer antisera. An associated soil control (4-C) tested negative to both of these animals, strengthening the interpretation that bear and deer were processed with this tool.

The positive to bear obtained here is most likely derived from black bear (*Ursus americana*), as other species of bear are unlikely to have occurred in this area within the last several thousand years. The black bear range extends from New England, New York, and Pennsylvania south through the Appalachians and into Florida. Though classified as a carnivore, most of its diet consists of vegetation, including twigs, buds, leaves, nuts, roots, various fruit, corn, berries, and newly sprouted plants. In the fall, black bears put on a good supply of fat and hibernate for the winter in a sheltered place (Whitaker 1980). Huron and Iroquois ethnographic evidence indicates that bear and deer were sources of meat during fall

and early winter; however, this may have been a small portion of their overall diet. Fish and aquatic animals appear to have been a more substantial, year-round source of food (Heidenreich 1971; Morton and Schwarcz 2004; Waugh 1973).

The positive to deer antiserum indicates that remains from a member of the deer family (Cervidae) were processed with this tool. Members of the Cervidae include deer (*Odocoileus* sp.), elk (*Cervus canadensis*), moose (*Alces alces*), and caribou (*Rangifer* sp.). Moose and caribou are found mainly in Canada, as well as in the northeastern United States and southwest through the Rocky Mountains to northeastern Utah and northwestern Colorado. Although now extirpated, moose were once found in New Jersey. Elk currently are found primarily in the Rocky Mountain region and along the Pacific northwest coast, with great numbers found in Colorado, Wyoming, Montana, and Washington. Elk are reported to have once ranged through most of the United States and Canada, but their numbers decreased due to hunting and reduction in habitat from settlement and farming. Before white settlers arrived in New Jersey, Eastern elk were found throughout the state, and their pre-contact ranges extended from New York to central Georgia (Fergus 2004; Kosak 2004). Mule deer or blacktail deer (*Odocoileus hemionus*) are found primarily in the western United States, extending east to Wisconsin and west Texas. Their prehistoric ranges could have extended further east. Whitetail deer (*Odocoileus virginianus*) are found throughout most of the United States in a variety of habitats, except for most of California, Nevada, Utah, northern Arizona, southwest Colorado and northwest New Mexico (Burt and Grossenheider 1980:215-222; Whitaker 1980:646-660).

The cervid most likely represented by the positive result to deer antiserum is whitetail deer, although elk and moose should not be ruled out. Deer, especially white-tailed deer, were very important resources for native groups in the northeast United States. Deer are noted to have been the most important game for the Delaware or Lenni Lenape groups. Moose also were hunted inland, and late fall was the principal season for hunting. Fresh meat was boiled or roasted on sticks set into the ground. Moccasins were generally made from deer or moose hide. Men wore roaches of dyed deer hair tied to a hemp base (Goddard 1978:216-218). Deerskins also were tanned to make clothing and packs. Clothing worn next to the body was usually made of deerskin or beaver skin, and hunters wore deer hides as camouflage. Antlers were made into jewelry and attached to handles and made into hoes. A hollow piece of deer antler was used to suck venom out of snake bites. Slivers from smashed bones were made into needles, and the sinew was made into thread. “When other remedies failed, a medicine was made from the scrapings of deer antlers” (Mauser 2006).

SUMMARY AND CONCLUSIONS

Organic residue analysis of the ceramic sherds from the Reeders Creek West site (28Me360) revealed that the samples are dominated by a general cellulose signature representing decayed plant materials. Cellulose in the samples is likely attributable to the natural breakdown of plant matter in the sediments at the site; however, it also might represent plants processed that can no longer be identified beyond their general cellulose signature. A sherd recovered from the large platform hearth (Feature 64, sample 1) was the only sample to suggest cattail root processing using ceramic vessels.

Of the four lithic tools submitted for protein residue analysis, only one yielded positive results. Sample 4, a biface found within a possible living surface at a depth of 162 cmbs, tested positive to both bear and deer antisera. This result indicates that the biface was used to processes remains from black bear (*Ursus americana*) and a member of the deer family (Cervidae).

TABLE 1
PROVENIENCE DATA FOR SAMPLES FROM THE REEDERS CREEK WEST SITE (28ME360), MERCER COUNTY, NEW JERSEY

Sample No.	Feature	Block	Unit	Stratum	Lvl	Depth (cmbd)	^{14}C Age	Provenience/ Description	Analysis
2	67	V	H33	3	5	52-64	AD 1040-1220	Ceramic sherd from a possible hearth	FTIR
3	73	Z	H26	5	6	70-80	2040-1880 BC	Ceramic sherd from a possible hearth	FTIR
1	64	S	M10	5	9	99-107	1330-1120 BC	Ceramic sherd from a large platform hearth	FTIR
1		Y	P22		5	44		Quartz stemmed biface from within a possible living surface	Protein
1-C		Y	P22		5	44		Soil control	Protein Control
2	52	P	P34			65-75		Jasper utilized flake from a possible hearth	Protein
2-C	52	P	P34			65-75		Soil control	Protein Control
3		F	J48		12	100-110		Jasper scraper from within a possible living surface	Protein
3-C		F	J48		12	100-110		Soil control	Protein Control

TABLE 1 (Continued)

Sample No.	Feature	Block	Unit	Stratum	Lvl	Depth (cmbd)	^{14}C Age	Provenience/ Description	Analysis
4		O	M42		17	162		Argillite biface from within a possible living surface	Protein
4-C		O	M42		17	162		Soil control	Protein Control

Lvl = Level
FTIR = Fourier Transform Infrared Spectroscopy

TABLE 2
FTIR PEAK SUMMARY TABLE FOR SAMPLES FROM THE
REEDERS CREEK WEST SITE (28ME360), MERCER COUNTY, NEW JERSEY

		Feature 67	Feature 73	Feature 64
Peak Range	Represents	2 Ceramic	3 Ceramic	1 Ceramic
3600-3200	Absorbed Water (O-H Stretch)	3302		3367
3089, 3088, 3085, 3084, 3068, 3064, 3063, 3062, 3041, 3031, 3029, 3027	Aromatic C-H stretch			3026
3000-2800	Aldehydes: fats, oils, lipids, waxes	2981		2954,2953 2916,2915, 2848
1700-1500	Protein, incl. 1650 protein	1624		1701
1500-1400	Protein	1411		1463,1432, 1411
1465-1455	Protein/lipids			1463
1490-1350	Protein	1411		1463,1432, 1411
1377	Fats, oils, lipids, humates (CH_3 symmetric bend)			1376
1350-1250	Serine (amino acid) O-H bending			1347,1330, 1311, 1296,1278, 1270,1259
1315	Calcium oxalate			1311
1202	Tertiary alcohol C-O stretch			1205
1188	Saturated ester C-C-O			1186
1162	Cellulose	1163/62	1162	1162
1100	Pectin			1099
1028-1000	Cellulose Carbohydrates	1002,1001	1000	
993, 910, 718, 640	Alkene out-of-plane C-H bend			992

TABLE 2 (Continued)

Peak Range	Represents	Feature 67 2 Ceramic	Feature 73 3 Ceramic	Feature 64 1 Ceramic
931	Starch			932
834	Pectin		833	
830	Symmetric C-C-O stretch			830
780	Calcium oxalate			777
750-700	Aromatic esters			728,720
722-719	CH_2 Rock (methylene)			720
692	Aromatic ring bend (phenyl ether)			692

TABLE 3
MATCHES SUMMARY TABLE FOR FTIR RESULTS FROM THE
REEDERS CREEK WEST SITE (28ME360), MERCER COUNTY, NEW JERSEY

Match (Scientific Name)	Match (Common Name)	Part	Feature 67 2 Ceramic (Range)	Feature 73 3 Ceramic (Range)	Feature 64 1 Ceramic (Range)
Deteriorated Cellulose	Deteriorated cellulose		1192-1141 1075-947	1186-1138 1072-941 809-788	1192-1126 815-785
Typha	Cattail	Root			1738-1664 1479-1392 1237-1210 1216-1192 1192-1174

TABLE 4
LIST OF ANTISERA USED IN TESTING LITHIC TOOLS FOR PROTEIN RESIDUES,
SITE 28ME360, MERCER COUNTY, NEW JERSEY

ANTISERUM	SOURCE	POSSIBLE RESULTS
ANIMALS:		
Bear	ICN Pharmaceuticals, Inc.	Black bear, Brown bear, Grizzly, Polar bear
Bison	Prepared under the direction of Dr. Richard Marlar at the University of Colorado Health Sciences Center	Bison, Domestic bovids
Bovine	Sigma Chemical Company	Domestic bovids, Bison
Cat	Sigma Chemical Company	Domestic cat, Mountain lion, Bobcat, Lynx, other wild cat species
Chicken	Sigma Chemical Company	Domestic chicken, Partridge, Quail, Grouse, Ptarmigan, Pheasant
Deer	ICN Pharmaceuticals, Inc.	White tail deer, Mule deer, Elk, Moose, Caribou, Wapiti
Dog	Sigma Chemical Company	Domestic dog, Coyote, Wolf, Fox
Duck	Nordic Immunological Laboratories	Duck, Goose, Pigeon, Domestic turkey, Wild turkey
Goat	Sigma Chemical Company	Pronghorn, Mountain goat, Domestic goat
Guinea pig	Sigma Chemical Company	Guinea pig, Porcupine, Beaver, Squirrel family (Squirrel, Marmot, Ground squirrel, Chipmunk, etc.)
Human	ICN Pharmaceuticals, Inc.	Human
Mouse	Sigma Chemical Company	Members of the New World rats and mice family, Members of the Old World rats and mice family
Pig	ICN Pharmaceuticals, Inc.	Domestic pig, Wild pig
Rabbit	Sigma Chemical Company	Rabbit, Jackrabbit (hare)
Rat	Sigma Chemical Company	Members of the New World rats and mice family, Members of the Old World rats and mice family
Sheep	ICN Pharmaceuticals, Inc.	Domestic sheep, Bighorn sheep
Turkey	Sigma Chemical Company	Domestic turkey, Wild turkey, Ducks

TABLE 4 (Continued)

ANTISERUM	SOURCE	POSSIBLE RESULTS
FISH/AQUATIC:		
American Eel	Robert Sargeant	American eel
Atlantic croaker	Robert Sargeant	Perciformes order (Spiny-rayed [percoid] fishes)
Bay anchovy	Robert Sargeant	Engraulidae family (Anchovies)
Catfish	Sigma Chemical Company	Catfish, Carp
Gizzard Shad	Robert Sargeant	Gizzard shad
Sturgeon	Robert Sargeant	Acipenseridae family (Sturgeons)
Striped bass	Robert Sargeant	Perciformes order (Spiny-rayed or percoid fish)
Trout	Sigma Chemical Company	Salmonidae family (Trout and salmon)

TABLE 5
POSITIVE PROTEIN RESIDUE RESULTS FOR LITHIC TOOLS TESTED FROM SITE 28ME360, MERCER COUNTY, NEW JERSEY

Sample No.	Description	Positive Result (Antiserum Type)	Possible Animal(s) Represented
4	Argillite biface from within a possible living surface (162 cmbs)	Bear	Black bear (*Ursus americana*)
		Deer	Members of the deer family (Cervidae)

REFERENCES CITED

Arms, Karen, and Pamela S. Camp
1995 *Biology*. Saunders College Publishing, Fort Worth.

Brill, Steve, and Evelyn Dean
1994 *Identifying and Harvesting Edible and Medicinal Plants in Wild (and Not So Wild) Places*. Hearst Books, New York, New York.

Bog-Hansen, T. C.
1990 Immunoelectrophoresis. In *Gel Electrophoresis of Proteins*, edited by D. Rickwood, and B.D. Hames, pp. 273-300. Oxford University Press, Oxford.

Burt, William H., and Richard P. Grossenheider
1980 *A Field Guide to the Mammals*. Houghton Mifflin Company, Boston and New York.

Carlile, Michael J., and Sarah C. Watkinson
1994 *The Fungi*. Academic Press, San Diego.

Chabannes, Matthieu, Katia Ruel, Arata Yoshinaga, Brigitte Chabbert, Alain Jauneau, Jean-Paul Joseleau, and Alain-Michel Boudet
2001 In Situ Analysis of Lignins in Transgenic Tobacco Reveals a Differential Impact of Individual Transformations on the Spatial Patterns of Lignin Deposition at the Cellular and Subcellular Levels. *The Plant Journal* 28:271-282.

Crawford, R. L.
1981 *Lignin Biodegradation and Transformation*. John Wiley and Sons, New York.

Creighton, Thomas E.
1993 *Proteins: Structures and Molecular Properties*. 2nd ed. W. H. Freeman and Company, Ltd., San Francisco.

Culliford, Brian J.
1964 Precipitation Reactions in Forensic Problems. *Nature* 201:1092-1094.

1971 *The Examination and Typing of Bloodstains in the Crime Laboratory*. United States Department of Justice, U.S. Government Printing Office, Stock 2700-0083, Washington D.C.

Esau, Katherine
1977 *Anatomy of Seed Plants*. John Wiley and Sons, New York.

Fergus, Chuck
2004 Pennsylvania Game Comission Wildlife Notes - Elk. Electronic document, http://www.pgc.state.pa.us/pgc/cwp/view.asp?a=458&q=150769, accessed March 20, 2006.

Foster, Steven, and James A. Duke
1990 *A Field Guide to Medicinal Plants: Eastern and Central North America*. Houghton Mifflin Company, Boston.

Furst, P., and P. Stehle
2004 What are the Essential Elements Needed for the Determination of Amino Acid Requirements in Humans? *Journal of Nutrition* 134(6):1558S-1565S.

Gaensslen, R. E.
1983 *Sourcebook in Forensic Serology, Immunology, and Biochemistry*. United States Department of Justice, Washington D.C.

Garrison, Robert , Jr., and Elizabeth Somer
1985 *The Nutrition Desk Reference*. Keats Publishing, Inc., New Canaan.

Gerlach, S. C., Margaret Newman, Edward J. Knell, and Edwin S. Hall
1996 Blood Protein Residues on Lithic Artifacts from Two Archaeological Sites in the De Long Mountains, Northwestern Alaska. *Arctic* 49(1):1-10.

Goddard, Ives
1978 Delaware. In *Northeast*, edited by Bruce G. Trigger, pp. 213-239. Handbook of North American Indians. vol. 15, W.C. Sturtevant, general editor. Smithsonian Institute, Washington D.C.

Gurfinkel, D. M., and U. M. Franklin
1988 A Study of the Feasibility of Detecting Blood Residue on Artifacts. *Journal of Archeological Science* 15:83-97.

Heidenreich, C.
1971 *Huronia, A History and Geography of the Huron Indians, 1600-1650.* McClelland and Stewart, Toronto.

Hogberg, Anders, Kathryn Puseman, and Chad Yost
2009 Integration of Use-wear with Protein Residue Analysis - A Study of Tool Use and Function in the Scandinavian Early Neolithic. *Journal of Archaeological Science* 36:1725-1737.

Hyland, D. C., J. M. Tersak, J. M. Adovasio, and M. I. Siegel
1990 Identification of the Species of Origin of Residual Blood on Lithic Material. *American Antiquity* 55(1):104-111.

Isaksson, Sven
1999 Guided By Light: The Swift Characterization of Ancient Organic Matter by FTIR, IR-Fingerprinting and Hierarchical Cluster Analysis. *Laborativ Arkeologi* 12:35-43.

Kooyman, B., Margaret E. Newman, Christine Cluney, Murray Lobb, and Shayne Tolman
2001 Identification of Horse Exploitation by Clovis Hunters Based on Protein Analysis. *American Antiquity* 66(4):686-691.

Kosak, Joe
2004 Pennsylvania Game Comission - History of Pennsylvania Elk. Electronic document, http://www.pgc.state.pa.us/pgc/cwp/view.asp?a=471&q=151455, accessed March 20, 2006.

Lebo, Stuart E., Jr., Jerry D. Gargulak, and Timothy J. McNally
2001 Lignin. In *Encyclopedia of Chemical Technology*. 4th ed. John Wiley and Sons, Inc.

Loy, T. H.
1983 Prehistoric Blood Residues: Detection on Tool Surfaces and Identification of Species of Origin. *Science* 220:1269-1271.

Marlar, R. A., Kathryn Puseman, and Linda Scott Cummings
1995 Protein Residue Analysis of Archaeological Materials: Comments on Criticisms and Methods. *Southwestern Lore* 61(2):27-37.

Martone, Patrick T., Jose M. Estevez, Fachuang Lu, Katia Ruel, Mark W. Denny, Chris Somerville, and John Ralph
2009 Discovery of Lignin in Seaweed Reveals Convergent Evolution of Cell-Wall Architecture. *Current Biology* 19(2).

Mauser, Linda
2006 Delaware History. Electronic document, http://www.delawareindians.com/delawarehistory.htm, accessed March 20, 2006.

Medsger, Oliver Perry
1966 *Edible Wild Plants*. MacMillan Publishing Company, Inc., Racine, Wisconsin.

Morton, June D., and Henry P. Schwarcz
2004 Palaeodietary Implications from Stable Isotopic Analysis of Residues on Prehistoric Ontario Ceramics. *Journal of Archaeological Science* 31(5):503-517.

Mothet, Jean-Pierre, Angele T. Parent, Herman Wolosker, Roscoe O. Brady, Jr., David J. Linden, Christopher D. Ferris, Michael A. Rogawski, and Solomon H. Snyder
2000 D-serine is an Endogenous Ligand for the Glycine Site of the N-methl-D-aspartate Receptor. *Proceedings of the National Academy of Sciences* 97(9):4926-4931.

Murray, Robert K., Daryl K. Granner, Peter A. Mayes, and Victor W. Rodwell
2000 *Harper's Biochemistry*. 25th Edition ed. McGraw-Hill, New York.

Nelson, D. L., and M. M. Cox
2005 *Lehninger Principles of Biochemistry*. 4th ed. W. H. Freeman and Company, New York.

Newman, M., and P. Julig
1989 The Identification of Protein Residues on Lithic Artifacts from a Stratified Boreal Forest Site. *Canadian Journal of Archaeology* 13:119-132.

Niering, W. A.
1985 *Wetlands*. The Audubon Society Nature Guides. Alfred A. Knopf, New York.

Peterson, Lee A.
1977 *Edible Wild Plants*. Collier Books, New York, New York.

Reeds, P. J.
2000 Dispensable and Indespensable Amino Acids for Humans. *Journal of Nutrition* 130(7):1835S-1840S.

Rodnina, M. V., M. Beringer, and W. Wintermeyer
2007 How Ribosomes Make Peptide Bonds. *Trends in Biochemical Sciences* 32(1):20-26.

Seeman, Mark F., Nils E. Nilsson, Garry L. Summers, Larry L. Morris, Paul J. Barans, Elaine Dowd, and Margaret Newman
2008 Evaluating protein residues on Gainey phase Paleoindian stone tools. *Journal of Archaeological Science* 35:2742-2750.

Sensabaugh, G.F., A.C. Wilson, and P.L. Kirk
1971 Protein Stability in Preserved Archaeological Remains, Parts I and II. *International Journal of Biochemistry* 2:545-568.

Smith, Brian
1999 *Infrared Spectral Interpretation, A Systematic Approach*. CRC Press, New York.

Stephen, Alistair M., Glyn O. Phillips, and Peter A. Williams
2006 *Food Polysaccharides and Their Applications*. Taylor & Francis, Boca Raton.

Updegraff, D. M.
1969 Semimicro Determination of Cellulose in Biological Materials. *Analytical Biochemistry* 32:420-424.

Wardlaw, Gordon M., Ph.D., R.D., L.D. and Paul M. Insel, Ph.D.
1996 *Perspectives in Nutrition*. Mosby-Year Book, Inc., St. Louis, Missouri.

Wardrop, A. B.
1969 The Structure of the Cell Wall in Lignifies Collenchyma of Eryngium sp. (Umbelliferae). *Australian Journal of Botany* 17:229-240.

Waugh, F.W.
1973 *Iroquois Foods and Food Preparation*. Anthropological Series No. 12, Memoir No. 86. Geological Survey of Canada, Ottawa.

Whitaker, John O., Jr.
1980 *The Audubon Society Field Guide to North American Mammals*. Audubon Field Guides. Alfred A. Knopf, Inc., New York, New York.

Wilkie, K. C. B.
1985 New Perspectives on Non-Cellulosic Cell-Wall Polysaccharides (Hemicellulose and Pectic Substances) of Land Plants. In *Biochemistry of Plant Cell Walls*, edited by C. T. Brett and J. R. Hillman. Cambridge University Press, Cambridge.

Yost, Chad, and Linda Scott Cummings
2008 *Pollen, Starch, Phytolith, Protein Residue, and Organic Residue Analysis of Artifacts from Northeastern Alberta, Canada*. Ms. on file with FMA Heritage, Inc., Calgary, Alberta, Canada. PRI Technical Report 08-84.

POLLEN, PROTEIN, AND ORGANIC RESIDUE (FTIR) ANALYSIS OF SAMPLES FROM THE REEDERS CREEK WEST SITE (28ME360), NEW JERSEY

By

Melissa K. Logan,
Kathryn Puseman,
and
Linda Scott Cummings

With assistance from
R. A. Varney,
Chad Yost,
and
Mikaela Murphy

PaleoResearch Institute
Golden, Colorado

PaleoResearch Institute Technical Report 11-137A

Prepared for

AECOM
Trenton, New Jersey

December 2011

INTRODUCTION

Fourteen ceramics from the Reeders Creek West site, 28Me360, were submitted for examination of organic residues using Fourier Transform Infrared Spectroscopy (FTIR). In addition, five sediment samples were examined for pollen, while two projectile point–type artifacts and a projectile point base were analyzed for possible protein residues. This site is a Native American campsite located above the Delaware River in Mercer County, New Jersey. This stratified site contains Middle Archaic through Late Woodland components. Pollen analysis is used to provide paleoenvironmental information, while organic and protein residues from artifact surfaces were analyzed to provide information concerning plant and animal resources cooked in the vessels or hunted/processed with the tools. Only FTIR analysis of organic residues can provide evidence of cooked proteins, while raw proteins are detected best with protein residue analysis.

METHODS

Pollen

A chemical extraction technique based on flotation is the standard preparation technique used in this laboratory for removing pollen from the large volume of sand, silt, and clay with which it is mixed. This particular process was developed for extracting pollen from soils where the preservation has been less than ideal and the pollen density is lower than in peat. It is important to recognize that it is not the repetition of specific and individual steps in the laboratory, but rather mastery of the concepts of extraction and how the desired result is best achieved, given different sediment matrices, that results in successful recovery of pollen for analysis.

Hydrochloric acid (10%) was used to remove calcium carbonates present in the soil, after which the samples were screened through 250-micron mesh. The samples were rinsed until neutral by adding water, letting the samples stand for 2 hours, then pouring off the supernatant. A small quantity of sodium hexametaphosphate was added to each sample once it reached neutrality, then the samples were allowed to settle according to Stoke's Law in settling columns. This process was repeated with ethylenediaminetetraacetic acid (EDTA). These steps remove clay prior to heavy liquid separation. The samples then were freeze dried. Sodium polytungstate (SPT), with a density 1.8, was used for the flotation process. The samples were mixed with SPT and centrifuged at 1500 rpm for 10 minutes to separate organic from inorganic remains. The supernatant containing pollen and organic remains was decanted. SPT again was added to the inorganic fraction to repeat the separation process. The supernatant was decanted into the same tube as the supernatant from the first separation. This supernatant was then centrifuged at 1500 rpm for 10 minutes to allow any remaining silica to be separated from the organics. Following this, the supernatant was decanted into a 50-ml conical tube and diluted with distilled water. These samples were centrifuged at 3000 rpm to concentrate the organic fraction in the bottom of the tube. This pollen-rich organic fraction was rinsed, then all samples received a short (20–30 minute) treatment in hot hydrofluoric acid to remove any remaining inorganic particles. The samples then were acetylated for 3–5 minutes to remove any extraneous organic matter.

A light microscope was used to count pollen at a magnification of 500x. Pollen preservation in these samples varied from good to poor. Comparative reference material collected at the Intermountain Herbarium at Utah State University and the University of Colorado Herbarium was used to identify the pollen to the family, genus, and species level, where possible.

A plus (+) on the pollen diagram indicates that pollen was observed, in spite of the fact that pollen was not present in a sufficient concentration to obtain a full count. The pollen diagrams were produced using Tilia 2.0 and TGView 2.0.2. Total pollen concentrations were calculated in Tilia using the quantity of sample processed in cubic centimeters (cc), the quantity of exotics (spores) added to the sample, the quantity of exotics counted, and the total pollen counted and expressed as pollen per cc of sediment.

"Indeterminate" pollen includes pollen grains that are folded, mutilated, or otherwise distorted beyond recognition. These grains were included in the total pollen count since they are part of the pollen record. The microscopic charcoal frequency registers the relationship between pollen and charcoal. The total number of microscopic charcoal fragments was divided by the pollen sum, resulting in a charcoal frequency that reflects the quantity of microscopic charcoal fragments observed, normalized per 100 pollen grains. Pollen analysis also included examination for starch granules and, if they were present, their assignment to general categories.

Protein Residue

Artifacts submitted for protein residue analysis were tested using an immunologically-based technique referred to as cross-over immunoelectrophoresis (CIEP). This method is based on an antigen-antibody reaction, where a known antibody (immunoglobulin) is used to detect an unknown antigen (Bog-Hansen 1990). Antigens are usually proteins or polysaccharides. The method for CIEP is based on forensic work by Culliford (1964; 1971) with changes made by Newman (1989) following the procedure used by the Royal Canadian Mounted Police Serology Laboratory in Ottawa, and the Centre of Forensic Sciences in Toronto. Further changes were made at the PaleoResearch Institute following the advice of Dr. Richard Marlar of the Thrombosis Research Laboratory at the Denver VA Medical Center and the University of Colorado Health Sciences Center. Although several different protein detection methods have been employed in archaeological analyses, including enzyme-linked immunosorbant assay (ELISA) and radioimmune assay (RIA), the CIEP test has been found to be extremely sensitive, with the detection of 10^{-8} g of protein possible (Culliford 1964:1092). The specificity of CIEP is further strengthened by testing unknowns against non-immunized animal serum and the use of soil controls to eliminate the possibility of false positives due to non-specific protein interactions.

Ancient protein residues are preserved and have been detected on stone tools of considerable age using CIEP (Gerlach et al. 1996; Hogberg et al. 2009; Kooyman et al. 2001; Seeman et al. 2008; Yost and Cummings 2008). In one of the largest samples of reactive protein residues from an archaeological site, Gerlach et al. (1996) report a total of 45 positive reactions obtained on 40 of the 130 stone tools tested from an early North American Paleoindian site (ca. 11,200–10,800 years BP).

In an archaeological context, an antigen is the unknown protein adhering to an artifact after its use. Ancient proteins undoubtedly break down into small fragments over time; however, antibodies can recognize small regions of antigens (Marlar et al. 1995). Studies by Loy (1983) and Gurfinkel and Franklin (1988) suggest that hemoglobin and other proteins bind to soil and clay particles through electrostatic interactions, and these interactions protect the proteins from microbial attack and removal by groundwater. Sensabaugh (1971) reported that dried blood proteins "covalently cross-linked to form a single proteinaceous mass with a high molecular weight, resulting in decreased solubility." Hyland et al. (1990:105) suggest that protein molecules may be conjoined with fatty tissues, resulting in an insoluble complex that is secure against dissolution by water. These studies may explain, in part, mechanisms for prolonged protein preservation and adherence to stone surfaces; however, they also illustrate the challenges of recovery from artifact surfaces.

Artifacts were washed using 1–2 ml of a 0.02M Tris hydrochloride, 0.5M sodium chloride, and 0.5% Triton X-100 solution. The projectile point base was placed in an ultrasonic bath for 30 minutes, on a rotating mixer for 30 minutes, then in the ultrasonic bath for an additional 30 minutes. The two projectile point–type artifacts made from mud/clay were only placed in the ultrasonic bath for 30 minutes. Because soils contain compounds such as bacteria and animal feces that can cause false positive results for artifacts buried in the soil, control samples also were tested. One gram of soil associated with each artifact was added to 1 mL of the Tris/NaCl/Triton solution, then refrigerated for several days prior to testing.

The residues extracted from the artifacts and the soil controls first were tested against pre-immune goat serum (serum from a non-immunized animal) to detect non-specific binding of proteins. Samples testing negative against pre-immune serum were then tested against prepared animal antisera obtained from ICN Pharmaceuticals, Inc. and Sigma Chemical Company, and against antisera raised under the direction of Robert Sargeant in Lompoc, California, and of Dr. Richard Marlar. Appropriate positive and negative controls were run for each antiserum. A positive control consists of the blood of an animal for which the antiserum is known to test positively, and a negative control consists of the serum/blood of the animal in which the antiserum was raised, either rabbit or goat.

CIEP was performed using agarose gel as the medium. Two holes were punched in the gel about 5 mm apart. The protein extract from each artifact was placed in the cathodic well and the antiserum was placed in the anodic well. The sample was electrophoresed in Barbital buffer (pH 8.6) for 45 minutes at a voltage of 130v to drive the antigens and antibodies towards each other. Positive reactions appeared as a line of precipitation between the two wells. The gels were stained with Coomassie Blue to make the precipitate line easier to see. Samples with initial positive reactions were re-tested with dilute antisera, usually 1:10 or 1:20, to distinguish between true and false positives, increase specificity, and to replicate the initial positive reaction. Positive reactions obtained after this second test then were reported.

Identification of animals represented by positive results is usually made to the family level. All mammalian species have serum protein antigenic determinations in common; therefore, some cross-reactions will occur between closely and sometimes distantly related animals (Gaensslen 1983:241). For example, bovine antiserum will react with bison blood, and deer antiserum will react with other members of the Cervidae (deer) family, such as elk and moose.

FTIR (Fourier Transform Infrared Spectroscopy)

A mixture of chloroform and methanol (CHM) was used as a solvent to remove lipids and other organic substances that had soaked into the surface of the ceramic. This mixture is represented in the FTIR graphics as CHM. The CHM solvent and sample were placed in a glass container, and allowed to sit, covered, for several hours. After this period of time, the solvent was pipetted into an aluminum evaporation dish, where the CHM was allowed to evaporate. This process leaves the residue of any absorbed chemicals in the aluminum dishes. The residue remaining in the aluminum dishes was then placed on the FTIR crystal and the spectra were collected. The aluminum dishes were tilted during the process of evaporation to separate the lighter from the heavier fraction of the residue. The lighter and heavier fractions are designated upper (lighter fraction) and lower (heavier fraction), respectively, in the subsequent analysis.

FTIR is performed using a Nicolet 6700 optical bench with an ATR and a diamond crystal. The sample is placed in the path of a specially encoded infrared beam, which passes through the sample and produces a signal called an “inferogram.” The inferogram contains information about the frequencies of infrared that are absorbed and the strength of the absorptions, which is determined by the sample’s chemical make-up. A computer reads the inferogram and uses Fourier transformation to decode the intensity information for each frequency (expressed as wave numbers) and presents a spectrum.

FTIR (FOURIER TRANSFORM INFRARED SPECTROSCOPY) REVIEW

Infrared spectroscopy (IR) is the study of how molecules absorb infrared radiation and ultimately convert it to heat, revealing how the infrared energy is absorbed, as well as the structure of specific organic molecules. Infrared spectroscopy has been experiencing a renaissance for identifying organic substances during the past few decades. It is currently considered one of the more powerful tools in organic and analytical chemistry. One of the primary advantages to FTIR is that it measures all wave lengths simultaneously. It has a relatively high signal-to-noise ratio and a short measurement time. Each peak in the spectrum represents either a chemical bond or a functional group.

Since molecular structures absorb the vibrational frequencies or wavelengths of infrared radiation, the bands of absorbance can then be used to identify the composition of the materials under study. In the case of the current research, the portion of the electromagnetic spectrum between 4000 and 400 wave numbers is used for identifying organic materials. Carbohydrates, lipids, proteins, and other organic molecules are associated with specific wave number bands (Isaksson 1999:36-39).

The infrared spectrum can be divided into two regions: the functional group region and the fingerprint region. These two groups are recognized by the effect that infrared radiation has on the respective molecules of these groups. The functional group region is located between 4000 and approximately 1500 wave numbers. The molecular bonds display specific characteristic vibrations that identify fats, lipids, waxes, lignins, proteins, carbohydrates, etc. The fingerprint region, located below 1500 wave numbers, is influenced by bending motions, which further identify the molecules present.

Using FTIR, it is possible to identify different types of organic compounds and eventually recognize different types of materials such as plant or animal fats or lipids, plant waxes, esters, proteins, carbohydrates, and more. Specific regions of the spectrum are important in identifying these compounds.

The results of the identification of specific wavelengths can be compared with commercial or laboratory-created analytical standards to identify the specific types of bonds present in different materials. By combining the results of the analysis of individual samples with all of the reference materials in the PaleoResearch Institute (PRI) library, the percent match with individual reference items can be displayed. For instance, plant lipids or fats are identifiable between 3000 and 2800 wave numbers. A match might be obtained on this portion of the spectrum with nuts such as hickory, walnut, or acorn, or with animal fats or corn oil. Recovery of high-level matches with several types of nuts (in this example) indicates that nuts were processed. If the match with the PRI library is with meats, then the fats matched are more consistent with those produced by meat than plant parts, such as nuts.

Samples containing many compounds are more difficult to identify, and many archaeological samples are complex mixtures. Multi-purpose artifacts, such as groundstone, which could have been used to crush or grind a variety of foodstuffs, or ceramic cooking vessels, which are expected to have been used to cook many different foods, might present a mixture problem. Mixtures sometimes have many absorption bands that overlap, yielding only broad envelopes of absorption and few distinctive features. FTIR analysis is expected to be particularly valuable in examining fire-cracked rock (FCR), for which few other means of analysis exist, since the fats, lipids, waxes, and other organic molecules contained in liquids that seep out of the food being processed become deposited on the rocks during the baking process. Once again, these rocks might have been present in more than one cooking episode, thus having the potential to yield a complex signature. The PRI extraction method gently removes these organic molecules from the groundstone, ceramics, and/or rocks so that they can be measured with FTIR and subsequently identified.

Organic molecules from sediments can be extracted and the sediments then characterized. This has the potential to be very useful in identifying signatures of the remains responsible for a dark horizon. For instance, if the dark horizons are the result of decaying organic matter (plant or animal), FTIR will yield a signature of decaying organic remains. If the dark horizons are the result of blowing ash from cultural features, the FTIR signature will be considerably different. This is an affordable technique for making distinctions between horizons and for identifying cultural horizons.

Carbohydrates

Carbohydrates are a product of photosynthesis in green plants. This group of compounds is the most abundant found on earth. The term carbohydrates encompasses three main groups of compounds: 1) sugars, 2) starches, and 3) fibers. To elaborate, sugars include the simple carbohydrates found in table sugar, honey, natural fruit sugars, and molasses. Starches and complex carbohydrates are present in legumes, grains, vegetables, and fruits. Fibers, including cellulose, hemicellulose, and pectin, are present in whole grains, legumes, vegetables, and fruits (Garrison and Somer 1985:13). Dietary carbohydrates provide energy for bodily functions, including our ability to digest and absorb other foods. They are the body's

preferred source of energy, although proteins and lipids also may be converted to energy. Carbohydrates are so important that an inadequate intake may result in nutritional deficiencies such as ketosis, energy loss, depression, and even loss of essential body protein. On the other hand, excess intake of carbohydrates causes obesity and dental decay.

To understand carbohydrates and their detection with FTIR, it is important to know that they are formed of carbon atoms coupled to hydrates, such as water, resulting in empirical formulas of $C_nH_{2n}O_n$ where "n" represents the number of atoms for C, H, and O, respectively. "Biochemically, carbohydrates are polyhydroxy alcohols with aldehyde or ketone groups that are potentially active" (Garrison and Somer 1985:13). Since carbohydrates are classified according to their structure and FTIR detects the bonds between molecules, we will review the simple sugars (monosaccharides), multiple sugars (oligosaccharides), and complex molecules (polysaccharides) that are made up of simple sugars.

Polysaccharides

These complex starchy compounds follow the empirical formula $C_6H_{10}O_5$. They are not sweet, do not crystallize, and are not water soluble. Simply defined, polysaccharides are complex carbohydrates found in plants as starch and cellulose, and in animals as glycogen. Because FTIR detects the bonds between atoms in molecules, it is important to know that polysaccharides are formed of repeating units of mono- or disaccharides that are joined together by glycosidic bonds. Polysaccharides are often heterogeneous. The slight modifications of the repeating unit results in slightly different FTIR wave number signatures. Types of polysaccharides are descriptive and include storage (starches and glycogen), structural (cellulose and chitin), acidic (containing carboxyl groups, phosphate groups, and/or sulfuric ester groups), neutral (presumably without the acid features), bacterial (macromolecules that include peptidoglycan, lipipolysaccharides, capsules and exopolysaccharides), and more. The study of polysaccharides is an ever-growing field and industry, since polysaccharides are important to proper immune function, bowel health, and a host of other factors that are important in human health. At present there is no comprehensive study of which plants and animal parts contain which polysaccharides. Research into this field is currently growing at a rapid pace. Some highlights for the purpose of our discussions are presented below.

Structural Polysaccharides

Structural polysaccharides, which are also known as dietary fiber, are indigestible by humans and other animals. Structural polysaccharides are primarily composed of cellulose, hemicellulose, pectin, gum, and mucilage (Wardlaw and Insel 1996:82). "The only noncarbohydrate components of dietary fiber are lignins, which are complex alcohol derivatives" (Wardlaw and Insel 1996:82). Lignins are complex alcohol derivatives that make up the non-carbohydrate components of insoluble plant fibers (Wardlaw and Insel 1996:82). As such, they cannot be digested by the enzymes animals produce (Carlile and Watkinson 1994). Lignin is found in all plants and is an important component of the secondary cell walls (Lebo et al. 2001) (Martone et al. 2009; Wardlaw and Insel 1996:82). One of the important functions of lignin is to provide support through strengthening of the xylem cells of wood in trees (Arms and Camp 1995; Esau 1977; Wardrop 1969). In linking plant polysaccharides, lignin provides strength to the cell walls and by extension to the entire plant (Chabannes et al. 2001). Because cellulose and chitin provide structural support to plants and animals they are not water soluble. Cellulose, hemicellulose, and pectin are all comprised of simple sugars, and their differences

are defined by the various inclusions, exclusions, and combinations of these sugars, as well as how the sugars are bonded, and the molecular structure of the sugars of these polysaccharides.

Cellulose

Cellulose is comprised of a long linear chain of glucose, whereas hemicellulose consists of shorter branched chains of simple sugars in addition to glucose, including especially xylose, but also mannose, galactose, rhamnose, and arabinose (Crawford 1981; Updegraff 1969). Pectin, however, may be found in either a linear or branched form of simple sugars that is primarily composed of rhamnose.

Hemicellulose

Hemicellulose resides in the cell wall structures of many plants, particularly grain and vegetable plants, and is a component of both insoluble and soluble fibers (Wardlaw and Insel 1996:82). Some specific hemicelluloses include galactan, galactoglucomannan, glucomannan, glucuronoxylan (GX), and xyloglucan (Walker 2006; Wilkie 1985).

Galactoglucomannan. Galactoglucomannan is a primary component of the woody tissue of coniferous plants (Gymnosperms) (Bochicchio and Reicher 2003).

Glucomannan. Glucomannan, which may be very concentrated in some roots or corms and in the wood of conifers and dicotyledons (dicots), is a soluble fiber used to treat constipation by decreasing fecal transit time (Bochicchio and Reicher 2003; Marzio 1989).

Xyloglucan. Xyloglucan is the most abundant hemicellulose in the cell walls of most dicotyledonous plants, and all vascular plants (Fry 1989).

> The primary cell wall of [these plants] is composed of cellulose microfibrils embedded in a matrix of hemicellulosic and pectic polysaccharides, of which the hemicellulose xyloglucan is a major component. Xyloglucan and cellulose together make up about two-thirds of the dry weight of primary cell walls and are the major tension-bearing components of the matrix. During cell expansion and elongation, the cell wall continually undergoes temporary loosening followed by rapid reinforcement of wall structure. Xyloglucan endotransglycosylases (XETs) are unique enzymes in plants that are capable of modulating the chemistry of the matrix and therefore performing both of these functions (Eckardt 2004:792).

It is through this process that plant cell wall growth and repair occurs (Moore and Saehelin 1988).

Pectin, Gums, and Mucilages

Pectin, gums, and mucilages are soluble fibers found inside and around plant cells that help “glue” them together (Wardlaw and Insel 1996:82). Pectin, a structural heteropolysaccharide, is a common substance found in many plants (apples, plums, gooseberries, and citrus), often used for its gelling or thickening action. Plant-derived gums and mucilages such as gum arabic, guar gum, and locus bean gum are also used for this purpose. Arabinan, arabinogalactan,

arabinoglucuronoxylan, and rhamnogalacturonan are some examples of these types of polysaccharides (Wilkie 1985).

Arabinoglucuronoxylan. Arabinoglucuronoxylan is found in the cell walls of softwoods and herbaceous plants (Sjostrom 1981).

Rhamnogalacturonan. Rhamnogalacturonans are specific pectic polysaccharides that reside in the cell walls of all land plants, and result from the degradation of pectin (Willats et al. 2001). They are visible by the presence of peaks at 1150, 1122, 1070, 1043, 989, 951, 916, 902, 846, and 823 wave numbers.

Esters

Esters are an important functional group because they are present as flavoring agents in food and are components of biological compounds such as fats, oils, and lipids. In an ester, the basic unit of the molecule is known as a carbonyl. The presence of the double peak between 3000 and 2800 wave numbers identifies the presence of the aldehyde functional group, which is present in fats, oils, lipids, and waxes.

There are two important groups of esters: saturated esters and aromatic esters. Aromatic esters take their name from their ability to produce distinctive odors and are present as flavoring agents in food. In contrast, saturated esters do not produce distinctive odors. Esters are expressed in the FTIR spectrum by three distinct peaks ("the rule of three") located at approximately 1700, 1200, and 1100 wave numbers, and a fourth peak in the region between 750 and 700 wave numbers, which represents the CH_2 bend associated with aromatic esters. The first peak for saturated esters falls in the 1750–1735 range, the second peak lies between 1210 and 1160, and the third peak sits between 1100 and 1030. Saturated esters have a unique peak for acetates at 1240. This band can be very strong in the signature. The first peak for aromatic esters falls in the range between 1730 and 1715, the second peak between 1310 and 1250, and the third peak between 1130 and 1100 (Smith 1999:110-112). Distinguishing between saturated and aromatic esters, which are both components of foods, is easy if all three bands are present, since they occupy different wave number regions.

Lipids

Lipids that are solid at room temperature are called fats, and those that are liquid at room temperature are referred to as oils (Wardlaw and Insel 1996:108). Both forms of lipids can be detrimental, as well as beneficial, to human health. Consumption of certain animal fats rich in saturated fatty acids can lead to heart disease, while ingesting omega-3 fatty acids such as EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid), found in fish and other plant sources, is essential to good health.

Fatty Acids

Fatty acids are found in most lipids in human and animal bodies, as well as in the lipids in foods (Wardlaw and Insel 1996:108). Long chains of carbons bonded together which are then bonded to hydrogens define the structure of fatty acids (Wardlaw and Insel 1996:109). A

fatty acid is considered saturated if the carbons are connected by single bonds. Saturated fatty acids occur in high proportions in animal fats. If the carbon chain has one double bond between two of the carbons, then the fatty acid is monounsaturated. If there are two or more double bonds between carbons, then the fatty acid is polyunsaturated.

Essential Fatty Acids

Essential fatty acids are those lipids critical to human health, such as omega-3 and omega-6 fatty acids, alpha-lineolic acid, and linoleic acid, that cannot be created within the body and must be obtained from dietary sources (Wardlaw and Insel 1996:110-111). These essential fatty acids are part of "vital body structures, perform vital roles in immune system function and vision, help form cell membranes, and produce hormone like compounds" (Wardlaw and Insel 1996:111). Diets high in essential fatty acids, like omega-3 and omega-6, reduce the risk of heart attacks because they minimize the tendency for blood to clot (Wardlaw and Insel 1996:112). Fish oils contain high concentrations of omega-3 and omega-6 fatty acids and may be administered as a dietary supplement.

Proteins

The human body uses protein from dietary plant and animal sources to form body structures and other constituents (Wardlaw and Insel 1996:152). "Proteins contribute to key body functions, including blood clotting, fluid balance, production of hormones and enzymes, vision, and cell growth and repair" (Wardlaw and Insel 1996:152). This constant regulation and maintenance of the body requires thousands of different types of proteins that are not all available within the body (Wardlaw and Insel 1996:152). The majority of the building blocks for these proteins, which are also known as amino acids, are produced by plants.

Amino Acids

Within the body, amino acids are linked to form the necessary proteins, making them not only essential for life, but key to nutrition. Amino acids can be combined in a multitude of ways to create a vast variety of proteins. These proteins are distinguished by the unique arrangements of amino acids. Proteins are created through a process called translation, in which amino acids are added, one by one, to form short polymer chains called peptides, or longer chains called polypeptides or proteins (Rodnina 2007). The order in which the amino acids are added is determined by the genetic code of the mRNA template, which is a copy of an organism's genes (Creighton 1993). Amino acids are divided into standard and non-standard types.

Standard Amino Acids

There are twenty naturally occurring amino acids on earth, called standard amino acids (Creighton 1993). These amino acids are encoded by the standard genetic code and are found in all forms of life (Creighton 1993). The standard amino acids are broken down into two different types: essential and nonessential.

Essential Amino Acids

Eight of the standard amino acids are considered “essential amino acids” because they are necessary for normal human growth and cannot be synthesized by the human body (Young 1994). Essential amino acids must be obtained from food sources, and include histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine (Furst and Stehle 2004; Reeds 2000; Wardlaw and Insel 1996:154).

Leucine. Leucine is used in the liver, adipose tissue, and muscle tissue. In adipose and muscle tissue, leucine aids in the formation of sterols, and slows the degradation of muscle tissue by increasing the synthesis of muscle proteins (Combaret et al. 2005; Rosenthal et al. 1974). Common sources of leucine in the diet include beef, fish, shellfish, nuts and seeds, eggs, and legumes.

Lysine. Lysine is important for calcium absorption, building muscle, recovering from injuries or illnesses, and the production of hormones, enzymes, and antibodies (Nelson and Cox 2005). Plants that contain significant amounts of lysine include legumes, gourds/squash, spinach, amaranth, quinoa, and buckwheat (Wardlaw and Insel 1996:158). Other dietary sources of lysine include beef, poultry, pork, fish, eggs, and dairy products.

Nonessential Amino Acids

The majority of the standard amino acids are considered “nonessential,” meaning that under normal circumstances these amino acids can be manufactured by the human body and are not required in the diet. However, some amino acids that are normally nonessential may become an essential part of the diet for a person whose health has been compromised (Wardlaw and Insel 1996:155). Nonessential amino acids include alanine, arginine, asparagine, aspartate (aspartic acid), cysteine, glutamate (glutamic acid), glutamine, glycine, proline, serine, and tyrosine (Furst and Stehle 2004; Reeds 2000; Wardlaw and Insel 1996:154).

Serine. Serine is important in metabolic function (Nelson and Cox 2005). It serves as a neuronal signal by activating N-methyl-D-aspartate (NMDA) receptors in the brain and helps to build muscle tissue (Mothet et al. 2000). Common sources of serine in the diet are beef, eggs, nuts and seeds, legumes, and milk.

ETHNOBOTANIC REVIEW

It is a commonly accepted practice in archaeological studies to reference ethnographically documented plant uses as indicators of possible or even probable plant uses in prehistoric times. The ethnobotanic literature provides evidence for the exploitation of numerous plants in historic times, both by broad categories and by specific example. The presence of numerous sources of evidence for exploitation of a given resource can suggest widespread utilization and strengthens the possibility that the same or similar resources were used in prehistoric times. Ethnographic sources both inside and outside the study area have been consulted to permit a more exhaustive review of potential uses for each plant. Ethnographic sources document that the historic use of some plants was a carryover from the past. A plant with medicinal qualities is likely to have been discovered in prehistoric times, with

is use persisting into historic times. There is, however, likely to have been a loss of knowledge concerning the utilization of plant resources as cultures moved from subsistence to agricultural economies and/or were introduced to European foods during the historic period. The ethnobotanic literature serves only as a guide indicating that the potential for use existed in prehistoric times, not as conclusive evidence that the resources were if fact used. Pollen and macrofloral remains, when compared with the material culture (artifacts and features) recovered by the archaeologists, can become indicators of use. Plants represented by organic residues will be discussed in the following paragraphs in order to provide an ethnobotanic background for discussing the remains.

Native Plants

Typha (Cattail)

Typha (cattail) are perennial marsh or aquatic plants with creeping rhizomes. This plant is a rich source of nutrients and noted to be one of the most important and common wild foods. Cattails were a staple for many Native American groups. Various parts of the cattail plant could be used throughout the year. In the spring, the young shoots could be peeled and the white inner core eaten raw or cooked like asparagus. Cattail shoots provide beta carotene, niacin, riboflavin, thiamin, potassium, phosphorus, and vitamin C. During the summer, the young flower stalks were taken out of their sheaths and cooked. The male portions of the immature, green flower head can be steamed or simmered and eaten like corn. The flowers were eaten alone or were added as a flavoring or thickening for other foods. The pollen-producing flowers and the pollen itself were collected and used as flour, either alone or mixed with other meal. In the fall, the root stalks were collected, the outer peel was removed, and the white inner cores of almost pure starch were eaten raw, boiled, or baked, or were dried and ground into flour. Cattail roots are richer in starch during the fall. Cattail starch flour is similar in quantities of fats, proteins, and carbohydrates to flour from rice and corn. The seed-like fruits also were collected and eaten in the fall. Native Americans processed these “seeds” by burning off the bristles. The seeds were then parched and could be more easily rubbed off the spike. The slightly astringent flower heads were sometimes used to relieve diarrhea and other digestive disorders. The “jelly” from between the young leaves and from pounded roots was applied to wounds, sores, carbuncles, boils, external inflammations, burns, and scalds, and was used to soothe pain. Cattail down was used as dressing for wounds and as padding in cradleboards and moccasins. The leaves and stems were used for weaving mats and baskets, to make toys, and to thatch roofs. Cattails form dense stands in marshes, swamps, ponds, sloughs, ditches, and shallow stagnant water, and at the edges of streams (Brill and Dean 1994:67-71; Foster and Duke 1990:312; Medsger 1966:196; Niering 1985:431-432; Peterson 1977:158).

DISCUSSION

The Reeders Creek West site, 28Me360, is located on the east side of the Delaware River within the interchange of Route 29 and Interstate 95. The local vegetation is dominated by sweetgum (*Liquidambar styriciflua*), eastern white pine (*Pinus strobus*), black locust (*Robinia pseudoacacia*), and multiflora rose (*Rosa multiflora*), with trident red maple (*Acer rubrum* var. *trilobum*), green ash (*Fraxinum pennsylvanica*), American elm (*Ulmus Americana*), poison ivy

(*Toxicodendron radicans*), fox grape (*Vitis labrusa*), garlic mustard (*Alliaria officinalis*), and meadow onion (*Allium canadense*) also present. This multicomponent site exhibits Middle Archaic through Late Woodland components. A series of excavation blocks were placed at the site, and samples were submitted for analysis from units in six of the blocks.

Block Z

Seven ceramic sherds were collected from units in Block Z (Table 1). Feature 70 is a possible hearth identified in Units H27 and I27. Five of the ceramic sherds (samples 15, 17, 16, 4, and 3) were recovered from Feature 70 at a depth of 60 cmbd in Level 4.

Feature 70

Organic residue analysis of the first ceramic sherd from Feature 70 in Unit H27 (sample 15) yielded peaks representing major categories (functional groups) of compounds (4000-1500 wave numbers), as well as specific compounds noted in the fingerprint region (1500-400 wave numbers) of the spectrum. The functional group peaks indicate the presence of fats/oils/lipids and/or plant waxes (Table 2). Peaks within the fingerprint region represent the presence of protein; calcium oxalates; pectin; cellulose and carbohydrates; and the polysaccharides arabinoglucuronoxylan, galactoglucomannan, and rhamnogalacturonan.

The only matches made with this signature were with deteriorated cellulose in portions of the spectrum representing cellulose and carbohydrates (Table 3). The presence of a single, somewhat broad, high-amplitude peak at approximately 1000 wave numbers is characteristic of the cellulose reference, and this basic signature is very similar to the one produced by the sample. Cellulose in the sample probably reflects the local environmental signature and the natural breakdown of plant matter in the sediments from which the sherd was recovered. However, the presence of cellulose also may indicate the processing of plants in the ceramic vessel that have deteriorated to the point where they are no longer visible beyond their general cellulose signature. Matches and peaks representing cellulose are common for this project and a complete restatement of their significance will not be made for each sample.

Several polysaccharides, including arabinoglucuronoxylan, galactoglucomannan, and rhamnogalacturonan, are common in the samples from this project. A peak at 1161 wave numbers, representing arabinoglucuronoxylan, suggests that the remains of softwoods and herbaceous plants are contributing to the signature (Sjostrom 1981). Galactoglucomannan, also indicated by this peak, reflects the presence of woody and fibrous tissues from coniferous plants in the sample (Bochicchio and Reicher 2003). The presence of terrestrial plants also is indicated by rhamnogalacturonan peaks at 825 wave numbers (Willats, et al. 2001). Although some of these polysaccharides can be used to indicate specific types of plants, they occur in many species, and it is difficult to determine whether the presence of these compounds reflects plants that were part of the local vegetation or plants that were culturally utilized, especially in the absence of matches. Due to the ubiquitous nature of these peaks, a complete restatement of their significance will not be reiterated for each sample.

A calcium oxalate peak at 776 wave numbers also was not matched. Peaks indicating this compound were identified and unmatched in all samples from this project and their significance also will not be reiterated for each occurrence. Calcium oxalates are present in

several native plants, often in the form of crystals, particularly in *Populus* (cottonwood), *Salix* (willow), and various plants in the Chenopodiaceae such as *Atriplex* (saltbush), *Chenopodium* (goosefoot), and others. Some edible plants that contain calcium oxalates include legumes (leaves and pods), goosefoot (and introduced spinach) greens (leaves), and the fruits of saltbush. Samples that exhibit one or more peaks associated with calcium oxalates, but no matches to specific plants, probably have suffered a higher degree of degradation of compounds, obscuring enough of the signature to make matching with modern references difficult. Calcium oxalate crystals are easily dissolved and rarely observed. Therefore, the recovery of an FTIR signature for calcium oxalates is considered to be a very valuable means of tracking the presence of this compound. The presence of calcium oxalates may suggest the processing of plants in the Chenopodiaceae (goosefoot) family, such as saltbush, goosefoot and others, although it is more likely that calcium oxalates reflect deterioration of plant matter from local vegetation that included cottonwood, willow, saltbush, goosefoot, and perhaps other closely related plants.

Sample 17, representing the second ceramic sherd recovered from the possible hearth (Feature 70) in Unit H27, yielded functional group peaks indicating the presence of absorbed water and fats/oils/lipids and/or plant waxes. Peaks in the fingerprint region represent aromatic rings; aromatic esters; protein; the essential amino acid lysine; calcium oxalates; pectin; humates; cellulose and carbohydrates; and the polysaccharides arabinoglucuronoxylan and galactoglucomannan.

The signature obtained from the second ceramic sherd (sample 17) also matched only with deteriorated cellulose for a single peak at 1004 wave numbers representing cellulose and carbohydrates. This match probably is attributable to the environmental signal, but also may indicate non-specific plant processing using the ceramic vessel represented by this sherd.

No good matches were made with a lysine peak at 1637 wave numbers. This essential amino acid (meaning that it must be obtained from the diet and is not synthesized in the body) is found in high concentrations in *Amaranthus* (pigweed) and meat. It is also a component in legumes, fish, and fowl. Lysine in the sample might represent either natural decomposition of pigweed, legumes, or other plants with similar compound compositions, and/or faunal remains or possibly plant and/or animal processing. Given this general level of interpretation and the fact that these peaks are common for this project, their significance will not be discussed for each sample.

The third ceramic sherd submitted from Feature 70 in Unit H27, represented by sample 16, yielded peaks indicating functional group compounds including absorbed water and fats/oils/lipids and/or plant waxes. Other peaks identified in the fingerprint range represent the presence of aromatic rings, aromatic esters, protein, calcium oxalates, pectin, cellulose, and carbohydrates.

Matches with the third ceramic sherd (sample 16) were made only with deteriorated cellulose for a prominent high amplitude peak at approximately 1004 wave numbers in a portion of the spectrum representing cellulose and carbohydrates. Cellulose in the sample probably reflects decaying plant matter in the sediments and, perhaps, non-specific plant processing.

Sample 4, representing the fourth ceramic sherd from Feature 70 in Unit H27, yielded no functional group peaks. Only peaks in the fingerprint portion of the spectrum representing aromatic rings, calcium oxalates, cellulose, and carbohydrates were noted.

The signature from this ceramic sherd also matched only with deteriorated cellulose for peaks in portions of the spectrum representing cellulose and carbohydrates. Matches with deteriorated cellulose probably are attributable to the local environmental signal.

The final ceramic sherd recovered from the possible hearth (Feature 70) in Unit I27 and analyzed for organic residues (sample 3) yielded peaks representing functional group compounds including absorbed water and fats/oils/lipids and/or plant waxes. Peaks identified in the fingerprint region indicate the presence of aromatic rings; protein; the essential amino acid lysine; calcium oxalates; pectin; cellulose and carbohydrates; and the polysaccharides arabinoglucuronoxylan, galactoglucomannan, and rhamnogalacturonan.

The fifth sherd (sample 3), submitted from the possible hearth (Feature 70), also yielded a signature nearly identical to those produced for the other four sherds (samples 15, 17, 16, and 4) from this feature. Again, deteriorated cellulose was the only reference to match peaks in portions of the spectrum representing cellulose and carbohydrates. The general presence of cellulose in the sample probably represents environmental contributions to the signature, rather than plant processing.

FTIR analysis also was performed on two ceramic sherds (samples 7 and 8) not associated with Feature 70. These samples were collected from Unit H26 at a depth of 80 cmbd in Level 6 and are associated with the Early/Middle Woodland horizon.

Sample 7 yielded functional group peaks indicating the presence of absorbed water and fats/oils/lipids and/or plant waxes. Peaks within the fingerprint range of the spectrum represent aromatic rings; aromatic and saturated esters; protein; the essential amino acid lysine; calcium oxalates; pectin; humates; cellulose and carbohydrates; and the polysaccharides arabinoglucuronoxylan, galactoglucomannan, and rhamnogalacturonan.

Deteriorated cellulose was the only match made with this sample. Matches occurred in portions of the spectrum representing cellulose and carbohydrates. These matches probably reflect decomposition of plants present in the local environment, and possibly the remains of non-specific plant processing using this ceramic vessel.

Examination of the organic residues from the second ceramic sherd (sample 8) yielded peaks representing functional group compounds including absorbed water and fats/oils/lipids and/or plant waxes. Other peaks in the fingerprint region indicating the presence of aromatic rings; aromatic esters; protein; the essential amino acid lysine; calcium oxalates; pectin; humates; cellulose and carbohydrates; and the polysaccharides arabinoglucuronoxylan and galactoglucomannan also were identified.

Matches with raw *Quercus* (acorn) nutshells were made with peaks representing aromatic esters, proteins, and lipids. These matches probably represent plants that were part of the local environment and/or that were discarded in this area. Nutshell matches that are not accompanied by matches with nutmeat are interpreted as representing the environmental component of the signature, because these plant parts are readily incorporated into the

sediments as a result of nut or seed drop from plants growing at or near the site and/or are expected to be present as a result of discard of plant remains after food processing. Matches with nutmeat, however, would be a more reliable indicator that nuts and/or seeds were being processed as food because they are the part expected to be consumed. It is unlikely that mere dry storage of whole unshelled acorns would introduce a strong signature into the ceramic fabric.

Other contributions from the local environmental signal are indicated by matches with deteriorated cellulose for portions of the spectrum representing cellulose and carbohydrates. Alternatively, these matches also might suggest the processing of plants that have decomposed to the point that they are only visible by their general cellulose signature.

Block M

Block M is represented by four pollen samples and three ceramic samples. Pollen analysis yielded sufficient pollen for interpretation in the upper two samples (18 and 19) but not the lower two samples (20 and 21). The upper two samples were collected from Horizons AE and E, while the lower two samples were collected from Horizons Bw2 and C/B. The pollen signature included *Carya*, *Juglans*, *Castanea*, *Liriodendron*, *Pinus*, *Quercus*, and *Ulmus* pollen (Figure 1, Table 4) representing hickory, walnut, chestnut, tulip tree, pine, oak, and elm trees. The total quantity of these pollen representing trees appears to be relatively consistent through time. Pollen types representing understory plants include Anacardiaceae, *Artemisia*, Low-spine Asteraceae, High-spine Asteraceae, Brassicaceae, Cheno-am, *Geranium*, Poaceae, Polygonaceae, *Eriogonum*, and *Salix*, representing a member of the sumac family, sagebrush, various members of the sunflower family, a member of the mustard family, Cheno-ams, geranium, grasses, a member of the knotweed family, wild buckwheat, and willow. It is likely that the *Ephedra nevadensis* pollen was present through long-distance wind transport, as ephedra is not anticipated to be part of the local understory vegetation community. Certainly the pollen record documents a mosaic of vegetation that included pine, oak, and elm; hickory, walnut, and chestnut; and tulip tree. The understory and local riparian vegetation appears to have been varied. It is likely that plants in this group occupied specific niches that were either more sunny or shady, grew interspersed with trees, or in larger sunny open spaces, or grew closer or farther from the river.

Given the low total pollen concentration in the lower two pollen samples, due in large part to the presence of very large quantities of microscopic charcoal that obscured the record, no emphasis is placed on absence of individual pollen taxa within samples from this site. The relatively poor recovery of pollen at this site appears to be due, in large part, to the large quantity of microscopic charcoal in the samples and should not be taken as an indication of poor preservation at other nearby locations. Quantities of microscopic charcoal varied from approximately 35,000 to more than 70,000 fragments in the space required to count 100 pollen. It is likely that the algal and fungal spores noted in high abundance in sample 20 also mark conditions that were hostile to pollen preservation. Due to the large quantities of microscopic charcoal in these samples, additional pollen analysis is not recommended at this site.

Organic residue analysis of a ceramic sherd (sample 9) recovered from Unit M29 at a depth of 44 cmbd in Level 4 and associated with the Late Woodland horizon yielded functional group peaks indicating the presence of absorbed water and fats/oils/lipids and/or plant waxes

(Table 5). Peaks representing aromatic rings; aromatic esters; protein; the essential amino acid lysine; calcium oxalates; pectin; humates; cellulose and carbohydrates; and the polysaccharides arabinoglucuronoxylan, galactoglucomannan, and rhamnogalacturonan also were noted in the fingerprint portion of the spectrum.

Matches with raw *Quercus* (acorn) nutshell lining for an aromatic ester peak at 1707 wave numbers probably represent the environmental component of the signature (Table 6). Although matches also were made with raw *Quercus* (acorn) nutmeat, which is a more reliable indication of nut processing, these matches only occurred with paired peaks between approximately 1479 and 1335 wave numbers, representing protein and lipids, that are common in many cultural and environmental references. References that match only with these peaks for a sample are interpreted as environmental, and may or may not be present in the sample.

Other matches also were made with deteriorated cellulose for portions of the spectrum representing cellulose and carbohydrates. These matches probably reflect the local environmental signal, but also may suggest non-specific plant processing using the vessel represented by this sherd.

Two ceramic sherds recovered from Unit L30 at a depth of 58 cmbd in Level 6 and associated with the Early/Middle Woodland horizon (samples 10 and 11) also were examined for organic residues.

Sample 10 yielded peaks representing functional group compounds including absorbed water and fats/oils/lipids and/or plant waxes. Peaks in the fingerprint range indicate the presence of aromatic rings; aromatic and saturated esters; protein; the essential amino acid lysine; calcium oxalates; pectin; cellulose and carbohydrates; and the polysaccharides arabinoglucuronoxylan, galactoglucomannan, and rhamnogalacturonan.

The only match made with this sample was with deteriorated cellulose for peaks in portions of the spectrum representing cellulose and carbohydrates. Cellulose in the sample probably is attributable to the natural breakdown of plant matter in the sediments, but also may indicate the cooking of plants in the ceramic vessel.

The second ceramic sherd, represented by sample 11, yielded functional group peaks indicating the presence of absorbed water and fats/oils/lipids and/or plant waxes. Peaks identified in the fingerprint region represent aromatic rings; aromatic and saturated esters; protein; the essential amino acid lysine; calcium oxalates; pectin; humates; cellulose and carbohydrates; and the polysaccharides arabinoglucuronoxylan and galactoglucomannan.

The best match for this sample was made with deteriorated cellulose for a broad high-amplitude peak between 1072 and 941 wave numbers, representing cellulose and carbohydrates. This match might reflect either the local environmental signal or non-specific plant processing.

Block N, Feature 44

Block N is located just south of Block M. Feature 44 is a possible hearth noted in the E horizon. Samples 1 and 2 are ceramic sherds associated with Feature 44. These samples were recovered from Unit L34 at a depth of 80 cmbd in Level 7.

FTIR analysis of sample 1 yielded peaks representing functional group compounds including absorbed water and fats/oils/lipids and/or plant waxes. Other peaks in the fingerprint region indicate the presence of aromatic rings; aromatic and saturated esters; protein; the essential amino acid lysine; calcium oxalates; pectin; humates; cellulose and carbohydrates; and the polysaccharide rhamnogalacturonan.

Raw *Quercus* (acorn) nutshells were matched with peaks representing proteins and cellulose. The cellulose peak between 1180 and 1153 wave numbers also was matched with raw *Carya* (hickory) nutshells. Nutshell matches only are interpreted as representing the environmental component of the signature, particularly when no matches with nutmeat are made, because these plant parts are readily incorporated into the sediments from plants growing in the local environment.

Contributions from the environmental signature also are visible in matches with deteriorated cellulose for portions of the spectrum representing cellulose and carbohydrates. These matches probably reflect the natural decomposition of plant materials, but also may indicate non-specific plant processing using the ceramic vessel.

Sample 2 yielded functional group peaks representing fats/oils/lipids and/or plant waxes. Peaks indicating the presence of aromatic and saturated esters; protein; the amino acids lysine and serine; calcium oxalates; pectin; humates; and cellulose and carbohydrates also were noted in the fingerprint portion of the spectrum.

Matches with duck skin for protein and aromatic ester peaks suggests meat (possibly fowl) may have been processed in the ceramic vessel represented by this sherd. Although matches are made with duck skin, they are interpreted at a general, rather than specific, level, meaning that although it appears the inhabitants of the site were processing meat, the particular species or types of animals that were being utilized cannot be identified. The identification of raw protein using protein residue analysis, which is based on immunological techniques, is the only method to identify specific animal proteins.

Raw *Achillea* (yarrow) stems; raw *Carya* (hickory) nutshells; and raw *Helianthus* (sunflower) seeds also were matched with protein and aromatic ester peaks. These matches may represent plants growing in the local environment or they may simply contain common proteins and aromatic esters that are shared with other plants that grow locally. Matches interpreted to represent part of the environment are not identifying specific plants, which would be more securely identified through pollen analysis, but rather indicating that a portion of the chemical signature is derived from plants with specific compounds that are represented in our reference collection by the plants named. This statement is applicable to each of the matches interpreted to represent a part of the environmental signal.

No good matches were made with a serine peak at 1259 wave numbers. This amino acid is common in nuts, seeds, and meat. Serine peaks may reflect the processing of nuts, seeds, or meat in the ceramic vessel; however, in the absence of matches with these peaks, the presence of this amino acid could equally be attributable to other floral and/or faunal remains naturally occurring in the sediments from which the sherd was recovered.

Other matches with raw *Typha* (cattail) roots for an alcohol peak at 1206 wave numbers suggest the possibility that this vessel was used to mix or contain cattail roots but was not used

to cook them. Cattail roots, even raw, contain a sufficient quantity of liquid that if they were mixed (either cut up or pulverized) in this vessel, they might well have imparted a chemical signature into the ceramic fabric.

Deteriorated cellulose was matched with peaks in portions of the spectrum representing cellulose and carbohydrates. Cellulose in the sample probably reflects the local environmental signature, or perhaps, non-specific plant processing.

Block R

Block R is located east of Block N. A single projectile point–type artifact (sample 13) and a soil control were recovered from Unit T34 at a depth of 140 cmbd in Level 13. This artifact appears to have been formed from hard-baked mud or clay, rather than by more traditional lithic flaking techniques. These samples (the artifact and soil control) were submitted for protein residue analysis. All artifacts and soil controls submitted for protein residue analysis from this site were tested against the various antisera listed in Table 7. Sample 13 yielded negative results to all antisera tested.

Block Q

Block Q is found southwest of Block N. Samples 5 and 6 consist of ceramics from Unit J40 associated with an Early/Middle Woodland horizon at a depth of 70 cmbd.

Organic residue analysis of sample 5 yielded peaks representing functional group compounds including absorbed water and fats/oils/lipids and/or plant waxes. Peaks in the fingerprint region indicate the presence of aromatic esters; protein; the essential amino acid lysine; calcium oxalates; pectin; cellulose and carbohydrates; and the polysaccharides arabinoglucuronoxylan and galactoglucomannan.

This sample matched only with deteriorated cellulose for peaks in portions of the spectrum representing cellulose and carbohydrates. Matches with deteriorated cellulose probably are attributable to the natural breakdown of plant matter in the sediments, but also may indicate the processing of plants in the ceramic vessel.

Sample 6, representing the second ceramic sherd from this block, yielded functional group peaks representing fats/oils/lipids and/or plant waxes. Other peaks indicating the presence of aromatic rings; aromatic and saturated esters; protein; the amino acids lysine, leucine, and serine; calcium oxalates; pectin; and the polysaccharide xyloglucan were identified in the fingerprint range.

The signature produced by this sample appears to be dominated by a high amplitude peak at approximately 960 wave numbers representing the aluminum dish used for collection of the sample. The prominent aluminum peak, in particular, indicates that only a small amount of organic residues were present in the ceramic sherd for extraction. Inspection of the aluminum dish also revealed an almost invisible film of residue. FTIR analysis was able to detect a general fats and lipids signature, represented by a double peak between 3000 and 2800 wave

numbers. Peaks in this portion of the spectrum are not diagnostic of specific floral or faunal species because these peaks indicate compounds common in both plant and animal materials.

Two amino acid peaks representing leucine and serine also were detected, but were not matched. Leucine and serine are common in nuts, seeds, and meat, and although the presence of these compounds in the sample might be attributable to processing foods rich in leucine and serine; it is more likely these peaks reflect compounds presents in the floral and faunal materials occurring naturally in the sediments from which the sherd was recovered.

Shifted peaks at 955 and 945 wave numbers in the signatures obtained from this sample also might reflect aluminum contributions; however, these peaks differ slightly in shape from the peak visible in this portion of the spectrum for the aluminum dish reference. This difference may be attributable to high concentrations of pectin and xyloglucan in the sample. Matches with raw *Carya* (hickory) nutshells, raw *Quercus* (acorn) nutshells, and raw *Helianthus* seed shells for the peak at 945 wave numbers, representing xyloglucan, suggest that this peak reflects compounds present in the local vegetation, particularly those in dicots such as hickory, oak, and sunflower. Pectin peaks might indicate the use of this vessel for processing plant parts rich in this compound, such as fruits, roots, and tubers, but it is more likely that this peak also represents the environmental signature. The absence of matches with the pectin peak makes it difficult to determine the specific species present in the sample.

Block D

Block D is situated at the southern end of the site. A projectile point base from Feature 33 in Unit L48 (sample 14) and a projectile point–type artifact from Unit K48 (sample 12) were tested for possible protein residues. Like sample 13, the projectile point–type artifact appears to have been made from hard-baked mud or clay. Both samples 14 and 12 tested negative to all antisera.

SUMMARY AND CONCLUSIONS

Ceramics, soil, projectile point–type artifacts, and a projectile point base were examined from the Reeders Creek West site, 28Me360, in Mercer County, New Jersey. The two projectile point–type artifacts were not made from stone, but rather from mud or clay. Both of these artifacts and the projectile point base tested for possible protein residues yielded negative results to all antisera tested. It is possible that the projectile point–type artifacts made from mud or clay were not designed for actual use. The projectile point base may have been used for hunting or processing resources other than those represented by the available antisera or that an insufficient amount of protein residues were retained on the artifact surface.

Pollen analysis of the four sediment samples yielded a record suggesting a mosaic of vegetation communities that included trees that may have grown individually or in clusters or wooded areas on the landscape. Interspersed with the trees would have been more open areas that supported a variety of shrubs, herbaceous plants, and grasses. The local growth of hickory, walnut, oak, and chestnut trees indicates that nut crops would have been available for use by

local residents. Various other plants in the Cheno-am group, mustard family, and grasses produce edible seeds that may also have contributed to the local subsistence economy.

As a whole, the FTIR record for the ceramic sherds from the Reeders Creek West Site (28ME360) was dominated by an environmental signal representing the natural decomposition of plant matter from local vegetation in the sediments from which the sherds were recovered. The presence of a general cellulose signal in the samples also may suggest non-specific plant processing using the ceramic vessels.

None of the ceramic sherds submitted for organic residue analysis from a possible hearth identified as Feature 70 in Block Z returned any matches indicating the processing of specific floral or faunal species. In fact, all of the samples from Block Z, including those from Feature 70, yielded only an environmental signal. Sample 8, a ceramic sherd associated with the Early/Middle Woodland horizon, was the only sample in this Block (Z) to match with a specific reference, raw acorn nutshells, which also was interpreted as representing compounds present in local vegetation. It is possible that recovery of these sherds from hearth fill indicates that they were burned after being discarded, which may have degraded their organic signatures beyond recognition.

All three ceramic samples (9, 10, and 11) from Block M yielded matches with deteriorated cellulose. Matches with acorn for sample 9 also were interpreted as part of the environmental signature.

The processing of cattail root and meat in the ceramic vessels was suggested only for sample 2, representing one of two ceramic sherds recovered from a possible hearth (Feature 44) in Block N. Other matches with hickory, sunflower, yarrow, and deteriorated cellulose for sample 2 were interpreted as environmental. Matches with raw hickory and acorn nutshells and deteriorated cellulose for the other ceramic sherd from Feature 44 (sample 1) also were attributed to the local environmental signal.

The two ceramic sherds from Block Q, represented by samples 5 and 6, yielded only an environmental signal. Deteriorated cellulose was the only match made for sample 5, while sample 6 matched with nut and seed shell references from hickory, acorn, and sunflower, which were interpreted as representing plants that were part of the local vegetation or compounds common in plants growing at the site.

TABLE 1
PROVENIENCE DATA FOR SAMPLES FROM
THE REEDERS CREEK WEST SITE (28ME360), NEW JERSEY

Sample No.	Block	Unit	Feature No.	Horizon	Lvl	Depth (cmbd)	Provenience/ Description	Analysis
15 (Cat#1085)	Z	H27	70			60	Ceramic associated with possible hearth	FTIR
17 (Cat#1085)							Ceramic associated with possible hearth	FTIR
16 (Cat#1085)							Ceramic associated with possible hearth	FTIR
4 (Cat#1085)					4		Ceramic associated with possible hearth	FTIR
3 (Cat#1113)		I27			4		Ceramic associated with possible hearth	FTIR
7 (Cat#1076)		H26			6	80	Ceramic associated with Early/Middle Woodland Horizon	FTIR
8 (Cat#1076)							Ceramic associated with Early/Middle Woodland Horizon	FTIR
18	M			AE		30-45	Soil	Pollen
19				E		45-70	Soil	Pollen
20				Bw2		100-165	Soil	Pollen
21				C/B		165-175	Soil	Pollen
9 (Cat#565)		M29			4	44	Ceramic associated with Late Woodland Horizon	FTIR
10 (Cat#554)		L30			6	58	Ceramic associated with Early/Middle Woodland Horizon	FTIR
11 (Cat#554)							Ceramic associated with Early/Middle Woodland Horizon	FTIR

TABLE 1 (Continued)

Sample No.	Block	Unit	Feature No.	Horizon	Lvl	Depth (cmbd)	Provenience/ Description	Analysis
1 (Cat#611)	N	L34	44	E	7	80	Ceramic associated with possible hearth from E-horizon	FTIR
2 (Cat#611)							Ceramic associated with possible hearth from E-horizon	FTIR
13 (Cat#817)	R	T34			13	140	Projectile point-type artifact made from mud/clay	Protein
13-SC							Soil control	Protein
5 (Cat#764)	Q	J40			7	70	Ceramic associated with Early/Middle Woodland Horizon	FTIR
6 (Cat#764)							Ceramic associated with Early/Middle Woodland Horizon	FTIR
14 (Cat#267)	D	L48	33			100	Projectile point base	Protein
14-SC							Soil control	Protein
12 (Cat#245)		K48			10	110	Projectile point-type artifact made from mud/clay	Protein
12-SC							Soil Control	Protein

Lvl = Level
FTIR = Fourier Transform Infrared Spectroscopy

TABLE 2
FTIR PEAK SUMMARY TABLE FOR SAMPLES FROM BLOCK Z AT THE REEDERS CREEK WEST SITE (28ME360), NEW JERSEY

Peak Range	Represents	Feature 70						
		15 Ceramic	17 Ceramic	16 Ceramic	4 Ceramic	3 Ceramic	7 Ceramic	8 Ceramic
3600-3200	Absorbed Water (O-H Stretch)		3373,3365	3336,3300		3373	3379, 3275	3379,3365, 3351
3000-2800	Aldehydes: fats, oils, lipids, waxes	2921, 2851	2922,2920, 2852,2851	2920, 2850		2920, 2853,2852	2953, 2922, 2852	2921,2920, 2852,2850
2959, 2938, 2936, 2934, 2931, 2930, 2926, 2924, 2922	CH_2 Asymmetric stretch		2922				2922	
1750-1730	Saturated esters (C=O Stretch)						1735	
1730-1705	Aromatic esters (C=O Stretch)		1719				1719	1709,1708
1700-1500	Protein, incl. 1650 protein	1654	1654,1648, 1637	1654,1648		1654,1648, 1636	1655,1654, 1648,1637, 1577,1541	1654,1648, 1624, 1601
1653	Proteins (Amide bands, 80% C=O Stretch, 10% C-N Stretch, 10% N-H Bend)	1654	1654	1654		1654	1654	1654
1680-1600, 1260, 955	Pectin	1654	1654,1648, 1637	1654,1648		1654,1648, 1636	1655,1654, 1648,1637	1654,1648, 1624, 1601

TABLE 2 (Continued)

Peak Range	Represents	Feature 70						
		15 Ceramic	17 Ceramic	16 Ceramic	4 Ceramic	3 Ceramic	7 Ceramic	8 Ceramic
1640-1610, 1550-1485	Lysine (amino acid) NH_3^+ bending		1637			1636	1637	1624
1500-1400	Protein	1420	1458,1420	1458		1458	1459,1458, 1438	1458,1436
1465-1455	Protein/lipids		1458	1458		1458	1459,1458	1458
1490-1350	Protein	1420	1458,1420	1458		1458	1459,1458, 1438	1458,1436,
1377	Fats, oils, lipids, humates (CH_3 symmetric bend)		1376				1376	1377
1375	CH_3 Umbrella mode		1376				1376	
1170-1150, 1050, 1030	Cellulose	1162,1161	1163/62/61	1163,1162	1163,1162	1162,1161	1162,1161	1162,1161
1162	Cellulose	1162	1162	1162	1162	1162	1162	1162
1161, 1151	Arabinoglucuron-oxylan + Galactoglucomannan	1161	1161			1161	1161	1161
1028-1000	Cellulose Carbohydrates	1004,1000	1004	1004,1000	1007,1002	1001,1000	993	1000
834	Pectin							834
830	Symmetric C-C-O stretch			828	828			

TABLE 2 (Continued)

Peak Range	Represents	Feature 70						
		15 Ceramic	17 Ceramic	16 Ceramic	4 Ceramic	3 Ceramic	7 Ceramic	8 Ceramic
823	Rhamnogalacturonan	825				825	823	
780	Calcium oxalate	776	776	776	777	777	777	776
750-700	Aromatic esters		722	712			721	723,721
722-719	CH_2 Rock (methylene)		722				721	721
692	Aromatic ring bend (phenyl ether)		693	693	693	692	692	693
660, 648	O-H Out-of-plane bend		648					

TABLE 3
MATCHES SUMMARY TABLE FOR FTIR RESULTS FROM BLOCK Z AT THE REEDERS CREEK WEST SITE (28ME360), NEW JERSEY

Match (Scientific Name)	Match (Common Name)	Part	Feature 70						
			15 Ceramic (Range)	17 Ceramic (Range)	16 Ceramic (Range)	4 Ceramic (Range)	3 Ceramic (Range)	7 Ceramic (Range)	8 Ceramic (Range)
Deteriorated Cellulose	Deteriorated cellulose		1069-941 812-788	1072-941 818-785	1072-941 818-785	1072-938 815-782	1072-938 815-782	1207-983 812-788	1186-908
Quercus	Acorn	Nutshell (raw)							1756-1682 1487-1398 1395-1353

TABLE 4
POLLEN TYPES OBSERVED IN SAMPLES FROM
THE REEDERS CREEK WEST SITE (28ME360), NEW JERSEY

Scientific Name	Common Name
ARBOREAL POLLEN:	
Castanea	Chestnut
Juglandaceae:	Walnut family
Carya	Hickory, pecan
Juglans	Walnut
Liriodendron	Poplar
Pinus	Pine
Quercus	Oak
Ulmus	American Elm or, White Elm, Water Elm
NON-ARBOREAL POLLEN:	
Anacardiaceae	Sumac family
Asteraceae:	Sunflower family
Artemisia	Sagebrush
Low-spine	Includes ragweed, cocklebur, sumpweed
High-spine	Includes aster, rabbitbrush, snakeweed, sunflower, etc.
Brassicaceae	Mustard or cabbage family
Cheno-am	Includes the goosefoot family and amaranth
Ephedra nevadensis-type (includes *E. clokeyi, E. coryi, E. funera, E. viridis, E. californica, E. nevadensis,* and *E. aspera*)	Ephedra, Jointfir, Mormon tea
Geranium	Geranium
Poaceae	Grass family
Polygonaceae:	Knotweed/Smartweed family
Eriogonum	Wild buckwheat
Salix	Willow
Indeterminate	Too badly deteriorated to identify
ALGAE:	

TABLE 4 (Continued)

Scientific Name	Common Name
Algal spore	Algal spore
Zygnema-type	Algal body
FUNGAL SPORES:	
Fungal spore	Fungal spore
Sporormiella	Dung fungus
Charcoal	Microscopic charcoal
Total pollen concentration	Quantity of pollen per cubic centimeter (cc) of sediment

TABLE 5
FTIR PEAK SUMMARY TABLE FOR SAMPLES FROM BLOCKS M, N, AND Q
AT THE REEDERS CREEK WEST SITE (28ME360), NEW JERSEY

Peak Range	Represents	Block M			Block N/Feature 44		Block Q	
		9 Ceramic	10 Ceramic	11 Ceramic	1 Ceramic	2 Ceramic	5 Ceramic	6 Ceramic
3600-3200	Absorbed Water (O-H Stretch)	3368	3380	3364,3345	3328, 3282		3384,3326	
3000-2800	Aldehydes: fats, oils, lipids, waxes	2919,2914, 2851/50/48	2954, 2923/21 2918, 2853/52/50	2921, 2851	2916, 2849	2917, 2849	2922,2921, 2853,2852	2925,2920 2854, 2850/49
2959, 2938, 2936, 2934, 2931, 2930, 2926, 2924, 2922	CH_2 Asymmetric stretch						2922	
1750-1730	Saturated esters (C=O Stretch)		1735	1735	1735			1735
1730-1705	Aromatic esters (C=O Stretch)	1707		1718	1706	1706		1719,1707
1700-1500	Protein, incl. 1650 protein	1654,1648, 1637/36,1618, 1609, 1571,1542	1655,1654, 1630	1664,1654, 1648,1647, 1637,1636, 1507	1654, 1648, 1637	1654	1654, 1637,1636, 1625, 1577,1560, 1541	1654, 1637, 1618, 1560, 1541

TABLE 5 (Continued)

Peak Range	Represents	Block M			Block N/Feature 44		Block Q	
		9 Ceramic	10 Ceramic	11 Ceramic	1 Ceramic	2 Ceramic	5 Ceramic	6 Ceramic
1653	Proteins (Amide bands, 80% C=O Stretch, 10% C-N Stretch, 10% N-H Bend)	1654	1654	1654	1654	1654	1654	1654
1680-1600, 1260, 955	Pectin	1654,1648, 1637/36, 1618, 1609	1655,1654, 1630	1664,1654, 1648,1647, 1637,1636	1654, 1648, 1637	1654	1654, 1637,1636, 1625	1654, 1637, 1618
1640-1610, 1550-1485	Lysine (amino acid) NH_3^+ bending	1637/36, 1618	1630	1637,1636	1637		1637,1636, 1625, 1541	1637, 1618, 1541
1500-1400	Protein	1458,1437, 1411	1458,1430	1459,1458	1459,1438, 1420,1411	1463,1458 1411	1459,1458, 1438,1420	1458, 1420
1465-1455	Protein/lipids	1458	1458	1459,1458	1459	1463,1458	1459,1458	1458
1490-1350	Protein	1458,1437, 1411	1458,1430	1459,1458	1459,1438, 1420,1411, 1364	1463,1458 1411	1459,1458, 1438,1420	1458, 1428, 1375
1377	Fats, oils, lipids, humates (CH_3 symmetric bend)	1376		1377	1376	1377		
1375	Leucine (amino acid) CH_3 symmetric bending							1375

TABLE 5 (Continued)

Peak Range	Represents	Block M			Block N/Feature 44		Block Q	
		9 Ceramic	10 Ceramic	11 Ceramic	1 Ceramic	2 Ceramic	5 Ceramic	6 Ceramic
1375	CH_3 Umbrella mode	1376			1376			1375
1350-1250	Serine (amino acid) O-H bending					1259		1260
1202	Tertiary alcohol C-O stretch					1206		
1170-1150, 1050, 1030	Cellulose	1162/61/60	1161,1160	1163/62/61	1162,1160	1163,1162	1162,1161	
1162	Cellulose	1162		1162	1162	1162	1162	
1161, 1151	Arabinoglucuron-oxylan + Galactoglucomannan	1161	1161	1161			1161	
1130-1100	Aromatic esters					1101		
1100-1030	Saturated esters					1052		
1028-1000	Cellulose Carbohydrates	996	1000	1009,1008	994	1001	989	
953	Pectin							955
945	Xyloglucan							945
941	Glucomannan					942		
830	Symmetric C-C-O stretch	830	831			830	830	830

TABLE 5 (Continued)

Peak Range	Represents	Block M			Block N/Feature 44		Block Q	
		9 Ceramic	10 Ceramic	11 Ceramic	1 Ceramic	2 Ceramic	5 Ceramic	6 Ceramic
823	Rhamnogalacturonan	823	824		824			
780	Calcium oxalate	777	778	777	776	776	776	776
750-700	Aromatic esters	721	722,721		722,719	722	720	721
722-719	CH_2 Rock (methylene)	721	722,721		722,719	722	720	721
692	Aromatic ring bend (phenyl ether)	693	693	693	692			693
660, 648	O-H Out-of-plane bend						648	660

TABLE 6
MATCHES SUMMARY FOR FTIR RESULTS FROM BLOCKS M, N, AND Q
AT THE REEDERS CREEK WEST SITE (28ME360), NEW JERSEY

Match (Scientific Name)	Match (Common Name)	Part	Block M			Block N/Feature 44		Block Q	
			9 Ceramic (Range)	10 Ceramic (Range)	11 Ceramic (Range)	1 Ceramic (Range)	2 Ceramic (Range)	5 Ceramic (Range)	6 Ceramic (Range)
ECONOMIC									
Typha	Cattail	Root (raw)					1216-1195		
Animalia	Duck	Skin					1508-1397 735-708		
ENVIRONMENTAL									
Achillea	Yarrow	Stem (raw)					1508-1397		
Carya	Hickory	Nutshell (raw)				1180-1153	1392-1362 977-902 735-708		1024-851
Deteriorated Cellulose	Deteriorated cellulose		1210-977 812-786	1072-941 821-785	1072-941	1135-986 821-782	1072-938	1213-1003	
Helianthus	Sunflower	Seed shell (raw)					1508-1397 735-708		1024-851

TABLE 6 (Continued)

Match (Scientific Name)	Match (Common Name)	Part	Block M			Block N/Feature 44		Block Q	
			9 Ceramic (Range)	10 Ceramic (Range)	11 Ceramic (Range)	1 Ceramic (Range)	2 Ceramic (Range)	5 Ceramic (Range)	6 Ceramic (Range)
ENVIRONMENTAL (Continued)									
Quercus	Acorn	Nutmeat (raw)	1476-1395						
		Nutshell lining (raw)	1723-1691						
		Nutshell (raw)				1389-1374 1180-1153			1024-851

TABLE 7
LIST OF ANTISERA USED IN TESTING ARTIFACTS FROM
THE REEDERS CREEK WEST SITE (28ME360), NEW JERSEY

ANTISERUM	SOURCE	POSSIBLE RESULTS
ANIMALS:		
Bear	ICN Pharmaceuticals, Inc.	Black bear, Brown bear, Grizzly, Polar bear
Bison	Prepared under the direction of Dr. Richard Marlar at the University of Colorado Health Sciences Center	Bison, Domestic bovids
Bovine	Sigma Chemical Company	Domestic bovids, Bison
Cat	Sigma Chemical Company	Domestic cat, Mountain lion, Bobcat, Lynx, other wild cat species
Chicken	Sigma Chemical Company	Domestic chicken, Partridge, Quail, Grouse, Ptarmigan, Pheasant
Deer	ICN Pharmaceuticals, Inc.	White tail deer, Mule deer, Elk, Moose, Caribou, Wapiti
Dog	Sigma Chemical Company	Domestic dog, Coyote, Wolf, Fox
Duck	Nordic Immunological Laboratories	Duck, Goose, Pigeon, Domestic turkey, Wild turkey
Goat	Sigma Chemical Company	Pronghorn, Mountain goat, Domestic goat
Guinea pig	Sigma Chemical Company	Guinea pig, Porcupine, Beaver, Squirrel family (Squirrel, Marmot, Ground squirrel, Chipmunk, etc.)
Human	ICN Pharmaceuticals, Inc.	Human
Mouse	Sigma Chemical Company	Members of the New World rats and mice family, Members of the Old World rats and mice family
Rabbit	Sigma Chemical Company	Rabbit, Jackrabbit (hare)
Rat	Sigma Chemical Company	Members of the New World rats and mice family, Members of the Old World rats and mice family
Sheep	ICN Pharmaceuticals, Inc.	Domestic sheep, Bighorn sheep
Turkey	Sigma Chemical Company	Domestic turkey, Wild turkey, Ducks

TABLE 7 (Continued)

ANTISERUM	SOURCE	POSSIBLE RESULTS
FISH/AQUATIC:		
Atlantic croaker	Robert Sargeant	Perciformes order (Spiny-rayed [percoid] fishes)
Catfish	Sigma Chemical Company	Catfish, Carp
Gizzard Shad	Robert Sargeant	Gizzard shad
Sturgeon	Robert Sargeant	Acipenseridae family (Sturgeons)
Striped bass	Robert Sargeant	Perciformes order (Spiny-rayed or percoid fish)
Trout	Sigma Chemical Company	Salmonidae family (Trout and salmon)

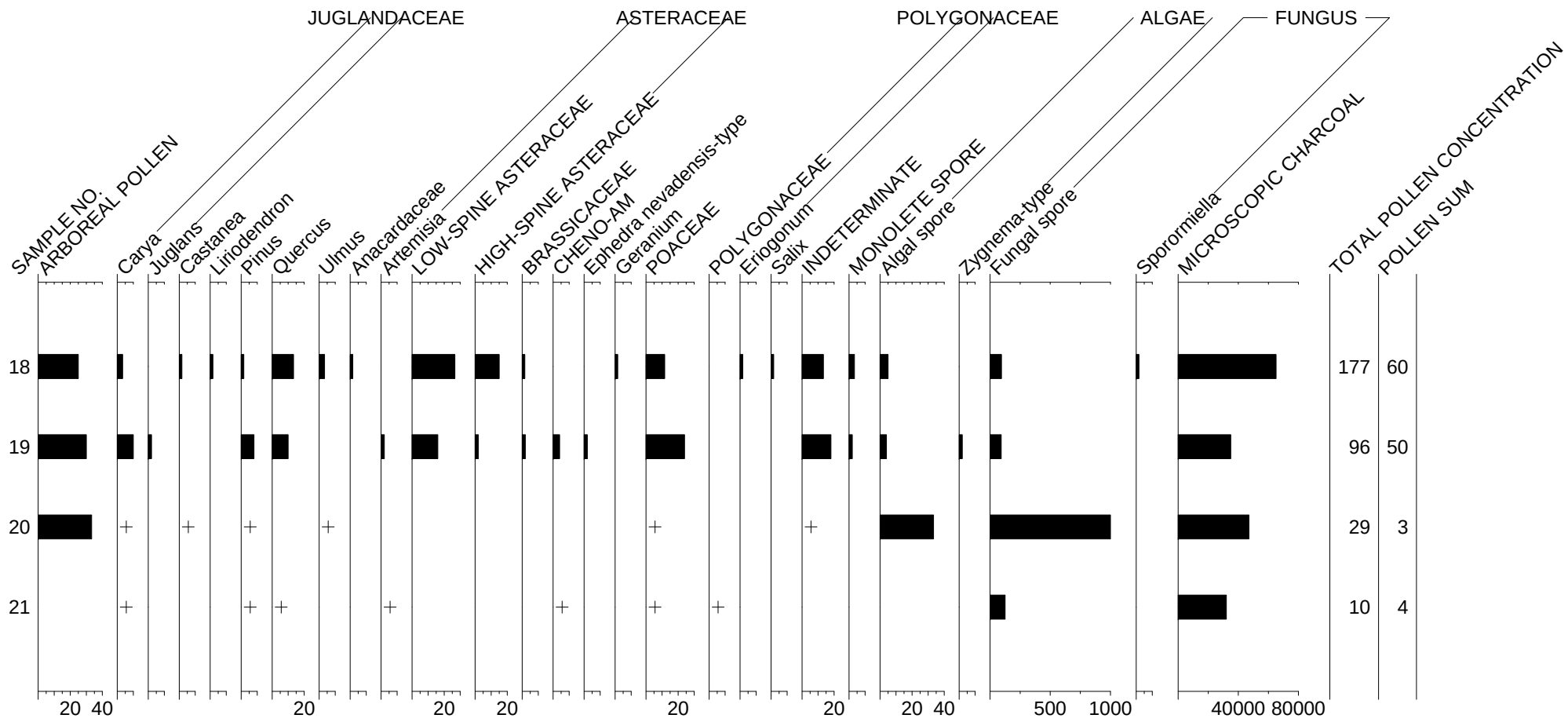


FIGURE 1. POLLEN DIAGRAM FOR THE REEDERS CREEK WEST SITE (28ME360), NEW JERSEY

REFERENCES CITED

Arms, Karen, and Pamela S. Camp
1995 *Biology*. Saunders College Publishing, Fort Worth.

Bochicchio, R., and F. Reicher
2003 Are Hemicelluloses from Podocarpus Lambertii Typical of Gymnosperms? *Carbohydrate Polymers* 53(2):127-136.

Bog-Hansen, T. C.
1990 Immunoelectrophoresis. In *Gel Electrophoresis of Proteins*, edited by D. Rickwood, and B.D. Hames, pp. 273-300. Oxford University Press, Oxford.

Brill, Steve, and Evelyn Dean
1994 *Identifying and Harvesting Edible and Medicinal Plants in Wild (and Not So Wild) Places*. Hearst Books, New York, New York.

Carlile, Michael J., and Sarah C. Watkinson
1994 *The Fungi*. Academic Press, San Diego.

Chabannes, Matthieu, Katia Ruel, Arata Yoshinaga, Brigitte Chabbert, Alain Jauneau, Jean-Paul Joseleau, and Alain-Michel Boudet
2001 In Situ Analysis of Lignins in Transgenic Tobacco Reveals a Differential Impact of Individual Transformations on the Spatial Patterns of Lignin Deposition at the Cellular and Subcellular Levels. *The Plant Journal* 28:271-282.

Combaret, Lydie, Dominique Dardevet, Isabelle Rieu, Marie-Noelle Pouch, Daniel Bechet, Daniel Taillandier, Jean Grizard, and Didier Attaix
2005 A Leucine-supplemented Diet Restores the Defective Postprandial Inhibition of Proteasome-dependent Proteolysis in Aged Rat Skeletal Muscle. *Journal of Physiology* 569(2):489-499.

Crawford, R. L.
1981 *Lignin Biodegradation and Transformation*. John Wiley and Sons, New York.

Creighton, Thomas E.
1993 *Proteins: Structures and Molecular Properties*. 2nd ed. W. H. Freeman and Company, Ltd., San Francisco.

Culliford, Brian J.
1964 Precipitation Reactions in Forensic Problems. *Nature* 201:1092-1094.

1971 *The Examination and Typing of Bloodstains in the Crime Laboratory*. United States Department of Justice, U.S. Government Printing Office, Stock 2700-0083, Washington D.C.

Eckardt, Nancy A.
2004 Inside the Matrix: Crystal Structure of a Zyloglucan Endotransglycosylase. *The Plant Cell* 16:792-793.

Esau, Katherine
1977 *Anatomy of Seed Plants*. John Wiley and Sons, New York.

Foster, Steven, and James A. Duke
1990 *A Field Guide to Medicinal Plants: Eastern and Central North America*. Houghton Mifflin Company, Boston.

Fry, S. C.
1989 The Structure and Functions of Xyloglucan. *Journal of Experimental Biology* 40:1-11.

Furst, P., and P. Stehle
2004 What are the Essential Elements Needed for the Determination of Amino Acid Requirements in Humans? *Journal of Nutrition* 134(6):1558S-1565S.

Gaensslen, R. E.
1983 *Sourcebook in Forensic Serology, Immunology, and Biochemistry*. United States Department of Justice, Washington D.C.

Garrison, Robert , Jr., and Elizabeth Somer
1985 *The Nutrition Desk Reference*. Keats Publishing, Inc., New Canaan.

Gerlach, S. C., Margaret Newman, Edward J. Knell, and Edwin S. Hall
1996 Blood Protein Residues on Lithic Artifacts from Two Archaeological Sites in the De Long Mountains, Northwestern Alaska. *Arctic* 49(1):1-10.

Gurfinkel, D. M., and U. M. Franklin
1988 A Study of the Feasibility of Detecting Blood Residue on Artifacts. *Journal of Archeological Science* 15:83-97.

Hogberg, Anders, Kathryn Puseman, and Chad Yost
2009 Integration of Use-wear with Protein Residue Analysis - A Study of Tool Use and Function in the Scandinavian Early Neolithic. *Journal of Archaeological Science* 36:1725-1737.

Hyland, D. C., J. M. Tersak, J. M. Adovasio, and M. I. Siegel
1990 Identification of the Species of Origin of Residual Blood on Lithic Material. *American Antiquity* 55(1):104-111.

Isaksson, Sven
1999 Guided By Light: The Swift Characterization of Ancient Organic Matter by FTIR, IR-Fingerprinting and Hierarchical Cluster Analysis. *Laborativ Arkeologi* 12:35-43.

Kooyman, B., Margaret E. Newman, Christine Cluney, Murray Lobb, and Shayne Tolman
2001 Identification of Horse Exploitation by Clovis Hunters Based on Protein Analysis. *American Antiquity* 66(4):686-691.

Lebo, Stuart E., Jr., Jerry D. Gargulak, and Timothy J. Mcnally
2001 Lignin. In *Encyclopedia of Chemical Technology*. 4th ed. John Wiley and Sons, Inc.

Loy, T. H.
1983 Prehistoric Blood Residues: Detection on Tool Surfaces and Identification of Species of Origin. *Science* 220:1269-1271.

Marlar, R. A., Kathryn Puseman, and Linda Scott Cummings
1995 Protein Residue Analysis of Archaeological Materials: Comments on Criticisms and Methods. *Southwestern Lore* 61(2):27-37.

Martone, Patrick T., José M. Estevez, Fachuang Lu, Katia Ruel, Mark W. Denny, Chris Somerville, and John Ralph
2009 Discovery of Lignin in Seaweed Reveals Convergent Evolution of Cell-Wall Architecture. *Current Biology* 19(2):169-175.

Marzio, L., R. Del Bianco, M.D. Donne, O. Pieramico, and F. Cuccurullo
1989 Mouth-to-Cecum Transit Time in Patients Affected by Chronic Constipation: Effect of Glucomannan. *The American Journal of Gastroenterology* 84(8):888-891.

Medsger, Oliver Perry
1966 *Edible Wild Plants*. MacMillan Publishing Company, Inc., Racine, Wisconsin.

Moore, P. J. , and L. A. Saehelin
1988 Immunogold Localization of the Cell Wall Matrix Polysaccharides Rhamnogalacturonan_I and Xyloglucan During Cell Expansion and Cytokinesis in Trifoliym pratense L. - Implications for Secretory Pathways. *Planta* 174:433-445.

Mothet, Jean-Pierre, Angele T. Parent, Herman Wolosker, Roscoe O. Brady, Jr., David J. Linden, Christopher D. Ferris, Michael A. Rogawski, and Solomon H. Snyder
2000 D-serine is an Endogenous Ligand for the Glycine Site of the N-methl-D-aspartate Receptor. *Proceedings of the National Academy of Sciences* 97(9):4926-4931.

Nelson, D. L., and M. M. Cox
2005 *Lehninger Principles of Biochemistry*. 4th ed. W. H. Freeman and Company, New York.

Newman, M., and P. Julig
1989 The Identification of Protein Residues on Lithic Artifacts from a Stratified Boreal Forest Site. *Canadian Journal of Archaeology* 13:119-132.

Niering, W. A.
1985 *Wetlands*. The Audubon Society Nature Guides. Alfred A. Knopf, New York.

Peterson, Lee A.
1977 *Edible Wild Plants*. Collier Books, New York, New York.

Reeds, P. J.
2000 Dispensable and Indespensable Amino Acids for Humans. *Journal of Nutrition* 130(7):1835S-1840S.

Rodnina, M. V., M. Beringer, and W. Wintermeyer
2007 How Ribosomes Make Peptide Bonds. *Trends in Biochemical Sciences* 32(1):20-26.

Rosenthal, J., A. Angel, and J. Farkas
1974 Metabolic Fate of Leucine: A Significant Sterol Precursor in Adipose Tissue and Muscle. *American Journal of Physiology* 226(2):411-418.

Seeman, Mark F., Nils E. Nilsson, Garry L. Summers, Larry L. Morris, Paul J. Barans, Elaine Dowd, and Margaret Newman
2008 Evaluating protein residues on Gainey phase Paleoindian stone tools. *Journal of Archaeological Science* 35:2742-2750.

Sensabaugh, G.F., A.C. Wilson, and P.L. Kirk
1971 Protein Stability in Preserved Archaeological Remains, Parts I and II. *International Journal of Biochemistry* 2:545-568.

Sjostrom, J.
1981 *Wood Chemistry: Fundamentals and Applications*. Academic Press, New York.

Smith, Brian
1999 *Infrared Spectral Interpretation, A Systematic Approach*. CRC Press, New York.

Updegraff, D. M.
1969 Semimicro Determination of Cellulose in Biological Materials. *Analytical Biochemistry* 32:420-424.

Walker, J. C. F.
2006 *Primary Wood Processing: Principles and Practice*. Springer, Dordrecht, The Netherlands.

Wardlaw, Gordon M., and Paul M. Insel
1996 *Perspectives in Nutrition*. Mosby-Year Book, Inc., St. Louis, Missouri.

Wardrop, A. B.
1969 The Structure of the Cell Wall in Lignifies Collenchyma of Eryngium sp. (Umbelliferae). *Australian Journal of Botany* 17:229-240.

Wilkie, K. C. B.
1985 New Perspectives on Non-Cellulosic Cell-Wall Polysaccharides (Hemicellulose and Pectic Substances) of Land Plants. In *Biochemistry of Plant Cell Walls*, edited by C. T. Brett, and John R. Hillman. Cambridge University Press, Cambridge.

Willats, William, Lesley Mccartney, William Mackie, and J. Paul Knox
2001 Pectin: Cell Biology and Prospects for Functional Analysis. *Plant Molecular Biology* 47:9-27.

Yost, Chad, and Linda Scott Cummings
2008 *Pollen, Starch, Phytolith, Protein Residue, and Organic Residue Analysis of Artifacts from Northeastern Alberta, Canada*. Copies available from Ms. on file with FMA Heritage, Inc., Calgary, Alberta, Canada. PRI Technical Report 08-84.

Young, V. R.
1994 Adult Amino Acid Requirements: The Case for a Major Revision in Current Recommendations. *Journal of Nutrition* 124(8):1517S-1523S.

Appendix G: Beta Analytic Radiocarbon Reports

Beta Analytic Inc.
4985 SW 74 Court
Miami, Florida 33155 USA
Tel: 305 667 5167
Fax: 305 663 0964
Beta@radiocarbon.com
www.radiocarbon.com

Consistent Accuracy . . .
. . . Delivered On-time

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

November 19, 2010

Mr. Brian M. Albright
516 East State Street
Trenton, NJ 08609
USA

RE: Radiocarbon Dating Result For Sample Scudders M14

Dear Mr. Albright:

Enclosed is the radiocarbon dating result for one sample recently sent to us. It provided plenty of carbon for an accurate measurement and the analysis proceeded normally. The report sheet contains the method used, material type, and applied pretreatments and, where applicable, the two-sigma calendar calibration range.

This report has been both mailed and sent electronically. All results (excluding some inappropriate material types) which are less than about 20,000 years BP and more than about ~250 BP include a calendar calibration page (also digitally available in Windows metafile (.wmf) format upon request). Calibration is calculated using the newest (2004) calibration database with references quoted on the bottom of the page. Multiple probability ranges may appear in some cases, due to short-term variations in the atmospheric 14C contents at certain time periods. Examining the calibration graph will help you understand this phenomenon. Don't hesitate to contact us if you have questions about calibration.

We analyzed this sample on a sole priority basis. No students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analysis. We analyzed it with the combined attention of our entire professional staff.

Information pages are also enclosed with the mailed copy of this report. If you have any specific questions about the analysis, please do not hesitate to contact us. Someone is always available to answer your questions.

The cost of the analysis was charged to the American Express card provided. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Mr. Brian M. Albright

Report Date: 11/19/2010

Material Received: 10/28/2010

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 287257	2500 +/- 40 BP	-24.3 o/oo	2510 +/- 40 BP

SAMPLE : Scudders M14
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 790 to 510 (Cal BP 2740 to 2460)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

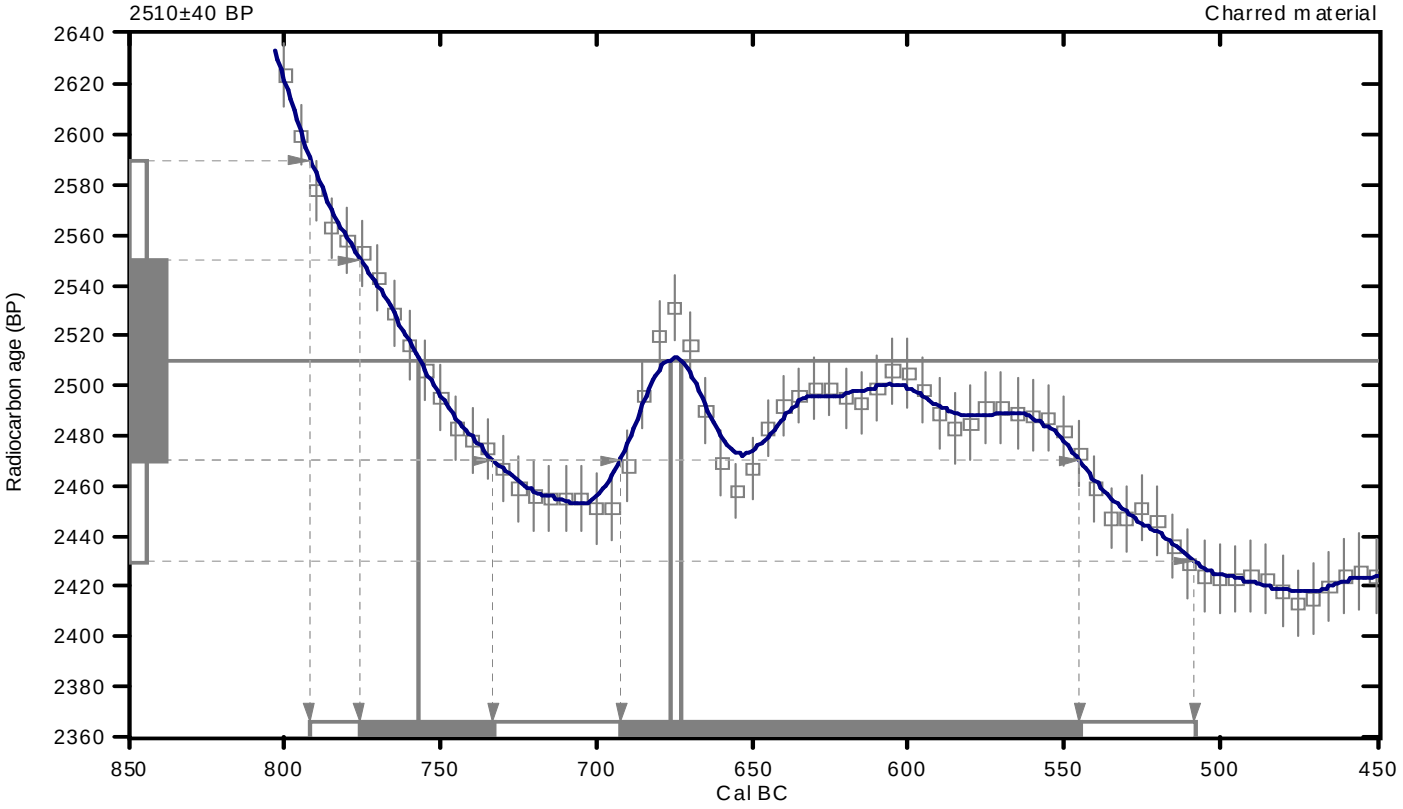
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.3:lab. mult=1)

Laboratory number:	**Beta-287257**
Conventional radiocarbon age:	**2510±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal BC 790 to 510 (Cal BP 2740 to 2460)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal BC 760 (Cal BP 2710) and Cal BC 680 (Cal BP 2630) and Cal BC 670 (Cal BP 2620)
1 Sigma calibrated results: (68% probability)	Cal BC 780 to 730 (Cal BP 2730 to 2680) and Cal BC 690 to 540 (Cal BP 2640 to 2500)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

Beta Analytic Inc.
4985 SW 74 Court
Miami, Florida 33155 USA
Tel: 305 667 5167
Fax: 305 663 0964
Beta@radiocarbon.com
www.radiocarbon.com

Consistent Accuracy . . .
. . . Delivered On-time

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

December 21, 2010

Mr. John W. Lawrence
AECOM
344 East Union Street
Burlington, NJ 08016
USA

RE: Radiocarbon Dating Results For Samples FEAT#27, L15-298 to 316cm

Dear Mr. Lawrence:

Enclosed are the radiocarbon dating results for two samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

The cost of the analysis was charged to the VISA card provided. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Mr. John W. Lawrence — Report Date: 12/21/2010

AECOM — Material Received: 11/17/2010

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 288328	1500 +/- 40 BP	-25.3 o/oo	1500 +/- 40 BP

SAMPLE : FEAT#27
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 440 to 490 (Cal BP 1510 to 1460) AND Cal AD 520 to 640 (Cal BP 1430 to 1310)

Beta - 288329	6140 +/- 40 BP	-21.6 o/oo	6200 +/- 40 BP

SAMPLE : L15-298 to 316cm
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION : Cal BC 5290 to 5040 (Cal BP 7240 to 6990)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

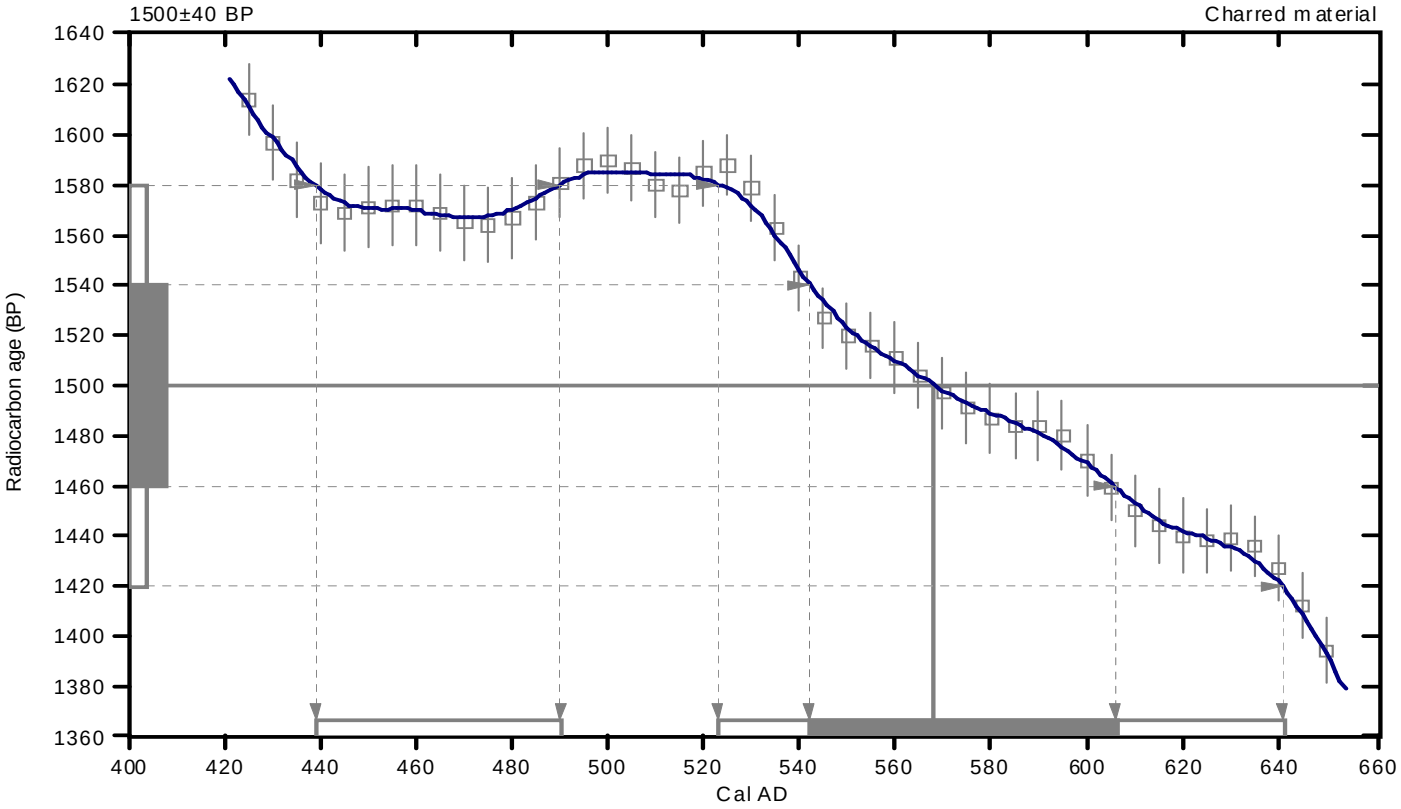
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.3:lab. mult=1)

Laboratory number:	**Beta-288328**
Conventional radiocarbon age:	**1500±40 BP**
2 Sigma calibrated results: (95% probability)	**Cal AD 440 to 490 (Cal BP 1510 to 1460) and Cal AD 520 to 640 (Cal BP 1430 to 1310)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 570 (Cal BP 1380)
1 Sigma calibrated result: (68% probability)	Cal AD 540 to 610 (Cal BP 1410 to 1340)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

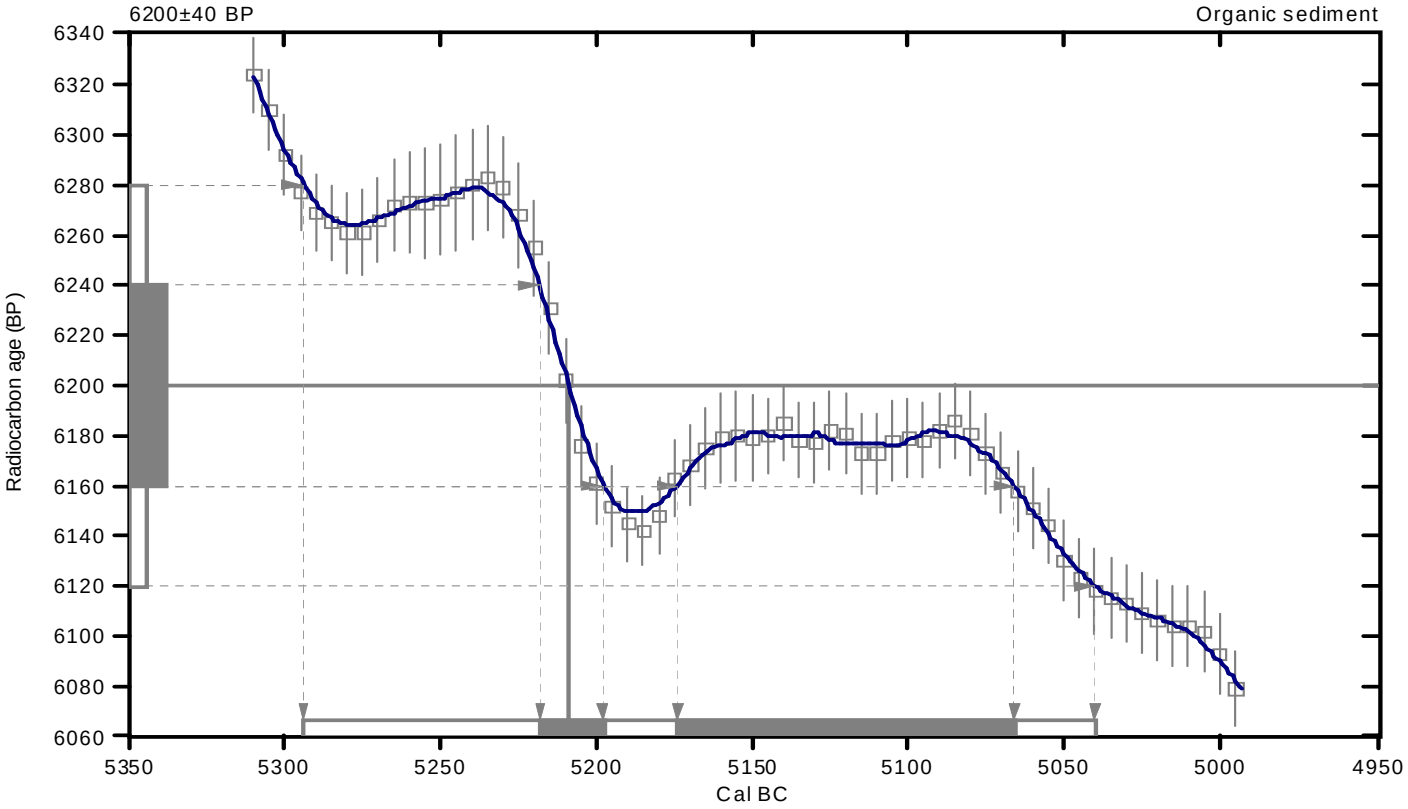
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.6:lab. mult=1)

Laboratory number:	**Beta-288329**
Conventional radiocarbon age:	**6200±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal BC 5290 to 5040 (Cal BP 7240 to 6990)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 5210 (Cal BP 7160)
1 Sigma calibrated results: (68% probability)	Cal BC 5220 to 5200 (Cal BP 7170 to 7150) and Cal BC 5170 to 5070 (Cal BP 7120 to 7020)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

Beta Analytic Inc.
4985 SW 74 Court
Miami, Florida 33155 USA
Tel: 305 667 5167
Fax: 305 663 0964
Beta@radiocarbon.com
www.radiocarbon.com

Consistent Accuracy . . .
. . . Delivered On-time

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

April 5, 2011

Mr. Frank Mikolic
AECOM
516 East State Street
Trenton, NJ 08609
USA

RE: Radiocarbon Dating Results For Samples FEAT#64 X, FEAT#67 V, FEAT#73 Z, N47 LV14 G

Dear Mr. Mikolic:

Enclosed are the radiocarbon dating results for four samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

The cost of the analysis was charged to the MASTERCARD card provided. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Mr. Frank Mikolic — Report Date: 4/5/2011

AECOM — Material Received: 3/9/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 295378	2980 +/- 40 BP	-24.6 o/oo	2990 +/- 40 BP
SAMPLE : FEAT#64 X			
ANALYSIS : AMS-Standard delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal BC 1380 to 1330 (Cal BP 3330 to 3280) AND Cal BC 1330 to 1120 (Cal BP 3280 to 3060)			
Beta - 295379	920 +/- 30 BP	-27.1 o/oo	890 +/- 30 BP
SAMPLE : FEAT#67 V			
ANALYSIS : AMS-Standard delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 1040 to 1220 (Cal BP 910 to 730)			
Beta - 295380	3620 +/- 40 BP	-25.6 o/oo	3610 +/- 40 BP
SAMPLE : FEAT#73 Z			
ANALYSIS : AMS-Standard delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal BC 2120 to 2090 (Cal BP 4070 to 4040) AND Cal BC 2040 to 1880 (Cal BP 3990 to 3830)			
Beta - 295381	3880 +/- 40 BP	-25.7 o/oo	3870 +/- 40 BP
SAMPLE : N47 LV14 G			
ANALYSIS : AMS-Standard delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal BC 2470 to 2200 (Cal BP 4420 to 4150)			

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

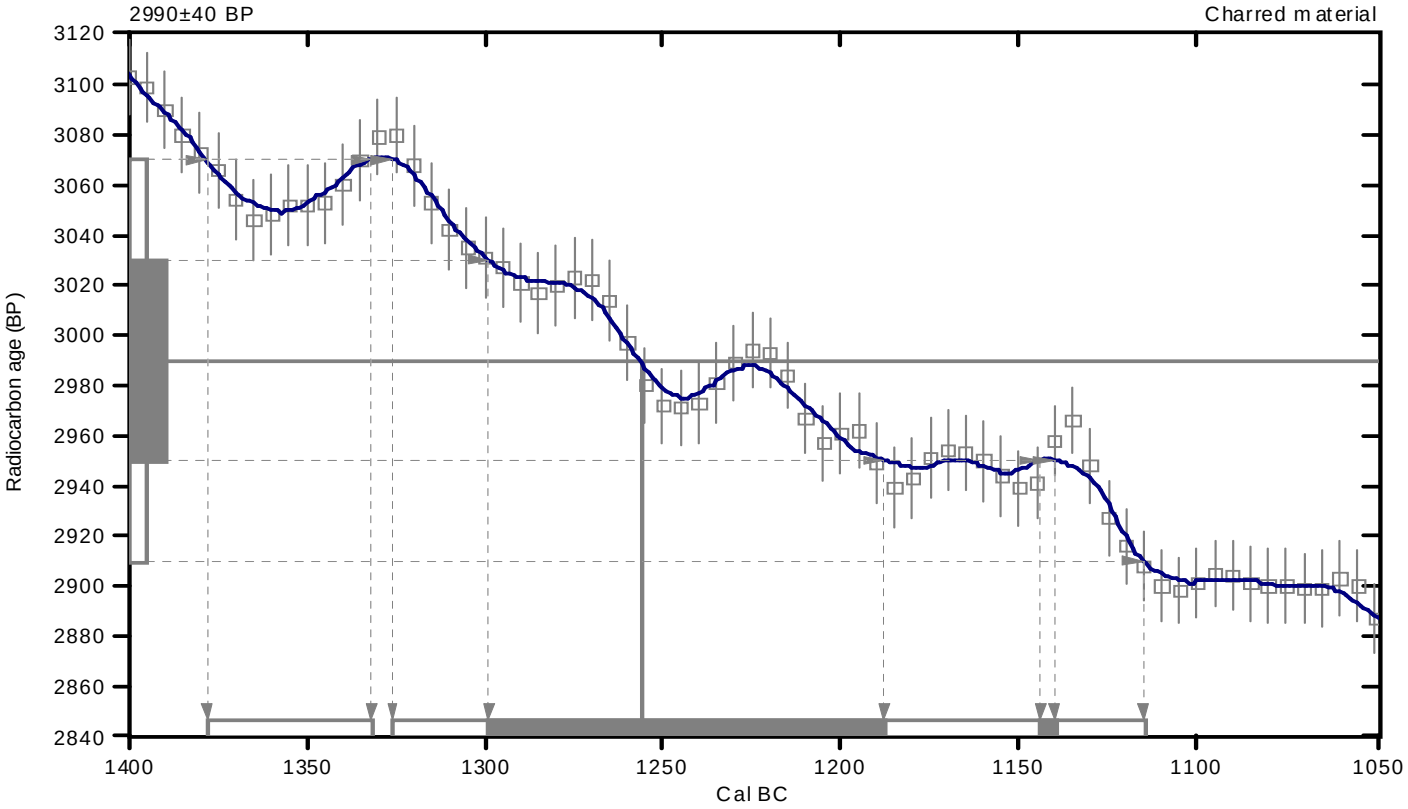
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.6:lab. mult=1)

Laboratory number:	**Beta-295378**
Conventional radiocarbon age:	**2990±40 BP**
2 Sigma calibrated results: **(95% probability)**	**Cal BC 1380 to 1330 (Cal BP 3330 to 3280) and** **Cal BC 1330 to 1120 (Cal BP 3280 to 3060)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 1260 (Cal BP 3210)
1 Sigma calibrated results: (68% probability)	Cal BC 1300 to 1190 (Cal BP 3250 to 3140) and Cal BC 1140 to 1140 (Cal BP 3090 to 3090)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

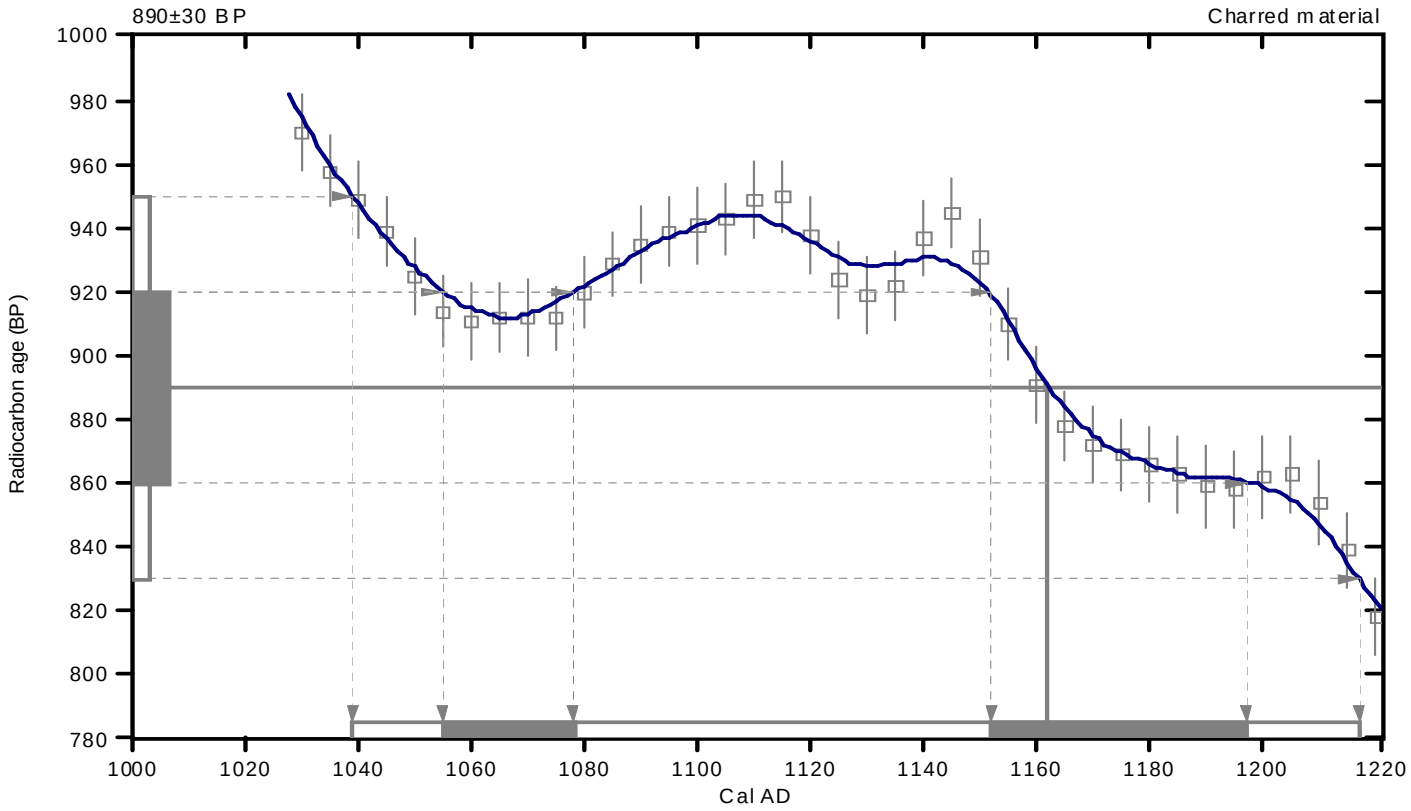
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-27.1:lab. mult=1)

Laboratory number:	**Beta-295379**
Conventional radiocarbon age:	**890±30 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 1040 to 1220 (Cal BP 910 to 730)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 1160 (Cal BP 790)
1 Sigma calibrated results: (68% probability)	Cal AD 1060 to 1080 (Cal BP 900 to 870) and Cal AD 1150 to 1200 (Cal BP 800 to 750)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

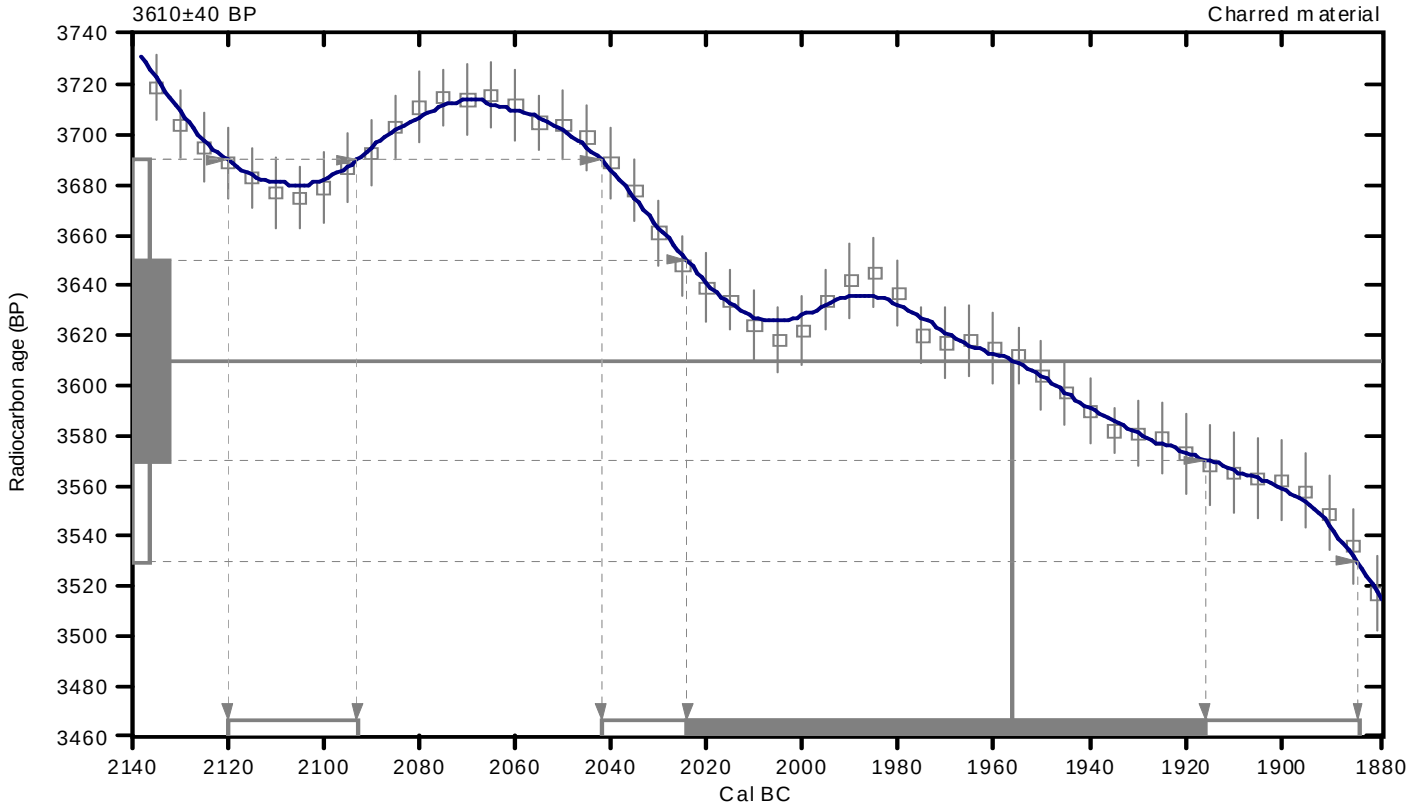
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.6:lab. mult=1)

Laboratory number:	**Beta-295380**
Conventional radiocarbon age:	**3610±40 BP**
2 Sigma calibrated results: (95% probability)	**Cal BC 2120 to 2090 (Cal BP 4070 to 4040) and Cal BC 2040 to 1880 (Cal BP 3990 to 3830)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 1960 (Cal BP 3910)
1 Sigma calibrated result: (68% probability)	Cal BC 2020 to 1920 (Cal BP 3970 to 3870)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

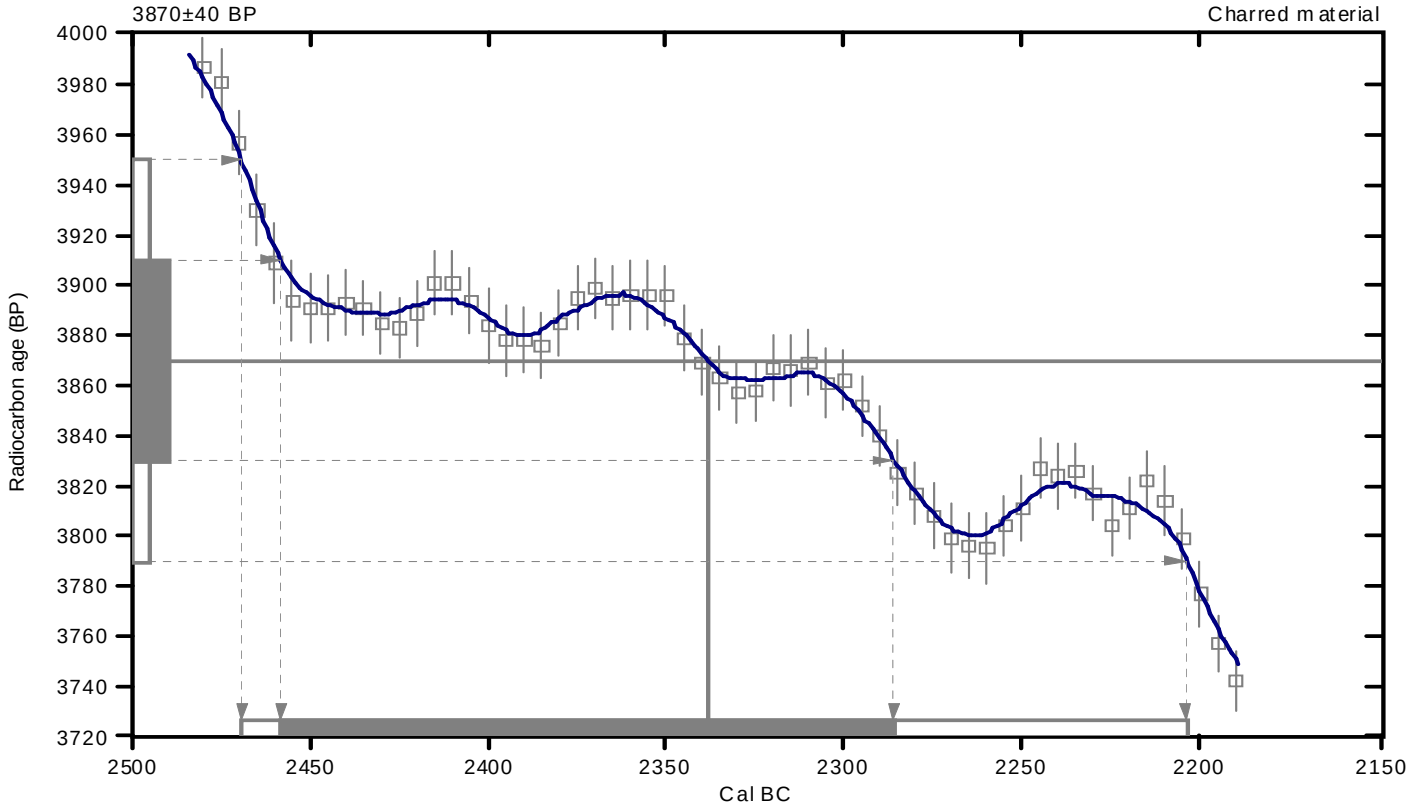
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.7:lab. mult=1)

Laboratory number:	**Beta-295381**
Conventional radiocarbon age:	**3870±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal BC 2470 to 2200 (Cal BP 4420 to 4150)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 2340 (Cal BP 4290)
1 Sigma calibrated result: (68% probability)	Cal BC 2460 to 2290 (Cal BP 4410 to 4240)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

Beta Analytic Inc.
4985 SW 74 Court
Miami, Florida 33155 USA
Tel: 305 667 5167
Fax: 305 663 0964
Beta@radiocarbon.com
www.radiocarbon.com

Consistent Accuracy . . .
. . . Delivered On-time

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

June 30, 2011

Dr. Alan D. Tabachnick
AECOM
516 East State Street
Trenton, NJ 08609
USA

RE: Radiocarbon Dating Result For Sample FEAT#75

Dear Dr. Tabachnick:

Enclosed is the radiocarbon dating result for one sample recently sent to us. It provided plenty of carbon for an accurate measurement and the analysis proceeded normally. As usual, the method of analysis is listed on the report sheet and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analysis. It was analyzed with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

The cost of the analysis was charged to the American Express card provided. A receipt is enclosed with the mailed report copy. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. Alan D. Tabachnick

Report Date: 6/30/2011

AECOM

Material Received: 6/13/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 300626	4120 +/- 30 BP	-24.2 o/oo	4130 +/- 30 BP

SAMPLE : FEAT#75
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 2870 to 2580 (Cal BP 4820 to 4530)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

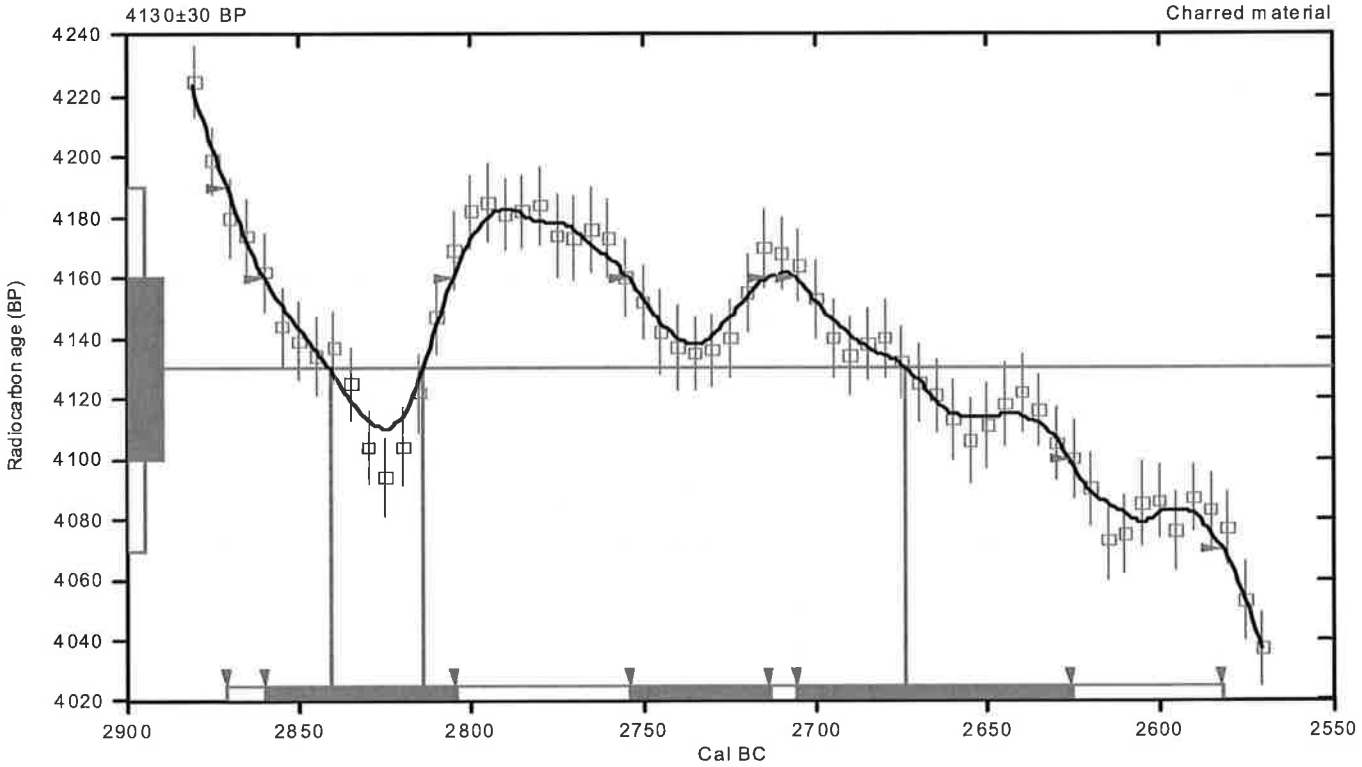
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.2:lab. mult=1)

Laboratory number:	**Beta-300626**
Conventional radiocarbon age:	**4130±30 BP**
2 Sigma calibrated result: (95% probability)	**Cal BC 2870 to 2580 (Cal BP 4820 to 4530)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal BC 2840 (Cal BP 4790) and Cal BC 2810 (Cal BP 4760) and Cal BC 2670 (Cal BP 4620)
1 Sigma calibrated results: (68% probability)	Cal BC 2860 to 2800 (Cal BP 4810 to 4760) and Cal BC 2750 to 2710 (Cal BP 4700 to 4660) and Cal BC 2710 to 2630 (Cal BP 4660 to 4580)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

Beta Analytic Inc.
4985 SW 74 Court
Miami, Florida 33155 USA
Tel: 305 667 5167
Fax: 305 663 0964
Beta@radiocarbon.com
www.radiocarbon.com

Consistent Accuracy . . .
. . . Delivered On-time

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

July 13, 2011

Mr. Frank Mikolic
AECOM
516 East State Street
Trenton, NJ 08609
USA

RE: Radiocarbon Dating Results For Samples FEAT#44, FEAT#45

Dear Mr. Mikolic:

Enclosed are the radiocarbon dating results for two samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

The cost of the analysis was charged to the MASTERCARD card provided. A receipt is enclosed with the mailed report copy. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Mr. Frank Mikolic — Report Date: 7/13/2011

AECOM — Material Received: 6/13/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 300629	2250 +/- 30 BP	-25.2 o/oo	2250 +/- 30 BP
SAMPLE : FEAT#44			
ANALYSIS : AMS-Standard delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal BC 390 to 340 (Cal BP 2340 to 2290) AND Cal BC 320 to 210 (Cal BP 2270 to 2160)			
Beta - 300630	3480 +/- 30 BP	-26.6 o/oo	3450 +/- 30 BP
SAMPLE : FEAT#45			
ANALYSIS : AMS-Standard delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal BC 1880 to 1690 (Cal BP 3830 to 3640)			

Dates are reported as RCYBP (radiocarbon years before present, “present” = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by “*”. The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the “Two Sigma Calibrated Result” for each sample.

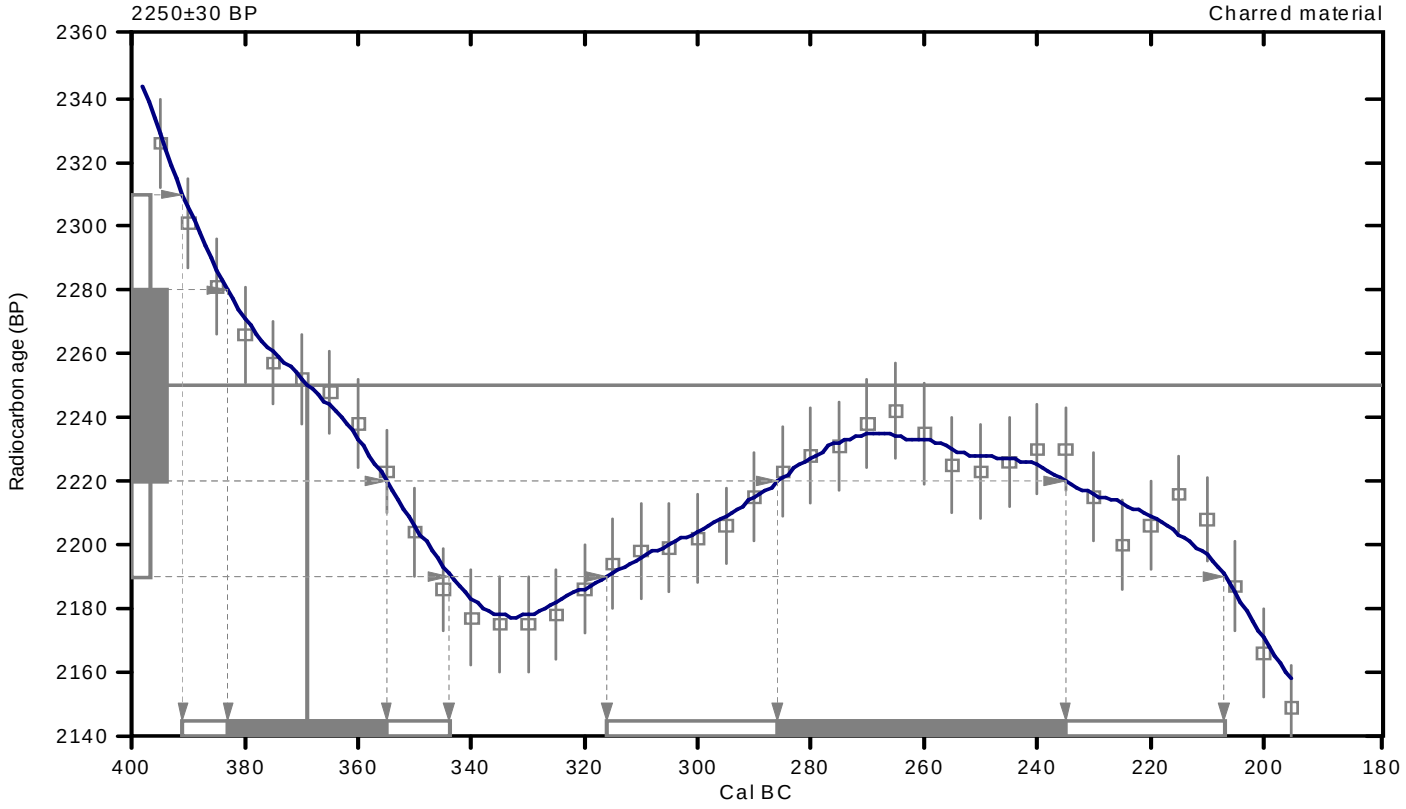
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.2:lab. mult=1)

Laboratory number:	**Beta-300629**
Conventional radiocarbon age:	**2250±30 BP**
2 Sigma calibrated results: (95% probability)	**Cal BC 390 to 340 (Cal BP 2340 to 2290) and Cal BC 320 to 210 (Cal BP 2270 to 2160)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 370 (Cal BP 2320)
1 Sigma calibrated results: (68% probability)	Cal BC 380 to 360 (Cal BP 2330 to 2300) and Cal BC 290 to 240 (Cal BP 2240 to 2180)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

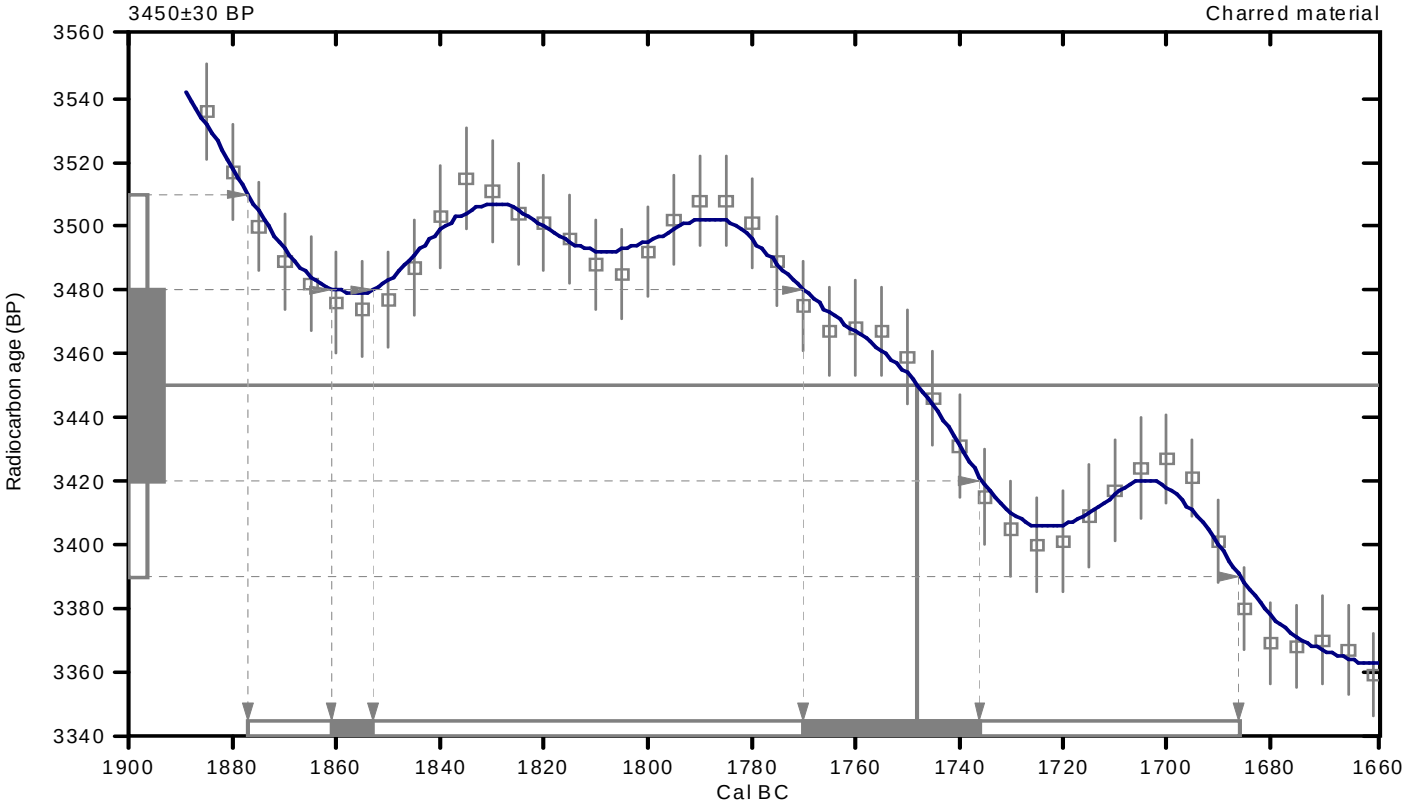
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.6:lab. mult=1)

Laboratory number:	**Beta-300630**
Conventional radiocarbon age:	**3450±30 BP**
2 Sigma calibrated result: (95% probability)	**Cal BC 1880 to 1690 (Cal BP 3830 to 3640)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 1750 (Cal BP 3700)
1 Sigma calibrated results: (68% probability)	Cal BC 1860 to 1850 (Cal BP 3810 to 3800) and Cal BC 1770 to 1740 (Cal BP 3720 to 3690)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

Beta Analytic Inc.
4985 SW 74 Court
Miami, Florida 33155 USA
Tel: 305 667 5167
Fax: 305 663 0964
Beta@radiocarbon.com
www.radiocarbon.com

Consistent Accuracy . . .
. . . Delivered On-time

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

July 13, 2011

Mr. John W. Lawrence
AECOM
516 East State Street
Trenton, NJ 08609
USA

RE: Radiocarbon Dating Results For Samples Feature 70, Feature 76

Dear Mr. Lawrence:

Enclosed are the radiocarbon dating results for two samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

The cost of the analysis was charged to the American Express card provided. A receipt is enclosed with the mailed report copy. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Mr. John W. Lawrence — Report Date: 7/13/2011

AECOM — Material Received: 6/13/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 300627	550 +/- 30 BP	-25.5 o/oo	540 +/- 30 BP

SAMPLE : Feature 70
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1320 to 1350 (Cal BP 630 to 600) AND Cal AD 1390 to 1430 (Cal BP 560 to 520)

Beta - 300628	4470 +/- 30 BP	-26.4 o/oo	4450 +/- 30 BP

SAMPLE : Feature 76
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 3330 to 3210 (Cal BP 5280 to 5160) AND Cal BC 3180 to 3150 (Cal BP 5130 to 5100)
Cal BC 3130 to 3020 (Cal BP 5080 to 4960)

Dates are reported as RCYBP (radiocarbon years before present, “present” = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by “*”. The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the “Two Sigma Calibrated Result” for each sample.

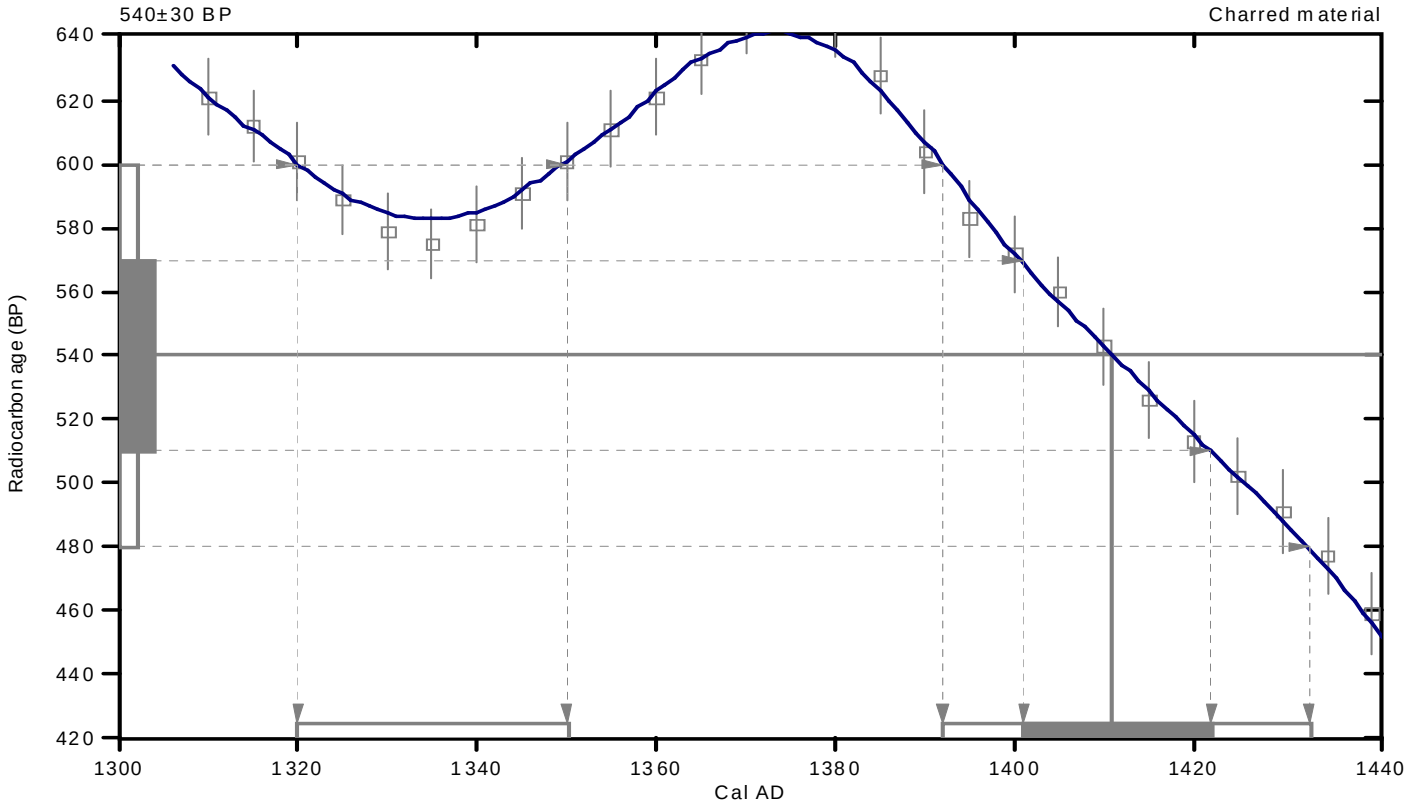
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.5:lab. mult=1)

Laboratory number:	**Beta-300627**
Conventional radiocarbon age:	**540±30 BP**
2 Sigma calibrated results: (95% probability)	**Cal AD 1320 to 1350 (Cal BP 630 to 600) and Cal AD 1390 to 1430 (Cal BP 560 to 520)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 1410 (Cal BP 540)
1 Sigma calibrated result: (68% probability)	Cal AD 1400 to 1420 (Cal BP 550 to 530)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

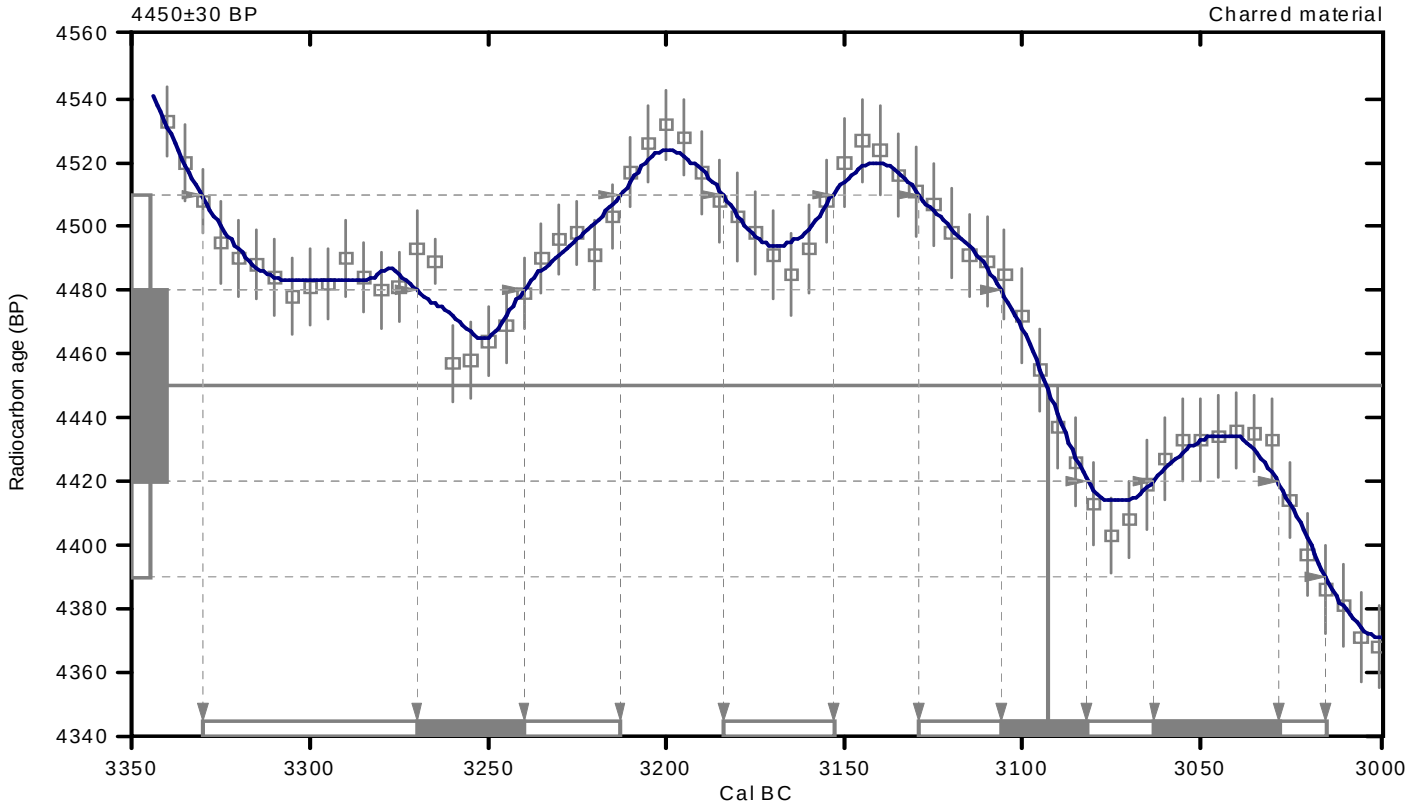
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.4:lab. mult=1)

Laboratory number:	**Beta-300628**
Conventional radiocarbon age:	**4450±30 BP**
2 Sigma calibrated results: **(95% probability)**	**Cal BC 3330 to 3210 (Cal BP 5280 to 5160) and** **Cal BC 3180 to 3150 (Cal BP 5130 to 5100) and** **Cal BC 3130 to 3020 (Cal BP 5080 to 4960)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 3090 (Cal BP 5040)
1 Sigma calibrated results: (68% probability)	Cal BC 3270 to 3240 (Cal BP 5220 to 5190) and Cal BC 3110 to 3080 (Cal BP 5060 to 5030) and Cal BC 3060 to 3030 (Cal BP 5010 to 4980)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com