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# The Feasibility of Using Computer Graphics in Environmental Evaluations

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## ABSTRACT

The purpose of this study was to develop a procedure that could be used to distinguish quickly between proposed transportation projects that would have an effect on the environment, and thus require special approval, and those that would not. It is intended that this procedure be used as a basis for agreements between the Virginia Department of Highways and Transportation and other state and federal agencies to expedite evaluations of environmental impact. Data collection, program selection, and retrieval and update procedures are described.

The Environmental Quality Division of the Virginia Department of Highways and Transportation (VDHT) is directed to assess the probable benefits and damages that will result from the construction of all the department's proposed projects. For state-funded projects, these assessments result in informal reports used as decision-making tools within the department. For federally funded projects, they result in some form of environmental impact statement (EIS).

Revisions to the National Environmental Policy Act (NEPA) have been made by the federal government with the intent of shortening the overall EIS process; however, the effects have been realized more at the reporting phase than at the data-collection

and analysis phase. For example, the scoping process (Section 1501.7 of the regulations of the Council on Environmental Quality) requires that an agency, as soon as possible after deciding to write an EIS on a proposed project, publish a notice of intent in the Federal Register. Among other objectives, this notice is aimed at assuring that all parties affected by or interested in the proposed action be invited to participate in determining the scope of the EIS, which includes establishing the significant issues to be studied, eliminating from study those issues considered insignificant, identifying and coordinating related EISs being written, and establishing the length of the final EIS. To prepare for and conduct the scoping process, initial data must be collected on all potentially significant variables, such as historic site locations, within the project area.

## PROBLEM STATEMENT

Requests for environmental surveys needed to comply with federal regulations are sent to the Environmental Quality Division of VDHT from the Location and Design Division and from the district environmental coordinators. In response, the Environmental Quality Division staff either performs the survey or contacts federal agencies and other state agencies to obtain information to satisfy the request. In most cases the information is manually maintained or must be collected for the first time, and where the department is dependent on other agencies for information, it cannot expedite retrieval.

It would be extremely rare for a project to af-

fect all variables that must be considered in an environmental impact assessment. Some of the more complex projects involve several variables, but the majority of all projects have no environmentally adverse effects. Consequently, a great deal of time is spent surveying projects to determine which of the variables require study.

#### OBJECTIVE

The objective of this study was to develop a procedure that could be used by VDHT to quickly distinguish between proposed transportation projects that would have an effect on the environment, and thus require special approval, and those that would not. It was intended that this procedure would be used as the basis for agreements between VDHT and other state and federal agencies to expedite evaluations of environmental impact.

#### DEVELOPMENT OF THE PROCEDURE

The procedure developed consists of selecting an appropriate computer program, developing a data base, and selecting a means of accessing and updating the information. A suggested agreement for implementing the procedure was devised. These steps are discussed under the subheadings that follow. Although the procedure can be applied for locating many different types of variables, the historic-landmark data base is used in the illustration presented here.

#### Program Selection

Two computer programs were evaluated: SYMAP, a program obtained from Harvard University that is designed to produce graphic output on a line printer, and the landmark data and list program (LDLP) developed by VDHT from a base program obtained from FHWA and having the capability of producing graphic output on a pen plotter.

#### SYMAP Program

The SYMAP program, obtained from Harvard University's Laboratory for Computer Graphics and Spatial Analysis in Cambridge, Massachusetts, was selected because of its proven reputation. It was developed at Harvard during the 1960s and is currently the most widely distributed general-purpose computer mapping software package. It can produce maps containing point, line, or area data or combinations of these. By electing certain built-in program options, SYMAP users can manipulate the size and scale of the maps produced and the symbols used to distinguish map features. The program can enlarge portions of a map, can be programmed to include only certain data features, and can produce cosmetic features such as legends and directional arrows within the map border. The output is produced by a standard line printer on standard computer paper (Figure 1). SYMAP was evaluated by using data obtained from the U.S. Geological Survey (USGS) series of maps of land use and land cover. Land cover maps describe natural land features such as vegetation, wetlands, rock outcropping, and glaciers. Land use maps show man's use of the land for facilities such as highways, bridges, buildings, and dams.

These maps are being developed by the USGS at a

scale of 1:25,000 [1 in. (25.4 mm) on the map equals approximately 4 miles (6.4 km)]. The land use and land cover classification system uses 9 general level 1 categories further subdivided into 37 level 2 categories. This evaluation revealed the following information:

1. The SYMAP program is an excellent tool for comparing data by using an overlay technique. For example, by graphically overlaying variables usually related to archaeological sites, areas of land on which a site may exist will be identified by a dark shading (Figure 2).
2. SYMAP is a reliable canned program and can easily be implemented on VDHT's IBM 370 computer.
3. SYMAP data can be transmitted from terminal to terminal by using equipment already available in VDHT's district offices.
4. SYMAP is not as accurate for point location as a program that uses a pen plotter for graphic output.
5. SYMAP is best used for representing continuous data on land use and land cover rather than point or line data.
6. In most cases the collection and reduction of data for SYMAP requires many man-hours. The work required is often in the form of digitizing, which in VDHT is performed without viewing the results and results in downtime for corrections.

#### LDLP

Several programs available within VDHT were consolidated to test the applicability of data graphically produced on a pen plotter. Although the resulting program, LDLP, does not provide the convenience of a canned program, the immediate availability of the component programs and the programming expertise make it an economical and tailored system.

The program was evaluated by using data obtained from the files of the Virginia Historic Landmarks Commission. These files contain approximately 20,000 historic locations identified in a survey of Virginia. Of these, 1,000 representing locations listed on or nominated for the National Register and those listed on the Virginia Register were selected.

The following findings are relevant to both the computer program and the historic site location data used:

1. The pen plotter is accurate for locating site-specific data;
2. The best results were obtained when data were overlaid on a USGS quadrangle map;
3. Data in this form could not be transmitted to other locations because of the need for specialized equipment;
4. Using the programs available within VDHT, data could be retrieved on a statewide basis to coincide with the state map, county map, or USGS quadrangle map;
5. By collecting only location data and limited descriptive data, a useful data base could be established;
6. The overlay method of depicting data is sufficient, given the time limitations of an environmental evaluation; and
7. The transmittal of information by mail is sufficient for environmental evaluations.

#### Conclusions

The findings from the two evaluations led to the selection of the LDLP for use in establishing the

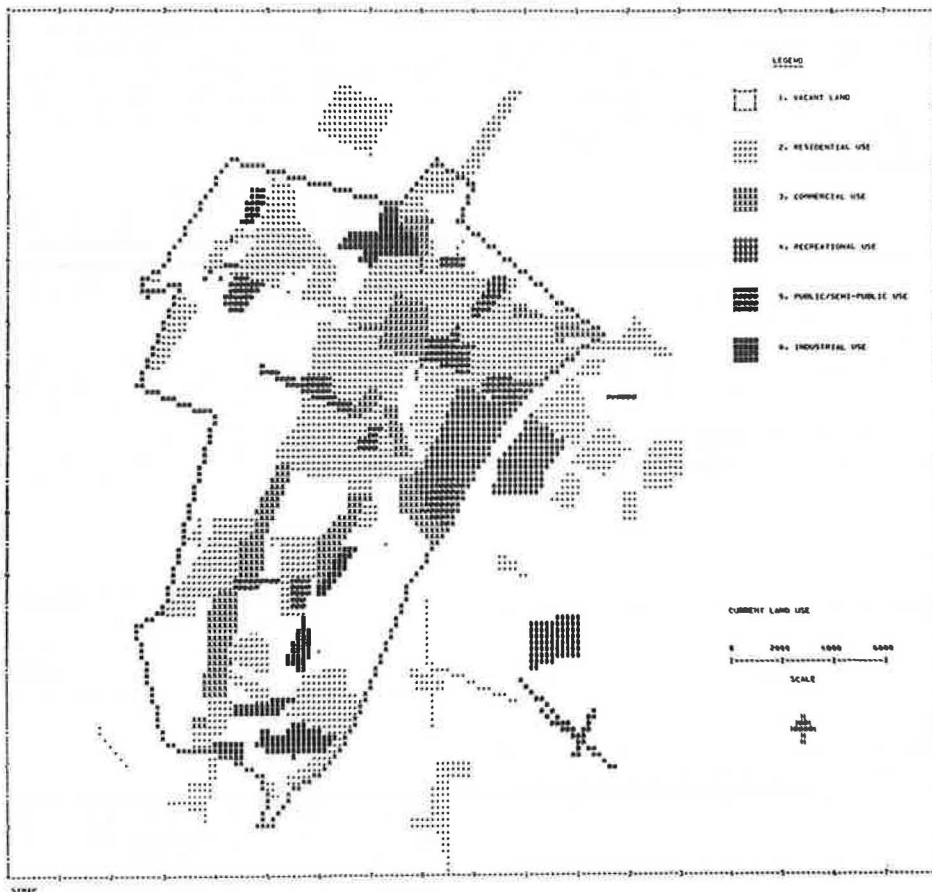


FIGURE 1 SYMAP-produced land use map of Winchester, Virginia.

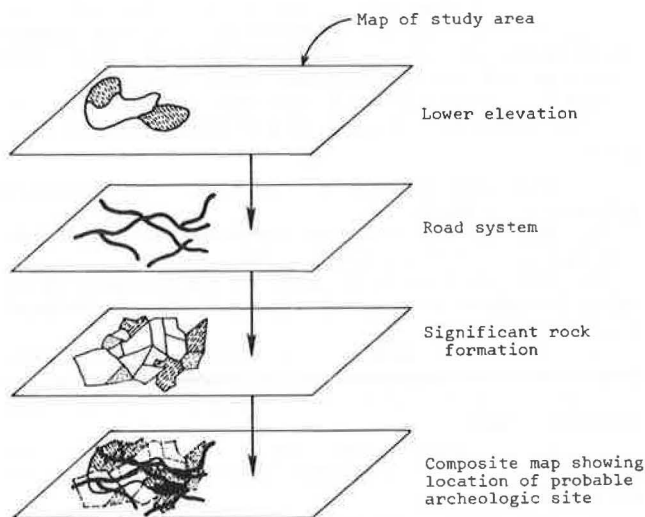


FIGURE 2 Sample overlays.

environmental data base. Program SYMAP could be used, it was decided, for some specific studies on a quadrangle level.

Development of a Data Base

Types of Data

For this illustration of the establishment of a data bank using historic site information, representatives of VDHT, the Virginia Historic Landmarks Commission, FHWA, and the registrar from the National Register of Historic Places were involved in deciding what types of data would be collected.

In addition to collecting the historic site information mentioned previously, information of interest to agencies other than VDHT was also collected. It was believed that to the extent that other agencies are interested in a specific data bank, they will aid in updating the data.

An effort was made to collect enough data to make the program useful to the Historic Landmarks Commission while at the same time not so complex that the time required to complete the data bank and the effort needed for updating would be unreasonable.

Data Input

The information selected for use was limited to that contained on the coding and input data sheets shown in Figures 3 and 4, respectively. Certain information on these sheets is applicable to all variables. Other information items are to be modified or the

Category (Column 7-46)

- |              |            |
|--------------|------------|
| 1. District  | 5. Object  |
| 2. Building  | 6. Public  |
| 3. Structure | 7. Private |
| 4. Site      |            |

Significance (Column 48-61)

- |                             |   |
|-----------------------------|---|
| 1. Archeology — prehistoric | 51. colonial settlement                           |
| 2. Archeology — historic    | 52. nautical                                      |
| 3. agriculture              | 53. biological                                    |
| 4. architecture             | 54. esthetic                                      |
| 5. art                      | 55. depth   |
| 6. commerce                 | 56. geological                                    |
| 7. communications           | 57. hydrological                                  |
| 8. community planning       | 58. paleontological                               |
| 9. conservation             | 59. length  |
| 10. economics               | 60. recreational                                  |
| 11. education               | 61. building                                      |
| 12. engineering             | 62. bridge  |
| 13. exploration/settlement  | 63. mill  |
| 14. industry                | 64. tavern  |
| 15. invention               | 65. church  |
| 16. landscape architecture  | 66. canal   |
| 17. law                     | 67. historic district                             |
| 18. literature              | 68. archeological district                        |
| 19. military                | 69. house   |
| 20. music                   | 70. courthouse                                    |
| 21. philosophy              | 71. glebe   |
| 22. politics/government     | 72.   |
| 23. religion                | 73.   |
| 24. science                 | 74.   |
| 25. sculpture               | 75.   |
| 26. social/humanitarian     | 76.   |
| 27. theater                 | 77.   |
| 28. transportation          | 78. FUTURE EXPANSION                              |
| 29. local history           | 79.   |
| 30. scenic                  | 80.   |
| 31. medicine                | 81.   |
| 32. presidential birthplace | 82.   |
| 33. animal husbandry        | 83.   |
| 34. folklife                | 84.   |
| 35. decorative arts         | 85. urban and built-up land                       |
| 36. 19th century townscape  | 86. urban commercial                              |
| 37. revolutionary history   | 87. urban industrial                              |
| 38. afro-american           | 88. urban institutional                           |
| 39. fire fighting           | 89. urban mixed                                   |
| 40. civil war               | 90. cropland and pasture                          |
| 41. printing                | 91. orchards, groves, vineyards,<br>horticultural |
| 42. resort                  | 92. rangeland                                     |
| 43. stone structure         | 93. forestland                                    |
| 44. presidential home site  | 94. streams and waterways                         |
| 45. equestrian              | 95. lakes   |
| 46. labor                   | 96. reservoirs                                    |
| 47. funerary art            | 97. bays and estuaries                            |
| 48. park planning           | 98. nonforest and wetland                         |
| 49. health                  | 99. barren land                                   |
| 50. maritime                |   |

Registration (Column 106)

- |   |  |
|---|--|
| 1. National Register of Historic Places | 5. Virginia Historic Landmark Commission Inventory |
| 2. National Historic Landmark           | 6. Protected                                       |
| 3. Virginia Landmark Register           | 7. Unprotected                                     |
| 4. Determination of Eligibility         |  |

FIGURE 3 Historic sites coding sheet.

data translated in order to be used. The items on the information sheet are explained in the following, and in cases where these items may need interpretation, examples are given. The following explanations are correlated with the data sheet items in Figure 4:

- File number: A six-digit number. The first three digits represent the geographic location of the site; the remaining three identify the specific site within that location. This variable is necessary for retrieval.
- Description: The preferred name of the location. This is not necessary and can be left blank.
- Category: A one-digit number that identifies the location as a district, a building, a structure, a site, or an object. This item can

be used to designate privately or publicly owned properties.

- Area of significance: A two-digit number that identifies the reason or reasons that the site is significant (e.g., architecture, art, commerce, or transportation). This item is used to describe the data and to identify the specific site or area to be recalled (searched). Some of the significance items are close in meaning in an attempt to accommodate subtle but significant differences in meaning between disciplines supplying the data. A maximum of seven codes can be used to describe and identify a particular item; the more exact the coding, the better the chances for a comprehensive retrieval.
- Acreage: The amount of acreage surrounding the site. This number may be an overestimate of the property involved. For example, if the record shows that the property is less than 1 acre, 1

VIRGINIA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION  
RESEARCH COUNCIL  
LANDMARK RESEARCH DATA

FILE NO COL 1-6

DESCRIPTION Name of Property  
COL 7-46

CATEGORY See Information Key  
47

AREAS OF SIGNIFICANCE See Information Key  
COL 48-61

ACREAGE In even numbers 1 through 1,000  
62-65

CITY/COUNTY/TOWN spelled out CITY/COUNTY/TOWN CODE Standard State Code  
66-68

QUADRANGLE MAP spelled out QUADRANGLE CODE USGS Code  
COL 69-72

LATITUDE 73-78 LONGITUDE 79-84

UTM COORDINATES  
NORTH 85-94 EAST 95-104

HABS "1" if yes, otherwise blank  
105

REGISTRATION See Code Sheet  
106

DATE Most significant or earliest  
107-110

ORIGINAL USE 111-113 HISTORIC USE 114-116

For future use

FIGURE 4 Input sheet.

acre will be the amount recorded; in other words, if the property is described as consisting of a fraction of a measurement, the next whole number will be recorded.

- City/County/Town: The name and a three-digit code assigned by the state, used to identify the geographic location of the site.
- Quadrangle map: The name and quadrangle number assigned by the USGS, used for location.
- Latitude and longitude: One system used to locate sites. The coordinate system was used to gather historic data before 1966; consequently these data must be gathered and translated into state plane coordinates (SPC) for use by VDHT. (A program obtained from the USGS is used to make these conversions.) Either this system or the Universal Transverse Mercator (UTM) system should be used, not both.
- UTM coordinates: System now used to locate historic sites. These are translated into SPC for use in the program. Either the UTM system or the latitude-longitude system should be used, not both.
- HABS: Refers to the Historic American Building Survey. A 1 is used to indicate that the historic site was a part of this survey. This item is used only with historic data.
- Registration: Indication of formal registration of a landmark; 1-5 are used to indicate that the landmark is on the National Register, is a National Historic Landmark, has been nominated to the National Register, is on the Virginia Landmark Register, or is registered by the Virginia Historic Landmark Commission; 6 and 7 apply to cave data. This item does not have to be used.

- Date: The most significant date of the property or a date that has been established for the origin of the property. It is important for description and identification.
- Original use: The use for which the landmark was originally constructed (e.g., the Alamo was originally a church; in Virginia, the Sutherland Mansion was originally a private residence), used exclusively for historic data.
- Historic use: The use for which the landmark is known and because of which it is deemed historically significant (e.g., the Alamo was originally a church but is historically noted as a fortress; the Sutherland Mansion was the last capitol of the Confederacy), used exclusively for historic data.

Data Access and Update

Information from the data bank established can be obtained on request from the Data Processing Division. Because the process is designed to be easily used by various agencies, the information can be retrieved by identifying the code number of the county or quadrangle for which it is desired. The information can also be retrieved by identifying the latitude and longitude, UTM, or state lane coordinates that encompass the area for which it is desired. By requesting a search of the data bank, the retrieval can be limited to any of the words under the significance coding or any date within a ± 25-year interval.

The retrieval process produces a series of standard printouts (Figure 5) and, on request, graphic representations. As previously noted, the scale can

VIRGINIA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION  
HISTORIC LANDMARK DATA

FILE NUMBER	099065	
DESCRIPTION	BRYAN SITE	
CATEGORY	SITE	
AREAS OF SIGNIFICANCE	ARCHEOLOGY - HISTORIC ARCHITECTURE	
ACREAGE	10	
CITY/COUNTY	YORK	COUNTY
QUADRANGLE	WILLIAMSBURG	096C
COORDINATES	NORTH	EAST
	18 4215820	353200
	18 4125700	353270
	18 4125800	352890
	18 4125920	352940
	18 4125820	353200
HABS	NO	
REGISTRATION	NATIONAL REGISTER OF HISTORIC PLACES	
DATE	1700	
ORIGINAL USE		
HISTORIC USE		

FIGURE 5 Typical printout of information contained in historic data bank.

be varied to enable displays at the state, the county, or the quadrangle level.

Information can be added to the data bank with the authorization of the manager of the Data Processing Division. Although the frequency of updating information will vary from variable to variable, information stored in the data bank can be changed by submitting it on a form to the Data Processing Division.

#### Agreement for Implementing System

To implement the procedure illustrated here, VDHT must obtain the agreement of any concerned agencies. Such an agreement is now being negotiated between the Environmental Quality Division and the Virginia Historic Landmarks Commission. The elements of the agreement that must be worked out are discussed in the following.

#### Type and Accuracy of Data to be Used

In the trial use of the procedure developed, the information used was taken from the Virginia Historic Landmarks Commission files. Most important were the coordinates designating the location of a historic site. These could be obtained either by copying those in the files or by interpreting the positions of landmarks located on maps. The accuracy of these data depends on the expertise of those who originally located the sites and the accuracy of those who then transcribed the information for the files.

#### Method of Data Reduction

In mapping, VDHT uses the SPC system. However, the files in the Virginia Historic Landmarks Commission

contain information located both by latitude and longitude for the period before 1966 and by UTM since that time.

#### Accuracy of Graphic Displays

To ensure that the data displayed on the computer-produced overlays were accurate, several random samples were checked against data transcribed on maps at the Virginia Historic Landmarks Commission. Several of these overlays were field checked as well. It is important that all data produced by the computer accurately represent data in the files. A breakdown could result in a lack of confidence that would invalidate any agreement between VDHT and a concerned agency.

#### Method of Updating Data

Personnel of the Virginia Historic Landmarks Commission agreed to fill out the computer input sheets for those properties placed on the Virginia register at their monthly meeting and for all newly surveyed properties.

#### Method of Notification

Once the questions relating to data are resolved, a method of notification must be devised. This method should (a) stipulate how VDHT is to give the other party to the agreement prior notice of any planned action and (b) specify a time period within which the other party is to make any desired response.

#### COST OF DATA BANK

The cost of establishing a data bank depends on such factors as the hardware and software available, the programming service needed, and the desired precision of the data. However, once the data base has been established, updating and maintenance are relatively inexpensive.

VDHT has the expertise to maintain a given data bank, and with other agencies participating in the updating procedures, the costs would be limited to those for storing and retrieving data and processing the updated information. For maintaining the historic site location data, the annual cost is estimated to be \$33.

#### RECOMMENDATIONS

Recommendations resulting from this study are stated in the following. They are all predicted on the implementation by VDHT of the procedure for distinguishing projects likely to have an undesirable environmental impact.

1. It is recommended that the historic landmarks data bank established in this study be maintained and updated as a routine operation.

2. It is recommended that the LDLP developed by the Data Processing Division of VDHT be used to store data on a statewide basis when the data are relatively easy to collect and reduce. The SYMAP program should be used on a limited basis, for example, for analyzing data in an area of the size represented by a USGS quadrangle map.

3. Because data collection is the most expensive aspect of this procedure, an effort must be made to

gather only information that will (a) aid in determining whether a project area is environmentally sensitive and (b) be of sufficient interest to encourage other state agencies to aid in maintaining and updating the data bases. Therefore, it is recommended that the authorization for establishing data banks within the system be obtained through the Environmental Quality Division or the Data Processing Division.

4. If data are needed and must be digitized for entry into the system, it is recommended that the Mapping Section of the Location and Design Division be consulted for assistance.

5. It is recommended that an agreement be made between VDHT and the Virginia Historic Landmarks Commission to the following effect:

a. The data available for the procedure to be implemented are sufficient to determine whether there is a question of impact;

b. The demonstrated procedure for data collection, interpretation, and method of display gives an accurate representation of the project area;

c. VDHT can assume that a project is clear of any adverse impact on a historical site when data in the system support this decision;

d. In each instance a memo will be sent to the director of the Virginia Historic Landmarks Commission informing him of action to be taken; and

e. If no reply is received within a stated time period, the action outlined by VDHT would be authorized.

This agreement is appropriate with the information now in the historic landmarks data base and could serve as an example for agreements with other agencies.

#### ACKNOWLEDGMENT

The research reported in this paper was sponsored by VDHT in cooperation with FHWA. The development of the system, including the computer hardware and software, and the collection and reduction of data required the efforts of personnel from VDHT, the Virginia Highway and Transportation Research Council, and the Virginia Historic Landmarks Commission.

The Environmental Division of VDHT, headed by Robert Hundley, initiated the research. Earl Robb, assistant environmental quality engineer, identified the problem and requested the research. Gene Wray,

environmental coordinator, provided the liaison with other agencies, and Lyle Browning, archeologist, gave technical assistance.

The Information Systems Division provided the hardware and developed the software for the system; Harris Allen was instrumental in coordinating and guiding the available personnel.

Personnel of the Location and Design Division reduced the data required to produce the desired graphics. Fred Bales, George Habel, and Kermit Wood directed the manpower efforts to provide digitizing and acquire information from various maps and aerial photographs.

Special appreciation is extended to Tom Slayton, digitizer, and Bill Ross, electronics technician, for their efforts. Especially appreciated was their tolerance in working with the researchers through many trial-and-error attempts to coordinate the equipment required to reduce the data.

Calder Loth, architectural historian, and Cory Hudgins, registrar, interpreted the information contained in the files of the Virginia Historic Landmarks Commission. C. Vernon March III, the environmental review officer, aided in reducing the information to that which was essential for environmental documentation. Bob Carter, historian and head of the Survey and Registration Division, is responsible for updating the information and the continued use of the program so that the benefits from the research can be realized. Randy Turner, prehistoric archeologist, and John Broadwater, nautical archeologist of the Research Center for Archeology, a satellite of the Historic Landmarks Commission, interpreted and classified the archeological data.

Bill Kelsh, research scientist, of the Virginia Highway and Transportation Research Council, was coauthor and technical advisor on a previous study that was used to test program options and select those most applicable for the research reported here.

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The opinions expressed in this paper are those of the authors and not necessarily concurred in by the sponsors.

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