APPENDIX H: WORK PLAN FOR PHASE III ALTERNATIVE MITIGATION

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April 30, 2013

David S. Clarke
DelDOT Archaeologist
Department of Transportation
P.O. Box 778, 800 Bay Road
Dover, DE 19903

Re: Technical and Cost Proposal
Phase III Alternative Mitigation
Stroud Site (CRS # N6693; 7NC-G-180)
U.S. Route 301
New Castle County, Delaware
DelDOT Parent Agreement 1537, Task 6

Dear Mr. Clarke:

Richard Grubb & Associates (RGA) is pleased to present this technical and cost proposal for the Phase III Alternative Mitigation of the Stroud Site (CRS # N6693; 7NC-G-180). The Stroud Site (7NC-G-180; CRS # N6693) was surveyed by Dovetail Cultural Resource Group, Inc. and is situated in New Castle County, Delaware. This proposal includes the completion of the Stroud Site Phase II archaeological survey technical report (Task 1) and an alternative mitigation on the Stroud Site (7NC-G-180; CRS # N6693) that will include the preparation of a document synthesizing the results of geochemical analysis undertaken at all historic period archaeological sites in Delaware to date (Task 2). This proposal was based on information provided by the Delaware Department of Transportation (DelDOT) in meetings on December 14 and 19, 2012. All work will be performed in accordance with the Secretary of the Interior's *Standards and Guidelines for Archaeology and Historic Preservation* and the *Guidelines for Architectural and Archaeological Surveys in Delaware* (1993) issued by the Delaware State Historic Preservation Office (DESHPO). Since federal funds are being used, this work will be completed under Section 106 of the National Historic Preservation Act and its regulations (36 CFR 800) and in accordance with the Memorandum of Agreement (MOA) for the U.S. Route 301 (Route 301) project. The comments received during meetings with DelDOT on March 19, 2013 and April 17, 2013 have been incorporated into this proposal.

Michael J. Gall, MA, RPA, will be the Principal Investigator for this project. Michael Gall has extensive experience in the analysis and interpretation of 18th and 19th century farmstead and tenant sites in the Middle Atlantic region, and has conducted several geochemical analysis studies on historic period archaeological sites in New Jersey with successful results. Mr. Gall is also the author of a recently accepted (2013) article in *Northeast Historical Archaeology*, titled, "It's Elemental!: A Case Study in the Use of Multi-element Geochemical Analysis as an Aid in Locating Cultural Features at the Foundation Site." The article focuses on the use of Mehlich-3 mixed reagent and Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) to calculate main and trace element densities from subsoil contexts at a Coastal Plain historic archaeological site. Graphically displayed quantitative multi-element densities using kriging algorithms were utilized as an archaeological prospection tool to identify former activity areas and to aid in cultural feature identification. Based on this work, Mr. Gall has knowledge of the application of Mehlich-3 and ICP analysis as applied as an interpretive tool on archaeological sites in the Coastal Plain. It is the understanding of RGA that several of the geochemical analysis studies undertaken on archaeological sites associated with the Route 301 project incorporated the use of Mehlich-3 and ICP soil sample analysis.

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A separate discussion of the tasks is presented below, including the Scope of Work, Deliverables, and Schedule, and, where appropriate, research goals.

TASK 1: STROUD SITE (7NC-G-180; CRS # N6693) PHASE II ARCHAEOLOGICAL REPORT

The Stroud Site was identified during a Phase I archaeological survey within the footprint of the Northern Stormwater Management Pond near the northeastern limits of the Route 301 project (Dovetail Cultural Resource Group, Inc. 2011a). The proposed stormwater facility is situated at the northwest corner of Hyetts Corner Road and U.S. Route 13. Background research had indicated the presence of a two story tenant house at this location as early as 1814 that was associated with the Stroud family. Phase I archaeological testing at this location produced artifacts dating to the late-eighteenth through mid-nineteenth century which were considered to represent a potentially significant archaeological resource (Dovetail Cultural Resource Group, Inc. 2011a). A Phase II evaluation-level archaeological survey was recommended.

In December 2011, Dovetail Cultural Resource Group, Inc. (2011b) completed Phase II archaeological testing, which included shovel test pit and unit excavation, the recovery and geochemical analysis of soil samples from 15-foot interval grid points, and artifact processing. The site was recommended eligible for listing on the National Register of Historic Places under Criterion D for its ability to contribute significant information on the domestic life, social context, subsistence/agriculture, and/or settlement patterns in New Castle County during the Period of Transformation from Colony to State (1770-1830) and the Period of Industrialization and Capitalization (1830-1880). The results of Phase II archaeological testing, data analysis, and background research were detailed in a Phase II archaeological management summary report that was submitted to and approved by DelDOT. The Delaware Delaware Division of Historical and Cultural Affairs (DHCA) concurred with the management summary report recommendations and in consultation with DelDOT determined that an appropriate approach to mitigate the site from adverse effects was an alternative mitigation (see Task 2 for a detailed description of the proposed alternative mitigation effort).

Data presented in the management summary, archaeological field forms, and correspondence with Dovetail Cultural Resource Group, Inc. will be utilized in the completion of a Phase II archaeological survey report. A full Phase II archaeological survey report will be completed that meets the requirements of the DHCA. Additional geochemical data analysis for soil pH will be incorporated into the Phase II survey report. The research design and work plan for the Stroud Site alternative mitigation will be included as an appendix in the Phase II survey report. The Phase II report will comprise Volume 1 of a two volume report. The second volume will comprise the Stroud Site alternative mitigation report. It is the understanding of RGA that all DHCA review comments for the Stroud Site alternative mitigation project will be addressed by DelDOT in a separate letter. Artifact curation for the Stroud Site will be completed by Dovetail Cultural Resource Group, Inc.

DELIVERABLES

Four (4) hard copies of the Phase II archaeological survey report will be provided to DelDOT with two (2) CDs containing electronic copies of the report.

SCHEDULE

RGA will begin the project immediately upon the notice to proceed (NTP) from DelDOT.

- NTP to 1 Month:
    1. Review of the Phase II archaeological management summary and electronic report documents from Dovetail Cultural Resource Group, Inc.
    2. Correspondence with Dovetail Cultural Resource Group, Inc., as necessary.

- 1-2 Months:
    1. Phase II archaeological survey report writing and graphics completion.
    2. Completion of Phase II archaeological survey report writing.
    3. Internal review of report.

- 2-3 Months:
    1. Submission of draft Phase II report to DelDOT.

TASK 2: STROUD SITE (7NC-G-180; CRS # N6693) ALTERNATIVE MITGATION

The Stroud Site represents a significant archaeological resource eligible for listing on the National Register of Historic Places. In an effort to mitigate adverse effects to the site by the Route 301 project, DelDOT determined that an alternative mitigation, rather than additional archaeological site excavation, would be an efficient approach to obtain significant archaeological site data. In consultation with the DHCA, DelDOT has proposed an alternative mitigation in keeping with archaeological data available from the site. The alternative mitigation program selected will consist of a document synthesizing geochemical soil data analysis gathered from historic period archaeological sites in Delaware to date. It is the understanding of RGA that the soil geochemical analysis has not yet been completed on all of the Route 301 significant historic archaeological sites, but soil testing and analysis is anticipated. Currently, soil geochemical analysis has only been conducted on soil samples from the Stroud Site. Soil samples from an additional nine sites are in the process of or are slated for geochemical analysis. The synthesis document will include available geochemical soil analysis data from Route 301 historic archaeological mitigation projects (n=9), the Stroud Site, and approximately 26 additional historic archaeological sites in Delaware (see Table 1). The completion of the alternative mitigation will be greatly dependant on RGA's receipt of the Route 301 archaeological mitigation geochemical soil analysis data and interpretation reports from DelDOT's current Parent Agreement archaeological consultants, as well as the data set available. Inconsistencies in available data sets may impact the ability to answer certain research questions.

Table 1: Historic Archaeological Sites in Delaware with Associated Geochemical Soil Analysis.

1- John Powell Plantation	2- William Strickland Plantation	3- Augustine Creek South	4- Bloomsbury
5- Charles Robinson Plantation	6- Benjamin Wynn Tenancy	7- John Darrach Store	8- Thomas Williams
9- H. Grant Tenancy	10- Jones Site	11- A. Temple Site	12- Moore-Taylor Farm
13- Wilson-Lewis Farm	14- Buchanan-Savin Farm	15- Moffett Dairy Farm	16- Richard Whitehart Plantation
17- Wilson-Slack Agricultural Works Complex	18- Locus Grove	19- C. Kimmey Tenant Farm	20- Mermaid Blacksmith Shop and Stable
21- Whitten Road	22-Nathan Williams House	23-Collins, Gedds Cannery	24-W. Eager House
25-Jacob B. Cazier Tenancy	26-Bear Trap Dunes**	27- Rumsey/Polk Tenant/Prehistoric	28- Stroud Site
29- Cardon-Holton	30- Elkins A	31- Elkins B Burials	32- Elkins B
33- Houston-LeCompt	34-Armstrong-Rogers	35- Bird-Houston	36-Noxon Tenancy

*Shaded sites are associated with the Route 301 project.
** Site not associated with a DelDOT sponsored archaeological survey

Research Goals and Questions

The use and benefits of geochemical analysis to provide information about activity areas within a site, as well as vertical and horizontal site boundaries has been well documented in the Mid-Atlantic region and elsewhere for over half a century (Bedell 2002: 80-82; Catts et al. 1995:97-99; Cook and Heizer 1965; Custer et al. 1986; Deetz and Dethlefsen 1963:242-243; Gall 2007; Gall, Lore, and Hayden 2006, 2007, 2008, 2009a, 2009b; Grettler et al. 1995: 71-74, 137-143; Heite and Blume 1998:139-147; Holliday and Gartner 2007:301-333; Middleton and Price 1996:673-687; Pogue 1988; Rypkema et al. 2007; Sopko 1983). The most intensively studied element determined to have a high correlation with anthrosol deposits is phosphorous (P) (Holliday and Gartner 2007). The process of utilizing geochemical signatures, particularly anthropogenic chemical residues of soil P, to locate areas of human habitation on the landscape developed in Europe during the early twentieth century. Studies conducted in Sweden by Arrhenius in the 1920s utilized soil phosphate to identify the location of prehistoric archaeological sites (Middleton and Price 1996:673). Decades of geoarchaeological research have identified a high correlation of soil P with anthrosol deposits, and the use of soil P analysis continues into the twenty-first century to identify former locations of prehistoric and historic human habitation, delineate vertical and horizontal archaeological site boundaries, and guide excavation placement (Bjelajac, Luby, and Ray 1996:243-248; Holliday and Gartner 2007:301-333; Middleton and Price 1996:673; Rypkema et al. 2007:185901867; Salisbury 2012:178-190; Sarris et al. 2004:927-939).

Examination of soil pH and additional elements for their relation to anthropogenic soils began in the third quarter of the twentieth century, and has intensified during the twenty-first century due to the availability of inexpensive and relatively quick soil testing approaches that extract and quantitatively measure a wide variety of elements in the soil (Cook and Heizer 1965; Deetz and Dethlefsen 1963:242-243; Eidt 1977; Entwistle, Abranhams, and Dodgshon 1998; Gall 2013; Middleton and Price 1996; Oonk, Slomp, and Huisman 2009; Parnell, Terry, and Nelson 2002; Vyncke et al. 2011; Wilson, Davidson, and Cresser 2006, 2008). Recent studies have demonstrated the successful use of anthropogenic multi-element chemical residue analysis for the detection, delineation, and interpretation of activities within sites and within structures (Cook et al. 2006; Gall 2013; Holliday and Gartner 2007:301-333; Middleton 2004; Middleton and Price 1996:673-687; Milek and Roberts 2013:1845-1865; Misarti, Finney, and Maschner: 1441-1455; Parnell, Terry, and Nelson 2002:379-404). Multi-element interpolated data analyses have also been utilized in recent decades for historic and prehistoric activity area prospection and site interpretation (Gall 2013; Parnell, Terry, and Nelson 2002:379-404; Oonk, Slomp, and Huisman 2009:35-51; Salisbury 2012, 2013; Sarris et al. 2004; Wilson, Davidson, and Cresser 2008:412-424). Data from a multitude of sites around the globe demonstrate a strong correlation between anthropogenic chemical residues, particularly P, and human habitation (Entwistle, Ambranhams, and Dodgshon 2000:302; Holliday and Gartner 2007:301-333). Anthropogenic chemical residues can vary in concentration from site to site based on site-specific activities, regional cultural practices, soil development, micro-environmental conditions, and post occupation activities (Fernández et al. 2002; Middleton and Price 1996:683; Vyncke et al. 2011).

Geochemical analysis undertaken at archaeological sites in the United States over the past several decades, particularly in the Mid-Atlantic region, has largely developed around agronomic geochemical analysis techniques. Such techniques typically rely on the quantified measurement of weakly sorbed, (i.e. extractable, available, weakly adhered) element forms on soil particles available for plant nutrient uptake. This method applies weak or moderately weak acid chemical extraction solutions, such as Mehlich-3, to separate element cation bonds, often quantifiably measured using an inductively coupled plasma (ICP) spectrometer, though other chemical solutions and measurement devices are available and each produces different quantified results. Therefore, the laboratory methods must be explicitly stated, and the ways in which those methods impact data used for interpretive purposes be understood. This cost and time efficient method, however, can be preferred over the use of strong acid extraction solutions. The latter can aid in the measurement of extractable element forms and those element forms tightly bound within mineral lattices to permit total element form measurement. Middleton and Price (1996:675) argue that total compositional element analysis can aid in determining the element's source, such as naturally and culturally deposited or weathered from parent material, of targeted elements within the soil, but can obscure the identifiable nuances of anthropogenic weakly sorbed chemical residues (Parnell, Terry, and Nelson 2002). The use of weak or moderately weak acid solutions typically only extracts available element forms, which generally represent a minute portion of total element composition (Holliday

and Gartner 2007:313). The decreased quantity of specific element forms available for analysis and interpretation with this method necessitates the use of a multi-element analysis approach to better identify and interpret anthropogenic chemical residues that may relate to past activities (Oonk, Slomp, and Huisman 2009; Wilson, Davidson, and Cresser 2008). In contrast, Holliday and Gartner (2007:303) argue that differentiation of the various element forms in terms of chemistry, the biochemical cycle, and sequential extraction is essential to utilizing geochemical data in archaeological contexts. Both methods have clear benefits and disadvantages, and documenting survey and laboratory methods and understanding the types of information each method provides is key to interpreting archaeological geochemical data, as well as performing intra- and inter-site data comparisons.

Examination of DHCA records indicates that geochemical analysis of archaeological site soils have occurred on at least 36 historic period archaeological sites in Delaware (Versar, Inc. 2012; Personal Communication: Alice Guerrant and Craig Lukezic- January 15, 2013, Kevin Cunningham and William Liebknecht-December 20, 2012, Kerri Barile and John Bedell-January 11, 2013). Of these, 25 geochemical studies were undertaken prior to 2002 on archaeological sites identified in association with DelDOT road improvement projects (see Table 1:Nos.1-25). Another 10 geochemical studies were conducted during Phase II and Phase III archaeological surveys in association with DelDOT's Route 301 extension project (see Table 1: Nos. 27-36). The remaining two surveys (see Table 1:No. 26) was completed in 2000 on an archaeological site not associated with a DelDOT project. The geochemical surveys employed at the Kent and New Castle County archaeological sites were used to aid spatial use and activity area identification and interpretations. At many of the sites, extensive plowzone sampling followed by mechanical topsoil removal was undertaken during data recovery investigations to identify sub-plowzone cultural features (Bedell 2002: 80-82). The application of geochemical analysis was used to confirm suspected or identified activity areas based on exposed sub-plowzone cultural features and/or high artifact plowzone densities, the latter of which may have represented the locations of non-extant cultural features (Bedell 2002:109). Plowzone artifact densities, however, rarely correspond with extant buried cultural features, increasing the interpretive value of geochemical analysis to archaeological surveys (Bedell 2002; Terry et al. 2004:1237).

Interpretation of geochemical site data requires knowledge of micro-environmental conditions, soil pH, soil cation exchange capacity (CEC), organic matter content, soil type, and the form of extracted and measured elements, in addition to chemical extraction and element measurement methods. Over 50 types of chemical solutions can be used to extract chemical residues from archaeological soils, including strong and weak acid extractants, mixed reagents, sequential extractants, single extractants, and chelates, each of which can extract a different form and quantity of an element or a suite of elements from soil (Holliday and Gartner 2007). The use of moderately weak acid mixed reagents, such as Mehlich 3 developed in 1984, are also quite popular in agronomy labs due to the wide range of elements the solution extracts in acidic and alkaline soils. It is assumed that many, but perhaps not all, of the soil tests conducted by the University of Delaware, College of Agriculture and Natural Resources (UDCANR) soil laboratory on archaeological soil samples from the Route 301 archaeological surveys have or will utilize the Mehlich 3 mixed reagent based on analyses completed to date. Like extractants, a variety of instruments can be used to quantify elements present in solution, including coloremetry and spectrometry. In the latter method, Inductively Coupled Plasma (ICP) spectrometers can be preferred due to the wide range of quantifiable elements measured and rapid measurement time. ICP instruments have gained popularity over the past few decades, particularly in agricultural soil laboratories. UDCANR currently utilizes an ICP-optical emission spectrometer (OES) to measure element densities in soil samples.

As noted above, understanding what element forms can be extracted and measured by the various solutions and instruments is crucial to interpreting multi-element quantified data from anthrosol deposits at sites and comparing data between sites. Unfortunately, this was not reported in any of the pre-2002 geochemical soil analysis studies. Only one historic archaeological survey conducted in Delaware for DelDOT prior to 2002 referenced the chemical extractant used (Versar, Inc. 2012). In this study, UDCANR applied the Mehlich 1 extractant to anthrosols from the Jones Site (7NC-J-204). Versar, Inc. (2012) did not specify the instrument UDCANR used at that time to quantitatively measure element levels, and only a partial quantified element analysis list is available for review. Most of the soil tests conducted on anthrosols from historic archaeological surveys by DelDOT archaeological consultants prior to 2002 appear to have been analyzed by UDCANR, but virtually none specified the extraction solution applied

or the measurement instrument used, and quantified element analysis lists for each site may be unavailable for review as part of this study. RGA will consult with UDCANR, the University of Delaware Center for Archaeological Research, the Delaware State Museum, and former DelDOT consultants to locate and acquire the geochemical analysis raw data logs associated with the above referenced pre-2002 archaeological surveys. It is possible UDCANR applied Mehlich 3 or Mehlich 1 solutions in the soil test process, but this is not certain. The lack of laboratory methodology documentation for most of the geochemical soil analysis prior to 2002 makes inter-site comparative analyses difficult. Further, the ways in which site-specific micro-environmental conditions affected extracted and measured element forms also does not seem to be widely reported for any of the pre-2002 surveys. It is unclear if such information will be reported for the geochemical soil surveys associated with the Route 301 project. For this reason, much of the statistical geochemical inter-site comparisons that may be made in the proposed synthesis study will likely be restricted to data associated with Route 301 archaeological surveys, provided the data is available. Regardless, the pre-2002 archaeological surveys may collectively provide data on archaeological geochemical signatures, and, for this reason, available data on the pre-2002 geochemical studies will be collectively interpreted, analyzed, and synthesized in this alternative mitigation report.

Despite the possible limitations presented by most of the pre-2002 geochemical surveys mentioned above, the potential exists for significant geochemical data to be generated by the Route 301 geochemical soil analysis studies. As part of these surveys, different soil collection strategies were employed between sites, including tightly spaced interval grid collection procedures, random sample procedures, and the recovery of samples within and below select cultural features. Samples that have currently undergone soil testing (i.e., the Stroud Site and Houston-LeCompt Site) have been processed in a similar manner by UDCANR using Mehlich 3 and ICP-OES to calculate pH, organic matter (OM) by loss of ignition (LOI), base saturation, estimated CEC, and the quantified mg/kg measurement of available forms of aluminum (Al), boron (B), calcium (Ca), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), phosphorous (P), sulfur (S), and zinc (Zn). It is assumed that the soil samples from the remaining Route 301-related archaeological sites will be processed in a similar manner, enabling intra-site comparisons between sites using appropriate statistical analyses (Wilson, Davidson, and Cresser 2008). Despite the range of elements tested, actual reported geochemical information for most of the pre-2002 surveys was restricted to pH, Ca, K, Mg, and P. Geochemical soil analysis report interpretations for the Stroud Site were further restricted to the analysis of Ca, K, Mg, and P (Dovetail Cultural Resource Group, Inc. 2011b). Extensive current scientific literature stresses the importance of understanding the role that both soil pH and texture have in the stability or mobility of weakly sorbed anthropogenic chemical residues (i.e., the type measured using Mehlich 3 and ICP-OES) in archaeological soils (Gall 2013; Holliday and Gartner 2007; Oonk, Slomp, and Huisman. 2009; Parnell, Terry, and Nelson 2002; Wells et al. 2000). Further, current literature also stresses the need to assess a variety of main and trace elements, particularly heavy metals like Cu, Fe, Mn, and Zn, when available element forms are relied upon for interpretation (Oonk et al. 2009). Recent data increasingly suggests that such elements can be relatively stable and may correlate well with anthropogenic chemical input in archaeological site soils, particularly metallic-based pigments in painted structures, and association with Fe with animal blood and butchering areas (Oonk, Slomp, and Huisman. 2009; Parnell, Terry, and Nelson 2002; Parnell, Terry, and Sheets 2002;Wells et al. 2000). It is unclear if such analysis will be included with the remaining nine Route 301 geochemical soil analysis studies, which may have implications on inter-site analyses.

Inter- and intra-site analysis and interpretation of anthropogenic geochemical residues will also depend on information provided by DelDOT's cultural resource management consultants. For example, obtaining excavation and cultural resource survey plan view maps will be necessary to understand how certain elements or element suites relate to functional activity areas or cultural feature types. Obtaining information about the types of material culture present in certain cultural features may also be necessary to understand and interpret element correlations with archaeological activity areas and the ways in which certain artifact types (e.g. shell, bone, and charcoal) load soils with anthropogenic chemical residues. Soil texture analysis data from geochemical samples will aid in understanding appropriate sampling strategies. It is assumed that DelDOT's consultants will provide soil test spreadsheets in Microsoft Office .xls format and excavation and cultural feature plan view data as GIS shapefiles to enable efficient data use. Electronic copies of geochemical frequency distribution maps will also be necessary for comparative purposes.

Utilizing available data from a multitude of geochemical soil surveys undertaken at historic period sites in Delaware, the geochemical data synthesis may have the ability to answer several research questions depending upon data form and quality as outlined above. Given several unknown factors stated above, available data may allow or restrict the ability to answer the following questions:

- Various soil sample collection techniques have been employed in Delaware, including close interval testing, random sample testing, and selective sample testing. Using multi-element distribution maps provided in archaeological survey reports and statistical analyses on raw data, can the advantages and disadvantages for the various sample extraction techniques be identified as they relate to the identification and interpretation of archaeological activity areas? Does one method work best as a tool for archaeological prospection and interpretation? Should combinations of both methods be used at different survey phases to maximize data for interpretive purposes?

- Does the use of available (weakly-sorbed) element forms in a multi-element analysis approach correlate with known archaeological activity areas based on archaeological excavation data? Should additional elements be analysed for archaeological interpretation purposes as suggested by current literature when only available element forms are extracted for measurement? Can multi-element analysis be successfully applied in Delaware as a cost/time efficient, minimally intrusive tool for archaeological prospection and archaeological activity area identification prior to large scale excavations?

- Depending on the data available, is there clear or general evidence for the most useful vertical or horizontal location in stratigraphic profiles from which to obtain anthropogenic chemical residues for archaeological activity area interpretation and prospection? Previous evidence from geochemical soil analysis conducted in Delaware suggests subsoil deposits can contain stronger anthropogenic residues at plowed sites than plowzone deposits, though the reasons for such a statement were not clearly explained (Heite and Blume 1998). Using Mehlich 3 extraction on samples in acidic Coastal Plain sandy soils, Gall (2012) has also found that available elements quantified from subsoil deposits also have a high correlation with former, historic activity areas, when compared to plowzone deposits, though this is likely a result of the effects of soil texture, soil type, CEC, and pH on element stability or mobility in the soil profile and implications such effects have on the type of laboratory chemical extraction solutions applied in the geochemical analysis process. Does this observation hold true in Coastal Plain deposits in Delaware, and if so, how can this be considered in future geochemical soil analysis of archaeological site soils?

- Does the soil geochemical analysis provide information on whether it is more appropriate to obtain samples for analysis from the plowzone or subsoil within archaeological sites? Several of the sites listed in Table 1 include geochemical analysis from both plowzone and subsoil deposits. Does the data indicate a closer link to anthropogenic geochemical patterns from the subsoil than the plowzone when weakly sorbed element forms are analyzed? Is the association of anthrosol chemical residues with specific soil strata influence by soil texture, soil type, soil pH, and cation exchange capacity? If so, should a soil texture analysis be done on plowzone and subsoil horizons prior to initiation of a geochemical study to assess appropriate sampling methods?

- Based on available data, can statistical analyses identify certain element suites that successfully correlate with specific feature types (e.g. paddocks, hearths, domestic buildings, middens, burials, butchering areas) or artifact-type concentrations (e.g. bone, shell, or mortar), as have been identified in other board comparative studies (e.g. Wilson, Davidson, and Cresser 2006, 2008)? Where appropriate, statistical analysis may be limited to select data sets or archaeological sites.

- Is there a close association with geochemical patterns and archaeological site types or functional areas within archaeological sites?

- Does a site-occupant's socio-economic status or cultural heritage influence anthropogenic chemical residue patterning at an archaeological site? If so, in what ways is the geochemical patterning different? Is geochemical analysis more effective in providing information about space use at sites associated with individuals of a certain socio-economic status? Should the use of geochemical analysis be restricted to sites associated with individuals of certain socio-economic status? In a similar vein, is geochemical soil analysis more effective or informative on archaeological sites dating to each of Delaware's historic context periods, or should geochemical analysis be restricted to sites dating to certain historic context periods?

- Does the data provide information on ways to differentiate between features that are cultural in origin from those that are natural (e.g. rodent burrows?). If so, how can each be differentiated? In what ways can geochemical analysis be used to define features that are not clearly culturally-linked. What does the analysis indicate about space use between features? Does evidence suggest that certain areas were heavily trafficked paths kept free of organic refuse?

- Given the variety of soils in which geochemical analyses have been conducted on historic archaeological sites in Delaware, do certain soil types and soil pH permit the retention of anthropogenic chemical residues based on correlations with identified activity areas and cultural features?

- What guidelines and standards should be recommended and employed for the future use of geochemical anthrosol analysis as an interpretive tool on archaeological sites in Delaware?

SCOPE OF WORK

The scope of work includes the following:

Sub-Task 2a: Consultation and Background Research
Sub-Task 2b: Data Analysis and Report Preparation
Sub-Task 2c: Public Outreach

A discussion of the work proposed under each sub-task is presented below.

Sub-Task 2a: Consultation and Background Research

Consultation will consist of correspondence with applicable cultural resource management firms associated with the Route 301 project that have or will undertake geochemical analysis of archaeological site soils. Consultation will include requests for geochemical soil sample laboratory test reports, preferably in MS Excel format, geochemical data distribution maps, GIS maps showing the location of identified cultural features and soil sample points, and geochemical analysis interpretation reports. Additional consultation may be required to determine micro-environmental conditions for each of the Route 301 archaeological sites considered and to obtain information on the types of artifacts present in select features. Consultation will also be made with the University of Delaware, Center for Archaeological Research and UDCANR to determine if soil test logs exist for the pre-2002 studies under consideration. Chuck Fithian of the Delaware State Museum will be contacted to determine if soil test logs associated with the pre-2002 studies are included with curated material and survey documents as part of the aforementioned studies.

Background research will include a list of references with information on current archaeological geochemical soil analysis published and gray literature to create a context for the current state of archaeological geochemical soil analysis and methodology, including appropriate statistical analyses. Consultation may be conducted with soil scientists at the University of Delaware to aid in synthesis interpretations. Further, consultation may be necessary

with DelDOT and the Delaware DHCA to re-evaluate the ability to answer certain research questions once all of the geochemical soil analysis for the Route 301 project has been received and examined.

Sub-Task 2b: Data Analysis and Report Preparation

Report writing will commence during and after the consultation and background research phase. The technical report will be divided into six sections. Section 1 will include an introduction to the alternative mitigation geochemical soil analysis synthesis study, its goals and parameters (i.e. archaeological sites considered). This section will also include a brief history of geochemical soil analysis, its role in archaeological investigations as an interdisciplinary approach, and a description of current geochemical soil analysis knowledge and methods as they are applied to archaeological contexts, referencing useful studies. A brief description of Delaware geology and soils covered by the 36 aforementioned archaeological sites will also be presented for context in evaluating the use of geochemical soil analysis within portions of the state. The location of each site will be displayed on physiographic, soil, bedrock and U.S.G.S. topographic maps for reference.

Section 2 will include a research design describing the purpose and goals of the synthesis study. The data parameters will be presented and their role in the ability to conduct inter- and intra-site analyses will be presented. This section will also discuss the types of appropriate statistical analyses that may be used to interpret data once received. Given the various unknowns at the time of this proposal it is unclear which statistical analyses will be most appropriate for use in the alternative mitigation report.

Section 3 will present a brief summary of the geochemical soil analysis methods and results from each of the 36 above referenced sites. Select geochemical distribution maps highlighting exemplary data may be included to provide a visual context for certain discussions. Where available and appropriate, copies of distribution maps in relation to feature contexts provided by DelDOT's cultural resource management consultants will be illustrated. RGA may also need to prepare distribution map data using either GIS or Golden Surfer 7.0 software with applied interpolated isopleth z-value results for certain data if available to further illustrate discussions. Section 3 will also include descriptive data tables for all 36 sites. The data table(s) will include, but may not be limited to: site name, citation reference, function, occupation period, physiographic province, site soils (from the web soil survey), soil hydrology, soil sample collection method, soil horizon sampled, horizontal/vertical sample location in relation to features, geochemical data tested (by the soil laboratory), geochemical data interpreted (by the consultant), and laboratory methods (chemical extractant and measurement instrument). The descriptive tables will also note key differences between the pre-2002 geochemical surveys and those conducted as part of the State Route 301 project in order to highlight changes in archaeological geochemical methodology and analysis over the past two decades in Delaware.

Section 4 will discuss the methodology, data, analysis, and interpretations from the pre-2002 geochemical surveys. This section will synthesize knowledge gained from the early use of soil geochemical surveys on a variety of archaeological sites in Delaware. Focus will also be placed on methodologies that were and were not useful in archaeological data acquisition and site interpretation. If possible, statistical analysis will be conducted on geochemical site data provided the raw data logs for each site can be located. Sites for which raw geochemical data analysis logs are available will be described more fully in Section 5.

Section 5 will present inter- and intra-site analysis interpretations based on available data. This section will attempt to highlight exemplary data from select sites with well-documented geochemical soil analysis. An attempt will be made to utilize the available data to identify chemical suites associated with certain types of known cultural features or archaeological activity areas, such as hearths, domestic structures, craft buildings, agricultural buildings, butchering areas, animal pens, gardens, pathways, and farm plots. This may be done using statistical analysis if the data is available. Multivariate exploratory and inferential statistical analyses will be applied to characterize the dataset, explore correlations that may exist among elements, assess the strength of correlative relationships among elements and identify elements and elements suites that are predictors of cultural activity. As appropriate to the structure of the dataset, multivariate statistical analyses to discriminate and compare groups within and between sites may also be conducted. Such analyses provide an alternative means to inform on the relative influence of individual elements or

suites of elements on group membership and composition. The data will be discussed in text and presented in tables that illustrate multi-element correlations and geochemical patterns associated with feature and activity area types. Section 5 will also evaluate the efficiency, benefits, and disadvantages of the various soil sample collection methods used; and ways in which soil geochemical analysis of archaeological anthrosols can benefit data acquisition on cultural resource management projects.

Section 6 will provide a summation of the results and include a discussion of appropriate geochemical soil analysis guidelines for future studies. All citations will be included in a references section. Raw data tables will be presented in an appendix for use by researchers.

As part of this sub-task, RGA will research XRF technology to assist DelDOT with assessing the type of machine that best suits their needs. RGA will provide some recommended options (i.e. hand held units vs. bench units) for consideration by DelDOT. After consultation with DelDOT, RGA will then procure an XRF machine on behalf of DelDOT.

Sub-Task 2c: Public Outreach

Public outreach for the alternative mitigation will include the preparation of a brief monthly blog entry about the ongoing analysis and findings associated with the alternative mitigation. The monthly blog will be submitted to DelDOT via email.

DELIVERABLES

Four (4) hard copies of the draft alternative mitigation report will be provided to DelDOT with two (2) CDs containing electronic copies of the report. It is the understanding of RGA that the draft report will be submitted by DelDOT for peer review and review by the DHCA. DelDOT will be responsible for addressing peer review comments and those of the DHCA.

ESTIMATED SCHEDULE*

Progress and completion of the draft report will be dictated by RGA's receipt of geochemical soil test report raw data, mapping as outlined above, geochemical soil analysis reports by DelDOT's cultural resource management consultants, and correspondence with them regarding site-specific archaeological data.

- NTP to 2 Months:
    1. Background research; review of published archaeological geochemical analysis literature.

- 2-5 Months:
    1. Receipt and review of geochemical soil test report raw data, mapping, and geochemical soil analysis reports by DelDOT's cultural resource management consultants.
    2. Correspondence with University of Delaware soil scientists, University of Delaware Center for Archaeological Research, and the Delaware State Museum.
    3. Geochemical soil analysis data receipt and review and preliminary statistical analysis.

- 6-8 Months:
    1. Interim progress and consultation meeting with DelDOT to review the dataset and adjust the research design, if necessary. Report writing will proceed upon the completion of the consultation meeting.

- 8-13 Months:
    1. Report writing and statistical analysis.

2. Completion of report graphics.
3. Report editing and formatting.

- 14-16 Months:
    1. Internal report review.
    2. Submission of the draft Alternative Mitigation report to DelDOT.

*This schedule is dependent upon the timely receipt of materials, as requested, from Route 301 archaeological consultants.

Please contact Paul McEachen at 609-655-0692, ext. 309, Michael J. Gall, ext. 318, or Richard Grubb at ext. 320 with any comments or questions regarding the proposal. We look forward to continuing this exciting project on behalf of DelDOT.

Very truly yours,

Alice Domm
Chief Executive Officer

PJM:cr

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