

**ENVIRONMENTAL INVESTIGATIONS
AT
THE PADUCAH GASEOUS DIFFUSION PLANT
AND SURROUNDING AREA
McCRACKEN COUNTY, KENTUCKY**

**VOLUME IV
CULTURAL RESOURCES INVESTIGATION**

**PART B
SENSITIVITY ANALYSIS**

Prepared by

**Department of the Army
Waterways Experiment Station, Corps of Engineers
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Volume 4B of 5

**May 1994
Final Report**

Prepared for

**Department of Energy
Oak Ridge Operations
Paducah Site Office
P.O. Box 1410
Paducah, KY 42001**

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Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	0.405	hectares
feet	0.3048	meters
inches	2.540	centimeters
miles	1.609347	kilometers
square feet	0.093	square meters

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Preface

This document provides results of one of four studies conducted to describe environmentally sensitive areas near the Paducah Gaseous Diffusion Plant properties at Paducah, Kentucky. This report presents the methods and results of the identification and evaluation of cultural resources on the Department of Energy and Tennessee Valley Authority reservations and selected areas not included as part of either reservation. The results of a pedestrian field survey are presented in Part A and the results of a statistical model of site occurrences in Part B.

This work was performed by the U.S. Army Engineer Waterways Experiment Station (WES). The report was prepared by Dr. Frederick L. Briuer of the Environmental Laboratory (EL). Dr. Kress was the WES project coordinator.

The work was conducted under the direct supervision of Mr. Roger Hamilton, Chief, Resource Analysis Branch. General supervision for the study was provided by Dr. Robert Engler, Chief, Natural Resources Division, EL, and Dr. John Harrison, Director, EL.

The purpose of the WES environmental investigations was to support PGDP's National Environmental Policy Act (NEPA) compliance program. These investigations provide current information about environmentally sensitive areas on the PGDP reservation and support the development of environmental impact statements planned for the PGDP site. These investigations also support current DOE regulations (10 CFR 1022) which implement Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands), and support DOE to comply with the National Historic Preservation Act and the Endangered Species Act of 1973.

The results of the environmental investigation are presented in five volumes as follows:

- Volume I: Executive Summary
- Volume II: Wetlands Investigation
- Volume III: Threatened and Endangered Species Investigation
- Volume IV: Cultural Resources Investigation
- Volume V: Floodplain Investigation

Director of WES during the preparation of this document was
Dr. Robert W. Whalin. Commander was COL Bruce K. Howard.

Acknowledgements

The research described here was made possible by contributions from a large team of archaeologists from Geomarine Inc., who performed the field survey and prepared the draft report that served as the informational basis for the predictive model described in this report. Special thanks are in order for Gary Hebler, WES contract student, for undertaking the field work involved in the initial literature and archival search and for competently digitizing and preparing ARC/INFO files and graphic output so critical to accomplishing the research. Maureen Corcoran, of the WES Geotechnical Laboratory prepared the geomorphic classification of the PGDP facility. Dr. Rose Kress supervised the team of Janet Holt and May Causey in digitizing and preparing ARC/INFO files in vital support of this research. Thanks also go to Charles Logston, James Ballard, and Brian Bowers from the PGDP, who were all instrumental in assisting the Geomarine and WES field crews in accomplishing their work. Finally, I would like to express my appreciation to Rob Karwedsky and Tom Swor of the Corps of Engineers, Nashville District, for their constant assistance along the way and for giving us the opportunity to perform this work.

1 Introduction

The Department of Energy approached the U.S. Army Corps of Engineers, Nashville District, in order to conduct environmental investigations of the Paducah Gaseous Diffusion Plant (PGDP). In view of the multidisciplinary expertise available at the U.S. Army Engineer Waterways Experiment Station (WES), the Nashville District in turn sought the assistance of the WES, who responded to a scope of work prepared by the Nashville District that required a variety of investigations including wetlands, threatened and endangered species, floodplains and cultural resources. This report documents a statistical model of cultural site sensitivity for the PGDP. The location of the study is shown in Figure 1.

Overall project responsibilities for the cultural resource survey were divided between a WES team of researchers and a team from Geomarine, Inc. Dr. Briuer at the WES prepared the scope of work for Geomarine, Inc. and designed the twenty percent stratified random sample. Volume IV, Part A of this report serves as the basis for meeting all legal requirements associated with the current archaeological survey and initial assessment of cultural resources in the study area and also serves as the informational basis for this site prediction model. The site prediction model described below is the sole responsibility of the author.

The WES team provided the overall management of the investigation and participated in the initial field reconnaissance, literature review, archival and records research performed in the field prior to issuing the Delivery Order to Geomarine, Inc. The extent of previous cultural resource surveys at PGDP, as determined by the literature review and records search, is shown in Figure 2. All known archaeological sites are shown in Figures 3a and 3b. These figures show recorded and unrecorded sites identified during the background search as well as new sites located during this field survey.

2 Research Strategy

A basic premise for generating a predictive model of archaeological site location is that archaeological sites can be expected to be highly nonrandomly distributed in space. Any attempt to give equal consideration by investing an equal effort for every square meter of the PGDP would be a very inefficient way to comply with cultural resource management legal requirements. Preferred locations were favored by different people at different times in the past and supportable conclusions about that unequal use of space are possible by surveying on a sampling basis.

Prior to this investigation, very limited pedestrian survey and shovel testing had occurred at PGDP. Earlier professional surveys were limited to only about six percent of the facility (Figure 2). About half of this area had been subjected to some shovel testing. The results of these earlier surveys were considered in designing the stratified random sample survey described here. Results from earlier surveys were particularly important in allocating shovel tests for each stratum proportional to expected site densities. Results of this earlier archaeological field work offer some supportable conclusions.

The earlier surveys recorded five prehistoric archaeological sites in approximately 81 hectares (200 acres) of lowland alluvial geomorphic landforms and one prehistoric site recorded in about 202 hectares (500 acres) of upland loess landforms. Given these initial and crude predictions, we might expect some 25 prehistoric sites in every 404 hectares (1000 acres) of alluvial strata surveyed and only 2 prehistoric sites in every 404 hectares (1000 acres) of upland loess surveyed. In other words, assuming that the early survey information was statistically representative of the sample universe, we might predict that there will be 12 times as many prehistoric sites in alluvial landforms as in the upland loess soils. Until rigorously tested with more reliable survey information, such a prediction, although supported by the initial available data, is not very useful for cultural resource management purposes.

The earlier surveys made no pretense of being representative samples of anything other than discreet areas defined solely in terms of planned Federal actions with potential for adverse effects to possible cultural resources; they were not representative of any formal variation across the facility. As "grab samples," they vastly overrepresented some strata, particularly certain alluvial strata, underrepresented some strata, such as upland loess, and completely left

out others. This 12-to-1 ratio of sites in 2 inadequately sampled and poorly defined environmental zones offers nothing about historic site locations, expected site sizes, expected depth of deposit of sites or other attributes of sites conventionally recorded during archaeological survey.

The purpose of the sampling strategy and methods of statistical analysis employed in this report is to improve the kinds of predictions available for archaeological sites and their geomorphic landscape. Doing this required keeping the results of the earlier, less rigorous surveys separate from the kinds of conclusions possible with a more statistically reliable survey. Predictions are based on a larger, more representative and reliable sample, using improved scales for measurement, quantitative analysis and a logically more consistent and coherent classification of both archaeological sites and geomorphic landforms. The goal of this effort is to generate more reliable and more useful predictions than are possible with the quality of information available from earlier surveys.

Database Development

A literature review (Appendix A) was prepared at the WES describing key citations and existing literature and reports from previous archaeological surveys and site recording efforts at the PGDP. This list describes the results of the existing data survey performed by the WES at Lexington and Louisville in the summer of 1992 and also contains significant literature sources for the immediate geographic region.

Additional Geographic Information System files were prepared in ARC/INFO. Analysis of these data was conducted in ARC/INFO. The results described below would have been extraordinarily laborious and time consuming without employing the ARC/INFO system for rapid calculation of areas of mapped polygons and creation of various map layers and combinations of layers.

Stratified Random Sample Design

The PGDP as shown in Figure 1, including the fenced security areas, covers 4,745 hectares (11,719 acres). The sample universe for the current archaeological survey was defined by considering the following factors. Certain areas within the PGDP were eliminated from the survey (Table 1). Excluded areas include those previously subjected to pedestrian archaeological survey (Autry, 1979a and 1979b; Butler, 1981; Sussenbach, 1991) (See Figure 2). Areas where previous archaeological work was of only a reconnaissance level of effort were included in the sample universe (Henderson, 1988; Hemberger 1988). This assumes that the intensity of coverage during these two reconnaissance level projects was not sufficient to exclude these areas from the sample.

The PGDP plant area and the Tennessee Valley Authority Shawnee Steam Plant area are intensively developed locations inside security fences. Both were also eliminated from the sample universe.

For a discussion of the rationale for eliminating these areas from the sample universe, see the memorandum by Mr. Rob Karwedsky (Appendix B.). In view of the development inside the security fence areas since the early 1950's, there would be no point in surveying these areas for prehistoric resources. If any prehistoric sites survived the development they would probably be buried under existing asphalt, concrete or buildings. Surveying for prehistoric sites under these circumstances would be pointless. Two sets of aerial photos, in stereo pairs, flown in 1943 and 1952 were examined with a stereoscope to determine 1) whether the two intensively developed areas inside security fences today had structures at these same locations in 1943 and 1952 and 2) whether these structures survived the construction activities after 1952. Evidence from the air photos, supplemented with a USGS 1:62,000 scale topographic map dated 1932, suggest that no structures built prior to 1952 have survived the construction that occurred inside these two developed areas inside security fences.

Other heavily developed areas were also eliminated from the sample universe. The extent of development of these areas and the absence of structures over 50 years of age were also confirmed by the stereoscopic analysis of the 1943 and 1952 air photos.

Despite several efforts on the part of plant personnel to secure permission for archaeologists to enter certain privately owned tracts, some areas had to be eliminated because the required permission could not be secured. However, private property where entry permission was granted was included in the survey universe.

Two areas comprising the abandoned Kentucky Ordnance Works (KOW), a gravel pit, and the water filtration plant were eliminated from the sample universe. In view of the wealth of supplemental information available for evaluating the KOW area, it was decided that for purposes of this survey, this particular area should be treated as one historic site that should be given special consideration in the future. In particular, site maps and detailed architectural drawings are available that inventory, describe and effectively classify the numerous and highly complex structures greater than 50 years of age on this site. Any effort to survey and record the KOW site without reference to critical existing information sources is not recommended.

In all, approximately 1,496 hectares (3,696 acres) were excluded from the study (Table 1). This leaves about 3,247 hectares (8,023 acres) to be subjected to stratified random sampling. To cover 20% of this sample universe requires a minimum sample size of 649 hectares (1,604 acres). Figure 4 illustrates collectively all areas excluded from the study.

A twenty-percent stratified random sample was selected for archaeological survey. The sample survey was designed using geomorphic landforms and major soil types as the basis for stratification.

The geomorphic classification used for stratifying the sample was developed by relying on existing geology and geomorphic information sources, such as published geology and soils maps, air photos and other published reports such as (Dreier, et al 1990; Finch, 1968; Nichols, 1968; and Pree et al 1957) (see Figure 5). Table 2 describes the sample universe along with the size of each of the twelve strata.

The PGDP can be divided into a lowland alluvial zone consisting of 7 different geomorphic landforms that are dominated by fluvial geomorphic processes. These 7 landforms together represent about 40% of the sample universe. The single upland loess zone resulting from aeolian processes represents about 60% of the sample universe. This fundamental distinction between a fluvial lowland and a loess upland is readily apparent in Figure 5. Landforms nearest the Ohio River have an orientation parallel to the river; upland aeolian landforms have a more random orientation except for tributary alluvium with a dendritic pattern draining toward the river.

A stratification scheme was selected that broke the huge upland loess stratum into 5 separate strata based on SCS soils classification. This combination of geomorphology and soils criteria was chosen to avoid sampling problems associated with comparing analytical units of disproportionately different sizes. In this way we are comparing expected and observed differences in strata that are more even in size. Geomorphic and soils classification were digitized as elements in the GIS database and plotted on USGS 7.5 minute sheets and CAD maps with one-foot contour intervals. The GIS and CAD maps were made available to the contractor for their use in field survey and data analysis.

Using a table of random numbers, sample units were selected. These consisted of quarter UTM quadrats, each 500 meters X 500 meters. Both partial and whole sample units were selected. The quarter quadrat is an appropriate and manageable sample unit for a survey area of this size. It has certain advantages over transects in that there is an increased chance of finding sites given the nature and size of the cultural resources expected. Also, the quadrat has the advantage of being a unit in space that can be increased in the future, should additional survey work be required. If not permanently marked, survey transects are often more difficult to relocate than survey units tied to the UTM system.

Considering both partial and whole grids, the twenty percent sample is spread out over 41 well-distributed sample units (see Figure 6). The 41 whole and partial sample units are equivalent to 668.9 hectares (1,653.1 acres), or 20.6 percent of the total sample universe.

For each of the 12 strata listed in Table 2, a twenty-percent target acreage was calculated. The process of selecting sample units at random continued until the twenty percent acreage figure for each stratum was nearly reached. At the point where a particular twenty-percent target acreage for a particular stratum had been approximately reached, no more sample units containing that particular landform were selected. This process of random selection continued until approximately twenty percent of each stratum was selected. The last few sample units became exceedingly difficult to select because by that time we were excluding all sample units that exceeded the targeted twenty percent goal. In order to keep each stratum at approximately twenty percent, the last 3 sample units (39, 40 and 41) were selected nonrandomly, or on a judgmental basis (see Figure 6). The total area and percent of each landform selected for survey is given in Table 3.

The goal of this sample selection method was to assure that each of the 12 strata would be surveyed at an intensity of approximately twenty percent. One stratum was slightly under-represented (Marshes); one was slightly over-represented (Terraces). A sample size of twenty percent was selected in consideration of the funding level available for this project.

3 Predictive Modeling Results

In attempting to complete the field survey for the sample chosen, the field crew encountered an unexpected problem. Because of unusually heavy spring rains, a significant portion of the stratified random sample was underwater or inaccessible because of flooding. A month delay waiting for the flood water to recede caused a delay in the completion schedule. Table 4 lists area by landform that could not be surveyed because of flooding and the area of each landform actually surveyed. Figure 7 illustrates areas flooded and plowed in each sample unit.

Inspection of Table 4 indicates that flooding affected 6 of the 12 strata, with the most obvious problem in the sample of Point Bars and Marshes. Marshes were somewhat underrepresented even without the flooding problem. There is also a slight reduction of the sample of the GRB3, Floodplains, Lacustrine, and Hn Loess strata. In general, the flooding appears to have only minor effects on the integrity of the twenty percent sample.

Appendix C consists of maps of survey units depicting the location of recorded archaeological sites with their boundaries and their Smithsonian trinomial designations. The first element of the trinomial designation refers to the alphabetical order of the state; all sites in Kentucky are 15. The second element of the trinomial is an abbreviation for McCracken County; and the third element is a mutually exclusive number for the site. In addition, archaeological localities without official site numbers are also plotted along with their boundaries. This map set also shows the geomorphic classification for each sample unit and the positive and negative results of shovel testing. See Volume IV, Part A for a discussion of shovel testing methods and results. Sample units with negative evidence are excluded from the map set.

Figures 3a and 3b depict the location of all sites and locations recorded during the twenty-percent stratified random sample survey as well as the location of all known sites from surveys prior to this effort. Also represented are sites known on the basis of knowledgeable informants but not yet recorded. Figures 3a and 3b illustrate known archaeological site based on all sources of information.

Results: Prehistoric. Table 5 summarizes the results of the sampling survey by showing prehistoric archaeological sites recorded, the sample unit, the sample stratum, and their size. Site size was determined by site mapping in the field and has been recorded on site forms found in Appendix D of Part A.

Based on survey data prior to this project, the prediction of 25 prehistoric sites for every 405 hectares (1000 acres) of alluvial lowlands surveyed is not consistent with the results of this research. If the stratified random sample indicates three recorded prehistoric sites in 96 hectares (237 acres) of lowland alluvial landforms (abandoned channels, floodplains, lacustrine deposits, point bars, terraces, tributary alluvium and marshes), the 405 hectares (1000 acres) might expect to have 12 prehistoric sites (p-sites), not 25.

Using the same argument and removing tributary alluvium from the analysis, the results of the stratified random sample producing 2 prehistoric sites in 475 hectares (1,174 acres) of upland loess are very close to the earlier prediction of 2 prehistoric sites expected for every 405 hectares (1000 acres) surveyed in the upland loess region.

These results suggest that the earlier surveys, which concentrated almost exclusively on lowland alluvial areas, overestimated the number of prehistoric sites expected in the lowlands but are quite consistent with earlier predictions about the upland loess. Instead of 12 times as many prehistoric sites in the lowlands, the results of this research indicate about 7 times as many prehistoric sites are expected in the lowlands as in the uplands. It is interesting to note that 3 prehistoric sites were recorded in 2 different alluvial strata (flood plains and marshes), while in the upland setting 2 prehistoric sites were recorded in only 1 of 4 relatively large strata (other loess).

Prehistoric sites recorded in the survey sample range in size from 36 square meters to 5,749 square meters with a mean site size of 2,214 square meters. Average prehistoric site size in alluvial strata is 3,045 square meters, while upland loess prehistoric sites average 1,935 square meters or about 2/3 the size of prehistoric sites recorded in the lowland alluvial strata.

Projecting the expected number of prehistoric sites in the entire sample universe based on the total number recorded in the stratified random sample (SRS) would predict 24.4 prehistoric sites to occur in the 80% of the installation not surveyed or 30 sites for the entire sample universe.

$$\frac{3,247 \text{ hectares (8,023 acres)}}{644 \text{ hectares (1,592 acres)}} = 5 \times 5 \text{ p-sites} = \frac{25 \text{ p-sites} + 5 \text{ SRS p-sites}}{30 \text{ p-sites}}$$

Since 63% of the unsurveyed portion of the installation is upland loess and 37% is located on alluvial landforms, it can be expected that about 19 pre-historic sites will fall in the former stratum with only about 11 sites likely to occur in the latter. In other words, if the results of the twenty-percent sample are representative of the unsurveyed portion of the facility, then the larger stratum would be expected to have a proportionally larger number of sites than the smaller stratum.

Further, the expected 19 sites on alluvial landforms can be expected to be on the average about 33% larger than those expected in an upland setting. Based on the results obtained in the stratified random sample where 3 out of 5 lowland sites (60%) were considered eligible for the National Register, about 11 lowland alluvium sites might be considered eligible and require further evaluative study in addition to field survey and recording. By the same token, fewer of the smaller upland prehistoric sites might be expected to fall into the category of potentially eligible sites.

Results: Historic. Having surveyed twenty percent of the sample universe and recording 4 historic sites (see Table 6) suggests that the other eighty percent of the unsurveyed portion of the PGDP will contain about 20 other historic sites, indicating a possible total of about 24 historic sites (h-sites) in the potential PGDP inventory.

$$\frac{3,247 \text{ hectares (8,023 acres)}}{644 \text{ hectares (1,592 acres)}} = 5 \times 4 \text{ h-sites} = \frac{20 \text{ h-sites} + 4 \text{ SRS h-sites}}{24 \text{ h-sites}}$$

Since all 4 of the recorded historic sites in the stratified random sample occurred in the upland loess, predictably the majority of the expected 24 historic sites in the sample universe would occur in upland loess. With zero site occurrence in the lowland alluvial stratified random sample, one can only conclude that historic sites will be less likely there. There is certainly no reason to presume their absence in the lowlands because of their absence in the twenty percent sample. The data from the sample suggest that the expected 24 upland loess historic sites will not be evenly distributed. The CaB stratum can be expected to contain a greater proportion of sites than would be expected in the other 5 loess strata. The size data in the historic sites sample suggest that the Hn loess stratum, although expected to contain fewer sites, will contain sites over 3 times as large as sites from the CaB and Other loess strata.

Historic sites recorded in the sample indicate a range in size from 548 square meters to 2,707 square meters with a mean size of 1,278 square meters. Comparing the size data by inspection does not reveal a significant difference between prehistoric and historic sites. On the other hand, the shovel test data (Volume IV, Part A) clearly indicate that the population of historic sites can be expected to have less depth of deposit than the population of

prehistoric sites. This in turn implies that future studies to evaluate potentially eligible sites in the PGDP should focus more heavily on subsurface examination of prehistoric sites.

4 Sensitivity Mapping

The hypothesis was tested that archaeological sites are evenly distributed in the 12 geomorphic landforms as a function of the relative size of each landform. The Chi-square statistic tests whether the observed frequencies in a distribution differ significantly from the frequencies that might be expected if sites were randomly distributed in each stratum in numbers proportional to the size of each stratum. For further explanation of classic Chi square statistical tests and standard notation for interpreting these tables reader is referred to Siegel (1956). Corresponding to each frequency predicted by the hypothesis of random distribution there will be an observed frequency, denoted by O and an expected frequency denoted E , then

Chi-square is calculated as the sum of terms like $\frac{(O-E)^2}{E}$

Table 7 lists the size of the universe and sample by geomorphic landform (strata), while Table 8 describes the frequency distribution. Table 9 describes the results of the Chi-square test of the prehistoric sites data.

Prehistoric Sites. With 11 degrees of freedom, the Chi-square value is significant at the one percent level. The hypothesis of no difference is rejected. There is insufficient evidence to indicate that prehistoric archaeological site density is the same in all twelve geomorphic landforms. In other words, the results of the test indicate that the probability of encountering prehistoric archaeological sites in the unsurveyed portion of the PGDP is not the same on all landforms. Clearly some landforms are favored over others. There is no reason to think that prehistoric site density is a function of the size of each landform. The degree to which a landform is favored over others serves as a quantitative basis for predicting which particular landforms will probably contain a greater number of prehistoric archaeological sites.

The results of the above Chi-square test are very encouraging. The data suggest that an index of expected site density per landform stratum is possible. There is good reason to think that certain landforms in the eighty percent of the unsurveyed portion of the PGDP can be expected to have a greater number of prehistoric sites that are not simply a function of the size of the particular landform. These "hot" landforms can be contrasted with "cold" landforms on a scale that measures relative likelihood of expected site density.

The index chosen is the value $(O-E)/A$ (see Table 10). The value $O-E$ is divided by A (hectares sampled). This value is used as an index. In other words, the value is calculated as the observed number of sites minus the expected number of sites divided by the size of the landform surveyed. Since there were five sites recorded in the sample, the statistic assumes that these would be evenly distributed in the twelve landforms as a function of the size of each. Thus, expected values are expressed as fractions of sites when calculating a sensitivity index. See Volume IV, Part A for an explanation of the difference between localities without management requirements and sites with cultural resource management requirements. This index of sensitivity gives greatest weight to landforms with a site density greater than expected when controlling for stratum size. Landforms with site density less than expected are weighted less heavily. Landforms without recorded sites (negative values) are weighted less than landforms where sites were recorded (positive values). The least weight in this index is assigned to large landforms where more than 91.5 hectares (226 acres) were surveyed and no sites were recorded (negative values with greatest hectares sampled).

The categories of prehistoric archaeological sensitivity and their numerical values are arranged in decreasing order in Table 10. Figure 8 depicts the PGDP sample universe by recombining (collapsing) the 12 landforms into the 4 categories Very High, High, Low and Very Low Index of Sensitivity or probability of site occurrence. This index is a quantitative expression about the probability that prehistoric site density is a function of the size of each stratum. In other words, the index is a probability statement about how many prehistoric sites can be expected per unit area surveyed. The index is based on the number of prehistoric sites recorded and the size of each stratum. This same index of sensitivity is plotted at larger scale in Appendix D.

On the one hand, Marshes and Floodplains have the highest positive values because the difference between the observed site numbers and expected site numbers $(O-E)/A$ is greatest while controlling for the size of these relatively small landforms. On the other hand, Loess CaA and Loess HN (Very Low Sensitivity) have negative values because no sites were encountered despite being very large strata, where a greater number of sites could be expected if sites were more evenly distributed throughout the PGDP.

Landforms with intermediate indices of sensitivity between these two extremes are more difficult to interpret. Those landforms determined to have Low Sensitivity had no sites recorded in areas that were intermediate in size. High Sensitivity was determined by positive values $(O-E)/A$ that were lower than those for landforms determined to have Very High Sensitivity. In general, the index tells us something about just how unevenly recorded prehistoric sites are distributed in the stratified random sample.

In devising this index, special consideration was given to Terraces and Tributary Alluvium. High Sensitivity was assigned to Terraces even though the data in this model would logically support the conclusion of a lower likelihood of encountering prehistoric sites in the Terrace stratum. One cannot

ignore information from past surveys, even if these surveys were not as rigorously designed and executed. Site occurrence information from previous surveys was taken into consideration when allocating shovel tests in each stratum. Past surveys resulted in the recording of five relatively large prehistoric sites on Terraces. For this reason the sensitivity index for Terraces does not strictly follow the rationale for an index of sensitivity. There is compelling reason for exercising caution should future plans involve actions that may have an adverse effect on cultural resources that can be expected to occur on Terraces.

Special consideration was also given to the landform classified as Tributary Alluvium. Although no sites were found in the stratified random sample, there is still an excellent chance that aggrading soils may have covered sites in the past, making them especially hard to find using the methods and procedures employed during this survey. Even though a higher number of shovel tests were allocated to the Tributary Alluvium stratum, the intensity of that testing is not such that we would want to place too much faith in the conclusion that site density will be low on tributary alluvium in the eighty percent of the unsurveyed facility. In other words, an inadequate intensity of shovel testing in Tributary Alluvium is probably more critical than an inadequacy of shovel testing in Loess strata. Again caution is exercised in conservatively assigning a higher sensitivity to a stratum where information exists about site occurrence, even though that information does not strictly fit the statistical model.

Geomorphic processes in the last 10,000 years are far more favorable for burying and preserving in-tact archaeological resources in Tributary Alluvium than on older Loess landforms. By virtue of the rapidity and extent of aggrading processes, archaeological resources can be expected to be well preserved in more recent Tributary Alluvium yet may not yield a great deal of surface evidence. Conversely, the much older Pleistocene Loess landforms are more likely to display an obtrusive archaeological record on the surface and less likely to have deeply buried and well preserved sites.

Historic Sites. The survey data on historic sites were analyzed separately. The same hypothesis was tested using the Chi-square statistic. Table 11 describes the observed and expected frequencies in each stratum, as well as the size of each stratum in hectares and acres and relative percentages. Table 12 describes the results of the hypothesis testing.

With 11 degrees of freedom, the Chi-square value is insufficient to reject the hypothesis of a difference of means at the five-percent confidence level. The hypothesis of no difference cannot be rejected. There is no strong evidence in our sample to indicate that historic archaeological site density is not a function of the size of that stratum. In other words, there is no clear indication that historic sites tend to concentrate on some landforms and not others. The 4 sites in the stratified random sample occurred only in the largest strata, as might be expected if historic site density were proportional to the size of each stratum. The data are not a strong case for predicting where historic sites are more likely to occur in the eighty percent of the PGDP that has not

been surveyed. Unlike the prehistoric site sample data, the results of this test do not offer encouragement for devising an index of historic site sensitivity.

This is not to say that historic sites at the PGDP are randomly distributed in space. Such patterns may be indicated with a larger, more reliable sample. Working with such small numbers of sites creates difficulty in demonstrating patterns that can be confidently used for sensitivity mapping in view of the geomorphic landform classification used in this research.

5 Summary and Conclusions

Section 106 Compliance

The stratified random sample survey described in Part A and the predictive model based on that survey described in Part B are not meant to be stand-alone events that put the PGDP in complete compliance with section 106 of the National Historic Preservation Act. Parts A and B collectively represent the completion of an important milestone in the ongoing cultural resource management process.

Until specific impacts and specific plans are identified that may have potential for affecting particular areas with cultural resources that may be considered eligible for inclusion in the National Register of Historic Places, this work should be considered primarily as a direct response to requirements contained in section 110 (2) of the National Historic Preservation Act.

“With the advice of the Secretary and in cooperation with the State Historic Preservation Officer for the state involved, each Federal Agency shall establish a program to locate, inventory, and nominate to the Secretary all properties under the agencies ownership or control by the agency, that appear to qualify for inclusion on the National Register in accordance with the regulations promulgated under Section 101 (a) (2) (A). Each Federal Agency shall exercise caution to assure that any such property that might qualify for inclusion is not inadvertently transferred, sold, demolished, substantially altered, or allowed to deteriorate significantly.”

The information contained in Parts A and B are important accomplishments with respect to the above legal requirement but may not be sufficient for complying with section 106 of the same Act. The adequacy of this survey and report will depend ultimately upon forthcoming specific Federal actions. If specific future Federal undertakings are identified that may impact areas not surveyed by this project, i.e. areas where the inventory of cultural resources is still unknown, it may be necessary to conduct new surveys over and above what has been conducted by this project. This project is not meant to put the

PGDP in compliance with all future, yet to be identified Federal Actions requiring section 106 compliance.

“The head of any agency having direct jurisdiction over a proposed Federal or federally assisted undertaking in any State and the head of any Federal department or independent agency having authority to license any undertaking shall, prior to the approval of the expenditure of any Federal funds on the undertaking or prior to the issuance of any license, as the case may be, take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register. The head of any such Federal agency shall afford the Advisory Council on Historic Preservation established under Title II of this Act a reasonable opportunity to comment with regard to such undertaking.”

Special Consideration For the KOW

Before summarizing the results of this survey and predictive modeling effort, a word needs to be said about buildings and structures associated with the old Kentucky Ordnance Works wherever these may be located. These World War II period structures should be inventoried and evaluated separately for possible inclusion in the National Register of Historic places. They were not included in this study for reasons discussed in the methodology section. A special consideration of World War II buildings and structures was well outside the scope of this survey. A separate archival research project is needed that would exploit available documents and historical information as the context for evaluating KOW related structures and buildings. Maps, plans and records essential for this kind of evaluation were not available to the Goemarine and WES team. It is recommended that a special project be programed that is designed to survey and inventory World War II structures and facilities associated with the KOW in order to comply with any future Federal actions that may impact cultural resources associated with the KOW.

SHPO Consultation

It is recommended that Parts A and B be coordinated at the earliest opportunity with the Kentucky State Historic Preservation Officer along with information regarding any specific Federal actions that may be in the early stages of planning, especially if such planned actions may have potential for adverse effects to cultural resources that may be considered eligible or potentially eligible for inclusion in the National Register of Historic Places. The information contained in Parts A and B represents an important management tool for continuing to cope with the Historic Preservation compliance process.

Predictive Model Conclusions

A two-step procedure was undertaken to prepare an archaeological sensitivity map for the PGDP. In step one the Chi-square statistical analysis indicated quite different results for prehistoric and historic archaeological sites. The test indicated that prehistoric site occurrence in sample strata is probably not a function of the size of the stratum. There is not an equal probability of finding sites in all strata. However, no strong evidence for this conclusion could be found for historic site occurrence. Historic sites probably tend to occur throughout the PDGP and appear to lack the stronger patterning displayed in the prehistoric data.

Therefore, step two, constructing a quantitative index of archaeological sensitivity, was undertaken for only prehistoric sites. The index of prehistoric site sensitivity is based on a quantitative expression of the differences between expected and observed site occurrence while controlling for differences in the size of strata sampled. The sensitivity map (Figure 8 and Appendix D) was constructed by combining the twelve geomorphic strata into four categories depicting Very High, High, Low and Very Low probability for site occurrence. The four collapsed site sensitivity categories considered information about site occurrence and geomorphic inferences in addition to the strictly statistical argument based on stratified random sampling procedure.

Finally, the areas of relative archaeological sensitivity are based on a probabilistic argument relying on the best available archaeological sample survey data. For example, should any particular area in the unsurveyed portion of the PGDP, happen to fall into a polygon labeled "Very Low," this does not mean that the area is clear. It also does not mean that future archaeological surveys, as required by Section 106 of the National Historic Preservation Act, will not be necessary, because there are not going to be archaeological resources encountered there. The map is simply a planning tool that informs us about the relative probability of encountering prehistoric resources based on the best available sampling data.

Planners may wish to consider avoiding "Very High" sensitivity areas for undertaking future actions with high potential for impact to cultural resources. Areas classified as "Very Low" may be considered as more cost-effective alternatives when considering the potential expense of survey, inventory and possible mitigation of sites that may be not only large and deep but comparatively densely distributed in areas where projects may be planned. The sensitivity map is the informational basis for predicting where prehistoric archaeological resources are most likely to occur. The relative probability of encountering prehistoric resources increases as one moves through the scale from "Very Low to Very High."

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