Integrated Cultural Resources Management Plan: 2024-2029

White Sands Missile Range, New Mexico

Appendices A to I

December 2024

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Appendix A:

Memorandum of Understanding for the Trinity National Historic Landmark

MEMORANDUM OF UNDERSTANDING
BETWEEN
NEW MEXICO HISTORIC PRESERVATION DIVISION
AND
DEPARTMENT OF THE ARMY WHITE SANDS MISSILE RANGE

WHEREAS, Department of Army, White Sands Missile Range (WSMR) recognizes that its actions, and the actions of its land users, may constitute a potential adverse effect on the Trinity Site National Historic Landmark (Trinity Site); and,

WHEREAS, WSMR recognizes its responsibility to protect and preserve Trinity Site in a manner fully consistent with federal policy, and the terms of National Historic Preservation Act of 1966 (as amended), and 36 CFR 800; and, WHEREAS, WSMR has consulted with the Advisory Council on Historic Preservation (ACHP) and the New Mexico Historic Preservation Officer, and these parties have executed a Programmatic Memorandum of Agreement (PMOA) regarding historic preservation on lands controlled or otherwise affected by the actions of WSMR, its programs, or the programs of the various tenants, clients or other users of its lands or facilities, and

WHEREAS, WSMR has developed a comprehensive Historic Preservation Plan, outlining procedures and policies for the protection and enhancement of the cultural environment under WSMR control;

NOW, therefore, WSMR and the SHPO agree to management of the Trinity Site, as a part of the WSMR Historic Preservation Plan, with the following stipulations, and with the incorporation of this agreement, into the Historic Preservation Plan:

1. All consultations regarding the Trinity Site will be undertaken under the terms of the PMOA, and the ACHP need not be afforded comment except as stipulated therein. However, all consultations, further agreements, plans or other documents developed under this agreement will be furnished to the ACHP for their information.

2. WSMR will develop and maintain an inventory of all post-Trinity test structures, facilities and other land modifications identifying their nature (temporary or permanent), source, disposition (date of removal, restoration, etc.), as well as accompanying maps indicating their locations in relationship to listed historic features of the Trinity Site. An inventory of Trinity historic features shall be prepared identifying all structures, facilities, roads, features, and historic locales associated with the landmark.

3. All future actions under WSMR control within or immediately adjacent to the generally agreed upon boundaries of the Trinity Site which require consideration under a Record of Environmental

Consideration, an Environmental Assessement or an Environmental Impact Statement will be communicated to the SHPO in a timely manner and the SHPO afforded the opportunity to comment prior to the foreclosure of options to avoid, reduce, or otherwise mitigate the adverse effects of those actions, within the comment periods set forth in the PMOA.

4. All future buildings, structures, embankments, etc., within the confines of Trinity Site will be temporary (e.g., manufactured housing, skid buildings) and will be removed after completion of the action requiring their construction, unless written agreement has been reached between WSMR and SHPO to approve their retention, or if the modifications are found to enhance the Trinity Landmark Site.

5. All future actions will be conducted to insure that no irreversible effects or damage will result to the most significant historic features (McDonald Ranch, Ground Zero and associated features).

6. Potential cumulative direct and indirect impacts to the Trinity Site and to its features as listed in the Historic American Engineering Record (HAER) and WSMR inventories will be assessed in consultation with the SHPO at five year intervals.

7. All past and future land modifications which might adversely affect the Trinity Landmark setting will be removed or restored to their original condition by regrading, or other treatments, as necessary.

8. Activities which might constitute any "irreversible or irretrievable" commitment that could result in an adverse effect on "Trinity Landmark Site" or foreclose the consideration of modifications or alternatives to the proposed undertaking that could avoid, mitigate or minimize such adverse effects will not be allowed except as provided in paragraphs 3 and 4.

9. WSMR will establish two land use zones within the Trinity Site:

- The Historic Zone will include the major known structures, features or remains of the Trinity Test, whether specifically listed in the HAER and WSMR inventories or otherwise known, and a buffer zone not less than 400 meters around these features. Lines of sight shall be established between Ground Zero and Observation Points and the McDonald Ranch House which will be 100 meters in width to insure adequate, long term preservation of all historic features. The southern sight line shall be 250 meters in width, but tests and temporary structures within previously disturbed areas shall be permitted. The Historic Zone will be strictly OFF LIMITS for mission activity, construction or modification, except for the use of existing roads and trails with written concurrence of the WSMR Environmental Office.

- A Limited Compatible Land Use (LCLU) Zone will include all those areas not specifically within the Historic Zone, and project use will be allowed, subject to the stipulations of this agreement and the WSMR Historic Preservation Plan. All LCLU land use will be subject to archaeological and historic resources survey and a specific consultation with the SHPO to assess indirect effects on the Trinity Site, including but not limited to the introduction of visible, audible or atmospheric elements that are not out of character with the Trinity Site or alter its general setting.

setting.

THOMAS J.P. JONES — DATE
Major General, U.S. Army
Commanding General

5-3-88

THOMAS W. MERLAN — DATE
State Historic Preservation Officer
New Mexico Historic Preservation Division

Appendix B:

1985 Programmatic Memorandum of Agreement

(WSMR will seek funding for FY 26 to update the 1985 PMOA. This type of funding is authorized by Army funding guidance.)

PROGRAMMATIC MEMORANDUM OF AGREEMENT

AMONG

THE DEPARTMENT OF THE ARMY, WHITE SANDS MISSILE RANGE

THE STATE HISTORIC PRESERVATION OFFICER

THE ADVISORY COUNCIL ON HISTORIC PRESERVATION

WHEREAS, the Department of the Army, White Sands Missile Range (WSMR) has determined that its ongoing mission activities will have an effect upon Properties included in or eligible for inclusion in the National Register of Historic Places and has requested the comments of the Advisory Council on Historic Preservation (Council) pursuant to Section 106 of the National Historic Preservation Act (16 U.S.C.470) and its implementing regulations, "Protection of Historic and Cultural Resources" (36 CFR Part 800),

NOW, THEREFORE, WSMR, the New Mexico State Historic Preservation Officer (SHPO), and the Council agree that the undertaking shall be implemented in accordance with the following stipulations in order to take into account the effects of mission activities on historic properties.

STIPULATIONS

1. White Sands Missile Range will treat Historic Properties according to their significance balanced against other public values and the military mission;

2. WSMR will develop and implement by September 1985 a comprehensive Historic Preservation Plan (HPP) for the WSMR installation, consistent with "A Cultural Resources Overview and Management Plan for the White Sands Missile Range" (1984) (Overview), which

a) integrates historic preservation requirements with the planning, and conducting of military training, testing, construction, other undertakings, and real property or land use decisions;

b) sets up legally acceptable compliance procedures with the Advisory Council on Historic Preservation and the New Mexico Historic Preservation Officer (refer to Stipulation 9, below);

c) sets priorities on the basis of the Overview, for field, analytical, and documentation projects that are designed to develop, evaluate, and manage the inventory of significant historic properties;

d) establishes and implements procedures for identifying and evaluating all National Register eligible properties;

e) ranks installation undertakings by their potential to damage historic properties;

f) provides guidelines for the protection or treatment, including nomination to the National Register, of historic properties;

g) identifies funding, staffing, and milestones.

3. WSMR will implement a cultural and historic Resource Protection Program (RPP) which,

a) places a statistically developed sample of potentially eligible resources "Off Limits" for field training exercises or other diffuse, irregular or indiscriminate disturbing activities;

b) posts individual and highly visible or well known resources, particularly historic structures which may be eligible to the National Register of Historic Places, with appropriate signs to help reduce on going vandalism;

c) develops and implements protection training and enforcement procedures for installation military police and security personnel;

d) monitors Off Limits compliance during field training exercises or other similar activities;

e) evaluates the success of HPP standards and procedures for realistic protection of historic properties;

4. WSMR will design and implement a Public Education Program (PEP) which,

a) communicates the results of cultural resource research and protection to the installation personnel, the scientific profession and the public;

b) educates the installation personnel and residents about the value, nature and vulnerability of historic and cultural resources, and their proper role in resource protection;

c) develops methods for periodic access for the public to visit significant historic properties in a manner which does not conflict or interfere with the military mission;

d) supports and encourages installation and public education in archaeology and history of the installation's cultural resources through lectures, brochures, audio-visual materials and other activities.

5. WSMR will consult with the SHPO to develop and implement a Research Administration Plan (RAP) which;

a) identifies and organizes a Board of Research Advisors, drawn from various cultural and environmental professions and from various local and regional research institutions, to assist WSMR to coordinate cultural, historic and related environmental research with similar efforts at the local, state and regional level;

b) develops a centralized archive to manage the cultural resource and environmental data base, library of publications, study and museum collections, and supporting materials (maps, imagery, etc.) and facilitates efficient access for consultation by authorized personnel and/or research contractors;

c) utilizes outside expertise for joint efforts in basic research to help reduce budgetary costs, eliminate redundancy and duplication of effort, and maintain a high degree of interaction between installation efforts and those taking place in other segments of the scientific and educational community.

6. WSMR will provide to the SHPO the following materials for comment and review, within 30 days;

a) copies of all final survey, excavation and research reports, site forms, technical manuals and other resource documentation, as completed;

b) copies of progress reports at not less often than annual intervals which evaluate the success and degree of completion of the several Plans and Programs described in these stipulations;.

c) draft manuscript of the various Programs, Plans, Procedures and other materials specified in these stipulations to help coordinate their development and implementation, to include, but not limited to:

1. Historic Preservation Plan
2. Resource Protection Program
3. Public Education Program
4. Research Administration Plan

d) WSMR will supply copies of items referred to in b) and c) above to the Council, for comment and review within 45 days.

e) WSMR will also distribute these materials, as appropriate, with deletion of locational information as necessary, to other institutions, the public and to Defense Technical Information Center, for possible inclusion in its and other data base archives.

7. WSMR will require all archaeological contractors to furnish all site records in Archaeological Records Management System (ARMS) format for inclusion in that system, and will continue to participate in, and help support the New Mexico ARMS System developed and maintained by the New Mexico Historic Preservation Division.

8. WSMR and SHPO will establish a separate data sharing agreement*

9. CONSULTATIONS

WSMR will continue to avoid all historic and cultural resources whenever possible.

Where it is not prudent or feasible to avoid any historic or cultural property located in accordance with AR 420-40 and the WSMR HPP which is included in or potentially eligible to the National Register of Historic Places, WSMR will consult with the SHPO and,

a) develop and institute a mutually acceptable data recovery program and/or other measures to mitigate the impact of the proposed action (IAW Stipulation #2 above) and the Advisory Council on Historic Preservation need not

be afforded further opportunity for review and comment.

b) should the SHPO object to all or part of a mitigation plan, or to any of the documents referred to in Stipulation 6, above, WSMR shall consult with the SHPO to remove the objection. Should the consultation fail to result in a mutually agreeable revision, WSMR shall submit its proposed plan or document, together with the SHPO's comments, to the Council. Within 30 days of receipt of complete documentation, the Council's Executive Director will either:

a) refer the matter to the Chairman of the Council pursuant to 36 CFR Part 800.6(b)(7); or

b) provide WSMR with recommendations, which WSMR shall take into account in developing the final mitigation plan or document.

c) If previously unknown historic or cultural properties should be discovered during implementation of any undertaking that would be covered by this agreement, WSMR will cause the undertaking to be delayed until it has the opportunity to consult with the SHPO and has complied with 36 CFR 800.7 of the regulations for the "Protection of Historic and Cultural Resources."

10. LIMITATIONS

a. Each provision of this memorandum is subject to the applicable laws and regulations of the Department of the Army, the State of New Mexico and of the United States.

b. This memorandum may be amended by consent of the Department of the Army, White Sands Missile Range, the New Mexico State Historic Preservation Officer and the Advisory Council on Historic Preservation.

c. This memorandum shall become effective as soon as signed by the parties hereto and shall continue in force unless formally terminated by the Department of the Army, White Sands Missile Range, the New Mexico State Historic Preservation Officer or the Council on Historic Preservation, after thirty (30) days written notice to the other parties.

Execution of this Memorandum of Agreement evidences that the Department of the Army, White Sands Missile Range, has afforded the Advisory Council on Historic Preservation a reasonable opportunity to comment on Range activities and their effects on historic properties and that the Department of the Army, White Sands Missile Range, has taken into account the effects of its activities on historic properties.

Niles J. Fulwyler 7 Mar 85
NILES J. FULWYLER date
Major General, USA
Commanding

2-22-85
THOMAS W. MERLAN date
Historic Preservation Officer
New Mexico Historic
Preservation Division

25 Mar 85
HENRY J. HATCH date
Major General, USA
Assistant Chief of Engineers

John M Fowler 4/10/85
for ROBERT R. GARVEY date
Executive Director
Advisory Council on
Historic Preservation

Alexander Aldrich 4/18/85
ALEXANDER ALDRICH date
Chairman, Advisory Council
on Historic Preservation

Appendix C:

WSMR ARPA Permit

FOR OFFICIAL USE ONLY
Date received:
Date approved:

United States Army-White Sands Missile Range

Application for a Federal Permit under
THE ARCHAEOLOGICAL RESOURCES PROTECTION ACT
Approved October 31, 1979
Public Law 9696 (93 Stat. 721; 16 USC 470aa470MM; 32 CFR 229)
or
THE ANTIQUITIES ACT
Approved June 8, 1906
Public Law 59-209 (34 Stat 225; USC 431-433; 43 CFR 3)

Instructions: Complete form and submit two copies to the White Sands Missile Range (WSMR) Directorate of Public Works-Environment (DPW-E). All information requested must be completed before the application can be processed. Use additional sheets of paper if more space is needed to complete the form.

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1. Name of Institution or company:

2. Address:

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3. Permit type: (check appropriate box)

☐ a. Surveys and limited testing or limited collections on WSMR lands (Army Fee-Owned)

☐ b. Excavation, intensive testing, major collections of specific sites on WSMR lands (Army Fee-Owned)

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4. Specific areas and/or sites for which the permit is requested: (include state and WSMR site numbers (if applicable), specific training areas, USGS quad names and legal descriptions for the study area. Maps may be attached)

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5. Nature and extent of proposed work, including purpose and methodology:

6. Include name, address, and institutional affiliation for persons in “a” and “b” below. Applicants must attach evidence of qualifications (vitae or resume) and meet the qualifications outlined in the Uniform Regulations:

a. Individual(s) proposed to be directly responsible for conducting the work in the field:

b. Individual(s) proposed to be responsible for carrying out the terms and conditions of this permit (in "general charge" of the project if different from "a" above):

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7. Proposed date field work will begin:

8. Proposed date for end of field work:

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9. Curation: All applicants for ARPA permits on White Sands Missile Range (WSMR) must agree to curate all materials at the Fort Bliss Curatorial Facility, following the specifications outlined in the current WSMR Curation SOP. All archaeological and paleontological materials removed from WSMR lands are the property of the US government.

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10. Proposed outlet and or method of public written dissemination of the results (Note: applicant must agree to provide final copies of all results, reports, articles, etc. to the WSMR Directorate of Public Works-Environment (DPW-E). WSMR DPW-E must have an opportunity to review and comment on all drafts before publication)

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11. Evidence of applicant's ability to initiate, conduct and complete the proposed activity including evidence of logistical support, equipment and laboratory facilities:

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12. Signature of individual in general charge (item 6b above) ______________________

13. Date of application: ________________________________

14. Signature of Garrison Commander or designated CRM: ____________________________

15. Date of approval: ________________________________

Appendix D:

WSMR Paleontological Resource Management Plan

White Sands Missile Range
Paleontological Resource Management Plan

Kate E. Zeigler, Zeigler Geologic Consulting, LL

Executive Summary

This document serves to review the general geology and previously documented paleontological resources of the White Sands Missile Range (WSMR) area, as well as provide an overview of federal policies that have been developed to protect fossil resources on public lands. WSMR is not public land, but these policies can be used to developed an informed standardized protocol for management of paleontological resources on WSMR. Thus, this document includes a review of the Bureau of Land Management's (BLM) classification system and the management and mitigation strategies the BLM has implemented. Numerous fossil resources have been documented within WSMR boundaries, as well as in the surrounding area. The goal of this Paleontological Resource Management Plan (PRMP) is to develop a standard protocol for management and mitigation of fossil resources on WSMR.

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Introduction

White Sands Missile Range (WSMR) spans approximately 2.2 million acres (3437.5 square miles) of the central and western Tularosa Basin in south-central New Mexico. The WSMR boundaries encompass a wide variety of geologic units with varying potential to produce fossil material. For example, the Pleistocene shoreline deposits in the center of the Basin have produced a wealth of scientifically significant vertebrate fossil material as well as fossil trackways. Due to the presence of known fossil resources within WSMR's boundaries, it is important to develop a standard protocol for the management and mitigation of these important resources. This document will review the geology and paleontological resources of the WSMR area and provide background on federal policies that can be used to develop a Paleontological Resources Management Plan (PRMP) for WSMR.

Geologic Background

WSMR is located in the Tularosa Basin, west of Alamogordo, and is bounded on the west by the San Andres, Oscura, and Organ Mountains. To the east, the Basin is bounded by the Sacramento Mountains (Figure 1). The Tularosa Basin is a deep basin between the Organ, San Andres, and Oscura Mountains to the west and the Sacramento Mountains and Sierra Blanca to the east. This basin formed as part of Basin and Range crustal extension which began approximately 30 million years ago. The Tularosa Basin consists of two deep half-grabens separated by the Jarilla Fault and the western half-graben contains the thickest amount of basin fill (Lozinsky and Bauer 1991). The San Andres Mountains, a west-tilted fault block between the Tularosa Basin and the modern Rio Grande valley, are comprised primarily of Precambrian crystalline rocks, Paleozoic sedimentary rocks and minor upper Mesozoic strata. Sedimentary rocks in the San Andres Mountains represent Cambrian through Permian time, some Late Triassic, both Early and Late Cretaceous and minor Tertiary time (Kottlowski et al. 1956; Kottlowski 1963; Sorauf 1984; Mack et al. 1989; Raatz 2002) (Figure 2). The majority of the rocks are limestone, with lesser sandstone, conglomerate, shale, and evaporite deposits.

Descriptions of the individual stratigraphic units described below come primarily from Kottlowski et al. (1956), Kottlowski (1963), Souraf (1984), Mack et al. (1998) and Raatz (2002). Cambrian-Ordovician strata exposed in the uplifts on either side of the Basin include the Bliss Sandstone and El Paso Formation. The Late Cambrian-Early Ordovician Bliss Sandstone forms a reddish brown ledge along mountain fronts, directly over the Precambrian granite. This ledge is composed of sandstone with lesser siltstone, limestone and dolomite and represents deposition along a shoreline transitioning to shallow marine as the region was slowly flooded by ocean waters. The El Paso Formation, which is predominantly fossiliferous limestone and laminated dolomite deposits representing shallow marine environments. The Middle-Late Ordovician Montoya Formation consists of fossiliferous limestone and dolomite with a basal pebbly sandstone and some siltstone beds. The Montoya Formation was deposited in an open-marine setting as the Paleozoic sea level transgression continued.

The Fusselman Formation is Silurian in age and forms an extensive ledge of dark gray dolomite with some fossils still preserved in spite of the pervasive dolomitization. The Devonian Oñate, Sly Gap, Contadero and Percha Formations comprise a mixture of calcareous shale, siltstone and minor limestone. Mack et al. (1998) do not recognize the Percha Formation in this part of southern New Mexico, although Kottlowski et al. (1956) described these strata as being present in the San Andres Mountains and Raatz (2002) indicates that the Percha Formation to the south is correlative with the Oñate, Sly Gap and Contadero Formations in the San Andres Mountains. The Oñate, Sly Gap and Contadero Formations represent shelf deposits that grade southward into the basin deposits of the Percha Formation, a dark shale representing anoxic conditions in a deeper basin setting than its northern counterparts. The Sly Gap Formation does represent a small regressive event when the shoreline briefly retreated southward before the area returned to marine depositional conditions. The Mississippian Caballero Formation consists of calcareous shale and fossiliferous limestone present in the San Andres and Sacramento Mountains, but not to the north or south. The Lake Valley Formation includes limestone with minor shale and siltstone in a sequence divided into six members that collectively represent a complex history of growth of algal mounds with their associated faunas.

Overlying the Lake Valley Formation is the Pennsylvanian Lead Camp Formation, a relatively thick sequence of limestones that represent deltaic deposits related to material shedding off of newly risen mountain blocks of the Ancestral Rocky Mountains. The Panther Seep Formation includes shale, limestone, sandstone and local horizons of gypsum and represents deposition in a cyclic environment ranging from flooding by seawater to aerial exposure.

The Permian strata in the mountain blocks include the Bursum, Hueco, Abo, Yeso, Glorieta and San Andres Formations. Early Permian deposition ranges from terrestrial to the north to marine to the south. The Bursum and lower Hueco Formations are comprised of limestone with some shale and siltstone horizons and are laterally equivalent. The Abo is primarily dark red shale, siltstone and sandstone representing terrestrial deposition, including fluvial and sabkha environments, and is laterally equivalent to the upper Hueco Formation, which is dominantly marine deposition. The Yeso is comprised of red and orange sandstone, gypsum, siltstone and limestone, continuing to represent a complex landscape of terrestrial deposition with some marine deposition. The San Andres Formation is almost entirely limestone and represents a return to marine depositional conditions in the mid-Permian.

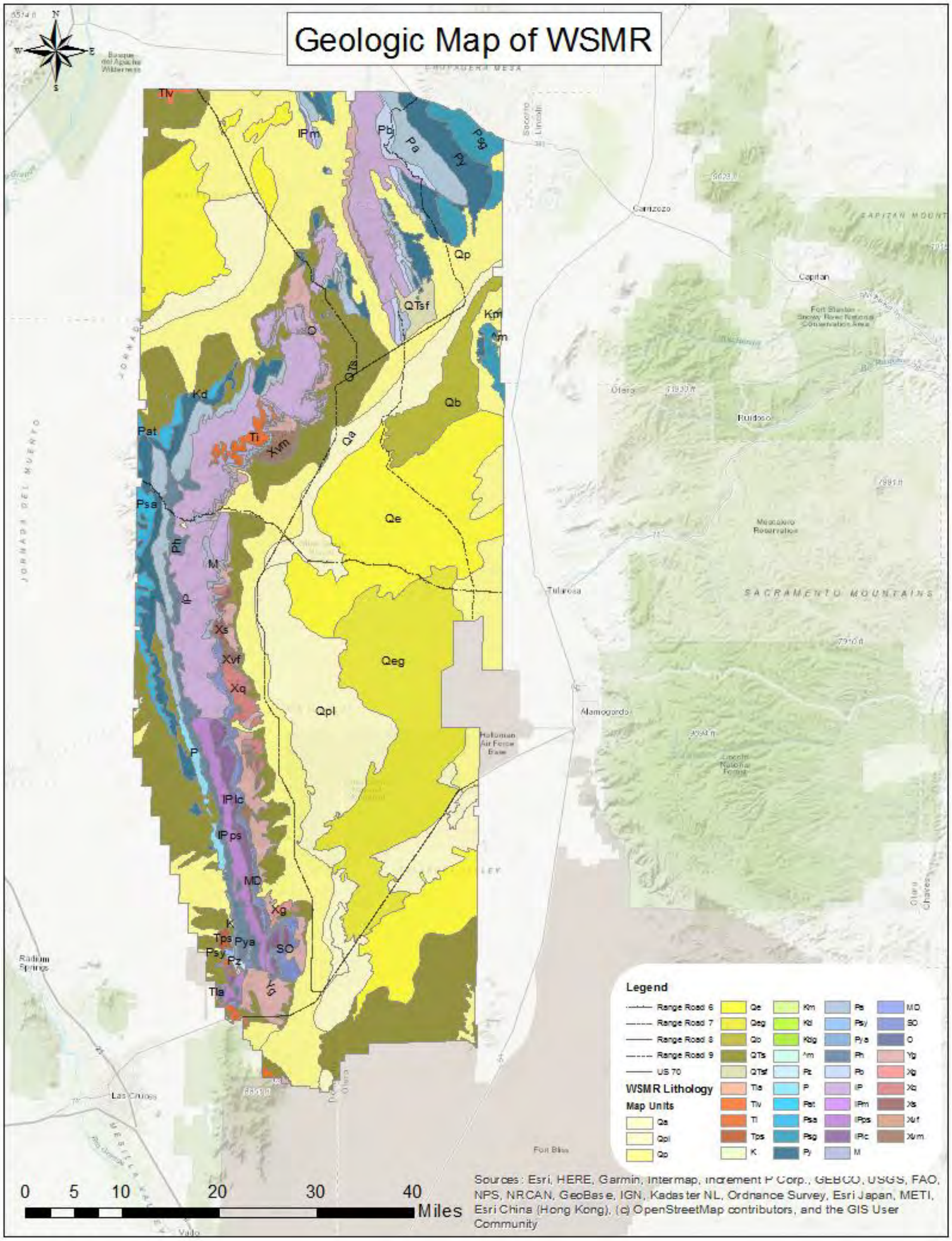

Figure 1. Geologic Map of WSMR

Geologic Age	Stratigraphic Unit	Fossils Observed	Avg. Thickness
Pleistocene	Otero Fm.	Megafauna and microvertebrates, trackways	~0-10 m
Eocene	Love Ranch Fm.		600 m
Paleocene	McRae Fm.		
Cretaceous	Crevasse Canyon Fm.	Bivalves	
	Gallup Sandst.	Bivalves	80 m
	Mancos Shale	Bivalves, ammonoids	200 m
	Dakota Gp.		55 m
	Sarten Sandst.		30 m
Triassic	Moenkopi Fm.	(Elsewhere vertebrates, incl. reptiles)	45 m
Permian	San Andres Fm.	Foraminifera, fusulinids, brachiopods, gastropods, nautiloids	120 m
	Yeso Fm.		300 m
	Hueco/Abo Fm.	Algae, foraminifera, bryozoans, rugose corals, brachiopods, bivalves, gastropods. Abo: plants, tetrapod and insect trackways	300 m
	Hueco /Bursum Fm.	Algae, fusulinids, foraminifera, ostracods, bryozoans, brachiopods, bivalves, gastropods, scaphopods, ammonoids, trilobites, crinoids	70 m
Pennsylvanian	Panther Seep Fm.	Algae, foraminifera, fusulinids, ostracods, brachiopods, crinoids	70 m
	Lead Camp Fm.		300 m
Mississ.	Lake Valley Fm.	Bryozoans, crinoids, reef mounds	125 m
	Caballero Fm.		20 m
Devonian	Contadero Fm.	Brachiopods	30 m
	Sly Gap	Stromatoporoids, corals, brachiopods, gastropods, ammonoids, crinoids	20 m
	Onate Fm.	Brachiopods, bryozoans	25 m
Silurian	Fusselman Fm.	Stromatolites, brachiopods, corals, crinoids	100 m
Ordovician	Montoya Fm.	Algae, brachiopod, corals, trilobites, gastropods, crinoids	130 m
	El Paso Fm.	Sponges, algae, brachiopods, corals, trilobites, gastropods, nautiloids, echinoderms	130 m
Cambrian	Bliss Ss.	Conodonts, brachiopods, trilobites, gastropods	40 m

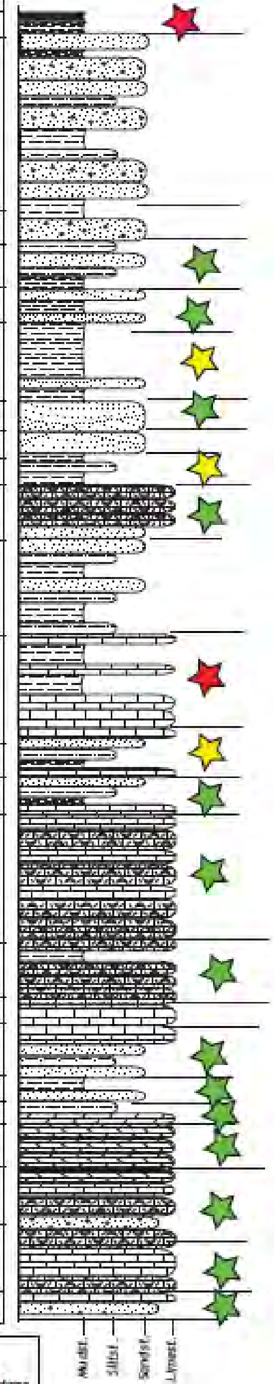

Figure 2. Stratigraphy Present in the WSMR Area and the Potential Fossil Yield Classification Score of Each Stratigraphic Unit.

Mesozoic strata preserved in the San Andres Mountains include possible outcrops of the Triassic Dockum Group in addition to the Cretaceous Sarten Sandstone, Dakota Sandstone, Mancos Shale, Gallup Sandstone and Crevasse Canyon Sandstone. Kottlowski et al. (1956) noted the possible presence of Dockum Group strata, which they described as red-brown calcareous shales with claystone and siltstone depositing in an entirely terrestrial environment. Raatz (2002) suggests these redbeds may be the Middle Triassic Moenkopi Formation, although there is no age control for this unit. The Lower Cretaceous Sarten Sandstone consists of shale and thin, brown sandstone units with a basal chert pebble conglomerate representing offshore deposition as the Cretaceous Interior Seaway began its incursion into North America. The Dakota Sandstone is comprised of a quartz arenite, that is pebbly and is interbedded with gray shales, representing the continued transgression of the Seaway. The Late Cretaceous Mancos Shale includes the Rio Salado Tongue, Tres Hermanos Formation and D Cross Tongue. The Rio Salado and D Cross Tongues are gray shales and the Tres Hermanos Formation includes a marine sandstone (the Atarque Member), interbedded sandstones and mudstones (the Carthage Member) and an upper marine sandstone (the Fite Ranch Member) (Hook 1983; Mack et al. 1998).

Above the Mancos Shale are the Gallup and Crevasse Canyon Sandstones. The Gallup Sandstone is primarily marine sandstone that is locally fossiliferous. The Crevasse Canyon Sandstone represents fluvial deposition and includes horizons of sandstone, shale and pebble conglomerates representing a brief regression of the Cretaceous Interior Seaway. Younger Cretaceous strata are missing from the area. The youngest strata preserved in the San Andres Mountains are the McRae Formation (possibly Paleocene) and the Love Ranch Formation, which is Eocene in age and is comprised of conglomerate, arkose, mudstone and gypsum and represents a return to terrestrial environments of deposition.

In the southeastern quadrant of the Range are the Jarilla Mountains, a small range of hills about 25 square miles in extent, with exposures of Pennsylvanian and Permian sedimentary rocks that are locally intruded by mid-Tertiary igneous rocks that are intermediate in composition (Schmidt and Craddock 1964; Warren 1988). These mountains are a localized, intrabasinal high of bedrock along the western margin of the eastern half-graben in the Tularosa Basin (Lozinsky and Bauer 1991). The intrusions caused contact metamorphism with these sedimentary strata that resulted in local accumulations of metallic and nonmetallic ores, including copper, silver, gold, lead, iron, malachite, chrysocolla, turquoise, chalcopyrite, pyrite and garnet (Schmidt and Craddock 1964), which were mined extensively in the late nineteenth century. Twin Buttes and Twin Buttes South are small, isolated outcrops of Permian sedimentary rocks and Tertiary intrusives, respectively. Twin Buttes outcrops include Hueco Group and Yeso Formation strata.

At the far northern end of the Tularosa Basin are a variety of young igneous rocks and igneous complexes that provide potential source areas for silicic and mafic igneous materials identified in this initial study. The Carrizozo lava flow is among the youngest in the United States and is comprised of three individual flows of subalkaline olivine basalt flows that come from features along the Capitan lineament (McLemore 1991). These flows are extensive, covering 204 km^2, and are approximately 5,000 years old (Salyards 1991; Dunbar 1999).

The heart of the central Tularosa Basin is dominated by Lake Lucero and an intricate set of inset shorelines that range from modern to Pliocene in depositional age. The ancestral playa, which was much larger in extent, is referred to as Lake Otero and deposits related to Late Otero are referred to as the Otero Formation (Herrick 1904; Lucas and Hawley 2002). Gypsum remobilized from evaporitic facies in the Yeso and San Andres Formations provides the material to create the white sand dunes for which the area is named. To the south of the white sands dune field is a large area dominated by quartzose coppice dunes heavily vegetated with mesquite.

Known Paleontological Resources

A number of localities containing paleontological resources have been documented on or near the WSMR area, and range from Pennsylvanian invertebrates to Pleistocene vertebrates. The Pennsylvanian age Panther Seep Formation has produced phylloid algae and foraminifer from the northern San Andres Mountains in Hembrillo Canyon (Kottlowski et al. 1956; Kues 2002b; Soreghan and Giles 1999a, 1999b; Soreghan et al. 2000; Doherty et al. 2002; Seals et al. 2002) as well as algal stromatolites, fusulinids, ostracods, brachiopods and crinoids from the Jarilla Mountains (Lucas and Krainer 2002). The Atrasado Formation (Pennsylvanian) has produced phylloid algae, foraminifera, ostracods, byrozoans, brachiopods, bilvaves, gastropods and echinoderms from exposures in the Oscura Mountains (Lucas et al. 2002a). The Bursum Formation (Permian) has produced algae, fusulinids, foraminifera, ostracods, bryozoans, brachiopods, bivalves, gastropods, scaphopods, ammonoids, trilobites and crinoids, also from Oscura Mountain exposures (Lucas et al. 2002; Kues 2002a). The Permian Hueco Group has produced phylloid algae, foraminifera, fusulinids, bryozoans, rugose corals, brachiopods, bivalves and gastropods from the Jarilla and southern San Andres Mountains (Lucas and Krainer 2002; Lucas et al. 2002b). The uppermost Hueco Group and overlying Abo Formation have produced plant fossils pertaining to *Walchia* as well as numerous tetrapod footprints and trackways (Lucas et al. 2002b). The Pleistocene deposits around the margins of Lake Otero have produced the most prominent vertebrate fossil material, including aquatic frogs, snakes, lizards, small birds, squirrel, vole, muskrat, mouse, rabbit, horse, camel and mammoth, as well as footprints related to mammoths, camels and sloths (Morgan and Lucas 2002, 2005; Lucas et al. 2002c). In addition, the remains of a juvenile mastodon were discovered in 2015 (Zeigler et al. 2019, unpublished report).

Paleontological Resource Management

Paleontological resources (fossils) include the skeletal remains and/or traces of previously living organisms as preserved in sediments and older sedimentary rocks. Fossilized material may include mineralized or partially mineralized skeletal elements such as bones and teeth, in addition to soft tissue, shells, wood, impressions of leaves and other plant-related parts, footprints, burrows, and/or microscopic elements of once living organisms. Paleontological resources not only include the fossils themselves but also their context: the associated rocks, sediments, and/or organic matter that host them inform our understanding of paleoenvironmental conditions.

Federal guidelines define a significant paleontological resource as fossil remains that are of scientific interest. This applies to most vertebrate fossil remains, fossil trackways and trace fossils, and rare or unusual invertebrate or plant fossils. Vertebrate fossils include direct remains such as bones, scales, and osteoderms (“scutes”), as well as trace fossils such as skin impressions, burrows, footprints and trackways, tail drag marks, coprolites (fossilized feces), gastroliths (“stomach stones”), and any other physical evidence of past vertebrate life or activities.

A paleontological resource has scientific importance if it meets one or more of the following criteria:

- Is of a rare or previously unknown species;
- Is of high quality and/or well preserved;
- Preserves a previously undocumented anatomical characteristic or other feature;
- Provides new information relevant to the history of life on Earth; and
- Has identifiable educational and/or recreational value.

A paleontological resource does not have scientific importance if it meets one or more of the following criteria:

- Lacks appropriate geologic provenance or context;
- Lacks physical integrity due to decay and/or natural erosion;
- Is overly redundant (e.g., abundant in the geologic record); and
- Is otherwise not of value for scientific research.

Given that the fossil record is the only evidence of life on earth for the last 3.6 billion years, fossils are considered a non-renewable resource. Because fossil resources are considered to be a non-renewable resource, they are protected across the United States by various federal laws, ordinances, regulations and standards (LORS, Table 1). In 1995, the Society of Vertebrate Paleontology established professional procedures for assessment and mitigation of potential adverse impacts to paleontological resources; these procedures were revised in 2010 (Society of Vertebrate Paleontology 1995; Society of Vertebrate Paleontology, Impact Mitigation Guidelines Revision Committee 2010). In early 2019, Murphey et al. (2019) published standardized procedures for professional paleontologists that built on the Society of Vertebrate Paleontology’s original documents.

In addition, federal and state LORS require that scientifically significant paleontological resources on public lands be managed and preserved. Currently, the state of New Mexico does not have LORS directly applicable to paleontological resources. While the WSMR area is not public lands, these principles may be applied to paleontological resources within the boundaries of WSMR in order to develop and maintain and appropriate PRMP.

Table 1. Federal LORS Affecting Paleontological Resources on Public Land.

LORS Level	Title	Website
Federal	National Environmental Policy Act	https://www.epa.gov/nepa
Federal	Paleontological Resources Preservation Act	http://vertpaleo.org/The-Society/Advocacy/Paleontological-Resources-Preservation-Act.aspx
Federal	Federal Land Policy and Management Act	https://www.blm.gov/or/regulations/files/FLPMA.pdf

Federal Level Regulations

The National Environmental Policy Act (NEPA) of 1969 recognizes the responsibility of the federal government to "preserve important historic, cultural, and natural aspects of our national heritage …", effectively meaning the processes inherent in NEPA are used to develop informed decisions with regards to a wide variety of environmental issues. Under NEPA, the federal agency is required to 1) consider the environmental impacts of proposed actions on federal land; 2) inform the public of the potential environmental impacts of proposed actions; and 3) involve the public in planning and analysis that is relevant to any actions that will impact the environment on federal land, among other actions. Paleontological resources fall under the "natural aspects" component of NEPA.

The Federal Land Policy and Management Act (FLPMA) was implemented in 1976 with the broad purpose of establishing public land policy and guidelines for the administration thereof, as well as to provide for management, protection, development and enhancement of public lands. While FLPMA does not identify fossil resources as a specific resource to be managed, it does require that public lands be managed in such a way that will "… protect the quality of scientific, scenic, historical, ecological, environmental, … and archaeological values …". Thus, FLPMA is nonprescriptive but can be used to manage and protect fossil resources through inventorying of specific areas and developing protective designations, such as the Fossil Forest within the larger Bisti/De-Na-Zin Wilderness Area managed by the BLM Farmington Field Office.

The Paleontological Resources Preservation Act (PRPA) was enacted in March 2009 and dictates that the Secretary of the Interior and/or Secretary of Agriculture "…shall manage and protect paleontological resources on Federal land using scientific principles and expertise." This Act requires the development of agency-appropriate plans to inventory and monitor for paleontological resources on lands administered by the Bureau of Land Management (BLM) and/or U.S. Forest Service (USFS) as well as coordination among agencies to protect these resources. It prohibits the collection of paleontological resources from federal land without a permit from the appropriate agency but, casual collecting of fossil resources is permitted under certain conditions without a permit. PRPA also lays out guidelines for the issuance of permits to collect scientifically significant fossil resources, along with defining prohibited acts, and the resulting civil and criminal penalties for illegal collecting. It also acts to ensure proper curation and confidentiality of paleontological localities.

Paleontological Resource Assessment Criteria

The BLM has developed a Potential Fossil Yield Classification (PFYC) system (2009, 2016) to evaluate the potential for significant fossil resources to be located in an area. Occurrences of paleontological resources are closely tied to the geologic units (i.e., formations, members, or beds) that contain them. The probability for finding paleontological resources can be broadly predicted from the geologic units present at or near the surface. For that reason, geologic mapping can be used for assessing the potential for the occurrence of paleontological resources.

The PFYC system classifies geologic units based on the relative abundance of vertebrate fossils or scientifically significant invertebrate or plant fossils, and their sensitivity to adverse impacts. For this system, a higher-class number (1-5) indicates a higher potential for significant fossil presence and/or adverse impact. This classification is applied to the geologic formation, member, or other distinguishable unit, preferably at the most detailed map level. The relative abundance of significant localities is intended to be the major determinant for the class assignment.

The PFYC system is meant to provide baseline guidance for predicting, assessing, and mitigating paleontological resources, if encountered. The PFYC system is considered an initial point in the prediction analysis and should be used in conjunction with geologic maps of the area and searches of paleontological resource locality databases to assist in determining the need for site-specific assessment or further mitigation actions. As discussed below, the potential for paleontological resources in and around Lordsburg Playa is effectively unknown, but based on results of the PFYC analysis, including review of geologic mapping and known localities, the probability for fossil material within the project area is relatively low. The following descriptions in Table 2 are taken from BLM IM 2016-124 (BLM 2016).

Table 2. PFYC Categories, Characteristics of the Geologic Units and Examples Thereof, and Mitigation/Management Strategies to be Applied.

PFYC	Geologic Unit Characteristics	Example Geologic Units	Mitigation and Management Strategies
Class 1 – Very Low	Geologic units are not likely to contain recognizable paleontological resources.	Igneous or metamorphic, excluding air-fall and/or reworked volcanic ash units. Precambrian age units.	Generally negligible or not applicable. May be very rare circumstances where an unanticipated occurrence is documented (e.g. map unit includes a previously unmapped fossiliferous unit inset within it). No further analysis is needed, but an UDP should be implemented.
Class 2 – Low	Geologic units are not likely to contain paleontological resources.	Units younger than 10,000 years before present, recent eolian deposits, diagenetically altered deposits that exhibit physical or chemical changes that make fossil preservation unlikely. Also includes areas that have been surveyed to verify that fossil resources are not present or very rare.	Generally minimal except where paleontological resources have been documented. Mitigation applied only where resources have been documented and on a case-by-case basis. No further analysis unless resources have been documented. UDP should be implemented.

PFYC	Geologic Unit Characteristics	Example Geologic Units	Mitigation and Management Strategies
Class 3 - Moderate	Sedimentary geologic units where fossil resources vary in significance, abundance and/or predictable occurrence.	Marine units with sporadic occurrences of fossil resources, units where resources occur but abundance is documented to be low, units where significant resources have been documented, but they are widely scattered. Also includes areas where the potential land use impact on fossil resources will be low to moderate.	Generally moderate and may include more extensive literature/database reviews, pre-project pedestrian surveys, on-site monitoring, area avoidance and other strategies. Mitigation will be based on the type of land use activity, including extent of disturbance. May require assessment by a qualified paleontologist to identify potential of fossil resources.
Class 4 – High	Sedimentary geologic units known to include a high occurrence of paleontological resources.	Units documented to contain significant fossil resources (may vary in occurrence), areas with documented rare or uncommon fossils (e.g., soft body preservation, unusual plant fossils). Also includes land use activities that will adversely affect paleontological resources, or areas known to have been subject to illegal collecting activities.	Significant strategies will be utilized, including in-field assessment by a qualified paleontologist. Requires a detailed literature/database review. Mitigation will take into account concerns regarding removal of or penetration of potentially protective soils/alluvial deposits, concerns for increased erosion due to ground disturbance and/or an increase in potential for looting due to exposure of fossiliferous units.
Class 5 – Very High	Sedimentary geologic units known to consistently and predictably produce significant fossil resources.	Units where significant fossil resources have been consistently documented with some predictability. Also includes resources that are highly susceptible to adverse impacts due to land use activities, and units that are frequently the focus of illegal collecting activities.	High level of management and mitigation will be required. In-depth database/literature reviews, in-field assessment and on-site monitoring during ground-disturbing activities are required. Other strategies include avoidance of fossil resources, establishing special management areas and/or strictly controlled access to preserve resources.
Class U – Unknown	Geologic units that have not been given an informed PFYC assignment.	Units for which there is little knowledge of potential preservation of fossil material. Units that are mapped as having potential based on their lithology and age, but have not been studied in detail. Units with little to no documentation in the literature that indicates the existence or type of fossil resources, or units for which reported occurrences are anecdotal. Includes areas where geologic units are poorly studied and have not been assessed.	Due to the unknown nature of fossil resources, management will be of a higher degree. Field survey would be required in order to assess potential for fossil resources.
* UDP = Unanticipated Discoveries Plan. Initial analysis step for all categories is a review of geologic maps and literature for the area.			

BLM Paleontological Resource Management Planning: An Example

As an example of how paleontological resource management is implemented for projects taking place on federal land, the BLM's protocol is described here. The BLM has developed a series of documents relating to the management of fossil resources (2007, 2016), including Manual H-8270 (Paleontological Resource Management) and Handbook H-8270-1 (General Procedural Guidance for Paleontological Resource Management), as well as BLM IM 2008-009, which defines the PFYC system. These were superseded by IM 2009-011(Assessment and Mitigation of Potential Impacts to Paleontological Resources) with Attachment 1-1 (Guidelines for Assessment and Mitigation of Potential Impacts to Paleontological Resources which includes the Paleontological Resource Assessment Flowchart.

In these guidance documents, determining the degree of management for paleontological resource management on BLM land is based on results of the PFYC system, including a review of geologic maps of the area, as well as literature and database reviews. It also takes into account the degree of proposed surface disturbance during a proposed project. IM 2009-11 defines "surface disturbance" as "disruption of the ground surface and subsurface." This disruption may damage or destroy paleontological resources as well as their geologic context and includes a wide range of activities including (but not limited to) grubbing, grading, ditching, some mechanized treatment of vegetation, and/or recreational activities.

In general, the approach for any project involving ground disturbing activities on BLM-owned or administered lands requires an initial PFYC analysis of the proposed project area and a buffer zone to determine the potential for paleontological resources. If the project area is determined to hold high potential for scientifically significant fossils or is classified as having unknown potential, the project proponent is then usually required to proceed with pedestrian survey by a qualified paleontologist of the portion(s) of the project area determined to have high potential. A qualified paleontologist is an individual holding a state BLM paleontological resource use permit. If the survey results in no discoveries of new fossil localities, there may still be a requirement for on-site monitoring during ground-disturbing activities (either continuous or spot monitoring).

WSRM PRMP

For the WSMR area, there are multiple known, documented fossil localities, with a high proportion of these including invertebrate faunas from the Paleozoic sequences in the San Andres and southern Oscura Mountains. The majority of these invertebrate faunas represent common (e.g. redundant) taxa and may not be considered to be a high priority in terms of protection of these resources. The most significant paleontological resources discovered on WSMR to date come from the Pleistocene Otero Formation and constitute a critical component of our understanding of Ice Age faunas in southern New Mexico. In addition, these fossil resources are the most likely to be impacted by ground-disturbing activities on the missile range. Thus, a paleontological resource management protocol would be most critical for these resources, but should include all potential fossil localities encompassed by WSMR's boundaries.

An example of potential management strategies for the Otero Formation could include a detailed review of databases and literature to ascertain the full nature and location of all vertebrate material collected from the formation on WSMR, a pedestrian survey of Otero Formation outcrops and documentation of all localities (including vertebrate skeletal material and trackways), and mitigation of any localities deemed critical from a scientific standpoint. Management strategies for unanticipated discoveries of paleontological resources should also be addressed in the PRMP. The following sections outline how the PRMP may be implemented on WSMR.

Pre-activity Site Review

Any area that contains PFYC Class 3-5 and U geologic units may trigger formal analysis in preparation of various land use activities, depending upon the degree of ground disturbance caused by these activities. Formal analysis may include a record search of previous paleontological studies in the area and/or pedestrian survey prior to land use activities. In-field pedestrian survey of an area designated for land use activities that have the potential to have adverse impacts on fossil resources should be performed by a qualified paleontologist. The results of this pedestrian survey will be provided to WSMR in formal report following the completion of the survey. If a qualified paleontologist will not be present during land use activities that include ground disturbance, it is recommended that personnel be provided appropriate training concerning the nature of fossil resources and the appropriate procedures to be followed in the event of the discovery of unanticipated paleontological resources. This training will also emphasize the sensitive nature of fossil resources and implement a strict policy prohibiting the collection of any paleontological resources.

Unanticipated Discovery of Paleontological Resources

A qualified paleontologist will be on call to examine potential fossil discoveries during implementation of ground disturbing activities that will take place in areas with a moderate to high potential for producing fossil resources. If unanticipated paleontological resources are discovered during ground disturbance, all activity will immediately cease within 200 feet in all directions of the discovery. The discovery will be immediately reported to the appropriate WSMR personnel and the paleontologist. The paleontologist will examine and record the discovery and evaluate the significance of the material to determine if mitigation in the form of collection and curation is applicable. All ground-disturbing activities within 200 feet of the discovery will not resume until the paleontologist and appropriate personnel have agreed that activities may resume. Agencies involved in the decision may inform the paleontologist of the decision to resume construction by telephone with follow-up documentation by mail or email. Agency contacts are listed at the end of this plan.

A full-time monitor may be required until it is determined that the likelihood of another discovery is negligible. Paleontological monitoring will consist of one of two methods for the duration of the ground disturbing activities throughout the area surrounding the discovery: spot checks and/or continuous monitoring.

Spot Checks: During spot checking of the disturbance, a qualified paleontologist will visually inspect specific locations after ground disturbance in areas near identified paleontological resources. Spot checks are conducted for efficiency so that large stretches of activity may be inspected at one time in areas where a full-time presence of a paleontological monitor may not be warranted. If further scientifically significant resources are identified during spot checking, a full-time monitor will be utilized for the remaining ground disturbing activity in the area. The paleontologist working with WSMR personnel will have the authority to adjust spot checking and/or continuous monitoring as warranted by the situation and any potential discoveries of fossil material.

Continuous Monitoring: Continuous monitoring of the area subject to ground disturbing activities would be conducted where these activities have encountered scientifically significant paleontological resources beyond the original discovery. There is always the chance that substantial articulated remains of vertebrate fossils (including mammals, reptiles, birds and/or amphibians) may be encountered during ground disturbing activities that have already been exposed by natural processes.

Recording Procedures for Unanticipated Paleontological Resources

All paleontological materials that are discovered during ground disturbing activities will be recorded using methods consistent with modern professional paleontology standards. Upon discovery of a paleontological resource, the paleontologist(s) will identify as much as possible the horizontal and vertical extent of the fossil-material as it is exposed in the area. Scientifically significant fossil vertebrate material will be collected and curated at a Department of Defense-approved federal repository.

Collection methods may entail wrapping the specimen in paper towels and packing in a ziplock bag for smaller specimens or for larger specimens, may involve plaster jacketing of large blocks of fossil material and rock. Standard paleontological data for the locality will be recorded and includes the lithology of the unit bearing the fossil material, the unit's stratigraphic position, Global Positioning System (GPS) coordinates for the locality and any other relevant geologic information. The locality (localities) will be plotted on the appropriate US Geological Survey 7.5' quadrangle and will be photographically documented. All of this information will be recorded on the standard paleontological locality forms (e.g. BLM form H-8270-3rev).

Emergency Salvage of Paleontological Resources

If paleontological resources are in imminent danger of destruction, WSMR personnel will, without delay, apply appropriate methods to preserve as much of the fossil material and related locality information as possible, including immediate cessation of all activity near the fossil material and marking the area with flagging tape or temporary enclosure material to designate the area as a no-traffic zone. Salvage activities will follow standard paleontological methods (outlined above) as much as possible, but human safety concerns or the immediacy of the threat to the paleontological resource may require less exact methods of excavation and/or protection, and can include rapid shovel excavation or use of backhoes or other equipment to remove the fossil material.

Final Report for Unanticipated Paleontological Resources

A final technical report will be prepared upon completion of the paleontological monitoring program and this report will contain the results of the work that was conducted during the course of all treatment activities. The report will include an accession list and final disposition of any fossil material collected, listed by locality. The report will also include a discussion of the scientific significance of the specimens and the geologic and evolutionary context of the fossils and their localities. A confidential appendix will be provided that contains copies of locality maps and standard locality data sheets for each locality where specimens were discovered and collected. Copies of the final report will be filed with WSMR and the acting federal repository.

Contacts for Unanticipated Paleontological Discoveries

Unanticipated paleontological discoveries should be reported immediately to the WSMR Environmental Division: (575)-678-2226.

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Appendix E:

WSMR Deliverables and Curation Guidelines

WSMR Deliverables Preparation Guidelines

Please note that the Scope of Work may contain project specific variations of the items below. If no artifacts are collected, do not fill out the Artifact Catalog and Artifacts Collected items. All paper used must be acid free.

Cover Letter

- ☐ Address to appropriate target audience
- ☐ Include WSMR and Contractor project numbers, and final report title
- ☐ Itemize deliverables enclosed
- ☐ Include Contractor's contact numbers for questions—P.I., usually.
- ☐ Signature line is Contractor's, with title below name

Project File (Include 1 each)

- ☐ Government Document page (Xerox)
- ☐ Title page of final report (Xerox)
- ☐ Abstract of final report (Xerox)
- ☐ NMCRIS Project/Activity Form (Xerox)
- ☐ Photo Logs (Xerox) and labeled contact sheets (Color copies, paper clipped to logs)
- ☐ Field Notes, maps and other field records (Xeroxes)
- ☐ Lab Notes, analysis sheets and other records (Xeroxes)
- ☐ IO List (Xerox list with UTM coords., etc.)
- ☐ Site Characteristic Table (Xerox)
- ☐ Artifact Catalog (Xerox)
- ☐ Any extra photos (labeled), correspondence, and/or extra ARMS search info.

SHPO File (Contains LA folders for each site)

- ☐ NMCRIS Project/Activity Form (Original)
- ☐ Final LA Forms (Original)
- ☐ Site maps
- ☐ USGS location maps

Report (File)

- ☐ Master copy of final printed report(s), "public" and "private" versions (unbound)
- ☐ CD-ROM of final report (do not include any disks other than CD)
- ☐ Designated number of unbound and bound copies of report (as per WSMR contract—or see default list)

Site Form File (Contains LA folders for each site)

- ☐ Final site form (Xerox is OK)
- ☐ Final site map (Original)
- ☐ Final USGS location map (Original)
- ☐ Field site form (Original)
- ☐ Field notes/maps/sketches (Original)
- ☐ Lithic (and/or other) Analysis form(s) (Original)
- ☐ Contact Sheet (Color Copy) and Photo Log for each site (Xerox) *(Use #2 pencil check to "highlight" appropriate site entries on shared log sheets)*
- ☐ Artifact Catalog (Xerox)

Artifact Catalog folder

- ☐ Artifact Catalogs (Original)

Artifacts Collected

- ☐ All curated artifacts, labeled and bagged correctly
- ☐ Artifact Catalogs paper-clipped to appropriate site or IO bags

Photographic Catalog folder

- ☐ Contact Sheets and Photo Logs (Original)
- ☐ All Photo Negatives, sleeved (Original)
- ☐ All digital photos (compiled in file on 1 CD-ROM)

WSMR Deliverables Preparation Guidelines

The Abbreviated Manual

For detailed instructions and special cases, see the complete manual:
Manual for Processing Archaeological Records, Photographs, and Collections, White Sands Missile Range, New Mexico.

Cover Letter: The cover letter should tell WSMR exactly what is enclosed in your deliverables package. Though the cover letter's font and paragraph format can vary according to Contractor's preferences, we recommend the general format for the letter follow the examples provided in Figures 1 & 2 and described in the section below. **FONT**: Standard readable font: Times, Book Antigua, Arial, etc. (11-12 pt.) are common, readable fonts, and therefore recommended.

- **PARAGRAPH**: Block style recommended (flush left or justified, single-spaced within paragraphs, with about 8-12 pt. white space between paragraphs).

Check your format and content with the following list:

(See labeled examples, **Figures 1 & 2**)

1. The letter is printed on Contractor's letterhead.
2. The letter is addressed to the appropriate WSMR target audience.
3. The letter provides a subject line for a quick preview of enclosures.
4. The letter includes WSMR and Contractor project numbers, and the final report title(s).
5. The letter specifically itemizes all deliverables associated with the project and report.
6. The letter includes the Contractor's contact numbers for questions—usually the name (and title, if appropriate) of the project Primary Investigator (PI).
7. The letter includes a signature line (Contractor's), with appropriate title (if any).

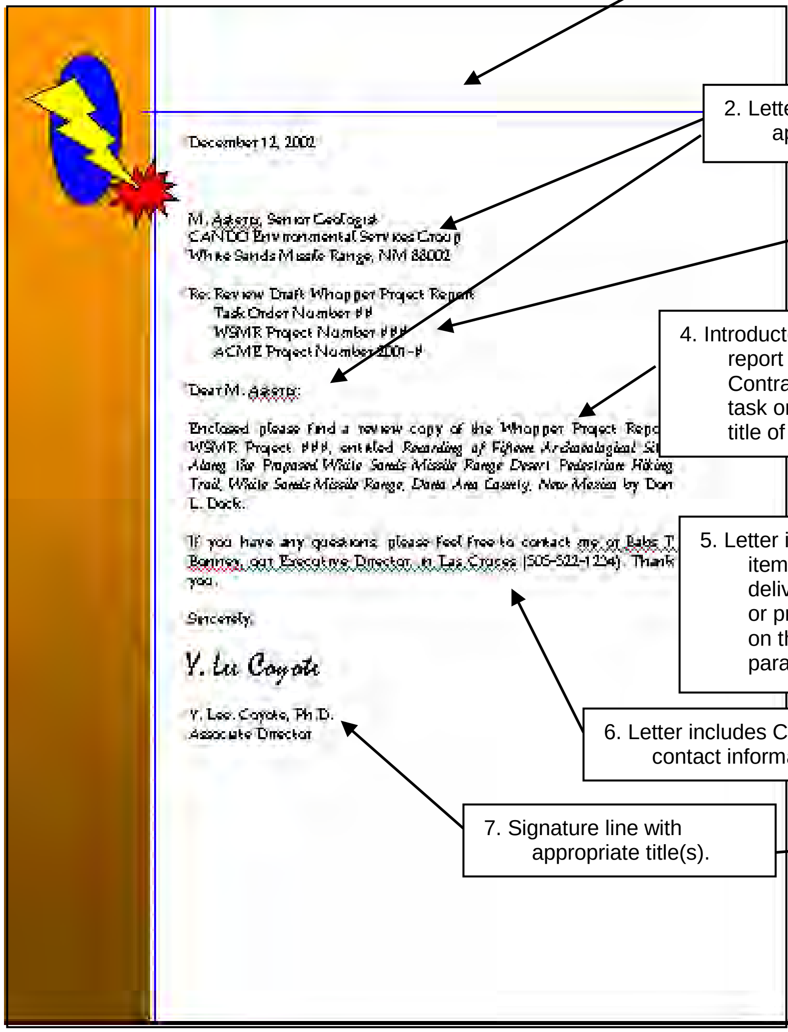


Figure 1. Review Copy Cover Letter.

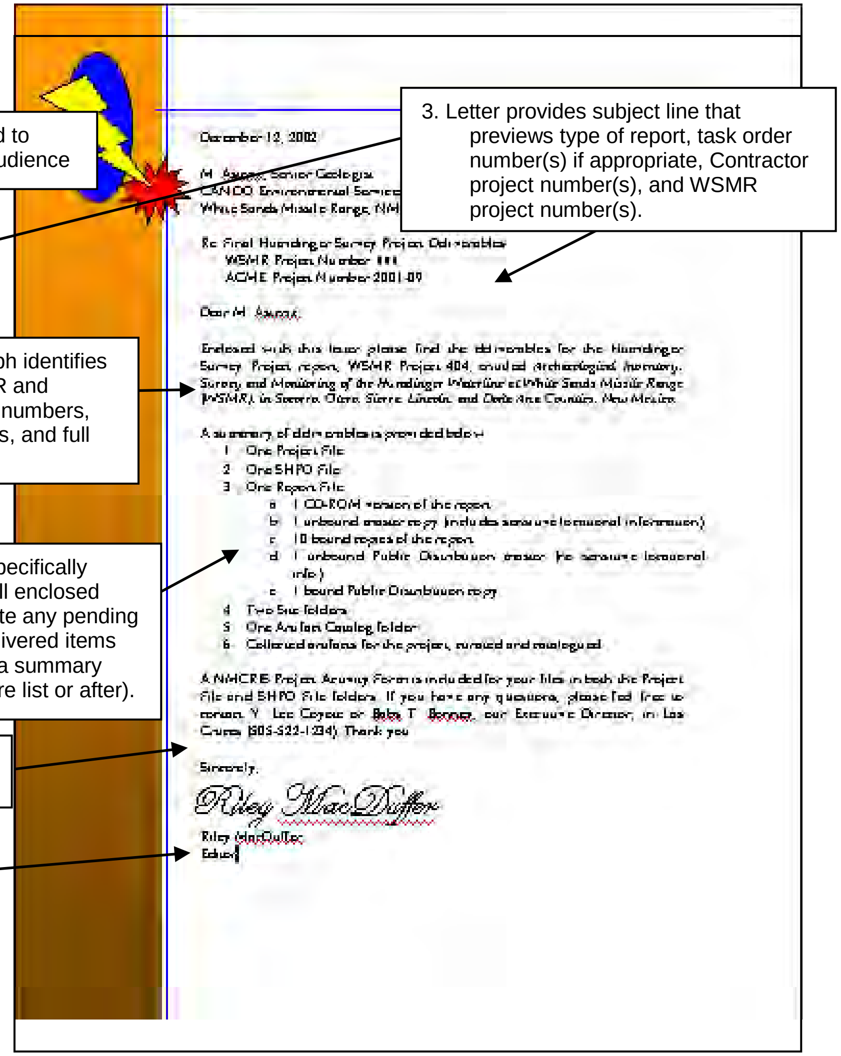


Figure 2. Final Deliverables Cover Letter.

Folders:

For WSMR projects, the deliverables package should include 6 acid free archival quality manila folders, labeled as follows: **Project, SHPO, Report, Site Forms** (to hold “1/3 cut tab” site record subfolders), **Photographic Catalog,** and **Artifact Catalog.** Labeling requirements for each folder are detailed in the sections and figures that follow.

Check that your file folders meet the following requirements:

(See examples, **Figures 3 & 4**)

1. Use acid free archival quality manila file folders for each of the 6 main files (**Figure 3**).
2. Use acid free manila file folders for each Site File subfolder in both the Site Form and SHPO main files (**Figure 4**).

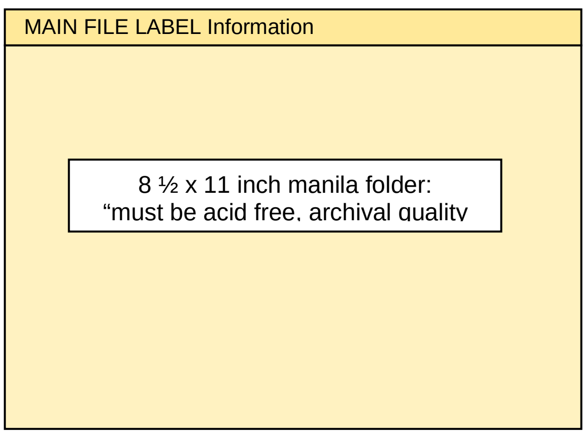
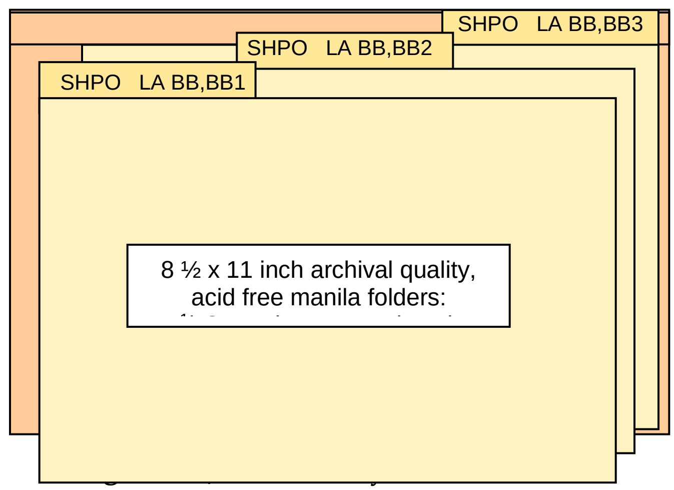


Figure 3. Archival quality, acid free style—for Main Files (SHPO, LA FORM, etc.).



Individual Site Files in the Main File. They should be arranged as follows: left, center, right, in repeating order.

Check that your folder labels follow format requirements:

(See examples, **Figures 5 & 6**)

1. Use a laser-printed label on each folder. Labels must be foil backed and of archival quality. Labels can be round or square corner.
2. Use 16 pt. and 9 pt. Times New Roman or Arial for the label font.
3. Format the information for maximum clarity in minimum space.
4. Specifically identify the contents of each folder.

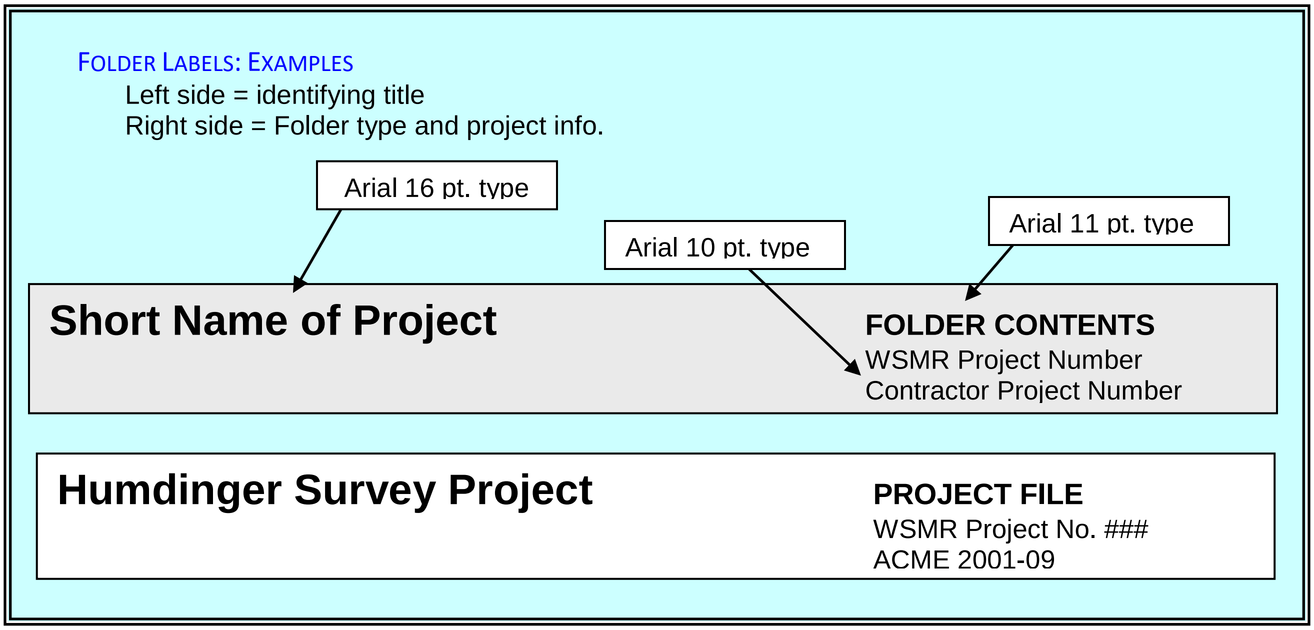


Figure 5. Example of Folder Label Format**.**

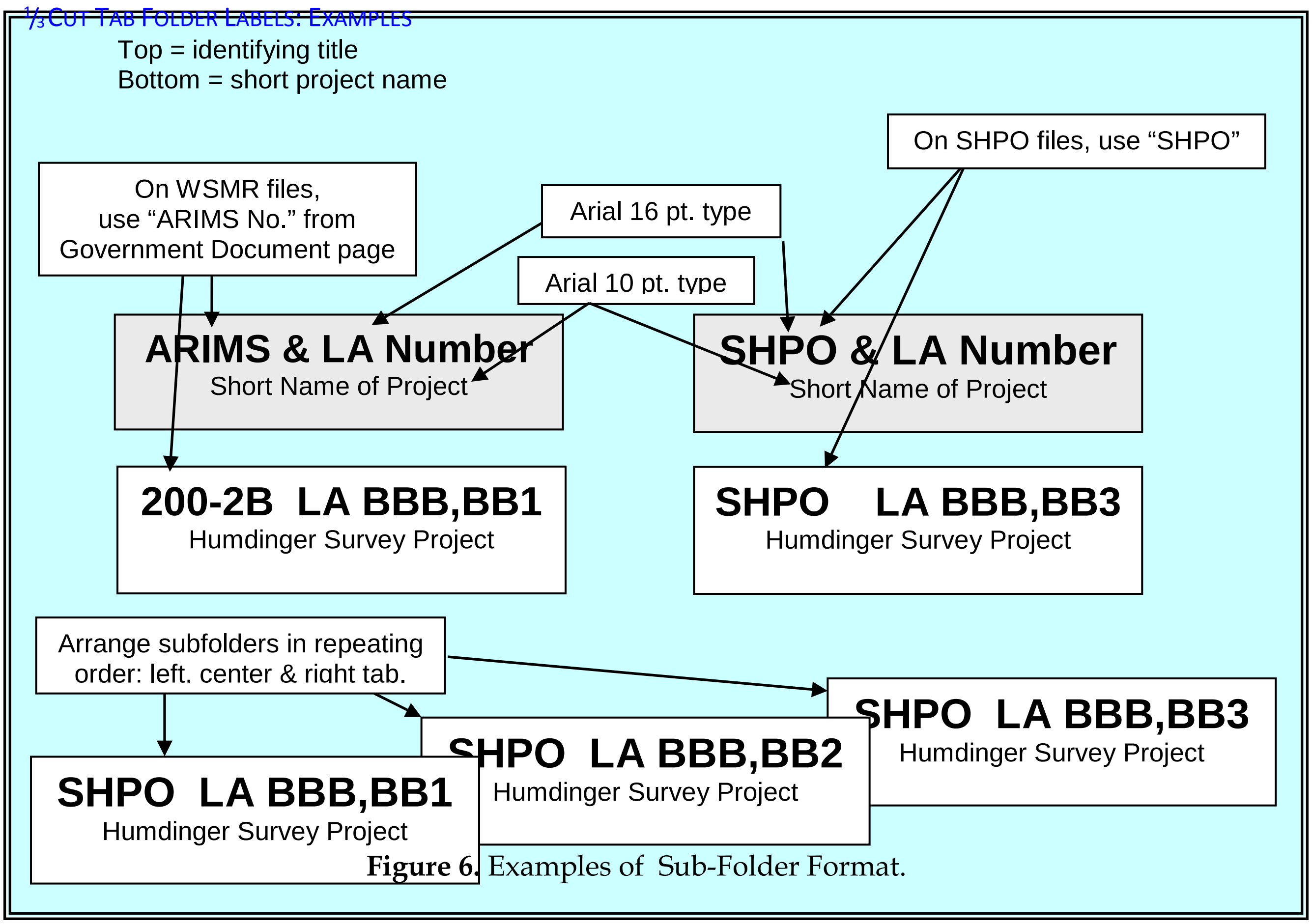


Figure 6. Examples of Sub-Folder Format.

Project File:

The project folder provides information from the report, as well as photographic and artifact logs, contract details, project specifications, contractor updates, and daily logs. In an archival (acid free) file folder, put one (1) each of the items on the checklist below.

Project File Checklist

(Include 1 each of the following. See examples, **Figures 7-9**.)

- ☐ Government Document page (Xerox) (**Figures 7 & 8**)
  (Click here for template & sample page.)
- ☐ Title page of final report (Xerox).
- ☐ Abstract/Management Summary of final report (Xerox).
- ☐ NMCRIS Project/Activity Form (Xerox). (*Click here for blank NMCRIS form*)
- ☐ Photo Logs (Xerox) and labeled contact sheets. *(Click here for photo log sample)*
  (Color copies of contact sheets paper-clipped to logs.)
  (*Click here for photo label template*)
- ☐ Field Notes, maps and other field records (Xeroxes).
- ☐ Lab Notes, analysis sheets and other records (Xeroxes).
- ☐ IO List (Xerox list with UTM coordinates, etc.).
- ☐ Site Characteristic Table (Xerox) *(Click here for example table).*
- ☐ Artifact Catalog (Xerox) (*Click here for artifact catalog sample*).
- ☐ Any extra (not used in report) photos, labeled and sleeved (**Figure 9**).
- ☐ Any project-related correspondence.
- ☐ Any ARMS search information.

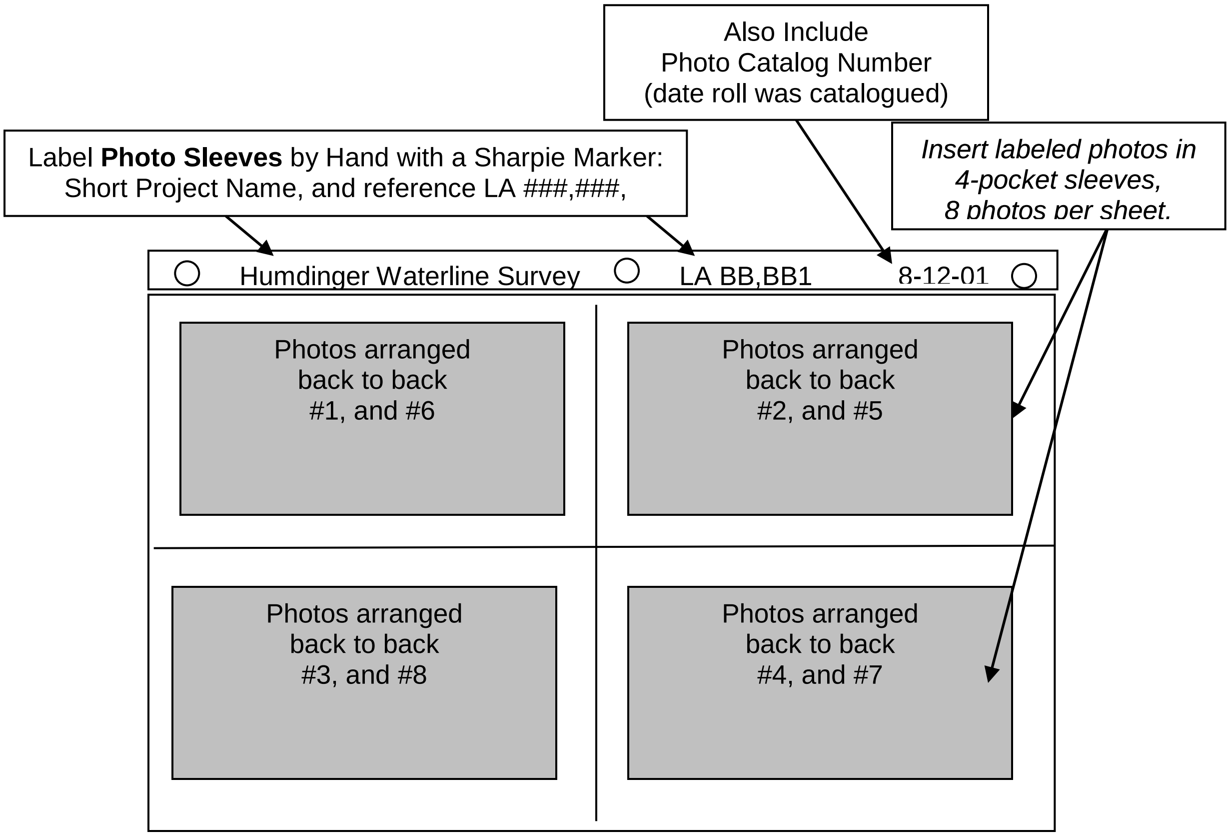
REPORT DOCUMENTATION PAGE			OMB No. 0704-0188
Public reporting burden for this collection of information estimated to average 1 hour per response, including the time for reviewing instructions. Send comments regarding this burden estimate or any other aspects of this collection information including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302 and to the Office of Management and Budget Paperwork Reduction Project (0704-0188), Washington DC 20503			
1. AGENCY USE ONLY *(LEAVE BLANK)*	2. REPORT DATE *The date you fill this form out*		3. REPORT TYPE AND DATES COVERED *"Draft" or "Final," with project dates as identified in report.*
4. TITLE AND SUBTITLE *Use the title (and subtitle) as written on report cover and title page*			5. FUNDING NUMBERS *Leave blank*
6. AUTHOR(S) *Name(s) of the Contractor(s) whose names appear as author(s) on report*			
7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES) *Contractor's full name and address*			8. PERFORMING ORGANIZATION REPORT NUMBER *Your number here*
9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES) Department of the Army U.S. Army White Sands Missile Range 100 Headquarters Avenue ATTN: CSTE-DTC-WS-ES-ES (*WSMR Technical Inspector name*) White Sands Missile Range, NM 88002			10. SPONSORING/MONITORING AGENCY REPORT NUMBER WSMR Project Number *Put WSMR-assigned number here*
11. SUPPLEMENTARY NOTES *(LEAVE BLANK)*			
12a. DISTRIBUTION AVAILABILITY STATEMENT *(LEAVE BLANK)*			12b. DISTRIBUTION CODE *(LEAVE BLANK)*
13. ABSTRACT (MAXIMUM 200 WORDS) *Abstract should be pasted or condensed from culled from information in the ManagersSummary in the report.*			
14. SUBJECT TERMS *You make them up* *Put MARKS (Modern Army Record Keeping System) catalog number here : Call Judy Langham, Corporate Librarian at WSMR: 678-0702*			15. NUMBER OF PAGES *Put total number of single-sided pages in the document, including appendices.*
			16. PRICE CODE *(LEAVE BLANK)*
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL

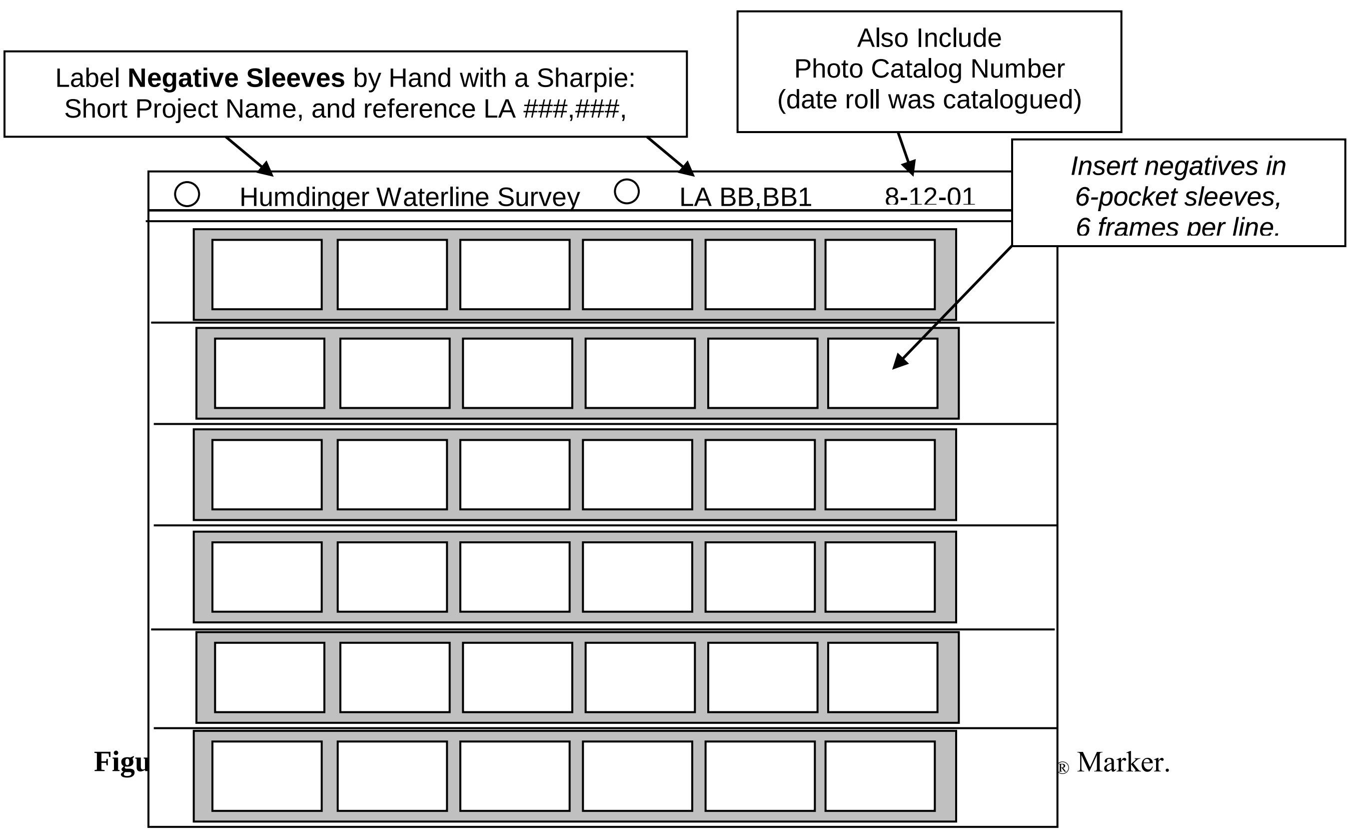
NSN 7540-01-280-5500 STANDARD FORM 298 (2-89) PREPARED BY ANSI Std 239-8 299-102

Figure 7. Full-Size Template: Government Report Documentation Page.

<table>
<tr><td colspan="3">REPORT DOCUMENTATION PAGE</td><td>OMB No. 0704-0188</td></tr>
<tr><td colspan="4">Public reporting burden for this collection of information estimated to average 1 hour per response, including the time for reviewing instructions. Send comments regarding this burden estimate or any other aspects of this collection information including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302 and to the Office of Management and Budget Paperwork Reduction Project (0704-0188), Washington DC 20503</td></tr>
<tr><td>1. AGENCY USE ONLY</td><td colspan="2">2. REPORT DATE
December 12, 2002</td><td>3. REPORT TYPE AND DATES COVERED
Final Survey Report, July 14, 2001–December 11, 2002</td></tr>
<tr><td colspan="3">4. TITLE AND SUBTITLE
Archaeological Inventory, Survey and Monitoring of the Humdinger Waterline at White Sands Missile Range (WSMR), in Socorro, Otero, Sierra, Lincoln, and Doña Ana Counties, New Mexico.</td><td rowspan="2">5. FUNDING NUMBERS</td></tr>
<tr><td colspan="3">6. AUTHOR(S)
Y. Lee Coyote, Ph.D.</td></tr>
<tr><td colspan="3">7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES)
ACME Archaeology, Unltd. (ACME)
P.O. Box 123456
Las Cruces, NM 88001-0002</td><td>8. PERFORMING ORGANIZATION REPORT NUMBER
ACME 2002-514A</td></tr>
<tr><td colspan="3">9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)
Department of the Army
U.S. Army White Sands Missile Range
100 Headquarters Avenue
ATTN: IMWE-WSM-PW-E-ES
White Sands Missile Range, NM 88002</td><td>10. SPONSORING/MONITORING AGENCY REPORT NUMBER
WSMR Project Number ###</td></tr>
<tr><td colspan="4">11. SUPPLEMENTARY NOTES</td></tr>
<tr><td colspan="3">12a. DISTRIBUTION AVAILABILITY STATEMENT</td><td>12b. DISTRIBUTION CODE</td></tr>
<tr><td colspan="4">13. ABSTRACT (MAXIMUM 200 WORDS)
ACME conducted an archaeological inventory and monitoring along the Humdinger Waterline route. A total of 100 cultural sites were identified within a 1-mile radius of the proposed waterline. Test excavations at site LA BBB,BB7, yielded a radiocarbon date of B.C. 770–360 or B.C. 780–240. Determinations of “no effect” are recommended for the following 70 sites: LA BB,BB1, LA BB,BB2, LA BB,BB3, LA BB,BB4, LA BB,BB5, LA BB,BB6, LA BB,BB7, LA BB,BB8, LA BB,BB9, LA BB,BB10, LA BBB,B11, LA BBB,B12, LA BBB,B13, LA BBB,B14, LA BBB,B15, LA BBB,B16, LA BBB,B17, LA BBB,B18, LA BBB,B19, LA BBB,B20, LA BBB,B21, LA BBB,B22, LA BBB,B23, LA BBB,B24, LA BBB,B25, LA BBB,B26, LA BBB,B27, LA BBB,B28, LA BBB,B29, LA BBB,B30, LA BBB,B31, LA BBB,B32, LA BBB,B33, LA BBB,B34, LA BBB,B35, LA BBB,B36, LA BBB,B37, LA BBB,B38, LA BBB,B39, LA BBB,B40, LA BBB,B41, LA BBB,B42, LA BBB,B43, LA BBB,B44, LA BBB,B45, LA BBB,B46, LA BBB,B47, LA BBB,B48, LA BBB,B49, LA BBB,B50, LA BBB,B51, LA BBB,B52, LA BBB,B53, LA BBB,B54, LA BBB,B55, LA BBB,B56, LA BBB,B57, LA BBB,B58, LA BBB,B59, LA BBB,B60, LA BBB,B61, LA BBB,B62, LA BBB,B63, LA BBB,B64, LA BBB,B65, LA BBB,B66, LA BBB,B67, LA BBB,B68, LA BBB,B69, and LA BBB,B70.
Determinations of “No Adverse Impact” are recommended for 30 rerouted/monitored sites: LA CC,CC1, LA CC,CC2, LA CC,CC3, LA CC,CC4, LA CC,CC5, LA CC,CC6, LA CC,CC7, LA CC,CC8, LA CC,CC9, LA CCC,C10, LA CCC,C11, LA CCC,C12, LA CCC,C13, LA CCC,C14, LA CCC,C15, LA CCC,C16, LA CCC,C17, LA CCC,C18, LA CCC,C19, LA CCC,C20, LA CCC,C21, LA CCC,C22, LA CCC,C23, LA CCC,C24, LA CCC,C25, LA CCC,C26, LA CCC,C27, LA CCC,C28, LA CCC,C29, and LA CCC,C30.</td></tr>
<tr><td colspan="3" rowspan="2">14. SUBJECT TERMS
Hazardous Test Area (HTA), Open Burn/Open Detonation (OB/OD), RDX, HMX, nitrate, perchlorate, RCRA subpart X, RCRA Permit, HSWA, Closure, risk assessment, health risks, contaminants of potential concern, toxicity assessment, ecological assessment, SWMU
MARKS Number: 02.##</td><td>16. NUMBER OF PAGES
250</td></tr>
<tr><td>16. PRICE CODE</td></tr>
<tr><td>17. SECURITY CLASSIFICATION OF REPORT
Unclassified</td><td>18. SECURITY CLASSIFICATION OF THIS PAGE
Unclassified</td><td>19. SECURITY CLASSIFICATION OF ABSTRACT
Unclassified</td><td>20. LIMITATION OF ABSTRACT
UL</td></tr>
</table>

Figure 8. Full-Size Sample Government Report Documentation Page.


Also Include
Photo Catalog Number
(date roll was catalogued)
Label **Photo Sleeves** by Hand with a Sharpie Marker:
Short Project Name, and reference LA ###,###,
Insert labeled photos in
4-pocket sleeves,
8 photos per sheet.
Humdinger Waterline Survey
LA BB,BB1
8-12-01
Photos arranged back to back #1, and #6
Photos arranged back to back #2, and #5
Photos arranged back to back #3, and #8
Photos arranged back to back #4, and #7


Label **Negative Sleeves** by Hand with a Sharpie:
Short Project Name, and reference LA ###,###,
Also Include
Photo Catalog Number
(date roll was catalogued)
Insert negatives in
6-pocket sleeves,
6 frames per line.
Humdinger Waterline Survey
LA BB,BB1
8-12-01

Figu ® Marker.

SHPO File (contains LA folders for each site)

The SHPO site folder contains information that will be sent to the ARMS files by the White Sands Archaeologist (to the SHPO, Historic Preservation Division, Santa Fe). This file should contain a copy of the site form(s) and/or building form(s) generated during the project and Laboratory of Anthropology Project/Activity Record(s). In an archival quality, acid free labeled manila folder, put one (1) each of the items on the checklist below. All items are to be printed in a laser printer on acid free paper.

SHPO File Checklist

(include 1 each):

- ☐ NMCRIS Project/Activity Form (Original).
- ☐ Final LA Form(s) (Xerox), organized in ⅓ cut tab manila folders.
  *Label with "SHPO" and Site LA number (***Figures 4–6***).*
- ☐ Site maps (Xerox), included in appropriate subfolder with LA form.
- ☐ USGS location maps (Xerox), included in appropriate subfolder with LA form.

WSMR Site Form File (contains LA folders for each site)

The Site Form File is an archival (acid free) file folder that holds all the Laboratory of Anthropology Site Records (LA Forms) and related site-specific project information. In each archival labeled folder, put one (1) each of the following checklist items into a labeled archival (acid free) file folder. Each separately archival quality, acid free manila folder should contain all original data and forms for that site. If there is more than one Site folder in the main file, be sure to alternate folder tabs in a repeating pattern from left, to center, then right, to insure maximum readability. All items are to be printed in a laser printer on acid free paper.

Site Form File Checklist

(include 1 each per subfolder. See **Figures 4-6** for labeling information):

- ☐ Final site map (Original).
- ☐ Final USGS location map (Original).
- ☐ Field LA Form (Original).
- ☐ Field maps/sketches of features, artifacts, etc. (Original).
- ☐ Lithic (and/or other) Analysis form(s) (Original).
- ☐ Contact Sheet (Color Copy) and Photo Log of each site (Xerox)
  (Use #2 pencil check to "highlight" appropriate site entries on shared log sheets)
- ☐ Artifact Catalog for collected artifacts (Xerox).
- ☐ *If there is more than one site subfolder, repeat the ⅓ cut tab sequence from left to center to right. Organize subfolders numerically, by LA Number. Be consistent so the forms will be easy to find.*

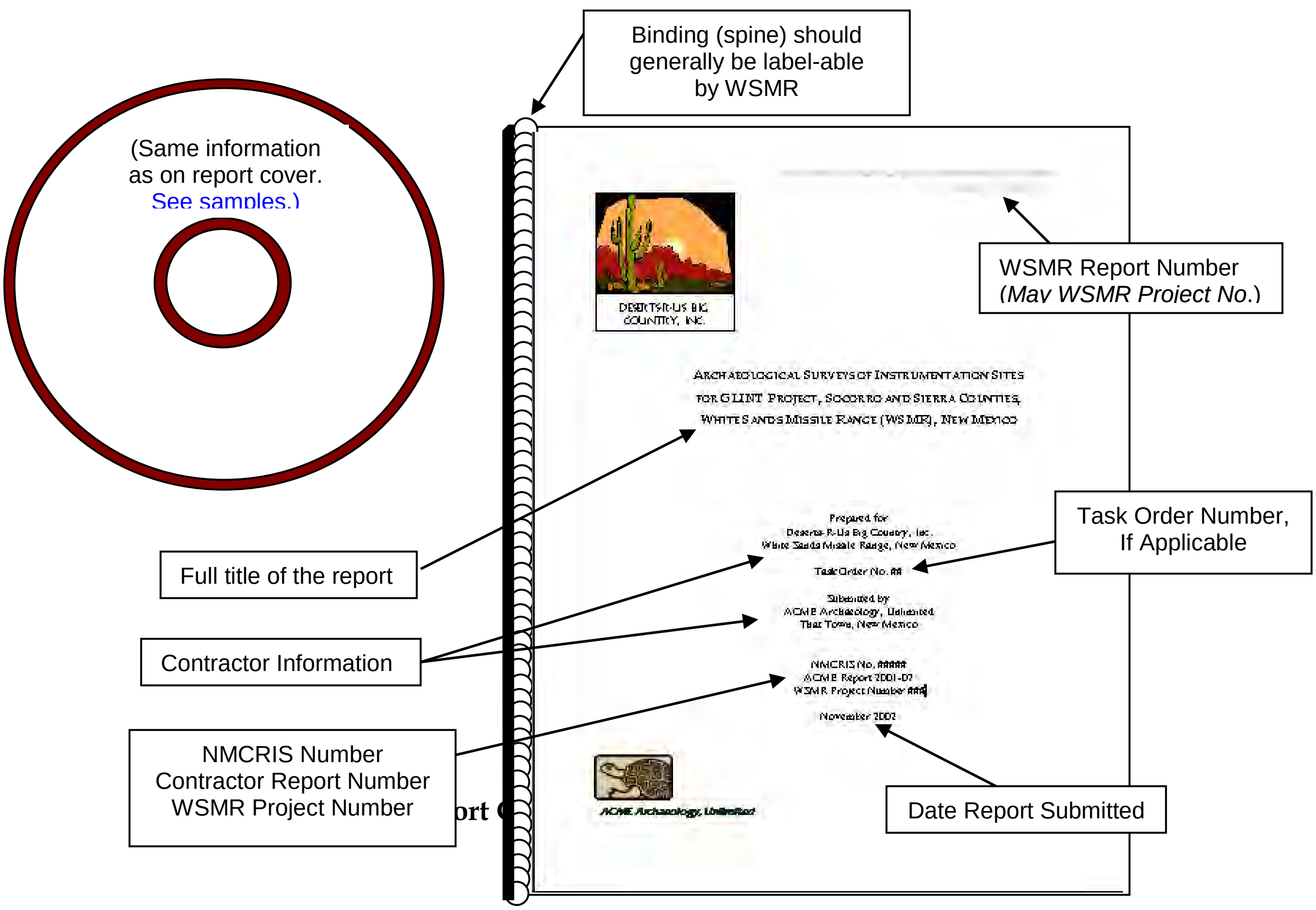
Report File

The Report File folder should contain all required bound and unbound copies of the report for distribution to appropriate WSMR document libraries. The archival quality, acid free manila file should also contain a labeled CD, with all versions of the document in Read-Only format (ideal final document format would be Adobe Acrobat). WSMR prefers that reports be perfect bound.

Report File Checklist:

(See examples, **Figure 10**)

- ☐ Unbound master copy of final printed report(s), ("public" and "full disclosure" versions. (*Click here to see sample covers*)
- ☐ CD-ROM of final report (do not include any other computer disks—only a CD). (*Click here to see sample CD labels*)
- ☐ Designated number of additional unbound copies of report (as per WSMR contract—or *see default list*)
- ☐ Designated number of bound copies of report (as per WSMR contract—or *see default list*)



Artifacts Collected

Along with the report and other deliverables folders, any collected artifacts must be turned over the WSMR for archival recordation and storage. In order to be stored correctly, they must be curated correctly. This section will provide samples and explanations of the correct formats and procedures.

Important Curation Note!

A WSMR Catalog Number is assigned to any project conducted on White Sands that results in an artifact collection. Because the Catalog Inventory Sheet is made up, in part, of the White Sands Project Number, the Contractor must contact the WSMR archaeologist to get the WSMR Project Number. For the WSMR catalog number, contact this person:

James Bowman: 505-678-7925.

It is the responsibility of a collections manager within the Contractor's organization to manage project collections in terms of WSMR Catalog Number, and to assure that all collections are properly catalogued and prepared for curation. *WSMR Project Catalog Numbers are unique.*

Identifying/Understanding Artifact Catalog Numbers:

The catalog number is generally composed of the last two digits of the calendar year when the artifact was catalogued (00, 01, 02, etc.), combined with the numerical sequence of WSMR collections (01, 02, 03, etc.). These numbers are separated by decimal points from each other and the rest of the catalog number: LA Site Number or IO number, and the number of the artifact.

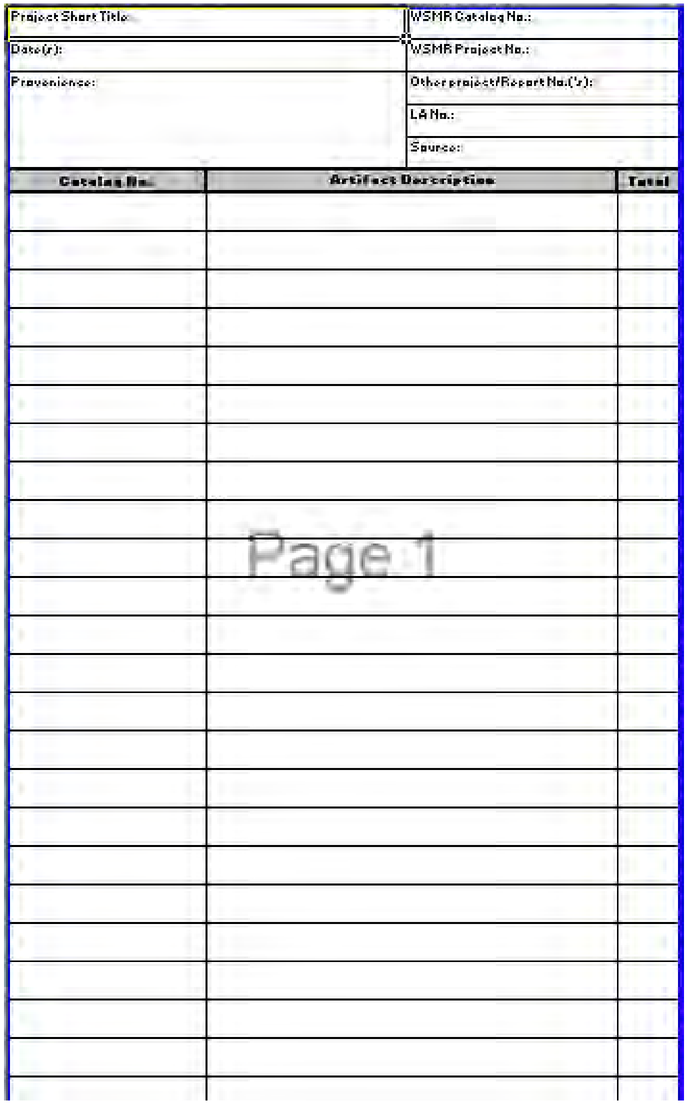
WSMR Catalog Project Number | Locational Data | Artifact Number | Year

01.03.LABB,BB1.00001 --- for site-related artifact (.00001, .00002 etc.)
01.03.IO.00001 -------------- for Isolated Occurrence (IOs)
01.03.NP.00001 --------------- for "No Provenience" (NPs)

Artifact Preparation and Labeling Checklist:

(See examples, **Figures 11-17**)

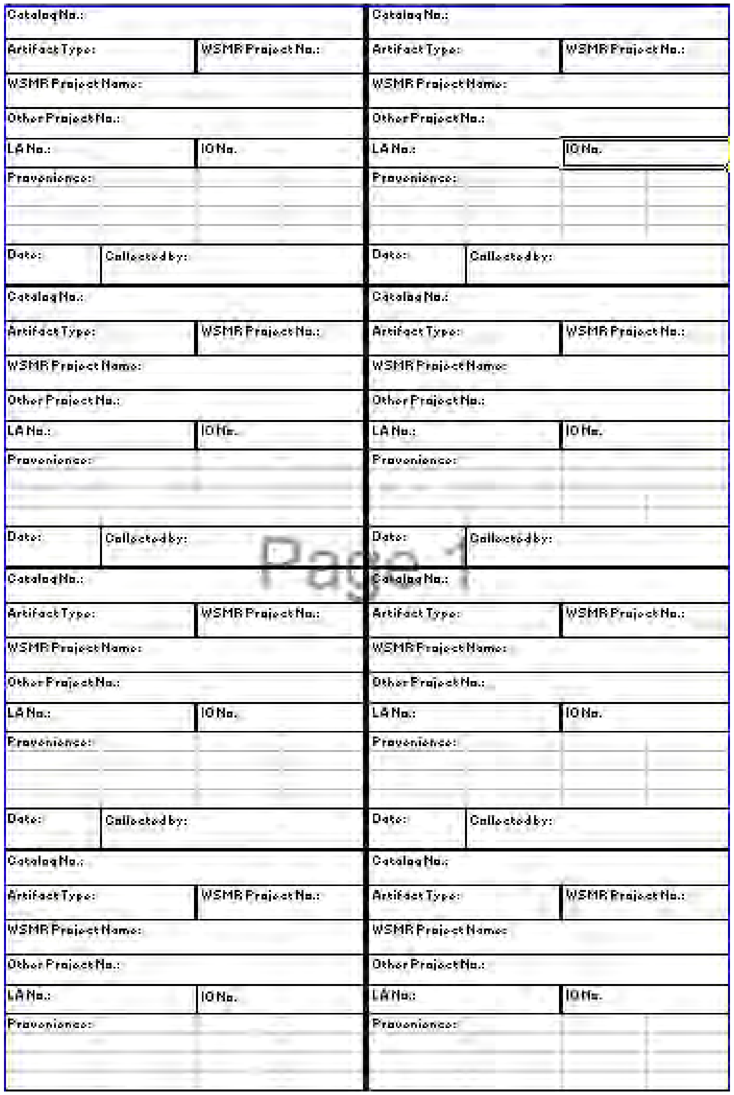
- ☐ Each site should have its own itemized collection catalog sheet, with accurate, detailed descriptions (Figure 11, Sample: Figure 13).
  (*Click here for Artifact Catalog Sheet Sample/Template (Excel file--Sheet 2).*)
- ☐ Each artifact should be individually bagged and labeled correctly, with acid-free pen/pencil on acid-free paper (Figure 12, Sample: Figure 14).
  (*Click here for Artifact Label Sample/Template (Excel file—Sheet 1)*)
- ☐ Each site's labeled collection should be consolidated into one or more larger bag(s), and labeled correctly (**Figure 15**).
- ☐ Oversized artifacts should be labeled correctly (**Figure 16**).
- ☐ Each site's final artifact collection bag(s) must have the site's catalog sheet(s) paper-clipped to it(them). (**Figure 17**).
- ☐ Each IO's final artifact collection bag(s) must have the IO's catalog sheet(s) paper-clipped to it(them). (**Figure 17**).



Project Short Title:	WSMR Catalog No.:
Date(s):	WSMR Project No.:
Provenience:	Other project/Report No.('s):
	LA No.:
	Source:

Catalog No.	Artifact Description	Total

Figure 11. Blank Artifact Catalog form.



Catalog No.:		Catalog No.:	
Artifact Type:	WSMR Project No.:	Artifact Type:	WSMR Project No.:
WSMR Project Name:		WSMR Project Name:	
Other Project No.:		Other Project No.:	
LA No.:	IO No.	LA No.:	IO No.
Provenience:		Provenience:	
Date:	Collected by:	Date:	Collected by:
Catalog No.:		Catalog No.:	
Artifact Type:	WSMR Project No.:	Artifact Type:	WSMR Project No.:
WSMR Project Name:		WSMR Project Name:	
Other Project No.:		Other Project No.:	
LA No.:	IO No.	LA No.:	IO No.
Provenience:		Provenience:	
Date:	Collected by:	Date:	Collected by:
Catalog No.:		Catalog No.:	
Artifact Type:	WSMR Project No.:	Artifact Type:	WSMR Project No.:
WSMR Project Name:		WSMR Project Name:	
Other Project No.:		Other Project No.:	
LA No.:	IO No.	LA No.:	IO No.
Provenience:		Provenience:	
Date:	Collected by:	Date:	Collected by:
Catalog No.:		Catalog No.:	
Artifact Type:	WSMR Project No.:	Artifact Type:	WSMR Project No.:
WSMR Project Name:		WSMR Project Name:	
Other Project No.:		Other Project No.:	
LA No.:	IO No.	LA No.:	IO No.
Provenience:		Provenience:	

Figure 12. Blank Artifact Labels form.

Project Short Title: **Humdinger Waterline Project**		WSMR Catalog No.: **##.##.LA BB,BB1.00001-00005**
Date(s): **July 14, 2001–December 11, 2002**		WSMR Project No.: **###**
Provenience: LA BB,BB1	T: 4E R: 12S Zone 13	Other project/Report No.('s): **ACME 2001-09**
	E: **##,###** N: **###,###**	LA No.: **LA BB,BB1**
		Source: **ACME Archeology, Unlimited**

Catalog No.	Artifact Description	Total
##.##.LA BB,BB1.00001	Potshatter, unknown Paleoindian, rimless	1
##.##.LA BB,BB1.00002	Mano fragment, grey chert	1
##.##.LA BB,BB1.00003	Stone ground point, broken biface	1
##.##.LA BB,BB1.00004	Rhyolite unfinished point, broken tip	1
##.##.LA BB,BB1.00005	Mano, medium, unknown Paleoindian	1

Page 1

Figure 13. Example of Itemized Collection Catalog (Artifact Catalog Sheet).

Catalog No.: **##.##.LABB,BB1.00001**			
Artifact Type: **Pot shatter**		WSMR Project No.: ###	
WSMR Project Name: **Humdinger Waterline Project**			
Other Project No.: **ACME 2001-09**			
LA No.: **LA BB,BB1**		IO No.	
Provenience:	T: 4E R: 12S	Zone 13	
	E: ##,###	N: ###,###	
Date: **Aug. 3, 2002**	Collected by: **Y. Lee Coyote**		

Figure 14. Example of Artifact Label.

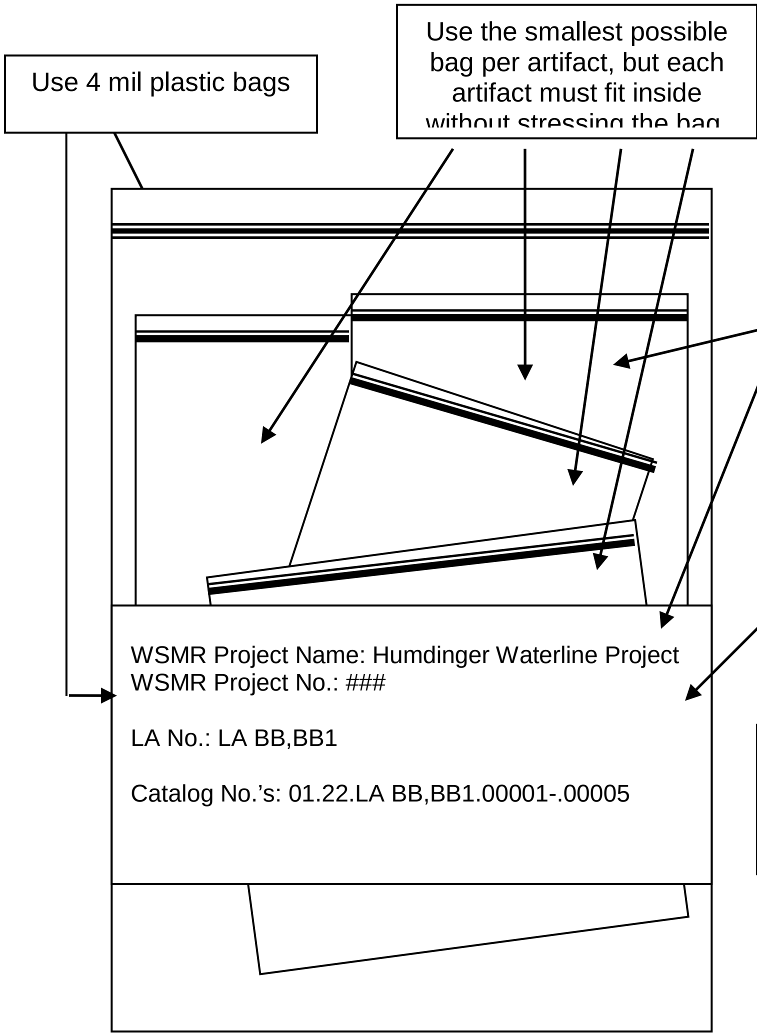


Figure 15. Artifact Collections must be consolidated.
Do not overstuff bags
Insert artifact label into each bag. Using a Sharpie®, label exterior of bag with identical information.

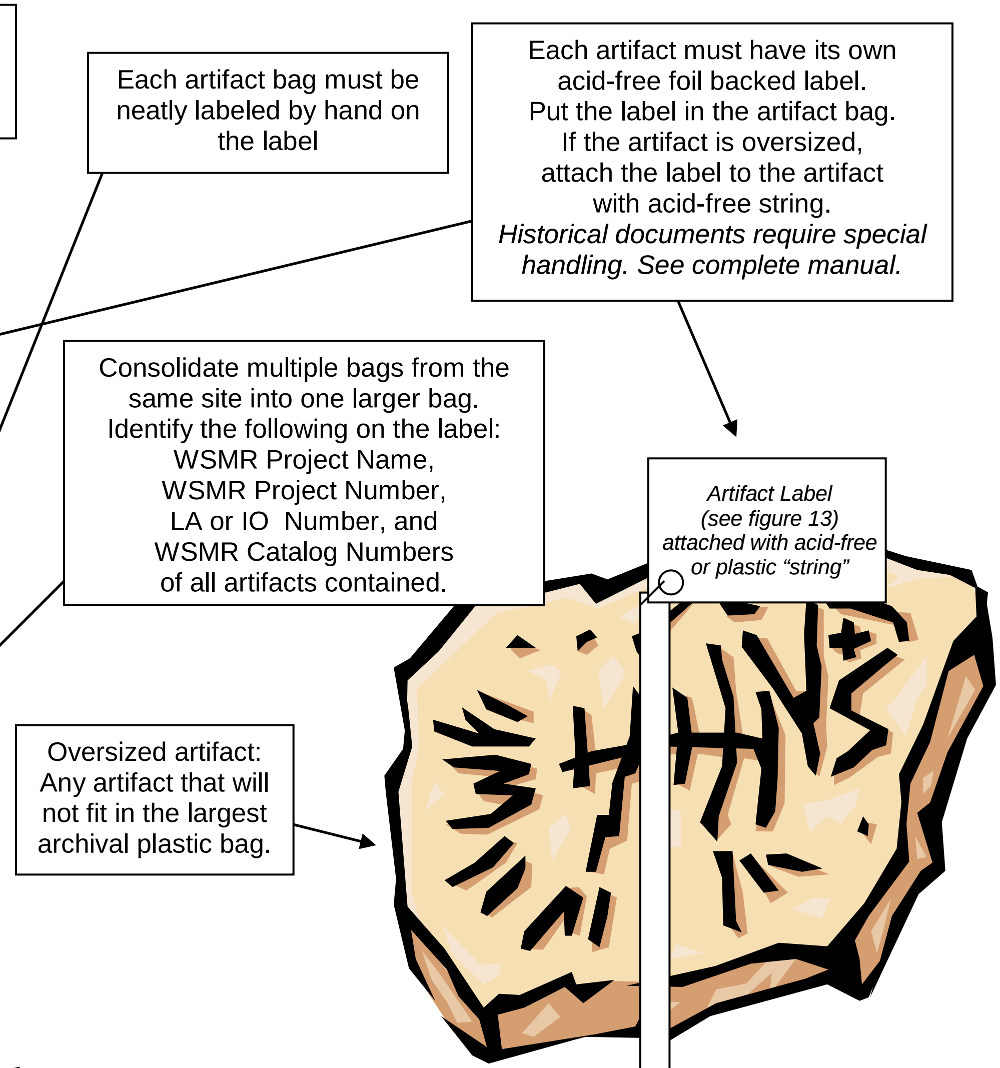


Figure 16. Oversized artifacts must be correctly labeled.
***Do not write directly on, or glue anything to, the artifac*!**
Use the same label as the bagged items.
Attach label via acid-free string or plastic.

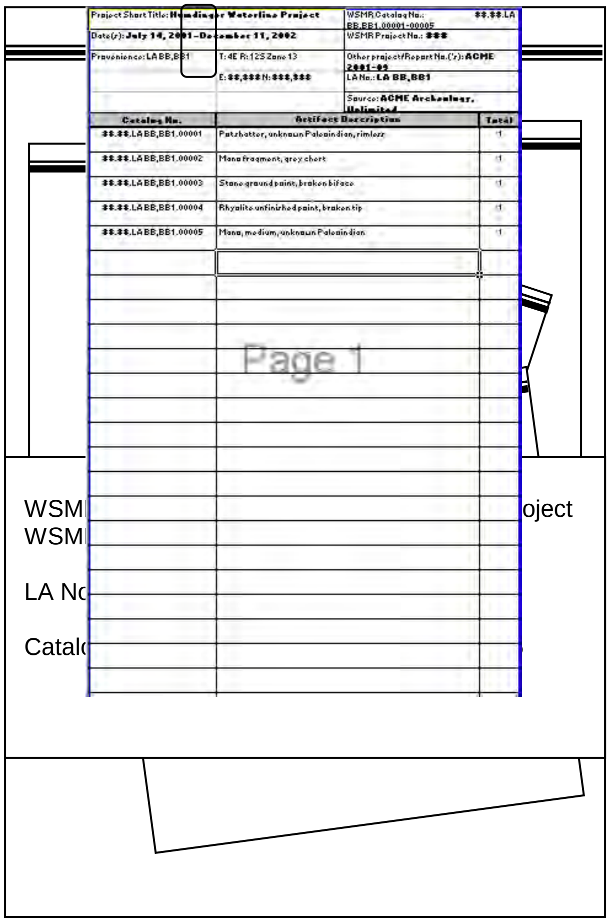


Figure 17. Catalog sheets must be paper-clipped to each consolidation bag and/or oversized artifact.

Artifact Catalog File

The archival quality, acid free labeled manila folder called the Artifact Catalog should contain all the information about collected and curated artifacts. Depending upon the size and number of collected artifacts, the folder may also contain the actual curated material(s)--the artifacts themselves. (For detailed instructions and special cases for artifact handling/preparation, see the ***Manual for Processing Archaeological Records, Photographs, and Collections, White Sands Missile Range, New Mexico**.)*

Artifact Catalog Checklist:

- ☐ Completed Artifact Catalog Sheets for each site (Original).
- ☐ Correctly curated artifacts to accompany the Artifact Catalog folder.

  If the artifacts are few and small enough, put the consolidation bag(s) inside the main folder; otherwise use a separate box. *See complete manual.*

Photographic Catalog folder

The full cut (straight cut), labeled manila folder called the Photographic Catalog should contain all the original contact sheets and extra photos, with negatives, all labeled and sleeved correctly. (For detailed instructions and special cases, see the ***Manual for Processing Archaeological Records, Photographs, and Collections, White Sands Missile Range, New Mexico****.)*

Photographic Catalog Checklist:

- ☐ Contact Sheets and Photo Logs (Original) *(Click here for photo log sample)*.
  (*Click here for photo label template*).
- ☐ All Photo Negatives, sleeved (Original) (figure 9).
- ☐ All digital photos (compiled onto 1 labeled CD-ROM).

Appendix F:

2020 Data Sharing Agreement

DEPARTMENT OF THE ARMY
US ARMY GARRISON WHITE SANDS MISSILE RANGE
100 HEADQUARTERS AVENUE
WHITE SANDS MISSILE RANGE, NEW MEXICO 88002

INTERGOVERNMENTAL AGREEMENT BETWEEN GARRISON COMMANDER, US ARMY GARRISON WHITE SANDS, WHITE SANDS MISSILE RANGE, NEW MEXICO AND THE NEW MEXICO STATE HISTORIC PRESERVATION OFFICER (SHPO)

SUBJECT: Concerning Automation and Management of Cultural Resources Information

This intergovernmental agreement, made and entered into pursuant to the provisions of the Federal Grant and Cooperative Agreements Act, 31 U.S.C.6301, and further pursuant to the provisions of the National Historic Preservation Act of 1966, 16 U.S.C. 470, as amended and further pursuant to the provisions of the Archaeological Resources Protection Act of 1979, 16 U.S.C. 470aa, by and between the UNITED STATES OF AMERICA, acting for this purpose through the White Sands Missile Range, hereinafter referred to as "WSMR," and by the New Mexico State Historic Preservation Officer, acting through its Historic Preservation Division, hereinafter referred to as the "State."

POLICY AND RESPONSIBILITIES

STATE

The State Historic Preservation officer of the State of New Mexico has the responsibility, under 16 U.S.C. 470a, as amended, to direct and conduct a comprehensive Statewide survey of historic properties and to identify and nominate eligible properties to the National Register of Historic Places. The State Historic Preservation officer administers the New Mexico Cultural Properties Act of 1969, as amended (18-6-1 through 17, NMSA 1978) which requires the maintenance of an inventory of cultural properties in the State Of New Mexico, consistent with but not limited by the provisions of the National Historic Preservation Act of 1966, as amended. Pursuant to its legal responsibilities, the State has established an inventory of cultural properties on all lands, irrespective of ownership, within the boundaries of the State and both the State and WSMR have established automated data files of such information for more effective and more rapid management, analysis and retrieval of information on cultural properties.

The State is uniquely qualified and willing to perform the services more particularly set forth below.

SUBJECT: Concerning Automation and Management of Cultural Resources Information

WSMR

It is the policy of the Federal government to administer federally-owned, administered or controlled prehistoric and historic resources in partnership with States, Indian tribes and other units of government, as set forth in 16 U.S.C. 470-1, as amended. White Sands Missile Range has responsibility for the preservation of historic properties under its ownership or control (16 U.S.C. 470a, as amended), as well as the responsibility to locate, inventory and nominate to the Secretary of the Interior all properties under the agency's ownership or control that appear to qualify for inclusion in the National Register of Historic Places. Pursuant to its legal responsibilities, WSMR has established an inventory of cultural properties on lands owned or controlled by the agency within the State of New Mexico.

(1) Army Regulation 420-40 (effective May 15, 1984) establishes historic property inventory standards (2-11), provides for the inclusion in inventories of new information and the correcting of existing information, requires the identification of historic properties (3-2) in all areas of effect, and provides further for coordination with the State Historic Preservation Officer (3-3) in location and inventory, evaluation and treatment of historic properties.

(2) A programmatic memorandum of agreement among WSMR, the State and the Advisory Council on Historic Preservation, ratified by the Chairman of the Council on May 18, 1985, stipulates that:
WSMR will require all archeological contractors to furnish all site records in Archeological Records System (ARMS) format for inclusion in that system, and will continue to participate in, and help support the New Mexico ARMS System developed and maintained by the New Mexico Historic Preservation Division. WSMR and SHPO will establish a separate data sharing agreement.

OBJECTIVES

The objective of this agreement is to ensure the maintenance, expansion and currency of an automated data file of cultural properties, including but not limited to properties under the ownership and control of WSMR, and to provide to WSMR, at stated intervals, current and comparable cultural resource information on lands owned or controlled by WSMR, or on identified sites throughout the entire State; and the further objective of this agreement is to achieve and maintain the comparability and accessibility of such information throughout the State, and particularly on all public lands, under whatever jurisdiction, in the interests of efficiency and of interagency cooperation and partnership among the federal and State, tribal and other governments set forth in the National Historic Preservation Act of 1966, as amended.

SUBJECT: Concerning Automation and Management of Cultural Resources Information

RESPONSIBILITIES

STATE

1. The State will maintain and expand an automated data file of comparable information for individual cultural properties, to be known as the Archaeological Records Management System (ARMS), in the format and meeting the specifications more particularly shown in the site and survey coding forms, and including, but not limited to information made available by WSMR. The State may add variables to the existing categories of information at the request of WSMR.

2. The State will initiate a statewide geographic information system to collect and manage information on the boundaries of archaeologically surveyed areas and on archaeological site locations.

3. At the request of WSMR but not more often than quarterly, the State will provide to WSMR all data contained in the ARMS. Bona fide representatives of the Agency will have access to supplemental files, collections and library materials, and may obtain copies of documents at cost.

4. The State will apply monies provided by WSMR only to the actual necessary cost and expense of maintenance and expansion of the ARMS including both direct and overhead costs.

5. The State will respond to specialized requests by WSMR, e.g. cross-tabulations or subsets of data for small areas.

6. The State will establish a committee of ARMS users including all land-managing agencies that provide categorical support to ARMS and will coordinate regular meetings of this committee to permit and to encourage consultation and coordination among ARMS users and oversight of expansion and redesign of ARMS.

7. All contractors conducting work under the behest of WSMR DMW-Environmental Division will be included under this agreement.

WSMR

1. WSMR will pay to the State the amount of $50,000 annually, beginning in FY20.

2. WSMR will supply to the State, on a continuous basis, data on all archaeological sites under its ownership and control as they are recorded.

SUBJECT: Concerning Automation and Management of Cultural Resources Information

3. Billing: The State will provide WSMR with two copies of an itemized invoice within 3 months of notice of availability of funds.

ADDITIONAL PROVISIONS

All information developed and disseminated under this agreement will be made subject by the State and WSMR to such restrictions of accessibility to ensure that its disclosure will not create a risk of harm to cultural resources or the site at which such resources are located, consistent with the provisions of Public Law 96-95.

This agreement is subject to appropriation of funds by Congress and available for purposes of this contract as determined by WSMR.

This agreement shall be effective for nine years from the date of execution, unless terminated by either party upon thirty days written notice, or amended or extended by the parties.

FOR WHITE SANDS MISSILE RANGE:

Chris J. Ward

CHRISTOPHER J. WARD
COL, FA
Commanding

DATE: 17 Jan 20

FOR NEW MEXICO STATE HISTORIC PRESERVATION OFFICER:

JEFF PAPPAS, Ph.D.
New Mexico State Historic
Preservation Officer

DATE: 1/15/20

Appendix G:

Published Reports

APPENDIX H: Cultural Resource Publications at WSMR

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
	1	A Preliminary Report of the Museum of New Mexico Participation and Archaeological Findings at Victorio Peak	16458
	2	73 Tech. Manual, Tularosa Basin	
	3	Program for the Eval. of	
	4	CR affected by Coop. Agreement	
	5	Prog. for Eval. of Impact	
	6	Eval. of Arch. & Related	
	7	Recon. Central & W. Portions	
CX702970060	8	WSNM Recon	
	9	An Archaeological Reconnaissance of 17 Drill Pads and Two Seismic Transects	8152
F19628-77-C-0095	10	An Archaeological Reconnaissance of Five Proposed Radar System Sites Located at Stallion Range Center & North Oscura Range	8150
DAAD07-77-M-7231	11	An Archaeological Survey of the Roland Test Facilities Complex and the CEI-3 Aerial Launcher Site	8159
	12	An Archaeological Clearance Survey of Four Drill Pads & Two Seismic Transects	8157
	13	An Archaeological Clearance Survey of Six Proposed Gravel Pit Sites	8193
DAAD07-77-M-7235	14	An Archaeological Survey of 6 Construction Sites at White Sands Missile Range	8192
DAAD07-78-A-6732	15	An Archaeological Survey of a Radar Area, Booster Disposal Zone & Power Access Route	11409
	16		
	17	A Cultural Resource Survey and Inventory of Dona Ana Range	
	18	An Archaeological Survey of a Proposed Borrow Pit on White Sands Missile Range	44
DAAD07-79-M-6725	19	An Archaeological Survey of Two 4000-Foot Diameter Impact Areas	11236
	20	An Archaeological Survey of Staging & Paddock Areas for NMDGF	11203
Antiq. Per. No. 80-NM-001	21	Final Report: Archaeological Assessment WSMR Section US 70 Corridor	22681
	22	A Vandalized El Paso Phase Pueblo on WSMR	11398
DAAD07-80-M-5771 & 5775	23	Investigations on White Sands Missile Range for White Sands Missile Range	11398
DAAD07-80-M-5775	24	An Archaeological Survey of Fixed Camera Complexes, 4 Vandal Launch Sites etc.	8204
DAAD07-80-M-5782	25	An Intensive Archaeological Survey of 2200 Acres on WSMR	23427
DAAD07-80-M-5787	26	An Archaeological Inventory for the PUP Target Site for WSMR	11152
	27	Letter Report for Survey Work on US 70 Performed by Bohannon-Houston	15706
	28	Archaeological Clearance Investigations of Borrow Pits Required for Construction of NMSHD Project F-FD-018-1	16787
	29	Prehistoric Subsistence Adaptations on WSMR	31025
DAAD07-80-M-5782 & 5784	30	An Intensive Archaeological Survey of Four Use Areas on WSMR	11143
DAAD07-81-M-768	31	An Archaeological Survey of the Mill Race	35144
	32	An Archaeological Survey of the Plains Electric Transmission Line from Las Cruces to Alamogordo	11080
DAAD07-81-M-7693 & 7696	33	An Intensive Archaeological Survey of 3 Use Areas on WSMR: Queen 15, Top Soil Borrow, Pershing II	32899
	34		

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
Antiq. Per. No. 81-NM-083	35	An Archaeological Survey of 8 Borrow Pit Access Areas & 1 Equipment Yard	62
DAAD04-81-D-0100-0002	36	Archaeological Survey of 6 Proposed Construction Areas on WSMR-Stallion Fence Project, MLRS Upgrade Launch Site, East Boundary	45817
DAAD04-81-D-0100-0012	37	Archaeological Survey of Three Proposed Military Use Areas on WSMR-P-001 Vandal Missile Range Fac, Vandal Alt Site No 1, Vand	45824
	38	Archaeological Survey of the Dragon Team Marshalling Area and Access Road	3956
	39	Patterns of Prehistoric Land Use in Dona Ana County, NM	309
Antiq. Per. No. 82-NM-074	40	Powerline Easement RATSCAT Advanced Measurement Site RAMS	15819
	41	Archaeological Clearance Survey-RATSCAT Advanced Measurement Site-RAMS	16099
Antiq. Per. No. 82-NM-074	42	Archaeological Clearance Survey-RATSCAT RAMS Construction Annex	15818
	43	WSMR CRMP & Overview	
	44	Archaeological Survey of a Segment of a Proposed Powerline Corridor-1.67 Miles Reroute-AMRAD	622
DAAD07-81-D-0100-0008	45	An Examination of the Macdonald Ranch Complex on the WSMR	
DAAD07-81-D-0100-0008	46	Archaeological Survey of a Proposed Military Use Area on WSMR-Direct Course	51936
DAAD04-81-D-0100-0008	47	Archaeological Survey of EP Electric's Proposed Powerline Corridor on the WSMR-AMRAD to Newman Plant 345kv Powerline Segment	508
DAAD07-81-D-0100-0010	48	Archaeological Survey of a Proposed Military Use Area on WSMR-Calibration Mound at Parker Lake	None
PSL	49	Prehistory of Rhodes Canyon	6914
DAAD07-81-D-0100-0007	50	Archaeological Survey of Two Proposed Military Use Areas-Permanent High Exp Test Site (Strain Path) & Infrared Test Range	45808
DAAD07-81-D-0100-0011	51	Archaeological Survey of Four Proposed Military Use Areas: Radar Site at Bldg. 21759, LC 32, South CAL Radar Site, WC -50	None
	52	Duplicate of Proj. # 38	
DAAD07-85-D-0006	53	Archaeological Survey of Five Installation Sites in Chupadero Mesa/Oscura Mountains for WSMR	6920
DAAD07-85-D-0006	54	Cultural Resources Inventory of Three Areas on WSMR: HQ, SRC, and Portions of Nike Ave	24872
	55	Archaeological Clearance Survey of Approx. 15 Miles of Fenceline at WSNM	7595
M.N.M.No. 4100335	56	Results of Testing Program	
DAAD07-85-D-0006	57	An Archaeological Survey of Two Areas Near the HELSTF Facility	8634
DAAD07-85-D-0006	58	A Cultural Resource Inventory of the Southern Edge of the Chupadero Mesa: The Sgt. York Arch Proj	20371
DAAD07-85-D-0006	59	Cultural Resources Surveys for Tularosa Gate, Dead Horse Site Relocation and the Cube Site	8486
DAAD07-85-D-0006	60	A Cultural Resource Inventory of 5.5 Miles of Access Road to Capitol Peak Valley	65319
DAAD07-85-D-0006	61	A Cultural Resource Inventory & Test Excavations Near AMRAD	8485
DAAD07-85-D-0006	62	Archaeological Survey of Six Test Locations on WSMR: BCCS Antennae, Minor Scale Van & Targer, Marine Weapons Test	8487
DAAD07-85-D-0006	63	Cultural Resources Surveys for Tularosa Gate, Dead Horse Site Relocation and the Cube Site	8486
US West	64	Monitoring for Two Mountain Bell Fiber Optics ROWS	46610

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
DAAD07-85-D-0006	65	Red Rio I: An Archaeological Survey of 1280 Acres Near Chupadera Mesa	7094
DAAD07-85-D-0006	66	The White Sands Missile Range Fiber Optic Communications Network Project	24873
DAAD07-85-D-0006	67	A Cultural Resource Survey of the Tertiary Outflow Line Project and the Dust Obscuration Test II Project	10669
DAAD07-85-D-0006	68	Archaeological Survey at Greasewood, Navy Ordnance Storage, & HELSTF Areas Test Excavations at HELSTF Site HSR 8529-6	16743
DAAD07-85-D-0006	69	Red Rio II: An Archaeological Survey of 2280 Acres Near Chupadera Mesa	17836
DAAD07-85-D-0006	70	240 Acres Near Stallion Range Center for WSMR-MLRS-SRC	11011
DAAD07-85-D-0006	71	An Archaeological Survey of 40 Acres near the Navy Blockhouse	16742
DAAD07-85-D-0006	72	An Archaeological Clearance Survey of Eleven Areas for the Bushwhacker/Blazing Skies IV Exercise	11117
DAAD07-85-D-0006	73	BORROW PIT FOR NASA	8956
DAAD07-85-D-0006	74	Misty Pictures Project: 10 Areas Near Trinity Site for WSMR (DNA Misty Pic.)	35778
DAAD07-85-D-0006	75	Cultural Resource Survey for 2 Telescope Scenes & 2000 x 2000 Ft Area Near ABC-1	35551
DAAD07-85-D-0006	76	An Archaeological Survey of a Proposed Testing Site	24273
DAAD07-85-D-0006	77	The MLRS-CINE Project: Archaeological Survey of Three Areas on WSMR	16739
DAAD07-85-D-0006	78	Marine Firebreak (Letter)	
DAAD07-85-D-0006	79	A Cultural Resource Inventory in the Vicinity of LC 39 Patriot, West of the Branch Site	16740
DAAD07-85-D-0006	80	An Archaeological Survey of the Missy Site	16738
DAAD07-85-D-0006	81	Archaeological Survey of Proposed Underground Cable Routes Near LC 50	17525
DAAD07-85-D-0006	82	Archaeological Clearance Survey of the DEW Patriot (LC 641 Alt.1) Location	16741
DAAD07-85-D-0006	83	Archaeological Survey of the Red Rio and Oscura Bombing Target Areas	35781
DAAD07-85-D-0006	84	Archaeological Clearance of a 60 Acre Missile Production Facility Area	21387
DAAD07-85-D-0006	85	Archaeological Survey of Cottonwood Spring & Indian Tanks Sites	24875
DAAD07-85-D-0006	86	A Cultural Resource Inventory of Drill Locations near Mockingbird Gap	67667
DAAD07-85-D-0006	87	Archaeological Clearance Survey of the MLRS One-Shot Site	18501
DAAD07-85-D-0006	88	Archaeological Clearance Survey for SDI Soil Test Locations Near Orogrande	42595
DAAD07-85-D-0006	89	HELSTF-EMRLD Power	35777
DAAD07-85-D-0006	90	A Cultural Resources Survey of a Segment of Range Road 21 and an Associated Borrow Pit	
DAAD07-85-D-0006	91	Amrad Rd. #252	
DAAD07-85-D-0006	92	Comm. R/Ws & 1 Access-DTK	24874
DAAD07-85-D-0006	93	Archaeological Survey of the FAADS I Project, Northern End of WSMR	42594
DAAD07-85-D-0006	94	The Environmental Test Area Project: An Archaeological Survey of 1070 Acres on WSMR	24273
BLM No. 57-2920-86-A	95	457 Acres for Groundwater Monitoring Well ROW for NASA White Sands Facility	18216
BLM No. 57-2920-86-A	96	GROUNDWATER DRILL HOLES AT NASA/WHITE SANDS FOR LOCKHEED ENGINEERING & MANAGEMEN	16492
BLM No. 57-2920-86-A	97	NASA 2ND DATA RELAY SATELLITE SYS GROUNDTERM FOR STEVENS ,MALLORY ETC ARCHITECTS	16491

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
BLM No. 57-2920-86-A	98	An Archaeological Clearance	
DAAD07-85-D-0006	99	Five Projects on White Sands (HSR 8701, HSR 8706, HSR 8708, HSR 8710)	20326
DAAD07-85-D-0006	100	Navy track LC-37	20326
DAAD07-85-D-0006	101	5 Projects on WSMR (8701, 8706, 8707, 8708, 8710)	20326
DAAD07-85-D-0006	102	GBFELTIE	
DAAD07-85-D-0006	103	High Velocity Missile Camera	20326
DAAD07-85-D-0006	104	The TACM Archaeological Project: Survey of 2950 Acres and Data Recovery at Six Sites	18995
DAAD07-85-D-0006	105	Road 7-Seg.2	20326
DAAD07-85-D-0006	106	FAADS II: An Archaeological Survey on the Northern End of WSMR	28485
DAAD07-85-D-0006	107	An Archaeological Survey of a Six Mile Fence on White Sands Missile Range North of Organ NM	18996
DAAD07-85-D-0006	108	The Small Missile Range Planning Survey and the HVM Camera Project: Archaeological Survey of 2040 Acres	23920
DAAD07-85-D-0006	109	EOVAF Monitor	
DAAD07-85-D-0006	110	The Range Road 7 at Sheep Mountain Project: An Archaeological Survey of 830 Acres	35776
DAAD07-85-D-0006	111	An Archaeological Survey of 75 Acres for a Precision Test Bed	43984
DAAD07-85-D-0006	112	Orbital Disservice Pad NASA	20369
DAAD07-85-D-0006	113	Archaeological Investigations in the HELSTF Area	21388
DAAD07-85-D-0006	114	The Deadeye Project: Archaeological Survey of Two Areas on WSMR	24275
DAAD07-85-D-0006	115	An Archaeological Survey of a Proposed Transmissometer Comparison Test Area	21092
DAAD07-85-D-0006	116	An Archaeological Survey of Rattlesnake Ridge	42855
	117	Cultural Resources Inventory of Proposed RATSCAT Modernization-WSMR	
BLM No. 5-2920-85-D	118	Summary of Cultural Resources	18385
57-8152-86-1	119	A Preliminary Report of t	
	120	Prehistoric Agriculture F	
	121	A Cultural Resource Inventory of Approximately 1200 Acres of Land at the NASA White Sands Test Facility Near Las Cruces, NM	20522
BLM No. 57-2920-87-C	122	Cultural Resources of the Alluvial Fan Zone on the West Side of the San Andres Mountains	21337
DAAD07-85-D-0006	123	The 15-Mile Fence Project: An Archaeological Survey Along the Northern WSMR Boundary	24647
DAAD07-85-D-0006	124	Archaeological Investigations of an Underground Fiber Optics Line Along Range Road 1	27982
DAAD07-85-D-0006	125	The West That Was Forgotten: Historic Ranches of the Northern San Andres	
DAAD07-85-D-0006	126	FAADS-LOS-F-H	23676
DAAD07-85-D-0006	127	Archaeological Survey of 144.4 Acres Near Trinity Site	24278
DAAD07-85-D-0006	128	GBL Testing, Monitor	24649
DAAD07-85-D-0006	129	Archaeological Survey of 72 Acres Near Launch Complex 38	24650
Permit No. COE-AD-89-1	130	Aguirre Springs Rd Phone	25203
DAAD07-85-D-0006	131	Archaeological Survey of Five Optical Tracking Locations On WSMR	27983
DAAD07-85-D-0006	132	Mountain of Sunlit Silence (FY89 Inventory)	35780
DAAD07-85-D-0006	133	Archaeological Clearance Survey for a Proposed Communications Corridor on NOP	31836
BLM No. 57-2920-88-D	134	An Archaeological Clearance Survey of 320 Acres of BLM Land Near NASA-WSTF	20751
	135	Archaeological Survey of	

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
	136	Archaeological Survey of Bear Creek Drainage & Adjacent Areas for NASA-WSTF/Lockheed	21021
	137	An Archaeological Clearance Survey of 690 Acres of NASA-WSTF Land in the Foothills of Quartzite Mountain	21024
	138	Isolated Buried Hearth Site on BLM Land Near NASA White Sands Test Facility	21338
Arch. Permit 88-035	139	640 Acres of State Trust Land for NASA-WSTF/Lockheed	21023
DACW63-86-D-0010	140	The 1986 GBFEL-TIE Sample Survey-NASA, Stallion, & Orogrande Alternatives	24216
DACW47-88-D-0008	141	THE HOLLOMAN TEST TRACK IMPACT AREA ARCHAEOLOGICAL SURVEY	25754
None-In House	142	Archaeological Survey of Proposed Asbestos Landfill	
	143	Archaeological Survey of	
	144	Survey of Seven Well	
	145	Cultural Resources Inventory for a Proposed Septic Drainage Field Stallion Range Camp	22778
DACA63-84-C-0215	146	Towards an Archaeology of Landscape: The Border Star 85 Survey	24868
Unknown	147	An Archaeological Reconnaissance of Certain Construction Areas Within the Boundaries of WSMR	
	148	LA 64084 Mitigation and Monitoring of GBFLTIE Facilities	
DAAD07-85-D-0006	149	MLRS WALT Site BCW	28486
DAAD07-85-D-0006	150	Navy Gun (16")	28487
DAAD07-85-D-0006	151	Archaeological Clearance Survey of a 9 Mile Long Proposed Communications Cable Line to SHOT Site	28488
Permit No. COE-AD-90-1	152	An Archaeological Survey of 200 Acres at Victorio Peak	None
DAAD07-89-D-0050	153	A Cultural Resource Survey for 19 Camera Locations on WSMR	36760
DAAD07-89-D-0050	154	Archaeological Investigations at Site LA 72859 Near C Station (MOTR)	28490
DAAD07-89-D-0050	155	An Archaeological Survey of the Dust & FLIR ABC-1-A, ABC-1-B & ABC-1-C	35194
DAAD07-89-D-0050	156	Archaeological Survey of the LBTS Project Area	35880
DAAD07-89-D-0050	157	Inventory Estey NR Nom	57722
DAAD07-89-D-0050	158	GBL	
DAAD07-89-D-0050	159	Archaeological Survey of a Flare Bunker Location Northeast of the Main Post Area	42189
DAAD07-89-D-0050	160	Archaeological Clearance Survey & Monitoring for the Kinetic Energy Missile Project in the SMR Area	35195
DAAD07-89-D-0050	161	The SAWS Archaeological Project: An Archaeological Inventory Survey of 3900 Acres East of Mine Site	31466
DAAD07-89-D-0050	162	Archaeological Clearance Survey for an Impact Assessment at the Orogrande RR Spur	31317
DAAD07-89-D-0050	163	Monitoring at ROWL Site During Expansion Construction of a Helicopter Pad (Letter Report)	44639
NONE	164	Archaeological Survey Report for Organ Mountain site for Contel Celluar	28081
NMSHTD 89-77	165	Cultural Resource Survey Along proposed Reroute of US 380	26699
NONE	166	Archaeological Survey of Atmospheric Sciences Lab Meteorology Lab	25360
	167	Cultural Resource Survey of State Road 380 East of Bingham, NM	19164
NONE	168	Archaeological Survey of Soledad Waterline	38997
DNA001-89-C-0014	169	Effects of the Misers Gold	
NONE-In house report	170	Communications Line, C-Station to Condron Field	38996
	171	Duplicate of Project # 16	
Unknown	172	530 Acres of NASA-WSTF Land-Slopes of Quartzite Mountain	26086

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
DAAD07-89-D-0050	173	Archaeological Clearance Survey for the Navy 16-Inch Gun Facility Near SW 50 Site	31838
DAAD07-89-D-0050	174	Archaeological Monitoring of the Ova Noss Family Partnership GPR & Entry Mapping Expedition	
DAAD07-89-D-0050	175	Reevaluation of Archaeological Sites in the Capitol Peak Valley	37998
DAAD07-89-D-0050	176	A Cultural Resources Survey of About 70 Acres at the Nuclear Effects Lab	32711
DAAD07-89-D-0050	177	Archaeological Investigations at the Richardson Ranch Training Facility	39059
DAAD07-89-D-0050	178	SRAM II	40883
DAAD07-89-D-0050	179	Archaeological Testing at the Navy 16" Gun Site	31838
DAAD07-89-D-0050	180	An Archaeological Survey of the Proposed Boundary Fence for the Ground Based Laser Facility, Strategic Defense Initiative	44908
DAAD07-89-D-0050	181	Northern San Andres Sample Survey (FY '90 Inventory)	44691
DAAD07-89-D-0050	182	Victorio Battlefield	
P.O. PSL 11296PR	183	The Aerial Cable Test Capability Project: An Archaeological Evaluation of the Jim Site & Fairview Alternatives	35759
DAAD07-89-D-0050	184	Archaeological Clearance Survey of 92 Acres for Naval Aerial Weapons Testing Area	36185
DAAD07-89-D-0050	185	Bliss '90 (Chronometric S	0
DAAD07-89-D-0050	186	Cultural Resource Survey of 2 Proposed Communication Lines to the Hardin Ranch & Telles Sites	45630
DAAD07-89-D-0050	187	A Cultural Resources Survey for Eight Locations for the Non-Line-of-Sight Exercise	39058
DAAD07-89-D-0050	188	Inventory Survey of Eight Sample Units in the Northeastern Oscura Mountains	60380
DAAD07-89-D-0050	189	Trinity '91	
DAAD07-89-D-0050	190	Ranches and Mines '91	60403
DAAD07-89-D-0050	191	Archaeological Survey of Proposed PHIL Site Launch Area and Communications Cable Route	36368
DAAD07-89-D-0050	192	Archaeological Survey of a Proposed Remote Interferometer Measuring Station	45627
	193	A Phase IA Cultural Resources	
	194	A Phase IA Archaeological	
	195	An Archaeological Survey of 7.0 Acres Near State Road 380	27941
	196	An Archaeological Survey of 20 Acres Near State Road 380	28857
DACW47-88-D-0008	197	Archaeological Testing of	
DACA63-87-D-0028	198	Small Site Distributions and Geomorphology: Landscape Archeology in the Southern Tularosa Basin-Volume 1	35899
	199	An Environmental Assessment	
	200	Cultural Resources Invent	
DAAD07-89-D-0050	201	An Archaeological Clearance Survey for a Proposed Buried Cable Line to the Search Site Near Stallion Range Center	45663
DAAD07-89-D-0050	202	Archaeological Testing of Site LA 81536 Located on the Crest of the Oscura Mountains	35759/4468
DAAD07-89-D-0050	203	Arch Survey of 31.6 Acres for a Proposed Construction Area & Access Road Near Brillo	45669
DAAD07-89-D-0050	204	Archaeological Survey for the ABC-1 Target LAT and MAT Locations	37307
DAAD07-89-D-0050	205	Archaeological Survey for U.S. Border Patrol Drag Roads Near Orogrande	50531
MEVATEC	206	C Station Water Line	
DAAD07-89-D-0050	206	Russ Project: Archaeological Survey of 87 Acres for a MOTR Installation at Three Rivers	45703

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DAAD07-89-D-0050	207	The HAWK-137 Project: An Archaeological Clearance Survey of 120 Acres Near Oscura Range Camp	45599
DAAD07-89-D-0050	208	Archaeological Clearance Survey of 44 Acres for SAWS III/ASWIX in the Trinity Basin	40888
DAAD07-89-D-0050	209	The EMPS Project: An Arch Survey Within Four Areas on WSMR	45585
DAAD07-89-D-0050	210	Archaeological Clearance Survey for NE-CI and ATACMS FIX Locations	40889
DAAD07-89-D-0050	211	The FAADS EIS Study: Sample Survey of Twelve Areas on WSMR	45590
DAAD07-89-D-0050	212	Archaeological Clearance Survey for the Hayfield ATACMS Location	45604
57-8152-86-1	213	The NASA-STGT Excavations	
Cult. Res. 70-2920-91-D	214	A Cultural Resource Survey of US 70 Over the Organ Mountains	37298
None-Volunteer	215	Rancharia Spring: Haven for the Mescalero Apaches	
	216	Ova Noss Family Partners	
DACA63-91-C-0100	217	Landscape Archeology in the Southern Tularosa Basin	
*	218	Archaeological Survey of the BAT Test Area	44926
DAAD07-89-D-0050	219	WSMR Spring Reconnaissance Survey	45295
DAAD07-89-D-0050	220	Archaeological Survey for a Proposed Work Area around Building 25850, Rampart Site	44721
DAAD07-89-D-0050	221	Archaeological Test Excavations as Site LA 59153, Evaluation of Sites LA 59141 and LA 59142 and Survey of 11.5 Acres Red Rio	41550
DAAD07-89-D-0050	222	Archaeological Survey Results for a LIDAR Laser Range Installation	45602
DAAD07-89-D-0050	223	An Archaeological Survey of 75 Acres for a Proposed Helicopter Pad North of Rhodes Canyon RC	44717
DAAD07-89-D-0050	224	Survey of an Access Corridor and Testing of 3 Sites for the DNA DIPOLE Test Bed	45606
none	225	JTF-6 Overview	0
Subcontract 29-930041-82	226	The EMP Simulator Project: Arch Survey of the Orogrande Site	42856
DAAD07-89-D-0050	227	Roving Sands/Hotel	
DAAD07-89-D-0050	228	Trinity at Fifty: Trinity Site NHL-New Mexico Technical Report No 1	44943
DAAD07-89-D-0050	229	CR Records	0
	230	Final Report: GIS Database	
	231	Yard Area, Sand and Gravel Pits and Haul Roads near Bingham, NM for J Hamilton Construction	39543
	232		
	233	Borrow Pit and 3 Waste Areas Near Bingham, NM for James Hamilton Construction	39741
	234		
	235	4.75 Mile Long Access Road	40577
	236	A Cultural Resources Survey of 185 Acres for the Proposed DNA High Explosive Testing Site	45067
DACA63-91-C-0100	237	Landscape Archeology in t	
	238	An Archaeological Survey	
DAAD07-89-D-0050	239	Cultural Resources Survey of 38 HA (93.5 Acres) of ROW along RR 347 to Sulf Site	45601
DAAD07-89-D-0050	240	SSRT (Letter)	
DAAD07-89-D-0050	241	An Archaeological Survey for LOSAT, A target Area	63004
DAAD07-89-D-0050	242	Archaeological Investigations for the SAFEAIR Project East of WSMR HQ	43531
DAAD07-89-D-0050	243	Effects of the Minor Uncle Event on the George McDonald Ranch House Trinity Site NHL	none
DAAD07-89-D-0050	244	Ranch Legacy	
DAAD07-89-D-0050	245	Archaeological Clearance Survey for Proposed Shist Drill Site Area	43780
DAAD07-89-D-0050	246	Archaeological Investigations of a Trespass in the Jarilla Mountains	44613

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DAAD07-89-D-0050	247	Mitigative Documentation of Nine Quonsets in the Post Area	
DAAD07-89-D-0050	248	HAFB	45380/4637
DAAD07-89-D-0050	249	Cultural Resources Survey of 15 HA (37 Acres) for a Proposed MOTR Radar Installation at Rita	44719
DAAD07-89-D-0050	250	Testing Results from Site LA 99591, for a DNA Trespass	44682
DAAD07-89-D-0050	251	Stabilization Plan for the V-2 Rocket	
DAAD07-89-D-0050	252	NR Noms '93	57722
DAAD07-89-D-0050	253	Riparian II	
DAAD07-89-D-0050	254	An Archaeological Survey of the Test Complex 31 Facility Near Dog Site	47413
DAAD07-89-D-0050	255	Cultural Resources Survey of 31 HA (77 Acres) for a Proposed HERA Construction Area at LC32	62997
92-035	256	A Final Report of the Arc	
	257	An Archaeological Clearance	41542
none	258	NEXRAD Radar Complex Cultural Resources Survey for HAFB	42521
	259	48th Air Rescue Squadron	43144
Subcontract 94S-0031-SB4	260	An Archaeological Survey of the Original ET-FIX Area AKA; Cultural Resources Inventory of 3 Area For WSMR FIX THAAD Sites	46561
DAAD07-94-D-0104	261	Trinity-Includes excavations at Trinity Shelters and commo lines	
DAAD07-94-D-0104	262	Additional Archaeological Survey at the G20 and G25 Impact Areas	45818/4890
DAAD07-94-D-0104	263	Archaeological Investigations at the ACTC Camera Sites Project Area	46146
DAAD07-94-D-0104	264	Cultural Resources Survey for a Proposed Bird Site Construction Area	
DAAD07-94-D-0104	265	Survey and Monitoring of the FJBT Project	45917
DAAD07-94-D-0104	266	Archaeological Monitoring of the Ova Noss Family Partnership Excavation Activities at Victorio Peak	60414
DAAD07-94-D-0104	267	Addendum to the Curation Guide for White Sands Missile Range: The Electronic WSMR Catalog System	0
DAAD07-94-D-0104	268	Lucero, Stabilization	48040
DAAD07-94-D-0104	269	Star Throwers of the Tularosa	56033
DAAD07-94-D-0104	270	An Archaeological Sample Survey of the Stinger & Chaparral Missile Impact Area	47407
DAAD07-94-D-0104	271	Holloman Survey 94	47757
DAAD07-94-D-0104	272	Jewels of the Desert: Collections from the First Dump at White Sands Proving Ground	46870
DAAD07-94-D-0104	273	Archaeological Survey for an ATACMS-FIX Test located on Lee Ranch	47052
DAAD07-94-D-0104	274	Resurvey of 27 Archaeological Sites on the Red Rio Bombing Range	64065
DAAD07-94-D-0104	275	Ranch Legacy	0
DAAD07-94-D-0104	276	The Central San Andres Mountains Project: 1994-1995 Archaeological Sample Inventory Survey	46510
DAAD07-94-D-0104	277	Damage Assessment Survey for the Roving Sands 94 Exercise	47584
DAAD07-94-D-0104	278	An Archaeological Survey of the Proposed THAAD MAB at LC-37	47442
DAAD07-94-D-0104	279	Archaeological Survey of the Proposed Patriot MAB and Access Roads at LC38	47597
DAAD07-94-D-0104	280	Archaeological Monitoring of the Ova Noss Family Partnership Excavation Activities at Victorio Peak	60414
DAAD07-94-D-0104	281	Ranches & Mines FY 95	48040
DAAD07-94-D-0104	282	Trinity at 50. Technical Report No. 2. Archaeological Survey and Reconnaissance of the Trinity Site Communications Lines	47964
DAAD07-94-D-0104	283	Unknown Project that Recorded a bunch of Sites-ARMS has reference to a Cold War study	49111
DAAD07-94-D-0104	284	Arch. Survey & Monitoring Activities along HERA Road & LC 94 Buried Commo Line	48222

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DAAD07-94-D-0104	285	An Archaeological Survey for the THAADS Project, White Sands Nat'l Mon	62633
DAAD07-94-D-0104	286	Archaeological Survey for the SHIST/Burris Well Areas	48396
NM DOT	287	A Cultural Resource Survey of 12.8 Kilometers (8 Miles) Along US 380 Near Bingham	45596
Batcho and Kaufmann	288	A Final Report of the Archaeological Mitigation of Site LA 101419 on the NASA WSTF	46050
Arch Services by Laura Michalik	289	An Archaeological Clearance Survey of 9.8 Miles of Proposed Waterline ROW, Booster Pump Site, 2 Water Wells & a Tank Site	45870
DAAD07-94-D-0104	290	Monitoring of the Placement of Stakes Around Facilities to be Used for Roving Sands 1995	
DAAD07-94-D-0104	291	Survey for Three MLRS Site Expansion Project	48907
DAAD07-94-D-0104	292	Archaeological Survey of the Proposed Patriot Missile Launch Sites and Road at LC-32	60305
DAAD07-94-D-0104	293	Exhibit	0
DAAD07-94-D-0104	294	Archaeological Monitoring of the Ova Noss Family Partnership Excavation Activities at Victorio Peak	60414
DAAD07-94-D-0104	295	Archaeological Survey of the HERA Missile Recovery Route	49247
DAAD07-94-D-0104	296	Archaeological Survey of a Power Line in the FIX Area of WSMR	58801
DAAD07-94-D-0104	297	Archaeological Survey for the THAAD Project at Site WC-50, WSMR	50325
DAAD07-94-D-0104	298	An Archaeological Survey of 10 Miles of Proposed Electric Transmission Line on the Oscura Mtns Escarpment	50052 or 5
DAAD07-94-D-0104	299	Legacy Resources Management Program-Ranching Oral History Project-Final Report	
DAAD07-94-D-0104	300	Tula Ecosystem	0
DAAD07-94-D-0104	301	McDonald Brothers Ranch Adobe House: Roving Sands Damage Report and Repair and Integrity Preservation	
PSL 60628BP	302	An Archaeological Survey of the Fiber-Optic Cable ROW for the Eastern and Western TSN	50197
DAAD07-94-D-0104	303	An Archaeological Survey of an Area Near Lumley Lake and an Area Near Capitol Peak	51520
DAAD07-94-D-0104	304	Archaeological Monitoring During the Recovery of Two Rocket-Launched Navy Rounds Near HELSTF	
DAAD07-94-D-0104	305	An Archaeological Survey of Two Proposed Drop Zones in Helms Valley	
DACA63-93-D-014	306	An Archaeological Survey of 220 Miles for TSN	45382
DAAD07-94-D-0104	307	Nat Reg 96 (Multiple)/Hem-Lava Gap Site Recordation	54764
DAAD07-94-D-0104	308	An Archaeological Clearance Survey at the DATTS Reactor Complex	66287
DAAD07-94-D-0104	309	CR Records	0
DAAD07-94-D-0104	310	TSN East Monitoring/Fiber	
DAAD07-95-C-0125	311	From Playas to Highlands: Paleoindian Adaptations to the Region of the Tularosa	56460
DAAD07-94-D-0104	312	Demolition 8 Bldgs.	
DAAD07-94-D-0104	313	Archaeological Survey of Proposed HAWK Launch & Support Facilities: Chew Site	
DAAD07-94-D-0104	314	Test Excavations at LA 78235, Near Burris Well	58748
DACA63-93-D-0014	315	The Air Force Special Weapons Complex Cultural Resources Survey	49615
	316		
unknown	317	Cultural Resource Survey of the Proposed DIPOLE-SAMPSON Project Area (report has 2 versions with 2 different titles)	53995
DACA63-93-D-0014	318	Red Rio Roads and Primary Impact Area Cultural Resources Survey	49802
DACA63-93-D-014	319	Archaeological Survey of 71 Acres Adjacent to AMRAD	49140

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DAAD07-97-D-0104	320	An Archaeological Survey of 2.79 Hectares (6.9 Acres) for Explosive Bunkers Near the PHETS Admin Area	60415
DAAD07-97-D-0104	321	Archaeological Survey (Private) for the Storm II MTTV Impact Target	57772
DAAD07-97-D-0104	322	Navy Bldg. Documentation	
DAAD07-97-D-0104	323	Archaeological Survey & Historic Properties Identification Program for the Tactical High Energy Laser (THEL) Project	
DAAD07-97-D-0104	324	The Salinas de San Andres Trail-A NRHP Multiple Property Documentation	59253
DAAD07-97-D-0104	325	Ranches & Mines IV	60629
DAAD07-97-D-0104	326	Exhibits	
DAAD07-97-D-0104	327	ACR Powerline Monitor	
DAAD07-97-D-0104	328	Oral History Video	
DAAD07-97-D-0104	329	Trinity	
DAAD07-97-D-0104	330	Report on Integrity Preservation at the McDonald Brothers Ranch Corral, Trinity Base Camp	0
DAAD07-97-D-0104	331	TSN Monitoring	
DAAD07-97-D-0104	332	Nat Reg Nom FY 98	
DAAD07-97-D-0104	333	Cultural Resource Records	0
DAAD07-97-D-0104	334	Hembrillo Battlefield	79401
DAAD07-97-D-0104	335	CR Records Database	0
DACA63-93-D-0014	336	Oscura Gunnery and Bombing Range Cultural Resources Survey	50198
DAAD07-97-D-0104	337	Web Exhibits: Three Lesson Plans from the Series "Lessons From the Past"	0
DAAD07-97-D-0104	338	An Archaeological Survey of the THEL Impact Target Locations	60222
DAAD07-95-C-0125	339	Historic Property Identification Efforts of Four Solid Waste Management Units on WSMR	60440
DAAD07-97-D-0104	340	Up range Build Recordation	
DAAD07-97-D-0050	341	An Archaeological Survey of 358.6 Acres of Proposed Runway Extension Near Stallion	61277
DAAD07-97-D-0104	342	22 Buildings	0
DAAD07-97-D-0104	343	Data Recovery for Site LA 78235, Area 5 at Burris Gap	89626
DAAD07-94-D-0104	344	The Trinity Experiments	
DAAD07-97-D-0050	345	Cultural Resources Inventory of 11 Ac (4.4 Ha) at LC 38	62146
DAAD07-97-D-0104	346	Final Report of Integrity Preservation at Rock House Spring (Site LA 104049)	None
DAAD07-97-D-0104	347	Final Report on Integrity Preservation Efforts at the Miller Ranch HQ (Site LA 116347)	70396
DAAD07-97-D-0104	348	Bright Eyes	62868
DAAD07-95-C-0125	349	Results of Data Recovery Excavations at Site LA 121626, Near Rhodes Canyon	60440
DAAD07-95-C-0125	350	Historic Property Identification Efforts for an 3.57 Hectare (8.82 Acre) extension of Main Post Landfill #2A	60440
DAAD07-97-D-0104	351	ICRMP	0
DAAD07-97-D-0104	352	Manual for Processing Archaeological Records, Photographs, and Collections, White Sands Missile Range, New Mexico	0
DAAD07-97-D-0104	353	An Archaeological Survey of 1.4 Miles of ROW to Gowain Site	63712
DAAD07-97-D-0104	354	Trinity 99	0
DAAD07-97-D-0104	355	LW Well Preservation Plan	0
DAAD07-97-D-0104	356	Archaeological Survey, Monitoring and Damage Assessment on Parcels Near Range Routes 13 and 26 and Along Roads at EMRE	64583
DAAD07-97-D-0104	357	Hembrillo Battlefield Pre	0
DAAD07-95-C-0125	358	Cultural Resource Survey of Main Post Landfill and Proposed Extension Area	65069

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DAAD07-97-D-0104	359	T-149 Interpretive Sign	0
DAAD07-97-D-0104	360	Cultural Resource Survey of the Stallion Range Center Landfill Extension Area	65868
DAAD07-97-D-0104	361	An Archaeological Survey and Relocation of Sites Along Range Road 2	73881
DAAD07-97-D-0104	362	Building Survey	
DAAD07-97-D-0104	363	Cultural Resource Records	0
DAAD07-97-D-0104	364	ICRMP FY00	
DAAD07-97-D-0104	365	Excavations at the West 800 Instrumentation Shelter Trinity Site NHL	84014
DAAD07-97-D-0104	366	Archaeological Survey Along Range Road 7 Near Tortilla Flats	67177
DAAD07-97-D-0104	367	Ranches/Mines Survey V	71036
DAAD07-97-D-0104	368	Trinity National Register	
DAAD07-97-D-0104	369	Miller Sign	
DAAD07-97-D-0104	370	Preservation Plan for the Greer House (Site LA 116340)	
DAAD07-97-D-0104	371	Cultural Resources Inventory of 34.6 AC (14 HA) of Harriet Powerline and Zurf Fiber Optic Line	67059
DAAD07-97-D-0104	372	THEL 1K Survey	
DAAD07-97-D-0104	373	A Cultural Resource Survey of the CHU SAM I and III Areas	67917
Mevatec 00S-2038	374	Cultural Resources Survey of Main Post Landfill No. 3 and Borrow Area	70717
Mevatec 00S-2038	375	An Archaeological Survey of 9.2 Miles of a Proposed Fence Line on WSMR, Socorro Co	72003
DAAD07-95-C-0125	375	Archaeological Monitoring of In Boundary Fence Construction	81353
DAAD07-97-D-0104	376	TSN II Monitoring	
DAAD07-97-D-0104	377	A Cultural Resource Survey of the Chu SAM Area, Phase II	70717
WSMR Internal	378	Archaeological Survey of Radar Areas at Bell and Harriet Sites	71224
Mevatec 00S-2038	379	Mevatec Buildings	0
Mevatec 00S-2038	380	General's Tour-KWL	0
Mevatec 00S-2038	381	Cultural Resource Records	0
Mevatec 00S-2038	382	Trinity FY 01	
Mevatec 00S-2038	383	ICRMP Update	
Mevatec 00S-2038	384	Archaeological Monitoring of 69 Sites for the Test Support Network Fiber Optic Cable Project	80389
Albuquerque District USACE	385	A Cultural Resources Inventory & Biological Survey of Approx. 37 Hectare	67873
Mevatec 00S-2038	386	Preliminary Report on Status of a Cultural Resource Inventory Survey in Support of the Upgrading of Water Lines S of LC 33	75556
Mevatec 00S-2038	387	Arch Clearance Surveys in Support of TSN Cable Installation on WSMR at Parker, SMR Salt Creek Dead Horse, Updoc, Trevor & Ben	78458
In house	388	Bob Burton Recovery of Chupadero B/W pot	73280
NOT USED	389	not used	
Parsons-Brinckerhoff	390	Cultural Resources Survey US 70/WSMR Interchange	80112
Walcoff 01-1	391	Denver, Rhodes wells	
Walcoff 01-2	392	An Archaeological Survey of Four Monitoring Wells and Landfill at PHETS	74563
HSR 2001-7	393	SHIST Expansion	
HSR	394	An Archaeological Survey of 8.42 Miles (89 Acres; 36 HA for a Proposed Water Line Right of Way Near C Station	75556
Walcoff 01-3	395	An Archaeological Survey of LOSAT Target Impact Areas	75073
Walcoff 01-5	396	An Archaeological Survey of 44 Acres at DOG Site	75393
Walcoff 01-6	397	An Archaeological Survey of 2 Acres Near Norma Site	75555
Lone Mt 550	398	An Archaeological Survey in Support of the hard Target Defeat Testbed Project	74181
HSR 2001-13	399	THEL ROAD	75996

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Walcoff 01-9	400	An Archaeological Survey of 18 Acres Near BECKAGE SITE	76303
Walcoff 01-8	401	Monitoring Report for Launcher Area L-001 Near Norma Site	76355
Walcoff 01-11	402	An Archaeological Survey of a Proposed Road at Chile Launch Site	77240
Walcoff 02-01	403	An Archaeological Survey Near Beckage Site	77455
HSR	404	Archaeological Survey of Instrumentation Sites for GLINT	78428
HSR	405	B-122 Sign	0
HSR	406	ICRMP Doc	
HSR	407	UXO Monitor	
HSR	408	Monitoring Activities for Corrective Measure Implementation at Solid Waste Management Units North Oscura Peak	79195
HSR	409	Archaeological Survey of 5 Acres (2 ha) for a Proposed Fenceline Around Portions of Site LA 116559, the Missile Graveyard	77372
HSR	410	Historic Bldg. Surveys	0
HSR	411	Archaeological Survey of 2.3 Miles for a Proposed Access Road From Trevor Site to Vic Site	77371
HSR	412	Trinity Site Signs	
HSR	413	CRR FY02	0
HSR	414	ICRMP Part 2	
Walcoff	415	An Archaeological Survey of a Proposed Monitoring Well Adjacent to Lee's Impact Area	77657
Walcoff	416	An Archaeological Survey of a Reroute of a Portion of Road, A Staging Area and Relocated Staging Area in Capitol Canyon	78078
Walcoff	417	A Pedestrian Survey of 640 Acres Near the AFSWC Target	78672
Walcoff	418	Archaeological Survey of Alex Site and a Nearby Location for the LPT Project	78753
Walcoff	419	An Archaeological Survey at Phillips Hill	79086
Walcoff (Lone Mt.)	420	An Archaeological Survey of 243 Acres within the Hazardous Test Area Site	79266
Walcoff	421	An Archaeological Survey of an Area Near LC-50	79310
HSR	422	Archaeological Evaluation and LA Site Record Update of Site LA 1204, Prairie Spring	79332
HSR	423	Mortar Site	
None	424	Bike Trail/Mound Springs	
Walcoff	425	An Archaeological Survey of a Linear Area Near LC-50	79750
HSR	426	An Archaeological Survey of 6.2 Km (4.2 Mi) Near Rattlesnake Ridge	79514
Walcoff	427	An Archaeological Survey of Two Proposed Instrumentation Sites North of Launch Complex 50	79989
Walcoff	428	An Archaeological Survey of a Lance Launch Site Near LER-4, Otero County and 2 Lance Aim Points	80078
Chris Ellison	429	Building 1592, The Von Braun Bunker. Testing in the Early Phases of the V-2 Project Hermes	
Garcia and Associates/ARI	430	Archaeological Damage Assessments Report for the Gold Camp Site	
ACOE Seattle District	431	100/500K NR Nom	
DAAD07-95-C-0125	432	The Results of Test Excavations at an Agave Roasting Midden at Site LA 72860	88040
HSR	433	Archaeological Survey of Five Springs in the Mound Springs Area of WSMR	80203
HSR	434	Recording of Seven Archaeological Sites Along the Proposed WSMR Bike Trail	80590
HSR	435	HTA Sites	80292
Walcoff	436	An Archaeological Survey of LOSAT Short-Range Target Area Near LC-50	80340

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Walcoff	437	Alex Site Monitoring	80930
Walcoff	438	An Archaeological Survey of LOSAT Long Range Target Area	80940
Walcoff	439	An Archaeological Survey of a Proposed Extension for a Planned Short-Range Target Area Near LC 50	81089
Walcoff/Geo-marine	440	An Archaeological Survey of the LPT Impact Area on WSMR	81972
HSR	441	Letter Report: Archaeological Survey of 52 UXO Sign Locations at COMA Site	81425
Walcoff	442	An Archaeological Survey of a Stationary Target Area Near Fisk Site	81482
Walcoff	443	An Archaeological Survey of LOSAT Midrange Target Area	81589
HSR	444	An Archaeological Survey at the Waste Water Treatment Facility	81719
HSR	445	Gowan Site Monitor	
Walcoff	446	An Archaeological Survey of a Hellfire Missile Launch Site and Target Area Near G-25	82129
HSR	447	An Archaeological Survey of 1.83 km (1.14 MI) of the Soledad Waterline Path	82132
Walcoff	448	Eyeball Arch Monitor	82263
Walcoff	449	An Archaeological Survey of a Proposed Missile Assembly Building and An Explosive Storage Building Near LC-50	82624
Walcoff	450	Monitoring Report for Fiber Optics Cable Installation Near Capitol Peak	82892
Walcoff	451	An Archaeological Monitoring Report for UXO Sign Locations in Lincoln and Socorro Counties	83199
HSR	452	THEL Impact Area Site Mon	
DAAD07-95-C-0125	453	Final Report-An Archaeological Inventory of Four Areas: The Salt Creek Survey Area; Tinaja Sheep Camp; Huntington Pueblo;	83523
HSR	454	Archaeological Monitoring of Sites LA 138557 and LA 138559 Associated with the Replacement of the Soledad Waterline	83579
Walcoff	455	An Archaeological Survey of Two Proposed Impact Areas Near Minnow Site	83785
Walcoff	456	An Archaeological Survey of a 1.2 Acre Area at Chile Launch Site	84418
Walcoff	457	monitor near LC33	84538
Walcoff	458	An Archaeological Survey of 12 Acre Area at Coker Site	84996
Walcoff	459	An Archaeological Survey of Five Acres for the Installation of a Portable Metal Magazine Near Vandal 1 Site	85117
HSR	460	An Archaeological Survey of Four Monitoring Well Locations at LC 38	85158
Geomarine	461	A Cultural Resources Investigation for the War Road Revitalization Project	81233
	462	An Archaeological Inventory Survey of 5.14 HA (11.5 AC) Encompassing Two Tracts of Land for Proposed Renewable Energy Study	85117
DABK39-03-P-1099	463	Magnetic Mapping at the Adobe Walls (LA 32079) and Indian Tank (LA 59560) Pueblos	
Doria	464	GPR Survey at Indian Tank	
WSMR Volunteers	465	Report on the Recording of the Jaggedy Site (LA 139863)	84030
HSR	466	police facility	85967
walcoff	467	Final Report-An Archaeological Survey of an Expansion of an Existing Staging Area In Capitol Canyon	85787
None-WSMR Volunteers	468	Archaeological Recording of Grandview 2 Site, LA 141737	85780
HSR	469	An Archaeological Survey of 4/95 Acres (2.0 Hectares) at the Denver Site	86001
HSR	470	An Archaeological Survey of 6.2 Acres (2.5 Hectares) at the Malpais Site	85967

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Northwind	471	PAD ABORT project	
HSR	472	RR 305 Survey	
HSR	473	An Archaeological Survey of 172.6 Hectares for a Cantonment Security Fence at Headquarters WSMR	87037
walcoff	474	losat midrange improvement	86705
walcoff	475	coker site addition	87131
walcoff	476	An Archaeological Survey of a Portion of fence From Denver WIT to Rhodes WIT	87142
Meade Kemrer	477	Fleck Ranch Village: A Salado Community in the San Andres Mountain	86890
Walcoff	478	An Archaeological Survey for an Existing El Paso Electric Powerline on WSMR and Fort Bliss	87289
Northwind	479	An Archaeological Survey of 1.88 ha for the Proposed New Automated RR 9 Gate	87362
Northwind	480	An Archaeological Survey of 4.89ha for the Proposed Design/Build Police Station Tula Gate	87363
HSR	481	Hembrillo Skirmish	
HSR	482	An Archaeological Monitor of Site LA 121626 at the Rhodes Canyon Landfill	89871
HSR	483	Reconnaissance Survey for a Prescribed Burn Near Dead Man Canyon	88144
HSR	484	Arsenic Sampling	
W9124Q-04-P-1060	485	An Assessment of Historic Ranching Sites at WSMR	88517
W9124Q-04-P-1065	486	Apache Rancheria Survey	90499
DAAD07-95-C-0125	487	An Archaeological Linear Survey of 73.5 Hectares (181.5) Acres and Site Recordation's Within the San Andres Mountains	88365
HSR	488	WSMR School Site Test	88853
Walcoff	489	An Archaeological Survey for the Light Training Maneuver Area	89014
Walcoff	490	An Archaeological Survey of Eleven Lightning Array System Areas	89409
Unknown	491	Archaeological Monitoring at Weston Site	89431
In-House-Pete Bullock	492	Survey of Borrow Pit on Hughes Road	
W9124Q-04-P-1218	493	Survey of 27,000 Acres Near the Cantonment	90354
W9124Q-04-P-1147	494	Archaeological Damage Assessment Report at the Bloody Hands Rock shelter	
Walcoff	495	An Archaeological Survey for an Extension of Existing LC35N Launch Area	91349
Gulf South Research	496	Cultural Resources Inventory for the National RCS Test Facility/RAMS Comprehensive Development Project	91464
Ecological Communications, Inc,	497	An Assessment of Historic Ranching Sites at WSMR	92121
None-In House report	498	Fiber Optics Survey West of Cantonment	
None-In House report	499	Red Rio Stage Road Segment	
None-In House Report	500	HUMRAAM at Ben Site	
None-In House Report	501	TSN Line to Nick and Jess Sites	
None-In House Report	502	Water Turnouts for the 416th Engineers	
In-House-Jim Bowman	503	Surface collection at various sites	
None-In House Report	504	Survey of Cantonment Berm Extension	
None-In House Report	505	Survey of Two Stinger Target Areas	
None-In House Report	506	Survey of Soil Survey Trenches	
DAAD07-85-D-0006	507	FAADS II Area and Antennae Locations Near Dog Site	23919
Dona Ana Archaeological Society	508	Rhodes Canyon Rock Art Project	77595
None-In House Report	509	Survey of a Portion of LC 37 for a Wash Rack	
DAAD-07-97-C-0108	510	Fiber Optics Cable, PVC Cable, Collimation Tower at LC 35N	96268

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DAAD07-85-D-0006	511	Damage Assessment of Site LA 60696 and Testing of LA 60747 in the FAADS Area	27331
DAAD-85-D-0006	512	A Cultural Resources Inventory of 1884 Acres in the Capital Peak Valley	7498
DAAD07-89-D-0050	513	Hotel Site (George 31) High Speed Cinetheodolite Station	
DAAD07-85-D-0006	514	Fiber Optics Commo Network Project: Survey & Testing for WSMR	24873
Unknown	515	North Oscura Peak Survey: Archaeological Studies :1988-1990	36759
None	516	Condron Field Site: Salvage Excavations on WSMR, A Preliminary Report	27456
DAAD07-89-D-0050	517	Excavations at Sites LA 81651 & LA 89556, BAT Test Track	66331
DAAD07-89-D-0050	518	Additional Archaeological Survey for the Aerial Cable Test Capability Project	44682
	519		
DAAD-07-97-C-0108	520	Condron Field UAV Maintenance Facility Survey	99314
Unknown	521	Historic American Engineering Record for Buildings 360, 362, 364, 365, 368	None
DAAD07-89-D-0050	522	Archaeological Investigations for the Proposed SAFEAIR Project Located Near the SHORAD Test Site	4560
DAAD07-89-D-0050	523	Archaeological Survey for the DNA DIPOLE Area	
	524	A Site Reevaluation For LA 101213 At Zumwalt Test Track	99474
	525	Access Road Survey	
DAAD-07-97-C-0108	526	An Archaeological Survey for the Installation of a Fiber Optics Cable South of the LC 35N Area	100968
DAAD07-89-D-0050	527	Archaeological Monitoring for the Aerial Cable Test Capability	
DAAD07-89-D-0050	528	Test Excavations at Sites LA 59150, LA 59151, & LA 59152 in the Red Rio Bombing Range	
DAAD07-89-D-0050	529	Excavation of a Hearth at Site LA 75023, Northern Jornada Del Muerto	45714
	530	Navy Impact Area near G-16	
W9124Q-06-P-0496	531	NRHP Evaluations of 130 Prehistoric Archaeological Sites in the Vicinity of the Old GBFLTIE Facility	103491
W9124Q-07-P-0081	532	Ecological Communications Survey of 7500 Acres; Contract MOD added acres	105163
DAAD07-94-D-0104	533	From Barren Desert to Thriving Community: A Social History of WSMR	
DAAD07-89-D-0050	534	Data Recovery at Sites LA 59141, LA 59150, and LA 59151	
DAAD07-89-D-0050	535	Reconnaissance Survey & Damage Assessment of the Roving Sands Trespass	
DAAD07-89-D-0050	536	An Archaeological Survey of 2 Miles of Proposed Waterline ROW from Stallion RC to the LBTS	35882
Unknown	537	Archaeological Clearance Survey of a Proposed Waste Area	
W9124Q-07-P-0101	538	NRHP Evaluations of 200 Prehistoric Archaeological Sites in the Vicinity of Orogrande Range Camp at WSMR	108888
W9124Q-04-P-1140	539	Ground Penetrating Radar Investigation Sites LA 76465, LA 76466, LA 138038, LA 138037 War Road Revitalization Project	
DAAD07-97-D-0104	540	Final Report of the Wood Frame House Preservation Activities at McDonald Bros Ranch and Trinity Base Camp	
DAAD07-85-D-0006	541	Fleck/SMR and HVM	23920
	542	Ranches & Mines FY 95	48040
DAAD07-85-D-0006	543	HELSTF-AMT, N-Bunk	31082
DAAD07-85-D-0006	544	The Navy Arena Project: An Archaeological Survey of Six Areas on WSMR	20325
DAAD07-85-D-0006	545	FAADS NLOS-EA	31318

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
	546	An Archaeological Clearance Survey of the Aero-Acoustic Research Complex	107890
	547	A Cultural Resources Survey of 29 Acres for 58th SOW Fairview Targets	107843
None	548	Small Arms Range Survey	
W9124Q-06-P-0496	549	Site Revisits and NR Evaluations-701 Sites for Test Center	110248
DAAD07-81-D-0100	550	Archaeological Survey of One Proposed Military Use Area-Ten Thousand Foot Slope Range	45823
	551		
	552	Meade Kemrer Agricultural Report	
DAAD07-81-D-0100-0004	553	Archaeological Survey of 5 Proposed Construction Areas on WSMR: AMRAD OMEW, Modified Landfills, South Center 50	45828
	554	Quail Run: Archaeological Data Recovery Excavations at LA 51225	108748
W9124Q-08-P-0272	555	HABS Documentation of Building # 122 (Former Officer's Mess and Club)	0
W9124Q-08-P-0301	556	Archaeological Mitigation of LA 147117, a Prehistoric Site on the Lower Alluvial Fans of the Organ Mountains	118023
	557	Archaeological Survey of 316 Acres at Slick City, White Sands Missile Range, NM	112645
	558	Archaeological Survey for the Directed Energy Program at White Sands Missile Range, NM	110259
	559	Archaeological Survey for an Access Road and Parking Area at the Joint Directed Energy Test Site	112646
None-In house	560	Archaeological Survey of Four Proposed Tank Trails and Training Area for the 2nd Engineer Battalion	113221
	561	MJDETS Survey by Zia	none
W9124Q-04-D-0012	562	Archaeological Survey-Main Post Landfill Groundwater Wells/STP Ditches	91386
None-In house	563	Archaeological Survey for a Borrow Pit Expansion Along Range Road 1	113220
None-In House	564	Archaeological Survey of Two Wildlife Rain Catchment Systems	none
	565	Redefinition of LA 32078	
NEWTEC Purchase Order S27646	566	An Archaeological Survey Alternate Seismic Hardrock In Situ Test Site	89703
NEWTEC Purchase Order S27645	567	An Archaeological Survey Seismic Hardrock In Situ Test Site	89702
NEWTEC Purchase Order S27647	568	An Archaeological Survey Capitol Peak	89701
None-In house	569	An Archaeological Sample Survey of 124 Acres for the Strawberry Peak Prescribed Burn	113720
None	570	An Archaeological Survey of 47 Miles of Fiber Optics Cable Right-of-Way for Mountain Bell Telephone Co	11116
Unknown	571	Historical Significance of the Askania Cinetheodolite Towers Located on Holloman AFB and WSMR	0
	572	Excalibur Test	113875
	573	An Archaeological Survey for a Fiber Optic Line Along War Road Near C Station on WSMR	144543
	574	Arch Survey Near G 25 on WSMR Dona Ana and Otero Counties, NM	114544
W81XWH-05-2-0050	575	WSMR 1_From Paleoindian to Guided Missiles: An Archaeological Survey of 50000 Acres in the Orogrande North Range	116827
	576	Cultural Resources Survey Report of 644 Acres on the Stallion Range, WSMR	99166
	577	A Cultural Resources Inventory for the Proposed Tri-State Las Cruces to Alamogordo Upgrade Project	114201

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
	578	An Archaeological Survey Near Zumwalt Test Track	115226
	579	NRHP Evaluation for Three Archaeological Sites on White Sands	115386
B912BV-08-D-2008	580	Tin Can Scatters, Historic Ruins, Mine Shafts and Prehistoric Artifact Scatters: Results of a Cultural Resource Survey	116020
	581	Testing of Five Sites in the ACTC Jim Area and Mitigation Plan for Four Sites	40887
	582	Data Recovery at Sites LA 81589, LA 81593, and LA 81596, Aerial Cable Test Capability	65951
	583	Chile Site Survey by Zia	115782
	584	DTRA Survey-SHIST Access Road	115803
DAAD07-81-D-0100-0012	585	Archaeological Survey of Three Proposed Military Use Areas on WSMR: Zurf Laser Target Roads, Static, NORMA Laser Target Road	None
None	586	Archaeological Survey of a Proposed Upgrade to the MAR Site Waterline	115933
DAAD07-89-D-0050	587	Monitoring, Testing, and Martin Ranch Studies in the BAT Test Area-Phase I	66328
	588	A Cultural Resources Inventory and Biological Survey of Approximately 37 Hectares on WSMR	67873
W9124Q-08-P-0301	589	Archaeological Mitigation at LA 147118 and LA 147144, Two Prehistoric Sites on the Lower Alluvial Fans of the Organ Mountains	118023
W9124Q-09-P0201	590	An Archaeological Survey for the Mountain Village Site	117230
Unknown	591	Report on an Archaeological Survey of Selected Portions of the US 70 Corridor	22466
W9124Q-10-C-0504	592	NR Evaluation for Archaeological Site LA16272 (LA100784) Near Shist Site	116789
	593	NR Evaluation of 10 Sites at LC 32	116790
	594	An Archaeological Site Assessment of LA 32078 for the Heavy Brigade Combat Team Area	116791
W9124Q-09-p-0201	595	Lizard Village: Data Recovery Excavations at LA 32078, WSMR	116792
W81XWH-09-2-0146	596	Corn, Cockleburs, Crickets: Life Along the Playas. National Register Eligibility Evaluation of 10 Sites at LC 38	118558
None	597	Archaeological Survey at the THEL Site for the Placement of Concrete Pads	117377
Meade Kemrer	598	LA 35337: An Upland Fourteenth Century Village, Dona Ana County, New Mexico	89111
Garcia and Associates	599	Archaeological Damage Assessment Report for Victory Mine (LA 108149)	84010
Garcia and Associates/ARI	600	Archaeological Damage Assessment Report for the Cascabel Mortar Site	84011
DAAD07-89-D-0050	601	Additional Archaeological Survey at the Test Complex 31 Facility Near Dog Site	47413
	602	Cultural Resource Survey for Proposed Structural Improvements to VO Bar Ranch Allotment	115209
	603	Addendum to VO Bar Report for WSMR Access to Install a Drinker	116216
None	604	Late Pueblo Occupation in the Southern San Andres Mountains, South Central NM	
DAAD07-97-D-0104	605	Final Report of the Wood Frame House Preservation Activities at McDonald Bros Ranch and Trinity Base Camp (LA 82956) Trinity	
W9124Q-10-C-0504	606	Archaeological Survey and Testing At the EMRE Test Facility	117872
None	607	Cultural Resource Monitoring Along Alamogordo Mainline in the Vicinity of LA 165417	
None	608	Cultural Resources Survey of a Proposed Tank Trail Along War Highway	

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
DAAD07-89-D-0050	609	Archaeological Monitoring of the Ova Noss Family Partnership Excavation Activities at Victorio Peak	54801
	610	Damage Assessment on Sites LA81562 and LA101232 Located in the BAT Test Area South of Stallion Range Center	66330
None	611	Survey of a Parcel for a Camera Location at Capital Peak	141270
W9124Q-04-P-1144	612	Cultural Resources Survey of 4324 Acres on WSMR	91897
Unknown	613	An Archaeological Survey of Eleven Lightning Mapping Array System Areas	89409
	614	An Archaeological Survey of an Access Road and Two Proposed Japanese Patriot Launch Sites Near West Pony	89433
Meade Kemrer	615	LA 35337: An Upland Fourteenth Century Village, Dona Ana County, New Mexico	89111
W81XWH-05-2-0050	616		
MIPR to USACE	617	A 190.68-Acre Cultural Resources Inventory of the Defense Threat Reduction Agency Intermediate Test Bed on WSMR	121172
Unknown	618	Site Salvage and Stabilization at the Bloody Hands Rock Art Site (LA 16289)	0
DAAD07-89-D-0050	619	Archaeological Monitor for an Overhead Powerline & Buried Cable in the BAT Test Area	44650
None	620	Missile Range Archaeology-Condron Field Pueblo Site	
None	621	Osteological Analysis from the Condron Field Site, LA 8673	
None	622	Archaeological Survey for the Boundary Line Fence	
None	623	An Examination of Faunal Materials From Two Archaeological Sites in Southern New Mexico (LA 8673 and LA 8697)	
None	624	Cultural Resource Survey Along US 380 Near Bingham, New Mexico	
	625	An Archaeological Survey for the Network Integration Evaluation	120264
W9124Q-10-C-0504	626	Archaeological Survey and NRHP Evaluation for One Archaeological Site for the High Powered Microwave	121062
W912BV-09-D-2026	627	A Cultural Resources Inventory Of The Advanced System Employment Project At Vick Site And Miller's Watch	120648
None	628	In House Condron Field Survey for NIE	
Mevatec 00S-2038	629	A Preliminary Report: An Archaeological Survey of 23 Miles (37 hectares) Along the Proposed Fence Line On the Central Portion of WSMR.	89280
Unknown	630	Archaeological Survey of the Three Rivers Drainage	38260
None	632	New Mexico Tech Mound Springs Mapping	NONE
	633	OPEN	
Unknown	634	An Archaeological Clearance Survey of Haul Road, Plant and Equipment Site, and Two Well Sites	3957
In House	635	Re-evaluation of SOTIM 1-LA 122287	121650
In House	636	Re-evaluation of Building 19310 at the 20 K Test Stand	121713
In House	637	Demolition of Building 23000	121821
DAAD07-85-D-0006	638	DRAFT-Non Line of Sight/Fiber Optics Guided Missile System: Environmental Assessment of Potential Impacts to Cultural Resources	
Unknown	639	Reconnaissance in the Upper Jornada del Muerto and Hembrillo Canyons and Other Special Projects	42596
In House by USFS Cibola NF	640	White Sands Missile Range Communication Tower Removal Project	121796
In House Alamo Peak	641	Survey at Alamo Peak for Installation of a septic system	
None	642	Explorations at Victoria Peak (Laboratory of Anthropology, Museum of New Mexico)	
Not Available	643	Historic Architecture Survey and NRHP Evaluation-NASA WSSH	

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
W9124Q-11-C-0504	644	An Archaeological Survey for the Extended Area Protection and Survivability System	122102
None	645	In House Survey of a Drop Zone for NIE	
W81XWH-09-2-0157	646	WSMR 2_Archaeological Survey of 19920 Acres in 12 Discontinuous Parcels on the Orogrande North Range	121255
W81XWH-09-2-0157	647	Data Recovery at LA 88662 and LA 88663	
W81XWH-09-2-0157	648	WSMR 3_Class III Survey of 17170 Areas	124555
In House	649	Mockingbird Gap Mine NR Eval and Bat Gate	122849
In house	650	Sandal Canyon Cave Recording	None
Not Available	652	San Andres Peak Helipad Survey	Unknown
In House	653	An Archaeological Sample Survey for the Field Site Prescribed Burn	123204
W9124-10-C-0504	654	A Cultural Survey and Damage Assessment of Archaeological Sites on WSMR (NIE Overrun Survey)	125607
DAAD07-81-D-0100-0009	655	Archaeological Survey of Two Proposed Military Use Areas-Launch Site LER 2 L617-Launch Site LER 3-L618	None
DAAD07-81-D-0100-0008	656	Archaeological Survey of Twenty Seven Proposed Barrow Pits and One Alternate Location	None
DAAD07-81-D-0100-0008	657	Archaeological Survey of a Military Use Area on WSMR-Direct Course Expansion	51936
DAAD07-89-D-0050	658	Archaeological Survey at the BAT Test Area Phase II, Vol 1 and 2	44926
DAAD07-89-D-0050	659	Testing of Two Sites in the BAT Test Area, Phase II	66329
W81XWH-09-2-0157	660	WSMR 4_FY 12 18000 Acre Survey	125559
PNM	661	PNM Monitor Powerline Maintenance	none
Mescalero Apache Tribe	662	Survey for Apache Ethnobotanic and Sacred Sites	
W9124Q-10-C-0504	663	Archaeological Survey for ChuSam KAI Radar Pad	124075
AmaTerra Cooperative Agreement	664	Test Ten Sites in the Coyote Training Area	124427
None	665	NMSU Field School at Cottonwood Spring-Multiple Years thru 2017	
AmaTerra Cooperative Agreement	666	Archaeological Investigation of 21 Archaeological Sites in the Vicinity of the Zumwalt Test Track at WSMR	124834
Zia Test Center Contract	667	LRLAP Survey by Zia	117710
MIPR to USACE	668	A 175.4 Acre Cultural Resources Inventory of the DTRA Intermediate Test Bed WSMR	124959
In House	669	Cultural Resources Survey of Proposed Road Improvements on Range Road 7-WSMR	125435
Zia Test Center Contract	670	Cultural Resources Survey for CCM Construction Areas at AMRAD	
HDR	671	White Sands Missile Range Cultural Resource Inventory of Sierra Maneuver Area-Paleoindian Hunting Camps to Mexican-American	125850
SRI	672	Cultural Resources Inventory and National Register Evaluation of Archaeological Sites at WSMR JUTC	126229
Zia	673	LRLAP Survey Near Brillo	117701
AmaTerra Cooperative Agreement	674	Skirting The Flow: Archaeological Inventory Along Range Road 312	125326
AmaTerra Cooperative Agreement	675	AN ARCHAEOLOGICAL SURVEY OF 47 ACRES FOR THE FWS-I EUA PROJECT ON WHITE SANDS MISSILE RANGE	126586
W9124Q-10-C-0504	676	Archaeological Survey of 18 Locations for the Short Range Precision Strike System (SRPSS)	127150
AmaTerra Cooperative Agreement	677	Salt Creek Bridge Survey	126588

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Zia Test Center Contract	678	Archaeological Survey for Aerial Cable Range Road Construction and Site Expansion	126674
US Border Patrol Contract	679	A 2.11 Acre Cultural Resources Survey for Proposed US Customs and BP Commo Tower Upgrades on NOP	119415
Zia Test Center Contract	680	Additional Archaeological Survey for the Extended Area Protection and Survivability System	127082
BLM Coring 1979	681	BLM Coring in San Andres Mtns	16614
AmaTerra Cooperative Agreement	682	Archaeological Survey of 2.7 Acres at the Red Butte Facility on WSMR	128279
AmaTerra Cooperative Agreement	683	Recon level survey of different portions of the Malpais	
Zia Test Center Contract	684	Zia Survey for 5 Inch Gun Project	
AmaTerra Cooperative Agreement	685	Archaeological Evaluation of Twelve Sites in the Burris Valley on WSMR	128121
Zia Test Center Contract	686	Recon Level Survey for MEADS Ground Level Test 2013	
HDR	687	Survey of Otero Training Area by HDR	126875
Zia Test Center Contract	688	Historic Properties Inventory in Support of Lance Missile Flight Tests-MEADS	128265
Vista Test Center Contract	689	Historic Propertied Inventory in Support of Extended Area Survivability Program	128901
Vista Test Center Contract	690	Historic Properties Inventory in Support of HEL MD Testing	128452
Geomarine CA with USAMRAA	691	Archaeological Survey and NRHP Evaluation of 12 Sites at Slick City and NRHP Eval of 16 Additional Sites	124287
AmaTerra Cooperative Agreement	692	NRHP Testing of Two Archaeological Sites Along Range Road 312	126252
AmaTerra Cooperative Agreement	693	Archaeological Testing in the Mine Site Live Fire Convoy Area	127883
AmaTerra Cooperative Agreement	694	Archaeological Investigations Along the Western Margin of the Tularosa Basin	128404
AmaTerra Cooperative Agreement	695	Range Road 5 Survey by Matt Cuba	128818
Vista Test Center Contract	696	Longbow Data Collection	
Vista Test Center Contract	697	Historic Properties Inventory in Support of the Demonstrator Laser Weapon System	129105
AmaTerra Cooperative Agreement	698	Survey at EMRE for Bataan Landing Zones	128222
Vista Test Center Contract	699	Survey for LRLAP	
Vista Test Center Contract	700	Survey for Mobile Target System for ISIS	
AmaTerra Cooperative Agreement	701	Archaeological Investigations of Historic Livestock Tanks in the Oscura Mountains	128348
Vista Test Center Contract	702	Historic Properties Inventory In Support of the IRAD Test Project	128762
UNM Cooperative Agreement	703	Re-Evaluation of LA 78235 at Burris Gap	125167
Vista Test Center Contract	704	Historic Property Inventory In Support of the Lance System Testing	128713

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HDR	705	Opportunities and Constraints-Paleoindian Hunters, Mogollon Rock Art, Rustlers, Homesteads, and Mining-Thurgood Survey	128637
Vista Test Center Contract	706	Historic Properties Inventory in Support of Non GPS Based Positioning System	128857
unk	707	Preliminary Report Archaeological Mitigation of RATSCAT Advanced Measurement Site	46616
	708	not used	
YA-512-CT7-255	709	Class I Archaeological Inventory of WSMR-Settlement Patterns of the Tularosa Basin South-Central NM	
AmaTerra Cooperative Agreement	710	Archaeological Survey of the Texas Canyon Trail for MWR	128987
UNM Cooperative Agreement	711	Test Excavations at LA 81591	126837
Not Used	712	NOT USED	
W912BV-11-D-0028	713	Between the Sand Sheets: Archaeological Survey of 2,293 Acres For a Prescribed Burn at WSMR	129534
W912BV-11-D-0028	714	NR Testing at D5	
W912BV-11-D-0028	715	Re-evaluation of 17 Archeological Sites at the Zumwalt Track (BAT Test Area) in the Jornada del Muerto	127058
AmaTerra Cooperative Agreement	716	LA107393 reevaluation at Rhodes Canyon Range Center	129113
AmaTerra Cooperative Agreement	717	Archaeological Evaluation of LA 76467 on WSMR	129134
In House	718	Survey for DTRA: Test of Sandstone for a Possible Impact Area	None
Vista Test Center Contract	719	Historic Properties Inventory of HVP Test Locations	129276
AmaTerra Cooperative Agreement	720	Archaeological Survey of 107 Acres Adjacent to Range Road Ten	129379
AmaTerra Cooperative Agreement	721	Archaeological Survey of 2700 Acres Near the Rhodes Canyon Range Center	129794
AmaTerra Cooperative Agreement	722	Cracks and Crevices: Archaeological Survey of 1600 Acres Near Oscura Range Center	129793
AmaTerra Cooperative Agreement	723	Archaeological Survey of 6432 Acres for the 2014 Network Integration Evaluation	128910
AmaTerra Cooperative Agreement	724	Murray Gravel Pit expansion survey	129437
USACE Abq District	725	A 155.32 Acre Cultural Resources Inventory of the DTRA Large Test Bed Site	129021
AmaTerra Cooperative Agreement	726	Thurgood Canyon Gravel Pit Survey	129448
AmaTerra Cooperative Agreement	727	Misc. Sites found with no undertaking	129568
AmaTerra Cooperative Agreement	728	Delineation of LA 104864	
Vista Test Center Contract	729	Navy Sensor Program Near Stallion	
Vista Test Center Contract	730	Historic Properties Inventory Report in Support of the CCTS Pad Abort Program	131737
Vista Test Center Contract	731	Cultural Resource Damage Assessment at Impact Locations Resulting From Lance Missile Tests	130647
AmaTerra Cooperative Agreement	732	NIE Rhodes Canyon "Fill in" Survey	129894

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
Vista Test Center Contract	733	Historic Properties Inventory Report in Support of the GBU 28 Impact and Recovery Assessment	130207
USACE Abq District	734	An 80.31 Acre Cultural Resources Survey of the Defense Threat Reduction Agency Granite Site at WSMR	129022
Vista Test Center Contract	735	Historic Properties Damage Assessment of a UAV Crash Location	131114
AmaTerra Cooperative Agreement	736	Reevaluation of LA 51231 on White Sands Missile Range	130381
AmaTerra Cooperative Agreement	737	Archaeological Survey of 5.38 acres for the South Well Wildlife Unit	130383
AmaTerra Cooperative Agreement	738	Archaeological Survey of 0.14 Acres for the Placement of Reptile Traps	130544
HDR Test Center Contract	739	Cultural Resource Survey for a Proposed Corridor from Oscura Gate to Thurgood Maneuver Area	130402
HDR Test Center Contract	740	White Sands Missile Range-Sierra Maneuver Area Cultural Resource Inventory and Summary	130705
Ft Bliss Contract	741	Archaeological Evaluation of 27 Sites on Red Rio Bombing Range	123913
Vista Test Center Contract	742	High Velocity Projectile	
AmaTerra Cooperative Agreement	743	National Register Eligibility Evaluation of the West Central 50 Site (WC-50)	130828
Vista Test Center Contract	744	Historic Properties Inventory in Support of the HVP Systems Testing-REC # 2014-0029	130965
AmaTerra Cooperative Agreement	745	Access road to HPM Area from War Road	
AmaTerra Cooperative Agreement	746	Archaeological Survey of 1.08 Acres for a Firefighter Training Area	131077
AmaTerra Cooperative Agreement	747	Access Road to the HPM installation	131103
Vista Test Center Contract	748	Historic Properties Inventory Report in Support of the Highwire Testing Program	131279
AmaTerra Cooperative Agreement	749	Archaeological Survey of 12.3 Acres for Fence Construction Along WSMR's Southern Boundary	131137
W912BV-09-D-2026	750	Naval Launched Test Article Parcel: Cultural Survey Report	131425
AmaTerra Cooperative Agreement	751	Seismic Locations for the SHIST Site	131432
AmaTerra Cooperative Agreement	752	JETS TLDS Target Boards	131439
In House	753	Survey of a Gravel Pit for Building 23680 Demolitions	
AmaTerra Cooperative Agreement	754	Archaeological Investigations of Six Sites at the Aerial Cable Test Facility	131141
AmaTerra Cooperative Agreement	755	NRHP Evaluation of LA 61781 and LA 135681 (Alex Site)	131299
AmaTerra Cooperative Agreement	756	Archaeological Survey of a Company Size Bivouac Area	
Vista Test Center Contract	757	USAF Light Array Survey	132110
HDR Test Center Contract	758		
AmaTerra Cooperative Agreement	759	National Register Eligibility Recommendations of the Mule Peak Site Lincoln National Forest	132081
AmaTerra Cooperative Agreement	760	Archaeological Survey of 205.31 Acres on WSMR for Salt Cedar Removal	132063

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
AmaTerra Cooperative Agreement	761	Survey of a New Conventional Target Location at Oscura Bombing Range	
AmaTerra Cooperative Agreement	762	Cultural Resource Assessment of The Green River Test Site	None
AmaTerra Cooperative Agreement	763	History of Cinetheodolite and Other Optical Tracking Technology at White Sands Missile Range, 1945-1965	
Epsilon Systems	764	A Historic Inventory for the White Sands Missile Range Small Missile Range, Dona Ana County, NM	
AmaTerra Cooperative Agreement	765	Archaeological Testing At Three Archaeological Sites Near Mine Site	131777
AmaTerra Cooperative Agreement	766	Archaeological Survey of 3371 Acres in the North Oscura Mountains	132243
AmaTerra Cooperative Agreement	767	Archaeological Survey of 88.8 Acres Near Muckerville on WSMR	132717
UNM Cooperative Agreement	768	Archaeology of WSMR-Reconnaissance Survey for Protection of Archaeological Sites Along Tank Trails	132468
In House	769	Survey of Access Road at SHIST Site for Recovery of Missed Projectile	
Open Number	770	Open Number	
CESU/UVM Cooperative Agreement	771	Condition Assessment and Treatment Recommendations	
NMSU/SRI Cooperative Agreement	772	Planning Level Study Leading to the Development to a Historic Context for WSMR	TBD
Human Systems Research	773	A Number of Things	57722
Goodwin Cooperative Agreement	774	404.5 Acres for WSMR	126667
Goodwin Cooperative Agreement	775	WSMR 5_FY 13 Large Survey	134172
W9124Q-13-D-0004	776	Cultural Resources Survey for a U.S. Navy QF 4 Target Drone Impact Recovery Near SW70 and Garcia Military Range Facilities	133612
W9124Q-13-D-0004	777	Cultural Resource Survey for a USAF HABU QF 4 Target Drone Impact Recovery Near Salinas Peak	138649
UNM Cooperative Agreement	778	Eligibility Evaluation of LA 105593 and Initial Recording of LA 178468 at the D-5 Site	129864
W9124Q-13-D-0004	779	Cultural Resource Survey for the Stryker Test Training Near the Gallegos Military Range Facility	133958
Epsilon Systems Solutions	780	AN/FPS-16 Radar Historic Context	
	781	NOT USED	0
UNM Lee Canyon Evaluation	782	NR Evaluation in Lee Canyon	
UNM/Northwind Zumwalt Eval	783	Re-evaluation of Ten Archaeological Sites at the Zumwalt Track (BAT Test Area) in the Jornada Del Muerto	133023
AmaTerra Cooperative Agreement	784	RR9 Survey	133206
Goodwin Cooperative Agreement	785	Preliminary Study of Paleolake Otero WSMR: Archaeological Survey, Paleontology and Geomorphology	
AmaTerra Cooperative Agreement	786	Archaeological Survey of 1.13 Acres for Power Pole Repair and Upgrades on WSMR	133269
AmaTerra Cooperative Agreement	787	Archaeological Survey of 160 Acres for the Fite Power Line Right of Way	133308

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
USACE Abq District DTRA Contract	788	A 50.0-ACRE CULTURAL RESOURCES INVENTORY OF THE POND ROAD AC-CESS ROAD FOR THE DEFENSE THREAT REDUCTION AGENCY GRANITE SITE	132958
FA3002-07-D-0014	789	NRHP Eligibility Evaluation of 4 Sites in the Oscura Lead In Line and 12 Sites on Oscura Bombing Range	133874
Berrier, M and L Unglaub	790	2010 Rock Art Recording at Cottonwood Springs (LA 175) New Mexico	
AmaTerra Cooperative Agreement	791	Lizard Trap Survey for Clay Noss	133549
VZII Technologies	792	Cultural Resource Survey for Road Repairs and Drainage Control at Aerial Cable Near Vic Site on White Sands Missile Range	133976
VZII Technologies	793	Cultural Resource Survey for the Expansion of the Julie Borrow Pit Survey at Muckerville/Zumwalt	133964
Epsilon Systems Solutions	794	A National Register Inventory and Evaluation of the Talos Defense Unit at WSMR	133164
Epsilon Systems Solutions	795	A National Register Inventory and Evaluation of the Small Missile Range at WSMR	131728
VZII Technologies	796	Cultural Resource Reconnaissance Survey for WIN-T Support at Space Harbor, White Sands Missile Range	133700
AmaTerra Cooperative Agreement	797	Archaeological Survey of 12.6 Acres Near Rhodes Canyon Gravel Pit	133750
W9124Q-13-D-0004	798	Cultural Resource Survey for Go Systems Student Rocket Test Program 2015 Impacts near the Launch Complex	133821
AmaTerra Cooperative Agreement	799	Archaeological Testing of Five Prehistoric Sites in the Burris Valley	132971
Unknown	800	NR Nomination for Ozanne Stage Line and Mountain Station	59502
VZII Technologies	801	Cultural Resource Survey for the Black Brant Recovery near LC-36 and LC-50 on White Sands Missile Range	133962
VZII Technologies	802	Cultural Resource Survey for the GQM 163 Coyote Test Program Missile Recovery Near WSSH	133919
VZII Technologies	803	Cultural Resources Survey THAAD Track EX recovery	134053
VZII Technologies	804	Cultural Resources Survey for a US Navy QF-4 SM6 Target Drone Impact Recovery	138751
UNM Cooperative Agreement	805	Data Recovery at Eight Sites in the Orogrande Training Area WSMR	134102
VZII Technologies	806	Cultural Resource Survey for the ChuSam Drone and Missile Recovery	134184
AmaTerra Cooperative Agreement	807	Cultural Resource Survey at ARC site	134171
AmaTerra Cooperative Agreement	808	Archaeological Survey of 11.9 Acres Near Malpais Spring and South Mound Spring	134258
W912BV-11-D-0019	809	WSMR Cultural Resources Report-Archaeological Site Testing-The Otero Maneuver Range: Carbon Stains and Ceramic Sequences…	134310
USACE Abq District	810	91.50 Acre Survey of DTRA Large Test Bed Site	134253
VZII Technologies	811	Cultural Resources Survey for the Remediation of a Small Diameter Bomb II (SDBII) Diesel Spill Clean-up at Muckerville	134473
NASA Contract	812	Historic Architecture Survey and National Register of Historic Places Evaluation of the NASA White Sands Space Harbor	
Goodwin Cooperative Agreement	813	WSMR 6-Survey of Alkali Flats and Rhodes Canyon	139880
NMSU Anthropology Dept	814	Proposal to Nominate LA52362 to the National Register of Historic Places	
Corps of Engineers CERL	815	Use of Remote Sensing to Enhance Archaeological Models of Site Location, Significance, and Integrity	0

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
AmaTerra Cooperative Agreement	816	An Archaeological Survey of Seven Acres for the JETS TLDS Project on WSMR	134720
AmaTerra Cooperative Agreement	817	Reevaluation of LA 64155 & LA 64074	134863
AmaTerra Cooperative Agreement	818	National Register Eligibility Recommendations of C-Station	134997
AmaTerra Cooperative Agreement	819	"Gap" Survey off of RR202	134973
Epsilon Systems Solutions	820	A National Register Inventory and Evaluation of Launch Complex 32 at WSMR	134999
AmaTerra Cooperative Agreement	821	Archaeological Survey of 65 Acres for the Reconstruction of Range Road 317	135160
Epsilon Systems Solutions	822	A Cultural Resources Inventory of 4,255 Acres in the Vicinity of Rhodes Canyon	
AmaTerra Cooperative Agreement	823	Reevaluation and Survey of LA 51232	135217
In House	824	Recordation of Col Hinman Rhodes House	135247
Epsilon Systems Solutions	825	History and development of Astrodomes	
Unknown	826	Recordation of Pat Garrett Ranch	45937
W9124Q-13-D-0004	827	Cultural Resource Survey for a QF-4 Target Drone Recovery at ABC-1 WIT, Otero County, White Sands Missile Range	135750
W9124Q-13-D-0004	828	Cultural Resource Survey for the Special Access Program (SAP) Missile Recovery near Slick City Military Range Facility	135458
W9124Q-13-D-0004	829	Cultural Resource Survey for the Navy High Velocity Projectile (HVP) Testing at Space Harbor on White Sands Missile Range	135448
W9124Q-13-D-0004	830	Cultural Resource Survey for the Recovery of an Orion Missile on Bureau of Land Management (BLM) Land	135753
AmaTerra Cooperative Agreement	831	An Archaeological Survey at Aerial Cable for a Proposed instrumentation Site	135537
NMSU CESU Cooperative Agreement	832	WSMR 8_Cultural Resources Inventory of 21,981 Total Acres of Parcels in the Mid and South Range Areas	139095
NMSU CESU Cooperative Agreement	833	Supersonic Shadows: NRHP Evaluation of 23 Nike Ajax Training Sites in Red Canyon	135606
In House	834	Miller's Watch Elevated Cinetheodolite	124730
In House	835	Cedar Spring Line Camp	129949
W9124Q-13-D-0004	836	Cultural Resource Survey for the Switchblade Unmanned Aircraft System (UAS), Phantom Quadcopter, and GPS Unreliability Test	135787
W9124Q-13-D-0004	837	Cultural Resource Survey for the Monitoring of the Air Missile Defense System (AIAMD) Limited User Test (LUT) Areas	135788
W9124Q-13-D-0004	838	Cultural Resource Survey for the Demolition of a T37E3 Warhead in Mockingbird Gap	136048
In House	839	In House In Fill Survey At EMRE by Pete Bullock-No Report	0
Ft WORTH District	840	Damage Assessment of Cultural Resources Impacted by Road Construction at Orogrande Range Camp	136308
VZII Technologies	841	Cultural Resource Survey of the D7 Military Range Facility for the WINT BLOS TROPO Test	135904
AmaTerra Cooperative Agreement_NMSU	842	NR Eligibility Determination-LA 108631 at Green Launch Site	
NMSU CESU Cooperative Agreement	843	NMSU Field School-Summer 2016	
NMSU CESU Cooperative Agreement	844	WSMR 7	140115

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
AmaTerra Cooperative Agreement	845	An Archaeological Survey of 596.29 Acres at White Sands Space Harbor for a Proposed Patriot Exercise on WSMR	136018
W9124Q-13-D-0004	846	Cultural Resource Survey for the Joint National Warfare Center (JNWC) AAJ Phase II Test, White Sands Missile Range	136131
W9124Q-13-D-0004	847	Cultural Resource Survey for the U.S. Air Force Very Low Frequency Test (VLFT) along the Western Boundary Fence Near Sulf	136821
NMSU	848	NMSU Field School Summer 2016 Edition	
W9124Q-13-D-0004	849	Cultural Resource Survey for the Recovery of a QF-4 Target Drone near Oscura Bombing Range	136244
W9124Q-13-D-0004	850	Cultural Resource Survey for the Vigilante Shield Exercise near the Fast Burst Reactor	136417
AmaTerra Cooperative Agreement	851	Reevaluation of LA 30759 and Survey of 3 Acres for a Power Pole Replacement Project	
AmaTerra Cooperative Agreement	852	Malpais Spring: Archaeological Survey of 600 Acres at the Southern Extent of the Lava Flow on WSMR	136426
VZII Technologies	853	Cultural Resource Survey for the Combat Archer QF-4 Target Drone Mission	137422
AmaTerra Cooperative Agreement	854	Test NR Eligibility of LA 156472 and LA 156481	
Epsilon Systems Solutions	855	Analysis and Recommendations for Concrete Surface Accretions on NHL Army Blockhouse	
NMSU CESU Cooperative Agreement	856	Ricochet Village, Archaeological Data Recovery at Two Sites at WSMR South of the Main Post.	
W9124Q-13-D-0004	857	Cultural Resource Survey for a Missile Flight Test Impact Southwest of PHETS	136584
AmaTerra Cooperative Agreement	858	SMR Survey	
AmaTerra Cooperative Agreement	859	An Archaeological Survey at Mine Site for a Proposed Missile Launch	136731
AmaTerra_CESU_NMSU	860	National Register eligibility Evaluation of the Ram and Rampart Sites WSMR	136459
In house	861	Archaeological Survey of DSWA Dipole Samson Test Area at Burris Well, Sierra County NM	
W9124Q-13-D-0004	862	Cultural Resource Survey for the Long Range Rocket Test near Balzar Military Range Facility	136651
AmaTerra Cooperative Agreement	863	EAPS additional Survey	
W9124Q-13-D-0004	864	Cultural Resource Survey for the Recovery of a PAC-3 Missile Impact Southeast of Thurgood Military Range Facility	136657
Unknown	865	Landing on the Lake: Archaeological Survey of 874 Acres within the WSMR-649 Landing Site	136608
AmaTerra Cooperative Agreement	866	An Archaeological Survey of 35.67 Acres at Muckerville, WSMR	136962
None	867	Cox Ranch ACUB Grazing Proposal	
Unknown	868	Museum of New Mexico 1963 Survey	
None	869	Nomination of the Fairview Claim in the Bear Canyon Mining District to the NRHP	129836
Ama Terra Cooperative Agreement	870	NR Eligibility Recommendations of Army/Navy Cantonment Historic District	
AmaTerra Cooperative Agreement	871	Cultural Resources Survey 0.25 Acres of State of New Mexico Land, Socorro County	136858
None	872	Curation of Artifacts from the MNM Collection Returned 2016	0

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W9124Q-13-D-0004	873	Cultural Resource Survey for the Horse Soldier Movie Impacts near the Curt Military Range Facility	137835
Unknown-Northwind	874	Mescalero Cultural Resources Brochure	0
W912G-14-2-SOI-0026	875	Re-Evaluation of Four Archaeological Sites at the Thurgood Maneuver Area	137026
W9124Q-13-D-0004	876	Cultural Resource Damage Assessment of Site LA 175819 near Malpais Springs on White Sands Missile Range	137427
Ama Terra Cooperative Agreement	877	Special Report-Green River Missile Repair	0
In House	878	Organ Mountain Riding Club Coordination and Documentation packet	
Vance Hollliday	879	Geomorphological Investigations on Paleo Sites (Holliday)	
AmaTerra Cooperative Agreement	880	Survey of 7.2 Acres at ALT SHIST Site	137032
W9132T-10-C-0042	881	Modeling of Archaeological Site Locations at WSMR	0
Unknown	882	Explorations at Victorio Peak	0
Epsilon Systems Solutions	883	NRHP Inventory, Evaluation and Determination of Effects for the Modifications to Launch Complex 35	137218
VZII Technologies	884	Cultural Resource Survey of 50-acres for Ground Clearing for Patriot	137430
		CR Survey of 50 Acres_Launchers South of the Large	
not used	885	not used	
W9124Q-13-D-0004	886	Cultural Resource Survey for the Recovery of an MQM-107 Drone Impact Northeast of Salt Springs	137440
AmaTerra Cooperative Agreement	887	An Archaeological Survey at J-180 for the C-UAS Program on WSMR, Dona Ana County, New Mexico	137329
AmaTerra Cooperative Agreement	888	Archaeological Survey for the Installation of Eagle Traps	137439
Amaterra Cooperative Agreement	889	An Archaeological Survey at the JDETS Facility on WSMR for a Small Diameter Bomb Impact	137384
W9124Q-13-D-0004	890	Archaeological Monitoring of the Long Range Rocket Test Recovery near Salinas de San Andres (LA 120641),	
W9124Q-13-D-0004	891	Cultural Resource Survey for the Missile Flight Test Impact Recovery Southwest of PHETS	137436
Unknown	892	A Cultural Resources Survey for Proposed Improvements Along US 70 from Milepost 162 to Milepost 170	136687
W9124Q-13-D-0004	893	Cultural Resource Investigations for the C-UAS Hardkill Challenge, White Sands Missile Range	138085
W9124Q-13-D-0004	894	Cultural Resource Survey for the Recovery of a Long-Range Rocket Test Impact near LA 120641, Salinas de San Andres	137598
W9124Q-13-D-0004	895	Cultural Resource Survey for the Recovery of the Commercial Crew Transport System near EC50	137775
W9124Q-13-D-0004	896	Cultural Resource Survey for the Small Diameter Bomb II Government Confidence Test near Zumwalt	137776
Hammerstone Arch Services	897	Cultural Resources Survey of 41.17 Linear Miles for the Fite Ranch Proposed Power Line Replacement	125934
Amaterra Cooperative Agreement	898	Archaeological Monitoring of Road Maintenance on the Rio Grande Electric Cooperative ROW Near Orogrande Base Camp	137652
NMSU Cooperative Agreement	899	Historic Contexts for the Prehistoric and Historical Periods at WSMR	0
W9124Q-13-D-0004	900	Cultural Resource Survey for the Strike-X Ballistic Test near ABC 1 WIT	137656
AmaTerra Cooperative Agreement	901	Archaeological Survey for NRCS Soil Survey Pits	137726
W9124Q-13-D-0004	902	Cultural Resource Survey for the Patriot IOTE near Mine Site, White Sands Missile Range, Socorro County, New Mexico	137836

Contract No.	WSMR Project No.	Project Name	NMCRIS Project No.
W9124Q-13-D-0004	903	Documentation of Two Cold War Era Sites in White Sands Space Harbor, White Sands Missile Range	137837
None	904	Testing at LA 178142-Double Flute Site	
W912PP-14-C-0009	905	Versar Inc Testing NRHP Eligibility of Five Sites at Oscura Bombing Range	
W9124Q-13-D-0004	906	Cultural Resource Survey for the NAVY High Velocity Projectile (HVP) Testing near NW30 and Green	137998
AmaTerra Cooperative Agreement	907	Archaeological Survey of 15.8 Acres for a gravel pit adjacent to RR5	137947
Epsilon Systems Solutions	908	A National Register Inventory and Evaluation of Launch Complex 50 at WSMR	138219
AmaTerra Cooperative Agreement	909	Sampling the Sandsheet: Archaeological Survey of 1800 Acres on Northern WSMR	137700
AmaTerra Cooperative Agreement	910	Mitigation Documentation-Range Control Center-Buildings 300 and 301	0
Inhouse	911	The Burris Ranch Main Residence-A Mitigation Report Submitted to the NM SHPO	0
Ft WORTH District	912	Damage Assessment LA 37340 Orogrande/Rio Grande Electric Company pole damage	0
Ft WORTH District	913	Evaluation of 37 Sites and Implementation of Site Protection Measures Between US 70 and Nike Road	130679
W9124Q-13-D-0004	914	Cultural Resource Survey for the Recovery of a Naval Integrated Fire Control-Counter Air (NIFC-CA) Rocket Motor near SC 50	138308
AmaTerra Cooperative Agreement	915	An Archaeological Survey of 12.9 Acres for a Series of Proposed Lizard Traps on WSMR, Otero County, New Mexico	138164
W912pp-14-C-0009	916	NRHP Eligibility Evaluation of Five Sites at Oscura Bombing Range	138203
AmaTerra Cooperative Agreement	917	Archaeological Survey of 74.01 Acres at the LPSF	138298
HZ Technical Services	918	Cultural Resource Survey for the USAF AFRL Missile Fly-Out Characterization Test at Bryce Site	139247
AmaTerra Cooperative Agreement	919	Archaeological Monitoring of the Tri State Transmission Line Pole Replacement Project	0
Stan Berryman	920	Various Berryman research projects	
Inhouse	921	Archaeological Survey of Proposed Asbestos Landfill WSMR Report 8802	138912
W91151-17-D-0007	922	Cultural Resource Support for the July 5th, 2017 Strike-X Ballistic Test, Otero Maneuver Area	139475
W91151-17-D-0007	923	Cultural Resource Damage Assessment of Site LA 156467 near TSC 30, Navy LRASM Test	139280
W91151-17-D-0007	924	Cultural Resource Survey for the Aerial Cable Range MANPAD Test	139518
Unknown	925	Mule Peak T-4 telescope relocation costs and method report	
Unknown	926	Advanced Gunfire Impact Area Survey	
AmaTerra Cooperative Agreement	927	Survey of SPEC Site for Patriot Exercises	
AmaTerra Cooperative Agreement	928	An Archaeological Survey of 39.23 Acres Along the Northeaster Fence line of WSMR for Fence Repair	139167
AmaTerra Cooperative Agreement	929	RR7 Powerline Survey	139060
Epsilon Systems	930	Liquid Propellant Storage Inventory	135488
AmaTerra Cooperative Agreement	931	Recon level survey of Condron Airfield	
AmaTerra Cooperative Agreement	932	NR Testing of 11 Sites in the Otero Maneuver Area	138906

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W91151-17-D-0007	933	Cultural Resource Survey for Patriot ADA 34-3 Training, White Sands Missile Range, Socorro County, New Mexico.	139568
W91151-17-D-0007	934	Cultural Resource Survey for a GMLRS Misfire, White Sands Missile Range, Dona Ana County, New Mexico	139532
W91151-17-D-0007	935	Cultural Resource Survey for the NAVY Hyper Velocity Projectile (HVP) Testing near NW30, ChuSam, and Midway	139399
AmaTerra Cooperative Agreement	936	Bridging the Gap II-More Survey to Fill In Gaps in WSMR	143947
AmaTerra Cooperative Agreement	937	Archaeological Evaluation of LA 104017 on WSMR, Lincoln County, New Mexico	
AmaTerra Cooperative Agreement	938	AN ARCHAEOLOGICAL SURVEY OF 11.6 ACRES FOR BRIDGE CONSTRUCTION LAYDOWN YARDS, OTERO COUNTY, NEW MEXICO	
W91151-17-D-0007	939	Cultural Resource Survey for the Recovery of a Roland Short-Range Ground-to-air Missile	139621
Epsilon Systems Solutions	940	A National Register Inventory and Evaluation of Launch Complex 33 at WSMR	139665
W91151-17-D-0007	941	Cultural Resource Survey for Small Unit Training, 724 STG Operator Training Course near Bubba MRFP	140037
AmaTerra Cooperative Agreement	942	An Archaeological Survey of 6.6 Acres Along the Northern Fence Line of White Sands Missile Range for Fence Repair	
In House	943	An Archaeological Survey of 2.5 Acres for a Fueling Station	139840
In House	944	Fiber Optic Line Near 500 k	
Unknown	945	Fence on Boundary Near Hembrillo Canyon	
W91151-17-D-0007	946	Cultural Resource Survey for the Radio Frequency Propagation Test at Skillet Knob	140047
AmaTerra Cooperative Agreement	947	FY 17 Prescribed Burn Survey	
W91151-17-D-0007	948	Cultural Resource Survey for the Shaker Expansion at 300K, White Sands	
		Cultural Resource Survey for Shaker Expansion 300 k	
W91151-17-D-0007	949	Cultural Resource Survey for the Navy Launch Complex Expansion at Vandal	140814
AmaTerra Cooperative Agreement	950	An Archaeological Survey of 13.7 Acres Along Range Road 12 for Fence Repair on White Sands Missile Range	
UNM Cooperative Agreement	951	Damage Assessment and Boundary Identification of LA 37470	139373
UNM Cooperative Agreement	952	Archaeological Site Identification and Site Protection along WSMR Tank Trails	
AmaTerra Cooperative Agreement	953	An Archaeological Survey of .26 Acres Along Range Road 332 for Equipment Installation on White Sands Missile Range	140194
AmaTerra Cooperative Agreement	954	Advanced Gunfire Survey	
AmaTerra Cooperative Agreement	955	Roads and Trails	140397
AmaTerra Cooperative Agreement	956	An Archaeological Survey of Two Areas on the Stallion Range, WSMR, New Mexico	
AmaTerra Cooperative Agreement	957	An Archaeological Survey of Thirteen Power Poles for Raptor Poles Project	140635
W91151-17-D-0007	958	Cultural Resource Survey for HELSTF Road Maintenance and Expansion at Nahim	
W91151-17-D-0007	959	Cultural Resource Survey for the Recovery of 4 Terrier Black Brant Research	141562
		Cultural Resource Survey for Rocket near SW50	

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W91151-17-D-0007	960	Cultural Resource Survey for the Recovery of Black Dagger Missile near Cain	141397
W91151-17-D-0007	961	Cultural Resource Survey for Proposed Trenching of a Fiber Optic Line, MAB 18	
UNKNOWN	962	Mitigation Documentation for LC 38 Building Demos	
AmaTerra Cooperative Agreement	963	1500-acre Burn Survey near Hunter's Lodge-FY 18	140396
AmaTerra Cooperative Agreement	964	Testing of Four Sites near LC 50/Alex Site	140588
AmaTerra Cooperative Agreement	965	AN ARCHAEOLOGICAL SURVEY OF 13.8 ACRES FOR A PROPOSED FIBER OPTIC LINE	141024
AmaTerra Cooperative Agreement	966	Testing of 16 (orig. 15) Sites near Rhodes Canyon	149067
Dos Rios Cooperative Agreement	967	The Mining History of White Sands Missile Range: A Documentary Review	
W91151-17-D-0007	968	Cultural Resource Survey for the ICE-SAT 2 Project, White Sands Space Harbor	141398
W91151-17-D-0007	969	Cultural Resource Damage Assessment for the Recovery of a BQM-34 Drone near Rhodes WIT	141399
W91151-17-D-0007	970	Cultural Resource Survey for Joint National Warfare Center (JNWC) Testing, Cain Site	141649
Epsilon Cooperative Agreement	971	Building 21630 and 21640 Renovation	140570
Epsilon Cooperative Agreement	972	Summaries of Oral Histories and Interviews, Facility Reduction Program Archival Research	0
Walcoff Technologies Inc	973	Addendum to Site Evaluation for LA 101213	125994
W91151-17-D-0007	974	Cultural Resource Survey for the NAVY Hyper Velocity Projectile (HVP) Testing 2018 near ChuSam, NW50, and NW70	
W91151-17-D-0007	975	Cultural Resource Survey for the CUAS Airbase Defense Program near Beck Site	142245
W91151-17-D-0007	976	Cultural Resource Survey for the Recovery of the Up Aerospace Motor near D5	142212
W91151-17-D-0007	977	Cultural Resource Survey for the CUAS Hardkill II Challenge Test at Brillo	142363
W91151-17-D-0007	978	Cultural Resource Survey for the DARC Project near Tiff Site	
Epsilon Cooperative Agreement	979	A National Register Inventory and Evaluation of 300k Test Stand at WSMR	
W91151-17-D-0007	980	Cultural Resource Survey for the HTKT Testing near Tellez Site	142377
In House	981	Cultural Resources Survey of 2 F 16 Fuel Tank Drops	
Amaterra Coop Agreement	982	Archaeological Investigations at the Oryx Track Site	140272
Amaterra Coop Agreement	983	Shedding Light on the Darkness-Rock Feature Sites on the Carrizozo Malpias	139807
In house	984	Damage Assessment of martin Ranch LA 82032	142079
In House	985	F 16 Fuel Tank Impact Survey	142080
Amaterra Coop Agreement	986	Antelope Hill Fence Survey	142219
Amaterra Coop Agreement	987	Zumwalt Testing Project	142167
Ft Bliss MATOC	988	Cultural Survey and National Register Evaluations of Archaeological Sites on White Sands Missile Range	

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Amaterra Coop Agreement	989	FOB Steel NR Testing	
Amaterra Coop Agreement	990	Range Road 16 Culverts	142302
Epsilon Systems	991	Recordation of Three Bunkers at Space Harbor for Boeing Crew Capsule project	142337
W91151-17-D-0007	992	Cultural Resource Survey for the Installation of Fiber Optic from RAD to Seehorn	142447
W91151-17-D-0007	993	Cultural Resource Survey for the HELSTF Road Construction from G20 to Nahim Site	142448
W91151-17-D-0007	994	Cultural Resource Survey for the Terrier Black Brant Research Rockets Green Sustainer Motor Recovery	142449
Unknown	995	Testing and Evaluation of LA 156440	142491
Amaterra Coop Agreement	996	Test Sites Near FOB Steel	142567
Unknown	997	Mescalero Plant Guide	0
UNM CESU	998	Damage Assessment of Cultural Resources Impacted by Road Construction at Smoker House Site LA 29999	142859
Epsilon Cooperative Agreement	999	NMCRIS 142350 1839 HCPI - In-house Demolition	
MATT'S	1000	NR Testing of Sites Along Range Road 7	144145
Epsilon Cooperative Agreement	1001	A National Register Inventory and Evaluation of the Meteor Trail Radar	
Epsilon Cooperative Agreement	1002	FRP Main Post HCPI Forms	140408
Epsilon Cooperative Agreement	1003	FRP Main Post HCPI Forms (120, 123)	142815
Epsilon Cooperative Agreement	1004	23480 HCPI Nike Firehouse Demolition	139804
Epsilon Cooperative Agreement	1005	456 HCPI Navy Barracks	140374
W91151-17-D-0007	1006	NRHP Survey, Testing and Evaluation of Four Prehistoric Sites near the Sergeant Facility	142918
W91151-17-D-0007	1007	Cultural Resource Survey Near Yucca Village	144388
SAS 019-04 EA	1008	Landing on the Lake II: Archaeological Survey of 1,036 Acres Within the WSMR North Landing Site	142924
None	1009	Preliminary Report and Interpretation of Investigations Concerning the Big Footprints of Alleged Camel Trackway	0
Meade Kemrer	1010	The Sherman Site (LA 144607) A Post Classic Mimbres Occupation in Dona Ana County	89110
W91151-17-D-0007	1011	Cultural Resource Survey for GQM 163 Impacts near Brillo	
W91151-17-D-0007	1012	Cultural Resource Survey for the Recovery of a Terrier Black Brant Research Rocket Sustainer Motor	
W91151-17-D-0007	1013	Cultural Resource Survey for the LLD Survey at THEL	
AmaTerra Inc	1014	Apache Dance	
AmaTerra Inc	1015	Reevaluation of LA 147142	
W91151-17-D-0007	1016	Cultural Resource Survey for the Aerial Cable Range Launch Site	143428
W91151-17-D-0007	1017	Cultural Resource Survey for the Recovery of a Single Stage Orion Rocket	143429
W91151-17-D-0007	1018	Cultural Resource Survey for the Navy Advanced Gunfire Environmental Assessment	143430
Amaterra Coop Agreement	1019	Revaluation of LA 72446	

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Epsilon Cooperative Agreement	1020	A National Register Inventory and Evaluation of Launch Complex 37	
Epsilon Cooperative Agreement	1021	A National Register Inventory and Evaluation of the Army Missile Assembly Area	
W91151-17-D-0007	1022	Cultural Resource Survey and Planning Support for the Installation of TSN Fiber Optic Network	144056
Amaterra Coop Agreement	1023	An Archaeological Survey of 67.6 Acres for a Proposed Ingress/Egress in the Stallion Range	144143
Epsilon Cooperative Agreement	1024	Malone Site FPS-16 Inventory and Evaluation (HCPIs)	137215
UNM CESU	1025	Archaeology of WSMR: Archaeological Identification and Protection of Five Sites at Davies Tank	144593
AmaTerra Cooperative Agreement	1026	Archaeological Survey of a Firebreak on WSMR	144736
AmaTerra Cooperative Agreement	1027	Survey of 2128 Acres in Yates Valley	144908
Epsilon Cooperative Agreement	1028	SWAF 4 PROJECT	
Epsilon Cooperative Agreement	1029	Assembly Building Historic Context	
AmaTerra Cooperative Agreement	1030	2200 Acres Survey Near Ben Site	144961
USAF Contract	1031	Option 13 Delivery Order-USAF	
W91151-17-D-0007	1032	Cultural Resource Survey for the ARC-685 Equipment Test, White Sands Missile Range, Sierra County, New Mexico	
W91151-17-D-0007	1033	Cultural Resource Survey in support of the LowERAD CTV1 Test Mission, White Sands Missile Range, Sierra County, New Mexico	
W91151-17-D-0007	1034	Cultural Resource Survey for MLRS SLV Anomalies, White Sands Missile Range, Otero County, New Mexico	
NONE	1035	SMU Proposed Summer 2020 Archaeological Research at LA 179735-WSMR and LA195110 WSMR	
W91151-17-D-0007	1036	Cultural Resource Survey for the Recovery of a TMO Aerial Target North of White Sands National Monument	

Appendix H: Standards,

Procedures, and Guidelines

APPENDIX H

STANDARDS, PROCEDURES AND GUIDELINES:

A TECHNICAL APPENDIX FOR CULTURAL RESOURCE MANAGERS

Scopes of Work

All scopes of work, unless prepared by the WSCRM, must be reviewed by the WSCRM prior to letting the contract. Scopes will be checked for archaeological and historical sufficiency, and compliance with the ICRMP.

Survey

All cultural resource surveys undertaken on WSMR shall consist of comprehensive, intensive, pedestrian examination designed to identify those cultural and paleontological resources that can reasonably be detected from the surface, that are exposed in profiles, or that can be found by shovel tests in the case of obscured surfaces. The purpose of archaeological survey is to obtain and report accurate, descriptive field data that are systematically collected and sufficiently detailed to assess the research potential of each site and isolated occurrence, make preliminary National Register of Historic Places (NRHP) evaluations, allow preparation of detailed testing plans and budget estimates, and consult with the SHPO and interested parties on effects of the project. The WSCRM must approve any deviations from these requirements in advance.

Cultural resources shall include both prehistoric and historic (to circa 1989) manifestations. The following site features will be field recorded with sub-meter accuracy GPS or EDM: site boundary; horizontal site datum; features; and collected artifacts. Historic remains also shall be recorded, including fences, wells, tanks, machinery, isolated occurrences (IOs), and ground modifications from the historic period. IOs that represent features shall be differentiated on maps from those representing individual artifacts. Military debris such as bullets, cartridges, and small fragments from missiles shall not be individually recorded unless they constitute a part of an identifiable historic event.

Investigators shall notify the WSCRM by email, letter, or telcom of any proposed fieldwork at least five working days prior to the fieldwork so that a field inspection can be scheduled, if necessary.

National Register Eligibility

The National Register of Historic Places (NRHP) is a list of properties that possess historic significance and integrity. To be listed, a property must qualify as significant under one or more of four National Register Criteria: a) association with historic events or activities, b) association with important persons, c) distinctive design or physical characteristics, or d) potential to provide important information about prehistory or history. The property must also exhibit integrity through historic qualities including location, design, setting, materials, workmanship, feeling, and association. Most properties on the NRHP are at least 50 years old; however, properties that have achieved significance within the past 50 years can be considered. Any prehistoric or historic site investigated should be evaluated as to its potential eligibility for inclusion on the NRHP. A discussion about the historic context(s) into which the site can be classified should appear in the site description.

Survey Design

Design of the survey shall incorporate all aspects of the mission or project, to include secondary effects. The Area of Potential Effect (APE) shall be determined for each project, and used in the establishment of survey area. Since time is often critical to WSMR projects, it is important to include enough survey area to permit alternatives, should they be required due to mission changes or the presence of cultural resources. All survey areas are to be defined in consultation with the WSMR Cultural Resources Manager. Generally, very small survey areas (less than 4 hectares or 10 acres) do not adequately allow for secondary impacts during construction and operation. Repeated disturbances, such as occurs in an impact area from multiple missile hits, requires survey in advance of the impacts. Previous surveys and site locations, as documented in the NM Historic Preservation Division records and WSMR databases, shall be determined prior to fieldwork. Both data sets must be checked.

Survey Intensity and Visibility

Distance between surveyors shall average 15 meters. Deviation requires prior approval by the WSCRM. Linear surveys for existing roads shall cover 30 meters on each side, not including previously disturbed graded or bulldozed areas. Linear surveys for communications lines normally shall be 15 meters wide.

All surveys shall be pedestrian and shall be conducted only when lighting, surface cover, and weather conditions permit effective viewing of the ground surface. Subsurface shovel testing is required where visibility of the ground surface is less than 30 percent. Snow cover in excess of 1 meter per 10 square meters (10%) shall preclude effective survey. Obstacles that may obscure the surface and hinder discovery of cultural resources (e.g. dense vegetation, recent alluvium, and sedimentation) shall be noted. The approximate boundaries of obscured areas larger than 2 ha (5 acres) shall be indicated on the appropriate USGS quadrangle, as shall ground that has been disturbed by earthmoving machinery.

Collections

Documentation of most cultural materials should be made in the field. Limited collections of diagnostics or other artifacts may be made for specialized studies (e.g. sherds for petrographic analysis or expert identification; obsidian for source and hydration studies, etc.), or for objects that might disappear through unauthorized collecting. Large objects such as metates and mortar holes are not normally collected. Mortar hole sediments will not be disturbed. The location of collected artifacts shall be piece-plotted in relation to the site datum and recorded on the site map, or, if an isolated object, the position plotted on a USGS quadrangle with the UTM (Universal Transverse Mercator) coordinates noted. Deviations from this collection method may be made only with prior approval of the WSMR Cultural Resource Manager. A catalog of collected items shall be prepared. The catalog shall contain the WSMR catalog number, location, information on the item, and other information as described in *Artifacts and Curation Standards*. All collected artifacts shall be digitally photographed at medium resolution and the images shall be reproduced in the final report.

Collected Samples

Soil samples for special analyses and materials collected for dating or other purposes shall be processed and analyzed during the laboratory phase. All remaining samples of pollen or charcoal shall be packaged for curation together with the artifacts from the project. Samples shall be collected from exposed hearths found in the survey area for dating and botanical identification. Obsidian samples shall be analyzed for source.

Field Logs

A Daily Log shall be prepared for all field work, listing name and WSMR project number, date, entry person, location of survey, time started and finished, field personnel, and a description of the work accomplished and archaeological findings, including UTM coordinates for the box surveyed. Describe any problems encountered and the manner of dealing with them. On survey, sites or any IO (Isolated Occurrence) features (e.g. fences, structures, isolated hearths) shall be described briefly. An archeological site is defined as five artifacts within a 20 m diameter area, or as an area with more a feature and at least one artifact.

When linear surveys are conducted, the exact width of coverage shall be stated in terms of meters on each side of the centerline; these will be described using compass directions in relation to the centerline. Right-of-Way (ROW) shall mean the total width of surveyed area, excluding any previously graded or bulldozed zones. The investigator shall report all dumps, spills of materials, possible hazardous wastes or materials, and wells to the WSMR Archaeologist (ES-ES) together with their location and directions for visit. Locations of potentially explosive munitions also shall be reported. Field logs should be emailed within 24 hours to the WSCRM.

Recordation

Information collected must be sufficient to complete the required cultural resource forms and to meet the detailed reporting requirements.

Site Documentation

Archaeological sites are differentiated from Isolated Occurrences (IOs) by the presence of at least as five artifacts within a 20 m diameter area, or by the presence of a feature and at least one artifact. The minimum survey data to be recorded include a description of the general environmental situation, the definition and location of site boundaries, a description of the location, number, and kinds of surface features, the nature of artifact assemblages, the density and frequency of artifacts, an assessment of site integrity, and an assessment of the potential for the site to yield information that may be used to address important research questions. The potential for chronometric (radiocarbon, dendrochronological, etc.) and paleoclimatological samples shall be noted. Evidences of site depth shall also be noted.

The entire boundary of each site also shall be recorded, even if it exceeds the edges of the survey boundary, although detailed descriptions of site features and artifacts outside the survey boundary need not be recorded. Generally, a sterile gap of 20 meters between artifacts indicates that more than one site is present. Sites separated by more than 20 meters between artifacts may be considered separate. Previously recorded sites shall not be split by investigators without prior permission, and usually require an inspection of the site by the WSCRM; dramatic revisions to existing site descriptions will not be accepted. Investigators shall take into consideration that visibility conditions may hide or reveal artifacts, and that the appearance of a site may change between visits. Site revision documents should build on previous observations rather than discard them.

Forms

Data required by the applicable state shall be obtained for each project and site. In New Mexico, Archaeological Resource Management System (ARMS) forms for activities and sites are to be prepared. The use of supplemental forms (e.g. artifact analysis forms, feature forms) is required because they encourage standardized, systematic recording of data. Revisitation of a site requires a supplemental form for submittal to ARMS. All forms are to be provided by the investigator. ARMS forms are available from the Historic Preservation Division website. Utah requires Intermountain Antiquities Computer System (IMACS) forms.

Features

All prehistoric and historic structural features (e.g. rooms, hearths, cists, depressions, terraces, burned rock concentrations, fences, corrals) shall be recorded noting size, shape, construction details, associated features and activity areas, fill, and probable function. All features shall be numbered and/or otherwise labeled to correspond with the feature descriptions within the inventory form/report. In addition to the descriptive information required for the report, a table shall be developed and included in the inventory form and report that includes information on probable function of feature, feature dimensions, and direction and distance from datum. Separate feature/historic structure forms (e.g. New Mexico Historic Building Inventory forms) for field use are required. Pre-1945 historic structures shall be recorded in accordance with the Secretary of the Interior's Standards and Guidelines for Historical and Architectural and Engineering Documentation. The level of documentation for historic structures will vary depending on the significance of the property. USGS section markers, fence lines, other historic features, and IOs shall be noted.

Artifact Description

Artifacts shall be recorded in a formal, replicable manner (e.g. an explicit definition of attributes used to place an artifact into one grouping or another shall be specified in the report). Artifacts to be addressed include, among others, debitage, formal chipped stone tools such as projectile points or bifaces, ground stone tools, ceramics, and metal or glass items. Rim sherds shall be characterized by shape of vessel, rim diameter, and percent of rim represented. The investigator shall design and implement a procedure for (1) estimating the density or range in density of surface artifacts and (2) estimating total frequency of surface artifacts for each of the artifact groups recorded at the site. Formal sampling procedures may include transects, quadrants, or other techniques, but the procedure shall be appropriate to the overall size and complexity of the site. In order to preserve the integrity of each site, artifacts shall be disturbed as little as possible during in-field analysis and shall be returned to their pre-analysis locations.

Site Maps

A detailed sub-meter accurate sketch map shall be prepared for each site. Minimally, the map will depict the relationship of the site to nearby physiographic and man-made features, the location of potholes or other evidence of vandalism or site disturbance, the size, shape, and location of artifact sampling units, activity loci, and feature, the location of the site datum, site and provenience boundaries, and the location of any collected or diagnostic artifacts. The field number shall be recorded on the field maps, but Laboratory of Anthropology or IMACS site numbers shall be used on final and published maps. Generally, the entire site boundary shall be recorded. Fewer details are required on features outside the survey area, but the complete boundary must be mapped. Every map shall contain a numbered metric scale, a north arrow depicting true or magnetic north, the date of recording, the name(s) of the recorder(s), and the observed site boundary. Published maps will not reveal the location of the site.

Site Depth

The investigator shall assess the potential of subsurface deposits at each site. If the investigator makes a professional judgment that a site is surficial, a clear statement citing evidence supporting that judgment shall be provided. If the investigator believes that a site contains subsurface deposits, a clear statement with supporting evidence shall be provided (e.g. strata visible in arroyo cut; results of auger tests). Auger tests, probes, shovel tests and other techniques which are of an extremely limited nature and which have minimal impact on the integrity of the site may be performed to serve as a basis for making a professional assessment of depth and extent of cultural deposits. These tests are considered a routine element of survey procedures and are distinct from the tests described in the section on Site Testing.

Site Integrity

The investigator shall assess the present condition of each site including: (1) identifying the kinds of post-depositional activities that have affected the site; (2) estimating the percentage of total site affected by each kind of disturbance; and (3) indicating those portions with good integrity.

Chronometric and Research Potential

For each site the investigator shall determine the potential for obtaining the following kinds of chronometric samples: (1) radiocarbon samples; (2) dendrochronological; (3) obsidian hydration; (4)

archaeomagnetic; (5) diagnostic artifacts; (6) thermoluminescence; and (7) other samples such as amino acid racemization. The type of chronometric analysis, sample sizes, and sampling methods will be dependent on the analytical method chosen, the site and feature type, and on the specific research design. Questions about sample methods, types, and numbers should be addressed to the WSCRM.

Significance Potential

For each recorded site, the investigator shall assess the significance and integrity of the site, and preliminarily determine the potential for the site to meet the criteria necessary for inclusion in the National Register of Historic Places, for archaeological interest according to the Archaeological Resources Protection Act (ARPA), or with respect to the American Indian Religious Freedom Act (AIRFA). The investigator shall document the basis for the preliminary assessment of significance.

Photography

Only individuals holding a valid WSMR permit shall carry out field photography. Each site, will be photographed for the purpose of locating and identifying the site upon future visits; site photos will include representative terrain. Individual features and selected artifacts, potholes, and examples of erosion or other factors that may affect the site's integrity and research potential shall also be photographed. Photographs of features, artifacts, and potholes must contain a scale and north arrow pointing to true north. Photographs of features must show the relative position of one feature to another. For security purposes, the Government reserves the right to review and approve each image prior to copying, use, or publication by the contractor. Film or digital photography are suitable. For digital photography, a camera with a minimum of 2.0 megapixels will be used, and imaged will be provided to WSMR in JPG format on a CD or DVD. Cameras should be set to medium resolution. If film is used, electronic images are additionally required, as defined in the section on reports. A photo log, a labeled set of photographs with negatives and slides, if appropriate, and thumbnail or contact sheets shall be provided to the WSCRM for all photos taken.

Maps

The surveyor or recorder shall plot each site and project on the appropriate master WSMR USGS quadrangle map. The actual boundary of each site, rather than a central point, shall be depicted, as shall the sites and survey areas, features such as fences, tanks, and other structures, hearths and other feature-type Isolated Occurrences (IOs), and modern features such as roads and power lines within the project area. The complete site boundary shall be mapped, although features outside the project area need not be completely mapped. These data also shall be supplied in electronic format, as defined in the section on reports. Each report shall contain project maps showing where the surveyed areas are, but not the locations of artifacts and sites. Artifact and site locations must be reported on a separate map(s), that also contains the project boundary. Project maps based on USGS 7.5 minute maps are required.

Isolated Occurrences

Isolated occurrences (IOs) contain fewer than five artifacts or consist of a single feature with no associated artifacts. In instances where the distinction between an IO and a site is in question, the investigator shall consult with the WSCRM to determine the designation. When an IO is found, it shall be plotted accurately on the appropriate USGS quadrangle and project map using GPS data. Each IO shall be numbered, described and measured, drawn or photographed if diagnostic, and documented in tabular form in the report. Feature IOs should be differentiated from ordinary IOs on maps by using a square symbol, unless it is a linear feature. IOs are also reportable in electronic database format (see Reports). The positions of all IOs shall be reported using a GPS, set to NAD 83 and UTM coordinates. The investigator shall report whether the data is base-station corrected.

Site Marking

Sites shall be marked inconspicuously by a piece of rebar measuring a minimum of 18 inches, driven into the ground with only a few inches visible at the surface. The marker should be placed on a mound or near trees so as to prevent loss by off-road traffic. Site numbers, both project number and field number, shall be permanently attached to or impressed on the rebar, but nothing on the marker shall indicate that the site is an archaeological property. At a minimum, the location of the site stake will be obtained with a GPS, and reported as a NAD 83 reading using UTM coordinates. During recordation, the investigator shall take care that temporary flags do not reveal the location of the site. Washers with flagging tape may be used as low visibility markers. All site boundary markers require the prior consent of the WSMR Cultural Resource Manager. Temporary boundary markings to allow projects to avoid sites should consist of lathes with flagging tape. The removal of temporary markers after the immediate need is the responsibility of the investigator, and should be documented in writing to the WSCRM. Permanent markers, and markings to prevent heavy equipment entry, should consist of metal fence posts with heavy wire at the top; these require prior approval by the WSCRM.

Historical Studies

Historic site recordation shall include features, identification of sites by historic review and any archival research, measured drawings, or photography required to record and evaluate the condition of resources, historic significance, and site associations. Historic artifacts and features such as cans, bottles, mining claim markers, fences, stock tanks, and water control features shall be recorded. Cold War structures shall include information related to the role the structure played in specific weapons systems. Engineering drawings often are available at the Post Engineer's office, and information on past use at the Master Planning office.

Testing

Testing is limited excavation in site deposits to determine depth, extent, and nature of the resource. Testing usually is carried out to determine the National Register eligibility of a site, but sometimes is completed to determine damage to a site. It is often undertaken to aid in the design and development of site-specific data-recovery plans. Because information is being extracted, methods and record keeping shall be the same as described in the sections on excavation. Tests, by definition, are to be of a limited nature and do not take the place of comprehensive site excavation. The exception is when a small site proves to have no further data potential beyond what is evident in the surface scatter and any already excavated features. The investigator shall consult with the WSCRM and obtain approvals for each testing project.

Testing Goals

Subsurface tests, such as 1x1 meter test pits or systematic augering, are used to assess the presence or absence of subsurface deposits. Non-intrusive methods such as subsurface radar also may be used. The investigator's determination of the presence or absence of subsurface deposits shall be defended explicitly with supporting evidence. Tests should attempt to determine the extent of trash mounds and the depositional depth at sites including lithic scatters, as well as to salvage obviously endangered chronometric samples (e.g. a hearth eroding from the face of an arroyo). Site data, if missing from the existing record, shall be recorded during testing. A Historic Preservation Division (HPD) update form shall be submitted to the WSCRM.

Significance Potential

The site shall be evaluated for its significance potential with respect to the criteria, including integrity, for inclusion on the National Register of Historic Places (NRHP) (36CFR60.4). It shall also be evaluated for archaeological interest according to the Archeological Resources Protection Act

(16USC470) and its implementing regulation (43CFR7), or with respect to sacred/religious characteristics according to the American Indian Religious Freedom Act (42USC1996). This evaluation shall be fully documented, including the basis on which the resource was considered significant.

Test Data

Test data will be recorded the same as excavation data. All tests and borings shall be plotted on the site maps. When subsurface tests are performed, all soil horizons and strata shall have written descriptions using standard scientific terms, including Munsell color descriptions. All excavated features shall be recorded using basic dimensions, orientation, and depth. Profile drawings and photographs shall be made of at least one wall of each test pit and tested feature. During excavations, all artifacts shall be collected. Artifact descriptions, photography, and maps shall be as described under survey techniques. The investigator shall place permeable geo-textile or some similar permanent substance (not impermeable plastic) in the bottom of test pits to preserve depth of disturbance. Upon completion of testing, sites shall be restored as nearly as possible to conditions prior to excavation, except on specific instructions from the WSCRM.

Data Recovery and Analysis

Mitigation through data recovery and analysis carried out on properties eligible for inclusion in the National Register of Historic Places shall be designed to minimize impact to those factors that contribute to the site's significance. Data recovery will require development of an explicit research design that identifies specific research topics, appropriate hypotheses, test implications, and analyses necessary to test the hypotheses. Field studies may include collection of surface and subsurface artifacts, subsurface tests to identify buried cultural lenses and features, controlled excavation of features and activity loci, or detailed architectural recording. Included in these activities is collection of specialized samples such as radiocarbon, dendrochronological, archaeomagnetic, flotation, pollen, soil, and obsidian sourcing; and other studies such as geomorphological, paleoenvironmental, and source materials. Use of mechanical equipment such as backhoes and application of remote sensing techniques may be required. Laboratory and analytical tasks will include processing, analysis, cataloging, and curation of materials. Normally, the effort will require computerization of data, which will include lithic, ceramic, faunal, metal, glass, statistical, and other analyses consistent with the needs of the research design. It also will include analysis of specialized samples and preparation and printing of technical and popular reports summarizing the results of the data recovery program. The following sections describe minimal acceptable levels of performance.

If, during the course of data recovery a modification of the plan is warranted, the WSCRM shall be notified and must provide approval. Investigators shall notify the WSCRM of any proposed fieldwork 5 working days prior to the work so that a field inspection can be scheduled, if necessary.

Exploratory Boundaries

The majority of the excavation or study shall occur within the limits of the defined project boundaries, which mark the area of the site that will be affected by the project. Limited tests outside the boundaries may be undertaken to better understand the context of the main excavations, or to excavate a discrete feature that extends beyond the boundary. Plan views of the entire site shall be prepared indicating the location of detailed studies.

Surface Collections

Controlled surface collection using a grid collection or point provenience method shall minimally include the site's project area. The selected grid unit size shall be specified in the research design and shall be appropriate for the site size/artifact density anticipated. Prior to any excavations, feature/artifact distribution maps shall be prepared. Excavation strategies may be based on the resultant surface feature/artifact map and if available, results of limited subsurface testing or augering.

Test Pits and Excavation Units

A combination of hand and mechanical methods may be used for excavation. Mechanical equipment may be used to define stratigraphy, locate subsurface features and activity loci, and to remove overburden as agreed upon by the WSCRM. Excavation of all features and activity areas shall be performed using hand tools. Excavation shall be conducted by natural stratigraphy subdivided into smaller increments as required by the local site conditions or by arbitrary levels if natural stratigraphy is absent. All hand-excavated material shall be dry screened through 1/4-inch hardware cloth, except in cases where soil samples are collected, or a smaller screen size is deemed appropriate. During excavations, all artifacts shall be collected. Scale diagrams and photographs shall be used to record stratigraphic profiles. All soil horizons and strata shall be described using standard scientific terms. Color descriptions shall be made in Munsell terminology. Features shall be recorded in three dimensions. All features observable from the surface shall be excavated in profile in order to obtain a view of the cross section and shall be recorded in three dimensions. Profiles of the cross-section shall be recorded using scale diagrams and photographs. Primary data such as maps plans, profiles, Munsell notation, descriptions of strata, or descriptions of features shall appear in the draft and final reports. In most instances, identified features and cultural soils within the right-of-way shall be excavated in their entirety. However, sampling of redundant features is permissible with the prior approval of the WSCRM.

Systematic Augering

Systematic augering and screening may be performed to determine the extent and depth of cultural strata and features, to collect surface soil samples, and to determine or verify the extent of site boundaries.

Post-Excavation Treatment

After completion of the excavations, assuming that all relevant information applicable to the research objectives has been collected, each excavation unit will be backfilled and restored as nearly as possible to its pre-excavation condition. In some instances, depending on the nature of the proposed undertaking and accessibility to the resource, mechanical stripping may be employed following excavation. The stripping should serve the dual purpose of disclosing features that were not found during testing, trenching, or excavation, and providing a check on the reliability of the data recovery sampling design. The data is useful for improving the reliability of future sampling designs for similar type-sites. Any features exposed during the mechanical stripping shall be mapped in relation to the site datum and be described. A suitable sample of datable artifacts and/or chronometric samples associated with each feature shall be collected. If possible, interpretations of the function of each feature shall be made.

Site Documentation

Site Staking

If the site marker will be disturbed by the proposed activity, the rebar marker will be moved to a portion of the site, if any, that will be preserved.

Data Recording Forms

The investigator shall complete appropriate forms necessary to properly record features, artifacts, chronometric data, etc., recovered during excavation.

Features

All structural features (e.g., rooms, hearths, cists, etc.) shall be completely excavated, unless prior approval for sampling has been granted by the WSCRM. All features found shall be excavated in profile and recorded in three dimensions and recorded by scale diagram and photography. Plan view and cross section drawings of each excavated feature shall be prepared and included in the final report, as shall size, shape, construction detail, probable function, and relationship to artifact activity areas, diagnostics, and datable artifacts. The descriptive analysis of structures and features shall include, but not be limited to, discussion of construction techniques, building materials, dimensions, associated features and activity areas, fill, and probable function. Separate feature forms shall be completed for each feature. All features shall be numbered or otherwise labeled to correspond with the feature descriptions within the feature form and report.

Site Maps

A good quality topographic map produced with high optical quality transit, alidade, or EDM, or sub-meter accurate GPS, shall be prepared for each site. It shall depict, minimally, the grid layout for the site; the location of potholes or other evidence of vandalism; the location, size, and shape of each site feature, excavation unit and test pit; the shape and location of artifact sampling units as well as activity loci; the location of the site stake, site and provenience boundaries, and the location of any diagnostic artifacts. In addition, each map shall contain a numbered metric scale, a dual north arrow indicating both true and magnetic north, the site number, and, if applicable, name, a legend identifying symbols contained within the map, the date of recording, the name(s) of the recorder(s), the observed site boundary, the suggested boundary for that portion of the site which appears to possess the qualities of integrity, and the relationship of the site to project boundaries (e.g., borrow pit boundaries, access road, and diversion channel rights-of-way, etc.). At the discretion of the WSCRM, site mapping may involve sub-meter accuracy GPS recording of the site and its features, and production of the map in GIS.

Site Depth

The contractor shall determine the horizontal and vertical boundaries of subsurface deposits at each site, by means of systematic augering or hand excavated test pits, if the site has not been previously well defined. This information, together with surface data and features, will assist the investigator in selecting excavation units.

Site Integrity

Following excavation, the investigator shall estimate the percentage of remaining site integrity and illustrate the intact portions of the site on the site map.

Photography

Each site shall be photographed using film or higher density electronic images (Images). It is important that photographs illustrate the general physiographic and environmental situation of the site. Individual features and diagnostic artifacts or clusters of artifacts shall be photographed as well. Photographs of potholes, erosion, or other factors that either have already affected or that may affect the integrity and research potential of each site shall also be taken. The investigator shall keep a photo log for each project that contains date of photograph, subject/content, site or IO number, feature number, direction of view, project name, photograph roll and frame numbers, name of photographer, and comments, if any. An electronic version of the log together with linked images is required per

Electronic Requirements. Each site and feature must be photographed, contain a visible scale and true north arrow, and if possible show the positions of features relative to each other. Complete or nearly so diagnostic artifacts and/or representative artifacts shall be photographed. Pothunters holes, mechanical and natural disturbance, and any other area of post depositional change shall be photographed. Representative photographs of the excavation process, including identified crew and director, shall be taken.

Paleoenvionmental Sampling

A paleoenvironmental-sampling program shall be specified by the investigator and approved by the WSCRM.

Processing and Cataloging

The investigator shall process and catalog all cultural, organic, and inorganic specimens recovered from the field investigations, whether or not they have been analyzed, according to the standards and guidelines specified in Curation.

Human Skeletal Remains

All NAGPRA cultural items shall be treated with dignity and respect. All human skeletal material shall be bagged and boxed separately from other material classes, using only natural materials and packaging. The investigator shall maintain a separate inventory of materials recovered in direct association with human skeletal remains, and shall store the materials with the remains at all times. All discovered remains will be treated per guidelines negotiated with the Tribes, or otherwise, per the provisions of NAGPRA.

Data Analysis

The Contractor shall use state-of-the-art laboratory procedures to accomplish all analyses and complete the goals of the project and of the research design. The analysis of data from each site shall contribute to an understanding of the site as a whole, and of the prehistoric and historic use of the area, as appropriate. The data analyses shall be both descriptive and interpretive, and shall incorporate, to the extent possible, data presented in previous archeological reports and archival materials. Types of analyses may include, but are not limited to occupational history; analysis of structures and features; artifact analyses, and specialized analyses.

Occupation History

Occupational sequences for sites may be reconstructed utilizing the results of chronometric studies, artifact seriation, analyses of natural stratigraphy, building sequences, analyses of cultural stratigraphy and material culture, historical records, ethnographic inquiry, etc.

Analysis of Structures and Features

The descriptive analysis of structures and features shall include, but not be limited to, discussion of construction techniques, building materials, dimensions, associated features and activity areas, fill, and probable function. Scaled plan and profile drawings illustrating construction techniques, dimensions, and relational features are necessary to supplement the narrative discussion. Higher-level HABS/HAER recording may be required on standing structures.

The basic information required is the information contained in the NM State Historic Division building recording form, including a picture. Very important is historic data on the buildings use, as well as nearby features that were connected to the use of the building, such as stands, towers, antennas, and pads. In addition to the illustrated forms, a site location map (1:24,000 scale USGS map with the building location) is required.

Artifact Analysis

Artifact and data analyses shall address appropriate research questions, but they shall go beyond mere descriptive information and reiteration of inherent problems relating to the various issues. The number and kinds of attributes and variables proposed to be monitored and measured, with statistical tests, are to be described in the data recovery plan. Artifact and data analyses shall be thorough enough to address basic issues such as site/feature function; subsistence products and procurement strategies; spatial organization and patterning; manufacturing techniques; artifact function, etc. The end result of the analysis shall be a synthetic interpretation of the data, which enhances our knowledge of the project area makes a meaningful contribution to bridging data gaps and resolving problematic archeological issues. The results of analysis shall be presented in both a descriptive and interpretive format with tables inserted as necessary to display pertinent data.

Specialized Analysis

Some studies that may be accomplished are listed below. The investigator shall identify which of the specialized laboratory analyses are required to adequately interpret the site. The investigator shall specify to the WSCRM the number, provenience, and context of samples recovered and shall identify those samples most likely to produce positive research results upon analysis. These analyses shall include but are not limited to: (1) pollen analysis, (2) flotation analysis, (3) archaeomagnetic dating, (4) dendrochronological dating, (5) radiocarbon dating, (6) obsidian hydration/ sourcing, (7) petrographic/ceramic temper analysis, (8) faunal analysis, (9) human skeletal analysis, and (10) wood identification and sourcing.

Ethnographic/Ethnohistoric Inquiries

All ethnographic/ethnohistoric inquiries shall meet or exceed those standards of performance indicated in the *Handbook of Method in Cultural Anthropology* (Naroll and Cohen, eds., 1970, Columbia University Press); *Anthropological Research: The Structure of Inquiry* (Pelto 1970, Harper and Row), and *The Conduct of Inquiry: Methodology for Behavioral Science* (Kaplan 1964, Chandler Press). The investigator shall ascribe to the Code of Ethics of the American Anthropological Association (http://www.ameranthassn.org/committees/ethics/ethcode.htm). In proposing any ethnohistoric research or study, the investigator shall maintain as much objectivity as possible toward the topic/people being studied. Potential interviewees include local landowners, land users, museum personnel, historians, ethnohistorians, and other individuals knowledgeable about the topic or region of study. All ethnographic/ethnohistoric field work must be supplemented by a thorough examination of the appropriate literature, historical documents such as homestead records, municipal and county court records, deed books, probate records, newspaper articles, etc.

Studies

The investigator shall develop and implement a systematic method for gathering pertinent informant data, including but not limited to the locations of resources, functions of resources, histories and anecdotal information pertaining to cultural resources, identification of burials/sacred-respected places. The investigator shall also present recommendations for significance according to NHPA, and recommendations for compliance with AIRFA. Should informants indicate that any resources are not to be publicized, the investigator shall place these locations in a "Close Hold" section delivered only to the WSCRM and White Sands Native American Coordinator (WSNAC). These properties shall be considered when avoiding project effects, but shall not otherwise be publicized. They shall be held in a manner accessible only to these two individuals, and shall not be subject to disclosure from a Freedom of Information Act request (WSMR, Sec. 9).

Traditional Cultural Properties (TCPs)

TCPs shall be defined in accordance with Bulletin 38 of the National Register of Historic Places Guidelines and as a result of consultations with the WSCRM and the WSNAC.

Monitoring

Monitoring to prevent disturbance to cultural resources is normally required during construction, training exercises, recovery operations, or other activities with the potential to disturb cultural resources. Even after survey, undiscovered cultural resources may be present just under the surface. Advisory Council on Historic Preservation (ACHP) regulations (36CFR800.13) requires notification and treatment of these discoveries, unless a pre-approved plan is in place. This section specifies certain limited actions that may be taken by White Sands as well as data collection and reporting, which constitutes White Sand's discovery plan. The monitor provides an intermediary between the WSMR Cultural Resource Manager (WSCRM) and operations personnel, and therefore should carry both a GPS and a wireless telephone. The archaeologist must meet requirements of 32CFR229.8 (WSMR Permit). Investigators shall notify the WSCRM of any proposed fieldwork 5 working days prior to the work so that a field inspection can be scheduled, if necessary. Monitors will submit a weekly report to the WSCRM.

New Ground Clearing or Brush Removal

During construction, monitoring is required, when appropriate, during the first ground clearing and during brush removal operations, since this is the most likely time for undiscovered sites to be found. Monitoring may also be required during deeper excavations if it is believed that buried archaeological materials may be present. Certain areas, such as Lake Otero or previously bulldozed sites, ***may*** be exempt from monitoring requirements. Artifacts discovered during clearing will be recorded as IOs, unless the density indicates that an undiscovered site is being disturbed, in which case work shall be suspended within the suspected site area and the WSCRM shall be notified. Bulldozing or brush removal may not be conducted on designated or discovered site areas, unless mitigation activities have been completed. Brush removal by hand, using chainsaws or other non-intrusive methods, may be permitted.

Discoveries while Monitoring

If an isolated archaeological feature is found, work within a 50-foot (15-meter) radius will be stopped until the feature is investigated further. The monitor shall excavate, collect, and analyze samples if the archaeological excavation can be completed within 2 hours, for example, a small hearth. Archaeological excavation does not preclude continued monitoring on other construction that requires monitoring. If the feature is excavated, the WSCRM will be notified within 24 working hours of the find and its location. At a minimum, radiocarbon and floatation samples shall be collected and analyzed, and sections of the feature recorded. Report requirements are the same as under testing reports. Human remains, of course, are excluded from this provision (see below).

Significant Discoveries

If the feature is significant, that is, not limited and isolated, the WSCRM will be immediately notified. The archaeologist responsible for monitoring shall consult with the WSCRM regarding a recovery plan, and the WSCRM will notify the Advisory Council on Historic Preservation (ACHP), State Historic Preservation Officer (SHPO), Tribes (Native American tribes that have indicated an interest), and interested parties, and, taking into account all comments and concerns received within 48 hours of notification, may authorize implementation of the plan if the area is essential for the project completion. If delay or avoidance is possible, the WSCRM shall consult with all parties regarding the plan before implementing it. The resulting report (see testing discussion in *Reporting Requirements*) will be submitted for comment.

Pipeline and Communication Lines

Narrow trenches will be monitored primarily for features, with artifacts being recorded as IOs (see Survey Requirements). The monitor shall not follow the trencher or heavy equipment too closely, since Unexploded Ordnance (UXO) may be plowed up (See UXO reporting requirements). When features (other than human remains) are detected, since the damage has already occurred, the monitor shall recover any fragments of feature matrix, mark the spot (GPS waypoint), and arrange to excavate a test unit to determine the source of the stain or other indication. Should the feature(s) represent a significant find, the archaeologist responsible for monitoring shall consult with the WSCRM regarding a recovery plan. The WSCRM will notify the SHPO, Tribes, and interested parties, and, taking into account all comments and concerns received within 48 hours of notification, will authorize implementation of the plan. The resulting report will be submitted for comment.

Recovery Operations

Search and recovery of missile and other munitions from the surface of the land are an essential part of WSMR's mission. Recovery allows analysis and determination of cause of failure, allowing the condition to be corrected, as well as recovery of sensors that record information regarding performance. Normally, searches are conducted by helicopter or on foot, and use a once-in, once-out entry to lift pieces that are too heavy to carry out by hand. These operations will not normally require monitoring, nor will activities within high impact WITs (Weapons Impact Targets) where the area has been previously surveyed and mitigation conducted on all cultural resources (e.g., Denver, Rhodes, 649, Stallion, and ABC-1). Conditions that require monitoring are: (1) where multiple entry of tracked or wheeled vehicles will establish a road, in which case the monitor shall select a track that avoids damage to cultural resources, (2) where digging is required to recover an instrument or part of the weapon, (3) off road activity when conditions are such that the land would be disturbed extensively by the traffic, for example crossing very wet ground, (4) operations outside the main boundary of WSMR, for example in the FIX area, where WSMR does not own the land, and in other situations where a monitor is required by another agency, SHPO, or Tribe.

Training

Training exercises rarely take place on White Sands, as the mission is to support testing and evaluation of weapons systems. Off road travel is limited to foot traffic and low impact vehicles unless the area used has had an archaeological survey and is free of cultural resources. Large-scale cross-country exercises are impractical on WSMR, since they require complete survey and mitigation prior to the exercise. The few small training exercises that do occur usually require monitoring to ensure avoidance of cultural resources. For unit emplacements, the monitoring shall be timed to coincide with training unit set-up, since encroachments on cultural resources can be prevented. A follow up site visit is also required to document actual use impacts on the training site. Cross-country training requires a post-operation reconnaissance to verify low impact operations were conducted. Secrecy concerns may require exact locations examined to remain unspecified in the report, but any damaged cultural resources must be described. Areas in which targets are established or live firing takes place requires prior archaeological survey. Proposed training undertakings will be coordinated through the WS-ES-C office.

Human Remains

The discovery of human remains will require immediate cessation of work within 50 feet (15 meters) of the discovery and notification of the WSCRM, who will notify the Coordinator for Native American Affairs (CNAA), SHPO, Tribes, and interested parties. The monitor, after taking steps to protect the remains from further disturbance, shall continue to monitor other construction to insure that additional materials are not disturbed. The remains shall be examined in place by the WSCRM to attempt to determine affiliation (e.g., Native American or European). The CNAA or WSCRM shall then consult with the proponent of the action to determine if avoidance is a possibility. The proponent should understand that, for Native American remains, a minimum of 30 days avoidance is required before work can proceed. If the remains are Native American or ethic affiliation cannot be determined, the WSCRM shall confer with the Tribes prior to any further actions, however, if an avoidance strategy is found, the construction may proceed, with care taken to protect the remains pending resolution with the Tribes over the procedures to be undertaken.

<u>Reports on Monitoring</u>

Reports including monitoring operations shall detail areas examined, resources discovered, and artifacts collected as well as a description of the work being monitored (see *Reporting Requirements*). Collected isolated occurrences shall be described, as will excavated isolated features. The report shall include details of samples recovered and their analyses, including dating, flotation, pollen, and macro-botanical analyses. Sites discovered during the course of monitoring shall be recorded and the site forms included in the report.

Reporting Requirements

All archaeological and historical survey, testing, monitoring, and data analysis performed on White Sands Missile Range (WSMR) will require the preparation of a written report. Written reports summarizing the results of work performed shall be prepared in a format reflecting contemporary organizational standards of professional archeological, architectural or historical journals. Electronic copies of the report are also required, in a searchable, unlocked, .pdf (i.e., Adobe Acrobat) format complete with all images and tables. In the future, it may be possible to eliminate paper copies of some of these reports or other requirements. If so, the requirements will be revised. All reports prepared for WSMR shall be free of copyright restrictions. WSMR shall be free to reproduce, copy, publish and disseminate all reports or data on the World Wide Web, if so desired.

Locational Data

Information that would allow archaeological and historical sites to be located shall not be released to anyone other than the WSCRM. The WSCRM shall protect the information, per DODI 4715.3, and only release it to qualified professional archaeologists and historians who have a need to know, as well as the SHPO and THPOs.

Public Release Reports. In reports for public distribution, specific locational data that would allow sites to be found by the reader shall be omitted from text and illustrations. Sites may be shown at 1:250,000-scale or less accuracy. The public release copies shall contain a map showing the survey area, but not sites and isolated occurrences (except military era buildings), and shall not contain map coordinates of any cultural resources except military era buildings. It is policy that the client receives only public release copies, since these copies do not have to have special access controls. The WSCRM will advise the client on restrictions and options, and arrange for an archaeologist to monitor if necessary.

Restricted Access Reports. All reports that have locational data shall be restricted, and contain the following notice on the front page regarding the Freedom of Information Act (FOIA) exemptions:

Exempt From Mandatory Disclosure Under FOIA Exemption 3 applies. National Historic Preservation Act of 1966, as amended, PL89-665, Sec 304

They shall also contain the text:

RESTRICTED ACCESS Information on the location of archaeological and historical sites may **not** be duplicated or reproduced

A banner line, in at least 14-point, boldface type, across the top edge of all copies of restricted access reports, including those kept by the contractor, shall read:

PROPERTY OF US GOVERNMENT RETURN TO WHITE SANDS MISSILE RANGE ENVIRONMENTAL

Geographic Information Systems (GIS). While the White Sands Environmental and Safety (WS-ES) GIS system is an intrinsic part of the management of cultural resources on White Sands Missile Range, site locations are stored in a private file accessible only to the cultural resources staff. This information shall not be shared as part of data sets for release to other agencies, groups, or individuals, except as specifically approved by the WSCRM. Investigators and contractors shall safeguard electronic information as well as paper products.

Information Sensitive to Native American Communities. Location of places that are sensitive to Native American Tribes shall be protected from disclosure to all but the WSCRM and WSNAC, who shall use the data to help protect these resources. This data will not be placed on Geographic Information Systems (GIS) but will be kept in locked file cabinets accessible only to the two individuals.

Data Sharing Agreement. White Sands Missile Range has a Data Sharing Agreement with the SHPO (see *Appendix B*) that requires site locational data to be shared with NMCRIS, the data storage section of the New Mexico Historic Preservation Division. This agreement, in part, requires that:

> All information developed and disseminated under this agreement will be made subject by the State and WSMR to such restrictions of accessibility to ensure that its disclosure will not create risk of harm to cultural resources or the site at which such resources are located, consistent with the provisions of Public Law 96-95.

Information obtained from NMCRIS is subject to the same provisions of confidentiality as from WSMR, and investigators or project personnel may be required to sign non-disclosure agreements.

Inventory/Testing/Data Recovery Technical Reports

Draft and final technical reports shall contain, minimally, a concise management summary; identification and description of the project; research design and approach; relevant discussions of past and modern environment; detailed description of methodology, technique, analyses and results; illustrative photographs, images, maps, and drawings, as appropriate; and the data compendium, if applicable.

Preliminary Reports. At the determination of the WSCRM, these brief reports describing fieldwork are submitted when project schedules demand rapid compliance procedures. The preliminary report does not satisfy the requirement for a final report. Investigators and the firms they work for must build a record of submitting professional quality final reports and project submittals before WSMR will submit a preliminary report on a project. Preliminary reports are often due within five working days of the completion of the bulk of the fieldwork. Preliminary reports shall be in sufficient detail to provide the New Mexico State Historic Preservation Officer (SHPO) and Tribal Historic Preservation Officers (THPO) information on which to render judgment as to whether sufficient data was collected to mitigate proposed governmental actions prior to the final report, or that adequate survey and identification was accomplished. The preliminary report shall contain a description of the survey or excavations, artifacts, and features, copies of field forms for features or sites, and the draft maps of site, features, or survey area. For excavations, the preliminary report should demonstrate that sufficient data has been recovered to meet the needs of the research design. Four copies of the Submission of the final report is required to fulfill obligations to the WSCRM, and failure to submit the final report would have a serious impact on White Sand's ability to deal with State and Tribal authorities. ***Any investigator or firm that does not submit the final report and other deliverables on time will not be permitted to conduct investigations on WSMR until the obligation is completed. After one year from the due date, if the report is still not submitted, the investigator and associated cultural resources firm will be banned from further work on White Sands for a period of 5 years. The project will be tasked to find another investigator to finish the report.***

Draft Report. This shall be a finished product and an accurate representation of the final report. Pages of all reports shall be numbered and on standard size paper (8 ½" x 11"). Reports shall be single-spaced, one to three column format. Photographs, images, plates, drawings, and other graphics shall appear in the same size format and general location in the draft report as they will appear in the final report. All hand prepared pages, such as maps and drawings, shall be neatly drafted.

<u>Final Report.</u> The final report shall address review comments submitted by the WSCRM. The text may be printed by offset press or reproduced by a clear, high quality photocopier or laser printer (ink jet printing is impermanent and not acceptable). Half-tone reproduction is required for photographs. Electronic images must be printed in a high density, publication quality mode. Text shall be single-spaced in a one to three column format with all pages of the text numbered. White space shall be reduced by printing front to back, reducing tables to a smaller print size, and eliminating title pages for appendices. The cover shall contain the words "White Sands Missile Range Archeological Research Report XXX", where "XXX" shall be a unique number assigned to the report by the WSCRM, as well as the WSMR project number. These numbers may be obtained by submitting an electronic Project Registration for the project number. The contract number shall be on the front cover. The Company that produces the report may place its logo and name on the cover, however this may not may exceed 24 square centimeters. Final reports exceeding 50 pages shall be perfect bound. Exceptions are to be pre-approved by the WSCRM.

Delivery Instructions

All required copies shall be delivered to the WSCRM. One copy of each final report and each data compendium shall be an unbound original suitable for automatic photocopying, printed on acid-free paper, and, for all illustrations, containing original photographic prints or high quality laser printed images. Two copies shall be delivered without locational data on cultural resources, one copy unbound and one bound, and marked on the cover "Public Release Copy." All remaining copies of the final reports shall be bound. All popular reports and other reports prepared for wider distribution shall be submitted in draft form for Government review prior to preparation of the final report. Unbound means no binding, 8 ½ x 11 inch archival paper with no holes.

Report Quantities

Required quantities of paper reports are as follows, unless otherwise specified:

- Survey and testing: 20 copies, including 18 restricted access reports (one of which is not bound), and 2 public release reports (one of which is not bound)
- Data recovery (large projects) or popular reports: 50 copies.
- Data compendiums: 4 copies (1 unbound)
- Draft technical reports and research designs: 3 copies.
- Preliminary reports of investigations: 4 copies.
- Monitoring reports: 4 copies.

Electronic Versions of Reports

The WSCRM shall receive a CD-ROM master of the final report, including the data compendium (if applicable), and also scanned figures, photographs, images, maps, tables, GIS Files, LA forms, catalog, IO list, and photo list and images). Both the reports with locational data and the public version shall be furnished in unlocked .pdf format. The scanned figures, photographs, maps, tables, and other images shall be included in densities and formats as specified in Images. A set of files with all text and data of the deliverables shall be furnished on the CD-ROM in PC ASCII, RTF, or html format; in both MS Word and .pdf format versions, or in another format acceptable to the WSCRM.

Technical Reports

Technical reports will normally contain a concise management summary; background on the study objectives; research design and approach; relevant discussions of past and modern environments; detailed discussion of methodologies, techniques, analyses and results thereof, and illustrative photographs (images), maps and drawings. Specific content requirements vary based on the needs of the study and will be specified in the individual delivery orders issued by the Contracting Officer.

Inventory/Testing/Data Recovery Technical Reports. These reports shall contain, but need not be limited to, the following information as appropriate:

- **Title Page.** A title page containing title, author, Contractor name and address, Principal Investigator, sponsor name, contract number, date (month and year), WSMR archaeological project number.

- **Abstract.** Short description of the project and major findings, and short list of quantified results. Include number of acres surveyed, survey interval, width and length of linear survey, number of total sites, number of new discovered sites recorded, number of components (separated into historic and prehistoric), IOs, plus the number and volume of collected artifacts. The abstract should also contain a short summary of recommendations.

- **Table of Contents/Figures/Tables**

- **Introduction.** A section that describes the nature of the undertaking, the project location (including state, county, legal descriptions, UTM coordinates, and land status), names of the project sponsor, contractor and principal investigator, dates the fieldwork was performed and names of the individuals conducting the fieldwork, and a discussion of the management and archeological objectives and the inventory/ testing/ data recovery methodologies employed.

- **Natural/Cultural Environment.** This is a section describing the natural and man-made environment of the project/inventory/data recovery area, including a listing of flora and fauna observed during the inventory, and any conditions limiting visibility.

- **Cultural History.** The cultural history of the project area, including the results of archival research and citations concerning previous research, shall be discussed.

- **Project Area and Methods.** The investigator shall describe the project area(s) and the inventory/excavation area(s), which shall include the dimensions, size and configuration of the project and inventory/excavation areas with all measurements provided in both English and metric units, and for survey, a section describing the inventory methodology including crew size, transect spacing, transect patterning, definitions of surveyed areas, resource recording, and a discussion of any problems encountered in executing the survey.

- **Excavations** (if applicable)**.** A section shall be included describing the testing/data recovery/data analysis methodology including crew size, auger hole/shovel test/excavation unit size and depth, extent of excavation/stripping, etc.; feature and extramural excavation and mapping techniques; screening techniques and size of screen used; site mapping techniques; excavation/data collection sampling techniques employed; specialized sample collection techniques; artifact processing techniques; analysis attribute selection process and justification for the attribute selection; statistical tests utilized for analysis; computerized data entry and data manipulation methods with justification; and complete discussion and justification for sampling methodologies to be used in data analysis.

- **Artifacts.** The contractor shall describe methods and results of (1) estimating the density (or range in density) of surface artifacts and (2) estimating total frequency of surface artifacts for each of the artifact groups. Artifacts shall be described in a formal, replicable manner (e.g., an explicit definition of attributes used to place an artifact into one grouping or another shall be specified in the report). Artifacts to be addressed include debitage, formal chipped stone tools (projectile points, bifaces, etc.), ground stone tools, ceramics, metal and glass items, and any other pertinent categories. All IOs and collected artifacts shall be listed in tables with identification or catalog numbers, location, illustration figure number, and category of artifacts.

- **Descriptive Data.** Each cultural resource inventoried/tested/excavated, including UTM coordinates and legal descriptions, shall be described. Minimal data to be included are the general environmental situation, definition and location of horizontal site boundaries, a description of the location, number, and kinds of surface features, nature of artifact assemblages, density and frequency of artifacts, and site integrity. Structural features (i.e., rooms, hearths, bins, depressions, terraces, etc.) shall be described noting size, shape, construction details, probable function, and relationship to activity areas. For survey, the investigator shall include his/her assessment of the potential of subsurface deposits at each site. Whether the investigator makes a professional judgment that a site is surficial or contains subsurface deposits, a clear statement with supporting evidence shall be provided (e.g., strata visible in arroyo cut, results of auger tests). The contractor shall include his/her assessment of the present condition of each site including: (1) identification of the kinds of post-depositional activities which have affected the site; and (2) estimate of the percentage of total site affected by each kind of disturbance and that portion retaining good integrity. For each site the contractor shall list the potential for obtaining the following kinds of chronometric samples: (1) radiocarbon samples (how many and in what context); (2) dendrochronological samples (how many and from how many different features); (3) obsidian hydration (how many and from what possible source area); (4) diagnostic artifacts (list kind and frequency); and (5) other (specify). The potential of the site shall also be described for addressing other current research questions. The contractor shall carefully avoid making statements that assess future research potential, since we cannot know what will be important in the future. Historic sites shall be described to include features, identification of sites by historic review and any other information gathered during archival research, measured drawings, or photography. Past owners of the property shall be indicated. The contractor shall also give his/her evaluation of the condition of resources.

- **Summary Table.** A table of sites and components found at the sites (LA number, contractor or field number, with short description, size, date, and potential research topics).

- **IO Table.** List IOs, material, short description, measurements, and UTMs. Indicate any collected material and WSMR catalog number.

- **Maps.** Include copies of appropriate portions of 7.5-minute series USGS topographic maps that depict the location and extent of the project area, the location and extent of the areas inventoried, as well as all inventoried resources. A general location map with the WSMR boundary and the project area shall also be included. For sites, a good quality sketch map shall be included which depicts, minimally, the relationship of the site to nearby physiographic features, the location of each feature, the shape and location of artifact sampling units, activity loci, the location of the site stake, site and component boundaries, disturbed areas (including type of disturbance), and the location of any collected artifacts. Laboratory of Anthropology (LA) site numbers shall be used on final and published maps. See Mapping Requirements, but note the restrictions for Public Access Reports.

- **Photographs.** Photographs or images that illustrate the project area, sites, artifacts, and environment shall be interspersed as appropriate. Photographs must be cleared for security concerns prior to publishing. In general, avoid images of buildings and test setups, unless the building is being recorded. Photographers must have on their person a WSMR Photo Permit. See Imaging.

- **Findings.** The results section shall detail the results of the architectural, artifactual, contextual, environmental, subsistence, etc. data analyses. The discussion shall focus on the goals and objectives of the research design and shall be interpretive and synthetic in nature.

- **Appendices.** Analytical reports, site forms, auxiliary feature and data analysis forms, catalog of collected artifacts, and site maps.

- **Legal/Religious Significance.** The investigator shall, if possible make an informed judgment, include individual recommendations on the significance of the inventoried/tested resources with respect to the qualities necessary for inclusion to the National Register of Historic Places, their relevance to Bulletin 38, and whether or not the individual resources are of archeological interest (per WSMR). The investigator shall be mindful that future developments in archaeology may allow a property to yield significant data and shall avoid statements that could be interpreted to mean it will never have significance.

- **Recommendations.** Recommendations concerning any additional evaluation and/or protection measures, treatment, and/or future management activities in the project area.

- **Cross Index.** For survey reports, a cross index giving the LA site number, page of the site description, and pages containing site maps shall be included as the last physical page of the report or on the inside back cover.

<u>Monitoring Reports</u>

Reports on archaeological monitoring tasks shall detail the areas examined, resources discovered, and artifacts collected, together with a description of the work that was monitored. Isolated occurrences that were collected shall be described, as well as any excavations. Details of samples, including their analyses, shall be reported. Analyses may include dating, flotation, pollen, macro-botanical, faunal analyses, and other specialized analyses. Sites discovered during the course of monitoring shall be recorded, and the site forms submitted with the report.

<u>Data Compendiums (Restricted Access)</u>

When a report contains more than 10 site forms, a data compendium shall be submitted that contains edited and typed site forms, clear site maps, and USGS quadrangle maps (or portions thereof) showing the location of the survey/project area(s) and all sites and isolated occurrences. Smaller reports shall have the data appended to the end of the restricted access copies. Labels on USGS 7.5' maps shall identify all sites and IOs. Field and Laboratory of Anthropology numbers shall be included on site forms, as well as WSMR site numbers if applicable. Early WSMR sites were recorded with WSMR site numbers, and provisional identification of sites is made with WSMR numbers. The data compendium may also include analyses, artifact provenience tables, and other details or recording forms used during the investigation.

Research Designs

Detailed technical plans shall be prepared for data recovery or integrity preservation projects. These plans shall include estimates of the labor effort for data recovery or integrity preservation based on known site characteristics. The discussion shall focus on the goals and objectives of the research design and shall be interpretive and synthetic in nature. The plans shall be of sufficient detail to allow technical review and approval by the WSCRM, SHPO, THPO, and/or other professional authority selected by the government.

Popular Reports

Popular reports are intended to transmit results from archaeological, historical, and architectural studies into a form accessible to an informed public. The text needs to be free from scientific jargon and illustrated with well-chosen illustrations. Where oral histories are involved in the study the text should use the informants words whenever possible.

Other Data Requirements

Film and Electronic Photographic Folders

The photographic or image log (on 8 by 10 or 81/2 by 11 inch paper) shall contain date of roll, date of image, subject/content (identify area of range, sites, and any people), site or IO number, feature number, direction of view, photograph roll and frame numbers (or file name), name of photographer, sensitivity, and any comments. Images should be classified as "sensitive" if they contain background imagery that could be used to locate the site. The electronic version of this log (required) is formatted to print the paper version (see Images). Attached to the paper version shall be archive storage polyethylene sleeves containing the color or black and white negatives, neatly labeled, with corresponding thumbnail print(s) (or same size reproductions of negatives or slides, in color if applicable). A labeled copy of the thumbnail images together with the photo/image log shall be placed in each applicable site folder as well as the project file. Slides shall be individually labeled and stored in archival polyethylene plastic sheets for binding in a 3 ring binder with a copy of the photographic log. If an image release clearance applies to the images, a copy of the clearance shall be inserted into the photographic or image log. The negative sleeve shall contain both the negatives and the photo log in a multiple pocket sleeve, not exceeding 9 by 11.5 inches in dimension. The sleeve has rows of negatives on one side, and a large pocket for the photo log on the other. Use a permanent marker to label the sleeve with the catalog date and roll number. An electronic photo log shall be prepared and incorporated into the CD. For digital photography, a camera with a minimum of 2.0 mega pixels will be used and images will be provided to WSMR in .jpg format on a CD or DUD. Medium resolution camera setting will be used.

LA Files

A copy of each LA form and building inventory form, with maps shall be delivered to the WSCRM in manila folders with the LA number placed on the three tab folder label in 24 point type.

For Cold War building recordation, the file will be labeled with the WSMR building number and will contain the NM HPD Building Inventory form and a written description of the building and its history and background. Both forms shall have labeled thumbnail images of relevant photographs or images included with the photographic log. An electronic version of each LA and building form is required, in Adobe .pdf format, with all text and illustrations, and labeled with either the LA number or building number. Site forms from other states shall contain the full site form together with maps and photograph thumbnail images.

WSMR File

A folder labeled "WSMR" will be delivered to the WSCRM containing the NM HPD activity form, LA or building inventory sheets, and one bound copy of the report. For other states, substitute the required site and permit forms.

Curation Catalog. This is a catalog of all curation items and verification of delivery to or storage of the curation items in a curation facility. The catalog shall describe each lot (as determined by provenience); a unique WSMR catalog number (supplied by the WSCRM); a consecutive number within the project; a list and counts of artifacts (or other curation items) contained within the lot and broken down by artifact type or curation item; field and report designations of the provenience; date of collection; and the description (see *WSMR Catalog Number System* for a complete description).

Project Folder

A folder will be delivered to the WSCRM with copies of the contract scope-of-work, project final cost, HPD activity form, and all analyses completed for the project. It will contain a copy of the research design, photo log and color thumbnail images, copies of all field notebooks and forms, laboratory notes and forms, audio and video tapes, curation catalog and any other data acquired. Rather than a full copy of the final report, the folder need only contain the cover sheet.

Mapping Requirements

Detailed 1:24,000 scale maps with USGS maps in the background are to be delivered with the final report. At this time the master map is still kept on paper, but White Sands is in the process of a migration to electronic format. The WSCRM will notify investigators when the paper requirements are no longer required. In the meantime, both paper and ArcView compatible electronic files will be required.

Map Deliverables

Maps are due to the WSCRM at the same time as the final report. A USGS map is to be submitted or, on approval of the WSCRM, the data may be entered on WSMR copies of the maps. In addition, a digitized Arc GIS shapefile of site boundaries, isolated occurrences, and survey boundaries, together with linked data cables will be furnished that is suitable for entry into the Environmental Stewardship Division Geographic Information System computer system. As an alternative, the contractor may enter the computer information directly into the government's computer located in the White Sands Environment and Safety Directorate. WSMR intends to convert to using the NMCRIS system in the future, and at that time the deliverable will be required to be entered into the state system. Data from other states will require compliance with that state's requirements, as well as a shapefile delivered to WSMR.

Preparation Instructions

Each site, each isolated feature, and boundaries of the areas surveyed or investigated shall be plotted on original USGS quadrangles (7.5 minute if available) and project maps with a solid line. The actual boundary of each site, not a central point, shall be plotted. Isolated features (such as structural features or hearths) shall be plotted using a square symbol unless it is a linear feature such as a fence or road, in which case appropriate mapping symbols shall be used. Each survey unit shall be identified with a contractor identification and project number, together with the date of the report. If multiple units have been surveyed, add other identifiers as appropriate, for example TSN W Link 19, the same designations as are used in the report. Do NOT map the boundary of the sampling area.

Labels

Laboratory of Anthropology site numbers shall be clearly printed next to the site, if appropriate. Some Cold War sites are identified by building number (B 29052 CW), which may be in addition to the LA number. Give the name of the site if it has a Cold War name, for example, AMRAD Site CW. For other historic sites, add an "H" and, if the site is associated with a ranching or mining property, the name of the site. If the site boundary is unknown indicate the probable area with a dashed box and a dot for the location of the labeled stake, if present. Unrecorded sites are denoted with a dashed box or circle, without the central dot.

Linear Surveys

Linear surveys must identify the width surveyed, usually multiples of 15 meters. If on an existing road, identify on which side(s) of the road the survey was conducted, with short arrows pointing to the side surveyed. Specify whether the figure is "one side" or "total" survey width.

Map Symbols

The following symbols will be used on maps:

- Historic sites - H
- Cold War Sites - CW
- Building - B
- Laboratory of Anthropology - LA
- Site boundary - solid line

- Survey boundary - solid line
- Unrecorded boundaries - dashed line
- Isolated Occurrence - solid dot
- Isolated Feature. square block

Submittals Checklist

- ❑ PRELIMINARY REPORT -- 4 Copies
- ❑ FINAL REPORT ˜ 7 copies Restricted Access (with locational information, bound); ˜ 1 copy Restricted Access (unbound) with original quality illustrations; ˜ 2 copies Public Release (1 bound, 1 unbound)
- ❑ MONITORING REPORT ˜ 4 Copies
- ❑ DATA RECOVERY (large projects) OR POPULAR REPORTS ˜ 50 Copies
- ❑ DATA COMPENDIUM (Restricted Access) ˜ 3 copies bound ˜ 1 copy unbound
- ❑ ARTIFACTS (All artifacts from Government land remain the property of US Government) ˜ Labeled polyethylene bags with artifacts ˜ Labeled archival boxes ˜ Curation catalog, 2 copies and electronic version
- ❑ PROJECT FOLDER ˜ Copy of contract scope of work ˜ Project final cost ˜ Copy of HPD activity form ˜ Analyses ˜ Research design ˜ Photo/image log and thumbnails ˜ Field notebooks/forms ˜ Laboratory notes/forms ˜ Other data ˜ Labeled audio/video tapes ˜ Curation catalog copy ˜ Cover sheet of preliminary, final reports
- ❑ LA/BUILDING FORMS ˜ Individually labeled 1/3 tab folders ˜ Form, narrative, project map, site map, photo thumbnails and log, artifact catalog copy
- ❑ BUILDING RECORDS ˜ Individually labeled 1/3 tab folders ˜ Form, narrative, project map, site map, photo thumbnails and log, artifact catalog copy

- ❑ MAPS ˜ Electronic and paper maps with sites, survey boundaries, IOs. 1:24,000 scale for paper
- ❑ PHOTO/IMAGE FOLDER ˜ Photo/image logs (electronic version also) ˜ Polyethylene sleeved negatives/slides ˜ Labeled thumbnail/contact sheets of images
- ❑ WSMR FILE ˜ HPD activity form ˜ LA/building forms ˜ Bound copy of report
- ❑ CD-ROM
- ❑ Final report (both public and restricted versions) in unlocked .PDF **and** text versions ˜ Data compendium ˜ Images: high, low resolutions and thumbnails ˜ Photo/image log ˜ IO database ˜ Artifact Catalog database ˜ GIS files (.WSMR) ˜ LA/Building forms in pdf format

Electronic Requirements

Request for WSMR Project Number and WSMR Permit

Contractors shall obtain a WSMR Project Number and WSMR Permit prior to starting fieldwork. The WSMR Project Number serves as a reference number for project documentation on all paper records and the records in the various electronic databases. The WSMR Project Number and WSMR Permit shall be obtained from the WSCRM.

Site Registration Copy

An electronic version of the NMCRIS Laboratory of Anthropology Site Record shall be made and submitted with the deliverables. The form will be in pdf format.

Copy of NMCRIS Activity Request

An electronic version of the completed NMCRIS Activity Request form shall be made and submitted with the deliverables. The form will be in pdf format.

Images

Photographic logs are required in a specific format, which is described in a formatted Excel spreadsheet. Data are entered on the spreadsheet, a paper copy printed out, and the data saved to a unique file name consisting of the date of the roll (yymmdd) followed by the role number (if required to differentiate the roll), and an 'a' and 'b' if the roll has more than 26 images. The spreadsheet is available from the WSMR.

All illustrations and record photographs/images shall be delivered to the WSCRM in electronic format. Images from electronic cameras shall be taken at high quality (usually 760x1028 or better) and obtained from the camera in .JPG format (no compression), with 24-bit color. Other photographs shall be scanned, preferably from clean (dust free) original negatives or slides, and furnished in .JPG at 2048x3072 pixels or, if scanning is purchased with film developing, high resolution Kodak Picture CD format (35-mm is 1024 by 1536 pixels). If the picture CD is obtained when the film is developed, the images shall be saved on a separate CD as .JPG, mid-level JPEG, and thumbnail images. A program that comes on the CD provides a "Save As" function.

All camera images shall also be furnished in 2 secondary formats, consisting of lower quality, compressed images. The mid-level images shall be stored as JPEG format, 24-bit, approximately 512 by 768 pixels, compressed to high resolution. The thumbnail images shall be stored as GIF89a or JPEG format, approximately 110 by 150 pixels.

File names for electronic camera images on the CD shall be composed of the roll date (yymmdd) plus the roll number if required, followed by the frame number as indicated on the photo log. The .JPG images are identified with the extension .tif, the mid-level images by .jpg, and the thumbnails with a "T" just before the extension, ".jpg" or ".gif". Each file name must be unique.

All diagnostic cataloged artifacts shall be imaged, and the file name of the image shall be the full catalog number, without periods. Multiple images of the same artifacts shall be denoted by consecutive letters; a, b, c.

Original videotapes shall be submitted for archiving with a complete, scene-by-scene description of the contents, length of scene, identification of the people interviewed, location of photography, subject of recorded discussion, and date. Release statements signed by the subjects and copyright assignments to WSMR shall also be attached.

Audiotapes shall be submitted for archiving with a complete description of the contents, including the interviewer, interviewee, subject, date of interview, and release statements signed by the subjects.

Photo Log Instructions

The Excel spreadsheet is designed to provide a printed photo log while formatting the information for entry into the photo database at White Sands Missile Range. Enter the data on "Photo Log" and press the submit button. The data is formatted and written to the Upload File worksheet. Save the photo log under the unique catalog date (yymmdd), Roll Number, and "a or b" identifier, then close the file and reopen the blank spreadsheet for the next roll.

- *Project Name/Location:* Enter the short project name assigned by WSMR and in what area the project is located. Include leading zeros to 4 digits.

- *Contractor ID:* Enter the initials of the company and the company's project number

- *Catalog Date:* One date is used to identify and file the entire roll. it is usually the date of the first photograph or the date when most of the photos were taken.

- *Roll Number:* This should be "1" unless more than one roll was taken on the Catalog Date. This is not the number of rolls in the project. Together with the Catalog Date it forms a unique identifier for the roll.

- *WSMR Project Number:* A unique number for the project assigned by the WSCRM in the format "WSMR XXX".

- *Photographer:* Name of the photographer who took the pictures.

- *Media:* Use the drop down box to select BW (Black and White), Color Negative, Slide, Digital, or Video.

- *Date:* For each image, enter the date the photograph was actually taken. Usually this is the same as the Catalog Date.

- *Frame*: The actual frame number on the negative or slide, or the image number on digital images.

- *Subject:* Give a complete description of the subject, including names of people, what is pictured, and identifying numbers (such as feature numbers). Note if the picture is copyrighted (Government contracted work is not copyrighted) and by whom. Include the file name for digital images, which should include the date (ddmmyy), roll, and image #. Include a full other site number if there is no LA number, for example, 42GR7 or WSMR 93-02.

- *Looking:* Direction facing: N, NE, E, SE, S, SW, W, NW, Up or Down.

- *Constrained:* If a site can be located using this picture, it is considered sensitive and the box is checked.

- *LA Number:* Give the LA or other site number if the image is associated with the site. Do not repeat "LA" and do not include commas or other punctuation. Add leading zeros to expand the number to six digits, e.g., LA 83,015 would be listed as 083015.

Project Information

The investigator shall submit the electronic **Beginning Project** data at the start of the project, together with WSMR information and the **Final Project** form at the completion of the project. They require the following information:

- *Initial Project information:*

    - *ProjNo:* The White Sands Archaeology Project Number (assigned by WSMR at beginning of the project). Include leading zeros to 4 digits.
    - *ContractNo:* The contractor name and their contract number (e.g., Walcoff 01-2).
    - *ShortName:* The short name assigned by the WSCRM at the start of the project.
    - *NMCRISNo:* The New Mexico Activity Number. Leave blank for other states.
    - *ARPANo:* The Federal WSMR Number.
    - *ProjDescrpt:* File name of a short description of the project, identifying who, what, where, when, and why in Word, Wordperfect, or text format. The file name should contain the short project title followed by a 4-digit project number (include leading zeros).

- *Final Project information:*

    - *ProjNo*: The White Sands Archaeology Project Number (assigned by WSMR at beginning of the project). Include leading zeros to 4 digits.
    - *TotalCost*: Total cost of project is the actual funds received for the work by the contractor. Apportion the cost of survey, recording projects, testing, excavating, monitoring, and other projects among the following fields.

- *SurveyCost*: The dollar amount that can be attributed to survey. This will equal the *TotalCost* for most survey projects.
- *RcrdingCost*: The dollar amount that can be attributed to recording cultural resources, for example for historic buildings or National Register studies. If the recording was done as part of a survey then it should not be separately reported in this column.
- *TestCost*: The part of *TotalCost* that can be attributed to testing cultural resources. This should be reported separately from survey cost.
- *MontrCost*: The part of *TotalCost* that can be attributed to monitoring cultural resources. This should be reported separately from survey cost.
- *Excvtncost:* The part of *TotalCost* that can be attributed to excavating or mitigating cultural resources. This should be reported separately from survey cost.
- *OtherCost*: The part of *TotalCost* that can be attributed to projects other than listed above, such as projects that manage records or curate artifacts.

Excel spreadsheets are available from the WSCRM to enter and submit this data.

LA and Building Forms

Besides the paper copies of the LA, NM Building, or other site forms, an electronic file with the narrative, maps, and thumbnail photos is required in Adobe Acrobat .pdf form. The name of the file should be the LA site number, WSMR building number (beginning with "B"), or other site number. If an LA file, the file name should be listed with "LA," followed by the site number with six digits (include leading zeros), and no punctuation (for example, LA080641.pdf; LA120673.pdf; B017384.pdf; or 42UN128.pdf).

Building Data

A database of buildings information is due with the forms. The format is as follows:

- *BuildingNo:* Text, 15 characters, include the prefix T for temporary building, S for semipermanent buildings, and M for mobile buildings.

- *BldgType:* Text, 30 characters, giving the official designation of the building.

- *ConstructionDate:* Number, 4-digit date of construction.

- *SiteText:* 30 characters. Official designation of area the building is located in, for example, Headquarters.

- *WSMRproj:* 15 characters. WSMR Project Number, assigned by WSMR. Include leading zeros to 4 digits.

- *CntrProjNo:* 15 characters. Contractor project number.

- *PackageDel:* 10 characters, date format, DD/MM/YYYY. Date recording package delivered to WSMR.

- *SHPOresponse:* 10 characters, date format, DD/MM/YYYY. Date recording package delivered to WSMR.

- *Eligible:* 1 character. E = eligible; N = not eligible; U = undetermined.

- *DemolishDate:* 10 characters, date format, DD/MM/YYYY. Date building was demolished.

- *Comments:* 50 characters. Include any site names other than that in "BldgType."

IO Database

An Excel spreadsheet is available from the WSMR for this database format, due at the completion of the project:

- *ProjectNo:* White Sands Project Number assigned by the WSCRM. Include leading zeros to 4 digits.

- *IONo:* Number of the IO as reported in the final report.

- *Description:* Description of the artifact(s).

- *UTMEast:* Nad 83 Universal Transverse Mercator easting. Numbers only, no punctuation.

- *UTMNorth:* Nad 83 Universal Transverse Mercator northing. Numbers only, no punctuation.

- *Count:* Number of artifacts included in this IO. Numbers only, no punctuation.

Electronic Copies of Reports

An electronic copy of the reports is required in Adobe .pdf format, with the WSMR issued short title as the name of the file. Also required is a Adobe .pdf file with the complete text, figures, and tables of the report.

The bibliography entry is required in the following database format:

- *ProjNo*: WSMR project number assigned by WSMR. Leave blank if the report is not a WSMR project. Include leading zeros to 4 digits.

- *Author*: Names, last name first, of the authors of the report. If more than 4 authors, cite the primary and add *et al.*

- *Date-Month*: Month the report was published.

- *Date-Year*: Year the report was published. Use digits only; do not include letters.

- *Title*: Full title of the report.

- *Publisher*: Name of the company that published the report.

- *Publisher Location*: Location of the publisher.

- *CntrReportNo*: The contractor's internal designation for the report.

- *Abstract*: File name of the electronic file that contains the abstract of this report.

- *FileNamepdf*: File name of the electronic file that contains the Adobe Acrobat .pdf file with the report.

Artifact Catalog

See curation procedures for entry procedures. An Excel spreadsheet entry form is available from the WSCRM.

Project Folder

The entire contents of the project folder should be scanned and placed on an Adobe .pdf file with the short name as the file title, prefaced by "Proj" and the WSMR Project Number, for example, "Proj0345TSNLink37.pdf".

Maps Data File

For survey and recording projects an ArcGIS shapefile shall be delivered with a View containing the boundaries of surveyed areas, a View containing the boundary of each site, and a View with each recorded property (buildings, fences, feature IOs). The associated tables shall contain the following fields, some supplied as defaults by ArcGIS:

- *Surveyed Areas.* Surveyed areas are of block tracts of land (e.g., target area) and linear tracts of land (e.g., utility and road rights-of-way). Data for the surveyed areas include a sequential identification number, area identification (project name), polygon showing total area surveyed, perimeter size, and total acres of the survey.

- *Site Boundaries.* Site boundary data use the multipoint format to show the shape of the site. The supporting cultural information includes Laboratory of Anthropology identification number (LA number), number of components, first culture, diagnostic artifacts, assemblage comments, and earliest and latest dates. Additional site data include chronometric data (e.g., radiocarbon dates, obsidian hydration results, and archaeomagnetic dates). The Shapefile should include dots or lines for boundary, centerpoint, UTMs NAD83, LA Number, and WSMR project number.

- *Buildings.* Building data include the building number (with prefix T, S, or M), building type, construction date, and location on WSMR. In addition, historic fences and isolated features (hearths, corrals, prospect holes, etc.) shall be entered as part of the map record.

Cultural Resource Database

The electronic Cultural Resource Database at WSMR is composed of smaller databases, which are listed below and identified as *Tables*. The *Project Numbe*r is the common link used to search the various databases.

Tables

Key: UPPERCASE - Name of Table; *Italic* - add or in another table; **Bold faced** - main key

- PROJECT NUMBER: main key. Sequential number that ties reports, sites, catalog numbers, photos, and project areas

- PROJECT TABLE:
    - **ProjNo** (Supplied by WSMR)
    - Short Name Supplied by WSMR
    - Contract No
    - DO or WAO No
    - NMCRIS No
    - Cntr. Proj No
    - Total$ Total $ cost of WSMR on project: Sum of Surv, Rec, Test, Mon, Excav, Other.
    - Survey$ Cost of survey effort
    - Recording$

- Testing$
    - Monitoring$
    - Excavation$
    - Other$
- REPORTS
    - **ProjNo**
    - Author(s)
    - Date-Month
    - Date-Year
    - Title
    - Publisher
    - Location
    - CntrProjNo

- ABSTRACT *Link to .pdf of report*

- PHOTO/IMAGE **(Split roll & image)**
    - **ProjNo**
    - RollNo
    - FrameNo
    - *Location – need drop down list of places on WSMR*
    - Subject
    - LANo
    - Photographer
    - Image Type (BW, NC, SL, IM)
    - Date (of roll, for photo filing)
    - Restricted?

- CATALOG
    - *ProjNo*
    - WsmrCatNo
    - LocType
    - LANo
    - ArtiNo
    - OtherNo
    - UtmEast
    - UtmNorth
    - Gridns
    - Grides
    - OtherProv
    - Level
    - Top
    - Bottom
    - ArtType
    - Descript
    - Portion
    - Material
    - Qty
    - Comments
    - BoxNo

- FILE DB
  - ProjNo
  - *BoxID*
  - *Description*

<u>GIS Tables</u>

- *SURVEYED AREAS*
  - **Proj No**
  - *Survey Interval* (From PROJECT)
  - *Land Status* (private, WSMR, BLM, Forest Service) (From PROJECT)
  - *Link to Sites*

- *SITES*
  - **ProjNo**
  - LANo
  - OtherSiteNo
  - Name
  - Historic? (from R&M table)
  - *Link to LA Forms (.pdf)*
  - *Link to Photos*
  - *Link to Catalog*

- *OTHER SITES*
  - Other Site No
  - Name
  - *Comment*

- MINES
  - Existing data only

- *HISTORIC ROUTES*
  - *Name*

- ***SITE COMPONENTS***
  - **LANo**
  - Period
  - Type

Artifacts and Curation Standards

All artifacts collected from U.S. Government land remain the property of the Government. While the artifacts are in the possession of investigators, all government artifact/sample containers shall be labeled as indicated below:

Property of U.S. Government (White Sands Missile Range)

Acknowledgments

Much of this curation guide was conceived, designed, and written by Toni Laumbach. Editing and changes have been made by WSMR from the original *Curation Guide for White Sands Missile Range*, by Toni Laumbach, Chris Wende, and Sara Eidenbach (1994), and the *Addendum to the Curation Guide for White Sands Missile Range: The Electronic WSMR Catalog System*, by Meade Kemrer, Toni Laumbach, and Martha Yduarte (1995).

Artifacts

<u>White Sands Missile Range (WSMR) Collection Policy</u>

Documentation of most cultural materials should be made in the field. Limited collections of diagnostics or other artifacts may be made for specialized studies (e.g., sherds for petrographic analysis or expert identification; obsidian for source and hydration studies, etc.), or for objects that might disappear through unauthorized collecting. Large objects such as metates and mortar holes are not normally collected, but may be pollen washed in the field. The location of collected artifacts shall be piece-plotted in relation to the site datum and recorded on the site map, or, if an isolated object, the position plotted on a USGS quadrangle and the coordinates noted (Universal Transverse Mercator (UTM)). During excavations, all artifacts shall be collected. Deviations from this collection method may be made only with prior approval of the WSMR Cultural Resource Manager (WSCRM).

Curation Introduction

Public and private agencies involved in archaeological activities are subject to federal and state laws for the protection of cultural resources. The cataloger must be in full compliance with regulations including, but not limited to, the National Historic Preservation Act (NHPA), Archaeological Resources Protection Act (ARPA), and Native American Graves Protection and Repatriation Act (NAGPRA).

Most typical cataloging situations are described below. Good organization and documentation of field collections is required, however, the system also allows some degree of flexibility in application to individual collections.

Archaeological field surveys and excavations vary in methodology and purpose. Any WSMR collections recovered from these activities must adapt to the White Sands cataloging system. This section provides the necessary guidelines to conform individual collections for transfer and integration in the WSMR Catalog System.

In general, most prehistoric and historic artifacts are stored in plastic, resealable (zip closure) bags, which are then curated in acid-free, prefabricated boxes. Guidelines and procedures for bagging, artifact consolidating, and boxing of artifacts are described below.

WSMR Catalog Number System

The primary purpose of cataloging collections is to make the permanent and individual identification of items in the collection. To catalog an item is to assign it to one or more categories of an organized classification system, ensuring permanent and individual identification. The following discussion describes each category of the WSMR Catalog Number System.

The WSMR Catalog Number System consists of four distinct segments: Year/ Catalog Number/Location Data/ Artifact Number, which provide each artifact or group of artifacts with a unique number. An example of a WSMR Catalog Number appears below:

93.1.LA39144.00001

93	1	LA39144	00001
YEAR	**CATALOG NUMBER**	**LOCATION DATA**	**ARTIFACT NUMBER**

YEAR

93.1.LA39144.00001

This first segment represents the calendar year beginning each January in which the specific project is cataloged into the WSMR Catalog Number System. Note: it does NOT represent the year in which the artifact was collected, the survey/excavation was performed, or the report was published.

WSMR CATALOG NUMBER

93.**1**.LA39144.00001

This second segment represents the WSMR Catalog Number. The catalog numbers restart, at one, each calendar year, and are assigned by the WSCRM. **Note:** this number does NOT represent the contractor's project number or the WSMR project number. The WSMR Catalog Number is different from the WSMR Project Number that identifies files, GIS survey area identification, and forms the unifying number for WSMR databases. There will be some project numbers that do not have artifact collections, but every WSMR Catalog Number will have collections.

LOCATION DATA

93.1.**LA39144**.00001

This portion designates the provenience information for each artifact. There are three separate and distinct provenience categories in which an artifact may be categorized-LA Number, IO, or NP.

LA NUMBER

LA39144

This represents a cultural site, officially recorded with the Archaeological Records Management System, Laboratory of Anthropology, in Santa Fe, New Mexico. The NM Historic Preservation Division issues numbers to the investigator.

IO (ISOLATED OCCURRENCE)

93.1.**IO**.00001

This represents an Isolated Occurrence (IO). Classify an artifact into this category under one of the following criteria:

- It does not fall within a recorded and registered site, ***and***
- It has provenience data in the form of Universal Transverse Mercator (UTM) coordinates on its collection bag/envelope or in the report, **or**
- The artifact has nonexact provenience information on its bag/envelope, is not in the report, but its location can be pinpointed on a USGS map. UTMs can then be calculated, **or**
- If the artifact has no exact or precise provenience information, such as UTMs, but its location can be found and pinpointed on a map in a report.

All attempts must be made to provide an exact location of IOs.

When cataloging an IO artifact, enter only "IO" in the Location Data portion of this segment, not numerical characters.

NP (NO PROVENIENCE)

93.1**.NP**.00001

This classification stands for No Provenience (NP). Classify artifacts under this category only as a last resort because there is absolutely no provenience information on an artifact. As with the IO, enter only the characters "NP" in the Location Data category. If a general area is known, such as southern WSMR, it should be entered in the Other Provenience. field.

ARTIFACT NUMBER

93.1.LA39144.**00001**

The last segment of the number system makes each artifact, or group of similar artifacts, unique within the WSMR Catalog Number System. Each artifact is assigned a five-digit number beginning with number one (00001). *For each LA Site, IO, or NP sequence, reset the* **artifact** *number to one (00001).*

Cataloging Artifacts

The following sections provide a thorough description of the different procedures to be used to sort, plan, organize, and catalog artifacts for WSMR catalog projects. Also included are recommended materials for various tasks.

Material Requirements

- Contractor's Technical Report with LA Forms / Field Notes

  Read report carefully. Gain an understanding of the methods used in field collections and laboratory analysis prior to sorting, organizing, and cataloging the collections. All field data, collection lists, and LA forms are useful.

- Artifacts
- Catalog Sheet form (Downloadable Access database from WSMR)
- Resealable polyethylene bags (2 mm thick with or without white write-on labels), varying from 3 by 4 inches up to 2-gallon capacity
- Black indelible/permanent ink markers
- Pilot extra fine point permanent marker (SCA-UF)
- Sharpie fine point and wide permanent marker
- Acid-free prefabricated curation boxes (12"w by 10"h by 15"l; blue; separate top)
- Permanent self-adhesive stickers
- Scissors.

The following are required for any Historical Papers:

- Acid-free bonded (25% Cotton Content) typewriter paper - 81/2 by 11 in
- Acid-free artist's sketch paper
- Regular copier paper

- Manila folders
- No. 2 pencil.

Procedures

The catalog number will be assigned by the WSCRM, different from the WSMR Project Number.

Sort by Location. Sort all of the artifacts according to their Location - LA Number, IO, or NP. **NOTE**: Do not separate artifacts from their locational information. Order the artifacts by LA number, IO, and NP.

Separate remaining artifacts with questionable location data according to whether there is any provenience data on them (refer to the report or collection envelope). Those with even a little provenience data should be sorted as IOs. If no data can be found, then sort as NPs.

Organize the Artifacts. LA Site Artifacts: In order to facilitate cataloging artifacts it is recommended that collections from sites with LA numbers be first sorted by provenience. Organize artifacts into groups according to surface collections, or grid and depth/level contexts where applicable. Some artifacts may have posthole, feature, trench, test pit, transect, unit, or other locational indicators. Sort artifacts together that have the same provenience:

- Sorting Example 1:
    - Grid 34N23W includes 1 projectile point Surface 2 El Paso Polychrome sherds 2 whole chert flakes
    - Grid 34N23W includes 1 bag of 9 whole/partial flakes Level 1 1 bag of 15 brown ware sherds 1 projectile point base
    - Grid 34N23W includes 1 Chupadero B/W sherd Level 2 1 obsidian biface
- Sorting Example 2:
    - Posthole #2 includes 1 schist palette 0 to 10 cm. B.S.
    - Posthole #3 includes 1 bag of 109 macaw skeleton bones 20 to 40 cm B.S.

When artifacts are sorted by provenience, the actual process of cataloging and description of artifacts can begin.

IO & NP Artifacts: Since IOs and NPs are cataloged individually due to their unique locations (IO) or lack of locations (NP); they do not require as thorough a sorting as artifacts from sites with LA numbers. However, large survey projects may use transects, lines, units, or survey area designations to control data derived from surveys. IOs or individual collections may need to be sorted by survey provenience and cataloged accordingly.

Cataloging and Artifact Description

Open the Catalog Sheet form in the Access Database. Select the first LA site collection to be cataloged and fill in the first entries. Each field is described below in *Database Format*. Enter the NMCRIS Activity Number, Year, and a Catalog Number according to the format described in *Catalog Number System*. Then enter Other Field Number**,** Provenience (see breakdown below), and Artifact Type. Enter information in the Artifact Description, Material Type, Portion, Quantity, and Comment columns. Alternatively, data may be entered in an Excel spreadsheet.

Artifact Description. Artifact descriptions must be as complete as possible. Record all available information about the artifact. Tables 1 and 2 list prehistoric and historic artifact attributes ranging from general to specific. The listing of attributes is not exhaustive. Other attributes may be apparent and should be recorded. (Note: Do NOT use abbreviations here.)

LA Artifacts. The artifact location should be listed to the nearest meter in UTM_EAST and UTM_NORTH, unless there is a grid coordinate. For excavations, list the depth below surface, in centimeters, in the TOP and BOTTOM fields, and the label of the level in the LEVEL field.

IO Artifacts. When listing IOs, provenience data (primarily UTMs) must be listed. This information shall appear in UTM_EAST and UTM_NORTH.

NP Artifact Descriptions. Since these artifacts have no locational data, enter only a physical description of the artifact itself and any pertinent field collection notations. Enter any provenience information in Other Provenience.

After each artifact has been assigned its number, label and bag the artifact. ***Double check that the label accurately states the provenience on the original bag***.

Curation Practices

This section discusses general curation methods for various types of artifact collections and the materials required to handle them. All efforts must be made to accurately bag and label the artifacts. Proper storage will help ensure the long-term preservation of these items.

Bagging

Bagging is the most fundamental stage of curation for prehistoric and historic artifacts. It provides a stable, airtight environment for an artifact in storage. Ideally, artifact bags received for WSMR Cataloging should be prepared in such a manner that no additional bagging is necessary.

Bagging Limitations

- Do NOT rip or tear the plastic bag. If this occurs, use a new one.
- Do NOT stuff or force an artifact into a bag. If it does not fit comfortably or close easily, place it in a larger bag.
- For oversized artifacts that do not fit into the large 2-gallon resealable plastic bag, write the WSMR Catalog Number and related information on a paper tag and firmly attach it to the artifact with string or wire.
- Do NOT place any kind of tape directly on the artifact.

Labeling. Record the following information on all artifact bags:

- LA number (when applicable)

- Contractor's project number and site number (when applicable)
- WSMR short project title (e.g., EPNG, Red Rio, FAADS) Control data (e.g., IO No., Collection No., Provenience Nos.) Date collected Artifact classification (general or specific)

When the information listed above is written on the plastic bag (particularly the 2 by 3 in. and 4 by 6 in. sizes), leave a blank space of 2 in. below the resealable seam. This will be used for the WSMR Catalog entries. Artifact bags may be received that have information written up against the resealable seam. In this case, find available space on the bag and enter the catalog number. All written information should be on the same side of the bag. Do not redo the bag unless writing is illegible or data are incorrect (Figure 1).

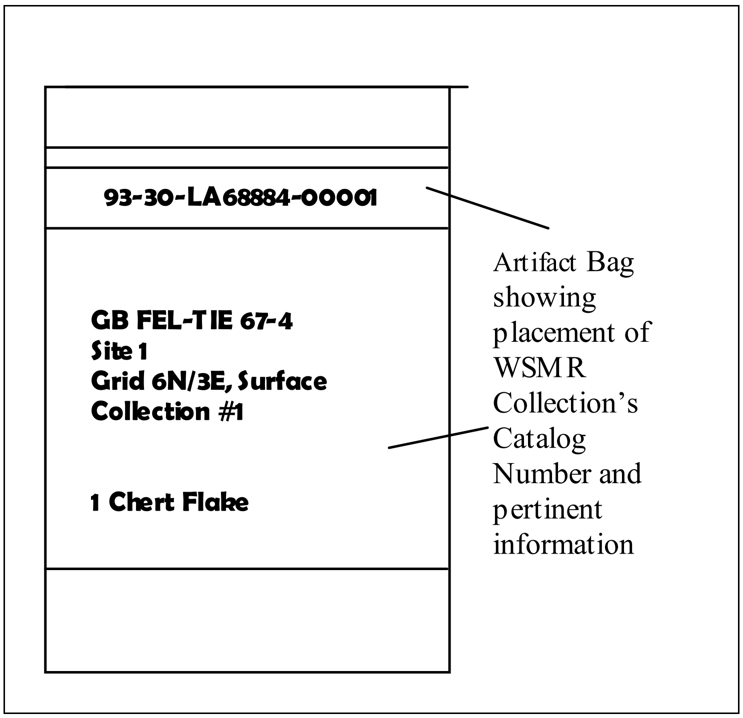

Figure 1. Artifact Bag with catalog number and pertinent nformation

In addition to the documentation on the plastic bag, a slip of acid free paper with the same information is included within the artifact bag (Figure 2). Information on the slip of paper should match the information on the plastic bag. The only exception to this is the inclusion of the field collector's initials on the slip of paper. The initials are not necessary on the plastic bag or the paper insert.

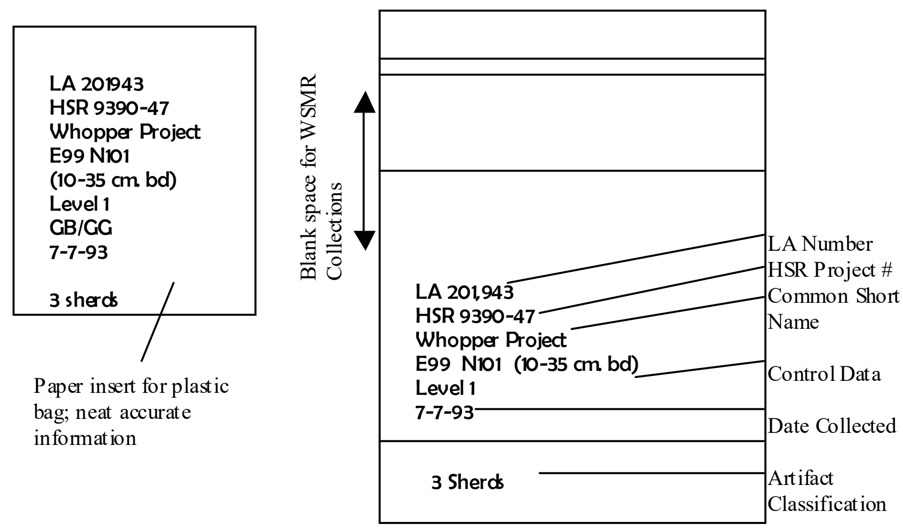

Figure 2. Plastic bag with paper insert

Field collections are often placed in paper bags or coin envelopes with field data written on them. If such artifacts are received, cut the portion of the envelope or bag containing field collection notes and insert it into the plastic curation bag. This is acceptable as long as all of the data are on the slip of paper and it is completely legible. Rewrite the label if it is sloppy, if the writing is illegible, or if the data are inadequate or incorrect.

Check that the information is on the outside of the bag as well as on a sheet of paper inside it. Redundancy is essential (see Figure 2).

Consolidation

The purpose of consolidating artifacts and bags of artifacts is to ensure that individual artifacts are not misplaced or lost from a site collection or WSMR catalog project. Since artifacts come in all shapes and sizes, the following discussions on consolidation must be taken as general guidelines.

Consolidation of Artifacts from a Site

This is the first level of grouping. To consolidate artifacts, place all artifacts from one location or LA Site into one resealable bag when possible. Do not place large heavy items in a bag or box with smaller or fragile items. Large items should be tagged and will be stored separately. Label this Site Bag with a black ink permanent marker in the following format:

93.30.LA 68884.00001-00007
GBFEL-TIE 67-4
Site 3
LA 68884

When there are more artifacts than can fit into the largest resealable bag, use another bag properly labeled in the above format. Make certain to specify which artifacts of that site and their corresponding numbers are in each consolidation bag.

Consolidation of WSMR Project Artifacts

The next level of consolidation is to group all cataloged artifacts within a single Project into a single resealable bag. Label this WSMR project bag in a prominent place in large block letters with a black ink permanent marker as follows:

WSMR Catalog number	**93.40**
WSMR Project Short Title	**FAADS II**
LA Numbers and/or IO Numbers	**LA 77923 – LA 77926** and/or **IO.00001-00045** and/or **NP.00001-00023**

Again, if the Project has more bags than can fit into the largest resealable bag, place remaining bags in a new bag and properly label it.

Boxing

Box Limitations

- Do **NOT** overburden a box with respect to volume. If it starts to bulge on the sides or the lid will not stay on securely, remove some of the artifacts and put them in another curation box.
- Do **NOT** overburden a box with respect to weight. If it takes a concerted effort to lift it off the floor/table, remove some of the artifacts and put them in another curation box.
- Do **NOT** place large heavy items in a bag or box with smaller or fragile items. Large items should be tagged and will be stored separately.

Box Labeling

Write the contents of a box on a self-adhesive label. Use one label for each WSMR catalog project contained in the box, in numerically ordered columns.

The label should use the following format:

WSMR Catalog No.	**93.40**
Project Title	**FAADS II**
Site Types & Nos.	**LA 77923 – 77926**
	and/or
	IO.00001-.00045
	and/or
	NP.00001 – 00023

Place Multiple Catalog Project Labels beginning at the upper left corner at the end of an acid-free box. If the project fills up the box, place the label in the center below the lifting slot.

Special-Needs Curation

Human skeletal remains are to be boxed together with associated artifacts. Each individual should be in its own box and packaged in natural materials, such as cotton or paper containers. These boxes are to be stored separately from the other artifacts, in a quiet place.

Some artifacts may be of such size and weight that they cannot be placed into an acid free, prefabricated curation box. Attempt to find or customize a plastic bag for this artifact. This is especially important for metal historical artifacts that may deteriorate further as a result of oxidation (rusting) by natural means and handling by people.

Box Labels for Special Instances

In some cases a curation box may only contain a portion of the artifacts from a large site. In this case the Project Label must be specific as to which artifacts are in the curation box. Examples of this format are as follows:

- Example 1:
  93.1 Rhodes Canyon LA 39144 00033-00065
  In this case, the box only contains artifacts .00033 through .00065 from LA 39144.

- Example 2:
  93.41 FAADS I IO - 00615 – 00683 NP .00001 - .00014 In this case, the box contains IO artifacts .00615 through .00683 and all of the NPs.

Historic Paper

Historic paper(s) require special care and attention. Most importantly, handle the paper as little as possible since the oils from the human body will quicken the decay of the paper, or it may disintegrate as a result of handling.

The following special storage materials are needed to aid in the preservation of historic paper:

- Acid-free bonded typewriter paper (8 1/2 by 11 in.)
- Acid-free artist's sketch paper
- Regular copier paper
- Manila folders
- No. 2 pencil

Procedures

- Lay out all of the original papers on a clean surface. If letters are in envelopes, leave them inside.

- Construct folders or envelopes out of acid-free sketch paper-typically to the dimensions of 8 ½ by 11 in., but larger if needed. The original historic papers will be stored in these.

- Carefully photocopy all original historic papers onto 8 ½-by-11-in. acid-free archival paper. Do NOT force the original historic paper flat. This will more than likely cause it to flake or disintegrate. Use an oversize backing sheet to prevent dark streaks on the edges. Check the contrast on each copy to make sure as much of the original contents were copied as possible. If necessary, make multiple copies at different contrasts in order to reproduce as much of the original as possible.

- With a No. 2 pencil, write the artifact's Catalog Number on the acid-free envelope and on the archival photocopies.

- Make working photocopies of each archival photocopy on regular photocopying paper.

- Carefully place the original historic paper in the hand-made envelope and write the Catalog Number on it with a No. 2 pencil.

- Place archival photocopies in the manila folders and write the Catalog Number on the tab with a No. 2 pencil.

- Carefully place manila and acid-free envelopes in a curation box with as much protection from other objects as possible. This can be done by using packing materials, by placing them in a custom-made acid-free box, or if there are sufficient numbers, by placing them in an acid-free prefabricated box of their own.

Error Checking

The most important part of the cataloging process is reviewing all materials to be sure the catalog accurately reflects the artifacts, and that all artifacts cataloged are present in the correct bags and stored in the proper box. Print a copy of the catalog entries and verify that all information is correct. The WSCRM will do a quality control check on the materials, and the entire project may be rejected if the cataloging is not done correctly. The artifacts are to be delivered with the final report together with paper and electronic copies of the catalog.

Database Format

Details and examples of the database format are found in Tables 1 and 2, under *Artifact Catalog Structure*.

- *NMCRIS Activity Number* **(Nmcris No):** Furnished to the investigator by NM Historic Preservation Division with LA numbers.

- *WSMR Project Name* **(ProjTitle):** This is a short, unique name assigned by the WSCRM to each project along with the Project Number at the beginning of the project.

- *WSMR Catalog Number* **(WsmrCat#):** The first part of this number is the last two digits of the year the cataloging is done, followed by the unique project number assigned by the WSCRM.

- *Location Type* **(LocType):** This field defines the Location Type . LA, IO, or NP.

- *LA Number* **(LANo):** If Location Type is LA, enter the LA number in this column. Enter only the numeral part, not the letters "LA".

- *Artifact Number* **(ArtiNo):** Unique identifying number for each artifact or group of artifacts. Each artifact is assigned a number beginning with number one (00001). *For each LA Site, IO, or NP sequence, reset the* ***artifact number*** *to one (00001).*

- *Other Field Number* **(OtherNo):** This is any other number relevant to an artifact or group of artifacts. Other field numbers might include collection number, field specimen number, surface collection number, or field accession number.

- *Provenience* **(UtmEast, UtmNorth, Gridew, Gridns, OtherProv, Level, Top, Bottom):** This describes the most precise, available provenience information for each cataloged artifact or group of artifacts. Categories include UTM East and North, Grid N/S or Grid E/W with Level, and "Other Provenience" information, which may include surface, grab sample, feature, test unit, and hearth stain. Top and Bottom refer to depth below ground level of the excavation layer.

- *Artifact Type* **(ArtType):** This indicates the nature or character of each artifact or group of artifacts. Examples of categories include lithic, ceramic, ground stone, charcoal, wood, soil sample, pollen sample, floatation sample, fabric/textile, basketry, human bone (separated from animal bone and other artifacts for NAGPRA purposes), animal bone, shell, leather, metal, glass, paper, porcelain, and plastic. Burial goods shall be kept with associated human skeletal material.

- *Artifact Description* **(Descript):** The artifact description will usually relate to the technique of manufacture or usage of the artifact. Examples of descriptors are listed below, but are not limited to these categories:
  - *lithic artifacts:* angular debris, flake, biface, core, uniface, scraper, drill, chopper, bead, pendant, hammerstone, and projectile point.
  - *ceramic artifacts:* bowl, jar, effigy, dipper, ladle, perforated disk, pendant, gaming piece, worked/utilized sherd, puki, and rim sherd.
  - *bone/shell/wood:* worked, unworked, fire hardened, awl, pendant, bead, effigy, bracelet, dart, needle, and whistle.
  - *historic artifacts:* insulator, plate, doll, spoon, hammer, pot lid, copper cable, 3 dram medicine bottle, canteen, spectacles, fountain pen, newspaper, gold pin, knife hilt, snap hook, hasp lock, button, post card, license plate, crimp seal can, etc., etc., etc.

  - In some cases the artifact description may be very specific and represent scientific, commercial, or well-known standard nomenclature. Examples include: Coca-Cola bottle, Bajada projectile point, .30-30 Winchester cartridge, Chupadero B/W, church key can opener, El Paso Polychrome rim sherd.

- *Material Type* **(Material):** This describes the elements or substances of which the artifact is composed. Material types of lithics, ground stone, wood, shell, textiles, and metal are often the most recognizable. At times, material type will only repeat the term that was entered for artifact type such as ceramic, glass, or soil sample.

- *Portion* **(Portion):** This represents the condition of the artifact. Categories include whole, frag, NA, or unk.

- *Quantity* **(Qty)**: This identifies how many artifacts are assigned to a unique artifact number. For example, catalog number 95.3.LA923.00024 has been assigned to a single Bajada projectile point. Catalog number 95.3.LA923.00025 has been assigned to a bag filled with 52 partial flakes.

- *Comment* **(Comments):** References to culture or temporal period and other relevant comments may be recorded here.

- *Hyperlink* **(Link):** Reference to the file name of a mid level image of the artifact (24 bit color, approximately 512x768 pixels, .JPG format)

Artifact Catalog Structure

Table 1. Fields in the WSMR Artifact Cataloging System

Name	Field Name	Data Type
NMCRIS Activity #	NmcrisNo	N
Project Short Title	ProjName	A50
WSMR Project #	WsmrProj	N
WSMR Catalog #	WsmrCat#	N
Location Type	LocType	A2
LA #	LANo	N
Artifact No.	ArtiNo	N
Other Field No.	OtherNo	A15
UTM East	UtmEast	A6
UTM North	UtmNorth	A7
Grid N/S	Gridns	A5
Grid E/W	Gridew	A5
Other Prov.	OtherProv	A25
Level	Level	A5
Depth, Top of Level	Top	N
Depth, Bottom of Level	Bottom	N
Artifact type	ArtType	A30
Artifact Description	Descript	A35
Portion	Portion	A5
Material	Mat	A30
Qty	Qty	N
Comment	Comments	A150
Hyperlink	Link	OLE

Table 2, part 1. Example of Artifact Catalog Entries

Nmcris No	ProjName	WsmrProj	Wsmr	LocTyp	LANo	Arti	Other No	UtmEast	UtmNorth	Gridns	Gridew	Other Prov
39058	NLOS South (HSR 9039)		9360	LA	82668	2	Coll #2	374550	3695130			
39058	NLOS South (HSR 9039)		9360	LA	82668	3	Coll #8	374550	3695130			
	Excavation LA 75023 Hearth (HSR		9361	LA	75023	1		344670	3739440			
	Excavation LA 75023 Hearth (HSR		9361	LA	75023	2	Coll #1	344670	3739440			
	Excavation LA 75023 Hearth (HSR		9361	LA	75023	3	Coll #2	344670	3739440			
	McDonald Ranch House (HSR 9042)		9362	LA	82956	1	#1	357160	3713880			NE of building 2
	McDonald Ranch House (HSR 9042)		9362	LA	82956	2	#2, #4	357160	3713880			N of chute in corral
	McDonald Ranch House (HSR 9042)		9362	LA	82956	2	#2, #4	357160	3713880			N of chute in corral
	McDonald Ranch House (HSR 9042)		9362	LA	82956	3	#3	357160	3713880			NE of chute in E.
	McDonald Ranch House (HSR 9042)		9362	LA	82956	4	#5	357160	3713880			Within wooden wall of
36368	Phil Site (HSR 9046)		9363	IO		1	IO #2	391540	3667530			
36368	Phil Site (HSR 9046)		9363	IO		2	IO #6	390860	3669560			
36368	Phil Site (HSR 9046)		9363	IO		3	IO #10	388660	3670500			
36368	Phil Site (HSR 9046)		9363	LA	82944	1		388400	3670480			
45627	RIMS (HSR 9047)		9364	IO		1	IO #1	375360	3668030			Truck Site
45627	RIMS (HSR 9047)		9364	IO		2	IO #1	373040	3672620			Stuck Site
37307	MATS (HSR 9112)		9365	NP		1						
37307	MATS (HSR 9112)		9365	IO		1	Target Pole	378240	3670160			Target Pole 3

Table 2, part 2. Example of Artifact Catalog Entries, continued

Level	Top	Bottom	ArtType	Descript	Portion	Material	Qty	Comments	Link
Surface			Lithic	Projectile Point	Whole	Quartzite	1	Early Archaic; base portion	
Surface			Lithic	Projectile Point	Frag	Chert	1	Middle Archaic; San Jose style	
			Hearth	Soil Sample	N/A	Soil	8	7 envelopes and 1 bag of hearth excavation	
			Ceramic	Brownware, undifferentiated	Frag	Ceramic	1	Possibly from RioGrande glazeware; body	
			Ceramic	Brownware, undifferentiated	Frag	Ceramic	4	Alma, Pitoche, or Jornada, body sherd;	
Surface			Historic	.22 Casing	Whole	Metal	1		
Surface			Historic	Chipped glass	Frag	Glass	2		
Surface			Lithic	Projectile Point	Frag	Chert	1	Base portion	
Surface			Groundstone	Groundstone, undifferentiated	Whole	Quartz	1		
In building			Historic	Bottle	Whole	Glass	1	With stopper and contents	
Surface			Historic	Iron tack buckle	Whole	Metal	1		
Surface			Ceramic	El Paso bichrome	Frag	Ceramic	2	Rim sherds	
Surface			Lithic	Projectile Point	Frag		1	Middle Archaic; one tang missing	
Surface			Lithic	Projectile Point	Frag	Chert	1	Early Formative, tip missing	
Surface			Ceramic	Chupadero Black-on-white	Frag	Ceramic	2		
Surface			Ceramic	Chupadero Black-on-white	Frag	Ceramic	5		
			Rat midden	Rat midden	N/A	Rat midden	2	Rat midden macros A & B	
Surface			Lithic	Angular debris			2		

Appendix I: SRI 2012

Predictive Modeling Report

Modeling of Archaeological Site Location and Significance at White Sands Missile Range, New Mexico

edited by Michael Heilen and Jeffrey H. Altschul

with contributions by

Jeffrey H. Altschul, Adam Byrd, Michael Heilen, Phillip Leckman, and Lynne Sebastian

PLEASE RETURN COMMENTS TO MICHAEL HARGRAVE VIA EMAIL (Michael.L.Hargrave@usace.army.mil) AT ERDC-CERL BY FRIDAY, FEBRUARY 10, 2012

Submitted to:

Engineer Research and Development Center-Construction
Engineering Research Laboratory (ERDC-CERL)
P.O. Box 9005
Champaign, IL 61826-9005

Contract Number W9132T-10-C-0042

Submitted by:

Technical Report 12-06
Statistical Research, Inc.
Tucson, Arizona

and

SRI Foundation
Rio Rancho, New Mexico

January 2012

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CHAPTER 1

Introduction

Michael Heilen and Jeffrey H. Altschul

To fulfill their legal obligations under the National Environmental Policy Act (NEPA) and the National Historic Preservation Act (NHPA), military installations need to demonstrate that cultural resource management (CRM) decisions are based on objective and replicable information on the distribution and significance of archaeological sites under their jurisdiction. The Department of Defense (DoD) has long taken a conservative approach to these legal mandates, with the agency's stated goal being to inventory all military holdings and evaluate all discovered archaeological sites. However laudable, these goals are unrealistic, and because they are so comprehensive, they leave little room for innovation.

In 2010, Statistical Research, Inc. (SRI), and the SRI Foundation (SRIF) entered into a contract (Contract Number W9132T-10-C-0042) with the Engineer Research and Development Center–Construction Engineering Research Laboratory (ERDC-CERL) to develop and test an approach to meeting DoD's NHPA and NEPA requirements that relies on utilizing knowledge already gained about the archaeological record. The objective is to provide mangers and stakeholders with reasonable information to make cultural resource decisions using models to predict the location of archaeological sites. Although the DoD has a long history of using predictive modeling (see Altschul et al. 2004), the models have generally not been sufficiently strong or accurate enough to meet the military's needs. However, using recent statistical and technological advances, archaeological models can be developed that help us to understand the intensity and extent to which operational training can impact the archaeological record. In short, archaeological models can reduce the time and money needed to complete the Section 106 process and lower the risk of mission delays.

To fully grasp the potential of predictive modeling for NHPA and NEPA compliance, we first must know what DoD is required to do under these laws. The remainder of this introduction describes DoD's legal obligations and presents a brief history of the military's experience with archaeological predictive modeling. We conclude the introduction with the goals and objectives of the ERDC-CERL project.

The Legal Framework: The Department of Defense's Approach to NHPA and NEPA Compliance

The DoD is obligated under Sections 106 and 110 of the NHPA of 1966, as amended, to identify cultural resources significant to our national heritage and to take appropriate steps toward preserving and protecting those resources. Under NEPA, DoD is also required to involve stakeholders in environmental-planning processes. These obligations are met by evaluating the environmental impacts of potential undertakings and proposing project alternatives, soliciting input from stakeholders through an open and transparent consultation process and, if necessary, mitigating any adverse effects an undertaking would have on historic properties.

Most CRM activities at military installations involve compliance with the Section 106 process, which requires agencies to take into account the effects of proposed undertakings on historic properties listed in or eligible for listing in the National Register of Historic Places (NRHP) and to provide the Advisory Council on Historic Preservation (ACHP) an opportunity to comment on an agency's undertakings. The

Section 106 process involves a series of steps, the first of which is to determine whether an undertaking has the potential to affect historic properties; these potential effects can be the result of training or construction activities that disturb the ground surface. If such potential exists, consultation with appropriate parties—including State Historic Preservation Officers (SHPOs), Tribal Historic Preservation Officers (THPOs), and other stakeholders—must be initiated.

The second step in the process is for the agency to make a good-faith effort to identify historic properties that fall within an undertaking's area of potential effects (APE) and to evaluate the eligibility of identified properties for listing on the NRHP. Identification of historic properties is routinely accomplished through inventory efforts, but evaluation of identified properties for eligibility in the NRHP is a comparatively rare occurrence. Rather than being evaluated, identified properties are often avoided. Alternatively, the bar for attaining eligibility is set very low, with virtually all historic properties being recommended eligible, regardless of their content or integrity. Although seemingly a viable approach to CRM on military installations in the short term, failure to evaluate historic properties for eligibility in the NRHP or to be selective in evaluating sites for eligibility becomes increasingly problematic as greater numbers of historic properties are identified across the DoD land base, impeding military operations, and as the DoD expands the footprint of its land-based operations.

The third step in the Section 106 process is to determine whether any historic properties within the APE will be adversely affected by the undertaking and, if so, to determine the nature these effects. If no historic properties are located within the APE, then the Section 106 process is completed with a finding of "no historic properties affected." Similarly, if eligible historic properties located within the APE will not be adversely affected by the undertaking, the Section 106 process ends with a finding of "no adverse effect." However, if it is found that the undertaking *will* result in any adverse effects on NRHP-eligible historic properties, then the agency is required to work with consulting parties to resolve the adverse effects. This step is often accomplished by either adjusting the footprint of an undertaking in order to minimize its impact on historic properties or through data recovery efforts aimed at mitigating the effects of an undertaking. Both of these outcomes can ultimately be costly to the mission in terms of time and money.

Section 110 of the NHPA further requires that agencies

- assume responsibility for historic properties under their jurisdiction;
- consider the effects of their undertakings on historic properties not within their jurisdiction;
- consult with other agencies, tribes, and the public in historic-preservation planning, and;
- develop a program for identifying, evaluating, nominating, and protecting historic properties.

In order to meet its legal obligations under NHPA and NEPA, the DoD has identified the following goals:

- Accurately inventory 100 percent of archaeological sites, Native American resources, and other cultural assets and establish quality ratings in the real properties inventory by the end of 2007 (DoD 2004; see also DoD 2007, which was updated to 2009).
- Develop standards to ensure that the possible presence of archaeological sites, Native American resources, and other cultural assets are modeled, inventoried, and managed in close integration with project and operational planning by the end of fiscal year 2006 (DoD 2004).
- Manage cultural resource assets efficiently, in full integration with other facilities and project planning activities, and in full compliance with all legal requirements (DoD 2007).

The DoD, however, is a long way from meeting those goals. To date, most of DoD land has not been inventoried, and it has been estimated that as many as 500,000 archaeological sites have yet to be discovered on DoD-administered land (Altschul 2007). An even larger number of sites, including those not yet discovered, has yet to be evaluated. Current methods for inventory and evaluation on military installations usually treat all areas of an installation as having an equal potential for containing archaeological sites, as if no knowledge exists regarding where sites tend to be located. Similarly, evaluation efforts tend to treat all sites as potentially unique and do not take into account the factors that have previously contributed to sites with similar attributes having been determined eligible for listing in the NRHP. Therefore, prior knowledge of the distribution of cultural resources and their potential significance is left untapped, and each inventory or evaluation effort is conducted in an ad hoc, reactive, project-by-project fashion.

Using current methods for inventory and evaluation, Altschul (2007) projected that the expenditure from $1.5 to $3 billion and more than 150 years of additional fieldwork will be required to complete inventory on DoD lands. Altschul also concluded that as much as $4.5 billion and an additional two centuries of additional fieldwork would be required to complete the evaluation of the recorded sites. Obviously, in order to be in full compliance with all legal requirements and to meet its CRM goals according to an acceptable schedule, the DoD needs to develop effective means of streamlining inventory and evaluation (Green et al. 2011).

Archaeological Modeling and Streamlining Compliance in the Military

Archaeological predictive models use prior knowledge to predict the expected nature and distribution of the archaeological record. Although many predictive models in the military are designed to predict the location of sites discovered through conventional survey techniques, there is no one kind of predictive model. In addition to predicting site location, models can be constructed to predict archaeological data quality, significance, the potential of encountering buried sites, and other features important to the management of cultural resources on military lands.

Predictive models of archaeological site location have been used in CRM since the 1970s, and over the past several decades, many military installations have developed them (Altschul et al. 2004). Most of these models have been used heuristically in order to provide installation managers with information on where cultural resources are likely to be discovered, but they have typically not been integrated into NEPA and NHPA compliance nor used to manage resources. The first substantial guidance for developing and using predictive models of archaeological site location came with a volume prepared by the Bureau of Land Management in 1988 that provided comprehensive information on how to develop, test, and use predictive models in CRM (Judge and Sebastian 1988). Following this volume, the development and testing of predictive models became increasingly feasible with continued advances in information technology, relational database systems, geographic information systems (GISs), and improvement in environmental data sets that could be used to develop models (Kvamme 1989, 1990, 1999; Mehrer and Wescott 2006; Zeidler 2001).

The first major breakthrough in using predictive models to aid in compliance came in 1997 with the Minnesota Department of Transportation's (MnDot) development of a statewide predictive model (BRW 1996; Hudak et al. 2002). After its development, the model was integrated into a Programmatic Agreement (PA) by the Minnesota Army National Guard as a planning tool for Camp Ripley. More recently, the scientific adequacy and managerial utility of predictive models was further illustrated by a series of three Legacy Resource Management Program (Legacy) projects. These projects showed that predictive models on DoD installations have worked well in predicting site location and provided a blueprint for using predictive models for CRM compliance (Altschul et al 2004, 2005; Cushman and Sebastian 2008). Further work for the Environmental Security Technology Certification Program (ESTCP) demonstrated that although existing predictive models at military installations have worked fairly well, they could be refined and validated with additional data and advanced statistical methods to achieve the confidence of stakeholders and can be incorporated programmatically into CRM compliance. The ESTCP project illustrated that there is no single kind of model that each installation needs (i.e., a locational model for all sites discovered through conventional survey methods) but that modeling should suit current and anticipated management needs in a flexible manner (Green et al. 2011). Furthermore, the project emphasized that modeling should be treated as an iterative process of model building, testing, and refinement and not as a static event culminating in the production of a sensitivity map (Altschul 1988).

These projects have identified archaeological modeling as one means of streamlining inventory and evaluation that could result in considerable cost and time savings for conducting CRM on military lands. For one, predictive models of archaeological site location can be used to guide survey efforts by helping managers decide on the level of effort, scheduling, and potential costs of survey in different areas of an installation. Locational models can also be used to identify areas where sites of a given type are more or less likely to be discovered. This kind of information can aid in the identification of areas where especially important site types (such as residential sites or sacred sites) are likely to be located; the identification of areas where very common and redundant sites are likely to be found; the interpretation of land use according to site function and temporal or cultural affiliation; and the identification of cases where a site falls in an anomalous location, possibly requiring further investigation.

In addition to locational models, models that place sites into significance categories based on site attributes—such as artifact and feature content, setting, and integrity—can also be highly useful tools for management, as they harness existing data about the nature and distribution of archaeological sites according to factors that will inevitably affect determinations of NRHP eligibility. These kinds of models, termed "significance models," can be used to place sites into significance categories using existing CRM and environmental data. The development and use of such models can provide a systematic and transparent framework for not only interpreting significance but also aiding in the identification of samples of sites to be placed in reserve for future research or tested in order to make determinations of eligibility.

Project Purpose and Goals

The purpose of the current project is to evaluate one approach to archaeological modeling and streamlining compliance by leveraging existing data from one installation where inventory and evaluation efforts have been extensive to predict archaeological site location and significance on an adjacent installation with a similar environment and where a large proportion of the installation area has yet to be inventoried and most sites have yet to be evaluated. Although this type of approach is routinely performed in academic settings where research is planned for poorly understood regions adjacent to better-studied ones, it has rarely been tried in compliance settings (see Altschul et al. 2010).

Fort Bliss Military Reservation and White Sands Missile Range (WSMR) were identified by the project sponsors as representing this situation. Both installations occupy a large proportion of the Tularosa Basin in south-central New Mexico in a broadly similar environment (Figure 1.1). Approximately 59 percent of Fort Bliss has been inventoried, a relatively large proportion for an installation of its size. Archaeological sites on Fort Bliss are routinely evaluated according to a transparent and systematic, rule-based framework, with the collection of information directly relevant to the interpretation of a site's significance and integrity beginning during inventory efforts when sites are defined and recorded. Data recovery efforts have added to this information with the knowledge gained incorporated into the significance standards. Through the efforts of a well-established cultural resource compliance program, the archaeology of Fort Bliss is relatively well known. In contrast, only 8 percent of WSMR has been inventoried. Surprisingly, given the small amount of survey, more than 5,000 archaeological sites have been identified on WSMR. Only a small fraction of these sites, however, have been evaluated.

The U.S. Army (Army) wanted to answer the following question: could it leverage its CRM investment at Fort Bliss to apply to WSMR? To answer this question, the project was divided into seven tasks.

1. Develop a predictive model of archaeological site location using available data from Fort Bliss.
2. Evaluate and refine the model using a sample of Fort Bliss sites not included in model development.

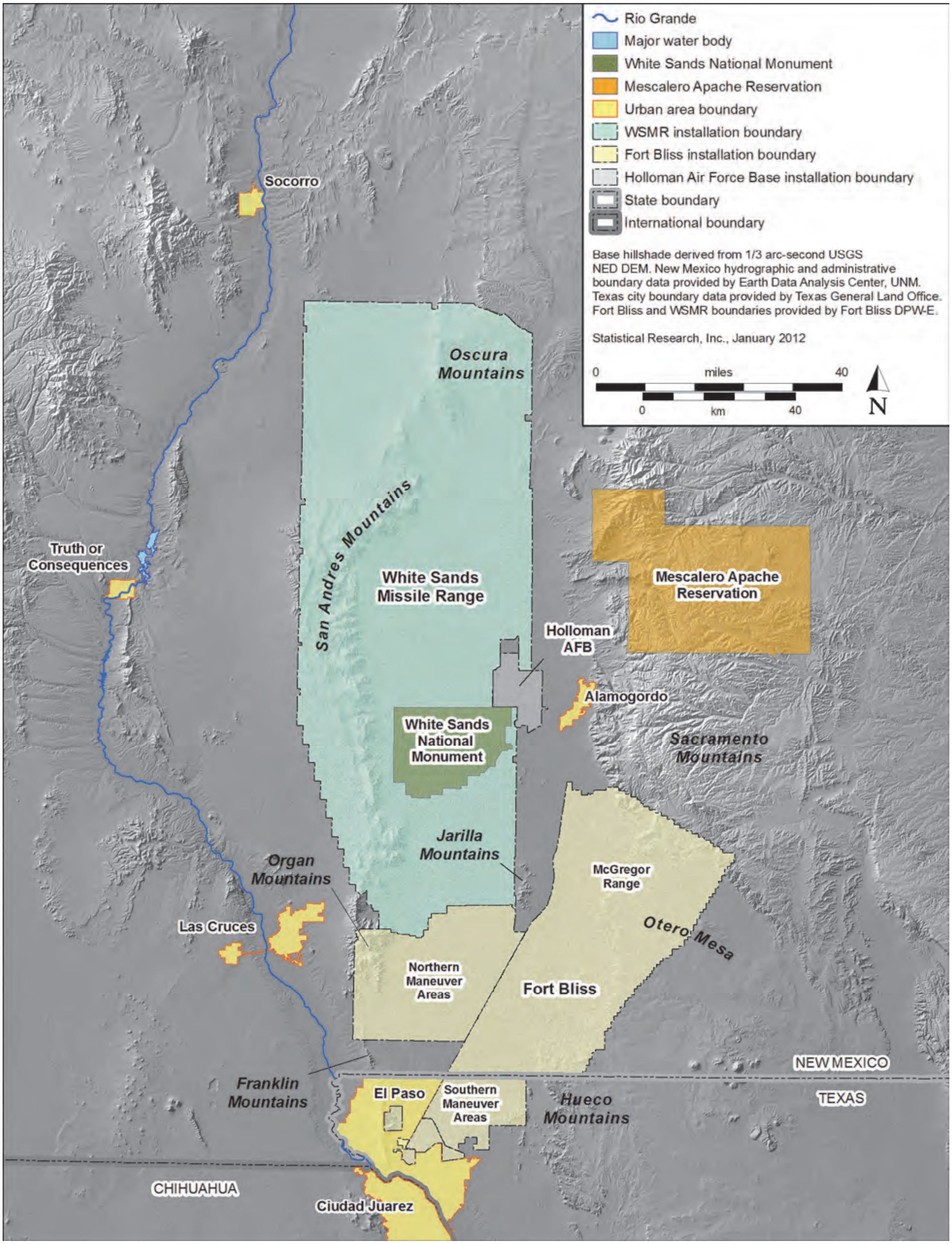

Figure 1.1. The location of White Sands Missile Range in New Mexico and the Fort Bliss Military Reservation in New Mexico and Texas.

3. Evaluate the feasibility of adapting the Fort Bliss location model for use at WSMR.
4. Develop a comprehensive group of archaeological site types at WSMR (based on factors such as site function, cultural and temporal affiliation, geographic associations, etc.); use the WSMR CRM data to refine the locational model originally developed using Fort Bliss data; and evaluate the effectiveness of the model in predicting the location of sites, according to site type.
5. Develop a significance model that sorts the WSMR archaeological sites into significance categories using site characteristics as a proxy for data potential in terms of NRHP Criterion d. Specify and justify the protocol for using the significance category assignments to help guide management, planning, and compliance decisions, including selection of representative samples of sites for various management options.
6. Work with WSMR and relevant stakeholders to identify compliance, management, and planning needs relative to archaeological resource management at WSMR and to explore potential uses of locational and site significance models to meet these needs. Develop programmatic approaches to streamline compliance with Section 106 of the NHPA that can serve as the basis for new PA or a component of a PA already under development by Fort Bliss.
7. Prepare a concise, professional, high-quality report that describes the methods used to accomplish each task, including detailed guidance for the use of the locational and significance models, and on other aspects of the programmatic approach.

It should be remembered that the project was designed in many ways as a methodological and sociological experiment. The overall goals of the project were (1) to develop strong locational and significance models in one area using data from another and (2) to determine if, and under what conditions, CRM stakeholders (SHPO, military cultural resource managers, Native Americans, etc.) would integrate those models into PAs to streamline compliance with Section 106 of the NHPA. Technically, the experiment was largely successful. Complete success was not reached for two reasons: (1) the state of the available CRM and environmental data for WSMR and (2) the status of WSMR's ongoing efforts to develop a PA for their CRM program. Specific reasons that the approach did not meet its overall goals are as follows:

- Comparable environmental layers do not currently exist for both WSMR and Fort Bliss for many aspects of the environment, such as soils and geomorphology. Fort Bliss has a much greater diversity of environmental layers, and these tend to be mapped at a finer scale than analogous environmental layers at WSMR.
- Available site attribute data are limited, restricting the ability to place sites into types for locational modeling or to marshal all the data necessary to place sites into categories for significance modeling.
- The development of a PA was already underway at WSMR when the project was begun and cultural resource managers at WSMR were concerned that introducing additional elements into the process (i.e., locational and significance modeling) could upset or derail their efforts. As a consequence, project participants were not permitted to view the draft PA or to participate in discussions regarding PA development.

Despite these challenges, we were ultimately able to develop locational models that worked well on both Fort Bliss and WSMR for a comprehensive group of site types and to identify areas where locational models can be improved with additional data. We were also able to develop a working significance model for WSMR that places sites into significance categories based on data potential, rarity, and sites that encapsulate especially important sacred values for stakeholders, such as burial sites, rock-art sites, and traditional cultural places. One of the problems with making these assessments was that a crucial variable for determining significance—assemblage size—was not populated for a large proportion of sites in the CRM database. Project approval was obtained to reallocate effort to obtain information from paper records in the New Mexico site files office on assemblage size. This reallocation greatly enhanced the ability of the significance model to place sites into significance categories, doubling the number of sites with sufficient data for making an assessment of a site's data potential.

WSMR sites, however, could not be fully evaluated using the significance model owing to missing information on a critical factor for determining eligibility: integrity. Determinations of NRHP eligibility are based ultimately on two factors: (1) significance and (2) integrity. A site can have attributes considered to be highly significant but be determined not eligible because it has no integrity. For instance, a residential site dating to the protohistoric period could be highly significant for its information potential, but if the site has been shown to be highly disturbed and with limited integrity, than it may be determined not eligible. Similarly, a site could be in excellent condition, with its deposits undisturbed and intact, but if it has limited data potential, such as consisting of a nondescript lithic scatter with no temporally or culturally diagnostic artifacts, the site could be determined not eligible owing to a lack of significance.

For this project, although existing CRM data on artifact, feature, and component types and counts could be used to infer a site's *significance*, information on a site's *integrity* was mostly lacking. Various ways of achieving proxy information on integrity using existing environmental data were experimented with, but ultimately, it proved impossible to develop adequate information to infer the integrity of a site using existing information. As a consequence, the significance model developed for the project can only provide information on a site's significance, and it can only do so for sites that have adequate attribute information. Nonetheless, the necessary structure of the model for predicting a determination of NRHP eligibility has been developed. Inferring the eligibility of a site based on a consideration of both a site's significance and integrity using the model will have to wait until information on site integrity can be incorporated into the CRM database.

Finally, because the WSMR CRM program was at the inception of this project in the process of developing a PA and consulting with stakeholders, WSMR staff felt that introducing additional variables (i.e., locational and significance models) could upset their progress and potentially cause confusion among consulting parties. As a result, we were unable to fully address Task 6 of the project. We do, however, offer recommendations on how the locational and significance models can be used to streamline compliance in the final chapter of this report.

Report Organization

This report is divided into five chapters. The first chapter has introduced the project purpose and goals and provided an outline of the project approach. The second chapter provides brief background information on the environmental, cultural, and administrative context of the two installations as relevant to the current project. Chapter 3 discusses how locational models were developed and tested for the project, and Chapter 4 discusses the development of the significance model for the project. The final chapter provides a brief summary of the project outcomes, conclusions, and recommendations on how to use and refine the significance and locational models to streamline Section 106 compliance.

CHAPTER 2

Administrative, Environmental, and Historic Context

Michael Heilen

This chapter provides the context for the modeling efforts of the ERDC-CERL project. We begin with brief summary information on the administrative histories of Fort Bliss and WSMR. Next, we provide information on the environment and culture history of the Tularosa Basin, which is the larger physiographic unit that covers the portions of WSMR and Fort Bliss that are being locationally modeled. Environments and cultural contexts outside the modeling area are discussed, as appropriate.

Fort Bliss

Fort Bliss Military Reservation (see Figure 1.1), located north of El Paso in south-central New Mexico and west Texas, is one of the nation's largest military reservations. The fort had its beginnings in November 1848, when the War Department ordered the Third Infantry to take up quarters in El Paso. Originally called the "Post of El Paso," the post was closed in September 1851 only to be reestablished in January 1854 in a new location 3 miles east of the original post. A few months after being reestablished, the post was renamed "Fort Bliss," after William Wallace Smith Bliss, a veteran of the Mexican War (Metz 1988:38–40). The fort was subsequently moved several other times before moving to its current location in 1893.

In its early years, Fort Bliss was one of series of forts located between Santa Fe, New Mexico, and San Antonio, Texas, that were intended to protect the expanding American nation against hostile Native American groups inhabiting the region. Although relatively small during the nineteenth century, troop strength at the fort was increased dramatically in 1910 after the Mexican Revolution to 50,000 men and was transformed from an infantry station to the largest cavalry post in the United States. The fort was the last remaining post of the mounted U.S. Cavalry until 1943, when the Cavalry was transitioned into using armored vehicles in place of livestock mounts. By this time, the fort was used primarily as an artillery post (Harris and Sadler 1993; Jamieson 1993; McMaster 1962).

Since World War II, the focus of most military activity at Fort Bliss has been on the training and testing of air defense systems. The Anti-Aircraft Training Center was established by the Army at Fort Bliss in 1940, and by the end of World War II, Fort Bliss had established the nation's first guided-missile unit. Training and testing of air defense systems continued at Fort Bliss during the Cold War and during the Gulf War of 1990–1991. As a result of the Base Realignment and Closure (BRAC) of 2005, the Air Defense Artillery Center and Air Defense Artillery School were moved from Fort Bliss to Fort Sill, Oklahoma. Fort Bliss was then transformed into a heavy-armor-training post. Today, the 1.1 million acre reservation consists of guided-missile ranges and maneuver and training areas with a main cantonment in El Paso, Texas.

White Sands Missile Range

In 1944, the Tularosa Basin was selected by the War Department and the U.S. Army Corps of Engineers as an area to launch the nation's accelerated missile program, with WSMR ultimately playing a major role in that program. The Tularosa Basin was selected over other areas of the United States for missile testing, because it had mostly clear skies and contained large expanses of relatively flat and uninhabited land where no railroad lines or air lanes would interfere with missile tests. Furthermore, the basin is surrounded by mountains that could serve as observation points for missile tests. Much of the land that would ultimately constitute WSMR was already controlled by the War Department by this time, including the Fort Bliss Antiaircraft Firing Range, Doña Ana Target Range, Castner Target Range, and Alamogordo Army Air Field's Alamogordo Bombing Range; public domain and private lands were eventually added to expand the range. Temporary buildings were moved to the range in 1945, and during its early years, administrative and supply services were provided by Fort Bliss (Boehm 1997; Eidenbach 1997).

The Army soon established its first launch area on the range, referred to as Launch Complex 33 (established in 1983 as a National Historic Landmark) and began preparations for launching of the modified V-2 rocket. Originally a German ballistic missile that came to be the progenitor of all modern rockets, development of the V-2 at WSMR involved a group of captured German engineers and scientists who had worked on the original rocket. The group was led by Dr. Wernher Von Braun and was known as "Operation Paperclip," because paperclips were placed on the folders of captured German scientists deemed suitable for the program. Development of the missile program at WSMR resulted in significant advances to the nation's space program, as well as to national defense.

By 1952, the DoD began consolidating control of WSMR (then known as White Sands Proving Ground [WSPG]) with the transfer of the Alamogordo Bombing Range from the Air Force to WSMR. The boundary line between Fort Bliss and WSMR was established the following year. With the Alamogordo Bombing Range, WSMR inherited the world-famous Trinity site, where the first atomic device was tested on July 16, 1945, for the Manhattan Project. WSPG was redesignated as WSMR in 1958 (Boehm 1997; Eidenbach 1997; Merlan 1997).

Missile and rocket development stemming from the V-2 program continued into the 1950s, with the development of the Sergeant, Redstone, and Nike series. The Patriot missile system used during Operation Desert Storm also began its development at WSMR during the 1970s. In 1983, the High Energy Laser Test Facility was established at WSMR. In just 6 years, destruction of a missile traveling at supersonic speed was demonstrated using the Navy's Mid-Infrared Advanced Chemical Laser (WSMR 2011). Today, WSMR covers more than 2,000,000 acres in southern New Mexico and continues to be the nation's premiere defense testing facility.

Environmental Setting

The Tularosa Basin is located in south-central New Mexico and is situated within the Mexican Highlands Section of the Basin and Range Province. The Basin and Range Province is a physiographic region that covers much of the American Southwest and is characterized by narrow, uplifted mountain ranges separated by relatively flat valleys. Valleys in the Basin and Range Province consist mostly of basin fill sediments overlying downfaulted bedrock, sediments that can be thousands of feet thick. Mountains bordering the basins trend north–south or northwest–southeast along their major axes and are often rugged, steep, and rocky, rising thousands of feet above basin floors (Fenneman 1931; Hunt 1967; Thornbury 1965). A consequence of this topography is that ecological resources are often vertically stratified, with different plant, animal, and water resources available in basin, foothill, and mountain environments.

In the southern portion of Fort Bliss, the Tularosa Basin transitions into the Hueco Bolson. Together, the Tularosa Basin and the Hueco Bolson form a continuous valley separated by a subtle change in topography. The western side of the Tularosa Basin is bounded by the Franklin, Organ, and San Andres Mountains, and the Tularosa/Hueco Valley, the Hueco Mountains, Otero Mesa, and the Sacramento Mountains border the eastern side of the basin. With the exception of Otero Mesa, which lies between the Sacramento and Hueco Mountains, steep and rugged mountains border the basin.

The Tularosa Basin is an internally drained, closed basin, with much of its watershed being encompassed within the boundaries of WSMR and Fort Bliss. Proximal and medial alluvial fans are found along the edges of the basin; distal fans are located on the basin floor. Alluvial fans are typically more gravelly than lower basin sediments and are found at a series of elevations. Some alluvial fans are covered with deep, aeolian sands. Coppice dunes and larger dunes are common on the basin floor as are numerous low-lying, level areas that may represent dry playas. In general, the bedrock geology along the eastern margin of the Tularosa Basin consists of sedimentary rock from the Otero Mesa escarpment and from the Hueco and Sacramento Mountains, providing sources of chert, chalcedony, sandstone, and silicified wood (Church et al. 1996). Igneous rock from Franklin, Jarilla, and Organ Mountains predominates on the western margins of the basin.

Surface-water resources are limited within the Tularosa Basin, because of low precipitation coupled with high infiltration and evaporation rates. Surface water generally is found as overland flow that runs into the basin from mountain streams during summer thunderstorms and accumulates in playas and other depressions. Salt Creek, which flows into WSMR from north to south, is the only major perennial stream within WSMR, although water from Tularosa Creek and Three Rivers can reach WSMR during periods of high precipitation. Currently, none of the surface waters on WSMR is considered potable (WSMR 2009). Similarly, surface waters on Fort Bliss are rare and short-lived. Perennial surface waters do not currently exist on Fort Bliss or in its immediate vicinity, and groundwater is considered to have been "completely unavailable to the prehistoric population and to plants" (Miller et al. 2009:2.48). Shallow surface waters would have periodically been available to plants in areas where restrictive layers of sediment, such as petrocalcic horizons, prevented water infiltration. Although important to plant production, these surface waters were not likely used often by people as a source of drinking water.

Soils in the Tularosa Basin are relatively diverse, with 90 different soil types being recorded on Fort Bliss, for instance. Highly gypsiferous soils are found on both installations but are especially common on WSMR, where they are found on a wide variety landforms, including dunes, alluvial flats, drainageways, and playas (WSMR 2009). Gypsum formed in the Tularosa Basin as a result of an ancient inland sea that existed in the area approximately 250 million years ago. Approximately 70 million years ago, a massive dome of gypsum deposits was uplifted and subsequently collapsed 10 million years ago when the Tularosa Basin was formed, providing a source for the gypsum common in many sediments in the Tularosa Basin (Trujillo et al. 2007). Extensive gypsum sand deposits are located on WSMR north and northwest of Lake Lucero; in contrast, sand dunes and sand sheets on Fort Bliss are primarily siliceous. The White Sands National Monument, located within the boundaries of WSMR, features the largest dune field in the world. The visually magnificent dune field formed from sands blown by wind from the lakebed of pluvial Lake Otero (WSMR 2005).

Most soils in the basin are well drained to excessively drained and many are susceptible to moderate to severe wind or water erosion. Unfortunately, fine-grained and detailed soil data are lacking for WSMR. Soils on WSMR have been mapped at a relatively coarse scale (1:100,000) (Neher and Baily 1976) in comparison to the more-recently mapped soils on Fort Bliss. In addition, the existing soil survey data for WSMR lack information on soil characteristics, such as information on organic matter content, available water capacity, and other soil characteristics. The development of new soil survey data mapped at a finer scale and including information on soil characteristics at WSMR is underway but is not yet available for use.

Soil and vegetation types in the Tularosa basin are strongly tied to landform, elevation, and landscape position. Much of the Tularosa Basin today consists of grasslands and shrublands. Grasslands were probably more extensive during prehistory and during the early historical period prior to historical-period disturbance. Historical-period descriptions of the basin indicate that grasses were at one time shoulder high in some areas. The Tularosa Basin portion of Fort Bliss has been divided into a mesquite zone on the basin floor, a creosote bush zone on alluvial fans immediately above the basin floor, and a yucca-grassland zone in the foothills (Miller et al. 2009:2.15–2.20). Similarly, Lowland Basin Grasslands are common in the Tularosa Basin portion of WSMR as are large areas of patchy and sparse vegetation, much of which are characterized as mesquite shrubland or creosote bush shrubland, as well as denser areas of shrubland in some portions of the basin (Muldavin et al. 2000, 2002). Modern fauna consist of a wide variety of bats, rodents, lagomorphs, artiodactyls, bird species, and reptiles, as well as numerous invertebrate species, including ants, beetles, spiders, scorpions, and centipedes. Prehistorically, many of the flora and fauna in the Tularosa Basin would have been used for food, medicine, clothing, shelter, and tools.

Today, the climate of the Tularosa Basin is arid. A semiarid climate prevails in higher portions of the surrounding mountains. Average temperatures in July are 34°C (94°F) in El Paso, Texas, and 35°C (95°F) in Alamogordo, New Mexico. Modern temperatures are only slightly cooler in the mountains during the summer months. Average January temperatures are at or below freezing in the Tularosa Basin (0°C [32°F] in El Paso and –3°C [27°F] in Alamogordo). Temperature extremes range from summer high temperatures above 43°C (110°F) and winter lows below –18°C (0°F). Precipitation is relatively low, averaging 20 cm (8 inches) in El Paso and 25 cm (10 inches) in Alamogordo; 30–46 cm (12–18 inches) of rain falls annually in the mountains. Approximately two-thirds of precipitation in the Tularosa Basin results from convective summer thunderstorms that occur from June through October. The remaining precipitation falls during winter cyclonic storms that originate in the Pacific Ocean. Precipitation resulting from summer storms generally falls too rapidly to infiltrate below the ground surface, however it produces brief, high-energy runoff events and results in a limited amount of water for people and plants.

Climate and, correspondingly, vegetation and fauna changed in the Tularosa Basin and surrounding region during prehistory. During the late Pleistocene, precipitation was higher during the winter and temperatures were cooler, particularly during the summer (Harris 1989, 1990). The climate was wet and cool enough that an extensive and deep pluvial lake, Lake Otero, covered large areas of the basin. By 12,000 B.P., effective moisture had begun to decrease and more-xeric species began to populate the region. By the early Holocene, desertscrub, succulents, and desert grassland conditions began to appear in the region as more temperate species disappeared, marking a long transition to more-modern conditions (Elias and Van Devender 1992; Van Devender 1990; Van Devender et al. 1984). Changes in vegetation and fauna by 8000 B.P. suggest that, although winter freezes remained frequent, summer temperatures began to rise substantially, and precipitation shifted from a winter-dominant to a summer-dominant regime. By the middle Holocene, around 6000 B.P., Chihuahuan taxa had still not appeared in the region, potentially owing to the persistence of severe winter freezes. Xeric grasslands were common and some mesic species were still present. In the subsequent millennia, pluvial lakes were completely replaced by mostly dry playas (Markgraf et al. 1984). Chihuahuan Desert Scrub taxa became common in the region by ca. 4000 B.P., although their distribution is probably not the same as it is today (Elias and Van Devender 1992).

After this point in prehistory, major changes in the composition of flora and fauna in the basin are not apparent, but the climate continued to shift during the late Holocene. Dendrochronological reconstructions of climate, for instance, suggest that repeated and major shifts between periods of drought and periods of higher precipitation were common from at least A.D. 600 and continued into modern times. These changes have been correlated with changes in the cultural sequence (Cordell and Gumerman 1989; Miller 2005a).

During the historical period, overgrazing and drought contributed to severe soil degradation and major changes in vegetation. Mesquite shrub plant communities expanded substantially during this period, and the current configuration of coppice dunes began to develop as a result of historical-period disturbance (Buffington and Herbel 1965; Dick-Peddie 1975; Gardner 1951; Johnson 1997; York and Dick-Peddie 1969). One implication of these changes for predictive modeling is that, although tied to soil characteristics and landscape position, the distribution of vegetation within the Tularosa Basin has changed dramatically during the prehistoric and historical-period cultural sequence. Associations between site location and modern vegetation likely reflect the complex interaction of multiple factors, including archaeological visibility and ongoing sedimentary processes, rather than settlement decisions affecting site formation. In addition, the current topography of coppice dunes is a reflection of historical-period disturbance and is also not immediately tied to behavioral factors affecting site location.

Culture History

People have made use of the Tularosa Basin throughout the prehistoric and historical-period sequences, beginning with Paleoindian period groups by ca. 11,500 B.P. Although large numbers of Paleoindian period projectile points have been discovered in the Tularosa Basin, little is known about Paleoindian period adaptations in comparison to later periods, particularly those dating to the early and late segments of the Paleoindian period (11,500–6000 B.P.). Folsom sites in the basin have been interpreted as representing a highly mobile adaptation focused on the procurement of game that moved frequently in small herds between patches of grassland and playa environments. Sites with Plano and Cody diagnostic materials dating between 8000 and 6000 B.P. are located on a variety of landforms but often are found near large playas or in the vicinity of the Rio Grande. Such locations appear to have been used as base camps during a period when the climate was becoming drier and precipitation regimes were shifting to a summer monsoonal pattern. As a result, settlement patterns during the late Paleoindian period may represent the reliance by both game and people on increasingly restricted water sources (Amick 1991, 1994, 1996, 2000; Beckett 1983; Carmichael 1986; Elyea 1988).

Archaic period (6000 B.P.–A.D. 200) archaeology in the Tularosa is somewhat better understood than Paleoindian period archaeology, but unlike other areas of the Southwest where detailed projectile point sequences have been developed, chronometric studies of Archaic period diagnostic materials have been scant, limiting chronological control for studying Archaic period lifeways. Studies of survey data have suggested that, as with other areas of the Southwest, the Archaic period represents a period of decreasing mobility and increasing population, along with an increasing reliance on a broad-spectrum diet and seasonally available resources (Anderson 1993; MacNeish 1993). Archaic period sites have been shown to be widely distributed across a variety of environments, a pattern that may reflect a diversification in diet (Carmichael 1986). By the Middle Archaic period, a greater focus was placed in the procurement of plant materials and small game for subsistence, with an increasing reliance on upland resources, such as piñon nuts, as well as agave and sotol (Vierra 2007).

Maize appears in the regional archaeological record by 1200 B.C., during the Late Archaic period, suggesting that the cultivation of domesticated plants began to be adopted by this time to supplement foraging diets (Hard and Roney 2005; Tagg 1996; Upham et al. 1987), with a possible increase in the use of alluvial fans for cultivation. Models of Late Archaic period settlement and land use have suggested residential use of the lower basin during the late spring through early fall to exploit mesquite, grasses, and lagomorphs, as well as exploitation of piñon, oak, deer, and bighorn sheep in the mountains during the summer and fall (Anderson 1993; Bohrer 2007; Lentz 2006; MacNeish 1993). Alternatively, Late Archaic period sites in the basin have been interpreted to reflect logistic use of the basin for hunting large game (Miller 2007).

Following the Archaic period, the subsequent Formative period is divided into three phases: Mesilla phase (A.D. 200–1000), Doña Ana phase (A.D. 1000–1300), and El Paso phase (A.D. 1275–1450). Models of settlement and subsistence suggest that a seasonal pattern of land use took place during the Formative period, with winter and spring residential sites located near mountain alluvial fans and lower basin areas being used logistically. Short-term residences are thought to have been occupied in the central basin during the summer and fall (Hard 1983a, 1986, 1994). There is a dramatic increase in site numbers and artifact densities associated with the Mesilla phase relative to the preceding Archaic period, although subsistence during the Mesilla phase appears to remain based primarily on hunting and gathering rather than agriculture (Hard et al. 1996; Miller and Kenmotsu 2004; Whalen 1977, 1978). Mesilla phase settlements were small in comparison to later periods, likely consisting of one to a few households. Studies of macrobotanical remains indicate that maize ubiquity was low during the Mesilla phase and substantially less than reported for later El Paso phase sites; reliance on cultigens could have been minimal. At present, it appears that cultivation continued to supplement a diet based in foraging for wild-plant foods (Adams 2009; Goldborer 1985; Miller and Burt 2007; Miller and Kenmotsu 2004). Ceramics appear during the Mesilla phase, but evidence for the use of the bow and arrow for hunting or violent conflict does not appear until late in the phase, and dart points continued to be used alongside the bow and arrow during this time (Kelley 1984; Miller and Kenmotsu 2004).

Prehistoric occupational intensity increased during the Doña Ana phase (Carmichael 1986), a phase that is considered to represent the pit house–pueblo transition. Doña Ana phase sites are typically identified through the detailed study of ceramic types and frequencies (Hard et al. 1994) but can be difficult to distinguish from multicomponent sites representing discrete occupations during multiple phases. In general, the phase is considered to be a transitional period, representing an increased reliance on agriculture and intensified plant exploitation, including the use of rock-lined roasting features for plant processing. Although investigators have noted some indications of aboveground adobe structures at Doña Ana phase sites, the few sites that have been excavated have tended to contain pit structures. By the beginning of the phase, pit structures are often rectangular or subrectangular in plan view, suggesting a potentially greater investment in architecture and increased residential stability (Miller 2005b). Differences in ceramic types at Doña Ana phase settlements between the northern and southern Tularosa Basin suggest that the basin began to be divided into two culturally distinctive areas during the Doña Ana phase or at least that ceramics were obtained through different exchange networks in the northern and southern portions of the basin (Vierra, Hanselka, and Windingstad 2010).

The El Paso phase represents the Late Formative period in the Tularosa Basin. During this period, reliance on maize agriculture appears to have reached its apogee. Sites of this phase tend to be larger and more clustered in their distribution and more intensively used than earlier sites, as indicated by higher artifact densities. Variability in architecture and site structure during the El Paso phase suggests differences among sites in social organization and identity. For instance, some villages consist of isolated or linear room blocks, and others consist of pueblos oriented around central plazas. In addition, some villages include structures built according to multiple architectural traditions. One interpretation of this variability is that El Paso phase sites represent multiethnic villages with inhabitants from multiple Pueblo communities coresiding with each other (Kemrer 2006).

El Paso phase sites appear to represent a change in settlement distribution that coincides with an increased dependence on maize cultivation. These sites tend to be located in a variety of settings, including on alluvial fans, near playa depressions, and in upland locations (Carmichael 1986; Church et al. 2002; Kludt 2007; Leckman et al. 2009; Mauldin 1986). Several reservoirs dating to the El Paso phase have been discovered in the southern Tularosa Basin, indicating an increased investment in water control coincident with increased occupational intensity and maize cultivation (Leach et al. 1993; MacWilliams et al. 2009). A pattern of dual residences in upland and lowland locations may have also emerged during the El Paso phase (Kemrer 2008; Mauldin 1986). Vierra, Leckman, and Heckman (2010) have argued that the location of El Paso phase fields varied with respect to annual rainfall, with fields located near playas and on alluvial fans during periods of high or average annual rainfall, on alluvial fans during periods of average rainfall, and at higher elevations in the Sacramento Mountains during periods of low annual rainfall. Based on differences in ceramic types, Whalen (1978) has argued that occupation of the southern Tularosa Basin shifted from the eastern to the western side of the basin during the El Paso phase. Lekson and Rorex (1994) observed that El Paso phase villages tended to be located in the foothills and canyons of the San Andres Mountains. Overall, El Paso phase settlement represents a continuation of "the increasing diversity of land-use strategies that appeared during the Doña Ana phase" (Vierra, Leckman, and Heckman 2010:13).

By the end of the El Paso phase, upland groups began to move into the area of the San Andres Mountains on the western side of the basin. Social conflict and warfare is one explanation for these moves, as environmental pressures (e.g., drought) do not appear to have been a factor (Kemrer 2006; Wiseman 1997). In addition, foraging groups moved into the region, followed by Athabaskan groups during the fifteenth century (Seymour 2002). The arrival of foraging groups may have resulted in a changing interaction sphere among local residents and more recent immigrants. The Pueblo occupation of the Tularosa Basin appears to end by A.D. 1450, a change that may have been triggered by two extreme droughts occurring from ca. A.D. 1405 to 1415 and ca. A.D. 1445 to 1450 (Grissino-Mayer et al. 1997). Drought may have resulted in increased competition over resources and resource depression, and possible evidence for warfare and violent conflict has been found at several sites (Hunter 1988; Miller and Kenmotsu 2004; Miller and Graves 2009; Seymour 2002).

As with many areas of the American Southwest, little is known about the period between A.D. 1450 and the arrival of the first Europeans in the area. Major changes in settlement and social organization appear to have occurred after A.D. 1450, particularly with the arrival of mobile and aggressive Athabaskan groups in the region, but archaeological or documentary information is scant. Prior to the arrival of Spaniards in A.D. 1581, the Tularosa Basin was used most heavily by Mescalero Apache whose territory centered on mountain ranges surrounding the basin. Organized into relatively small bands based on kinship, the Mescalero Apache consisted of highly mobile groups whose subsistence depended on hunting, wild-plant collection, trade with agricultural Pueblo settlements, raiding of settlements for supplies and personnel, and some horticulture. Major food sources included buffalo meat obtained from the Plains, as well as agave.

In the vicinity of the Tularosa Basin, Apache settlements depended on spring locations and were located in the Organ, Sacramento, and San Andres Mountains surrounding the Tularosa Basin rather than within the basin itself. The basin was used mainly for hunting and gathering as well as for travel; moreover, the Apache threat appears to have kept other indigenous groups from using the basin (Basehart 1971; Faunce 2000; Opler and Opler 1950; Worcester 1941, 1979). The limited use of the basin, especially for residential purposes, left scant traces in the archaeological record regarding the Apache presence.

Spaniards first arrived in the area of Tularosa Basin with the Chamuscado-Rodriguez expedition in 1581–1582. The expedition, which sought to obtain gold and Christian converts, followed the Camino Real along the Rio Grande in what is today southern New Mexico. Focusing on areas mostly to the south and west of the Tularosa Basin, the expedition's members made few observations relevant to the Tularosa Basin. Subsequent expeditions in the following decades also paid little interest in the Tularosa Basin. By the mid-1600s, however, the Spaniards found a reason to venture into the Tularosa Basin more resolutely and that reason was salt. In 1647, the Spaniards established the Salt Trail from El Paso to Lake Lucero, on the west side of the Tularosa Basin, where they obtained salt for many Spanish settlements in the region. Punitive expeditions led by the Spaniards into the Tularosa Basin in pursuit of Apache raiding parties also began to occur around this time. Additional salt deposits were discovered in the eastern portion of the basin by the end of the seventeenth century; these were also mined to supply the region with salt (Faunce 2000).

After the Pueblo Revolt in northern New Mexico in 1680, use of the Tularosa Basin by Spaniards increased as more-northerly Spanish settlements were abandoned. The population increased in the El Paso area and areas near the southern edge of the Tularosa Basin, such as the Hueco Bolson, and it began to be used for grazing of livestock. Apaches continued to use the mountains around the basin heavily, establishing permanent settlements in the Organ Mountains, for instance, and raiding other settlements. Apaches also began migrating into the area from northeastern New Mexico under pressure from Comanches, who had become an increasingly strong military presence in New Mexico and Texas. These demographic changes exerted increasing pressure on precarious Spanish settlement in the region such that, by 1772, the Spanish Crown had issued regulations aimed at establishing a system of presidios to protect the frontier of northern New Spain from hostile indigenous groups. Use of the Tularosa Basin still remained limited, however, even with the discovery of silver in the Organ Mountains during the early nineteenth century, as the area remained dangerous to settlers, travelers, and miners alike and was largely considered to be inhospitable because of a lack of reliable water sources (Faunce 2000).

The southern Tularosa Basin became part of Mexico with the winning of Mexican Independence in 1821. Documents pertaining to the Mexican period are sparse, but what is clear is that use of the Salt Trail continued and the mining of salt from the Tularosa Basin was intensified. Use of the southern Tularosa Basin for grazing also appears to have increased during the Mexican period. A brief respite from hostile interactions with Native Americans during the 1820s led to an influx of miners and ranchers into the region, but increased hostilities and revolts in subsequent decades led to further unrest.

At the close of the Mexican-American War in 1848, control of the Tularosa Basin fell within the hands of the United States, as did other large portions of what is now the southwestern United States. The United States soon began to establish military posts, such as Fort Bliss in the southern part of the basin and Fort Stanton in the northern basin, to protect settlers from hostile Native American groups and to establish economic and political control over the region. Although attempts were made at establishing treaties with Mescalero Apache, hostilities continued. With the continuous arrival of settlers into the region, settlement expanded along the Rio Grande and soon began infiltrating into the Tularosa Basin.

As settlers moved into the Tularosa Basin, disputes emerged among recent settlers and Mexican-American inhabitants over property rights and access to resources, such as the salt deposits of Lake Lucero. Backed by the United States, settlers now fought to gain individual property rights over resources and land areas once held in common. Transportation and communication facilities that supported the expansion of the United States also began to be established in the Tularosa Basin at this time. The Butterfield Overland Mail Route, for instance, was established through the southern Tularosa Basin in 1857. With increased military protection, mining and ranching activities in the basin expanded rapidly, although hostile interactions with raiding Native American groups continued. Mining activities typically resulted in few valuable discoveries and were soon abandoned, resulting in numerous prospect holes and backdirt piles being created throughout the basin where mineral wealth was suspected to be below ground. Near the end of the nineteenth century a railroad was established between El Paso, Texas, and Alamogordo, New Mexico (near the Sacramento Mountains), facilitating the establishment of towns in the Tularosa Basin and further use of areas in and around the basin for mining and ranching.

During the early twentieth century, the Tularosa Basin continued to be heavily used for ranching activities, with many ranchers establishing earthen or metal water tanks in convenient areas where water tended to pool or could be easily impounded. Oil and gas exploration also occurred within the basin during this time, although efforts at finding valuable deposits were largely fruitless. Many of the historical-period archaeological sites that are known within the Tularosa Basin pertain to this later period of ranching and mining activities during the late nineteenth and early twentieth centuries, when historical-period occupants created facilities and deposits substantial enough to be recognized archaeologically. By contrast, earlier activities in the Tularosa Basin—which mostly focused on travel, limited grazing, and the extraction of salt—left comparatively few archaeological traces.

The military presence in the basin began to expand during the early twentieth century, as the U.S. military acquired additional land for training, such as the Doña Ana Target Range in the Organ Mountains, which was acquired in 1911 for artillery training. Military land holdings continued to increase with the purchase of Biggs Army Air Field and the Castner Target Range in 1925 for weapons and air defense training. During the 1930s and 1940s, the Army lobbied heavily to gain control over huge areas of public land within the Tularosa Basin, as well as to purchase large, private landholdings. Public sentiment was largely against these acquisitions, which disrupted ranching and other activities in the basin, but the Army was ultimately able to defend its need for large training areas, acquiring vast areas of land for training and testing that today cover much of the Tularosa Basin. Negotiations with ranchers culminated in the purchase of most of the private landholdings by the government, but when an agreement could not be reached, the U.S. military would condemn properties in order to acquire the land. The three main areas acquired through these activities were the Doña Ana Range, the McGregor Range, and the Texas Maneuver Area.

One individual who became particularly well known for his refusal to sell 28,000 acres of land on Otero Mesa was John A. Prather. After a failed attempt at evicting Prather, he gathered a large contingent of friends and relatives to protect his property. Fearing the effects of negative publicity, the U.S. military reached a verbal agreement with Prather to allow him a lifetime lease on his house and 15 acres. However, he refused to sign any kind of written contract or to cash the check made out to him for the more than $100,000 the government had agreed to pay him. Prather was unwilling to accept the government's terms and continued to operate on portions of his original ranch until his death in 1965. Prather became a folk hero and symbol of the independent spirit of settlers of the old west (Faunce 2000).

Summary

The Tularosa Basin has been occupied since the late Pleistocene and continued to be occupied in some fashion or another throughout much of the prehistoric and historical periods. Early use of the basin occurred under climatic and ecological conditions far different from those of today. During the Paleoindian period, a large portion of the basin was covered by an extensive pluvial lake, and in general, the environment was cooler and wetter, supporting more mesic animal and plant life. Paleoindian period use of the basin focused on the pursuit of mobile, large-game animals. A focus on hunting continued into the subsequent Archaic period but with an increasing attention paid to the exploitation of smaller game animals, as well as plants. Throughout the Archaic period, climate and environment changed as storm systems shifted and drier and hotter conditions began to prevail, ultimately resulting in the migration of Chihuahuan desert taxa into the basin.

Although domesticated plants were available to inhabitants of the basin, a focus on hunting and gathering, rather than agriculture, appears to have prevailed throughout the Archaic period and into the subsequent Formative period. During the Formative period, population increased and settlements became somewhat larger and more stable, but foraging lifeways remained prominent despite the use of ceramic-container technologies and some increase in the cultivation of maize. Frequent movement among different settings in the basin, foothills, and mountains remained common in order to exploit seasonally available resources. By the Late Formative period, increased reliance on maize resulted in the establishment of larger and more-permanent settlements, along with the construction of reservoirs to support the demand of these settlements for water. Variation in architectural styles and village layouts suggests that multiple ethnic groups were coresiding in the basin at this time, possibly as a result of pressure from groups moving into the region.

Although drought could have triggered population movement and decline, little is known about what happened to the occupants of the Tularosa Basin after A.D. 1450. By the time the first Spaniards arrive in the late sixteenth century, Mescalero Apache were the main occupants of the region, although they resided mostly in the mountains and used the basin environments exclusively for hunting-and-gathering activities. The threat of Apache raiding activities was a severe impediment to use of the Tularosa Basin by Spaniards, Mexicans, and subsequent American settlers for the first several centuries of Euroamerican occupation of the region. While under control of the Spanish or Mexican governments, the Tularosa Basin was accessed mostly to obtain salt from Lake Lucero and other deposits, but otherwise, the basin was considered a desolate and largely uninhabitable area owing to both the Apache threat and a lack of water resources. Some livestock grazing in the southern portion of the Tularosa Basin and limited mining in nearby mountains occurred during the late eighteenth and early nineteenth centuries but still left few traces in the archaeological record because of fairly fleeting use of basin environments.

With the acquisition of the Tularosa Basin by the United States following the Mexican American War and the treaty of Guadalupe Hidalgo, the Tularosa Basin began to be increasingly used for ranching, mining, and transportation, as well as military activities. Ranches were established in many areas of the basin to exploit the extensive grasslands present at the time, and a railroad was eventually established by the end of the nineteenth century through a portion of the basin. Mining activities and oil and gas exploration also occurred within the basin, leaving archaeological traces, but these activities were largely unsuccessful in finding lucrative deposits. Ultimately, ranching activities caused extensive ecological changes in the basin, spurring the loss of vast areas of grassland and the expansion of mesquite and creosote bush shrublands. With these changes, interest in maintaining a ranching economy continued among ranchers in the basin, but use of basin shifted to its more-modern uses centered around military testing and training.

CHAPTER 3

Development and Testing of Locational Models

Michael Heilen

Many archaeologists have insight into where sites, including sites of different types, are likely to be located. These insights, gained through hard-won experience with the local and regional archaeological record, can be crucial to understanding how to preserve and protect our national heritage, as well as how the nature and distribution of archaeological sites can impact the military mission. Yet, when not translated into formal frameworks that can be consistently applied to archaeological data and operationalized in a GIS, the utility and reliability of locational models are limited. Subjective models are difficult to demonstrate and, unless they are well documented, cannot easily be replicated, refined, or tested. By contrast, models that have been formalized and operationalized in a GIS can be tested using existing data or additional data developed independent of model construction. Formal models can be improved and, because their logic must be transparent, they are easier to communicate and hence more likely to be accepted by stakeholders. Moreover, formal GIS models are spatially explicit and scalable and can be incorporated as GIS layers in military planning and research.

There are multiple ways to construct models of archaeological site location. Models can be deductive, based on theoretical principles regarding how natural or cultural formation processes created the regional archaeological record; they can be inductive, being based on empirical associations between site location and environmental or cultural variables; or both. Inductive models tend to perform much better than deductive models when tested, but incorporating deductive principles in model development can help investigators interpret why models work (or do not work) and how they are related to past human behaviors.

Many models of archaeological site location in the military are models that predict the location of all sites on a reservation, regardless of type. These kinds of models can be useful in developing expectations about where sites in general are more or less likely to be found. Because they mix human adaptations and their corresponding settlement patterns, "all-site" models tend to be poor predictors. Hence, they commonly do not work well as compliance tools. They can, however, be very useful in the planning process, particularly when it is less critical to know what type of site may be encountered than it is that any type of site may be found in a proposed APE.

Inductive models, by nature, are associational as opposed to interpretive. The relationships between independent variables are manipulated in ways to maximize an outcome; in the case of archaeological site locations, known site locations are maximally differentiated from known locations without sites. Although it is easy to explain why the model works from a statistical perspective, explaining human behavior (why people chose a place to use or settle) can only be done in a post hoc manner that remains tautological at worst or hypothetical at best. In other words, in the former case, an investigator may observe that sites are associated with potable water sources, leading to the interpretation that humans sought out water sources above all other resources and argue, tautologically, that the interpretation is demonstrated by model predictions showing most sites are located close to water. Alternatively, an investigator may hypothesize that humans focused settlement on water sources above all other resources and develop a means to test the hypothesis using independent data.

One means of approaching a better understanding of past human behavior and its influence on the archaeological record is to develop predictive models of individual site types. Site type locational models have the potential of demonstrating, using existing data, where sites of a particular type tend to be located on the landscape and how the distribution of a site type relates to the environment. In this way, site type models allow managers to approach a better understanding of why sites are located in specific areas of a reservation and how this relates to the significance of a site. Another advantage of site type models is that they can perform better than models of all archaeological sites, because they better approximate specific land-use patterns, instead of representing the combined result of all human activities on a military landscape over the millennia.

Site type models, although preferable to all-site models, are not common in CRM. In large part, their spotty use is a reflection of the nature of the data required and the amount of work to construct them. Site type models presuppose that site recorders used consistent site type definitions or that the information recorded was sufficiently consistent and accurate to classify sites according to type, sometimes long after inventories have been completed. The archaeological record also needs to be sufficiently diverse so that site types can be related in a consistent manner to a set of human behaviors. Often, it is the case on military reservations that the most frequent type of site is a small scatter of artifacts that cannot be related to a common set of activities.

The point is that "one size does not fit all"; predictive models need not be treated simply as heuristic devices for assessing where sites are more or less likely to be discovered. They can be used as planning tools for managing different parts of a reservation as well as contribute to significance determinations by providing an objective assessment about how much is known or unknown about the specific archaeological resources managed by the DoD.

Although they can be used for many CRM-related tasks, any particular predictive model can only be as good as the data and methods used in its construction. A major limitation of predictive modeling in the military is the quality and availability of the CRM and environmental data that can be used to construct the models. As alluded to above, information that can be used to assign meaningful site types is often lacking or inconsistently coded in digital databases, even though much or all of the necessary information was collected at considerable cost during fieldwork and may be preserved in paper site records or hard-copy reports. The locations and boundaries of sites can be represented to varying degrees of accuracy as can site attribute information collected in the field (Heilen et al. 2008). Moreover, environmental data can be of varying quality, resolution, and extent, placing limits on the ability to derive meaningful associations between a site and its environment. The representativeness of data for modeling archaeological site location is another concern. Many archaeological surveys on military lands have been geared toward clearing areas that require the most immediate access, rather than sampling the environment in order to obtain a representative sample of sites and environmental contexts. As a result, the available CRM data are rarely in a state that would be ideal for predicting site location and are instead biased in particular geographic and environmental settings as well as in how they were recorded. This situation may tend to skew predictions toward identifying as sensitive the particular contexts that have been studied archaeologically and ignore those contexts that have been subjected to little or no study.

How associations between site location and predictor variables are derived is also important. For instance, some models may simply identify particular landforms or soil types as important to site location, whereas others may partition environmental variables into favorability classes and then intersect a series of maps to determine where the combined favorability from a series of maps is highest or lowest. Still other kinds of models may take advantage of multivariate statistical techniques to determine relationships among variables and to derive statistical measures of model performance.

In essence, predictive models can be of varying degrees of utility depending on the quality and representativeness of available data, the methods used in their construction, and the creativity that managers employ in adapting modeling efforts to specific management needs, now and in the future. An important point to take away from this discussion is that modeling is a process, not an event resulting solely in a static map to be consulted when planning a survey. Models should be periodically tested and refined to remain useful, and the uses to which models can be put should also be periodically reevaluated.

The ERDC-CERL Predictive Modeling Project

This chapter focuses on the efforts to develop and test locational models for the ERDC-CERL predictive modeling project. As discussed in the introduction to this report, the tasks for this project in developing models of archaeological site location are as follows:

1. Develop a predictive model of archaeological site location using available data from site files, digital databases, and other data sources from Fort Bliss.
2. Use a sample of Fort Bliss sites not included in model development to evaluate and refine the locational model using statistical measures.
3. Evaluate the feasibility of adapting the Fort Bliss locational model for use at WSMR.
4. Use available digital data, gray literature, and regional scientific syntheses to develop a comprehensive group of archaeological site categories at WSMR based on site function, cultural and temporal affiliation, geographic associations, etc. Use the WSMR data to refine the locational model that was originally developed using Fort Bliss data. Evaluate how effectively the refined locational model can be used to predict the locations of various site categories at WSMR.

In this chapter, we discuss how the locational modeling tasks defined for this project were accomplished and evaluate the results of each of those efforts. The information provided includes procedures for defining the modeling area, model variables, and site types; the statistical techniques used to build and test the models; and the results of those modeling efforts. We conclude with a brief summary discussion of the modeling results and their implications for management.

The Modeling Area

At the kickoff meeting for the project, stakeholders in the project raised concerns that the culture history and environment of Fort Bliss and WSMR were too different from each other for a model developed for Fort Bliss to legitimately apply to the entirety of WSMR. The mountainous areas at Fort Bliss are substantially less extensive in comparison to WSMR and have been subjected to only minimal survey. In addition, WSMR includes valley settings outside the Tularosa Basin in the Jornada del Muerto on the western side of the San Andres Mountains. These areas were judged to be too distant and disparate culturally and environmentally to be analogous to the Fort Bliss environment and culture history. After some discussion, it was agreed by stakeholders in the project that it would be necessary to restrict the modeling area to the Tularosa Basin portion of each installation. The mountain areas present at WSMR were not adequately represented by Fort Bliss environments, and areas outside of the Tularosa Basin, such as the Otero Mesa at Fort Bliss and the Jornada del Muerto in the northwestern corner of WSMR, were considered too distinctive environmentally to be included in the modeling exercise.

To define the modeling area in a GIS, upland areas of WSMR and Fort Bliss were identified by selecting all cells in a 10-m resolution digital elevation model (DEM) of the project area that were at least 1,590 m above mean sea level (AMSL) in elevation, as this elevation cleanly divided most upland areas from lowland areas. Because there are some mountainous areas in southern New Mexico that are at lower elevations, we also selected pixels for which more than 32 m of relief were identified within a 400-by-400-m area around each pixel, as areas with this amount of relief were consistently identified as mountains or escarpments.

The resulting raster classifying areas above 1,590 m AMSL or with more than 32 m of relief in a 400-by-400-m area was then converted to a polygon layer. The polygon layer was cleaned up using a public domain GIS algorithm available on the internet (Lemmens 2005) to remove small holes that were in the upland polygon layer where elevation or relief was slightly below the cutoff value used to develop a first approximation of upland areas.

The modeling area was also confined to the state of New Mexico, because evaluation of environmental GIS data revealed that a number of important primary data sets were distinctively different in how they were mapped between Texas and New Mexico, a situation that could result in apparent differences in modeled site distributions between the two states simply owing to differences in how environmental variables were mapped.

The resulting modeling area, although covering only portions of either reservation, is still quite large, covering a substantial portion of the Tularosa Basin and extending across nearly the entire length of the basin (Figure 3.1). The modeling area within Fort Bliss covers over 650,000 acres of land in the southern Tularosa Basin, extending approximately 70 km from east to west and approximately 77 km from north to south. The modeling area within WSMR is even larger, although more narrow, covering some 1.1 million acres and extending approximately 47 km from east to west and approximately 147 km from north to south.

Model Variables

In order to develop locational models for the project, care needed to be taken to develop independent variables that could be used to predict site location at both Fort Bliss and WSMR. In essence, environmental variables needed to be mapped and categorized in the same manner for both installations in order to apply to WSMR a model developed using Fort Bliss data. For instance, if we were to use the best environmental layers from Fort Bliss to predict site location but similar layers were not available for WSMR, then we would be unable to extend a model to WSMR owing to a lack of appropriate and comparable data for WSMR.

To address this issue, reservation-specific environmental layers supplied by Fort Bliss and WSMR were evaluated to determine which layers could be usefully applied to modeling for both of the installations. Unfortunately, it quickly became clear that although Fort Bliss has a large number of well-developed and highly detailed environmental layers that would be very useful to modeling site location—such as the distribution of geomorphic features, ecological settings, vegetation types, and soils—similar layers were mostly lacking for WSMR or mapped at a much coarser resolution, using different protocols, or using different data categories.

Of particular concern were the soils data and geomorphic data, as both kinds of data would likely have strong potential for predictive modeling within the basin. Unfortunately, although detailed geomorphic data were available for Fort Bliss, similar data were not available for WSMR. Surface geology data are available for the state of New Mexico, but these data are mapped at a very coarse resolution and would be unlikely to produce useful modeling results. Similarly, U.S. General Soil Map (STATSGO2) data are available that cover both installations but also at a coarse resolution.

The best environmental data for modeling site location, therefore, could not be used as part of the modeling exercise. If we find that the model works well, but not as well as we would like, then it would be useful to explore bringing the WSMR environmental data to the Fort Bliss standard.

Another problem we encountered with the environmental data sets involved, in some cases, data on particular resources (such as the location and extent of playas) that appeared to be incomplete. In an attempt to overcome these problems, we combined environmental data when possible from Fort Bliss, WSMR, and from national mapping agencies to develop environmental variables. For instance, to derive variables related to the locations of potential water sources, reservation data on water sources of particular types (e.g., springs or playas) were merged with data available from the USGS National Hydrography

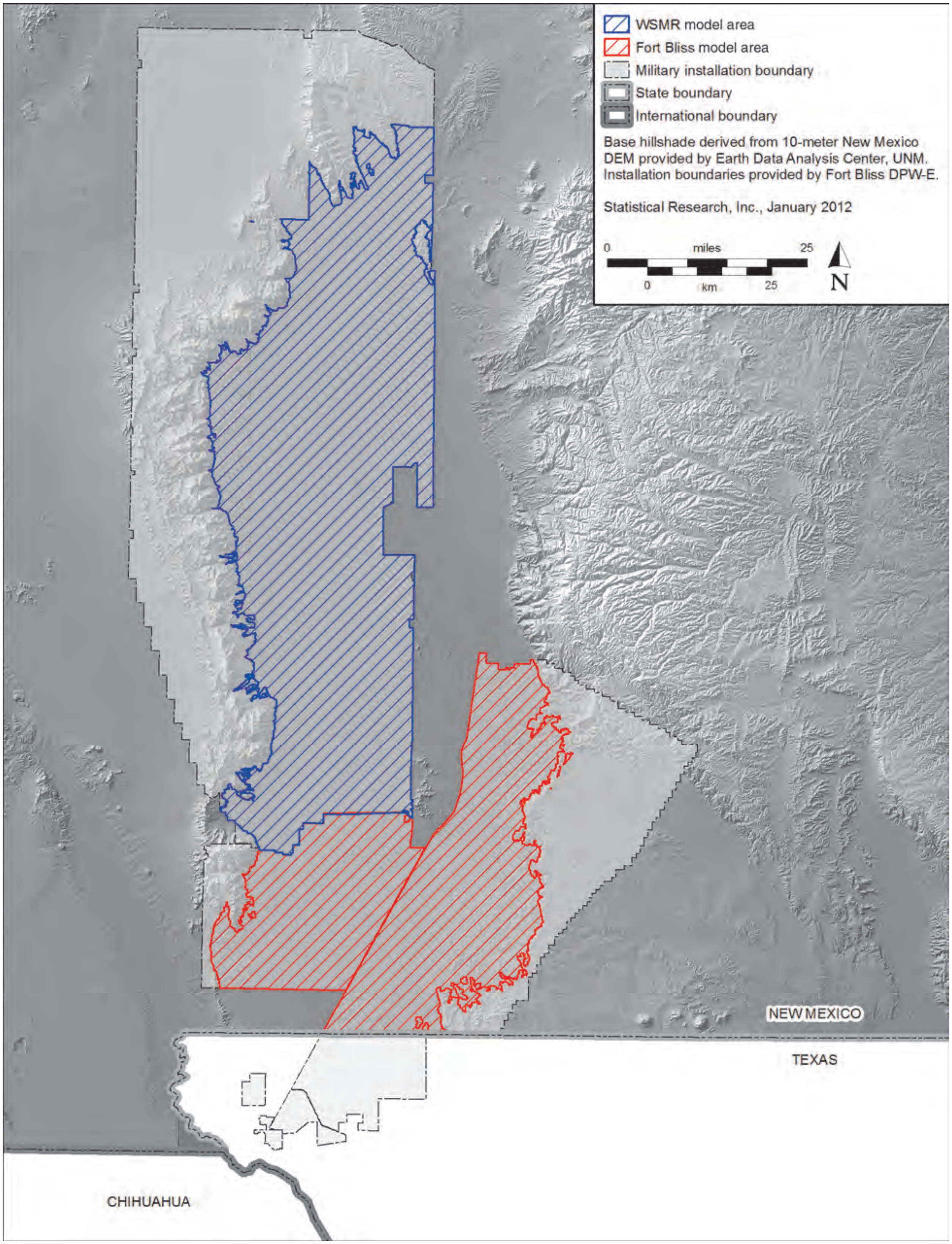

Figure 3.1. The modeling area within the White Sands Missile Range and Fort Bliss, New Mexico.

Dataset Plus (NHDPlus) (U.S. Environmental Protection Agency [EPA] 2006) to develop a more comprehensive data set for water resources.

Another problem that we encountered is that many of the environmental variables that were ultimately developed are distributed differently on the two reservations. When assessing the feasibility of adapting a model developed for Fort Bliss to apply to WSMR, model runs revealed that if a model developed using strictly Fort Bliss data was to be extended to WSMR, few areas would be identified as medium or high sensitivity for archaeological sites. Moreover, areas that could be classed as medium or high sensitivity for archaeological sites in the resulting models tended to cluster in the southern and northern ends of the WSMR within the Tularosa Basin. Analysis of the distribution of environmental variables revealed that roughly half of the environmental variables had a dissimilar distribution between the two reservations. To evaluate the effect of this situation on modeling, we used a tool available in the Geospatial Marine Ecology toolset (Roberts et al. 2010) that identifies where in a model area one or more variables are outside the range of the values of predictor variables used to develop the model. The somewhat surprising result was that approximately 75 percent of the model area within WSMR fell outside of the range of values for variables used to develop the model using Fort Bliss data. As a result, the variables that could be usefully applied to modeling for both Fort Bliss and WSMR were further restricted for some modeling attempts to only those variables that were similarly distributed at both reservations. Fortunately, when data from WSMR were combined with data from Fort Bliss, the areas of WSMR where values of environmental variables were outside of the range of sample values contracted dramatically from 75 percent of the modeling area within WSMR to just over 5 percent.

The variables developed for modeling included sets of variables related to topography, soil attributes, water resources, vegetation, and social factors. These variables were conceptualized as proxies for factors that affected how people moved through and used the landscape. That is, we do not expect that ancient humans of the Tularosa Basin measured the slope of their prospective campsites or the distance between the camp and potable water. Instead, they may have placed themselves in relation to certain plant resources, in areas upwind of their trash dumps, and near enough to water to transport it easily in vessels but not so close as to disturb game animals. We can never reconstruct the exact logic used by prehistoric humans, but if this logic was replicated over time and space, we can expect to discern it from the relationship of sets of environmental and social variables related to these actions. To develop the independent variables, we experimented in defining variables in multiple ways and according to multiple scales of measurement in order to identify variables that performed best in predicting site location. The variables developed for modeling purposes were related to topography, soils, water, vegetation, and social factors.

Topographic Variables

Variables related to topography, such as slope and aspect, are frequently considered to be important in predicting site location. For instance, residential sites are often located in areas of relatively low slope or on slopes facing a particular direction, because of the protection they offer from prevailing winds or variation in their exposure to solar radiation. Other topographically related variables commonly used in predictive modeling include measures of terrain roughness and shelter. Topographic variables were derived in ArcGIS using an enhanced 10-m DEM for the state of New Mexico but were ultimately coarsened to a cell size of 30 m because of the need to speed up processing times for generating model maps.

Slope

One of the most-common topographic variables used in predictive modeling is slope, as measured either in degrees slope or in percent slope or a transformation of either of these scales. Percent slope was calculated in ArcGIS for the study area using the 10-m DEM. One of the problems with deriving slope using the available DEM data is that the simple calculation of slope on a per pixel basis revealed the presence of contour lines in the underlying DEM data. As a result, adjacent cells could have very different slopes depending on whether they were on, above, or below a contour line used to develop the DEM, rather than based on real variation in slope between adjacent cells. In addition, slope can vary according to the spatial scale at which it is measured. Several ways of defining slope according to different scales and measures were experimented with

- mean slope within a 100-m radius
- maximum slope within a 100-m radius
- mean slope within a 1-km radius
- range in slope within a 1-km radius

Ultimately, all of the above variables showed promise during initial model runs in predicting site location, but given intercorrelations among the variables, they were subjected, along with other DEM-derived variables, to a principal components analysis (PCA) to reduce the effect of intercorrelations among the variables (as discussed below).

Cost Surface

Topographic data can also be used, in combination with other variables, as necessary, to create cost surfaces that represent the relative cost of moving across the landscape. To create a relatively simple cost surface for the model area that could subsequently be used to calculate the cost distance to environmental features of interest, the mean slope within a 1-km radius was used as the primary measure of the cost to traverse each raster cell in the modeling area. We used this rather coarsely defined variable instead of the local value or slope calculated using a smaller radius because of the problem noted above wherein slope values along contour lines result in local variation in slope that is largely inaccurate. In addition, because a lot of variation in slope today within the modeling area is the result of undulating landscape surfaces (e.g., coppice dunes) that formed as a result of historical-period disturbance, a more general depiction of variation in slope was thought to be potentially more relevant than slope measured at a finer scale.

A cost value above zero is required to develop valid cost distances in ArcGIS, and a substantial number of pixels in the modeling area have a mean slope value of zero or near zero. To derive valid cost values for the modeling area, a value of one was added to each mean slope value. In addition, because wetland areas, such as playas, could have been difficult to traverse during wet periods, wetlands were assigned a value of 10. The resulting cost surface was used to develop a number of cost distance layers, including cost distance to streams, cost distance to wetland areas, cost distance to mountainous areas, and cost distance to least-cost paths between large prehistoric sites, which are discussed below.

Aspect

Aspect, or the direction in which a slope is facing, is another common topographic variable used in predictive modeling. Aspect is considered to be a kind of measure of exposure. For instance, south-facing slopes can offer greater exposure to the sun or, in areas where prevailing winds can interfere with daily activities, aspects opposing the direction of prevailing winds can offer protection from winds.

When aspect is calculated in ArcGIS, the resulting values correspond to the azimuth of a spherical coordinate system or, in other words, the degrees on a compass. One of the issues faced when using aspect as a variable in predictive modeling, however, is that because of the way degrees are scaled, similar aspects, such as 359° and 1°, can be quantitatively quite distinctive. One means of addressing this problem is to transform aspect values such that they range in value from 0° to 180° rather than from 0° to 360°, with these values distributed symmetrically along either a north–south or an east–west axis (Kvamme 1988:337). In other words, to calculate the north–south aspect, the aspects were transformed such that northerly directions approached 0° (regardless of whether they fall on the east or west side of a compass), whereas southerly directions approach 180°. Strictly east or west directions, in this case, were both 90°, rather than 90° and 270°, respectively.

The east–west aspect was calculated in a similar manner but with easterly directions approaching 0° and westerly directions approaching 180°. In this case, strictly north and south directions are both 90°, rather than 0° and 180°, respectively. The advantage of this approach is that it allows one to model aspect relative to cardinal directions and along a continuous scale of measurement while avoiding the quantitative problems associated with using a spherical coordinate system to model aspect.

The issues identified above concerning the effect of contour lines on the derivation of slope values also apply to aspect. In other words, adjacent cells could have very different aspect values depending on their location with respect to a contour line, rather than correspond to fine-scale variation in aspect among nearby cells. Hence, as with slope, local value for the east–west aspect or the north–south aspect was not used in modeling. Rather, aspect was calculated at a variety of spatial scales by calculating the mean aspect within a specified radius. Experimentation with these variables revealed that the mean aspect within a 1-km radius proved to be important to modeling site location. As with slope-related variables, aspect variables were subject to a PCA to reduce the effect of intercorrelations among variables.

Terrain Roughness

Surface texture or roughness is another variable that can be important to site location as rough terrain can "inhibit day-to-day activities and travel to and from sites" (Kvamme 1988:333). One way to measure terrain roughness is referred to as relief, or the range in elevation within a predefined radius. Relief was calculated for a series of radii, including 100 m, 200 m, 1 km, and 5 km. Model runs tended to indicate that relief within a 1-km radius or within a 5-km radius were important variables, whereas relief at smaller spatial scales was not particularly important to predicting site location.

Another measure of roughness is referred to as terrain texture, which is defined as the amount of variability in elevation within a predefined radius. Terrain texture was derived by calculating the standard deviation in elevation within a radius of 100 m, 200 m, 1 km, and 5 km. Similar to relief, terrain texture measured in scales of a 1-km and 5-km radius tended to be important variables in model runs, whereas terrain texture at smaller spatial scales was less important.

Shelter

Yet another topographic variable that is often considered to be important to site location is shelter, or the degree to which topographic features offer shelter from weather, the sun, or even visibility. For instance, a low-lying site surrounded by hills would have a high degree of shelter, whereas a site on an isolated hilltop would have a low degree of shelter. A site on a level plain would have a neutral degree of shelter. Although a number of investigators have identified shelter as an important variable in deciding where to place settlements, the variable has proven difficult to operationalize in a GIS. The methods that have traditionally been applied to calculate shelter are useful mostly in calculating shelter by hand for a small number of isolated locations, rather than automating the calculation to derive shelter over large areas (Kvamme 1988:336). In attempting to model shelter as part of this project, it was discovered that a simple and effective means of modeling shelter is to divide the mean elevation within a specified radius by the local elevation of a given raster cell. Values above zero correspond to sheltered environments, as most land surrounding a raster cell is located above the elevation of the raster cell. By contrast, values below zero correspond to unsheltered environments in that most land surrounding a raster cell is below the local elevation. As with other model variables, shelter proved to be most important to site location when radii of 1 km and 5 km were used in the calculation.

Principal Components Analysis of Topography-Related Variables

It is often recognized that many environmental variables derived from a DEM will be intercorrelated in some fashion. For instance, slope and aspect may both be correlated with elevation as well as with each other. Most multivariate statistics assume that the independent variables (environment) being used to predict the dependent variable (site location) are independent of one another. Because many of the above variables could be related in some fashion, it is important to transform them into uncorrelated variables, which we accomplished by using PCA. PCA converts a set of observations of correlated variables into a set of values of uncorrelated variables, termed principal components, using an orthogonal transformation. We ran PCA in ArcGIS on topographic variables that had been indicated by initial model runs as being important to predicting site location. These included

- mean slope within a 100-m radius
- maximum slope within a 100-m radius
- mean slope within a 1-km radius
- range in slope within a 1-km radius
- east–west aspect within a 1-km radius
- north–south aspect within a 1-km radius
- terrain texture within a 1-km radius
- terrain texture within a 5-km radius
- shelter within a 1-km radius
- shelter within a 5-km radius
- relief within a 1-km radius
- relief within a 5-km radius

The first five topographic principal components resulting from the analysis were used in predicting site location.

Cost Distance to Uplands

After a number of initial models had been run using the PCA topography-related variables and other variables developed for the project, it became apparent that an additional topography-related variable could be useful in modeling: cost distance to uplands. Cost distance to uplands was modeled using the cost surface discussed above, along with the upland areas identified early in the modeling efforts, in order to define the modeling area. Cost distance to uplands was used as a predictor variable in developing several of the models of site location for the project when measures of variable importance indicated it as a potential predictor of site location.

Soil-Attribute Variables

A useful soils data set for modeling site location on the Fort Bliss and WSMR would have been National Resource Conservation Service (NRCS) Soil Survey Geographic (SSURGO) data. Although state-level data are mapped at a scale of 1:250,000, SSURGO data are mapped at a much finer scale of 1:24,000. In addition, SSURGO contains data on a wide variety of soil attributes (organic matter content, available water capacity, bulk density, etc.) that can be extracted from a database and used to attribute individual mapping units. When these data are mapped, detailed variation in soil attributes relevant to soil quality, depositional processes, and geomorphic setting can be used as predictor variables in modeling site location.

SSURGO data are available for Fort Bliss and much of the Tularosa Basin, but they are not available for WSMR. WSMR is currently involved in developing SSURGO data, but the data are not yet available.

Initial examination of site location with respect to variables derived from the SSURGO data for Fort Bliss revealed that soil-related variables derived from the SSURGO data were often strongly associated with site location and to a much greater extent than many other environmental variables. The soils data that WSMR has are from a survey conducted in 1976 using a mapping scale of 1:100,000 (Neher and Bailey 1976). Basic information on soil type is available for the WSMR soils data from the U.S. Natural Resources Conservation Service (http://soils.usda.gov/technical/classification/osd/index.html), but none of the detailed soil-attribute data that are available for SSURGO data sets is available for the WSMR data set. The result is that soil-quality variables derived from the SSURGO data could not be extended to WSMR, and thus, SSURGO soil-attribute data were not used in developing the models for the project.

Recognizing that detailed geomorphic data were absent for WSMR and the soils data were largely deficient, we endeavored to make the best use of the WSMR soils data by using NRCS soil descriptions to identify a number of general soil attributes that had some potential to be associated with site location and that could be attributed to soils at both reservations. To do this, we examined the soil unit descriptions for each soil type mapped on the two reservations as well as a for a 5-km-wide buffer zone surrounding the two installations. General soil characteristics that could be used to attribute soils on the two installations were the presence or absence of the following:

- shallow soils
- loamy soils
- aeolian soils
- alluvium
- colluvium
- gravelly soils
- gypsiferous soils
- calcareous soils
- petrocalcic soils
- rock outcrops

For each of the above soil attributes, soil layers were created identifying the presence or absence of each attribute. In addition to presence/absence, we experimented with different ways of mapping these variables. These included the Euclidean distance to a soil of a given characteristic, the proportion of land area within a 1-km radius containing soils with a given characteristic, and the proportion of land area within a 5-km radius containing soils with a given soil characteristic. These variables were conceptualized as representing the potential access that inhabitants of a given site could have to a soil resource. Experimentation with these variables indicated that the proportion of a given soil characteristic within a 1 km or 5 km radius generally had the strongest association with site location. However, 1-km- and 5-km-radius-scaled soil variables often performed similarly, so the 1-km-radius-scaled variables were ultimately used in developing the models for the project.

Principal Components Analysis of Soil-Related Variables

One problem with these data is that the individual soil characteristics used were often overlapping, in the sense that a given area could contain gravelly soils as well as contain both alluvium and aeolian soils. To avoid problems with overfitting the data as a result of intercorrelations between variables, a PCA was computed on the 1-km-radius soil-attribute variables, and a separate PCA was computed on 5-km-radius soil variables. Evaluation of the resulting variable layers and scree plots (line segment plots showing the fraction of total variance explained by each principal component) suggested that the first six soil PCA factor variables would be potentially useful for modeling. Subsequent modeling runs revealed that the 1-km-radius soil PCA factor variables tended to be similarly or more important than the 5-km-radius PCA factor variables. Hence, only the 1-km-radius soil PCA factor variables were used to develop locational models for Fort Bliss and WSMR.

Water-Resource Variables

As discussed in Chapter 1, surface-water resources are rare in the Tularosa Basin. Nonetheless, landscape features that could have provided surface-water resources after precipitation episodes and during wet periods, such as playas or desert washes, are considered important to site location. To model the availability of water resources, wetland areas described as playas, marshes, or riparian zones were identified using NHDPlus data (EPA 2006), as well as comparable wetland layers provided by Fort Bliss and WSMR. The locations of spring and seeps were also included as potential water resources. Although such features are rare within the modeling area for either installation, located mostly in upland areas surrounding the basin, the proximity of such water resources to sites within the basin remains important. The water-resources data were merged into a single GIS layer that was then used to calculate the Euclidean distance to wetlands, cost distance to wetlands, and the number of raster cells containing wetland within 1-km radius.

Distance to Tanks

Information was available in the NHDPlus data as well as in GIS data provided by WSMR and Fort Bliss on the location of artificial tanks for storing water, many of which would likely have been constructed and used during the historical period. Because these could potentially be useful for modeling the location of historical-period sites, the Euclidean distance to tanks was calculated using these data. Interestingly, the resulting variable was also frequently identified as important to prehistoric site location in addition to historical-period sites, as discussed below.

Distance to Streamlines

Drainages were also considered as a potential source of water, as well as landscape features that could potentially influence movement and resource use. To develop a layer identifying the locations of streams, streamlines were extracted from NHDPlus data. Features identified as either pipelines or canals were removed from these data, so that only naturally occurring linear water features were considered in making calculations. Streamlines on either installation generally are located along the valley margins and do not extend far into the modeling area on either reservation. In addition, streams would have typically been dry, carrying water principally after periods of rain. However, streams could have offered potential sources of water during flood events, guided movement through the landscape, and provided floral or faunal resources located along stream margins.

Distance to streamlines was calculated in two ways: Euclidean distance to streamlines and cost distance to streamlines. Euclidean distance was calculated for each raster cell in the model area using the Euclidean distance tool in GIS. Cost distance was calculated using the Cost Distance tool in ArcGIS and the cost surface described above.

Streamline Characteristics

In modeling water availability it is not only important to have variables measuring distance to water sources but also the potential abundance of water provided by a water resource. NHDPlus data provide information on drainage characteristics, such as the mean annual flow of a stream segment and the cumulative annual drainage of a stream segment. To test whether the volume of streamflow in a given stream would be useful to modeling site location, these variables were modeled using the Euclidean Allocation tool in ArcGIS by finding the mean annual flow of the closest stream segment and the cumulative annual drainage of the closest stream segment, up to a maximum distance of 5 km, with the assumption that site occupants would not have traveled farther than 5 km to take advantage of streamflow in some capacity. Neither of the above variables proved to be important to modeling site location during initial modeling runs, and thus, they were not used to develop locational models for Fort Bliss or WSMR.

Elevation Relative to Water

Elevation relative to water is sometimes considered to be an important variable for modeling site location, in part because a site may be close to water horizontally but distant from water vertically. In other words, a ridge overlooking a drainage may be horizontally close to a stream but located far above the water. To model elevation relative to water, pixels identified as potential water sources (including streamlines) were attributed with elevation data. The Euclidean Allocation tool in ArcGIS was then used to identify any raster cell for which the elevation of the closest pixel represented a water source. The elevation of the closest water source pixel was then subtracted from the local elevation of each raster cell to calculate elevation relative to water, with positive values indicating that a cell was higher in elevation than the closest mapped water source and negative values indicating that a cell was lower in elevation than the closest mapped water source.

Principal Components Analysis of Water-Related Variables

As with other suites of environmental variables developed for the project, PCA was performed on water-related variables to reduce intercorrelations among variables. Interestingly, experimentation with the Euclidean distance to tanks variable suggested that the variable was important to predicting both prehistoric and historical-period site location. It is not uncommon for historical-period sites to converge on prehistoric sites and for prehistoric and historical-period land use to target some of the same environmental variables. Although most of the tanks in question would not likely correspond to water sources during the prehistoric period (although, theoretically some of them could have originally been prehistoric reservoirs), it is at least theoretically possible that tanks were located in some cases in areas where surface waters tended to pool or where other important resources were located (e.g., see Faunce 2000:282). Because Euclidean distance to tanks was frequently identified as important to both prehistoric and historical-period site location, the variable was one of several that were used as inputs in a PCA. The variables used to develop PCA factor variable layers were the following:

- Euclidean distance to streams
- Euclidean distance to wetlands
- Euclidean distance to tanks
- The number of raster cells identified as wetland within a 1-km radius
- The number of raster cells identified as wetland within a 5-km radius
- Elevation relative to water

Evaluation of the resulting PCA layers and scree plots for the PCA components suggested that a total of five PCA components could be useful to modeling, and these were used to develop models of site location.

Several variables that ultimately proved important to modeling site location were developed after the PCA was performed: cost distance to streamlines and cost distance to wetlands. It was felt that these variables could perform better than the Euclidean distance variables, and indeed, they did in a number of cases. Thus, these cost distance variables were used in place of the PCA water variables related to distance to water (PCA Water Components 2 and 3) when model runs indicated that they were more important than the corresponding PCA water variable.

Vegetation Variables

As discussed in Chapter 2, vegetation is considered to have changed dramatically in the Tularosa Basin as a result of disturbance associated with historical-period land use. Thus, it is not likely that the current distribution of vegetation is similar to the distribution during prehistoric times. In addition to change that occurred during the historical period, the presence or absence and distribution of vegetation types also changed during the prehistoric period.

Nonetheless, attempts were made to use the available vegetation data for modeling, because other environmental layers were often lacking. Vegetation maps provided by WSMR and Fort Bliss did not appear to be particularly comparable to each other in terms of mapping scales or vegetation types, however. To develop vegetation-related variables that could be applied equally to both reservations, vegetation data were obtained from the Gap Analysis program, a National Land Cover Data program that provides data on major vegetation types (U.S. Geological Survey [USGS] 2010).

Using these data, individual vegetation types were examined using histograms and *z*-score tests of proportion to determine which vegetation types had a potential association with site location at Fort Bliss and WSMR. Rasters were subsequently developed that represented the presence or absence of a given vegetation type, Euclidean distance to a given vegetation type, and the proportion of a given type within a 1-km radius and a 5-km radius. Experimentation with these variables revealed, somewhat surprisingly, that vegetation type within a 1-km radius or 5-km radius was often substantially more important than the presence or absence of a given vegetation type or the Euclidean distance to that vegetation type. Hence, the 1-km- and 5-km-scaled vegetation variables were used to develop locational models for the project.

Principal Components Analysis of Vegetation-Related Variables

As with the other variables developed for the project, vegetation-related variables were subjected to PCA to reduce intercorrelations among variables. Similar to the soil-attribute variables, separate PCA analyses were performed using the 1-km-scaled vegetation variables and the 5-km-scaled vegetation variables. Ultimately, the 1-km PCA vegetation components tended to be more important than the 5-km PCA vegetation component variables, and thus, they were used for developing location models.

Because vegetation is considered to have changed dramatically during the prehistoric and historical periods, care was taken to avoid using vegetation-related variables if other variables were deemed of similar importance. However, vegetation variables were often related strongly to site location and were consequently retained as variables, although their relationship with site location could be more closely related to factors such as archaeological visibility or disturbance rather than the true abundance of archaeological sites.

Social Factors

One of the deficiencies in many predictive models is that they often rely completely on environmental predictor variables and do not include consideration of social factors. To address this situation, some investigators have developed variables representing the gravity that central places or cultural features, such as roads or pathways, play in minimizing or directing the movement of people across a landscape. In an attempt to model potential movement between places, we calculated a series of least-cost paths between a sample of large prehistoric sites (>10 acres in size) that have been recorded in either the New Mexico

Cultural Resources Information System (NMCRIS), WSMR, or Fort Bliss CRM databases, including sites that fell outside of the model area.

To develop least-cost paths between sites, we randomly split the sample of large prehistoric sites in half and calculated least-cost paths from one-half of large prehistoric sites to the other half of prehistoric sites using the cost surface described above. We then repeated the process an additional three times in an attempt to generate a sample of possible paths between large prehistoric sites, recognizing that although many of the sites may not have been contemporaneous, they could have represented central places where resources were locally abundant at different points in prehistory (Figure 3.2). The path distance to the closest least-cost path was then calculated in ArcGIS using the Path Distance tool. The resulting layer provides an approximation of how people may have moved among sites in the Tularosa Basin at various points in prehistory; however, it is limited by the number and location of large prehistoric sites that have been recorded. One of the potential problems with the variable is that it is spatially autocorrelated with the location of large prehistoric sites. However, we felt it would be useful to retain the variable, because it often appeared that large sites were typically separated by small sites that, in some cases, may have been limited-activity sites related to the use of larger residential sites and central places.

Model Development

To develop predictive models of archaeological site location for the project, we first developed a locational model for archaeological sites at Fort Bliss using only data obtained from the most-recent surveys, all of which used the same methods for discovering and recording archaeological sites. Because those data were fairly biased in their geographic location, being confined mostly to the McGregor Range on Fort Bliss, an additional sample of CRM data was developed for other areas that were not represented by the original sample (i.e., the Northern Maneuver Area). Those data were subsequently used to evaluate the performance of the original model and to develop a refined model of archaeological site location for Fort Bliss.

We experimented with several different ways of refining the model using the additional sample of CRM data developed from early survey at Fort Bliss, along with the transect recording unit (TRU) data (see below). One thing that was discovered in evaluating the original model is that the location of large sites was predicted best, whereas small sites were predicted less well. This is not surprising, because large sites, many of which are multicomponent sites with potential residential functions, tend to be clustered in their location, whereas small sites are widely distributed across Fort Bliss. Thus, one of the ways we experimented with developing a refined model was to model large and small sites separately and to characterize small sites using cluster analysis according to their geographic associations. This effort resulted in a model that performed only marginally better than the original model, however.

Another way we experimented with refining the model was simply to model all sites using the new sample, without any divisions among sites according to type or geographic location. This model performed substantially better than the either the original model or the refined model based on large and small site classes.

To evaluate the feasibility of adapting either model to Fort Bliss, the resulting models were projected onto WSMR. We were discouraged to discover that projecting the models developed using only Fort Bliss data resulted in models that would obviously perform poorly for WSMR. Large proportions of sites at WSMR were not captured by the models, and areas identified as medium or high sensitivity in the resulting models tended to concentrate on either the southern or northeastern ends of the WSMR modeling area. To test whether the distribution of predictor variables across the two reservations was partially responsible for this result, we used a tool in ArcGIS that allows a user to identify where in a modeling area predictor variables fall outside the range of the sample values used in creating a model. This analysis revealed that, indeed, approximately 75 percent of the WSMR modeling area fell outside the range of

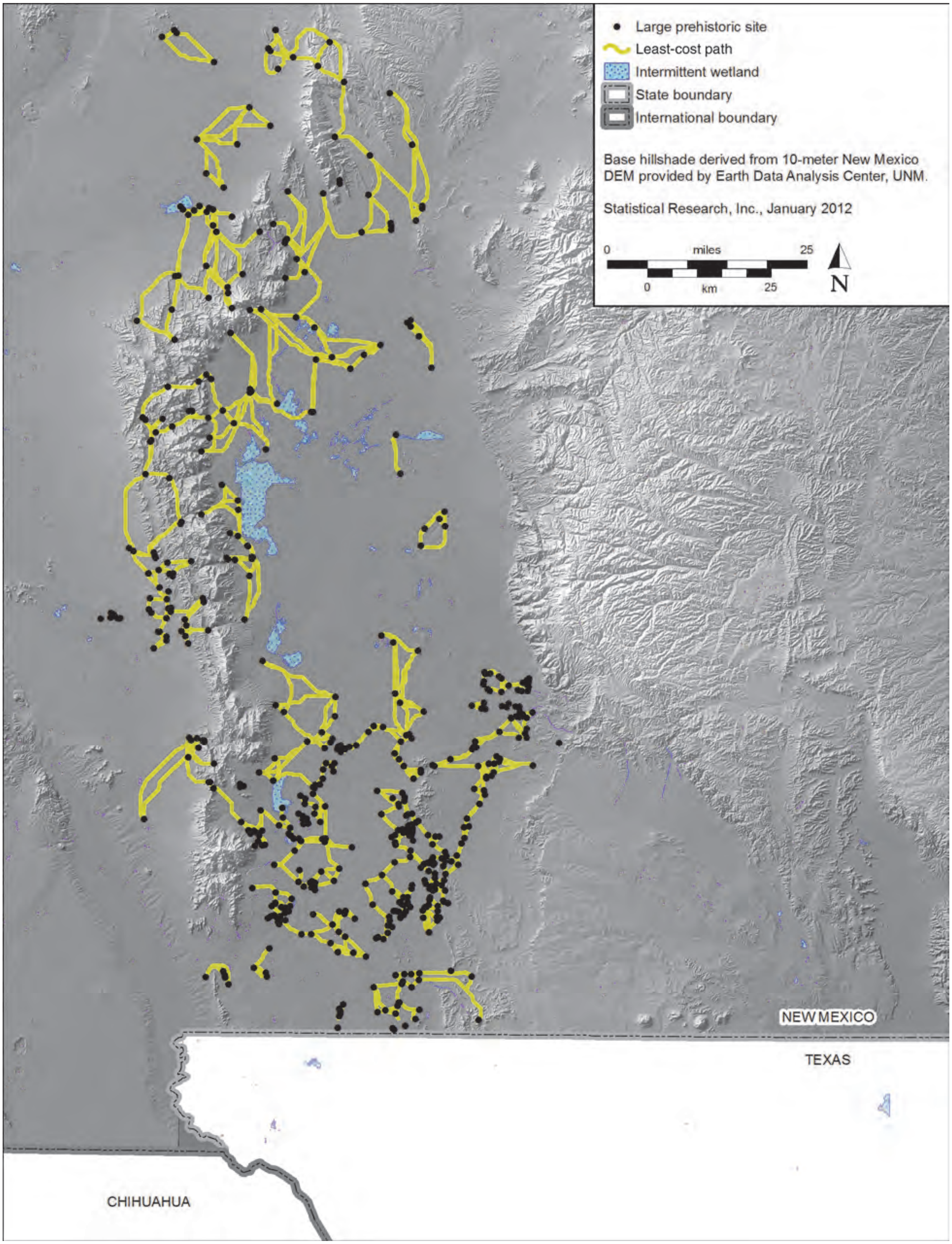

Figure 3.2. A model of least-cost paths between large prehistoric sites.

values for variables used in creating the models. In addition, the areas where predictor variables were similar in their distribution between the two reservations were essentially the same areas where archaeological sensitivity was predicted to be greatest at WSMR.

To adjust for this problem, the model variables were evaluated to determine which variables were most similar between the two installations. Subsequently, refined models were developed for Fort Bliss using only those variables that were most similar in their distribution between the two installations. Using only these variables allowed us to develop models that still performed moderately well for Fort Bliss but still did not work particularly well when projected to WSMR.

To further refine a locational model in order for it to apply to WSMR, we then developed two separate series of site type models using site types defined for the project. The first series of site type models were constructed using only Fort Bliss CRM data and the variables evaluated as most similar in their distribution between the two installations. In evaluating the performance of this first series of site type models, it was learned that the site type models worked quite well in predicting the location of individual site types at Fort Bliss but worked worse when the models were projected to WSMR, in some cases performing quite poorly. The second series of models were constructed using a combination of both Fort Bliss and WSMR CRM data and the full range of predictor variables developed for the project. When applied to Fort Bliss, the resulting site type models tended to perform similarly to the first series of site type models; the same models also performed quite well for WSMR. Although we think that the performance of the models for WSMR might be overstated owing to a variety of factors, they nonetheless perform substantially better than any previous model developed and applied to WSMR.

The individual site type models were subsequently combined into an all-sites model that also performed well in predicting the location of all sites as well as individual site types for portions of the WSMR modeling area. The models tended to perform least well for the area of WSMR south of I-70, largely because vast majority of this area was predicted to be of high sensitivity. However, the result is not necessarily problematic, as it is more a consequence of how performance metrics were calculated to determine a model's predictive capacity, as will be explained later in this chapter. Outside the area south of I-70, the combined site type model performs well according to performance measures and shows some promise in being used as a planning tool. In addition to the combined all-sites model for WSMR, another kind of model, which we have termed a differentiated land-use model, was also created. This model combines the predictions of the individual site type models to show where land use of different periods and site functions (i.e., residential site functions) is expected to have occurred, based on existing knowledge of site location and attributes. Given the current incomplete state of site attribute data for WSMR, the model also shows where land use of undetermined type is predicted to have occurred, as well as where within the modeling area predictions cannot be accurately made.

Modeling Technique

The modeling approach used to develop all the models discussed in this report is a recently developed statistical approach referred to as Random Forests (Breiman 2001; Prasad et al. 2006). We also experimented with logistic regression models, general additive models, and stochastic gradient boosting models. None, however, performed better than Random Forest models, so we remained with Random Forest models to maintain consistency in developing each of the models discussed in this report.

Random Forests are a kind of nonparametric decision tree statistical learning technique that fall within a larger class of models known as Classification and Regression Tree (CART) models. CART approaches to modeling perform classification or regression analysis depending on whether the dependent variable that is being predicted is a continuous or categorical variable. In our case, the dependent variable is a categorical binary variable (presence or absence of an archaeological site), and thus the approach that is applied is a classification analysis.

The decision trees developed in CART are formed by creating a series of rules that partition independent variables in order to differentiate observations with respect to the dependent variable, in this case, the presence or absence of an archaeological site (Figure 3.3). For instance, if a site was most often present when a given variable had a value equal to or above 10 and absent for values below 10, then a node in the decision tree would be formed with a split for that variable at a value of 10, forming two child nodes beneath that node, one corresponding to site presence and the other corresponding to site absence. If further partitioning is possible, those child nodes could themselves become parent nodes and be further split into subsequent child nodes based on splits in other variables. The splitting of parent nodes into child nodes ends when no further gain in predictive power is attained by the creation of additional child nodes, or alternatively, the tree is developed exhaustively and then pruned in order to optimize gain in prediction.

Random Forests is an approach to CART that was specifically designed to overcome problems with overfitting the data that are common to other multivariate statistical modeling techniques used to predict archaeological site locations. In general, models that incorporate a large number of independent variables relative to the number of observations used in the model have a tendency to be overly influenced by minor fluctuations in the data set (i.e., random error or “noise”) and thus “fit” to the particulars of the data set and not the underlying relationships between the dependent and independent variables. In Random Forests, multiple trees are constructed using bootstrapped samples[1] of both the independent variables and the cases. In other words, the CART approach to constructing decision trees is repeated numerous times in a Random Forest model to create hundreds or thousands of trees, with each tree formed using a randomized set of predictor variables and cases. For instance, if there were 20 variables and 600 cases, each tree would be formed using a random subset of variables (e.g., 7 variables) and a random subset of cases (e.g., 400 cases). Each tree is grown to its maximum size without pruning, with error estimates (referred to as the out-of-bag [OOB] estimates) made using the sample of cases withheld from tree formation.

The repeated formation of independent trees using randomized sets of predictors eliminates the need for creating separate test and training sets, as these sets are continually created hundreds or thousands of times through the bootstrap process. The outputs are averaged by taking a vote across the trees for each node with the most common outcome for that node (or majority vote) being taken as the final result. This process generates a model that is robust to overfitting, diminishes problems with intercorrelations between variables, and reduces bias introduced by individual variables or cases. A disadvantage of the approach is that it is somewhat of a black box; it is not possible to interpret easily how individual trees contribute to the final model, as literally hundreds or thousands of trees are created. However, the approach does provide a number of statistical measures that allow the estimation of the importance of each variable in creating the model and in estimating the error rate of the model predictions (the OOB error).

Random Forest models were developed using a program called ModelMap (Freeman and Frescino 2009), which is available in R, an open-source statistical platform available on the internet (R Development Core Team 2008). ModelMap allows the user to create a Random Forest classification or regression model using a table of cases consisting of a response variable and corresponding values for any number of categorical or continuous predictor variables. The program then allows the user to run internal validation tests and calculate statistics on model performance, including OOB estimates and the Area under the Receiver Operating Characteristics Curve (AUC), as well as provides graphs of variable importance. Once a satisfactory model has been developed and tested internally, a user can call on ModelMap to create a prediction raster using the Random Forest model file created by ModelMap.

[1] Bootstrapping refers to a resampling process used in statistics whereby multiple samples are drawn with replacement from a larger sample (an individual case can be drawn more than once). Bootstrapping is often used to calculate the accuracy of sample statistics.

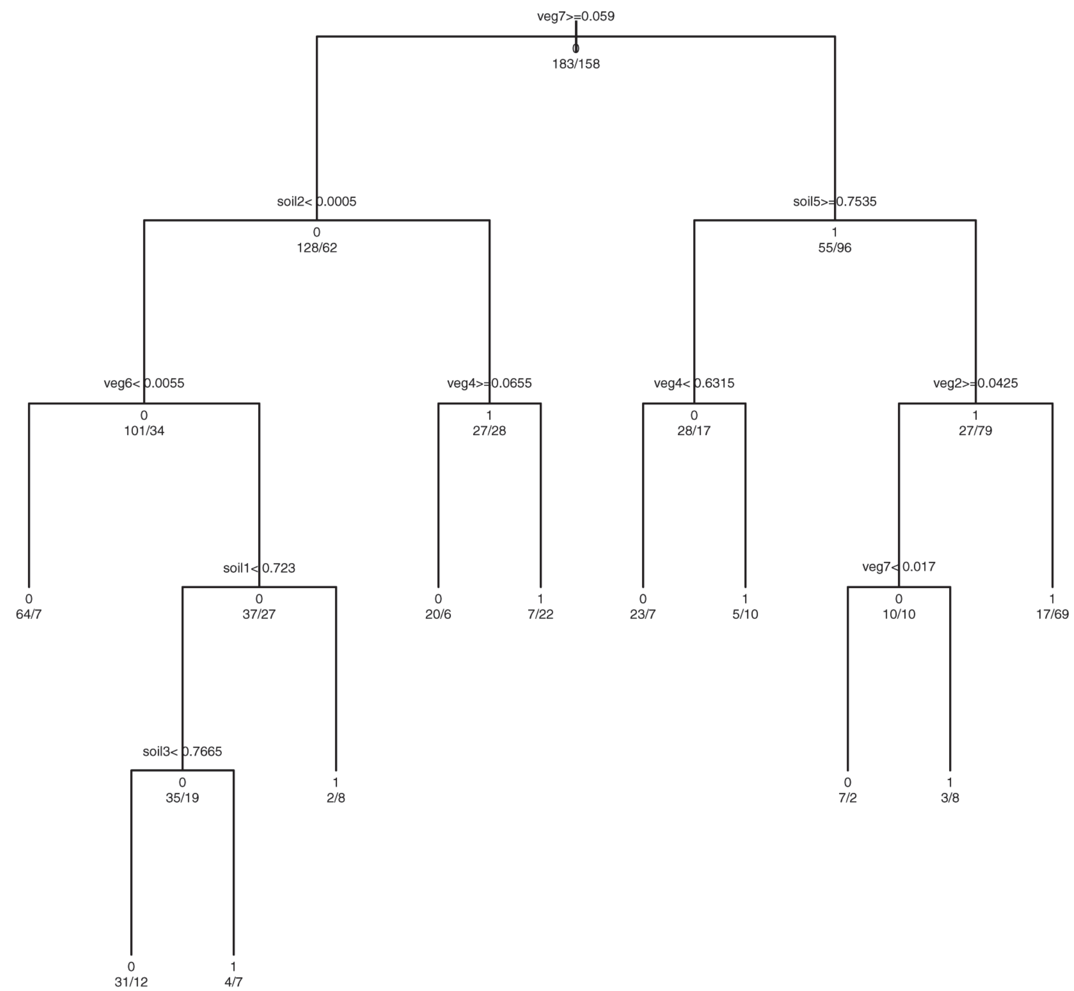

Figure 3.3. An example of a Random Forest tree graph, showing the variable states for which parent nodes are split into child nodes for a binary response variable.

Modeling Procedures

For all of the models developed for this project, a general set of procedures was followed. For any specific sample of site and nonsite locations, a random set of site samples was selected from within site polygons located within surveyed areas. The centroid of each site was used as a sampling point for site-positive locations. Additional points were selected randomly from within the boundary of larger sites, based on site size, using the following formula:

2 + Int((log([site acres]/10)*2.303585))

The above equation derives sample numbers at a decreasing rate as site size increases (Figure 3.4). This approach to sampling from larger sites was applied to avoid samples being too heavily biased toward large sites.

Nonsite samples were selected at a uniform density from negative space within survey areas (where no sites or other documented archaeological finds have been discovered). Because there are high densities of sites at Fort Bliss, we were concerned that substantial numbers of nonsite samples would be located too close to the boundaries of recorded sites. To avoid this problem and to achieve better separation between site

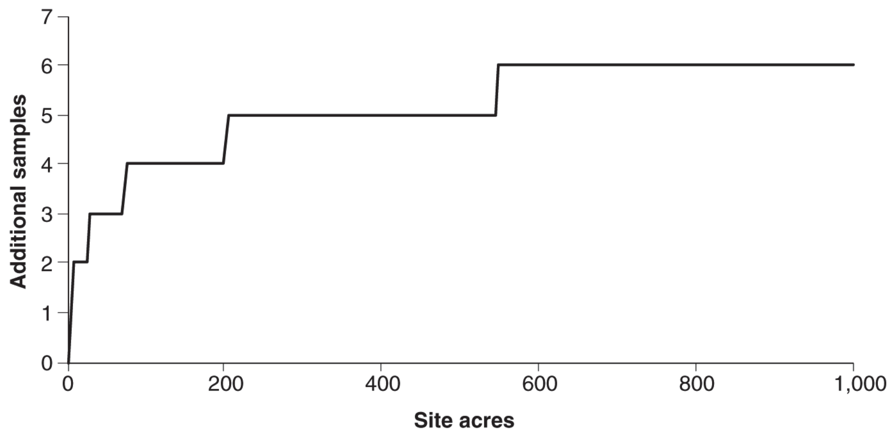

Figure 3.4. Graph showing the number of additional samples taken per site, according to site size.

and nonsite locations according to environmental variables, we systematically removed all nonsite samples that were less than 150 m from a site boundary, resulting in a sampling density of roughly 1 nonsite sample per 25 acres of negative survey space. For any given sample to be used in model development, nonsite locations were selected randomly from a larger set of nonsite samples and adjusted in size until site and nonsite samples were roughly equal in size, as is common practice in predictive modeling.

Although Random Forest modeling does not require the use of separate training and test sets for modeling, we chose to be conservative in our sampling approach and randomly divided in half each sample of site and nonsite samples to derive training and test sets for model development and testing. The training set was used to develop the model and the test set was used to derive model performance statistics and to estimate variable importance.

The performance of each model was assessed initially using a series of metrics related to model performance: True Positive Rate (TPR), False Positive Rate (FPR), AUC, and the OOB Error Rate (discussed above). In the case of archaeological locational modeling, the TPR is the number of site-positive cases that were correctly predicted as sites by the model, divided by the total number of cases representing archaeological site locations. By contrast, the FPR is the number of site-negative cases that were incorrectly predicted to be sites by the model, divided by the total number of cases representing nonsite locations. The TPR is an expression of the sensitivity of the model, in that the higher the rate, the more sensitive the model is to correctly identifying site locations. The FPR is, by contrast, an expression of the specificity of the model (FPR = 1 – specificity); the lower the FPR, the more specific the model is in predicting site location.

For instance, if the TPR of a model was 0.9, the model could be considered to be highly sensitive in predicting site location, because 90 percent of site locations were predicted correctly. If the FPR was 0.3, however, the model could not be considered to be highly specific in predicting site location, as roughly one-third of nonsite locations were predicted incorrectly as site locations. The AUC is an expression of the relationship between sensitivity (TPR) and specificity (1 – FPR). Varying between 0 and 1, the AUC is above 0.5 for a model that performs better than random, whereas a value below 0.5 would indicate a model that performs worse than random. A model that performs perfectly by predicting all cases correctly, a rare occurrence, would have a value of 1. Typically, values above 0.9 represent models that perform exceptionally well, being both highly sensitive and highly specific, but models considered to perform satisfactorily may often have values in the range of 0.75 or higher. The OOB error estimate provided by Random Forest models is a composite metric that represents the overall rate of error in model predictions and is closely correlated with the TPRs and FPRs.

For each model developed for the project, all of the variables discussed above (as measured according to different scales, etc.) were used for the first iteration in order to determine which variables were most important in predicting site location using variable-importance scores provided by ModelMap. Subsequent models focused on using a restricted set of the most-important variables with an aim toward minimizing the number of predictor variables used in analysis (to avoid overprediction) and maximizing the sensitivity and specificity of the model. Once all the variables had been developed and tested, we restricted the variables to the PCA component variables (corresponding to topography, water resources, vegetation, and soils) and to several variables that were developed after the PCA variable were developed: cost distance to mountains, cost distance to wetlands, cost distance to streams, and path distance to least-cost paths between large prehistoric sites. Limiting the variables to components and select environmental characteristics was done to avoid potential problems with overfitting and intercorrelations among variables. Even though Random Forests are specifically constructed to minimize such problems, it was felt that the minimizing these problems for this project was especially important given the need to extend a model from an area where archaeological data were abundant to a reservation where they were comparatively scarce.

Euclidean distance to streams and Euclidean distance to wetlands were also included in later model iterations as independent variables to test whether they performed better for some models than cost distance to streams or wetlands. In cases where one or more distance to water variables were identified as being of similar or higher importance the corresponding PCA water component variables (PCA Water Components 2 and 3), we used those variables in place of the water PCA component variables in order to avoid redundancy between variables and potential overfitting of the model.

Once a satisfactory model had been developed in R and evaluated quantitatively using the test and training sets, it was used, along with rasters representing the model's predictor variables, to generate a raster representing the model predictions. Given the manner in which the model maps were generated, with predictions for each cell being calculated with the decisions trees developed by the model, generating a map in R could take 8 hours or more to complete, depending on computer processing power and the size and number of rasters used in generating the model. For this project, we started out using rasters snapped to a DEM with a 10-m cell size, but owing to the very long processing times needed to generate each individual map, we ended up having to upscale our predictor rasters to a 30 m cell size and narrow the overall extent of the rasters in order to generate maps within a practical time frame.

Evaluation of Model Maps

Models for which maps were generated were first examined visually, along with site locations and attribute data. This inspection determined if a model had potential for predicting site location accurately, or if there were problems that needed to be addressed with further model iterations. To statistically evaluate model maps that appeared to have potential, sensitivity zones were defined using the categories of low, medium, and high (or just low and high, as for the site type models) and tested with Gain and Gain over Random (GOR) statistics.

Kvamme (1988:329, emphasis in original) defined the Gain statistic to indicate whether a predictive model demonstrates "*gain* (e.g., in terms of percent correct predictions) over a purely random model with no predictive capacity." The Gain statistic is calculated as follows using a random sample from surveyed areas:

Gain = 1– (percentage of total area covered by model/percentage of total sites within model area)

For values of the statistic greater than 0, the Gain statistic indicates an increase in a model's predictive capacity as the statistic approaches 1. Values near 0 indicate a model that has limited predictive utility, whereas negative values indicate a model that performs worse than random chance. For instance, if 85 percent of sites are found within 50 percent of surveyed area (1 – 85/50), the Gain statistic would equal 0.41, indicating a low to moderate gain in predictive capacity. If, by contrast, 85 percent of sites are found within 25 percent of survey area (1 – 85/25), the Gain statistic would equal 0.7, indicating substantial improvement in predictive capacity. When the percent of surveyed area is close to the percent of sites found within a model area, the gain statistic approaches 0, indicating no gain in predictive capacity. For the purposes of this project, we defined the model area (in order to calculate the Gain and GOR statistics) as medium- and high-sensitivity zones combined, or for models consisting of only low and high-sensitivity zones, the high-sensitivity zone was defined as the model area.

GOR is a related statistic that uses the same input variables as the Gain statistic in order to estimate the difference between the percentage of sites within a model area and the percentage of surveyed areas indicated as medium or high sensitivity, such that:

GOR = (percentage of sites within model area – percentage of area covered by model area)

GOR ranges from –100 to 100, with negative index values indicating a model that works worse than random chance, low positive values indicating a model that works little better than random chance, and high positive values indicating a model that accurately predicts site location within a relatively small model area. With the same values used to illustrate the Gain statistic above, the GOR for the former case is 30 (i.e., 85–50), indicating the model predicts sites accurately but within a relatively large model area. In the latter case, however, the GOR is doubled to 60 (i.e., 85–15), indicating a substantial improvement in a model's specificity as most sites were discovered within a model area half the size of the former model.

Models

In this section, we discuss and compare the different location models developed for the project, beginning with the baseline model developed using an initial sample of data from Fort Bliss and ending with discussion of models developed for WSMR using a combination of Fort Bliss and WSMR CRM data.

Baseline Fort Bliss Model

Initial modeling efforts focused on sampling from the most-recent survey data, which has been conducted according to the TRU survey method (Kludt et al. 2007; Lukowski and Stuart 1996; Mauldin et al. 1997; Stowe et al. 2005) (Figure 3.5). The TRU method is an innovative approach to survey that involves a combination of site-based and nonsite approaches to archaeological discovery and recording. For the TRU method, survey areas are divided up into grids of 15-by-15-m cells, within each of which field crew record and provenience all cultural materials. Site recording, or the definition of site boundaries, is left until the end of fieldwork instead of conducted in the field during survey. Sites are defined in a GIS using a standard algorithm using provenienced artifact and feature data recorded in the field per TRU cell. The approach allows for a consistent and analytically sound means of recording and defining archaeological manifestations as well as enables the archaeological survey record to be analyzed and interpreted according to both a site-based and a continuous grid-based or gradient approach. Because the TRU method has likely resulted in the most-recent, accurate, and consistently recorded archaeological data, it was considered that TRU data had some of the greatest potential for developing predictive models of site location at Fort Bliss.

In attempting to use the TRU data for modeling, we initially explored the possibility of using the actual TRU cells as observation units, rather than using the sites derived from TRU cell data as observation units in order to determine if individual TRU cells could be useful for modeling purposes. Artifact and feature data associated with individual TRU cells were used to derive different classes of archaeological finds corresponding to different sets of land-use behaviors. However, use of the TRU cell data tended to produced very noisy results with high error rates unless only those TRU cells with high artifact diversity

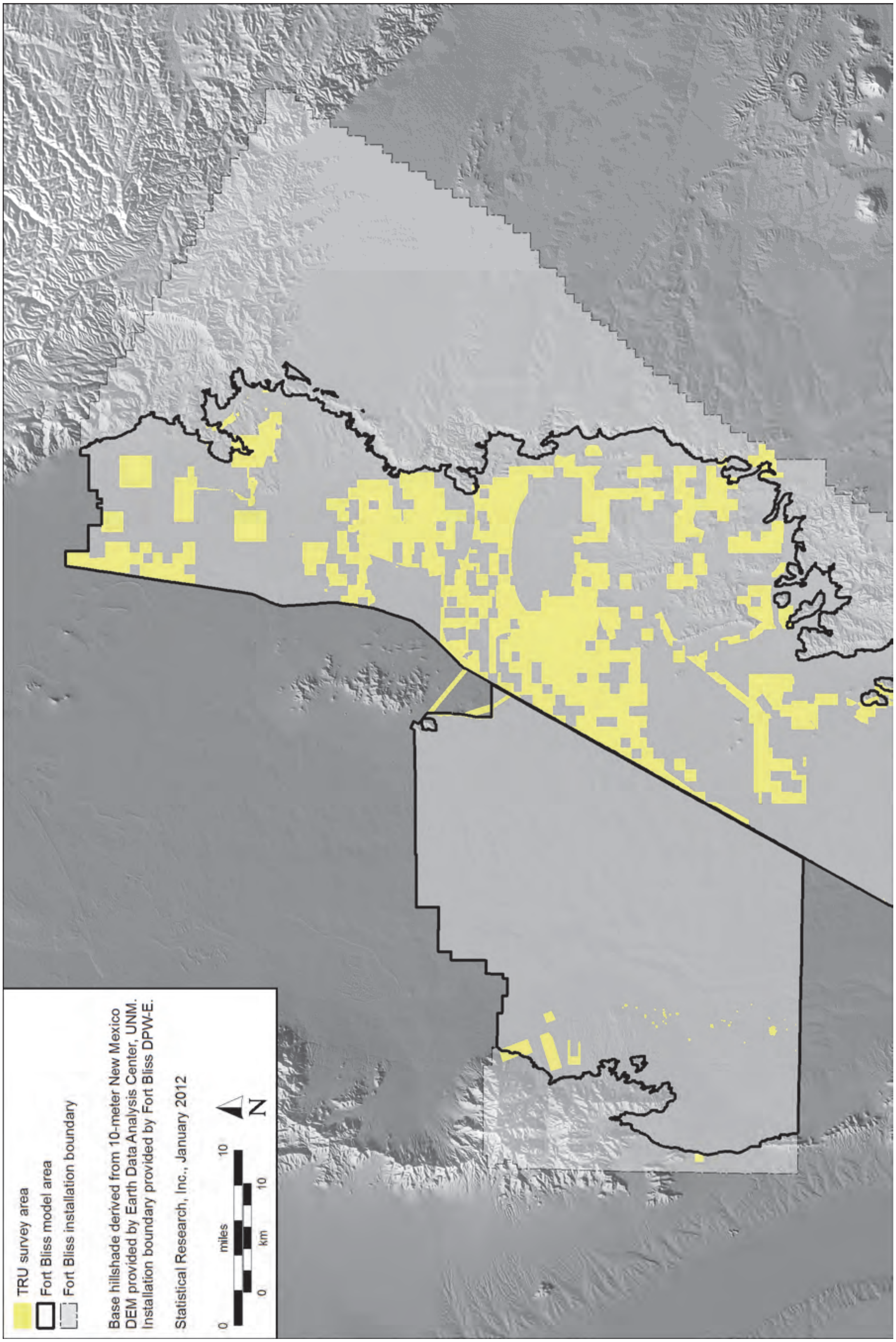

Figure 3.5. The location of TRU survey areas used to derive samples for modeling.

and density or containing features were used in modeling. Because cells with high artifact density and diversity or features tended to converge, in many cases, on areas encompassed by large sites, this ultimately suggested that use of such data for the current project would be essentially equivalent to modeling large sites. Partially as a result of this, we abandoned use of the TRU cell data and switched to using sites defined by TRU survey as our observation units (n = 1,210).

The baseline model presented here was created to predict location of archaeological sites at Fort Bliss using the TRU site and survey data and was developed using a total of five predictor variables: PCA Soil Component 2, PCA Vegetation Component 1, PCA Water Component 4, PCA Topography Component 2, and path distance to least-cost paths between large sites (Figure 3.6). The TPR for the model was fair, at 0.82, indicating that around four of every five site cases were correctly predicted by the model, whereas the FPR was 0.17, indicating that around one of every six nonsite cases was predicted incorrectly as representing a site location. The AUC was 0.9, suggesting that the model was both relatively specific and sensitive in predicting site location. The OOB error estimate for the model, calculated using test samples withheld during model construction, was 16.8 percent.

One of the potential problems with using the TRU data, like so many other CRM inventory data, is that TRU survey areas are not randomly or evenly distributed across Fort Bliss within the model area. Instead, they cluster almost entirely in the eastern half of the model area and are also present near the far western edge of the project area, whereas the lower areas of the basin are devoid of TRU survey data. Much of the lower and western portion of Fort Bliss within the model area consists of areas that were surveyed prior to the inception of the TRU method, according to more-conventional survey techniques, and without the benefit of the highly accurate Global Positioning Systems used to conduct survey and record archaeological manifestations using the TRU system today. As a result, the spatial accuracy and comparability of the data is substantially less than in areas where TRU survey has been conducted.

Despite the reduced data quality of survey data from the lower basin, it was felt that using non-TRU data, at least in the western portion of the range where TRU data were largely absent (in the Northern Maneuver Area), was necessary to refine the model and could also be used, along with TRU site data not used in the original model, to test the performance of the model based solely on TRU data (Figure 3.7). The model was tested and evaluated using Gain and GOR statistics with a sample of TRU sites (n = 727) not used in model construction and an additional sample of 4,789 sites from non-TRU surveys in the Northern Maneuver Area, in the western portion of the basin.

Gain and GOR statistics indicate that the model does not perform well in predicting site location at Fort Bliss. The model had a relatively low GOR of 24.4 and a Gain of 0.39 when tested using data from the western portion of the modeling area, along with TRU data not used in constructing the model. In addition, Gain and GOR statistics were substantially different depending on whether the model was tested using data from the eastern or western portions of the reservation. When only data from the McGregor Range were used, in the eastern portion of the Fort Bliss modeling area from which most TRU data were derived, the GOR statistic was calculated as 35.9, and the Gain statistic was calculated as 0.53. By contrast, when only data from the western portion of the Fort Bliss modeling area were used to test model performance, performance was worse than the overall model; the GOR statistic was calculated as 20.5, and the Gain statistic was calculated as 0.33, indicating that the model performs worst in areas of Fort Bliss where CRM data was not used in developing the model.

Comparison of the Baseline Model to a Previous Site Locational Model for the McGregor Range

It is worth noting that the baseline Fort Bliss locational model developed for this project model does represent some improvement over the previous favorability model developed by ERDC-CERL to predict site location on the McGregor Range. One of the models evaluated by Legacy Project No. 01-167 (see Chapter 1) was developed by the ERDC-CERL for predicting archaeological site location at Fort Bliss within the 700,000-acre McGregor Range in the Tularosa Basin (Zeidler et al. 2002). The model was developed

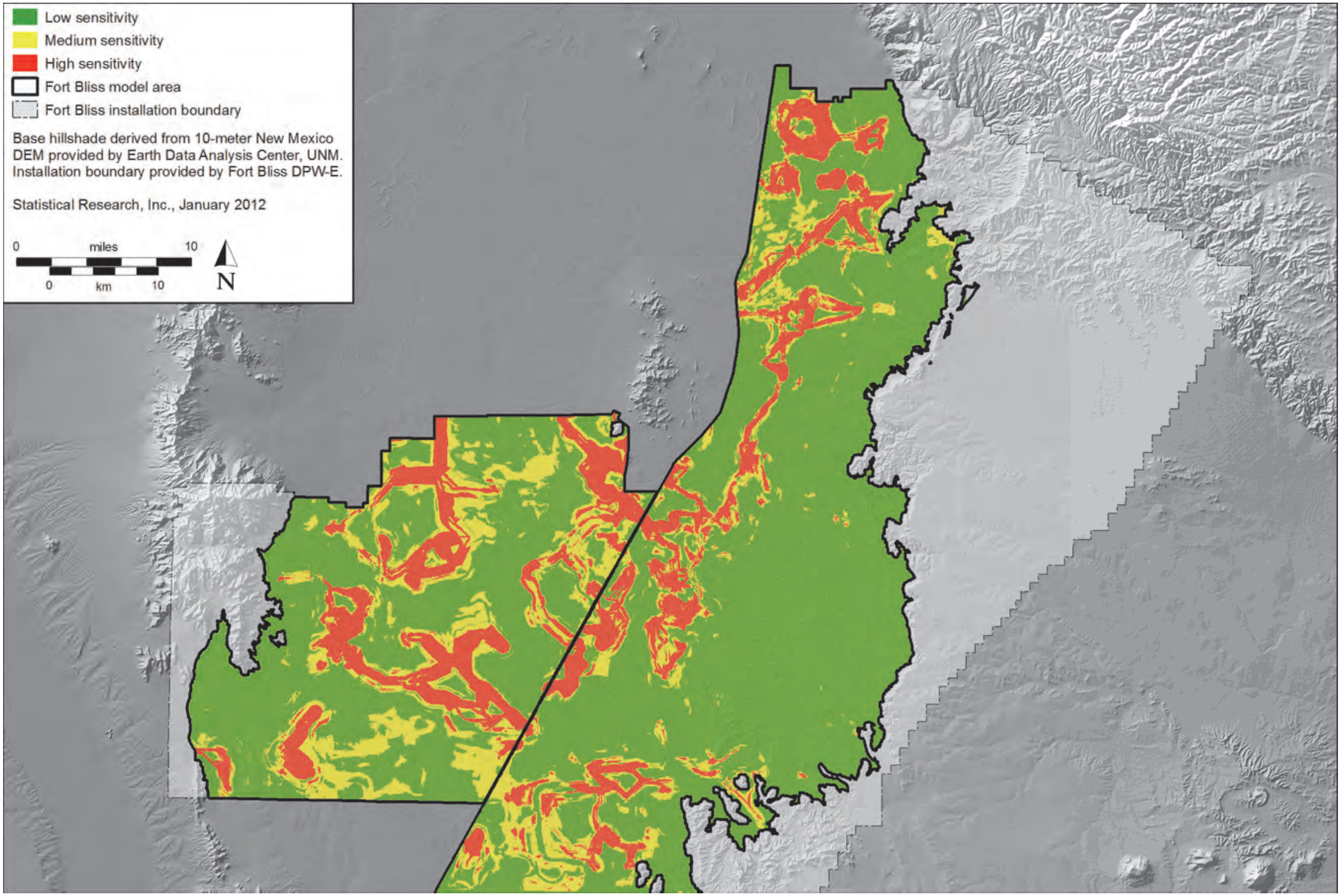

Figure 3.6. Sensitivity map of the baseline model on Fort Bliss, developed using only TRU survey data.

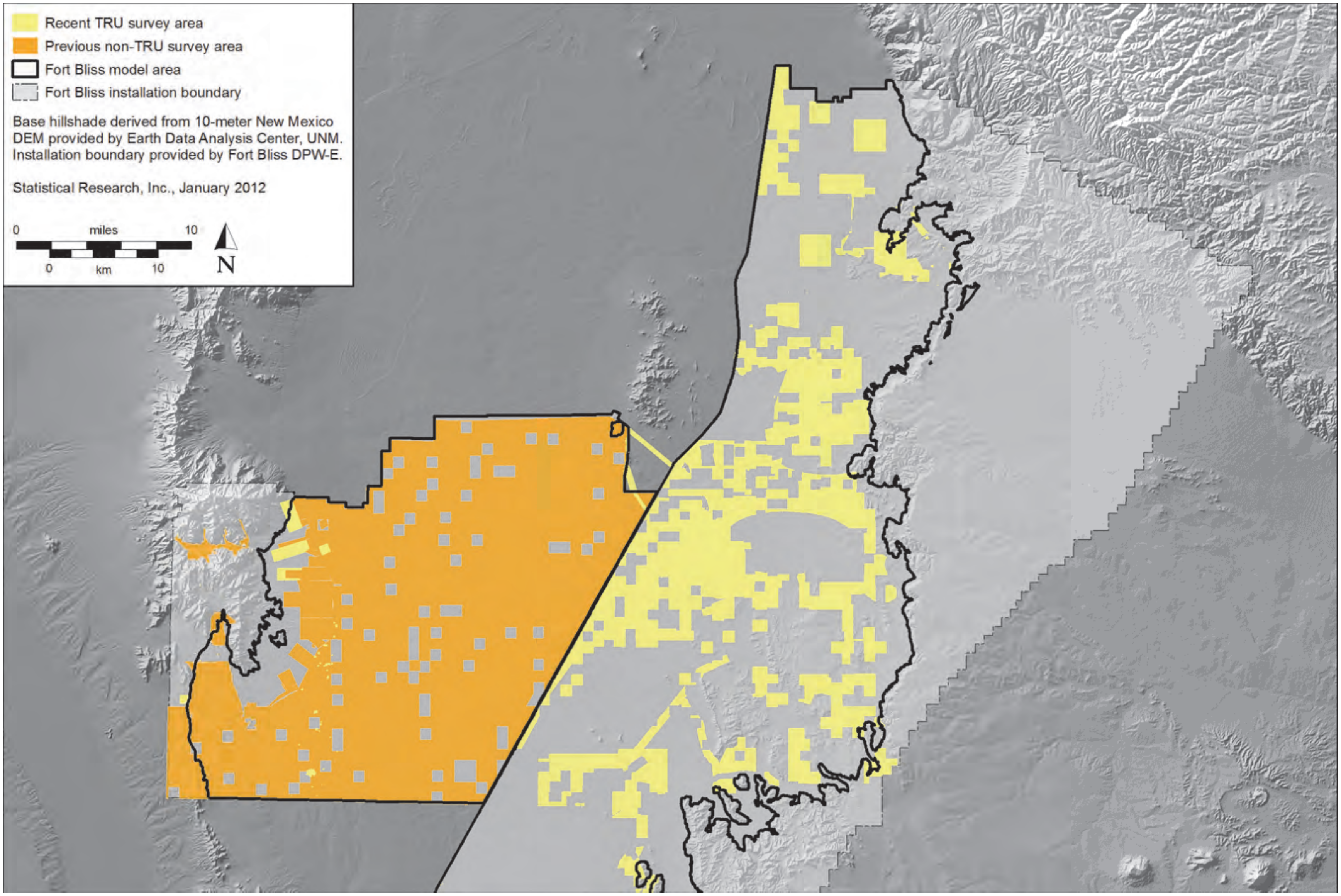

Figure 3.7. The location of TRU survey areas and previous survey areas in the Northern Maneuver Area used to derive samples for modeling.

by classifying environmental variables (elevation, slope, aspect, distance from streams, distance from playas, geomorphic features, soils, soil-moisture indexes, and vegetation) as favorable, unfavorable, or neutral using associational statistics that established the covariance between archaeological site location and environmental variables. Environmental layers classified according to low, neutral, or high favorability for site location were then intersected in order to predict the locations of sites classified as limited-activity, extended-activity, and rockshelter sites. Multiple sensitivity maps dividing the McGregor Range into six favorability classes were ultimately created by the project: an all-sites model; a limited-activity-sites model, and an extended-activity-sites model map that predicted archaeological site location using the environmental variables of elevation, slope, aspect, landform type, and soil type; and a rockshelter-sites model that predicted archaeological site location using elevation, slope, aspect, landform type, and distance to water (Altschul et al. 2004; Zeidler et al. 2002).

Subsequent evaluation of the McGregor Range model showed that it worked best in predicting sites in high-sensitivity zones, essentially neutral (performing close to a random model) in predicting site location in medium-sensitivity zones, and somewhat better than random in predicting the absence of archaeological sites in low-sensitivity zones (Altschul et al. 2004). Problems that were noted with the model included "the lack of site boundaries [to represent sites], reliance on the intersection method, and correspondingly, the lack of more rigorous analytical modeling procedures, such as regression-based modeling techniques" (Altschul et al. 2004:31). To improve the model, it was recommended that more comprehensive site boundary data be developed (as site locations were represented by site datums), that sensitivity zones be collapsed into a smaller and more manageable number of categories, that more site attribute data be used to inform the model, and that more-rigorous, multivariate statistical techniques be used to refine the model.

The McGregor Range model (Zeidler et al. 2002) was tested during Legacy Project No. 01-167 using a statistic related to the Gain statistic referred to as the Sensitivity Score (Altschul et al. 2004). The Sensitivity Score was defined as the proportion of surveyed space per sensitivity zone divided by the proportion of site area per sensitivity zone. Calculation of the Sensitivity Score suggested that the model constrained a substantial amount of site area within a relatively small area of high sensitivity. However, the results were not as promising after the values used in calculating the Sensitivity Score were converted to Gain and GOR statistics and used to estimate the overall performance of the model. Unlike the manner in which data are derived for calculating Gain and GOR statistics, the data presented in Altschul et al. 2004 were not derived from a random sample of sites and survey areas. Instead, they were derived by intersecting site polygons and survey polygons with the model classed according to sensitivity zones in order to derive the proportion of survey area falling within low-, medium-, and high-sensitivity zones and the proportion of site area falling within low-, medium-, and high-sensitivity zones. Despite this difference in how the data were derived, the relative proportions of site area and survey area in each sensitivity zone should roughly approximate a random sample of sites and survey areas, especially if a large random sample were used.

When the proportions used to calculate the Sensitivity Score are instead used to calculate Gain and GOR statistics, the results indicate that the earlier model had substantially less predictive capacity than the current baseline model developed using only TRU data (Table 3.1). This is likely because the earlier model relied on less-accurate and less-detailed site locational data, as well as on an intersection method rather than multivariate statistical analysis. When medium- and high-sensitivity zones are combined in making the calculation, the Gain statistic for the earlier McGregor Range model was only 0.11, indicating very low predictive capacity, whereas the GOR statistic was just 9.9, indicating almost no gain over a random model. This is because although 87.5 percent of site area was found within medium and high-sensitivity zones, these zones composed nearly 77.6 percent of surveyed areas. The Gain statistic for the high-sensitivity zone alone was fairly high, at 0.81, in large part because a relatively large percentage of site area (16.2 percent) fell within the high-sensitivity zone in comparison to the very small percentage of high sensitivity located within surveyed areas (3.0 percent). Although producing a high Gain statistic, these percentages alone are quite small relative to the overall distribution of sites and survey areas with

Table 3.1. Performance Metrics of the McGregor Range Model (Zeidler et al. 2002)

Sensitivity Zone	Survey Area (m^2)	Site Area (m^2)	S	Gain	GOR
Low	115,434	1,838	1.79	–0.79	–9.9
Medium	385,373	10,526	1.05	–0.05	–3.3
High	15,805	2,393	0.19	0.81	13.2
Total	516,612	14,757	1.00		
Medium and high combined	401,178	12,919	0.89	0.11	9.9

Key: GOR = Gain over Random; S = Sensitivity Score.

respect to the model, and hence, the GOR statistic for the high-sensitivity zone alone was only 13.2, suggesting that the prior model worked little better than a random model.

In summary, Gain and GOR statistics indicate that using the TRU data alone to develop a predictive model of site location for Fort Bliss resulted in a model that does not perform exceptionally well, but they do represent an improvement over an earlier model that did not have the benefit of using these data. Moreover, the model works best when applied to that portion of the range from which most samples were derived and performs less well for other areas. It is worth noting that, because the main goal of the locational modeling portion of the project was to develop a locational model for WSMR using a combination of Fort Bliss and WSMR CRM data, variables that would likely have performed best in predicting site location (i.e., variables derived from fine-grained and detailed soils and geomorphic data) were not used in developing the model, because those variables could not be usefully applied in developing a locational model for WSMR. Had those more-refined variables been used to develop a model for Fort Bliss, the resulting model would likely have performed better. At the same time, using a larger and more representative sample of CRM data from Fort Bliss alone does result in models that perform better, as will be discussed in the following section.

Refined Fort Bliss Locational Model

The second task of the project involved evaluating the performance of the baseline model using a sample of data not used in constructing the model, as was discussed above, and then using the additional sample data to refine the model. The additional data that were used to evaluate and refine the model consisted of CRM data from the Northern Maneuver Area located immediately to the west of the McGregor Range. The data from the Northern Maneuver Area are known to have spatial accuracy problems and were less consistently recorded than the later TRU data have been recorded, but they do at least cover a large area of the lower basin that is not represented well by the TRU data.

In evaluating the model's performance, it became apparent that the location of large sites tended to be predicted better than small sites. Large sites, for instance, could be predicted using the larger data set by a model with a Gain calculated as 0.66 and a GOR of 55.8, representing a substantial improvement over models developed using only TRU data and all sites combined. This is not surprising, as large sites in general "tend to be more patterned than smaller sites, which as a group are functionally more variable" (Kvamme 1985, 1988:384). At Fort Bliss, small sites are widely distributed across much of the reservation at relatively high densities, whereas large sites are more clustered in their distribution, making their location easier to predict.

In an attempt to create a locational model that represented small sites better, a cluster analysis was performed on small sites according to environmental variables, resulting in a series of four arbitrary classes of small sites classed according to their environmental associations. Separate models were then developed for each of the arbitrary small-site classes as well as for large sites. The individual models for small sites are not particularly useful in and of themselves, because high- and medium-sensitivity zones tended to converge on the geographic areas corresponding to each of the arbitrary small-site classes. To combine the models into a single locational model, the maximum probability for site location was calculated per raster cell using each of the underlying models of large sites and small-site classes. Combining the models of large sites and small-site classes resulted in a model that performed somewhat better than the original baseline model but not markedly so. The combined model for large sites and small-site classes resulted in a small increase in GOR, from 33 to 38, and a small increase in Gain from 0.39 to 0.45.

Evaluation of the distribution of small sites using TRU data suggested, in particular, that further separating out small sites according to archaeological attributes (such as artifact and feature classes and diversity) could potentially result in better prediction of the location of small sites at Fort Bliss. We did not focus extensively on such an effort, however, because evaluation of WSMR CRM data suggested that we would likely not have the appropriate data to develop a similar model for WSMR using a combination of Fort Bliss and WSMR CRM data.

Instead, we developed an alternative refined model that is directly comparable to the original baseline model in that it was constructed using samples from sites regardless of site type (Figure 3.8). Thus, the model could be used to demonstrate the result of including additional data that cover a larger area and a greater diversity of environmental contexts, albeit one characterized by reduced spatial accuracy for site locations and less consistent techniques for discovering and recording archaeological sites. The model was developed using the following variables: Euclidean distance to streamlines, Soil PCA Component 1, Vegetation PCA Components 1 and 3, Water PCA Components 1 and 4, Topography PCA Component 2, path distance to paths between large prehistoric sites, and cost distance to uplands.

In comparison to the initial baseline model, this alternative refined model (developed using samples from sites regardless of type or size and data from TRU survey and earlier data from the Northern Maneuver Area) had a slightly higher TPR of 0.84 (increased from 0.83), but it also had a higher FPR of 0.19 (increased from 0.17) than the original baseline model. The OOB error also increased slightly from 16.9 to 17.3, and the AUC was equivalent for both models, being equal to 0.90. These metrics indicate that the sensitivity and specificity for the baseline model and the refined model are roughly similar.

However, owing to the more geographically representative data set used to generate the model, the Gain and GOR statistics showed marked improvement over the baseline model. The Gain statistic increased from 0.39 to 0.51 for the refined model, indicating a modest but substantial increase in predictive capacity. In addition, the GOR statistic nearly doubled, increasing from 24.4 to 46.5. In the original baseline model, random samples from surveyed areas resulted in approximately 63 percent of sites falling within medium- and high-sensitivity zones, which together constituted 37 percent of surveyed areas. By contrast, in the refined model, random samples from surveyed areas resulted in 92 percent of sites falling within medium- and high- sensitivity zones, which together constituted 45 percent of surveyed area.

The Feasibility of Adapting the Fort Bliss Locational Model to WSMR

Evaluation of the feasibility of adapting the Fort Bliss locational model to WSMR began very early on in the project. As discussed earlier in this chapter, consultation with stakeholders in the project during the kickoff meeting resulted in the decision to limit the modeling area within WSMR to the Tularosa Basin and to not attempt to apply the model to mountainous areas or to areas outside the basin. Feasibility considerations also played a major role in the definition of variables for modeling. As discussed above, predictor variables needed to be consistently defined across both Fort Bliss and WSMR in order to develop a model using data from either Fort Bliss or both reservations. Given disparities in the environmental data available for the two reservations, we had to use environmental data for developing predictor variables that were in many cases more-coarsely defined than data available for Fort Bliss, a condition that ultimately restricted the kinds of variables we were able to use in modeling. This situation undoubtedly reduced to some extent the potential for developing strong locational models for Fort Bliss as well as reduced the possibilities for extending a model from Fort Bliss to WSMR using the available environmental data for both reservations.

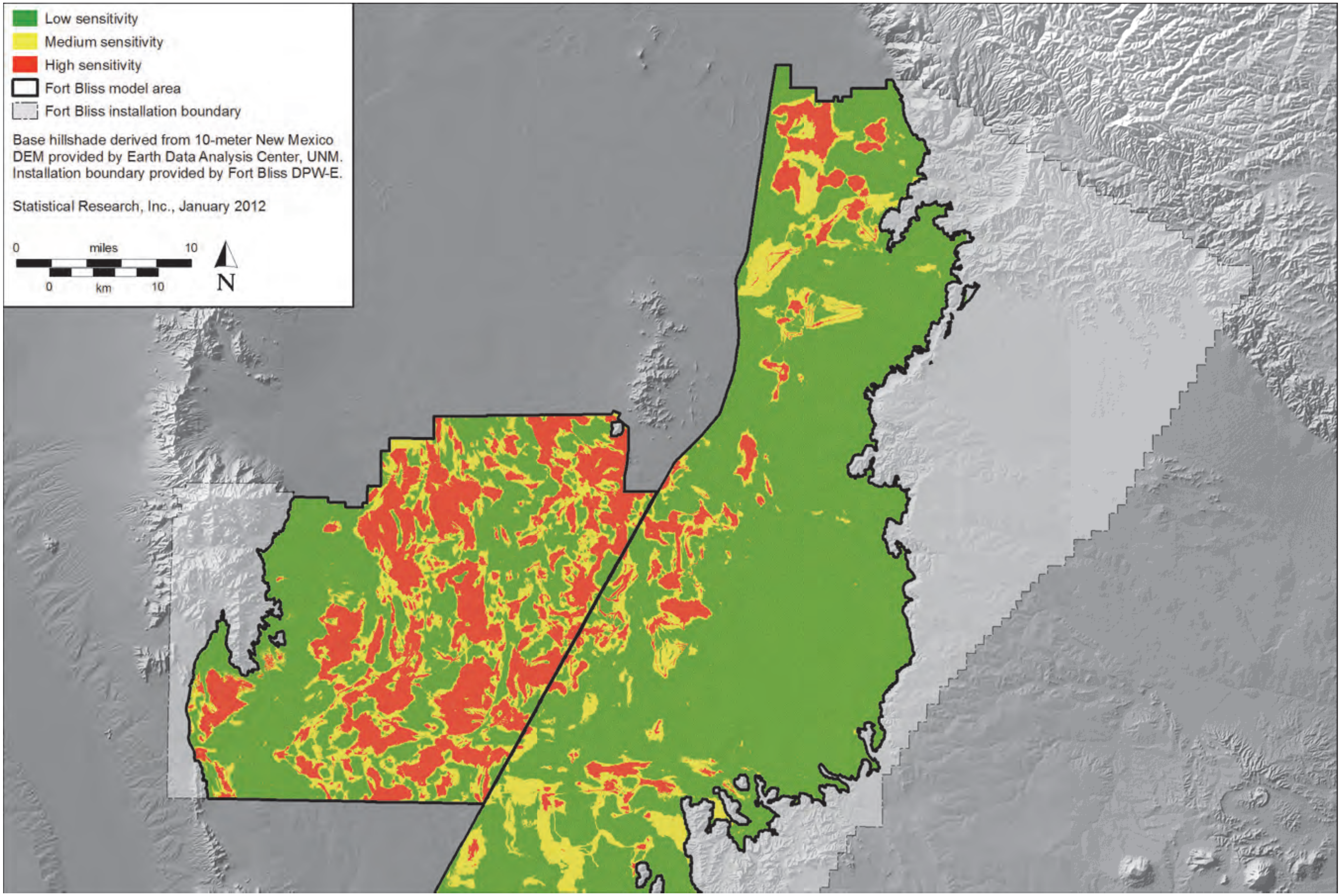

Figure 3.8. Sensitivity map of the baseline model on Fort Bliss, developed using a combination of TRU survey data and previous survey data.

Feasibility evaluations showed that, when projected onto the WSMR modeling area, many models that we experimented with resulted in high-sensitivity zones that were concentrated either in the northeastern or southern portion of the WSMR modeling area; the intervening space was modeled as low sensitivity. In addition, medium- or high-sensitivity zones consisted of relatively small areas, suggesting that there were few areas that were similar environmentally between the two installations. It was suspected that this pattern was related to how the independent variables were distributed across the installation, rather than actual differences in archaeological sensitivity.

To test for this possibility, we used a tool available in the Geospatial Marine Ecology toolbox (Roberts et al. 2010) that allows the user to identify where in a modeling area the values of predictor variables fall outside the range of the values used in creating the model. The tool is intended to allow users to identify areas within a modeling area where a model cannot justifiably be applied because of an absence of positive or negative cases from similar environmental contexts. We used this tool to run a hypothetical model using all of the predictor variables as input and all of the sample sites at Fort Bliss used in creating the refined model and then applied the resulting model to the WSMR and Fort Bliss modeling areas. Indeed, the result indicated that approximately 75 percent of the WSMR modeling area fell outside the range of values of environmental samples derived using the Fort Bliss CRM data (Figure 3.9).

We thus experimented with developing a series of models that used a restricted set of variables that were more similarly distributed at both Fort Bliss and WSMR to determine if using only those variables would have more promise in predicting site location at WSMR using Fort Bliss data. Unfortunately, although these models could still predict site location at Fort Bliss moderately well and tended to result in additional areas of WSMR being identified as medium or high sensitivity for archaeological sites, they tended to incorrectly place a large proportion of sites in low-sensitivity areas. Not surprisingly, site location could be predicted somewhat better in the southern portion of WSMR in areas relatively close to Fort Bliss. However, overall, the implication of these results suggested that a model developed using strictly Fort Bliss data would not be successful in predicting site location at WSMR. Thus, it was concluded that a reliable model of archaeological site location could only be developed for WSMR if WSMR CRM data were included as training data for developing a locational model.

WSMR CRM Data

A key aspect of using WSMR CRM data to develop and test a model of archaeological site location is the distribution of site and survey areas and the availability of associated attribute data. Survey areas within the WSMR portion of the modeling area are concentrated in the southern portion of the range, consisting mostly of an extensive array of large and contiguous block surveys (Figure 3.10). Comparatively small linear, quadrat, block, and circular survey areas are widely distributed across the remainder of the modeling area, providing at least some coverage in the other portions of the modeling area within WSMR. Together, survey areas recorded within the WSMR portion of the modeling area total approximately 165,000 acres, or approximately 14 percent of the modeling area, with one-third of surveyed area being concentrated in the area south of I-70 in the southeastern corner of the range.

The analysis discussed above to determine how much of the modeling area falls within the range of predictor variables for Fort Bliss was performed using a combination of data from WSMR and Fort Bliss survey areas. The results indicated that adding WSMR CRM drastically reduced the size of areas within the WSMR modeling area that fall outside of range of predictor variable samples. Whereas using only Fort Bliss data showed that 75 percent of the WSMR modeling area was outside the range of predictor variable states, approximately 5 percent of the modeling area fell outside the range of predictor variable states when WSMR data were included in the analysis. This suggests that the WSMR CRM data are much more applicable to modeling site location at WSMR than the Fort Bliss data alone.

However, a relatively strong bias in the available data is the distribution of recorded sites and the attribute data associated with those sites. Although comprising only one-third of surveyed area within the modeling area, the area south of I-70 contains approximately 90 percent of recorded sites. Although this

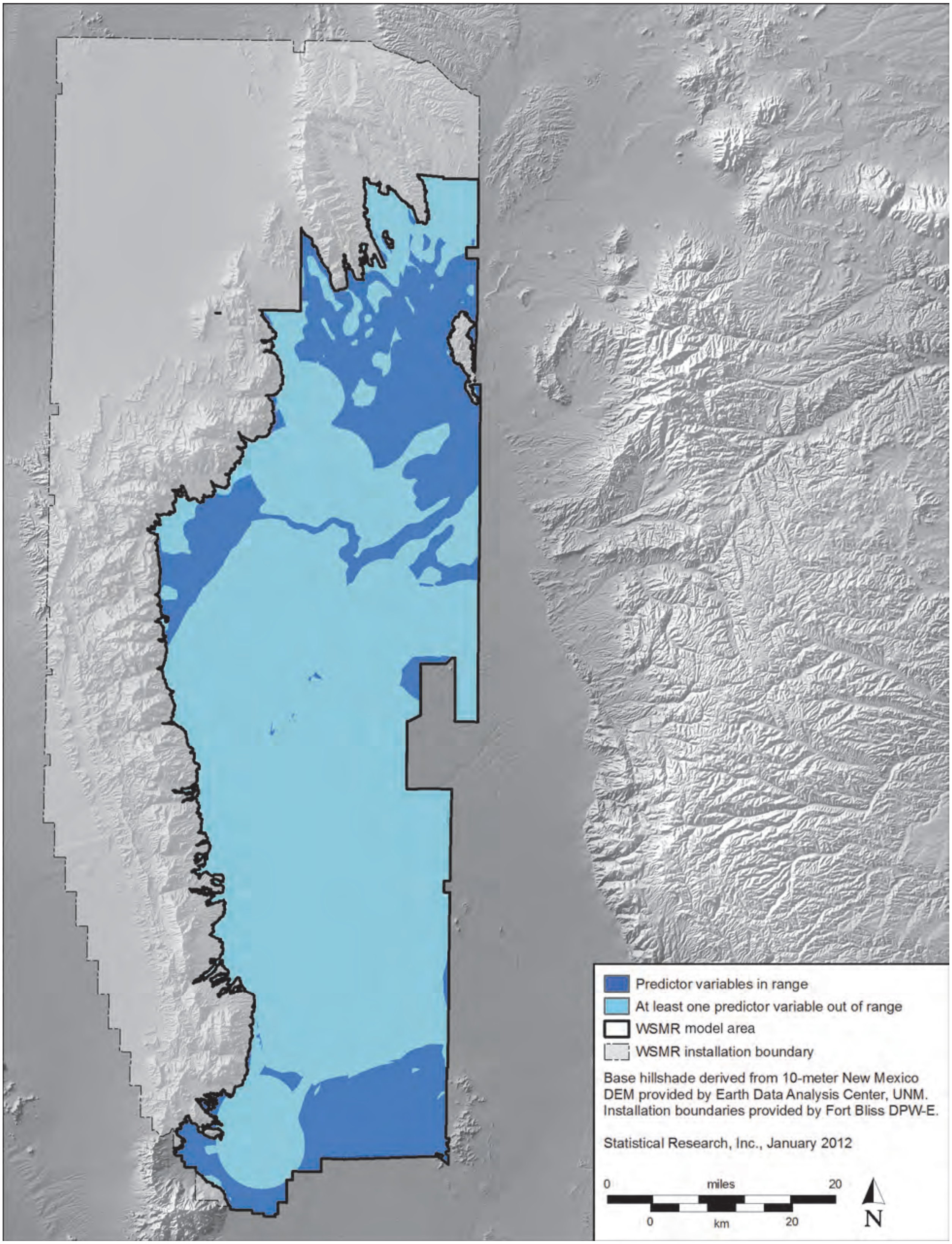

Figure 3.9. Portions of the WSMR modeling area that fell outside the range of values of environmental samples derived using the Fort Bliss CRM data.

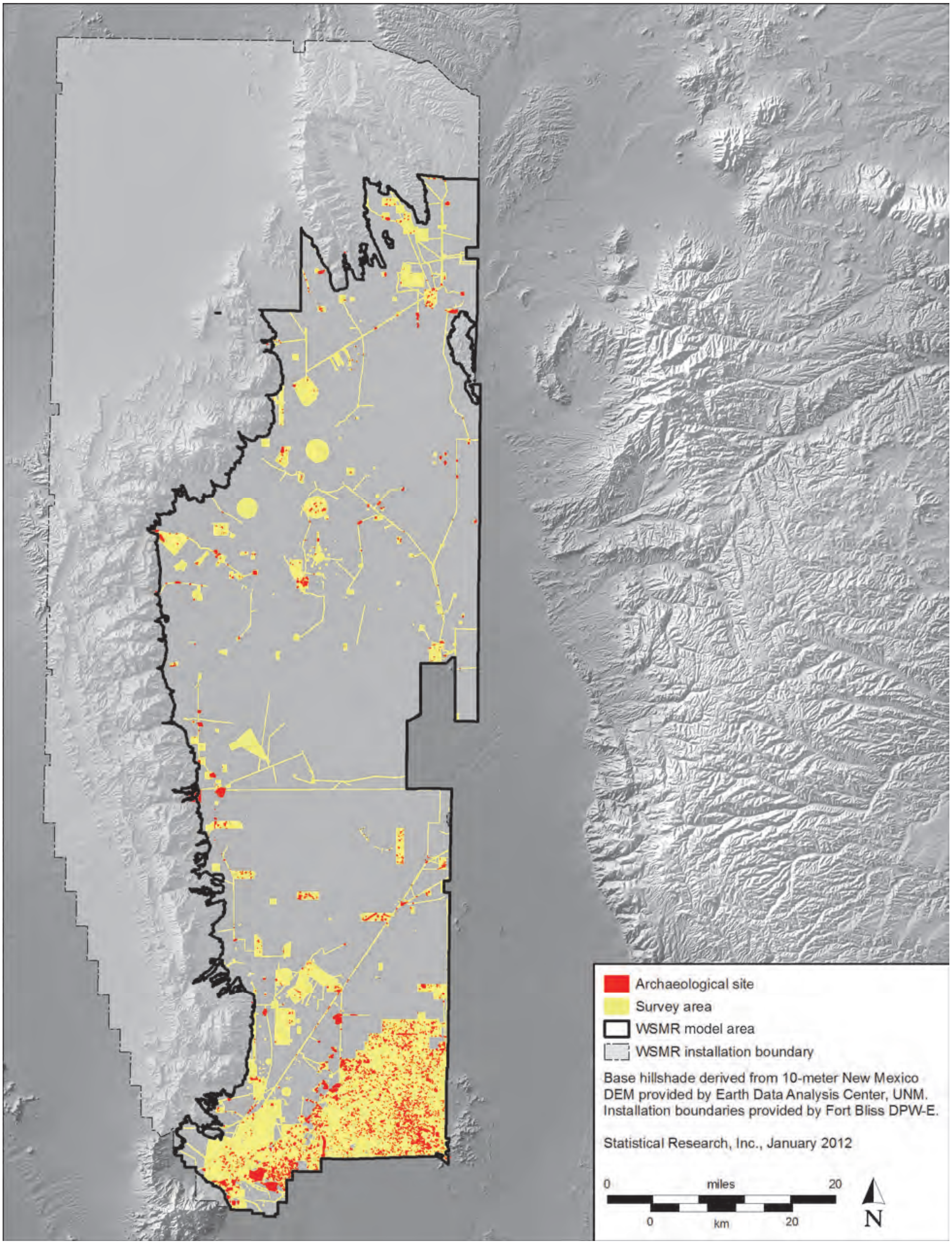

Figure 3.10. The distribution of WSMR CRM data within the modeling area.

disparity in site density could certainly result from actual differences in site distribution between this area and other portions of the range, differences in site definition criteria, as well as in the completeness of the data set for different portions of the range, could also explain some of this disparity.

Moreover, most of the sites at WSMR with associated component type information are located in the area south of I-70, whereas many sites in other portions of the WSMR modeling area lack information that could be used to define sites according to type. Sites within the area south of I-70 with associated attribute data are also unevenly distributed, a situation that appears to relate to site attribute data not having yet been entered into either the WSMR or NMCRIS CRM database for many surveys, including those within the area south of I-70.

To develop a more comprehensive sample of sites that could be classed according to type, we used NMCRIS data to augment the WSMR CRM data. To do this, we merged NMCRIS and WSMR CRM data to develop a more comprehensive CRM data set for the modeling area and eliminated any sites or survey areas that were redundant between the two data sets. Although NMCRIS site polygons are often circular or elliptical in shape and are generated using the maximum dimensions of a site, the site polygons in the WSMR data set appear to have more-precisely defined boundaries. Therefore, WSMR site polygons were retained in place of NMCRIS site polygons when a site polygon for the same site was present in both databases. Adding the NMCRIS data resulted in a modest increase in the number sites in the modeling area (3,214 to 3,462 sites, or an additional 248 sites). Fortunately, most of the NMCRIS sites (72 percent) that were added to the WSMR data set were located outside the area south of I-70 and helped to provide additional information on sites in other portions of the range.

Site component data were also augmented using the NMCRIS data. As with sites in the WSMR CRM database, many of the additional NMCRIS sites lacked data that could be used to assign sites to either the historical period or periods within the prehistoric sequence. Adding component information from NMCRIS resulted in an additional 93 sites that could be assigned to the historical period, one or more prehistoric periods, or both. Fortunately, many of these sites are located in areas where similar site components were not recorded in the WSMR CRM data set and, although relatively few in number, the additional sites with component data provided supplementary information as to where sites of specific types are located across the range.

Site Types

One of the main aspects of adapting a Fort Bliss locational model to WSMR was to use WSMR CRM data to refine the model by developing a comprehensive group of site types and to use those data to refine the model for WSMR. At the kickoff meeting, it was decided that it would be useful for site types to focus on major temporal periods of the prehistoric sequence (Paleoindian, Archaic, Early Formative, and Late Formative) and differentiate between residential and nonresidential site functions for Formative period sites. Although the focus of discussion was prehistoric sites, some meeting participants suggested that it would also be helpful to model the location of historical-period sites.

SRI reviewed the Fort Bliss and WSMR CRM databases to determine how site types could be derived. Both databases are similar in their construction and in the data categories present, in part owing to institutional overlap in CRM staffing at the two installations. The Fort Bliss CRM database, however, contains more data categories, with entries present for relevant fields for most sites. By contrast, the WSMR database contains fewer fields actually populated with data, thus reducing the potential of the database for identifying sites according to type or other relevant attributes. We had hoped to use artifact and feature types, counts, and diversity to aid in identifying potential residential components, as well as other possible site functions, but these kinds of data were unevenly populated, nonspecific, or absent in the CRM databases. After discussion with Fort Bliss and WSMR staff, it was decided that, other than using ceramic presence/absence data to identifying temporal components for Formative period sites, refining site types with additional artifact and feature information would not be pursued.

How to define site types for the project was later revisited in a meeting with WSMR staff to ensure that the suggested site types remained relevant to WSMR's management needs and to discuss the schemes that would be used to assign site types using available site attribute data. It was agreed that the site types discussed earlier in the project remained relevant and that the following site types would be used for modeling purposes:

- Paleoindian
- Archaic
- Early Formative Nonresidential
- Early Formative Residential
- Late Formative Nonresidential
- Late Formative Residential
- Historical period

Based on review of the information available in CRM databases and discussions with WSMR staff, sites were defined using the following criteria. Sites with Formative period components were grouped into Early and Late Formative periods based on phase designations made by investigators, ceramic types, or both. Site components identified as having a Mesilla phase component were identified as Early Formative period components, and site components identified as having an El Paso phase component were identified as Late Formative period components.

The decision to not include Middle Formative period (or Doña Ana phase) sites as a category was arrived at because the number of Doña Ana phase sites was small in both the WSMR and Fort Bliss data sets and because the validity of the Doña Ana phase site identifications in the Tularosa Basin is unclear. Doña Ana phase sites have traditionally been identified based on the relative frequencies of ceramic types from earlier and later time periods. It is thus quite difficult to identify whether a site is a Doña Ana phase site or a multicomponent site that was reused multiple times during the Formative period. In addition, artifact counts within the available CRM databases for specific ceramic types were largely unavailable, so establishing the relative frequencies of ceramic types was not feasible.

Owing to these considerations, Doña Ana phase components were assigned to Early or Late Formative periods based on the ceramic types present. Similarly, sites that were identified simply as Formative period in the database were assigned to Early or Late Formative period components based on the ceramic types present.

The scheme for identifying sites as Early or Late Formative was as follows. If Mimbres ceramic types or El Paso brownware ceramic types were present and no later ceramic types were present, then the component was assigned to the Early Formative period. If nonlocal ceramic types other than Mimbres ceramic types were present or if El Paso Polychrome ceramic artifacts were present, then the component was assigned to the Late Formative period. Sites with components dating to other periods could be readily identified using component type information indicating their use during the Paleoindian, Archaic, or historical periods. Formative period sites were identified as having a residential function if the site had burials, large stains, exposed walls, or middens, which are categories of feature types available in the CRM data.

Using the above methods for defining site types, we were able to develop a sample of sites for both Fort Bliss and WSMR that could be used to model site location according to type (Table 3.2). For WSMR, we were able to identify 998 sites out of a total of 3,462 sites within the modeling area that could be assigned to one or more of the above site types, all of which were located within recorded survey boundaries. Of 8,043 sites within the Fort Bliss modeling area, 2,575 could be assigned to specific site types; 1,745 were located within survey areas from which site and nonsite samples were drawn.

Interestingly, the numerical distribution of site types is distinctively different between Fort Bliss and WSMR for a number of site types. Late Formative Residential and Nonresidential sites are found at Fort Bliss in relative frequencies more than twice as often as they do at WSMR, as do historical-period sites. Paleoindian and Early Formative Residential sites are also substantially more common in terms of relative frequency at Fort Bliss than at WSMR. By contrast, Early Formative Nonresidential sites, many of which

Table 3.2. Distribution of Site Type Components from Site Samples Used in Modeling Site Type Location on Fort Bliss and WSMR

Site Type	Fort Bliss Site Type Sample	WSMR Site Type Sample
Paleoindian	54	22
Archaic	440	237
Early Formative Nonresidential	183	569
Early Formative Residential	350	115
Late Formative Nonresidential	688	155
Late Formative Residential	205	55
Historical period	165	45

Note: An individual site type can be counted in multiple rows if more than one component was present.
Key: WSMR = White Sands Missile Range.

are located in the area south of I-70, were found (in relative frequency) at WSMR five times more often than at Fort Bliss. Only Archaic sites are found in similar relative frequencies on the two installations.

Some of this patterning likely has to do with biases in which sites have been attributed with component and artifact information in the CRM databases for the two installations. On the other hand, some of the patterning may have to do with substantial differences between the two reservations in how land was used in the past. However, if we remove Early Formative period nonresidential sites from consideration, which appear to be the major anomaly in site component numbers between the two installations and compare the relative numbers of site types between the installations, differences between the two installations become much less dramatic. With Early Formative Nonresidential sites removed from consideration, the relative frequencies of site components are quite similar for most site types, with the exception of Paleoindian and Archaic sites, which then appear to be relatively more common at WSMR in comparison to Fort Bliss. The implication is that there are an unusually large number of Early Formative period nonresidential sites at WSMR and that Paleoindian and Archaic period sites could possibly be more common at WSMR relative to other site types, in comparison to Fort Bliss.

Models of Site Type Location at Fort Bliss and WSMR

The final component of the locational modeling effort for the project was to use the site type data discussed above to refine and evaluate a locational model for WSMR, using a combination of Fort Bliss and WSMR CRM data. Given the problems experienced with projecting models developed using Fort Bliss CRM data onto WSMR as well as differences between the two installations in the distribution of component types, we felt it would be useful to first develop a series of site type models using only the Fort Bliss data and to compare how well those models work when tested for both Fort Bliss and WSMR. This was followed by the development of another series of site type locational models that were constructed using site and nonsite samples drawn from both Fort Bliss and WSMR and drawing from the larger set of variables (Appendix A). This process allowed us to assess how well the models would work if one were to use only Fort Bliss CRM data vs. using a larger data set from both reservations and a wider range of applicable predictor variables.

For each site type, we first developed a model using only the Fort Bliss data and the predictor variables that were most similar in their distribution between the two installations. To ensure consistency in comparing the performance of the different models and to simplify their interpretation, the models were classed according to high- and low-sensitivity zones, rather than low-, medium-, and high-sensitivity zones. The cutoff for defining high- and low-sensitivity zones was established by using the threshold probability value at which sensitivity equaled specificity for each of the models, a value that is supplied by ModelMap using a model optimization routine. This value, where sensitivity equals specificity, is considered to be the optimal cutoff point above which site presence is increasingly probable and thus permits a rigid comparison of the performance of each model.

Performing this exercise revealed that locational models of individual site types perform much better than models that lump all sites together. The TPR, FPR, OOB error, and AUC for these models are broadly similar to models developed for Fort Bliss using all sites, without respect to type (Table 3.3). Overall, these models have a similar level of sensitivity and specificity in comparison to all-sites models, but they are much more closely tied to the factors affecting the location of individual site types. When mapped on the ground, they show a much higher propensity than all-sites models to accurately predict the location of a site of a given type.

The Gain and GOR statistics indicate that models of individual site types have a much higher predictive capacity than all-sites models and perform substantially better than other models in predicting the location of specific site types (Table 3.4). Of the site type models, models that predict Early or Late Formative period residential site location perform best. As these site types involve more regular and concentrated use of the landscape than other sites that may have been more functionally diverse, this is not surprising. This kind of information is very useful, however, because residential sites are often highly significant resources that are important to understanding many issues in prehistory. Moreover, because these kinds of sites can be very costly to mitigate if accidentally discovered and can disrupt mission activities, it can be especially important to understand during planning activities where residential sites are expected.

Site Type Model Constructed Using Only Fort Bliss CRM Data

None of the site type models developed using only Fort Bliss CRM data perform as well when extended to WSMR as they do for Fort Bliss alone (see Tables 3.3 and 3.4). Some of them still perform moderately well at WSMR—notably, the Archaic, Late Formative Residential, and Late Formative Nonresidential site type models—but not as well as they do for Fort Bliss. The Gain and GOR statistics decrease for all these site type models when applied to WSMR. GOR decreases between Fort Bliss and WSMR by a minimum of 11 percent for Late Formative Nonresidential sites and decreases by much larger percentages for other site types. For two of the site type models—Paleoindian and historical period—GOR decreases from relatively high values above 60 to negative values, indicating models that actually work worse than a random model when applied to WSMR. The Gain statistic also decreases dramatically for these models to values near or below zero. Similarly, Gain and GOR statistics decreases substantially for the Early Formative Nonresidential site type model developed using only Fort Bliss data. Clearly, although some of the site type models are somewhat reliable when applied to WSMR, they perform less well than they do for Fort Bliss, and several of the models perform quite poorly.

Site Type Locational Models Developed Using both Fort Bliss and WSMR CRM Data

By contrast, locational models of individual site types perform substantially better when they are constructed using a combination of Fort Bliss and WSMR CRM data (Tables 3.5 and 3.6). The TPR, FPR, OOB error, and AUC for the models constructed using a combination of Fort Bliss and WSMR CRM data are similar to those for models constructed using Fort Bliss CRM data only. There are some differences, however. The AUC increased for Paleoindian, Early Formative Nonresidential, and historical-period sites as the FPR decreased, suggesting that the models are more specific in predicting where sites are not likely to be located in comparison to models created using only Fort Bliss CRM data. By contrast, the AUC decreased by a similar margin for the remaining three site types, and for Early Formative Residential and Late Formative Residential sites, the FPR increased, suggesting that these models became somewhat less

Table 3.3. Standard Model Statistics for Site Type Models Developed Using Only Fort Bliss CRM Data

Site Type	Optimal Probability Threshold	TPR	FPR	OOB	AUC
Paleoindian	0.34	0.82	0.22	0.20	0.85
Archaic	0.50	0.85	0.21	0.18	0.90
Early Formative Nonresidential	0.50	0.79	0.25	0.23	0.85
Early Formative Residential	0.48	0.87	0.13	0.13	0.93
Late Formative Nonresidential	0.55	0.80	0.23	0.21	0.90
Late Formative Residential	0.57	0.89	0.10	0.11	0.96
Historical period	0.52	0.78	0.32	0.27	0.80

Key: AUC = Area Under the Receiver Operating Characteristic Curve; FPR = False Positive Rate; OOB = out-of-bag; TPR = True Positive Rate.

Table 3.4 Gain and GOR Statistics for Site Type Models Developed Using Only Fort Bliss CRM Data

Site Type	Fort Bliss		WSMR		Percent Change	
	GOR	Gain	GOR	Gain	GOR	Gain
Paleoindian	61.0	0.71	–6.4	–0.82	–110.5	–216.0
Archaic	57.5	0.63	42.0	0.56	–27.0	–10.5
Early Formative Nonresidential	57.6	0.61	34.4	0.52	–40.3	–14.6
Early Formative Residential	68.7	0.74	8.5	0.27	–87.6	–64.0
Late Formative Nonresidential	61.7	0.95	54.4	0.86	–11.8	–9.5
Late Formative Residential	67.6	0.85	45.4	0.62	–32.8	–27.1
Historical period	67.2	0.94	–7.6	0.14	–111.3	–85.1

Key: GOR = Gain over Random; WSMR = White Sands Missile Range.

Table 3.5. Standard Model Statistics for Site Type Models Developed Using a Combination of Fort Bliss and WSMR CRM Data

Site Type	Optimal Probability Threshold	TPR	FPR	OOB	AUC
Paleoindian	0.48	0.83	0.20	0.19	0.88
Archaic	0.51	0.82	0.17	0.18	0.90
Early Formative Nonresidential	0.50	0.83	0.18	0.17	0.87
Early Formative Residential	0.52	0.87	0.19	0.16	0.91
Late Formative Nonresidential	0.52	0.81	0.23	0.19	0.87
Late Formative Residential	0.64	0.91	0.15	0.12	0.95
Historical period	0.46	0.77	0.22	0.22	0.85

Key: AUC = Area Under the Receiver Operating Characteristic Curve; FPR = False Positive Rate; OOB = out-of-bag; TPR = True Positive Rate.

Table 3.6. Gain and GOR Statistics for Site Type Models Developed Using a Combination of Fort Bliss and WSMR CRM Data

Site Type	Fort Bliss		WSMR		Percent Change	
	GOR	Gain	GOR	Gain	GOR	Gain
Paleoindian	57.5	0.93	71.9	0.94	25.0	1.1
Archaic	57.9	0.92	74.7	0.96	29.0	4.3
Early Formative Nonresidential	55.4	0.90	58.8	0.93	6.1	3.3
Early Formative Residential	62.0	0.87	70.4	0.96	13.5	10.3
Late Formative Nonresidential	59.4	0.95	73.5	0.97	23.7	2.1
Late Formative Residential	68.0	0.86	75.9	0.82	11.6	–4.7
Historical period	61.7	0.87	72.0	0.98	16.7	12.6

Key: GOR = Gain over Random; WSMR = White Sands Missile Range.

specific than their previous iterations. Despite these differences, however, the internal statistical performance of the models was generally similar for models created with and without the benefit of WSMR CRM data.

However, when mapped out on the ground and tested with Gain and GOR statistics, the performance of site type models for WSMR was dramatically improved, whereas the performance of site type models for Fort Bliss was mostly similar or improved in comparison to models created using only Fort Bliss data. With the exception of Archaic and Late Formative Residential site models for Fort Bliss, which had almost no change in the GOR statistic, site type models developed using Fort Bliss and WSMR CRM data combined resulted in a small decrease in the GOR statistic for Fort Bliss. This suggests that for most site types, high-sensitivity areas are slightly larger proportionally than they had been for models created using Fort Bliss data alone. In comparison, the Gain statistic exhibited either little change—as in the case of Paleoindian, Archaic, and Early Formative Nonresidential sites—or increased substantially, suggesting that these site type models actually increased in their predictive capacity owing to the benefit of WSMR data.

The performance of all of the site type models developed for WSMR using a combination of Fort Bliss and WSMR CRM increased substantially. On average, the GOR statistic increased by 47 for site type models for WSMR, and the Gain statistics increased by 0.69. In other words, the performance of all the site type models for WSMR improved when a combination of Fort Bliss and WSMR data was used to develop the models. Interestingly, these site type models perform better for WSMR than they do for Fort Bliss. This might actually be due to the relative lack of data on site component information for WSMR sites. In other words, sites that could be of a certain type but are not recognized as such because of a current lack of information could potentially fall in the low-sensitivity zone, but we have no way of knowing this without component type data. Moreover, because large areas of WSMR have yet to be surveyed, it could be the case that any of the given site types are located in a wider range of environmental contexts than are represented by the models. Thus, the current site type models could work better for WSMR because the limited data artificially restricts the range of environmental contexts in which specific site types have been found. In any case, the Gain and GOR statistics suggest that site type models do have good potential for predicting site location for individual site types at WSMR when they are constructed using a combination of Fort Bliss and WSMR CRM data.

Combining Site Type Models into an All-Sites Model for WSMR

The individual site type models can be very useful in providing information on where specific site types are likely to be found, as opposed to all-sites models, which only specify where a site of any type is likely to be discovered. Thus, site type models can be useful in interpreting land-use patterns corresponding to different periods and activities (e.g., residential vs. nonresidential). Although sensitivity zones for different site type models often overlap, they are not the same. Therefore, if high-sensitivity zones are added together, a large proportion of the installation could be considered highly sensitive to archaeological sites, making it difficult to identify where on an installation sites are least likely to be found.

In order to develop a combined sensitivity model based on the predictions of the individual site type models, the maximum probability for site presence was calculated per pixel using all of the site type models developed using a combination of Fort Bliss and WSMR data. This maximum probability layer was then converted into a sensitivity map consisting of low-, medium-, and high-sensitivity zones. Upon doing so, it immediately became apparent that there was one area of WSMR in the middle portion of the area south of I-70 where large numbers of sites have been recorded but where sites were not predicted to be present by any of the site type models. Evaluation of the distribution of component types revealed that sites were not being predicted in this area because component information that could be used to assign sites to the types defined for this project was lacking for a majority of sites. However, these sites, including those in the area south of I-70, are considered to be prehistoric and are identified as such in the WSMR site polygon layer.

To account for this situation, we developed an additional model of unknown site types using only data from WSMR. The Fort Bliss data were not used, because the lack of component data for the sites at WSMR is not due to an absence of recognizable temporal or functional information on sites (e.g., as may occur with nondescript lithic scatters) but rather because of an absence of available attribute data. The purpose of this exercise was mainly to account for the large number of sites missing attribute data in the area south of I-70. This model of sites of unknown type was created using methods identical to those used to develop the other models for the project. This model had a higher TPR (0.93), higher AUC (0.95), and lower OOB (0.11) than any other model created for the project, as well as a low FPR (0.15), because it was mainly predicting a tight cluster of sites located in the area south of I-70. The model also had a very high Gain statistics (0.91), because it had a high capacity for predicting its target (i.e., sites of unknown type), but in contrast, it had a lower GOR statistic than the site type models (33.3), because it was finding a majority sites within a proportionally large area of high sensitivity; that is, within the area south of I-70.

When this additional unknown-sites model is combined with the site type models, the hole in the area south of I-70 is filled in, and the combined model performs moderately well in predicting the location of sites at WSMR, with some qualifications (Figure 3.11). When the model is tested with all sites using the Gain and GOR statistics for the entirety of the WSMR modeling area, the model has a relatively low Gain of 0.32 and a GOR of 30.4. However, this low to moderate level of performance is mainly because most sites are concentrated within the area south of I-70, which is entirely classified by the model as high sensitivity. In fact, if the model is tested only in this area, then the Gain statistic is quite low, at 0.17, and the GOR statistic is similarly low, at 16.5. However, classifying this area as high sensitivity seems reasonable given the nearly continuous and high-density distribution of sites found throughout much of the area. Moreover, WSMR is committed to inventorying this area in order to make it available for training missions. By contrast, when the model is tested for the remainder of the modeling area within the range, outside the area south of I-70, the model performs much better, having a Gain statistic of 0.62 and a GOR statistic of 52.7. These metrics suggests that the model actually works moderately well outside of the area south of I-70 and has a fairly strong predictive capacity.

Testing the model according to site type supports this interpretation (Table 3.7). When the model is tested using each of the site types for the entire WSMR modeling area, including the area south of I-70, Gain ranges from 0.31 to 0.35 and the GOR statistic ranges from 28 to 35 for all site types. In the area south of I-70, these statistics are considerably lower; the Gain statistic ranges from 0.15 to 0.19 and the GOR statistic ranges from approximately 15 to 19. By contrast, outside of the area south of I-70, the Gain statistic ranges from 0.61 to 0.68 and the GOR statistic ranges from 49 to 68. The most variation in any of these statistics occurs for the GOR statistic outside the area south of I-70. In these areas, the GOR statistic suggests that the model performs best in predicting the location of Paleoindian, Early Formative Residential, and Late Formative Residential sites. Because all of these site types would likely be considered

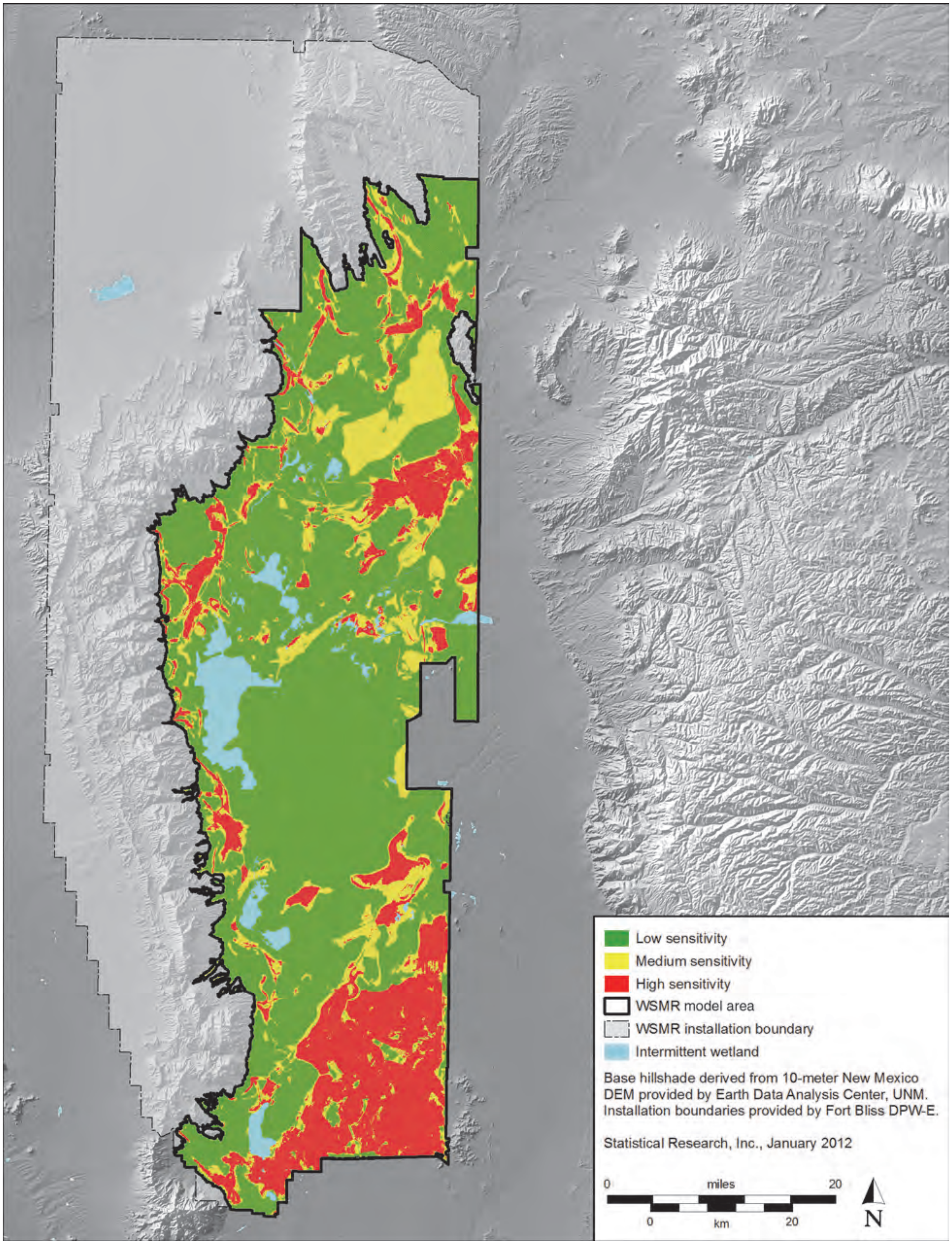

Figure 3.11. All-sites sensitivity model for WSMR.

Table 3.7. Gain and GOR Statistics for the Combined Site Type Model for WSMR

Site Type	Gain			Gain over Random		
	Entire Installation	North of I-70	South of I-70	Entire Installation	Outside Southern Maneuver Area	Southern Maneuver Area
Paleoindian	0.35	0.68	0.18	34.6	67.9	17.8
Archaic	0.33	0.62	0.17	31.3	53.3	16.9
Early Formative Nonresidential	0.32	0.64	0.15	30.9	58.1	14.9
Early Formative Residential	0.34	0.66	0.18	33.9	62.6	17.9
Late Formative Nonresidential	0.34	0.61	0.18	33.9	49.7	17.7
Late Formative Residential	0.35	0.68	0.18	34.7	67.9	18.1
Historical period	0.31	0.63	0.19	29.7	54.9	18.6
Undetermined	0.31	0.62	0.17	28.8	51.8	16.7
Average	0.33	0.64	0.18	32.2	58.3	17.3

highly significant (see Chapter 4), the stronger performance for these site types is fortuitous. Performance of the model for the remaining site types is somewhat lower, being lowest for sites of undetermined type.

Comparison of the Combined Model with an Existing Model of Site Location at WSMR

As part of the project, WSMR provided SRI with a copy of a locational model of archaeological sites for WSMR that had been developed by WSMR staff (Figure 3.12). Limited information is available on how the model was developed. It appears that the model was developed to predict all sites at WSMR using multiple logistic regression and WSMR environmental layers.

The existing model of archaeological site location converges in a number of respects with the combined all-sites model for WSMR discussed above. In both models, much of the area south of I-70 is identified as high sensitivity. In addition, the same general areas of the range within the Tularosa Basin are predicted as medium or high sensitivity and many of the same landscape features are identified as important to site location. A major difference between the two models, however, is that sensitivity zones are much more patchy and broken up in the existing WSMR model of archaeological site location, such that archaeological sensitivity is predicted to vary at a very fine scale. In some portions of the model, predictions alternate from pixel to pixel between low- and medium-sensitivity zones or medium- and high-sensitivity zones, almost as if one were looking through a cloth mesh (Figure 3.13). The result is that many individual sites fall within multiple sensitivity zones. By comparison, zones in the combined all-sites model developed for this project and discussed above are more homogeneous at the scale of individual sites in defining sensitivity zones.

Given the similarities and differences between the existing WSMR model and the combined all-sites model discussed above, we felt it would be useful to test the existing model using the Gain and GOR statistics in the exact same manner as the combined all-sites model was tested. Doing so revealed that, despite some general similarities between the two models, the existing model for WSMR performs little better than a random model. Within the WSMR modeling area defined for this project, the model overall has a Gain of 0.06 and a GOR of 5.1. Similarly, for the area south of I-70, the model has a Gain of 0.12 and a GOR of 6.4. For the remainder of the WSMR modeling area, the model performs slightly worse than random,

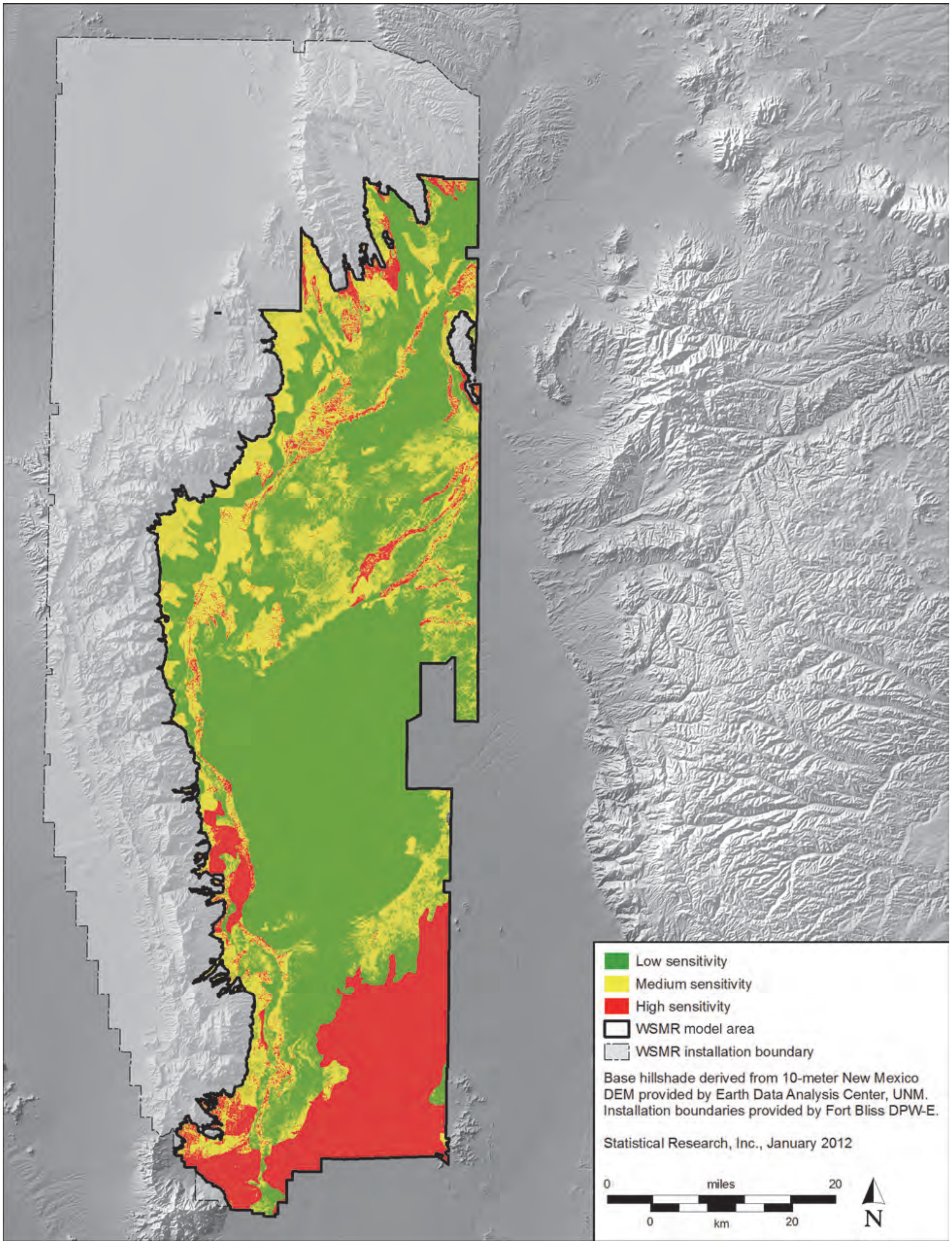

Figure 3.12. The existing sensitivity model of archaeological site location for WSMR.

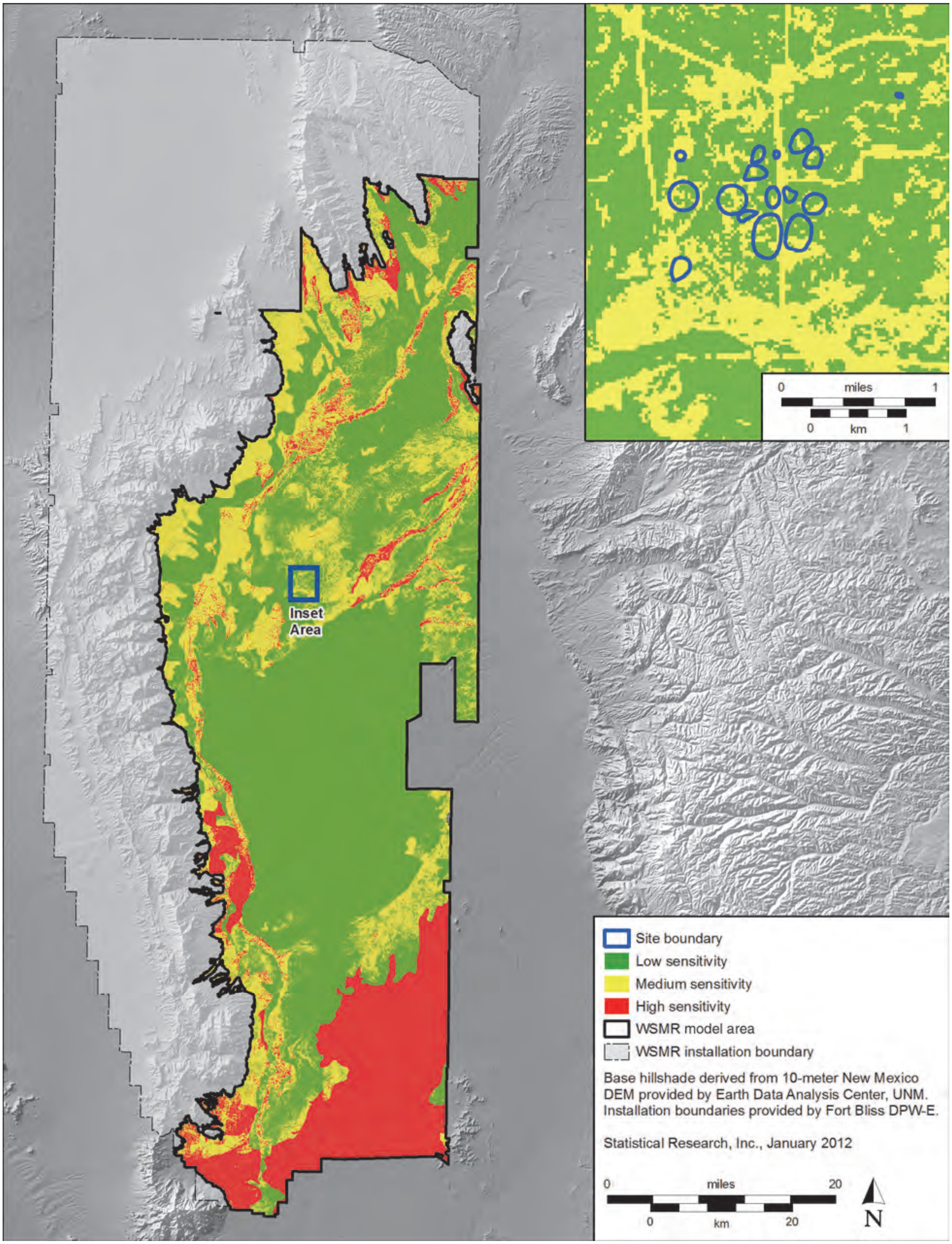

Figure 3.13. Close-up view of the existing sensitivity model of archaeological site location on WSMR, illustrating fine-scale variation in sensitivity predictions.

having a Gain of –0.01 and a GOR of –1.2. Thus, unless used in a very general sense, the existing model appears to be of limited utility in predicting archaeological site location.

Combining Site Type Models into a Differentiated Land-Use Model

Another way to make use of the site type models developed for WSMR is to combine all the site type models together into a multilayered site type model that we refer to as a differentiated land-use model. To do this, we combined all of the site type models, along with the model of unknown site types and the zones within the modeling area where environmental variables fell outside the range of predictor variable states, using the Union command in ArcGIS. The resulting shapefile contains the individual zonal predictions of each of the underlying site type models as well a variety of combinations of the site type model predictions that can be used to predict different kinds of land use within the WSMR model area. Thus, the model can help managers to determine where different kinds of land use have been predicted by the site type models, including Formative period residential and nonresidential land use (Figure 3.14); land use during the prehistoric period, historical period, or both (Figure 3.15); and land use during the Paleoindian, Archaic, and Formative periods (Figure 3.16). Of course, all of these renderings of land use are limited by the availability of site attribute data that could be used to type sites. Given the limited data on site components at the moment, it is likely that updating these models with additional site type data could result in substantial revisions to model predictions. However, the differentiated land-use models do present a transparent picture of land-use patterns at WSMR and Fort Bliss as predicted using the available CRM data.

Summary and Conclusions

In this chapter, we have presented information on how locational models were developed for the project and evaluated their performance. It should be clear from these discussions that the ability of a model to predict site location at Fort Bliss or WSMR is dependent on the availability, representativeness, and quality of CRM and environmental data used to construct a model, as well as on the modeling technique.

One of the major issues confronted while developing these models was that installation-level environmental data for Fort Bliss and WSMR were largely incommensurate with each other, a situation that precluded us from making the best use of many of the more abundant and detailed Fort Bliss environmental data. To work around this problem, environmental data that covered both installations were obtained from national mapping agencies and, to the extent possible, were supplemented with installation-level environmental data made available by Fort Bliss and WSMR. There was an extensive effort to make use of the data that were available for WSMR, such as in the case of the WSMR soils data. To make use of those data, NRCS soil descriptions were reviewed for hundreds of soil types at WSMR, Fort Bliss, and surrounding areas in order to derive soil attributes that could be used to develop soil-related predictor variables. It is likely that, had we been able to use environmental data similar to the data available for Fort Bliss to model site location at Fort Bliss and WSMR, the models for both installations would have been more accurate and refined.

Another related problem that we encountered is that site attribute data were only minimally available in the WSMR CRM database, hindering our ability to place sites into site type categories. Relevant data that would have been useful to further refining site type categories, such as artifact and feature counts, were also not available consistently enough in either the WSMR or Fort Bliss CRM databases to categorize sites according to additional factors such as artifact density and diversity, although in general, such data were more readily available in the Fort Bliss CRM database. Nonetheless, we were able to develop samples of site types for both Fort Bliss and WSMR and to supplement the WSMR CRM data with additional

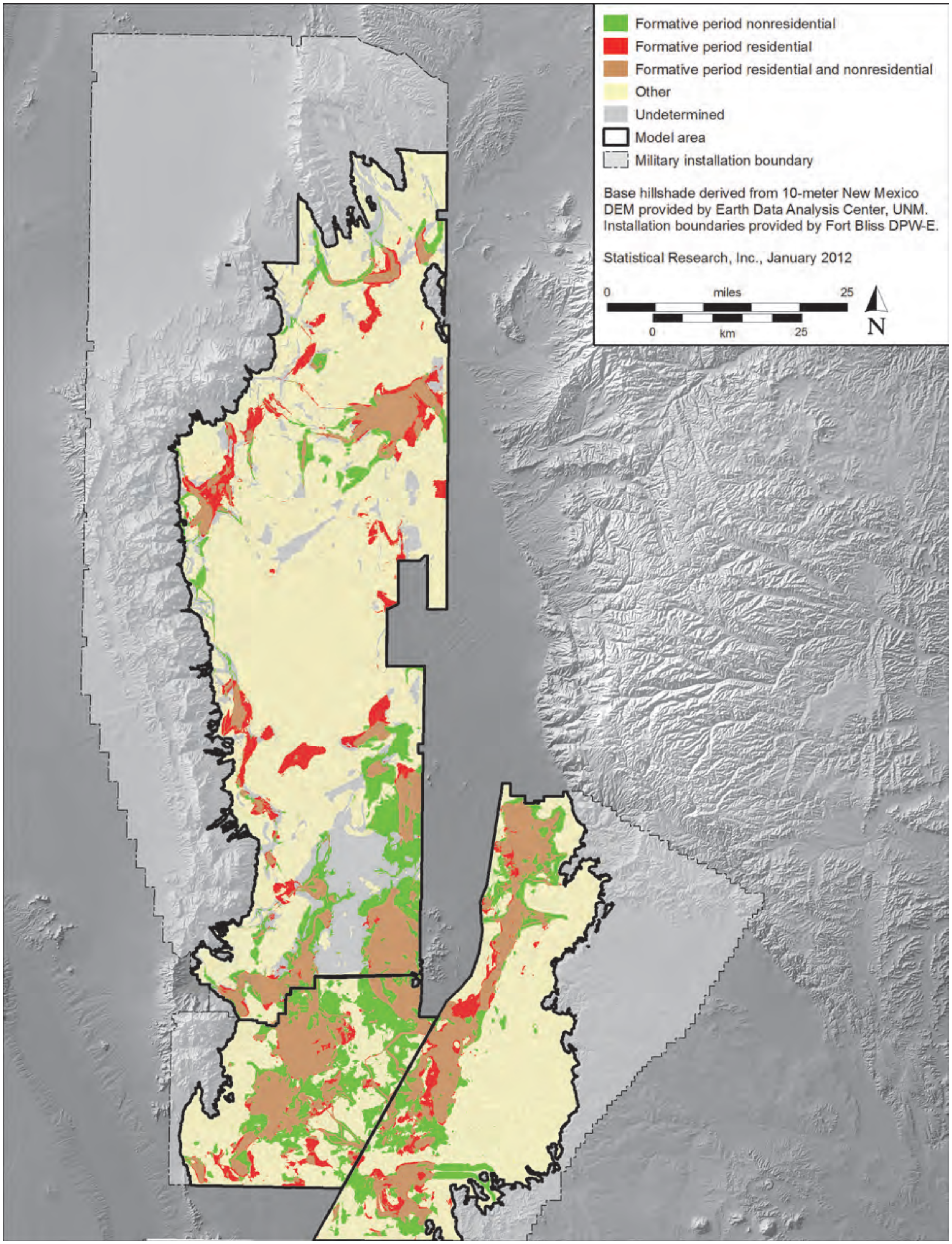

Figure 3.14. Residential and nonresidential land use on Fort Bliss and WSMR, as predicted by site type models developed using a combination of Fort Bliss and WSMR CRM data.

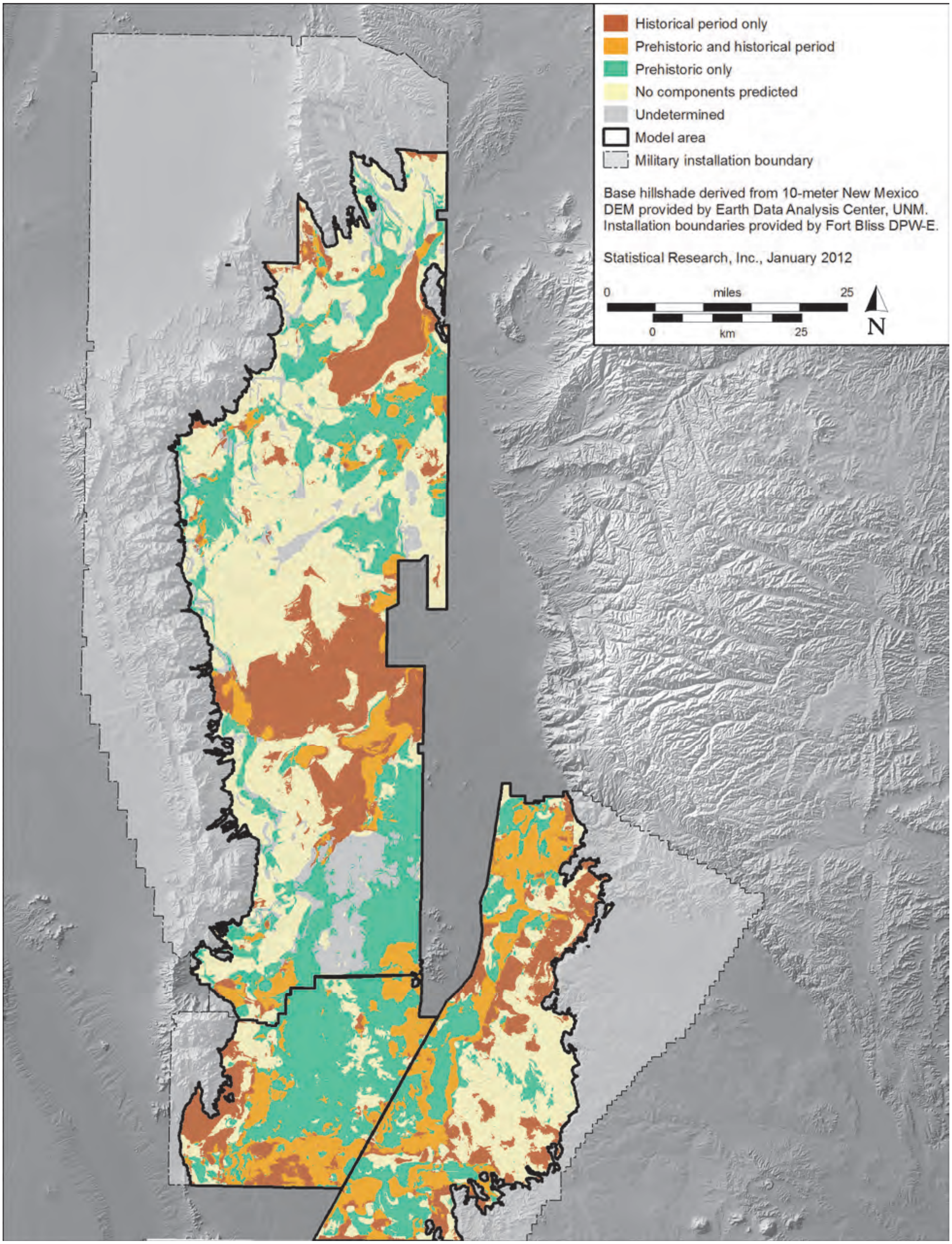

Figure 3.15. Land use on Fort Bliss and WSMR during the prehistoric and historical periods, as predicted by site type models developed using a combination of Fort Bliss and WSMR CRM data.

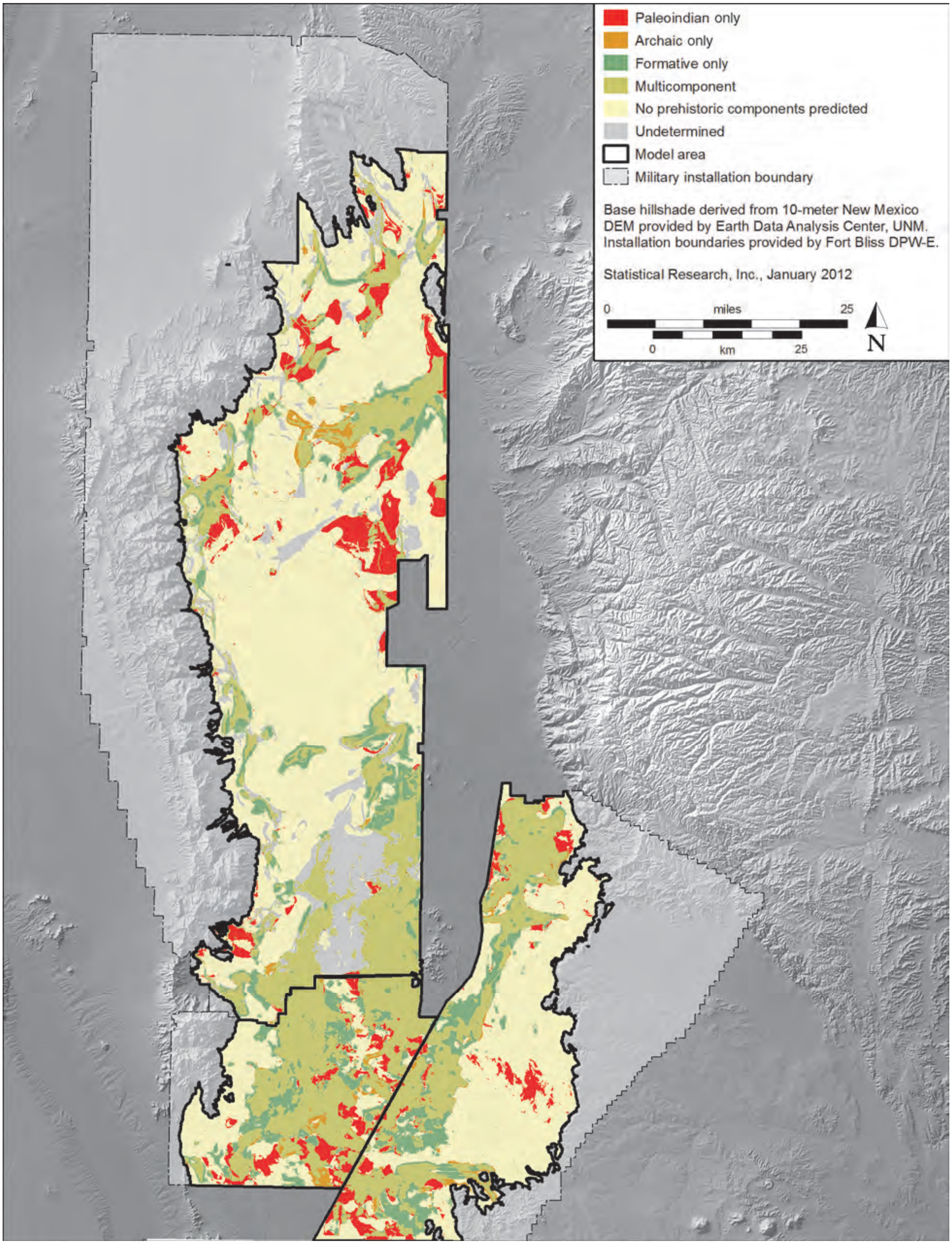

Figure 3.16. Land use on Fort Bliss and WSMR during the Paleoindian, Archaic, and Formative periods, as predicted by site type models developed using a combination of Fort Bliss and WSMR CRM data.

NMCRIS CRM data in order to develop site type models and to evaluate the all-sites model developed for WSMR according to site type, as was specified in the project scope of work.

The result of all these efforts was a series of models that show some interesting trends when they are considered in the light of the data and methods used to construct models. At Fort Bliss, we first developed an all-sites model using only TRU CRM data. The model performed better than a random model but not especially well. Part of the problem with this model was simply that the TRU data are confined mostly to the McGregor Range portion of the Fort Bliss modeling area, although the predictor variables defined for the project also likely played a role in the success of the model. Despite the relatively poor performance of the model, it did perform better than a previous all-sites model developed for the McGregor Range at Fort Bliss. This model was constructed without the benefit of site polygon data (site datums were used to represent sites) and used a modeling approach—the intersection method—that is less robust than multivariate approaches. A subsequent model that was constructed for this project based on the combination of a large-sites model and several small-site models and the use of a larger sample of CRM data from both the McGregor Range and the Northern Maneuver Area of Fort Bliss performed better than the baseline model, but only marginally so. We chose not to focus a lot of discussion on this model given that a subsequent refined model performed better, but it serves as a useful point of comparison.

The subsequent refined model for all sites at Fort Bliss, regardless of site type, was demonstrated to perform better than the previous models. Although this model could probably be further refined with better environmental data, it is worth noting that the distribution of sites in the Fort Bliss modeling area is remarkably dense, a situation that ultimately places constraints on the degree to which site locations can be differentiated statistically from nonsite locations using the available data. Moreover, many of the sites in the Northern Maneuver Area of Fort Bliss, which were recorded without the benefit of the TRU survey method, are known to have spatial accuracy problems and were recorded according to different site definition criteria. Resurvey in some portions of the Northern Maneuver area using the TRU method has resulted in substantial revisions to the extent and distribution of previously recorded sites. Nonetheless, the model captures nearly 92 percent of sites within approximately 45 percent of surveyed areas, which is an acceptable result, considering the circumstances.

Although successful in confining the vast majority of site area to less than half of surveyed areas in a context where sites are densely distributed and unevenly recorded, models that performed best in predicting the location of sites at Fort Bliss were models developed for individual site types. These kinds of models are useful beyond simply identifying where sites are more or less likely to be discovered, because they help to delineate patterns of land use for different periods and sites functions. Thus, they provide a layer of information that is useful to understanding why sites of a given type are located in specific areas over others. In addition, these kinds of models can be used to identify cases where sites are discovered in anomalous locations with respect to other sites of the same type. And, in the case of residential sites, site type models can be used to identify areas that have a high potential for containing sites that would be costly to the mission, in both time and money, if discovered accidentally, i.e., red-flag sites (Altschul 1990).

Comparing the Gain and GOR statistics for locational models at Fort Bliss shows that with each of the models discussed above, the GOR statistic rose progressively with each model in a nearly linear fashion (Figure 3.17). In essence, each of the successive models was able to place more and more site area within proportionally smaller sensitivity zones. The Gain statistic also increased with each model but rose more rapidly than the GOR statistic, from the McGregor Range intersection model to a multivariate all-sites model. Site type models, however, show a dramatic increase in the Gain statistic over all previous models, suggesting that these models have by far the highest predictive capacity.

As useful as the site type models may be, they did not extend well onto WSMR when only Fort Bliss CRM data were used in their construction; nor did any of the other models constructed using only Fort Bliss CRM data. When Fort Bliss and WSMR CRM data were combined, however, site type models performed well for both Fort Bliss and WSMR. The GOR statistic was, on average, very similar for Fort Bliss regardless of whether only Fort Bliss or Fort Bliss and WSMR CRM data were used in model construction (Figure 3.18). By contrast, the GOR statistic increased dramatically for the same models for

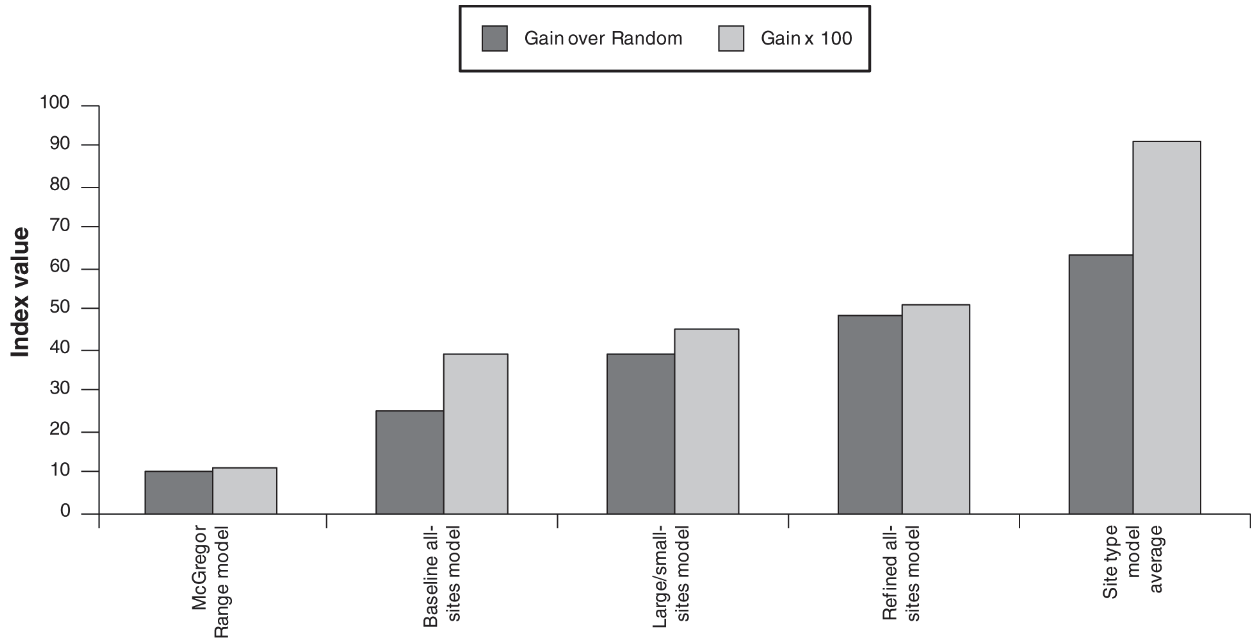

Figure 3.17. Bar graph showing the Gain and GOR statistics for locational models for Fort Bliss.

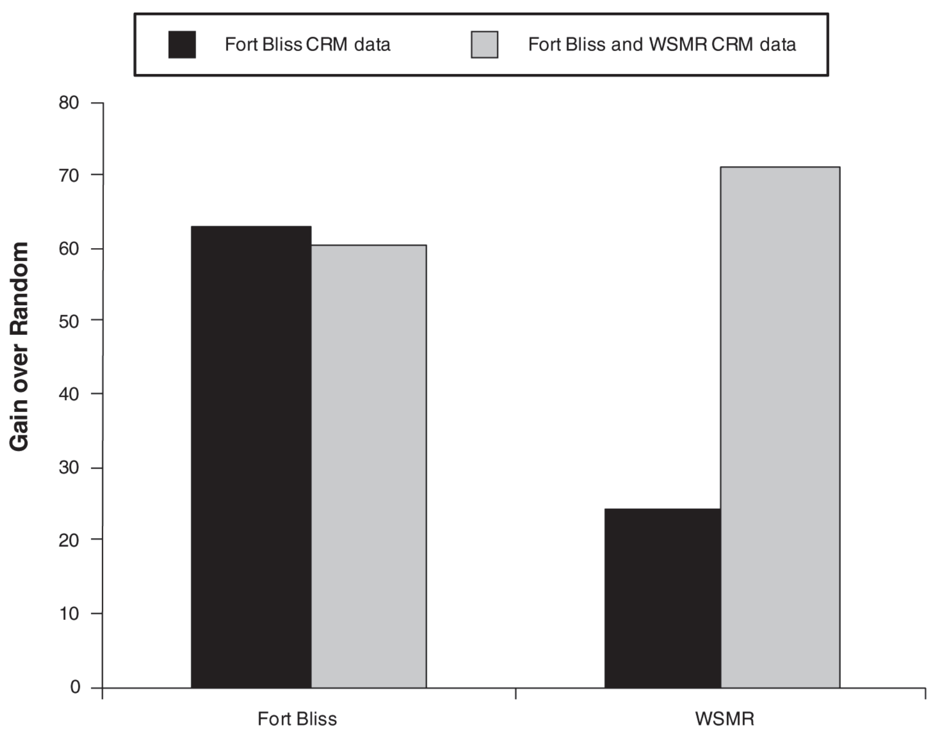

Figure 3.18. Bar graph showing the average GOR statistic for site type models constructed using only Fort Bliss CRM data or a combination of Fort Bliss and WSMR CRM data.

WSMR when Fort Bliss and WSMR CRM data were used in model construction. There was a similar result with the Gain statistic, with the exception that the Gain statistic actually increased on average for some site type models for Fort Bliss when Fort Bliss and WSMR CRM data were used in model construction (Figure 3.19). This suggests that the predictive capacity of site type models increased for both reservations when the combined CRM data set was used.

Following analysis of the performance of the individual site type models for both reservations, an all-sites model was constructed for WSMR using the site type models. In doing so, it was observed that the large number of sites lacking attribute data in the database resulted in a large gap in the area south of I-70 where site types could not be defined. An additional model of undetermined site types at WSMR was constructed to account for this situation and combined with the other site type models. When evaluated with Gain and GOR statistics, the combined all-sites model for WSMR performs at a low to moderate level overall. This result is largely owing to the vast majority of sites at WSMR having been discovered in the area south of I-70, much of which is identified as a high-sensitivity zone in the combined model. However, when the performance of the model was tested for sites in the remainder of the modeling area, the Gain and GOR statistics indicated that the model actually worked fairly well, predicting 85 percent of sites in medium- and high-sensitivity zones, which together constituted just 32 percent of surveyed area. Moreover, evaluation of the model using individual site types showed that the model also performs well in predicting the location of individual site types, performing best for Paleoindian period sites and Formative period residential sites, a useful result given the high degree of significance often attributed to these kinds of sites.

In addition to the combined all-sites model for WSMR, a differentiated land-use model was constructed by combining together all the individual site type models using the Union command in ArcGIS in order to show possible patterns of land use for different periods and for residential and nonresidential site functions. The model includes predictions for sites of undetermined type, which helps to show patterns of land use that cannot be associated at this time with particular site types but nonetheless form an important part of the known archaeological record at WSMR.

Although the WSMR models appear to perform well and can be used to delimit land-use patterns that could contribute to an improved understanding of the distribution and significance of different site types, some caution must be exercised in their interpretation. Given the large number of sites polygons that have yet to be attributed with site type information and the uneven distribution of survey at WSMR, it is quite likely that the predictions of these models will change as new data are developed. As a consequence, we recommend that attribute data be added to the WSMR CRM database in order to further identify sites according to type and that additional sample survey be placed in areas of the range that have been subjected to minimal survey. Once additional CRM data are available that can be used to develop a large and more representative sample of sites across the range, according to type, it is recommended that the models be further refined with the additional CRM data, along with higher-quality environmental data, such as the detailed geomorphic data and the SSURGO data that WSMR is in the process of preparing.

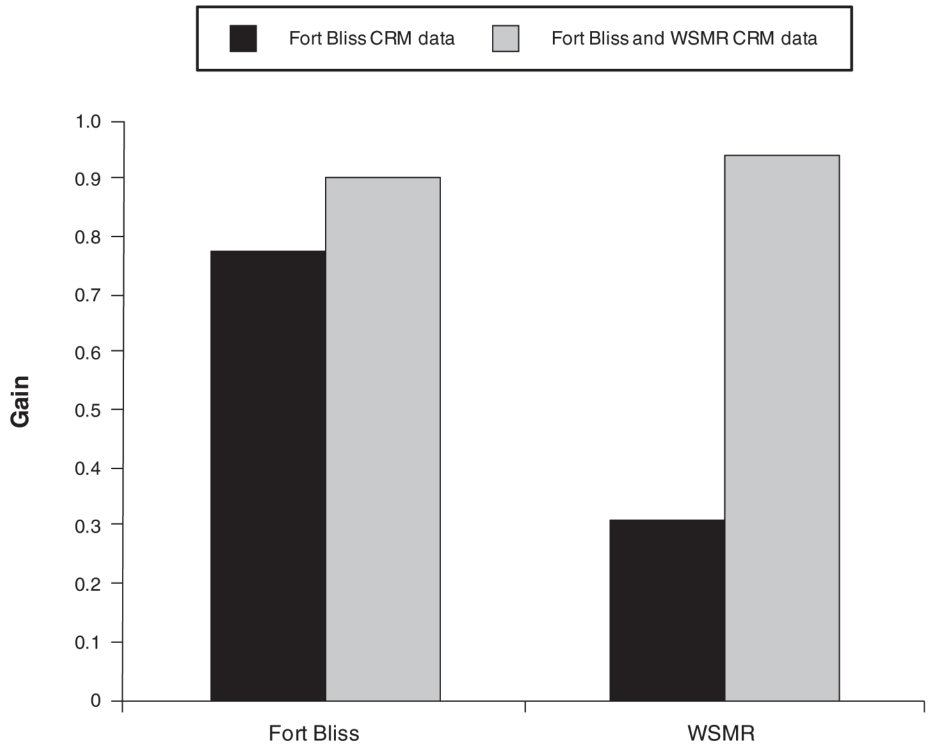

Figure 3.19. Bar graph showing the average Gain statistic for site type models constructed using only Fort Bliss CRM data or a combination of Fort Bliss and WSMR CRM data.

CHAPTER 4

An Archaeological Significance Model for White Sands Missile Range

Lynne Sebastian, Phillip Leckman, and Adam Byrd

Introduction to Significance Modeling

The concept of "significance" modeling arose from discussion at a 2004 DoD Legacy Program–sponsored workshop on predictive modeling and CRM on military installations (No. 03-167) (Altschul et al. 2005). Much of the workshop was focused on locational models that use statistical techniques and correlations between known archaeological site locations and multiple environmental variables to assess the probability that an archaeological site would be encountered at any given location. Although locational models are excellent tools for many CRM needs, the workshop participants identified a major need that these models cannot address: evaluation of the significance or data potential of sites that have already been identified.

For many years, military installations have been carrying out surveys to identify archaeological sites within areas projected to be affected by construction, training, and operations, as required for compliance with the NHPA. Whenever possible, they have then redesigned or relocated the proposed activities to avoid impacts to all sites rather than spending the time and money to evaluate which sites warranted avoidance and which did not. This approach worked well in most cases, but it has left many installations with hundreds, even thousands, of unevaluated sites that constrain the locations currently available for mission-related activities.

In order to plan for new and expanded uses as required by BRAC and other authorities, installations need to know not only where concentrations of archaeological sites are located and where sites are rare but also which sites would require avoidance, which would require expensive mitigation, and which would be straightforward to deal with, in terms of resolving adverse effects. Answering these questions on a site-by-site basis through testing and on-site evaluation is both expensive and time-consuming. The workshop attendees questioned whether it would be possible to develop a modeling approach that could assess the NRHP eligibility of previously recorded sites based on existing data for those sites.

In a subsequent Legacy Program–funded project (No. 06-167) (Cushman and Sebastian 2008), the SRIF explored the potential for a rule-based approach, using existing site and environmental data, for assigning known sites to categories that would indicate their potential to yield different types of information about the past. In a simplified pilot project using data from the Utah Test and Training Range administered by Hill Air Force Base, we determined that such an approach was possible and, if successful, could permit installations to make many planning decisions and could support some types of compliance decisions, as well.

A subsequent attempt to develop a full-scale significance model for Fort Benning, Georgia, was unsuccessful. A workshop was held with base personnel, Georgia SHPO staff, and private-sector archaeologists with long-term experience in working with the archaeological record of Fort Benning. The purpose of the workshop was to identify variables routinely recorded during archaeological surveys that could potentially be used to sort sites in the installation database into categories by their data potential. What we discovered was that none of the variables identified as potentially useful—for example, assemblage size, assemblage diversity, presence/absence of features, and potential for buried material—were coded in the installation database. Because neither the state of Georgia nor Fort Benning uses site forms to record survey results, the only means of acquiring the needed data would have been to search through the text and tables of each of the survey reports from the base and create a new database. This was considered to be cost prohibitive.

What we learned from the Fort Benning experience was that in significance modeling, as in so much of archaeology, it is all about the data. When installations develop locational predictive models for archaeological sites, there are ways of compensating for questionable or missing data. The key archaeological variable in these cases is the location of known sites. More sophisticated, finer-grained models can be created by including site size, time period, functional site type, and other archaeological variables in the modeling process. But very serviceable, useful models can be created using no archaeological information other than the single variable of site location (e.g., a site centroid or polygon location). This is not the case with a significance model. There are several classes of archaeological information that are essential to assessing the significance or data potential of archaeological sites, and the more categories of archaeological data that are available in computerized format, the more accurate and nuanced the model will be. A brief discussion of the process by which significance (data potential) is generally assessed on a site-by-site basis will help to make it clear why this is so.

NRHP Eligibility and Archaeological Significance

The underlying concept of what we are calling "significance" modeling is an attempt to replicate, programmatically and through the use of computerized site data, the process that federal-agency and SHPO staff go through when assessing site significance as part of consensus determinations of eligibility (DOEs) under Section 106 of the NHPA. The process for determining the eligibility of a historical-period or prehistoric site for listing in the NRHP is laid out in a series of guidance documents referred to as National Register Bulletins; the two most germane to this project are National Register Bulletin 15, *How to Apply the National Register Criteria for Evaluation* (National Park Service 1995), and the unnumbered bulletin on archaeological properties, *Guidelines for Evaluating and Registering Archeological Properties* (Little et al. 2000).

The first step in the process of determining eligibility for listing in the NRHP is to assess the significance of the historic property. "Significance" means the property's importance in U.S. history, architecture, archaeology, engineering, or culture as evaluated relative to four criteria: (a) association with significant events; (b) association with significant persons; (c) embodiment of particular qualities of construction, design, or aesthetics; and (d) potential to yield important information about history or prehistory. Once it has been established that the property meets one or more of the evaluation criteria, the next step is to determine whether the property retains sufficient integrity of location, design, setting, materials, workmanship, feeling, and association to convey its significance. It is the combination of significance and integrity that informs the decision regarding NRHP eligibility. Although it is often claimed that there is and should be no difference in how significance is assessed for the purposes of formally listing a property in the NRHP and deciding which properties should receive consideration in the Section 106 process, the majority of people who work with Section 106 DOEs for archaeological sites on a daily basis know that this is not, in fact, what happens.

NRHP significance for archaeological sites is most commonly evaluated under eligibility Criterion d: places that "have yielded, or may be likely to yield, information important in prehistory or history." National Register Bulletin 15 addresses the issue of "important" information as follows:

> [T]he information must be carefully evaluated within an appropriate context to determine its importance. Information is considered "important" when it is shown to have a significant bearing on a research design that addresses such areas as: (1) current data gaps or al-

> ternative theories that challenge existing ones or (2) priority areas identified under a State or Federal agency management plan [National Park Service 1995:21].

Because of the focus on current data gaps and theoretical perspectives, the NRHP requires that significance be evaluated using "historic contexts"—that is, discussions of important research issues grouped by place, time, and theme. Historic contexts, it is argued, enable us to define important information and thus identify NRHP-eligible archaeological sites. Virtually every theoretical discussion on the topic of making better decisions about significance for archaeological sites concludes that what is needed are more and better historic contexts.

In practice, though, very few people making Section 106 decisions about the significance and eligibility of archaeological sites actually use the historic contexts that we currently have in any meaningful way to make those decisions. Instead, they evaluate the physical characteristics (including setting) and the morphology (i.e., the form, content, and structure) of a site and make a decision based on those. Is the site largely intact, or is it eroded or looted? Is it mostly buried or exposed on the surface? How many artifacts are visible? What kinds of artifacts are visible? Is there evidence of features or structures? Are there temporally diagnostic artifacts or features?

Consensus DOEs take this approach because archaeologists gather a relatively fixed set of data from all archaeological sites, regardless of the historic context. Archaeological data, regardless of location and time period, come from artifacts, features, structures, pollen samples, flotation samples, chronometric samples, ethnobotanical samples, perishables, faunal materials, and human remains and associated grave goods, plus all of the provenience information for those things. Some sites have all of these categories of things, and others have only a few. It is by looking at the physical characteristics and morphology of a site encountered during survey that archaeologists assess the site's potential to yield archaeological data in these categories.

This brings us back to the issue of how Section 106 consensus DOEs are actually made. Most of the time, archaeological survey is performed by a third-party contractor who provides the federal agency with a set of facts and interpretations about each of the archaeological sites encountered. Most often, this information is summarized in a standardized site form (although our Georgia experience taught us not to take that for granted) supplemented by a detailed site report. Using the site setting, content, and structure data provided on the site form, with occasional references to the report if clarification or supplemental information is needed, the agency staff person makes recommendations regarding the site's significance—its potential to yield information—and integrity and combines those into a recommendation regarding the site's eligibility. The site form and the report are then sent to the SHPO, and SHPO staff also look at the morphological information, including assemblage size and diversity, presence/absence of features and structures, and potential for buried deposits. SHPO staff use their own assessments of that information in deciding whether or not to concur with the agency's eligibility recommendation.

If the SHPO agrees with the agency's recommendation, the process is complete. For the purposes of the undertaking (project) that caused the survey to be carried out, the site is treated as though it were eligible or not eligible for listing in the NRHP. What this means for the federal agency is that any effects of the undertaking on the consensus-eligible properties have to be taken into account, and if any of the effects are found to be adverse, the agency must consult with SHPO, interested Indian tribes, and possibly other parties about measures to resolve the adverse effects. What this does *not* mean, in the case of archaeological sites, is that eligible sites must be preserved or that all eligible sites that cannot be preserved must receive full-scale (or any) data recovery. Which sites to preserve, which to let go, which to slate for data recovery, and many other issues are management decisions made by the agency in consultation with other parties. In other words, the fact that an archaeological site has been recommended eligible for listing in the NRHP does not determine how it will be treated; treatment is determined in a separate decision-making process.

The implications of actually listing an archaeological site or any kind of historic property in the NRHP are very different from the implications of a consensus determination for the purposes of Section 106. There may be, for example, both fiscal and legal implications when listing a property. Further, the NRHP is an honor roll, intended to recognize and encourage preservation of a representative sample of the best that our country has to offer in terms of tangible remains of our shared heritage. The process of selecting properties to place on that list should include considerable research and deliberation.

Data Availability and a Significance Model for WSMR

The ERDC-CERL asked SRI and the SRIF to develop a significance model for prehistoric archaeological sites at WSMR in New Mexico as part of a project to develop a programmatic approach to the management of archaeological resources on the installation. As described in the scope of work, the significance-modeling task is to

> sort the WSMR archaeological sites in significance categories using site characteristics as a proxy for data potential in terms of National Register of Historic Places criterion D. Specify and justify the protocol for using the significance category assignments to help guide management, planning, and compliance decisions, including selection of representative samples of sites for various management options (for example, site avoidance and preservation; mitigation of adverse impacts, etc.).

As noted in the Fort Benning example, availability of computerized data, including the key variables used in case-by-case consensus DOEs, is key to the successful development of a significance model. WSMR maintains a database of archaeological site-attribute data that currently contains more than 2,000 records. The State Historic Preservation Division Archaeological Records Management Section (ARMS) maintains a statewide archaeological database called NMCRIS. In NMCRIS, there are over 5,000 site numbers assigned to WSMR, but some 1,500 of these are placeholders for sites that have been identified during surveys on the installation but for which complete information has not yet been submitted to the state database. If we disregard those records and the records of sites of recent-historical-period age (which are not addressed in this model, because evaluation of their significance relies much more heavily on documentary sources than on the archaeological remains at the sites), records for 3,445 prehistoric or protohistoric sites within WSMR boundaries are currently available in NMCRIS.

The WSMR database contains 264 sites coded as eligible for listing in the NRHP and 484 sites coded as not eligible; the remaining 1,376 sites are coded as undetermined. In NMCRIS, 281 sites are coded as eligible, and 89 are coded as not eligible. An additional 161 sites are coded as undetermined. It is only in recent years that ARMS has begun tracking the information regarding DOEs in the database; so, more than 2,900 WSMR sites in NMCRIS have no information regarding eligibility. There is an overlap of 199 sites that have eligibility information in both databases. By working between the WSMR and NMCRIS databases, we might be able to increase the number of sites in NMCRIS with eligibility information, but at best, there would still be approximately 1,300 sites with no eligibility information (those sites that appear in NMCRIS but not in the WSMR database) and more than 1,200 sites with an "undetermined" coding. These numbers indicate why a significance model to categorize the sites for which eligibility information is unavailable could be of substantial management importance.

The purpose and value of the significance model discussed below are in providing the installation with a mechanism for programmatic identification of the likely data potential of the roughly 2,500 sites without DOEs. As things currently stand, those sites are little more than dots on a map (or, more literally, polygons in a GIS layer) that represent constraints on mission-related activities. Without information as to relative data potential, all dots pose equal constraints, and the installation's ability to assess relative environmental effects of alternative project locations, to estimate potential costs of archaeological mitigation, and to meet other important planning needs is unnecessarily limited.

In order to decide which database to use for the modeling project, we evaluated how effectively each of them provided data for what were likely to be important or even critical variables for the modeling process. One obvious advantage of NMCRIS was the much larger number of WSMR sites included in the state database. Originally, we thought that the difference in the number of sites was perhaps a result of either sites with very early recording dates not having been included in the WSMR database or the most recently discovered sites not having been added to the WSMR database. A comparison of the WSMR and NMCRIS databases revealed, however, that neither of these was the case. The sites included in NMCRIS but not in the WSMR database have Laboratory of Anthropology (LA) numbers ranging from the 2,000s through the 150,000s, and the gaps in the WSMR numbers are spread throughout that range.

One of the most critical sorting variables that we identified for the significance model was the estimated number of artifacts on a site, or "assemblage size" (see Structure of the WSMR Significance Model, below). Although the WSMR database provides quite detailed presence/absence data for different types of ceramics and for stone tools, there are no assemblage-size data, either for individual artifact types or for the assemblage as a whole. The NMCRIS database contains a variable entitled "assemblage size" as well as separate entries for numbers of lithics and ceramics, but only 22 percent of the WSMR sites in NMCRIS have the assemblage-size information coded. Total-assemblage-size data were routinely recorded on the site forms for many years, but it was not until the late 1990s (approximately site number LA 101,000) that this information began to be included among the variables coded in the NMCRIS database.

As a test, we physically pulled the LA site records for approximately 100 of the sites with missing assemblage-size information, to determine how long it would take to code this critical piece of information for the roughly 2,700 sites in the database for which this information is not coded. What we discovered was that this process was time-consuming for the very earliest sites (those prior to about LA 50,000) because no standard process or standard forms were used for recording site information. Beginning about 1985, however, standard LA forms were used for surveys on the installation, and from that point onward (that is, for the approximately 2,450 uncoded site records between LA 50,000 and LA 101,000), the site-assemblage information can be located and coded very quickly.

A second critical category of information needed for assessing the data potential of prehistoric archaeological sites comprises the presence, number, and nature of structures and other features at a site. Features and structures have high potential to provide information about chronology, site function, and activities carried out at a site, regardless of time period or historic context. For each site, the WSMR database contains the following numerical information about features: the total number of features, the number of various types of thermal features, and the number of midden, rock-art, and ceramic features (presumably scatters). NMCRIS provides information regarding feature types and numbers by temporal component rather than by the site as a whole; it allows for the coding of a wide variety of different possible feature types, and as many types as needed can be associated with each component of each site. Because many of the WSMR sites contain multiple components representing entirely different archaeological cultures and time periods, we felt that the NMCRIS database, which links features with components, would be more useful for the modeling exercise.

Other potentially important categories of data for significance modeling include information on assemblage diversity and site size. The WSMR database contains quite detailed information, in a presence/absence format, as to types of pottery and chipped and ground stone artifacts for each site. NMCRIS provides less-detailed presence/absence information for certain categories of artifacts—debitage, chipped stone tools, ground stone tools, bone tools, diagnostic ceramics, other ceramics, etc. Either or both of the databases could potentially be used to generate some fairly low-level measures of assemblage diversity, but presence/absence data do not yield very strong or accurate diversity indices. One other potentially useful variable available in NMCRIS is the presence/absence of nonlocal lithic materials, but the number of WSMR sites coded as having these materials is very small (n = 108).

Both the WSMR database and NMCRIS contain information on site area or site size. Unfortunately, a quick comparison between the two databases indicated that in most cases, they contain substantially different (sometimes wildly different) estimates of site area for the same site. Presumably, this reflects different approaches to calculating site area. NMCRIS uses an oval calculated from maximum length and maximum width; the WSMR numbers are very specific and likely have been calculated using polygon information. Survey-based estimates of site size tend to be unreliable in any case, especially for an installation like WSMR, where large parts of the terrain are covered in dunes and sand sheets. In such locales, the apparent site area is as likely (or more likely) a reflection of where blowouts occur as a reflection of actual site size.

The Fort Bliss Significance Standards

Because the statement of work for the locational-modeling portion of this project involves coordination of approaches and use of data from both WSMR and the nearby and more intensively studied Fort Bliss, it seemed appropriate to consider the Fort Bliss approach to evaluating significance in developing the WSMR significance model. In the late 1990s, Fort Bliss funded large field projects to evaluate the eligibility of hundreds of archaeological sites that had been identified on the installation since the 1970s. To guide these evaluation efforts, the installation developed a document entitled *Significance Standards for Prehistoric Archeological Sites at Fort Bliss: A Design for Further Research and the Management of Cultural Resources* (Abbott et al. 1996).

The approach to NRHP-eligibility evaluations laid out in Abbott et al. (1996) was used at Fort Bliss for more than a decade until, in 2009, the Abbott et al. (1996) volume was replaced with a massive study entitled *Significance and Research Standards for Prehistoric Archaeological Sites at Fort Bliss: A Design for the Evaluation, Management, and Treatment of Cultural Resources* (Miller et al. 2009). The purpose of the latter document was to "identify and frame the types of scientific research that are needed to further our knowledge of regional prehistory, and [suggest] methods and analyses that are useful for filling in the 'gaps' and reconciling the ambiguities in the database" (Miller et al. 2009:1.1). This document provides not only an excellent research framework for future archaeology on Fort Bliss but also "explicit standards of significance" for NRHP-eligibility evaluations (Miller 2009:1.6).

The 2009 significance standards, like those in the 1996 document, are designed for application in the field by archaeologists actually observing the site morphology, setting, depositional environment, etc. This is clear from both the kinds of data needed and the kinds of judgments required. In the case of WSMR, we are trying to develop a standardized approach to categorizing the data potential (significance) of already recorded sites based solely on computerized legacy data, much of it decades old. Clearly, our approach for WSMR will not reach the levels of sophistication and consistency called for in the Fort Bliss approach.

Another difference between what was accomplished at Fort Bliss and what we are attempting here is that the Fort Bliss approach to determining significance (data potential) is tied explicitly to a series of highly detailed historic contexts and is based on mandates in the National Park Service guidance documents (National Register Bulletins) that describe the process for nominating properties for listing in the NRHP. We have not adopted the historic-context-based approach here because we are focused not on the NRHP nomination of sites or even the completion of formal DOEs but rather on providing a flexible, long-term management tool for the installation that uses basic archaeological characteristics as a proxy for data potential.

Historic-context-based DOEs purposely focus on *current* research interests and *current* data gaps in determining the significance of a site. In a management context, what this means is that decisions about significance are made on the basis of short-term archaeological interests but that these decisions are then used to guide long-term management of the archaeological record. All sites of a particular type could be found to be not eligible today because they are not relevant to *current* research interests. Once such a determination is made, all sites of that type become permanently vulnerable to damage or destruction. If future research interests indicate that sites of that type may actually be very relevant, we run the risk of having none of them left when they are needed. For short-term or immediate management purposes, such as data recovery in anticipation of a specific development project, historic-context-based research designs focused on current research interests and data gaps are essential. For long-term management purposes, however, it is better to focus on preserving a representative sample of sites with different types of basic archaeological data potential as indicated by site contents, depth, setting, etc.

Significance vs. Eligibility

It is important to note that the discussion thus far of the WSMR modeling effort has been focused on significance—that is, the potential of a site to yield important information about history or prehistory—and not on eligibility for listing in the NRHP. To address eligibility in the WSMR model, we would have to combine the assessment of each site's potential significance with some evaluation of its likely integrity—that is, the site's ability to convey its significance.

In the case of archaeological sites on WSMR, and indeed in most of southern New Mexico, the question of integrity largely comes down to geomorphology and the identification, dating, and mapping of the Quaternary stratigraphy. Beginning with the work of Blair et al. (1990), geomorphologists and archaeologists working in the Tularosa Basin have identified four basic stratigraphic units in the Quaternary sediments: the Q1, which predates human occupation in the basin by tens of thousands of years; the Q2, which dates approximately 9,000–15,000 years before present; the Q3, which, following a major episode of erosion, dates approximately 100–4,300 years ago; and the Q4, which comprises the loose, recent sand sheet created largely as a result of grazing impacts since the mid-nineteenth century.

A number of subsequent studies within the Tularosa Basin and the Hueco Bolson to the south (e.g., Hall 2007; Monger 1993, 1995; Monger and Buck 1995) have worked toward refining the chronology and depositional history of these Quaternary units, especially as they relate to the sequence of archaeological cultures known from the region. There are many questions that remain to be resolved, but it is clear that the presence and intactness of the Q3 unit is the best overall predictor of the integrity of archaeological sites in the Tularosa Basin, although there are certainly examples of sites that have yielded significant information despite the near total erosion of the Q3 (see Gerow 1994).

The Fort Bliss significance standards address not only significance but integrity. Indeed, the Fort Bliss approach actually requires an assessment of site integrity first, before addressing significance, making integrity one of their two first-tier evaluation variables. The authors of the Fort Bliss study defined site integrity as geomorphological and geoarchaeological (spatial) integrity. Miller et al. (2009:14.4) noted that:

> Assessments of site integrity should include geomorphic observations on the micro-topographic context of the site (presence of advanced coppice dunes with interdunal erosional surfaces, the presence or absence of lag gravels in surface sands of limited depth, and presence of sheet sands or dune piles) and the presence, absence, depth, and extent of Holocene soil deposits and subsurface cultural deposits. In addition, observations of natural and cultural disturbances are important and require a judgment of the degree to which disturbances have compromised the research potential of a site. The process described above is designed, among other things, to evaluate the integrity of site deposits through geomorphic, geoarchaeological, and specific disturbance information that will be collected during site evaluations.

Given that our WSMR significance-model development involves no field inspection, and because there have been no broad-scale efforts to map the Quaternary sediments at WSMR, we looked at existing data on landforms, soils, and depositional environment to determine whether it might be possible to put together a set of proxy measures for site integrity. We asked the question, "To what extent might some combination of available data indicate whether the physical relationships among artifacts, features, and other deposited materials are likely to be preserved?"

Proxy assessments of integrity generally depend on information about the depositional environment and degree of disturbance. Has the site been buried by subsequently deposited wind- or water-laid sediments, or is it being eroded by the forces of wind and water? Is there evidence for human, animal, or mechanical disturbance? Neither the WSMR database nor NMCRIS is as helpful in this regard as one might wish.

The WSMR database does not have information on depositional environment, potential for buried materials, or other geomorphic variables. It does, however, have several site-condition variables, including presence/absence data for erosion by wind or by water and for damage from vandalism, wheeled vehicles, and tracked vehicles. It also has a category called "Impact," which we assume has to do with effects from ordnance of various sorts. Because these data are noted only in terms of presence/absence, rather than quantitative or even qualitative, it is not possible to use them to assess site condition. Virtually every site is coded as impacted by wind erosion, and a large percentage are coded positive for water erosion, as well. Vandalism and damage from tracked vehicles are very rare, but 18 percent of the coded sites have effects from wheeled vehicles noted, and 20 percent are coded as having "impact" effects. To what degree these factors actually correlate to integrity, though, is unclear.

NMCRIS includes a variable indicating basic depositional environment (alluvial, aeolian, colluvial, residual, or no deposition) as well as variables characterizing the depth of subsurface deposits (no subsurface deposits, subsurface deposits present [with an estimate of depth], stratified subsurface deposits present, and unknown). NMCRIS also includes a variable representing the percentage of disturbance for a site. Although these variables would be very useful for assessing the likely integrity of archaeological sites at WSMR, these data were not included in the database that became NMCRIS until around site number LA 80,000, in roughly 1993. This means that approximately 2,600 of the 3,445 WSMR sites do not have this information coded.

Because of the weaknesses of the information available in the two databases, as described above, we also examined the possibility of using some of the GIS environmental themes developed as part of the locational-modeling effort to create a proxy measure for site integrity. Maps for both soils and geological units are available for WSMR, the former from the NRCS and the latter from the New Mexico Office of the State Engineer. In addition, as part of the locational-predictive-modeling effort for this WSMR project, staff from SRI used the information from the soils map and from descriptions of the soil types to generate maps of the general distribution of aeolian and alluvial soils within the installation.

Clearly, soils and geologic units are not independent variables, but we examined the possibilities for using one or both of them to programmatically assess the potential integrity of sites on WSMR. Conceptually, we think it is possible that a proxy measure of site integrity could be derived from data on soils and/or geological units. Even if it were not possible to predict where good spatial integrity would be found, it might at least be possible to design a measure that would indicate where preservation of spatial integrity is *not* likely. In practice, however, we chose not to pursue this possibility because of the coarse scale at which the mapped data are available—1:100,000 for the soils and 1:500,000 for the geologic units. With mapped data at these low-resolution scales and sites with a median site area somewhere between 3,000 (if we use the NMCRIS figures) and 829 m^2 (if we use the figures in the WSMR database), it is impossible to say with any confidence which soil type or geologic unit correlates with the location of each site.

More important, even if we were to disregard the scale problem and the resultant uncertainty of association, we currently do not have information that would enable us to identify correlations between site integrity and soil types or geologic units. The ideal solution to modeling potential integrity for known sites at WSMR would be a large-scale project to evaluate, record, and map the Quaternary stratigraphy of the installation. Given that funding for such a substantial effort is unlikely to be available, we would suggest that a priority for future research might be a pilot study that looks at excavated and tested sites on WSMR and available geology, landform, and soil data. Such a study might employ techniques similar to those used in locational predictive modeling in an attempt to identify correlations between aspects of a site's geologic and pedologic setting and the degree of integrity of the site as revealed through excavation.

Other Differences from the Fort Bliss Approach

The two first-tier variables used to evaluate archaeological site eligibility in the Fort Bliss case were integrity, as discussed above, and chronometric potential. Miller et al. (2009:14.3–14.4) argued that

> the presence of chronometric materials at a site, whether they are based on relative, sidereal, or isotopic methods, is an important threshold in the evaluation of the site's eligibility for inclusion in the NRHP. Simply stated, in order for any site to empirically address any research question the site must have something that allows researchers to place it in a temporal framework.

They go on to explain, "For purposes of NRHP evaluations at Fort Bliss, the basic definition is that chronometric data potential refers to *the presence of one or more interpretable associations of datable archaeological contexts and material remains at a site* [emphasis in the original]*"* (Miller et al. 2009:14.4).

Miller et al. (2009) maintained that, in the absence of clear indications of dating potential, a site is a priori not eligible. Although we do not question the importance of chronometric control, in the case of the WSMR significance model, we chose not to follow the Fort Bliss approach. Because the archaeology of WSMR is much less well known than that of Fort Bliss, we have taken a more conservative approach. Allowing resources to be considered significant even if they can only provide data on site function or technology will allow archaeologists to develop general models of human adaptation that can then be refined as more is learned.

We also have taken a conservative approach on the issue of "rarity." The 2009 Fort Bliss significance standards document (Miller et al. 2009) states that sites should not be considered eligible just because they are rare; they must meet all the same requirements for integrity, chronological potential, and analytical potential that any site must meet in order to be considered eligible. Of course, we agree that sites are more significant in terms of research potential when they can yield a greater quantity and diversity of information, but we are also mindful that sites of certain cultures are so rare that any evidence of their presence in the archaeological record should warrant management consideration.

Accordingly, as discussed in the Structure of the WSMR Significance Model section below, we have systematically coded sites with Paleoindian and Apache period components as having high data potential. If, in the future, a site with one of these component types will be adversely affected by an undertaking and if it turns out that that the site's integrity has been entirely compromised or that the Paleoindian or Apache "component" consists only of an isolated projectile point or is otherwise uninformative, then the management and treatment decision that no data recovery or other mitigation is warranted can be made.

Using Fort Bliss Significance Standards to Inform the WSMR Model

In the Fort Bliss procedures, once the first-tier decisions (integrity and chronometric potential) are made, then the issue of significance is addressed through time-period-specific data requirements. For ease of comparison and for convenient reference when the WSMR significance model is reevaluated or updated in the future, we quote the "data requirements" statements from Chapter 14 in Miller et al. (2009) below. If more than one set of data requirements is listed for a time period, it is because there are multiple themes discussed for the period, and we have indicated the theme in brackets at the end of the data-requirements line. Numbering of data requirements is as it appears in the original.

Paleoindian

Data Requirements/NRHP Eligibility Threshold

(1) Isolable Paleo-Indian chipped stone assemblage, including caches, debitage, and tools; and
(2) Sufficient sample counts for examination of subsamples of raw materials and quantitative analysis of flake and tool sizes; and
(3) Identification of specific regional and extra-regional raw material types

Early Archaic Period (6000 to 4000/3000 B.C.)

Data Requirements/NRHP Eligibility Threshold
(1) Isolable Early Archaic chipped stone assemblage, including debitage and tools, of sufficient sample size in a dateable context; and
(2) Identification of specific regional and extra-regional raw material types; and
(3) Ground stone and cookstone materials associated with the chipped stone assemblage

Middle Archaic Period

Data Requirements/NRHP Eligibility Threshold ***[Subsistence, Technology, Settlement Patterns]***
(1) A statistically quantifiable assemblage of chipped stone and/or ground stone items in unambiguous association with a feature or context securely dated to the Middle Archaic temporal interval through absolute (radiocarbon) or relative (projectile point styles) methods; and
(2) Presence of formal tools and projectile points; and/or
(3) Presence of associated thermal features or residential structures for comparative analysis of morphology and function

Data Requirements/NRHP Eligibility Threshold ***[Territorial Ranges, Extra-Territorial Contacts]***
(1) Sufficient sample sizes and raw material variability in chipped-stone tool and debitage assemblage; and
(2) Presence of formal tools and debitage

Data Requirements/NRHP Eligibility Threshold: ***[Settlement Organization, Projectile Technology]***
(1) Middle Archaic projectile points in association with a dateable feature and activity area

Late Archaic Period (1000 B.C. to A.D. 200/400) and
The Early Formative Period (A.D. 200/400 to 1150)

Data Requirements/NRHP Eligibility Threshold ***[Site Structure And Settlement Organization]***
(5) Presence of discrete activity areas associated with dateable features; and
(6) Ability to correlate activity areas via spatial and chronometric analyses; and
(7) Suitable surface artifact distributions for distributional plotting; or
(8) The presence of habitation structures and associated activity areas is needed for the study of . . . different technological and settlement aspects of sites with habitation structures versus those with more ephemeral or short-term residence

Data Requirements/NRHP Eligibility Threshold ***[Technological Response to Changing Subsistence Practices]***
(1) Artifact assemblages of sufficient sample counts in association with one or more dateable features or contexts; and
(2) One or more of the following attributes:

> *a.* Sufficient chipped stone sample counts for quantitative analysis of flake and tool sizes among subsamples of raw materials;
> *b.* Early El Paso brownware ceramics in association with dateable feature and in sufficient sample numbers for technological and functional analyses;

c. Ground stone items for quantitative analysis of size and type or qualitative analysis of recycled ground stone in dated features

Data Requirements/NRHP Eligibility Threshold ***[Decreasing Territorial Ranges/Exchange Relationship]***
(1) Presence of high numbers of obsidian artifacts and particularly projectile points; or
(2) Presence of rare or unusual items in secure context and associated with other material culture yielding corroborative territorial and social information; or
(3) Projectile points in unambiguous association with dateable contexts that, through stylistic, morphological, or chemical analysis may yield corroborative information on territorial mobility ranges and social interaction; or
(4) Identification of geochemical compositional groups among El Paso brownware and nonlocal ceramic assemblages

Mesilla Phase (A.D. 200/400 to 1100) and Early Doña Ana Phase (A.D. 1000 to 1150) Residential Occupations
Data Requirements/NRHP Eligibility Threshold ***[Settlement Structure and Site Formation]***
(1) Two or more residential structures with good integrity; and
(2) Evidence of stratification among cultural and natural deposits; and
(3) Presence of refuse deposits of good integrity

Data Requirements/NRHP Eligibility Threshold ***[Settlement Organization and Subsistence Economies]***
(1) Architectural structures with good integrity; and
(2) Preserved organic and refuse deposits for recovery of botanical and faunal material; and
(3) El Paso brownware ceramics in association with dateable contexts and in sufficient sample numbers for geochemical compositional analysis

Data Requirements/NRHP Eligibility Threshold ***[Technological Response to Changing Settlement and Subsistence Organization]***
(1) Artifact assemblages of sufficient sample counts in association with one or more dateable contexts; and
(2) One or more of the following:
a. Sufficient chipped stone sample counts for quantitative analysis of flake and tool variability among subsamples of raw materials;
b. El Paso brownware ceramics in association with dateable contexts and in sufficient sample numbers for technological and functional analyses;
c. One or more intact and dateable structures;
d. Ground-stone items for quantitative analysis of size and type

Low-Density/Low-Intensity Occupations of the Late Formative Period (Late Doña Ana Phase [A.D. 1150 to 1300] and El Paso Phase [A.D. 1300–1450])
Data Requirements/NRHP Eligibility Threshold ***[Extractive Technologies]***
(1) Suitable sample counts of artifacts for technological and compositional analysis in association with dateable features or contexts; and
(2) Morphological data on dated thermal features (associated with artifacts)

Data Requirements/NRHP Eligibility Threshold ***[Logistical Procurement Behaviors]***
(1) Presence of suitable sample counts of artifacts for technological and compositional analysis in association with a dateable context

Data Requirements/NRHP Eligibility Threshold ***[Logistical Procurement Behaviors – Mountains]***
(1) Presence of suitable sample counts of artifacts for technological and compositional analysis in association with a dateable context; or
(2) Presence of prehistoric mining or extractive tools (axes, mauls, hammerstones, other battered stones); presence of ritual paraphernalia (ceramics, projectile points, wood items, pigments, fossils); or
(3) Evidence of prehistoric mining or extraction activities such as adits or pits placed in mineral deposits as well as waste materials and debris

Data Requirements/NRHP Eligibility Threshold ***[Economic and Functional Role of Large Thermal Features]***
(1) Presence of one or more large burned thermal features with suitable integrity for subsistence analysis; and
(2) Suitable sample counts of artifacts in dateable contexts for technological and compositional analysis

Late Formative Residential Sites
Data Requirements/NRHP Eligibility Threshold ***[Responses to Environmental Risk]***
(1) Multiple contexts that can be dated chronometrically; and
(2) Well-preserved architectural features in association with extramural activity space and other features; and
(3) Artifact assemblages of sufficient counts and context for analysis of accumulations research models, technological organization, and chemical composition; and
(4) Well-preserved organic deposits, faunal remains, and large wood charcoal fragments

Data Requirements/NRHP Eligibility Threshold ***[Subsistence, Mobility, and Isolated Structural Sites]***
(1) Presence of one or two isolated residential structures (hut, pit house, formal pit room) with acceptable integrity; and
(2) Presence of associated artifacts in suitable sample numbers

Data Requirements/NRHP Eligibility Threshold ***[Social, Ritual, and Economic Interaction]***
(5) Statistically robust samples from secure contexts of non-local ceramics from general culture regions (e.g., Casas Grandes, western Mogollon, Chupadera Mesa); or
(6) Samples of turquoise (finished items or manufacturing debris); or
(7) Obsidian artifacts from secure contexts, or
(8) Statistically robust samples from secure contexts of marine shell; or
(9) Large sherds from non-local vessels in well-preserved contexts; or
(10) Unusual, exotic, or rare items of mineral, pigment, stone, fossil, or other items

Data Requirements/NRHP Eligibility Threshold ***[Ritual Performance And Social Organization]***
(1) Ritual contexts and deposits (caches, subfloor pits, special areas in rooms or sites); or
(2) Unusual and rare artifacts such as fossils, minerals, and pigments; or
(3) Rock art, ceramics, or other media with unequivocal evidence of ritual imagery; or
(4) Features, architectural forms, or other constructions indicating ritual use; or
(5) Evidence of shrines and other ritual use of certain landforms such as springs, hill and mountain tops, and rock shelters

Data Requirements/NRHP Eligibility Threshold ***[Subsistence and Subsistence Economies]***
(1) Well-preserved faunal remains in midden contexts; or

(2) Well-preserved wood collections of sufficient size for species and identification of heartwood and sapwood; or
(3) Presence of eggshell, special ritual contexts, or other contexts, items, or organic residues indicating the presence of plant or animal remains that were not used for food

Data Requirements/NRHP Eligibility Threshold ***[Technology]***
(1) Chipped stone assemblages of sufficient counts and spatial integrity; or
(2) Ceramic assemblages of sufficient counts and spatial integrity; or
(3) Ground stone assemblages of sufficient counts and spatial integrity (including sufficient numbers of whole specimens); or
(4) Presence of well-preserved burned rock earth ovens with associated organic deposits and artifact assemblages; or
(5) Presence of storage facilities; or
(6) Presence of water or soil control features; or
(7) Evidence of lapidary industries (note: evidence of manufacture, not just presence of finished items)

Clearly, with only computerized legacy data available for use in this significance model—especially given some of the limitations of those data, as discussed above—we could not hope to develop anything as detailed and nuanced as the Fort Bliss significance standards. An examination of the data requirements outlined above, though, quickly reveals some potentially useful patterns.

The clearest of the patterns is that for every time period, at least one, and often more than one, of the sets of data requirements includes the requirement "sufficient sample size." Regardless of the historic context, assemblage size matters. The definition of "sufficient" for sample size may vary, depending on the artifact type and the questions being addressed, but assemblage size is a quick way to roughly assess the potential of a site to yield some sort of useful data. There are many caveats that can be placed on this use of assemblage size. In general, though, assemblage size is a key indicator of the potential of a site to address a range of research issues.

Another pattern observable in the Fort Bliss data requirements concerns the importance of features on Archaic sites. Because of the long time span covered by the Archaic period lifeway, the presence of potentially datable features at an Archaic site is a key indicator of data potential. This is especially reflected in the Fort Bliss data requirements as they pertain to thermal features and structures.

Similarly, for the Formative (Mogollon) period, the Fort Bliss data requirements place special emphasis on the presence of structures and middens as well as nonlocal ceramics and well-preserved thermal features. We have tried, as demonstrated in the following section, to incorporate these patterns of data requirements into the WSMR significance model to the extent possible, both because we think they are important indicators of data potential for the sites in question and because we would like to make our approach at least minimally compatible with the Fort Bliss significance standards.

Structure of the WSMR Significance Model

What follows is a discussion of the choices and assumptions that formed the basis for the initial version of an archaeological significance model for previously recorded sites on WSMR. Because this model is simply a set of sorting algorithms for dividing a database of WSMR sites into categories by likely data potential (high, medium, and low), the choices and assumptions can easily be modified or changed completely as better computerized data or additional information from testing and excavation of sites on the installation becomes available. For each step in the modeling process, we provide a discussion and a simplified, plain-English version of the algorithms used for that sorting event or series of sorting events. The actual algorithms used to operationalize the choices and assumptions of the model are provided in Appendix B. The database of WSMR sites used to run the model is provided as Appendix C, and the results of the modeling effort—a list of LA numbers with data potential coded as high, medium, low, high cultural significance (see explanation below), or insufficient data—is provided as Appendix D. An initial test of the effectiveness of the model is discussed in a later section of this report.

First-Tier Sorting Rules

For reasons discussed above, we chose assemblage size as the basis for the first-tier sort in the WSMR significance model. This choice meant that we would have to use the NMCRIS rather than the WSMR database, a decision that we would probably have made in any case, because of the considerably greater number of WSMR sites recorded in NMCRIS and because of the linkage of features with components in NMCRIS. For the purposes of the model, we made the assumption that sites with assemblage size coded as thousands or tens of thousands have a high potential to inform us about the past, regardless of time period or historic context. Therefore, all sites with these values coded in the variable of "assemblage size" would be categorized as sites with high data potential. Sites with tens or hundreds of artifacts were assumed to require additional sorting on the basis of other variables, and sites with ones or zero values recorded in the "assemblage size" variable were assumed to have low data potential.

There are three problems, however, with using assemblage size as the basis for our initial sorting rule. The first problem has to do with the data-gap issue discussed earlier: a very high proportion of the WSMR sites in NMCRIS do not have assemblage size recorded in the database, although this information is easily available on the site forms. Based on our experience of pulling and coding a sample of the sites with missing assemblage-size data, we asked ERDC-CERL for permission to expand our scope of work to include acquiring and coding the missing assemblage-size data for the WSMR sites in NMCRIS. The results of this effort are discussed in the Model Results section below.

The second problem has to do with the rarity issue, also discussed earlier. Paleoindian and Apache sites or components of sites are very rare, and there is much still to be learned about both of these culture types from the archaeological record. Even a very modest amount of new information about these adaptations could be extremely important. Sites of both cultural types frequently have very few artifacts, however, and using assemblage size as our first sorting variable would tend to sort most of them into the low-data-potential category.

Once a site has a code entered under the variable of "site data potential" as a result of the application of a sorting rule, the site is removed from further consideration during the application of further sorting rules. For this reason, we created a sorting rule to classify rare site types that is applied before the assemblage-size rule. In this first sort, we make the assumption that all sites coded as having a Paleoindian or an Apache component should be categorized as having high data potential. As noted above, that potential may not be realized if the condition of the site is very poor or if the Paleoindian or Apache designation turns out to be based on unassociated artifacts, but these are issues that should be addressed at the management or treatment level rather than at the significance level.

The third problem with making assemblage size our first-tier sorting variable has to do with site types or features that have religious and cultural significance to Indian tribes. In the case of WSMR, the known examples of this are sites with pictographs, petroglyphs, shrines, or burials. These features will almost always have a 0 or 1s value in the "assemblage size" variable, but their non-data-related significance must be recognized. To accomplish this, we created a rule for culturally sensitive sites; this rule is also applied before the assemblage-size rule. The second sort rule characterizes all sites with petroglyph, pictograph, shrine, or burial/grave features as having high cultural significance. Whatever the data potential of these sites might be, they should be managed with that cultural significance as a major determining factor.

Once these two special cases had been dealt with, we were ready to apply the assemblage-size rule for the third sort. As stated above, sites with thousands or tens of thousands of artifacts are identified as having high data potential in the third sort, and sites coded as having artifacts numbered in the ones or tens are identified as having low data potential. Sites lacking assemblage-size data in this third sort are identified as having insufficient data. Sites not identified as a result of this sort as having either high or low data potential or insufficient data are subjected to further sorts, based on component information.

In simplified language, the first three steps in the sorting process can be envisioned as follows:

First Sort—*assigns site data potential to sites containing rare component types and removes these sites from the sorting process before the assemblage-size cut offs*

For all sites where site data potential = [blank]:

If any component culture type = Apache, **then** site data potential = high.

If any component culture type = Paleoindian, **then** site data potential = high.

Second Sort—*assigns sites with special cultural and religious significance to Indian tribes to a special management category*

For all sites where site data potential = [blank]:

If any component feature type = petroglyph **or** pictograph **or** shrine **or** burial/grave, **then** site data potential = high cultural significance.

Third Sort—*assigns site data potential to tiny and huge sites and removes them from the sorting process, leaving the "assemblage size = 10s or 100s" sites for further sorting*

For all sites where site data potential = [blank]:

If site assemblage size = 0 ***or*** site assemblage size = 1s, **then** site data potential = low.

If site assemblage size = 1000s ***or*** site assemblage size = 10,000s, **then** site data potential = high.

If site assemblage size = [unknown], **then** site data potential = insufficient data.

Once the first-tier rules (sorts one through three) have addressed special cases and made the rough sort based on assemblage size, we are ready to develop culture-type- and time-period-specific sorting rules for the sites in the tens and hundreds assemblage-size categories. In moving to this part of the modeling process, we shift from a consideration of sites as a whole to a consideration of individual site components, because it is the components that are coded for culture type and time period in NMCRIS. Associated features are also coded at the component level.

Because determinations of site significance (and management decisions) must be made at the site level, the sorting rules for the various culture and time combinations assign the components to "**component** data potential" categories. The final sorting step in the model then examines the "component data potential" assignments for all the components at a site and assigns the highest of those component scores as the "**site** data potential" value for the site. Any component that does not meet the requirements of any of the sorting rules for its culture type (e.g., Archaic or Mogollon) will have no value entered into the "component data potential" field. If the final site-data-potential rule encounters no value in the "component data potential" field for any of the components at the site, it will assign the site to the "low site data potential" category.

Archaic Period Components

Sites of the Early and Middle Archaic time periods are relatively rare on the installation (n = 47 and n = 102 out of 849 total Archaic period components in NMCRIS), and not a great deal is known about them. Based on this rarity, we made the assumption in the fourth sort that any Archaic period component assigned to a purely Early Archaic time period, a purely Middle Archaic time period, or mixed Early and

Middle Archaic time periods would be assigned to the "high component data potential" category. A mix of Early through Late Archaic time periods for a single component or a mix of Middle and Late Archaic time periods would be assigned to the "medium component data potential" category.

For Late Archaic period components, which are much more common and better known, there must be either one or more associated features OR a site-assemblage size in the hundreds for the component to be placed in the "high component data potential" category. Archaic period components whose time period is unspecified (presumably components that are judged to be Archaic period based on lithic technology but that lack diagnostic projectile points) must have both one or more associated features AND a site-assemblage size in the hundreds to be placed in the "high component data potential" category.

Thus the fourth-sort rules look like this:

Fourth Sort—*assigns Archaic period components of sites where assemblage size = 10s or 100s to **component-based** data-potential categories. The rules for this sort assign high and medium values; a component that does not meet any of the requirements in the rules is automatically considered to have low component data potential. The sites of which these components are a part remain in future sorts so that other site components can be assigned to a component-based data-potential category. In the final step of the model, these component-data-potential assignments are used to sort the sites into **site**-data-potential categories.*

For all sites where site data potential = [blank]:

If culture type = Archaic
 and early period = Early Archaic
 and late period = Early Archaic, **then** component data potential = high.
If culture type = Archaic
 and early period = Early Archaic
 and late period = Middle Archaic, **then** component data potential = high.
If culture type = Archaic
 and early period = Early Archaic
 and late period = Late Archaic, **then** component data potential = medium.
If culture type = Archaic
 and early period = Middle Archaic
 and late period = Middle Archaic, **then** component data potential = high.
If culture type = Archaic
 and early period = Middle Archaic
 and late period = Late Archaic, **then** component data potential = medium.
If culture type = Archaic
 and early period = Late Archaic
 and number of observed features ≥ 0[1]
 or site assemblage size = 100s, **then** data potential = high.
If culture type = Archaic[2]
 and early period = unspecified
 and number of observed features ≥ 0
 and site assemblage size = 100s, **then** component data potential = medium.

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[1] In the NMCRIS database, if only presence/absence data are available for features associated with a component, the "no_obs" column shows a 0; if there are no reported features, the "no_obs" column is blank.

[2] All Archaic period and other culture-specific components not meeting the conditions set by the various if/then statements will have a blank in the "component data potential" variable and will not contribute to the derivation of site data potential.

Mogollon Components

The Fort Bliss significance standards divide the historic contexts for the Formative period archaeological record on that installation into an early period, the Mesilla and early Doña Ana phases, and a late period, late Doña Ana and El Paso phases. Although the WSMR data in NMCRIS are not uniformly coded by these phase names, we can substitute the period-of-occupation codes from NMCRIS. The Early Pithouse and Late Pithouse periods (A.D. 200–1100) largely correspond with the early period at Fort Bliss, and the Early Pueblo and Late Pueblo periods (A.D. 1100–1400) largely correspond with the late period at Fort Bliss. NMCRIS contains 381 WSMR components from the Early and Late Pithouse periods and 439 components from the Early and Late Pueblo periods. There are also 139 Mogollon components that span all or part of both the Pithouse and Pueblo periods and 588 Mogollon components for which the occupation periods are "unspecified" and the date range is shown as A.D. 200–1400.

The Fort Bliss data requirements also divide the Formative period archaeological record into residential and nonresidential sites. We examined the possibility of dividing our data-potential evaluations into residential and nonresidential, as well, but the number of residential features associated with Formative period components in the NMCRIS database is small; so, we chose to evaluate all components with features together. In future iterations of the significance model, it would be easy to alter the sorting rules to give greater weight to components with residential features if the installation wishes to do so.

More than half of all components that can be assigned to a culture type are Mogollon, and nearly half of all Mogollon components could not be assigned to a period of occupation. We assumed that for Mogollon components that were assignable to a single period (Pithouse or Pueblo) and that had features, data potential would be high. For Mogollon components assignable to a period but lacking features, if the component was part of a site with an assemblage size in the hundreds of artifacts, we assigned the component a medium data potential. It is possible, of course, that the hundreds of artifacts at a site might relate to a different component and not to the Mogollon occupation at all. In future iterations of the model, the installation may choose to omit this sorting rule and adopt a more conservative approach.

Components that could not be assigned to an occupation period but did have associated features were assumed to have a lower data potential than components with an occupation period *and* features, but this may be too conservative, given that a number of these components are coded as having residential features. On the other hand, these could be coding errors; if the component has a room block, why would it not be assigned to the Pueblo period? By giving these components a "medium component data potential" score, we can assure that they are considered further in the future. This value-assignment decision may help to account for the high proportion of medium-data-potential sites that are recorded as having been found eligible for listing in the NRHP in NMCRIS and/or the WSMR database (see the discussion of model evaluation below).

Given these assumptions, the sorting rules for Mogollon components are as follows:

Fifth Sort—*assigns Mogollon components from sites where assemblage size = 10s or 100s to* ***component-based*** *data-potential categories. The rules assign high and medium values; a component that does not meet any of the requirements in the rules is automatically considered to have low component data potential. The sites of which these components are a part remain in future sorts so that other site components can be assigned to a component-based data-potential category. In the final step of the model, these component-data-potential assignments are used to sort the sites into* ***site****-data-potential categories.*

If culture type = Mogollon **and** early period = Early Pithouse **or** Late Pithouse
and late period = Early Pithouse **or** Late Pithouse
and number of features observed ≥ 0, **then** component data potential = high.
If culture type = Mogollon **and** early period = Early Pithouse **or** Late Pithouse
and late period = Early Pithouse **or** Late Pithouse
and number of features observed = [blank]

and site assemblage size = 100s, **then** component data potential = medium.

If culture type = Mogollon **and** early period = Early Pueblo **or** Late Pueblo
and late period = Early Pueblo **or** Late Pueblo
and number of features observed ≥ 0, **then** component data potential = high.

If culture type = Mogollon **and** early period = Early Pueblo **or** Late Pueblo
and late period = Early Pueblo **or** Late Pueblo
and number of features observed = [blank]
and site assemblage size = 100s, **then** component data potential = medium.

If culture type = Mogollon **and** early period = Early Pithouse or Late Pithouse
and late period = Early Pueblo or Late Pueblo
and number of features observed ≥ 0, **then** component data potential = medium.

If culture type = Mogollon **and** early period = Unspecified Jornada Mogollon **or** Unspecified Mimbres Mogollon
and number of features observed ≥ 0, **then** component data potential = medium.

Anasazi and Mixed Anasazi/Mogollon Components

There is no mention of Anasazi or mixed Anasazi/Mogollon components in the Fort Bliss significance standards, which is not surprising, given the location of the installation. There are 86 such components in the NMCRIS database for WSMR; 28 components are recorded as Anasazi, and the rest, as mixed. The nature of the interface between these two archaeological traditions is a subject of broad interest in New Mexico archaeology, and the northern part of the installation occupies a substantial part of the "borderlands" between the two.

The Anasazi components largely reflect seasonal activities; most of them have no features, a few have hearths (and one has multiple hearths), and only one Anasazi component has any indication of a structure—a mound with the note, "possible jacal." There are no early Anasazi components (Basketmaker or Pueblo I), but the full range of Anasazi temporal components from Pueblo II to Spanish contact are represented.

The Mixed Anasazi/Mogollon components cover a longer time range. There are a number of early components (Basketmake III and Pueblo I/Early Pithouse) and the full range of later time periods, as well (Pueblo II/Late Pithouse through Pueblo IV/Late Pueblo). These mixed components also reflect more intensive use of the area; 36 of 58 components have features, and at least 10 of them are coded as having structures.

Although Anasazi and Mixed Anasazi/Mogollon components would seem to fit the "rarity" criterion, this is largely a function of geography; WSMR is at the extreme southern edge of the prehistoric pueblo range. The distribution of Mogollon and Anasazi sites and components is described in the installation's Integrated Cultural Resource Management Plan and repeated in Ackerly et al. (2010:17) as follows:

> Most Formative period material culture on White Sands Missile Range is referred to as the Southern Branch of the Jornada Mogollon or the Northern Branch of the Jornada Mogollon. However, elements of the Western Mogollon (Mimbres) and Anasazi or Ancestral Piro material cultures also are present. These archeologically defined groups overlap temporally and spatially. The Southern Branch of the Jornada Mogollon includes most of the southern half of the range south of the Carrizozo Lava Flow or *Malpais*. The Northern Branch of the Jornada Mogollon includes the northeastern portion of the range east of the *Malpais*. The Mimbres Mogollon extends from the Rio Grande across the Jornada del Muerto and the southern San Andres Mountains into the Tularosa Basin. The Ancestral Piro utilized the northwestern and extreme north-central portions of the range.

Given this distribution, the relative rarity of Anasazi and Mixed Anasazi/Mogollon remains may also be a result of differential intensity of modern activities (and the resultant archaeological surveys) between the northernmost reaches of the installation, where sites of this type would occur, and the rest of WSMR.

Given the limited nature of the Anasazi components, their data potential is not likely to be high. The components with features, however, could potentially contribute to our understanding of the nature of this relatively little-known use of the northern part of the range; so, we have assigned a medium component data potential to Anasazi components with features. This value-assignment decision may help to account for the high proportion of medium-data-potential sites that are recorded as having been found eligible for listing in the NRHP in NMCRIS and/or the WSMR database (see the discussion of model evaluation below).

The Mixed Anasazi/Mogollon components, on the other hand, not only have the structures and features that constitute very likely sources of significant data, as described in the Mogollon Components section above, but also may be able to inform us about the nature of Anasazi/Mogollon interaction in this borderland/frontier setting. For this reason, the components with features are scored as having high data potential, and the components without features are scored as medium. This is another area where the installation may wish to adopt a more conservative approach in future versions of the model.

Sixth Sort—*assigns Anasazi and Mixed Anasazi/Mogollon components from sites where assemblage size = 10s or 100s to* ***component-based*** *data-potential categories. The rules assign high and medium values; a component that does not meet any of the requirements in the rules is automatically considered to have low component data potential. The sites of which these components are a part remain in future sorts so that other site components can be assigned to a component-based data-potential category. In the final step of the model, these component-data-potential assignments are used to sort the sites into* ***site****-data-potential categories.*

For all sites where site data potential = [blank]:
If culture type = Anasazi
and number of observed features ≥ 0, **then** component data potential = medium.
If culture type = Mixed Anasazi/Mogollon
and number observed features ≥ 0, **then** component data potential = high.
If culture type = Mixed Anasazi/Mogollon
and number observed features = [blank], **then** component data potential = medium.

Historical-Period Components

Neither the Fort Bliss significance standards nor this model addresses historical-period sites or components. The sites that date entirely to the historical period were excluded from the modeling database, but sites with both prehistoric and historical-period components are included in that database. The seventh-sort rules were written to specifically exclude the component data potential of historical-period components from consideration in deriving the overall site data potential for the sites of which they are a part. These rules, which assign a “not applicable” component-data-potential score to historical-period components, were added only to make clear the way in which historical-period components of multicomponent sites were treated. They are not needed for the purpose of the model. If we had simply not assigned any component-data-potential value to these historical-period components, the outcome would have been the same. These components would not influence the site-data-potential determination for the sites of which they are a part, because this model is specific to prehistoric components and sites.

Seventh Sort—*removes historical-period components of sites where assemblage size = 10s or 100s from consideration in the process of determining the site data potential for those sites.*

For all sites where site data potential = [blank]:

If culture type = Anglo, **then** component data potential = N/A.

If culture type = Unknown

and early period = Unspecified/Other Historic, **then** component data potential = N/A.

Unknown Components

The 3,445 sites in the NMCRIS database comprise a total of 4,631 components. For 1,731 of these components, culture type is coded as "Unknown" (n = 1,644) or "Unknown Aboriginal" (n = 87) in the "culture type" variable. Of the Unknown, 41 are coded as historical period, and these are removed from the set of Unknown components through application of the seventh-sort rules, leaving a total of 1,690 prehistoric Unknown components. Because there are no clear differences between the prehistoric Unknown and Unknown Aboriginal components in component types or feature types represented, we have treated these two classes of components as a single type for the purposes of the model.

Only 416 of the prehistoric Unknown components have features associated with them (and in at least 5 cases, the type of feature recorded indicates that the component should have been coded "Anglo" or "Unknown historic" and not as "prehistoric Unknown"). All 1,274 of the other Unknowns show simply "artifact scatter" or "unknown" in the "component type" variable. As shown below, we have proposed that the Unknown components with features be sorted into the "medium component data potential" category, which leaves all the other Unknowns blank or, de facto, in the low-potential category. We considered applying the "if the site assemblage size is 100s" rule to move some of the Unknown components without features into the medium category, but if the component could not be assigned to any temporal category on the basis of the surface artifacts, it does not seem likely that it would matter whether there were tens of them or hundreds. This is one of the assumptions of the model that could be altered in future iterations.

Eighth Sort—*assigns prehistoric Unknown components from sites where assemblage size = 10s or 100s to* ***component-based*** *data-potential categories. The rules assign medium values; a component that does not meet any of the requirements in the rules is automatically considered to have low component data potential. The sites of which these components are a part remain in future sorts so that other site components can be assigned to a component-based data-potential category. In the final step of the model, these component-data-potential assignments are used to sort the sites into* ***site****-data-potential categories.*

For all sites where site data potential = [blank]:

If culture type = Unknown

and early period = Unknown **or** Unspecific/Other Prehistoric

and number of features observed ≥ 0, **then** component data potential = medium.

If culture type = Unknown Aboriginal

and number of features observed ≥ 0, **then** component data potential = medium.

Deriving Site Data Potential from Component-Data-Potential Values

The final step in the modeling process is to use the component-data-potential categories derived from the previous steps to assign a site-data-potential category to the remaining uncategorized sites. Although it might seem that the way to accomplish this would be to add up the scores for all the components at a site and divide the total by the number of components, this is actually not the right way to go about the task. The purpose of the model is to help guide management of archaeological **sites**, and each site must be managed for the potential of its highest component data potential, regardless of whether there are other components and regardless of the data potential of those other components. If we have a Middle Archaic period component with high data potential, for example, the **site** has to be managed in a way that takes into account the data potential of that component, even if the site also contains a component of some other period with low data potential.

For this reason, the final sort takes each site that does not yet have a site-data-potential assignment and examines each of the site's components in turn, looking first for high component-data-potential scores and then for medium scores. If a component with a high score is found, the site is assigned a data-potential score of "high," and the scores of the other components are not considered. The next rule is then applied to the remaining sites, and if a component with a medium score is found, the site is assigned a "medium" site-data-potential score. The final rule identifies all the sites that still do not have a value (high, medium, low, insufficient data (i.e., no assemblage-size information), or high cultural significance) in the "site data potential" variable and assigns them the value "low" for site data potential.

Ninth Sort—*assigns site data potential based on an evaluation of the component-data-potential scores derived in previous steps in the model.*

For all sites where site data potential = [blank]:

If any component data potential = high, **then** site data potential = high.
If any component data potential = medium, **then** site data potential = medium.
If site data potential = [blank], **then** site data potential = low.

Implementing the Model

As noted earlier, archaeological data drawn from NMCRIS were chosen to serve as the raw inputs for the significance sorting process. As also noted, each site record in NMCRIS is associated with one or more archaeological components, each indicating the presence of materials associated with a particular time period and/or cultural affiliation at the site. Although some site attributes, such as total assemblage size, site area, and depositional environment, pertain to the site as a whole, other attributes, including feature types and counts as well as temporal and cultural affiliation, are linked to individual components. As a result, NMCRIS data were compiled into two separate Microsoft Access queries. The first of these queries summarizes attributes that occur at the component level. This query appears in Appendix C as "qry_NMCRISsites_ComponentDataSummary." The second query appears in Appendix C as "qry_NMCRISsites_SiteAssemblageDetails" and summarizes data for site-level attributes.

Once the sorting rules (see Appendix B) had been developed, they were implemented as a series of additional queries in Microsoft Access directed at the two data-summary queries. Each sorting rule was represented as a query, and each subsequent sorting-rule query was based upon previous query results. The results of the final sorting query are presented in Appendix D. The first results table, "qry_Components," contains a "component data potential" designation for each individual site component; multicomponent sites are therefore represented by multiple data-potential records. Next, the "component data potential" designations were grouped by site. In this process, the highest "component data potential" score (highest to lowest: high cultural significance, high, medium, low, and insufficient data) for any individual site component determines the "site data potential" score for the whole site. The individual component data were collapsed into single fields in the final site results (see "qry_Sites_011312," in Appendix D).

In order for the model to be most effective as a management tool for WSMR, it was important that the data be as complete as possible. As noted earlier, SRI requested permission from ERDC-CERL to expand the project scope of work to include examination of the paper records at ARMS and collection of the missing assemblage-size data for the WSMR sites. Permission was granted in late December 2011, but when the site forms were pulled and coded, we found that 1,752 sites still did not have assemblage-size information. Nearly all of these sites (n = 1,613) have LA numbers in the 62,000–64,000 range.

It appears that most of these sites with missing assemblage data were identified during two very large projects in the 1980s: the Border Star 85 survey (Seaman et al. 1988) and the surveys carried out prior to the ground-based free-electron laser project (GBFEL-TIE) (Anschuetz et al. 1990). These surveys employed a “nonsite” approach in which all cultural materials in systematically defined transects were recorded individually as they were encountered on the landscape, with no effort made to group artifacts and features into the artificial constructs that archaeologists call “sites.” Although it is unquestionably true that this approach creates an archaeological landscape that more closely approximates the way humans use, perceive, and interact with their surroundings, the resultant data could only be analyzed at the scale of the landscape. For both analytical and CRM purposes, it was necessary to use cluster analysis and other methods to identify concentrations of cultural materials that could then be subjected to comparative analyses and managed as part of the installation’s compliance with Section 106 and the NEPA. Unfortunately, as our data-gathering efforts at ARMS revealed, the process of creating “sites” as management units did not include development of LA site forms with assemblage-size information. Also unfortunately, by the time we discovered this gap in the data, there was insufficient time to solve the problem, either by redesigning the model or by gathering additional data.

It should be possible to improve this situation in the future. The Border Star 85 and GBFEL-TIE raw data still exist, although not (as far as we have been able to determine) in any digital form. They may, in fact, only be available as microfiche. It very likely would be possible to find and code assemblage-size data for the analytically created sites from these two projects, but it is not possible, without some further investigation, to determine how large an effort would be required.

Alternatively, it might be possible to design a new significance model that would not require assemblage-size data or would not make this variable such a prominent feature of the sorting algorithms. It would be difficult, however, to create an effective model without using assemblage size as a variable, given the small number of systematically available categories of information. The current model is nearly entirely dependent on assemblage size and presence/absence of features for its sorting rules. Additionally, even without revamping the model completely, the “insufficient data” sites that include features (n = 384) could probably be sorted into component- and site-data-potential categories using the rules in sorts four through eight without introducing too many anomalous results.

Modeling Results

Because of the problem with the Border Star 85 and GBFEL-TIE data, we were only able to sort 1,693 of the WSMR sites in NMCRIS into site-data-potential categories (the remaining 1,752 sites have no assemblage-size data). This is a very substantial sample, however, and it is more than sufficient to permit us to develop, test, and evaluate the potential of this technique for creating consistent, replicable assessments of site data potential using legacy data.

Table 4.1 shows the results of the model as currently designed. Figures 4.1–4.4 show the distribution of sites across the range according to their significance categories. An obvious implication of these maps is that although sites of all significance categories are distributed across the installation, sites also tend to cluster spatially according to significance. As discussed in the section covering management applications below, this clustering could be used for planning purposes to identify specific areas of the installation where sites tend to be of either high or low significance. The maps also indicate that, based on the current modeling rules, sites with high cultural significance tend to be located in close proximity to the mountains, another important consideration for planning. The dense clustering of gray symbols in the southeastern corners of Figures 4.1 and 4.2 confirms our conclusion that the high proportion of "insufficient

Table 4.1. WSMR Sites in NMCRIS Coded by Site Data Potential

Data Potential	Number of Sites
High	483
Medium	279
Low	907
High cultural significance	24
Insufficient data	1,752
Total	3,445

Key: NMCRIS = New Mexico Cultural Resources Information System; WSMR = White Sands Missile Range.

data" sites in NMCRIS is largely a result of the Border Star 85 and GBFEL-TIE projects, which were located in that area.

One of the questions that we examined in interpreting the model results was how the sites that sorted as “high cultural significance” would have been coded had we not created this special management category. In other words, how would these sites have been coded if significance were assessed using only the model rules and the high, medium, and low data-potential categories? Because these sites, by definition, have features (i.e., petroglyphs, pictographs, shrines, or burials), most would have been in the high or medium data-potential categories. Of the 24 sites coded as “high cultural significance,” 14 would have been coded as “high data potential” because they have a large number of artifacts, because one of the components was coded Apache, or because they are Archaic period sites at which, based on the rules for sorting Archaic period components, the presence of features caused a component to be sorted into the “high data potential” category. Four other sites would have been sorted into “medium data potential,” again because of the presence of features, and 2 would have been sorted into “low data potential” because they have assemblages sizes coded as 0 or 1s. The remaining 4 sites would have been coded “insufficient data” because they have no assemblage-size information.

Table 4.2 provides information on the component-data-potential values assigned by the model to components of the various culture types. Approximately 25 percent of the Archaic period components, 44 percent of the Mogollon components, and 66 percent of the Unknown components come from sites for which there is no assemblage-size data. Table 4.3 shows the percentages of components typed high, medium, and low in potential, for those sites where assemblage size is known.

Evaluating the Model

In assessing the performance of the model, the site- and component-data-potential information displayed in Tables 4.1–4.3 can be examined to determine whether the results seem reasonable—that is, whether they seem to comport with our knowledge of the WSMR archaeological record. If they do, then the sorting rules in the model can be assumed to yield a useful management tool for the purposes discussed in the section covering management applications below. If the results seem skewed in one way or another, the sorting rules can be adjusted to yield more generous or more conservative estimates of site or component data potential, and the model can be run again.

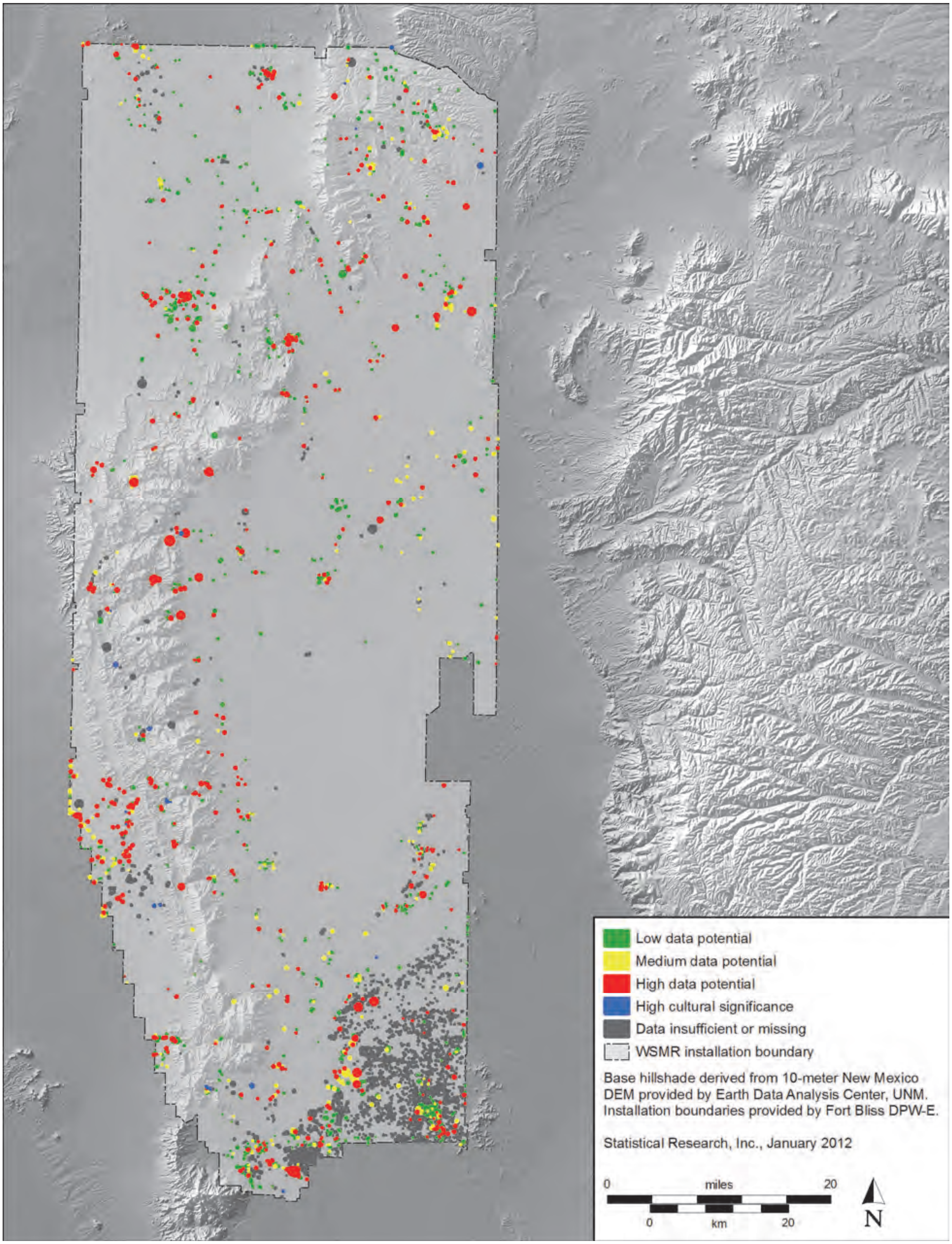

Figure 4.1. The distribution of recorded sites on WSMR, by significance category.

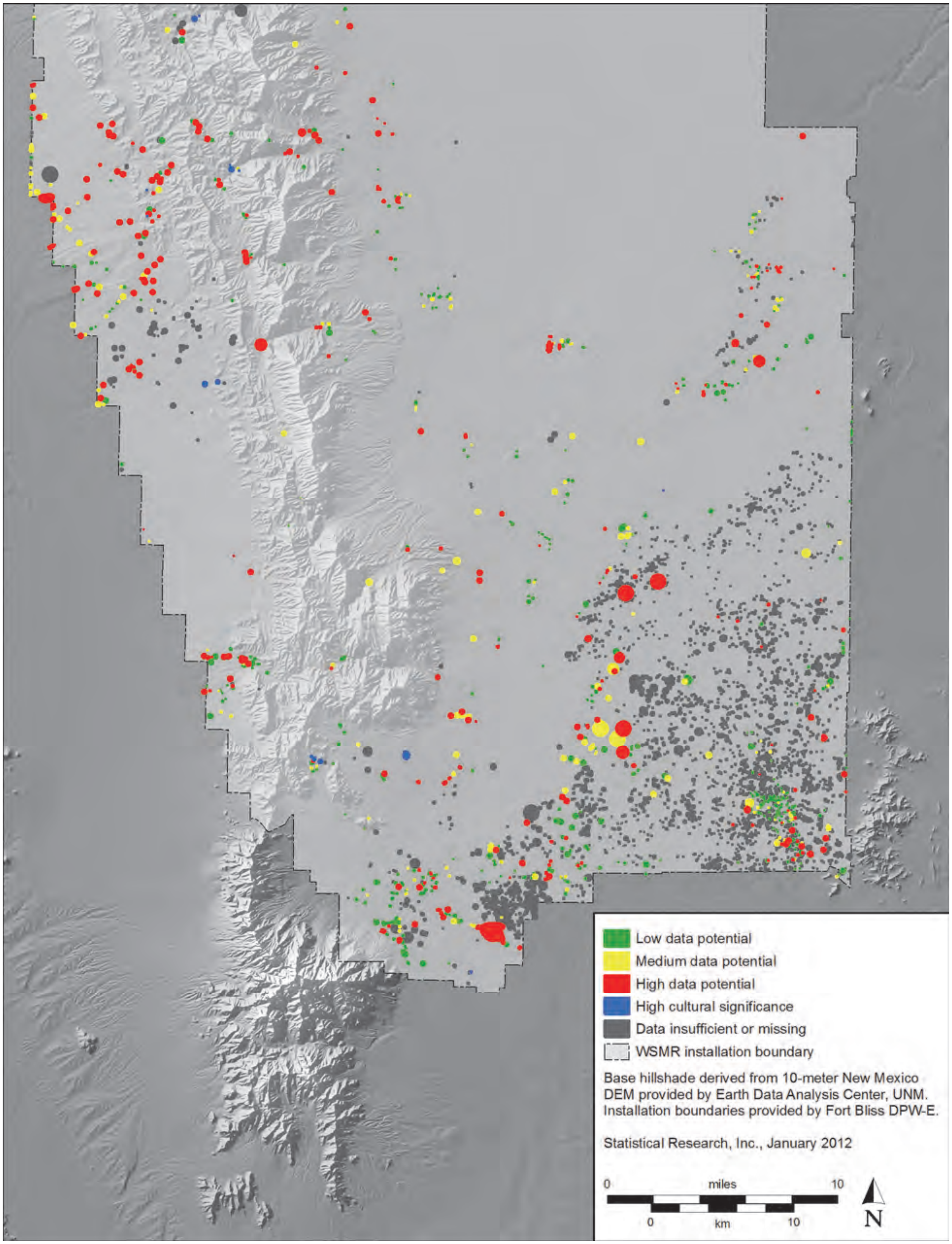

Figure 4.2. The distribution of recorded sites in the southern portion of WSMR, by significance category.

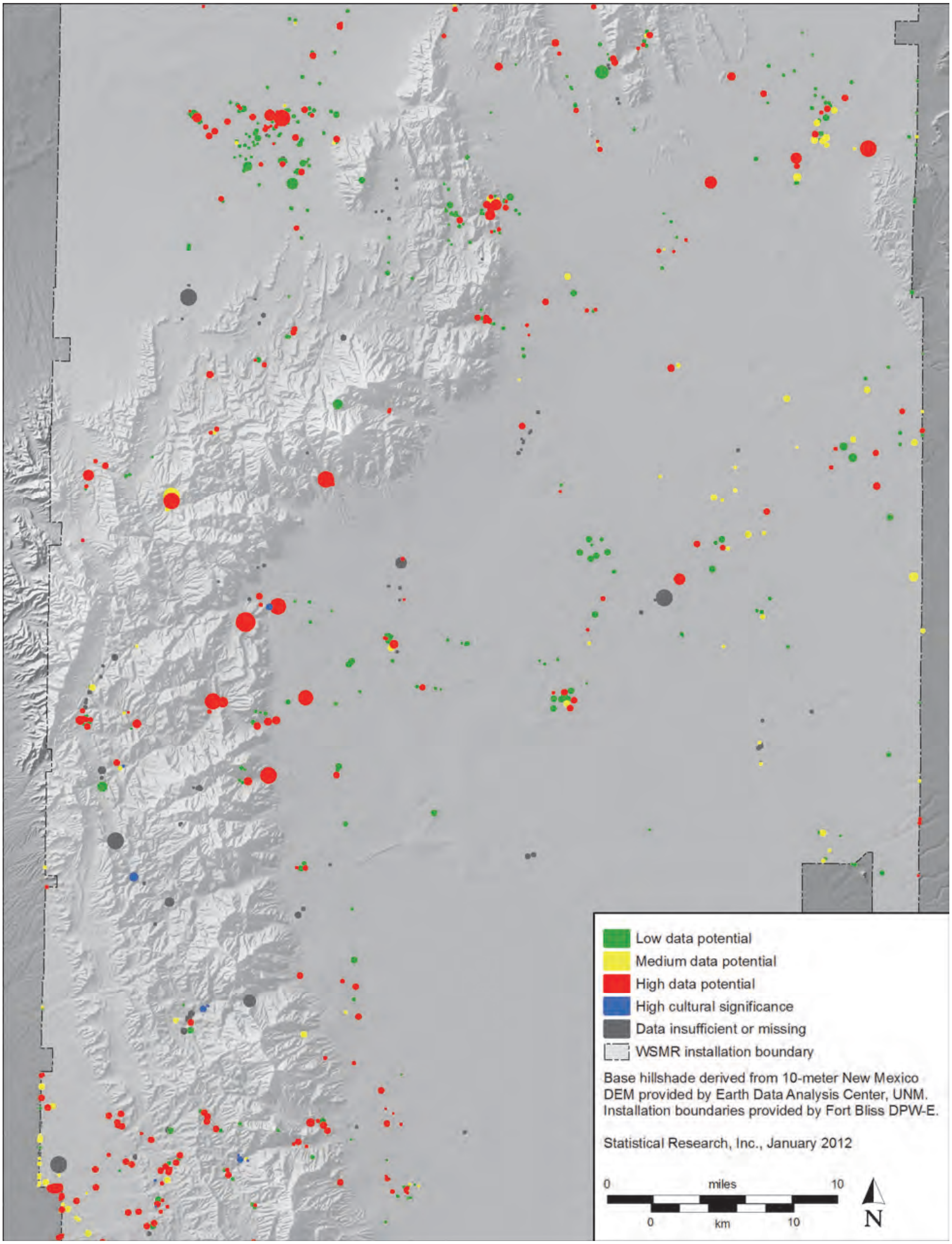

Figure 4.3. The distribution of recorded sites in the central portion of WSMR, by significance category.

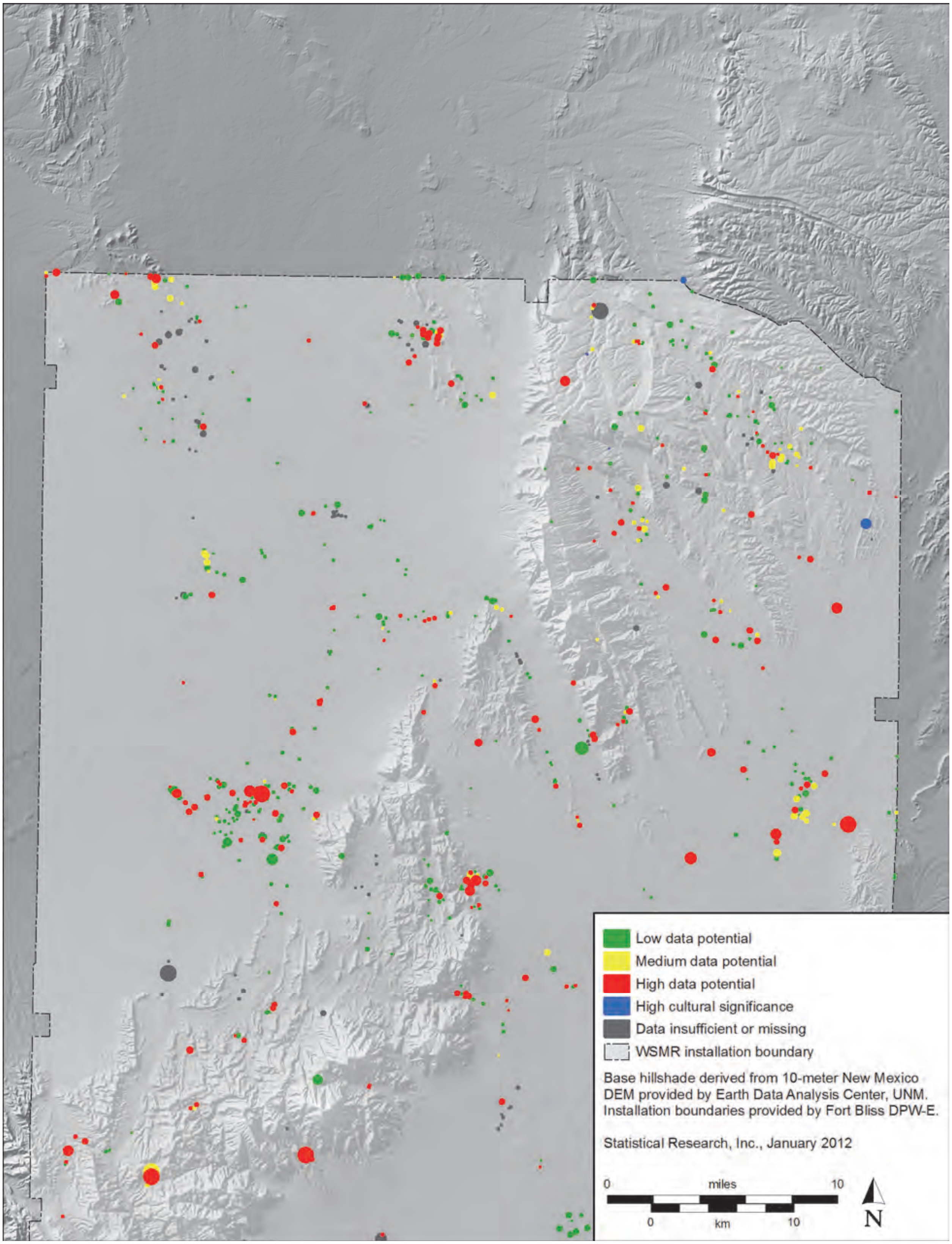

Figure 4.4. The distribution of recorded sites in the northern portion of WSMR, by significance category.

Table 4.2. WSMR Components in NMCRIS Coded by Component Data Potential

Culture Type	High Potential	Medium Potential	Low Potential	High Cultural Significance	Insufficient Data	Total
Paleoindian	66	—	—	—	—	66
Archaic	325	65	245	6	208	849
Anasazi	2	5	18	—	3	28
Mixed Anasazi/ Mogollon	34	17	3	3	1	58
Mogollon	307	216	321	18	684	1,546
Apache	12	—	—	—	—	12
Unknown	17	66	469	5	1,087	1,644
Unknown/aboriginal	3	27	55	—	2	87
Total	766	396	1,111	32	1,985	4,290[a]

Key: NMCRIS = New Mexico Cultural Resources Information System; WSMR = White Sands Missile Range.
[a]The remaining 341 components in the database are post-Euroamerican contact and were not considered during the modeling process.

Table 4.3. WSMR Components in NMCRIS, Percentage by Culture Type and Component Data Potential

Culture Type	High Potential (%)	Medium Potential (%)	Low Potential (%)
Paleoindian	100		
Archaic	51	10	39
Anasazi	8	20	72
Mixed Anasazi/Mogollon	63	31	6
Mogollon	36	26	38
Apache	100		
Unknown	3	12	85
Unknown/aboriginal	3	32	65

Key: NMCRIS = New Mexico Cultural Resources Information System; WSMR = White Sands Missile Range.

One way to assess the “reasonableness” of the sorting results is to look for internal consistency. The set of results for a particular culture type can be partitioned based on criteria that should not affect the data-potential outcome, and the resultant sets can be compared with one another. For example, Archaic period components with odd site numbers and Archaic period components with even site numbers should not be statistically different. To assess internal consistency, then, we used odd and even LA numbers to divide the Archaic period components that could be assigned to “high,” “medium,” or “low component data potential” into two groups. We found that the odd-numbered group comprises 320 components, 54 percent of them assigned a high component-data-potential value, 9 percent of them a medium value, and 37 percent a low value. The even-numbered group consists of 315 components, of which 48 percent were assigned a high data-potential value, 11 percent a medium value, and 41 percent a low value.

Data Potential	Odd LA numbers	Even LA numbers	Total
High	174	151	325
Medium	29	36	65
Low	117	128	245
Total	320	315	635

Using a simple chi-square test to assess the distribution of values, we found that the chi-square statistic is 2.84 and the degree of freedom is 2, resulting in a *p* value of .2417, meaning that differences between the two samples in the distribution of data-potential results are insignificant. Other odd-/even-group tests yielded similar statistically insignificant results.

At first, this may seem like an obvious outcome. The rules are very specific and mechanical; if we apply them uniformly to components of the same type from the same area, we would expect very similar results. This proved not to be the case, however, when we divided the Archaic period components into two other mechanically selected groups by LA number, this time dividing the whole set of LA numbers in half and creating a "low-number" group and a "high-number" group. The low-number group consisted of LA numbers lower than or equal to LA 72,100, and the high-number group comprised site numbers higher than LA 72,100. Because site numbers are assigned sequentially, the first set of numbers was given to sites recorded earlier in time than the second set, but the groups would not be expected to be archaeologically or environmentally different from one another. When we looked at the percentages for these groups, we found that of the low-number group (n = 224 components), 33 percent of the components were coded as having high data potential, 10 percent as having medium data potential, and 57 percent as having low data potential. Of the components with the higher LA numbers (n = 411), in contrast, 61 percent were coded as having high data potential, 10 percent as having medium data potential, and 29 percent as having low data potential.

The Archaic period components themselves should not be different from one another just because some were recorded earlier in time than others. Possible explanations for this difference between the lower-number and higher-number groups include changes in recording procedures through time, the effects of having most of the "insufficient data" sites in the "lower" LA number group (thus greatly reducing the sample size and increasing the potential for skewing), and changing perceptions of the Archaic period archaeological record through time.

To examine the first two possible explanations, we divided the Mogollon components into the same low-number/high-number groups. The low-number group again had most of the "insufficient data" sites in it, and Mogollon components in both groups would have been subject to any changes in recording procedures that affected Archaic period components in these two groups. In this case, however, 36 percent of the lower-number group of Mogollon components (n = 256) were coded as having high data potential, 30 percent as having medium data potential, and 34 percent as having low data potential. Of the higher-number group (n = 588), 36 percent were coded as having high data potential, 24 percent as having medium data potential, and 40 percent as having low data potential.

It would appear, then, that the much greater differences between the high-number and low-number groups of Archaic period components may reflect actual change through time in how archaeologists have perceived and recorded Archaic period components of archaeological sites at WSMR. The significance model is operating consistently in sorting Archaic period components, but in this instance, it has also helped us to discover a potentially important factor that may affect the management of the Archaic period archaeological record on the installation. The most likely explanation for this difference between the lower-number group and the higher-number group is a change through time in awareness among archaeologists of the sometimes very subtle ash stains and other indicators of features on Archaic period sites. As we have grown more skilled at recognizing these features, the proportion of Archaic period components with recorded features has increased, accounting for the much higher proportion of Archaic period components being into the “high component data potential” category among the later sites (61 percent high data potential for components recorded later in time vs. 33 percent for components recorded earlier in time).

Another approach that can be used to assess reasonableness of the model results is a comparison between the results of the model and the known DOEs for sites on the installation. Although DOEs are different from data-potential scores in that the former take into account integrity as well as data potential, one would expect that, for example, sites with high data potential would generally *not* be coded as “not eligible” and that sites with low data potential would generally *not* be coded as “eligible.”

Both NMCRIS and the WSMR database contain information on DOEs for some sites, as shown in Table 4.4. The NMCRIS records reflect actual consensus DOEs. Many of the WSMR cases reference consultation with the SHPO, but it is unclear whether all of the DOEs in the WSMR records are from consensus determinations or whether some are the installation’s opinion about eligibility. The proportions of the different determinations in the table are obviously very different, but nearly 1,100 of the “undetermined” eligibility records in the WSMR database (roughly 80 percent) are for sites in the LA 62,000–64,000 range; it is likely that the anomalous process and results of the Border Star 85 and GBFEL-TIE projects account, at least in part, for the difference between DOEs in the two databases in the proportion of sites that were evaluated as being of undetermined eligibility.

To get the most reliable sample against which to compare our model results, we planned to use DOEs that were recorded in both of the databases, but we quickly encountered an unexpected problem. There are 199 cases in which DOEs for sites appear in both databases. The two databases agree as to the eligibility statuses of these sites in only 125 (63 percent) of the cases (Table 4.5). This substantial level of disagreement between the two databases was disconcerting. We completed comparisons between the model results and all of the available DOE information (see Appendix E), therefore, hoping to identify patterns that might be useful in refining the model’s sorting rules.

Of the 24 sites assigned to the “high cultural significance” category by the model, only 4 have previously recorded DOEs. The WSMR database records 3 of these sites as “undetermined” (NMCRIS shows 1 of them as “eligible”) and 1 site as “not eligible.” Although the numbers are small, this would indicate that it is important to identify sites of religious and cultural significance to Indian tribes through special sorting rules, because standard evaluations of eligibility under NRHP Criterion d cannot be relied upon to extend adequate protection to these sites.

Of the 483 sites assigned to the “high data potential” category by the model, 208 have DOE information in one or both databases. Of these 208 sites, 50 percent (n = 104) are recorded as “eligible” for listing in the NRHP in one or both databases. The “undetermined” NRHP category accounts for 46 percent (n = 95) of the “high data potential” sites, and 8 percent[3] (n = 16) of the “high data potential” sites have been recorded as “not eligible” in one or both of the databases. Because eligibility considers both significance (data potential) and integrity, it is likely that the “not eligible” findings for “high data potential” sites indicates sites with compromised integrity, although that does not account for the 3 cases in which the WSMR database records “not eligible” but NMCRIS indicates “eligible.”

Of the 270 sites sorted by the model into the “medium data potential” category, 144 have DOE information in one or both databases. Of these 144 sites, 46 percent (n = 66) of the “medium data potential” sites have been recorded as “eligible” in one or both databases, and 42 percent (n = 60) are recorded as “undetermined.” These proportions are very similar to the proportions for the “high data potential” sites. A somewhat higher proportion (17 percent; n = 24) of the “medium data potential” sites are recorded as “not eligible,” but overall, the high- and medium-data-potential sites have quite similar patterns of DOEs. In future iterations of the significance model, it would be worth considering whether “medium data potential” is a useful or meaningful category.

Of the 907 sites categorized by the model as having “low data potential,” 457 have DOE information in one or both databases. For these 457 sites, 21 percent (n = 94) are recorded as “not eligible,” 62 percent (n = 285) are recorded as being of “undetermined” eligibility, and an unsettling 21 percent (n = 94) are recorded as “eligible.” It is not surprising that a large proportion of the low-data-potential sites have been categorized as “undetermined” in consensus DOEs. In the Section 106 process, a determination that a site

[3] The percentages add up to more than 100 because of the sites with conflicting information in the two databases.

Table 4.4. Determinations of Eligibility for WSMR Sites as Recorded in NMCRIS and the WSMR Database

NMCRIS-Recorded Determinations of Eligibility	Number	%	WSMR-Recorded Determinations of Eligibility	Number	%
Eligible	281	53	eligible	264	12
Undetermined	161	30	undetermined	1,376	65
Not eligible	89	17	not eligible	484	23
Total	531			2,124	

Key: NMCRIS = New Mexico Cultural Resources Information System; WSMR = White Sands Missile Range.

Table 4.5. Cases for Which Determinations of Eligibility for Sites Appear in Both Databases

WSMR	NMCRIS	Number of Cases
Eligible	not eligible	4
Eligible	undetermined	5
Eligible	eligible	62
Not eligible	not eligible	34
Not eligible	undetermined	19
Not eligible	eligible	25
Undetermined	not eligible	6
Undetermined	undetermined	29
Undetermined	eligible	15
Total		199

Key: NMCRIS = New Mexico Cultural Resources Information System; WSMR = White Sands Missile Range.

is “not eligible” for listing in the NRHP means that the site will receive no further consideration and may be destroyed. The finality of that decision creates a tendency toward conservative decisions when it comes to sites with apparently limited data potential. The relatively high proportion of “low data potential” sites (as defined by the model) that have been found “eligible” in some past determination of eligibility, however, is difficult to explain and, as discussed below, should be explored further in future refinements of the model.

Refining the Model

Future refinements of the WSMR significance model will be key to its successful use. Consisting of a sequential set of “if/then” statements, the structure of the model is simple, intuitive, and modular. This means that the assumptions can be changed, the data-potential scores can be tweaked, and rules can be added or subtracted easily to take into account new knowledge or to meet changing needs, or even a specific need. Because of its simple structure, new sites can be added to the database and the model can be rerun without major technical knowledge required.

The end product of this model is a relative measure of the data potential and likely management requirements of known sites on the installation. The current iteration of the model applies the same rules across the entire installation, but if sites or components of a particular type are known to be more or less likely to yield useful information in a particular setting or part of the installation, rules can be added in future iterations to adjust for these differences. Every archaeologist who looks at this model will find something (or many things) in the assumptions and rules with which he or she disagrees, and that is good. The assumptions and rules of this model should be taken as a starting point or baseline upon which we can build using new data and new knowledge about the nature and meaning of the WSMR archaeological record.

There are several changes or additions to the model that we suggest be considered in future revisions. The most important of these would be to examine the possibilities for securing assemblage-size data for the Border Star 85 and GBFEL-TIE sites. The NMCRIS data for these sites are minimal in many ways; an initiative to locate, review, and computerize the information from these two large projects would be valuable in many ways that go well beyond expanding the coverage of this significance model.

We suggested above that the "medium data potential" category may prove not to be of great utility, given that these components tend to have more or less the same proportions of "eligible," "not eligible," and "undetermined" DOEs as do "high data potential" components. The installation cultural resource staff might want to consider whether this category has utility and, if so, whether there are potential changes to the sorting rules that would make it more useful.

Another possible change in the data-potential categories that might prove useful would be to separate out the "high data potential" components with residential features and create a separate category for them. Again, this would be easy to do by adding new sorting rules if the installation staff would find it helpful to be able to track residential sites separately from other "high data potential" sites.

As noted in our evaluation of the modeling results, a puzzling proportion of the sites sorted into the "low data potential" category are recorded in either the WSMR database or NMCRIS has having an "eligible" DOE. By definition, the "low data potential" sites have no features, modest numbers of artifacts, and no components that sorted into medium or high potential. We examined a small sample (four records from each database) in an attempt to determine whether there is a systematic problem with the model. Nothing in the site records from the WSMR database provided any clue as to why these sites would have been considered eligible; there is simply a reference to a SHPO letter.

For two of the sites in our NMCRIS sample that sorted as having "low data potential" but are recorded as having been found eligible for listing in the NRHP, there is again no indication as to why they would have been considered eligible: one is a Mogollon single-component site with tens of artifacts and no features, and the other is an Unknown single-component site with 1s in the assemblage-size field and no features. A third site was coded appropriately by the model for the prehistoric component, but there is a substantial historical-period component that was the reason for the "eligible" DOE for the site. The fourth site is a single-component Archaic period site that was categorized by the model as "low" because its assemblage size is coded as 0, but the site record indicates eight hearth features. Because the combination of zero artifacts and eight hearths seems an unlikely one, this is probably a data-entry error. For future iterations of the model, the installation might wish to examine more of these "low data potential" sites with "eligible" DOEs to determine whether any alterations of the model are needed and to identify possible data-entry errors in the databases.

One final suggestion about possible additions to future iterations of this significance model has to do with the "high cultural significance" category. We created this category to address feature types that are generally known to be of religious and cultural significance to Indian tribes. We would recommend that as part of future consultations with tribes about CRM issues, installation staff explore with the tribes other possible types of "high cultural significance" sites.

Applications of the Model for Management of the WSMR Archaeological Record

As noted earlier in this report, the purpose of an archaeological significance model is to provide cultural resource managers with a flexible tool that can be used in planning, compliance, and long-term management. Once the WSMR model database is fully populated with assemblage-size information, we can anticipate several immediate uses.

The model results could be used in long-range, broad-scale planning efforts in tandem with the locational predictive model developed as part of this project. The locational model identifies where on the range high and low densities of currently unknown archaeological sites are likely to be found. The significance model enables CRM staff to estimate the archaeological data potential and other cultural sensitivity of the already-known sites located in those same areas.

The model results can also be used for project-specific planning. Very early in the planning process for new developments and new or relocated activities on the range, the locational model will indicate the likelihood that currently unknown sites will be encountered, and the significance model will indicate whether the areas under consideration contain known sites that warrant preservation in place or large numbers of sites that would require expensive data recovery. The NEPA-compliance process requires a commensurate level of analysis of each project alternative under consideration, and the analyses need to be replicable and scientifically valid. Both the locational model and the significance model will assist the installation in meeting these standards for potentially impacted archaeological resources.

There are also a number of ways that the results of the significance model could be used to meet the requirements of the NHPA. Section 106 of the Act requires federal agencies to identify and evaluate the NRHP eligibility of historic properties (including archaeological sites) that may be affected by their undertakings. Where some or all of the area that may be affected by an undertaking has been previously surveyed for archaeological sites, the model results could provide a consistent evaluation of the significance of the previously recorded sites. The concept of "high cultural significance" could also be used to identify potential issues that will affect tribal consultation and require additional review and discussion.

As discussed earlier, determinations of NRHP eligibility require both an evaluation of significance and an evaluation of integrity, and we currently do not have the data that would enable us to programmatically assess integrity and, thus, eligibility. We do, however, have the ability to programmatically address significance using the model. In the future, if appropriate geomorphological data for modeling integrity become available, those data can be added to the model, and a process can be created for making programmatic recommendations about NRHP eligibility. Indeed, by involving the SHPO in further refinement and development of the model, it might someday be possible to complete consensus DOEs programmatically, without the delay and uncertainty of case-by-case consultation.

Once the Section 106 process has reached the determination-of-effect stage, if adverse effects are anticipated, the results of the significance model could be used to redesign the project to avoid or minimize effects on sites with high data potential. For those sites that cannot be avoided, the results of the model could be used to develop early estimates of the potential costs and time involved in mitigation through data recovery.

The results of the model could assist WSMR in meeting the requirements of Section 110 of the NHPA, which requires that installations assume responsibility for the preservation of historic properties under their jurisdiction. In order to fulfill their responsibility to manage and protect our nation's cultural heritage, installation managers need to know not only what properties are located on DoD property but why they may be important.

Finally, one of the unexpected discoveries made in the process of developing and evaluating this model, as discussed above, was an indication of a change through time in how Archaic period components have been perceived and recorded. We also, as discussed, discovered some potential problems with data entry and with recorded DOEs. Because the model uses consistent rules, consistently applied to sort the components and the sites into data-potential categories, it provides a tool for identifying inconsistent information, biases in recording, and other data-quality issues.

CHAPTER 5

Summary, Recommendations, and Conclusions

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Two of the most common and important activities overseen by DoD CRM programs are inventorying DoD lands for archaeological sites and evaluating the eligibility of sites for listing in the NRHP. The DoD has a legal obligation to assume responsibility for historic properties (including archaeological sites) under its jurisdiction; to preserve and protect sites listed or eligible for listing in the NRHP; to identify potential impacts to these sites resulting from an undertaking; and to the extent possible, minimize adverse effects to NRHP-listed or NRHP-eligible sites. The DoD has recently planned to complete inventory and evaluation of archaeological resources on lands under agency control in a matter of years; in fact, the target dates for completion have already passed (see Chapter 1). Altschul (2007) has argued, however, that as noble as these goals are, they are unrealistic. It would take billions of dollars and centuries of additional work to complete inventory and evaluation according to current methods and at the current rate. Approaches to inventory and evaluation have not changed since the NHPA was passed in 1966. Although it made sense in the years immediately after passage of the law to adopt a comprehensive approach to inventory and evaluation in which every acre was surveyed and each site was independently evaluated, such approaches today are unnecessary. Current approaches should make use of knowledge gained over the last 45 years about the distribution and nature of archaeological sites in order plan how resources are managed and how current and future CRM activities should be conducted to support the mission while also preserving and protecting our national heritage. However, these are not the current practices, and as a result, they take too much time, are too costly, and provide little opportunity for developing new knowledge.

Most DoD CRM activities are performed in a reactive, project-by-project basis with little systematic use of existing knowledge to guide planning decisions (Green et al. 2011). True, information on the recorded location of archaeological sites is routinely used to assess the potential effects of an undertaking and to redesign projects, but rarely has prior knowledge been leveraged according to a transparent and logical framework that can be used by stakeholders as a basis for agreement on where dollars and resources should be placed to achieve the best preservation outcome for an installation.

A related problem is that most CRM efforts in the military have focused on inventory activities and substantially fewer have focused on evaluating recorded sites for NRHP eligibility. As long as land is available, this approach makes sense: find and avoid. Standard practice is to forgo making eligibility determinations until absolutely needed, because the process can be costly for many sites. In the meantime, installation managers treat all sites as if they were potentially eligible for listing in the NRHP. All undetermined sites are treated as equal in their potential to yield important information on history or prehistory. As more inventory is conducted, installations face two problems. First, increasingly scarce human and financial resources are spread over more sites. Second, as more unevaluated sites take up more space on the installation, military activities become increasingly constrained.

The development of transparent and systematically derived planning tools (such as locational and significance models), along with programmatic approaches to implementing these tools, is a necessary step in streamlining and improving compliance. These kinds of tools can be applied to a wide range of management needs; they can be refined as new data or understandings are developed, and they can be used to arrive at consistent and logically transparent management decisions. The goals of the current project were to test an approach to DoD CRM that takes advantage of existing knowledge and information to develop planning tools and approaches that can be applied to contexts where knowledge is more limited. Thus, the current project endeavored to develop models that leveraged data from an installation where extensive efforts at inventory and evaluation had been conducted (Fort Bliss) to an installation where the extent of inventory and evaluation was limited (WSMR). This was to be achieved by developing locational and significance models for WSMR using CRM and environmental data from WSMR and Fort Bliss and to develop approaches to using these tools programmatically in streamlining compliance. Locational models have a long history in the DoD and the ability of such models to accurately predict site location has improved in recent years with advances in computing technologies, data availability, and statistical techniques. Significance models, by contrast, are a relatively new concept that, until the current project, had yet to be fully realized. Nonetheless, they represent an essential component in helping the DoD understand the characteristics of the historic resources under its jurisdiction. As such, the development of a significance model for this project represents an important landmark in the use of modeling for streamlining compliance.

Numerous hurdles were encountered in attempting to meet the project goals, principal among them being the quality and availability of relevant CRM and environmental data. Other difficulties had to do with the fact that, although a goal of the project was to develop programmatic approaches to using significance and locational models for WSMR, the timing of the project was not ideal for interjecting a third party into WSMR's existing and ongoing efforts to develop a programmatic agreement. Despite all of these difficulties, the project was successful in developing working locational and significance models for WSMR and in recommending how these models can be used programmatically.

In the following sections, we summarize the efforts to develop locational and significance models for the project and suggest methods for refining the models in the future. These discussions are followed by a series of recommendations about how the models can be used programmatically to streamline compliance.

The Locational Model

The project scope of work specified that a series of locational models be developed for Fort Bliss and WSMR that leverage data from Fort Bliss, where inventory has been extensive and the archaeological record is relatively well known, to model site location on WSMR, where inventory has been limited and large areas of the range have yet to be surveyed. Current inventory efforts at WSMR are geared toward inventorying the southeastern portion of WSMR south of Interstate 70. Inventory in other parts of the range has consisted mostly of comparatively small circular, linear, and quadrat surveys with vast areas left untouched by inventory efforts. Despite the small area surveyed relative to the large size of the range, more than 5,000 sites have been recorded thus far. Attribute information on many of these sites is limited, however, and few sites have been evaluated. Environmental data that could be used to model site location on WSMR are also limited in comparison to Fort Bliss.

Based on the input of project stakeholders, the modeling area defined for the project was confined to the Tularosa Basin portions of WSMR and Fort Bliss. Archaeologists from the installations argued that Fort Bliss CRM data could not be legitimately applied to the more mountainous areas of WSMR or to valley areas outside the Tularosa Basin, because environmentally and culturally similar areas have not been surveyed on Fort Bliss. The modeling area within Fort Bliss was also confined to New Mexico, because important environmental layers available for the Texas portion of Fort Bliss tended to be developed according to different protocols or using different data categories or scales of measurement than data available for New Mexico. Using the data available for New Mexico and Texas together without extensive processing would likely have resulted in anomalous modeling results that would have been driven mostly by methodological differences between environmental datasets rather than prehistoric decisions about settlement and land use. With the above geographic constraints, the modeling area on the two reservations is still quite large, consisting of approximately 650,000 acres of land on Fort Bliss and 1.1 million acres of land on WSMR.

Model Variables

A major issue that was faced in developing locational models for Fort Bliss and WSMR is that fewer environmental data were available for WSMR and many of the data were more coarse-grained in comparison to data available for Fort Bliss. In particular, detailed soils and geomorphic data were available for Fort Bliss but were lacking for WSMR. As a consequence, many of the environmental data most likely to have been associated with archaeological site location for Fort Bliss could not be used to model site location, because the same kinds of data were not available for WSMR. To develop independent variables, data were gleaned from a variety of sources (including WSMR, Fort Bliss, and national mapping agencies) and combined to cover the modeling area on both reservations. Soils data appeared to be particularly important to modeling site location on Fort Bliss but comparable soils data were not available for WSMR (although these data are currently under development). Thus, a special effort was made to develop soils data that were comparable between the two installations. We accomplished this objective by identifying attributes in the NRCS soils descriptions that had a potential association with site location (presence of alluvium, petrocalcic layers, gravelly soils, etc.) and then mapping out those attributes using the available soils polygon data for the two reservations.

Once GIS data were combined to cover the modeling area of both reservations, these data were used to derive a series of independent variables related to topography, water resources, soils, vegetation, and social factors, including slope, aspect, distance to water, alluvium, vegetation type, distance to least-cost paths between large sites, and other variables. Variables were defined in multiple ways—such as the proportion of a resource within a specified radius, the Euclidean distance to a resource, the cost distance to a resource, or the presence/absence of a resource—in order to determine which variable definitions worked best in predicting site location. In order to limit intercorrelations among independent variables, PCA was run on related sets of variables, with the resulting components used as independent variables. Additional variables were also created while modeling was underway, when it was suspected that variable refinements could improve model performance.

Modeling Approach

A variety of modeling approaches were experimented with to determine which approaches worked best in modeling site location. These techniques included logistic regression, general additive models, stochastic gradient boosting, and Random Forest models. Ultimately, we settled on using Random Forest modeling to develop models for the project and applied a consistent approach to model development in order to make strict comparisons among models. Random Forest models are considered to be highly robust to overfitting and limit the effects of intercorrelations among variables. These issues were of primary concern, because the project involved extending predictions from areas that had been intensively surveyed to vast areas where no empirical data were available on site location.

Unlike many other modeling techniques, the use of separate training and test samples for model development and testing is considered unnecessary in Random Forest modeling, because the approach repeatedly samples the modeling data to develop hundreds or thousands of decision trees that are ultimately combined into a final model. To be conservative, however, we randomly split the samples in half to form test and training sets to be used in developing and testing each of the models. Models were first tested internally using standard measures of model performance, including TPR, FPR, AUC, and OOB Error Rate (a measure used to calculate the overall error rate of Random Forest models). Models that proved sufficiently powerful to map on the ground were then subsequently tested using two statistics developed specifically for testing the performance of archaeological models of site location: Gain and Gain over Random (Kvamme 1988, 1990). These statistics randomly sample from surveyed areas to develop performance measures based on the proportion of site and nonsite areas falling within a sensitivity zone relative to the size of the sensitivity zone and can be used to assess the predictive capacity and efficacy of locational models.

Model Development and Testing

The first models developed for the project were geared toward modeling site location exclusively at Fort Bliss. An initial baseline model was created using only the most-recent and consistently developed inventory data. Such data were derived from the TRU inventory system (see Chapter 3). Although more reliable than data developed earlier for Fort Bliss using more-traditional survey methods, TRU data proved to be too limited in their geographic extent to adequately model site location within the Fort Bliss modeling area. In particular, TRU data were available mostly for the McGregor Range portion of the modeling area and in a few areas along the western edge of the modeling area but were unavailable for large areas of the lower basin within the Northern Maneuver Area. The resulting model performed fairly well in the McGregor Range portion of the modeling area but did not perform well in other areas of Fort Bliss. When tested using model performance statistics, the model did perform better than a previous one created to predict site location on the McGregor Range (Zeidler et al. 2002). This improvement in performance appears to be owing to more-reliable CRM data (the TRU data) being available for the current modeling effort and the more-robust multivariate statistical techniques that were applied in developing the current model.

Subsequent models were developed using a combination of TRU data and data from earlier surveys conducted at Fort Bliss. These additional data were derived from more-traditional approaches to archaeological survey and were developed using different site definitional criteria than current approaches. Initial modeling attempts using both the TRU data and the expanded dataset suggested that large sites could be predicted better as a class in comparison to small sites, so we experimented with different ways of modeling small and large sites and to combine these models into an all-sites model for Fort Bliss. When models of small and large sites were combined, the resulting model performed only marginally better than the baseline model developed using only TRU data, however. Modeling all sites together, without respect to site size, resulted in a model that worked better in predicting site location at Fort Bliss. This all-sites model placed 92 percent of sites within medium- or high-sensitivity zones, which together constituted approximately 45 percent of the surveyed area. Given the high density of sites on Fort Bliss within the modeling area, this result is acceptable. It should be acknowledged, however, that the model probably does not perform as well as it could have performed had the more-refined environmental data available only for Fort Bliss been used in model development.

In developing and testing each of the models created for Fort Bliss, we evaluated how well they would perform if extended to WSMR. Unfortunately, it was clear that the models that had been developed would not extend well to WSMR, in part because the samples used to predict site location on Fort Bliss were not especially representative of the WSMR environment. To address this problem, we determined which variables were most similar in their distribution between the two installations and used only those variables to experiment with model development. We found that using only Fort Bliss CRM data and the more-restricted set of variables resulted in models that worked well for Fort Bliss but did not work particularly well for WSMR. Once CRM data from Fort Bliss and WSMR were combined, however, samples used in model development proved to be much more representative of the environment of WSMR, allowing models to be developed that performed well for both Fort Bliss and WSMR.

According to the project scope of work, the ultimate models developed for WSMR were to be developed using a comprehensive series of sites types. Relevant site types were created in consultation with WSMR staff and consisted of Paleoindian, Archaic, Early Formative Residential, Early Formative Nonresidential, Late Formative Residential, Late Formative Nonresidential, and historical-period sites. To test how well site type models worked using only Fort Bliss CRM data or a combination of Fort Bliss and WSMR CRM data, we first created a series of site type models using only Fort Bliss CRM data and tested how well the models performed for both reservations. These models performed well for Fort Bliss and substantially better than any of the all-sites models but did not perform well when extended to WSMR. Models created using a combination of Fort Bliss and WSMR CRM data, by contrast, performed well for both reservations and, for some site types, models developed using a combination of the two datasets actually performed better for Fort Bliss than models developed using only Fort Bliss data. Models of Early Formative and Late Formative residential sites performed best for WSMR, a useful result given that these kinds of sites are often highly significant and require a large level of effort to mitigate if impacted. Evaluation of the site type models revealed that, although they worked well, site location was not being predicted well in a large area in the southern end of the range, because most sites in this area did not have adequate attribute information to assign site types. Thus, an additional model was developed for WSMR sites of undetermined type in order to account for areas where large numbers of sites had been recorded but where site types could not yet be assigned based on a lack of attribute information.

The resulting site type models developed using a combination of Fort Bliss and WSMR CRM data and the model of sites of undetermined type were combined to create an all-sites model for WSMR. Based on Gain and GOR statistics, the all-sites model for WSMR performs least well in the southeastern portion of the range, south of Interstate 70, where very large numbers of sites have been recorded. The relatively poor performance of the model in this area of the range is the result of the area having been defined mostly as a high-sensitivity zone, with very little low- or medium-sensitivity areas. Performance statistics used for this project indicate a model is working well when a large proportion of sites is found within a small proportion of surveyed area defined as high sensitivity. However, for the remainder of the range within the modeling area, the model performs well when tested using all sites combined or using individual site types. Among individual site types, the all-sites model for WSMR performs best in predicting the location of Paleoindian, Early Formative Residential, and Late Formative Residential sites. The model also performs substantially better than an existing model of site location on WSMR that was developed prior to the current project.

In order to make further use of the site type models, what we have referred to as a "differential land use model" was also developed. This model combines the site type models in a variety of different ways to predict land use according to temporal period and function, allowing managers to get a stronger sense of where sites of different types tend to be located on the range (e.g., residential vs. nonresidential Formative period sites or prehistoric vs. historical-period sites) as well as begin to interpret different kinds of land use that may have occurred prehistorically and historically on the range. The differentiated land-use model should help managers to develop an understanding of how different areas of the range within the Tularosa Basin have been used in the past and where sites representing different management concerns are likely to be located. Another advantage of this model is that, because it also includes predictions where sites of undetermined type are likely to be found, the model allows managers to identify data gaps and to target areas where additional data is most needed.

Model Refinements

Given the limited environmental and CRM data available for model development on WSMR, it will be worth refining the locational model with additional data. We envision several refinements that would likely lead to an improved site locational model for WSMR:

- *Develop refined variables using the new soils data for WSMR once they become available*. Once SSURGO data are available for WSMR, it should be possible to develop soil-derived variables that are not only mapped at a finer scale but that relate more closely to soil characteristics affecting site location (organic matter content, available water capacity, surface horizon thickness, erosion susceptibility, etc.).
- *Develop more-comprehensive site attribute data.* Although a substantial sample of sites according to type was developed for this project, the majority of recorded sites could not be placed into specific site types owing to a lack of site attribute data. Attributing all recorded sites with data relevant to defining site types would likely allow models based on these data to more accurately predict site location according to site type.
- *Perform sample survey in understudied areas of WSMR.* To date, most of the surveyed area at WSMR is confined to the southeasternmost portion of the range, south of Interstate 70. Vast areas

of the range have been subjected to minimal or no survey. Given the large size of WSMR, it would certainly benefit the CRM program to gain a better understanding of how sites are distributed in different parts of the range. Conceivably, sample survey conducted using samples stratified according to soils or geomorphology could help the installation develop a more representative sample of sites on WSMR. The additional CRM data could also be used to further refine locational models for WSMR.

The Significance Model

Archaeologists are supposed to assess significance through an evaluation of how a site's attributes relate to historic contexts and current research directions. In theory, a site is determined significant under Criterion d of Section 106 of the NHPA if it can address data gaps or priorities identified in historic contexts and research designs and if it can be used to challenge existing theories. In practice, however, the significance of a site is often assessed based on how much "stuff" it has (i.e., the number and diversity of artifacts and features on the surface) and its condition (i.e., whether the deposits appear intact or have been destroyed or heavily disturbed). "Stuff and condition" are often used as a proxy of the data potential, regardless of historic contexts or current research approaches.

In Chapter 4, it was argued that the form, content, and structure of a site are often the most important factors considered in evaluating significance. Rather than asking whether a site addresses a current research question, archaeologists often look at more-basic factors to determine significance, such as assemblage size and diversity, feature types, or the potential for buried deposits. This simple and elegant observation is amply demonstrated by the Fort Bliss significance standards (Miller et al. 2009), which were analyzed in detail as part of this project in order to develop a significance model for WSMR. The Fort Bliss significance standards are explicitly tied to a series of highly detailed, informative, and sophisticated historic contexts and associated research questions. Despite the impressive sophistication and detail of this massive document, the main variables used to evaluate significance are largely independent of historic context: assemblage size and the presence or absence of features—particularly structures, middens, and thermal features.

As stressed in Chapter 4, how a site relates to current data gaps or research interests is a short-term concern. Research questions and data gaps change through time; what was unimportant 10 or 20 years ago may be very important now, and vice versa. If research interests and associated data requirements change, as they inevitably will, so too will the significance of a site. A site that did not address current research questions or data gaps when evaluated could certainly address future interests or needs. Although research foci can be short lived, sites need to be managed for the long term. Thus, site attributes that speak to the basic data potential and cultural significance of a site can be more meaningful and conservative indicators of site's significance in the long term than the considerations that federal agencies have suggested archaeologists apply in determining significance under Criterion d.

Moreover, when little is known about cultural resources under DoD jurisdiction (as is the case for WSMR), understanding the data potential of a site in terms of basic archaeological attributes is likely to be more useful than attempting to link a site's attributes to a historic context or to discern how a site addresses research questions or data gaps. As indicated in Chapter 4, rather than simply focusing on those sites that address current, and probably short-term, research needs, we recommend preserving a representative sample of sites according to the archaeological data potential and cultural significance of a site.

Significance Model Construction

At WSMR, determinations of eligibility have been made for only a small percentage of sites, and the number of sites requiring evaluation will only increase as more of the range is inventoried. Thus, a systematic and rule-based approach to evaluating significance should be very useful to managing this expanding resource. To develop such an approach, we developed a series of algorithms that sort sites into significance categories based on existing site attribute information (see Chapter 4). The resulting model is essentially a decision tree that sorts sites according to a hierarchical series of rules. The overall structure and logic of the decision tree is what is most important; the specific details of the rules used to place sites into significance categories are easily changed as more information is developed or as management needs change.

An important point that needs to be emphasized is that determinations of NRHP eligibility are based not only on a site's significance but also on a site's integrity. As discussed in Chapters 1 and 4, a site can be considered highly significant but have limited integrity, and vice versa. Unfortunately, as important as integrity is to evaluating eligibility, little information was available in either the WSMR or NMCRIS databases that could be reliably used to assess integrity. Examination of environmental variables that could potentially be used to infer integrity suggested that the existing data were unfortunately too coarse-grained to develop a reliable proxy measure. As a result, the significance model developed in this report does not include a prediction of a site's integrity; instead, it includes only the significance of sites in terms of data potential and cultural significance. It is also worth noting that, because the significance of historical-period sites is often determined through documentary and other information not present in site attribute tables, the model deals only with prehistoric sites and components.

The model was built using a series of rules that place sites into the categories of high, medium, or low data potential, high cultural significance, or insufficient data. Given the importance of assemblage-size data in determining a site's data potential, assemblage size is a major variable considered early on in the sorting process. However, two kinds of relatively rare sites about which little is known and which are likely to be considered highly significant are Paleoindian and Apache sites. Because sites of these types tend to have few artifacts, sorting on assemblage size first would place these site types automatically into the low data potential category when, in fact, any new information stemming from the study of these kinds of sites could be important. As a result, the first sorting rule established for the significance model entails the identification of sites that are especially rare and understudied. These sites are automatically assigned to the high data potential category and dropped from further consideration by the model algorithm.

A second sorting rule addresses a similar issue by identifying sites that have high cultural significance due to their associations with religious or sacred values, regardless of assemblage size: sites having features identified as petroglyphs, pictographs, shrines, or burials. Sites with these kinds of attributes tend to be highly valued by descendant groups, such as Native American tribes and, thus, merit special consideration regardless of assemblage size or other attributes.

In brief, sites that are either rare (i.e., Paleoindian and Apache sites) or have high cultural significance are coded by the algorithm as having a high level of significance and dropped from any further consideration in the model. Once these sites have been coded in terms of their significance, then the key variable of assemblage size is applied to the remaining sites. In this third sort, sites that have thousands or tens of thousands of artifacts are coded as having high data potential, whereas those having artifacts counted in the ones or tens are coded as having low data potential. Sites having low or high data potential based on assemblage size are subsequently dropped from further consideration by the model.

The remainder of sites (i.e., those that are not rare site types or of high cultural significance and have tens or hundreds of artifacts) are sorted according to data potential based on component-level rather than site-level data. Because determinations of NRHP eligibility are made at the level of site, site data potential resulting from these component-level sorts is predicted per site using the component with the highest data potential. In other words, if a site had three components and two were of low potential and a third was of high data potential, the site would be considered to be of high data potential. Components that are considered in these subsequent sorts are Archaic period, Mogollon, Anasazi, mixed Anasazi/Mogollon, and Unknown prehistoric components. Because the model deals only with prehistoric components, historical-period components are also flagged to clearly identify how they are treated by the model, but their presence or absence does not affect model results.

Archaic Period Components

For Archaic period components, components that have materials dating to either the Early or Middle Archaic period but not the Late Archaic period are assessed as having high data potential, given that little is known about Early or Middle Archaic period sites. Archaic period components that have a mixture of Late Archaic period and earlier materials are considered to be of medium data potential, whereas Archaic period components that date exclusively to the Late Archaic period must have at least one feature or hundreds of associated artifacts in order to be coded as having high data potential. Archaic period components that cannot be dated to finer periods must have at least one feature and hundreds of artifacts to be coded as having high data potential. The remaining Archaic period components are coded as having medium data potential.

Mogollon Components

Mogollon components, which constitute most of the WSMR prehistoric components in NMCRIS, were assigned as having high data potential if they could be dated to a specific period within the Formative period sequence (e.g., Early or Late Formative period) and had associated features. Mogollon components without features that could be assigned to a specific period within the Formative period sequence and form part of a site with hundreds of artifacts were identified as having medium data potential. Mogollon components that had features but could not be assigned to a specific period within the Formative period sequence were also identified as having medium data potential. By default, Mogollon components that lacked the above combinations of attributes were not assigned a data potential category which, in the context of the model, means that the associated site would ultimately be identified as having low data potential should no other components of a site be identified as having medium or high data potential.

Anasazi and Mixed Anasazi/Mogollon Components

Anasazi and mixed Anasazi/Mogollon components are relatively rare at WSMR, in part because most of WSMR is beyond the geographic extent of Anasazi occupation. Parts of the northern portion of WSMR, however, are considered to have been borderlands between Anasazi and Mogollon culture areas. Purely Anasazi components at WSMR are relatively small components that appear to represent seasonal use of WSMR for limited activities. However, because such components could inform on how areas in the northern part of the range were used and little is known at the current time, Anasazi components are identified as having medium data potential. In comparison to purely Anasazi components, mixed Anasazi/Mogollon components more often have structural features and other important attributes and could provide more information on the nature of interactions between Anasazi and Mogollon groups. As a result, mixed Anasazi/Mogollon components with features are identified as having high data potential, whereas those without features are identified as having medium data potential.

Unknown Prehistoric Components

Unknown prehistoric components were identified as having medium data potential if features were present. Otherwise, these components were not assigned a data potential category. As with other component-level sorts, if a data potential category is not assigned based on this sort and no other component for the site are indicated as having a high, medium, or low data potential, then the site is considered to be of low data potential.

Model Results

As discussed earlier in this report, assemblage-size data were collected as part of this project in order to increase the number of sites that could be placed into significance categories by the model. Adding the new assemblage-size data to the model using data on site forms held at ARMS doubled the number of sites that could be evaluated for significance using the model. Roughly one-half of the sites remain coded as having insufficient data, however, because assemblage-size data are not currently available on site forms or in the NMCRIS database for those sites. Of the sites that could be placed into significance categories *other than insufficient data*, approximately one-third were assigned to the high data potential category, one-sixth were placed in the medium data potential category, and approximately one-half were placed in the low data potential category. Less than 2 percent of sites fell into the high cultural significance category. Geographically, sites of all significance categories are located throughout WSMR, but many are clustered according to data potential. The clustering suggests that the data potential categories could be very useful in determining where sites of high or low data potential are common. In addition, sites with high cultural significance as currently defined tend to be located in close proximity to mountains, suggesting that areas similar to where these sites are located could be of special management concern.

To evaluate the internal consistency of predictions made by the significance model, sites with specific component types were split into random groups to determine if there were systematic differences between samples in the proportion of components assigned to high, medium, and low data potential categories (see Chapter 4). Although there were no statistically significant differences between random samples, when they were split chronologically, based on site numbers assigned earlier and later in time, there were substantial differences in data potential predictions for the Archaic period components. Archaic period components recorded earlier in time were most often predicted to have low data potential, whereas Archaic period components recorded later in time were most often predicted to have high data potential. The difference between the earlier and later samples of Archaic period components are statistically significant ($\chi^2 = 51.89$, $df = 2$, $p < .001$). Similar differences in data potential predictions for earlier and later site recordings were not observed for the other component types, which suggests that the manner in which Archaic period sites have been interpreted and recorded has changed over time (see Chapter 4). In particular, there has been an improvement in the ability of investigators to recognize subtle indications of features such as ash stains at Archaic period sites; thus, more Archaic period sites are being recognized as having features. Consequently, when evaluating the significance of an Archaic period site, it will likely be important for WSMR to consider when it had been recorded.

The results of the significance model were also analyzed in terms of their correspondence to the known DOEs that are listed in both the NMCRIS and WSMR CRM databases for some sites. However, the NMCRIS DOEs appear to likely correspond to the final DOEs arrived at through consensus involving multiple stakeholders, including SHPO, whereas DOEs in the WSMR database appear, at least in some cases, to possibly correspond to WSMR's opinion regarding NRHP eligibility, rather than a final, consensus DOE. Analysis of these DOE data showed that when a determination was recorded in both databases for a site, DOEs were only in agreement between the two databases for roughly two-thirds of the sites. Moreover, in both databases, a substantial number of sites are coded as having an undetermined DOE, a designation that is applied to sites for which insufficient data are available to make a definitive determination.

In the NMCRIS database, roughly one-third of sites with DOE information have an undetermined DOE, whereas in the WSMR database, roughly two-thirds of sites with DOE information have an undetermined DOE. As discussed in Chapter 4, it appears that the vast majority of the undetermined DOEs in the WSMR database come from two projects that used nonsite survey approaches, the results of which have proven difficult to translate into the operational management units referred to as archaeological sites.

Obviously, the disparity in the proportion of undetermined DOEs in the two databases skews the proportion of sites in either database with definitive DOEs of eligible or not eligible.

However, if we consider *only* those sites that have a *definitive* DOE of either eligible or not eligible in either of the two databases, relatively strong patterns emerge in the correspondence between DOEs and predicted data potential. If we consider all definitive DOEs that are in agreement between the two databases or occur in only one of the two databases, close to 90 percent of sites with high data potential were determined eligible, whereas roughly 80 percent of sites with medium data potential and 50 percent of sites with low data potential were determined eligible. This pattern suggests that the model results are generally consistent with how DOEs are made, because the percentage of sites determined eligible declines consistently as data potential goes from high to low.

However, if we consider the definitive NMCRIS DOEs as representing consensus DOEs and the WSMR DOEs as sometimes representing WSMR's opinion rather than a consensus DOE, then another potentially meaningful pattern emerges (Figure 5.1). For definitive DOEs recorded in NMCRIS, roughly 90 percent of sites with high data potential and roughly 90 percent of sites with medium data potential were determined eligible, whereas roughly two-thirds of sites with low data potential were determined eligible. These data suggest that the threshold for determining eligibility by consensus is relatively low, with most sites being determined eligible. Sites with low data potential are determined eligible less often than sites with medium or high data potential but are nonetheless determined eligible most of the time.

An almost opposing pattern is observed for sites with definitive DOEs recorded in the WSMR database. Less than two-thirds of sites with a definitive DOE and high data potential are considered eligible in the WSMR database. For sites predicted to have either medium or low data potential, less than one-third are considered eligible. These data suggest that WSMR may set the bar much higher for considering sites as eligible in comparison to consensus determinations and that, in contrast to the NMCRIS DOEs, the major shift in the percentage of DOEs evaluated as eligible occurs with the medium rather than the low data potential category. In other words, in addition to possibly applying stricter requirements on determinations of eligibility, WSMR may recommend the majority of sites with medium or low potential data potential as not eligible. These data also suggest that the greatest amount of disagreement between WSMR recommendations and consensus DOEs may occur for sites with medium data potential. In other words, roughly two-thirds of sites with medium potential are most often considered by WSMR to be not eligible, whereas consensus determinations would consider 90 percent of those same sites as eligible. Although the disparities between the two databases for the DOEs could point to data-entry problems or other factors, they also suggest that an open and frank discussion among WSMR, SHPO, and other stakeholders regarding what is necessary for a site to be determined eligible or not eligible for listing in the NRHP would be helpful.

Recommendations for Refining the Significance Model

As with the locational model, there are certainly opportunities for refining the significance model for WSMR as new data are available and as WSMR further evaluates the results of the model in terms of management needs and stakeholder concerns. Recommendations for refining the significance model are as follows:

- *Secure assemblage-size data for the Border Star and GBFEL-TIE sites*. These data would allow most sites in the NMCRIS database currently assigned to the insufficient data category to be assigned to low, medium, or high data potential categories.
- *Evaluate whether the medium data potential category is useful*. Consider whether changes to the model rules could enhance the utility of this category.

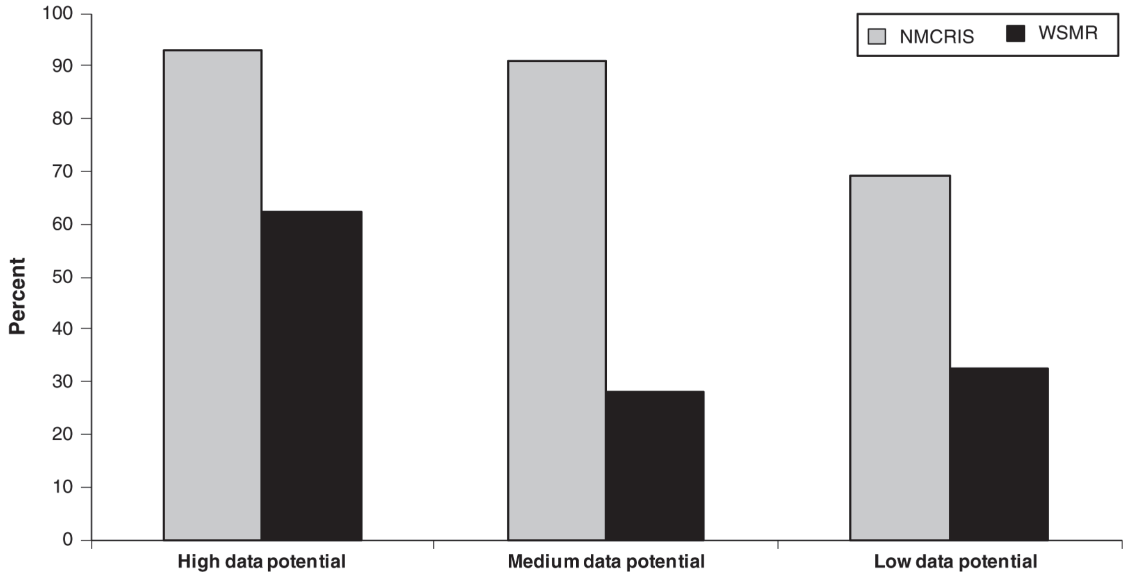

Figure 5.1. The percent of definitive DOEs for WSMR sites determined eligible or recommended eligible for listing in the NRHP, according to the NMCRIS and WSMR databases.

- *Consider identifying sites with high data potential and residential features as a separate management category*. Currently, these sites would be coded simply as having high data potential, but specifically flagging these sites as having residential features could support preservation and protection of these sites and prevent mission delays.
- *Examine sites with low data potential that have been determined or recommended as NRHP eligible.* Because such cases represent unexplained anomalies in model results, examining these cases would help to determine if refinements to the model are necessary, or if data-entry problems could account for some cases.
- *Explore with stakeholders what site attributes could be used to identify sites of high cultural significance*. In addition to petroglyphs, pictographs, shrines, and burial/grave features, additional feature types or site attributes, including geographic location, could be of special cultural importance to stakeholders. Identifying these kinds of attributes would likely instill stakeholder confidence as well as facilitate identification of sites requiring special management attention.
- *Perform a pilot study that aims to assess the correlations between site integrity and geology and soils data*. Modeling integrity based on environmental setting using a sample sites that have been excavated and tested on WSMR would allow integrity to be predicted in much in the same way that a locational model predicts site location using correlations between site location and environmental variables. As such, predictions of significance and integrity could be used together predict eligibility.
- *Engage the SHPO in future development and refinement of the model*. Allowing the SHPO to comment on and influence model refinement would help to ensure stakeholder buy-in for using the model programmatically.

Potential Programmatic Uses of the Locational and Significance Models

As discussed in the introduction to this report, it was not possible to fully accomplish Task 6 of the project, because we were not permitted to review the draft PA under development or engage with stakeholders to develop PAs to streamline compliance. It is still possible, however, to provide recommendations about how the locational and significance models can be used programmatically. Therefore, we present the following recommendations.

- *Use the locational model to estimate the kinds of resources anticipated in an APE*. The individual site type models, as well as the differentiated land-use model developed for WSMR, could be used to identify the kinds of resources anticipated in an APE.
- *Use the locational model to design sample surveys*. Sensitivity zones defined by the locational model could be used as strata for designing sample surveys, along with factors such as soils or geomorphology.
- *Use the significance model to provide a consistent evaluation of the significance of previously recorded sites in an APE*. Evaluating the NRHP eligibility of sites that may be affected by an undertaking using the significance model would help achieve stakeholder confidence as well as fulfill NEPA requirements to develop project alternatives using scientifically valid and replicable techniques. Pending appropriate data, the significance model can also be combined with a predictive model of site integrity to make programmatic recommendations about NRHP eligibility.
- *Use the category of "high cultural significance" in the significance model to identify issues that may require additional review, discussion, and consultation*. Understanding the cases in which stakeholder concerns may be greatest and where special consideration is needed will help support positive relationships with stakeholders and prevent mission delays.
- *Use the locational and significance models to redesign projects to minimize effects.* Sensitivity zones predicted by the locational model for specific site types and site significance predicted by the significance model could be used to determine where the effects of an undertaking would be minimized.
- *Use the locational and significance models to assist in fulfilling Section 110 of the NHPA*. Section 110 requires the DoD to assume responsibility for the preservation of historic properties under their jurisdiction by developing knowledge about the potential importance of individual sites.
- *Use the locational and significance models to identify potential problems with data quality*. The locational and significance models can be used to identify where site attribute data are incomplete or potentially inaccurate as well as identify cases where variation in field methods may have biased model results.
- *Use the locational and significance models to estimate the cost of inventory, evaluation, or mitigation in an APE*. Cost estimates for conducting inventory or evaluation efforts could be developed for individual site types and significance categories and be used to estimate the relative or absolute costs of inventory or evaluation. The significance model can also be used to identify whether an APE contains recorded sites that will need to be preserved in place or require expensive data recovery.
- *Use the locational and significance models to develop historic contexts, research designs, and field methods*. Understanding where sites of specific types and significance categories are located would help in the development of historic contexts as well as in project planning. For instance,

specific research questions or field methods can be tailored to address the kinds of resources anticipated in a project area.

Conclusions

The project described in this report had a number of significant challenges to overcome, but despite these difficult challenges, useful locational and significance models were developed for WSMR and a series of recommendations on how to use these models programmatically was presented. Particularly owing to the limitations in the data available for modeling, these models would benefit from further refinement as new data become available and as WSMR continues to build and refine knowledge about the location and significance of cultural resources under its jurisdiction. This project shows that it is possible to leverage existing knowledge and data effectively to predict characteristics of the archaeological record (i.e., the location and significance of archaeological sites), identify data gaps, and develop a set of planning tools that can be used programmatically to streamline compliance.

The project demonstrates that the technology exists to create locational and significance models that should be of benefit to the management of cultural resources on military installations. What is left unanswered is whether the models can change the culture of CRM. For many stakeholders in the CRM process, the issue comes down to one of risk. Will important sites be missed if we do not survey an area? What will we lose if we do not consider a site eligible for the NRHP? For some, any loss is too much. For others, the inability of archaeologists to articulate what they have learned in any meaningful sense is taken as evidence of the lack of importance of archaeological resources. Most of the stakeholders are in between these extremes and believe that archaeology can be of public benefit but recognize that this benefit is elusive, and often, lots of time and money are expended in efforts that produce little in return.

Modeling is a tool that provides decision makers with a framework through which resources can be allocated: (1) minimize the chance of making mistakes (i.e., missing sites or evaluating a site with important data potential as nonsignificant) and (2) maximize the intellectual return on an installation's "investment" (i.e., provide the best chance of finding or excavating important sites). Most importantly, modeling provides us a tool for measuring our success (or lack thereof) in CRM decision making. Additional inventory provides the means of testing our models and, over time, allows all stakeholders to become comfortable with CRM decisions. For example, at some point, stakeholders should agree that the chances of missing important sites in areas of low sensitivity are small enough to stop or limit survey. This may require several refinements in the model and changes to the configuration of sensitivity areas. Similarly, after excavating numerous rock features without learning anything new, stakeholders may decide to change the significance logic tree so that these sites move from high to moderate, and in time, to low significance.

Although use of the WSMR locational and significance models may not lead to these kinds of decisions right away, the modeling effort has provided a successful starting point to move the culture of CRM in the military away from a comprehensive approach where every acre is surveyed and every site is tested to a more realistic approach that uses the vast amount of data that has been and continues to be accumulated to streamline the inventory and evaluation process.

APPENDIX A

Site Type Sensitivity Maps for Fort Bliss and White Sands Missile Range, New Mexico

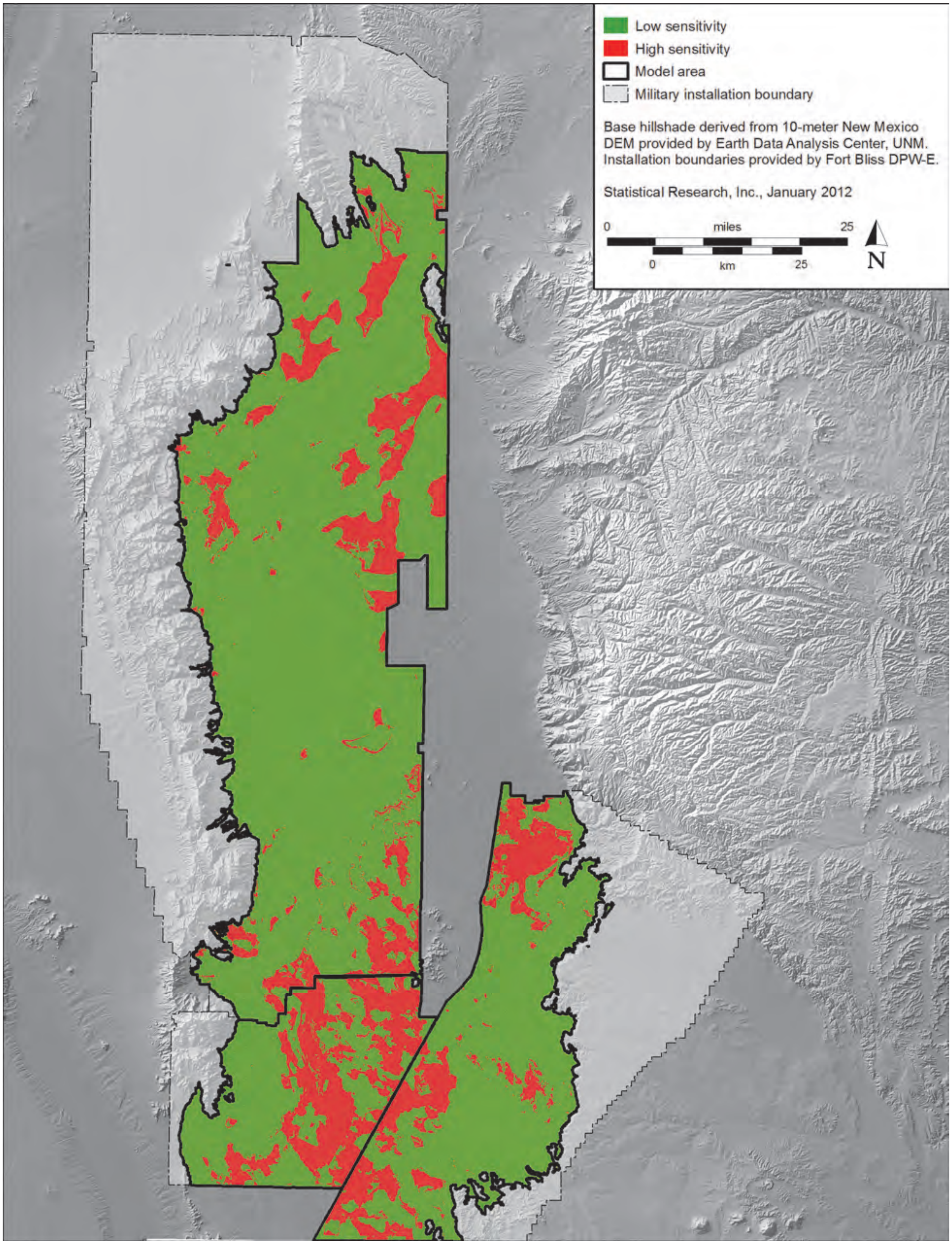

Figure A.1. Predictive model of Paleoindian site locations on Fort Bliss and WSMR.

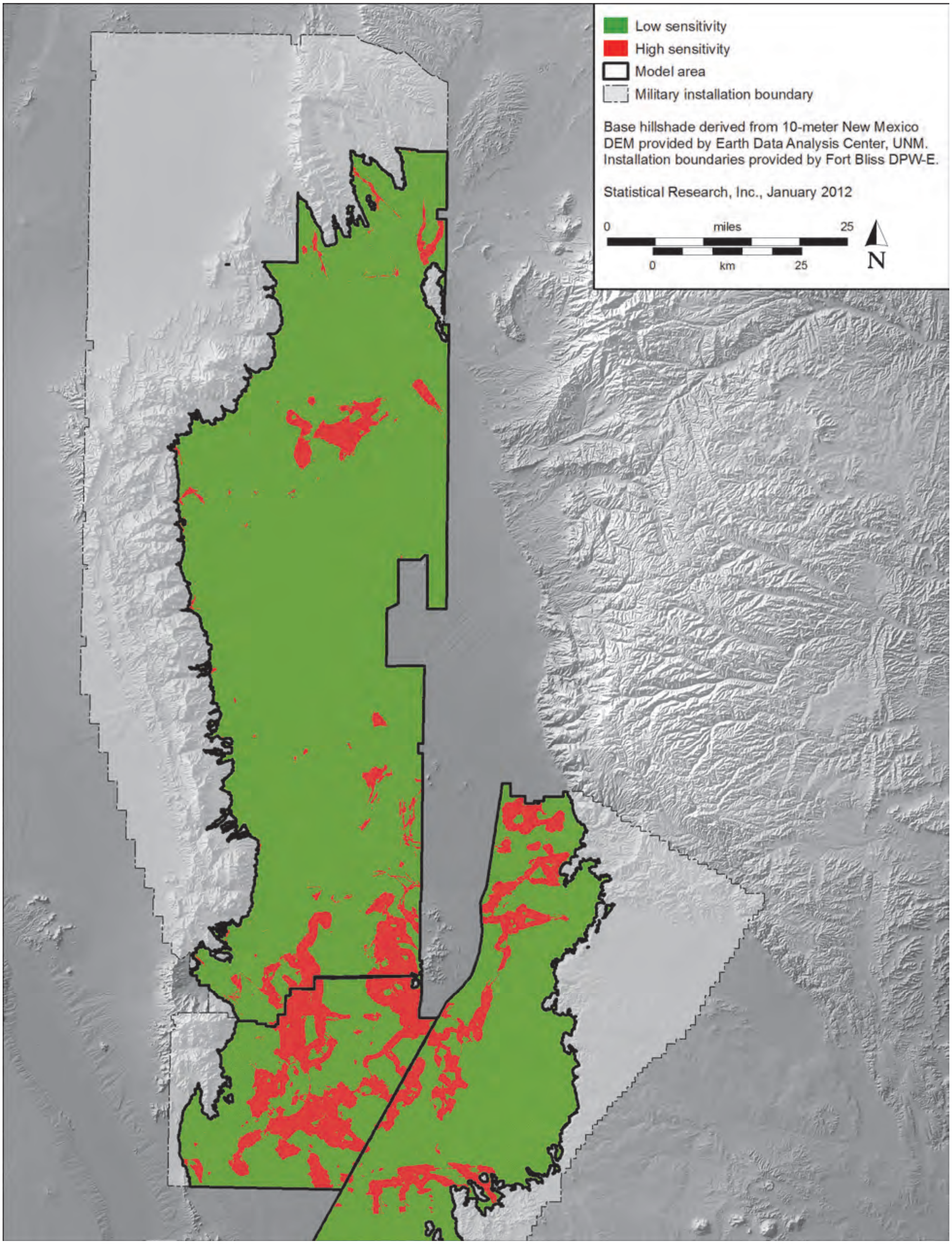

Figure A.2. Predictive model of Archaic site locations on Fort Bliss and WSMR.

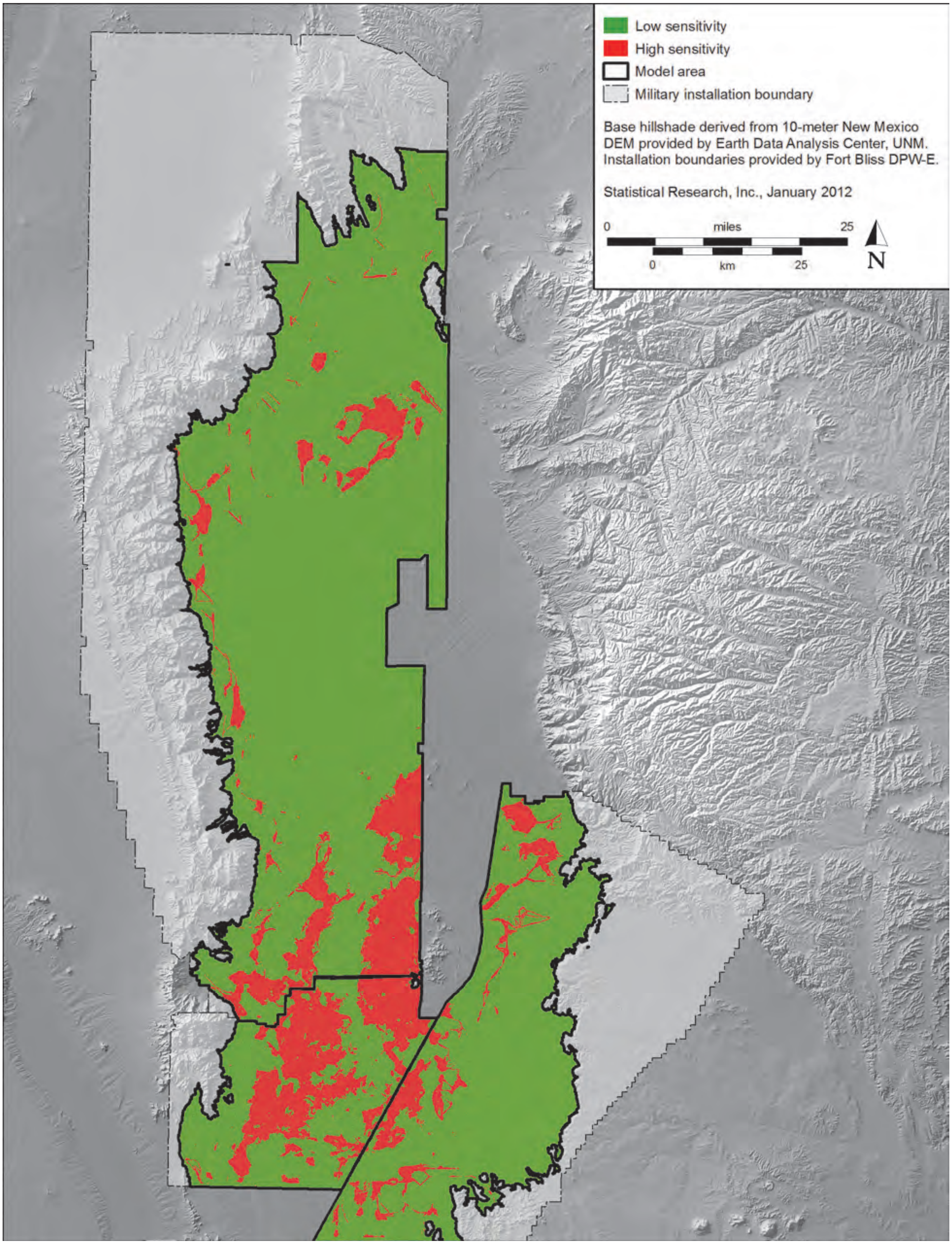

Figure A.3. Predictive model of Early Formative nonresidential site locations on Fort Bliss and WSMR.

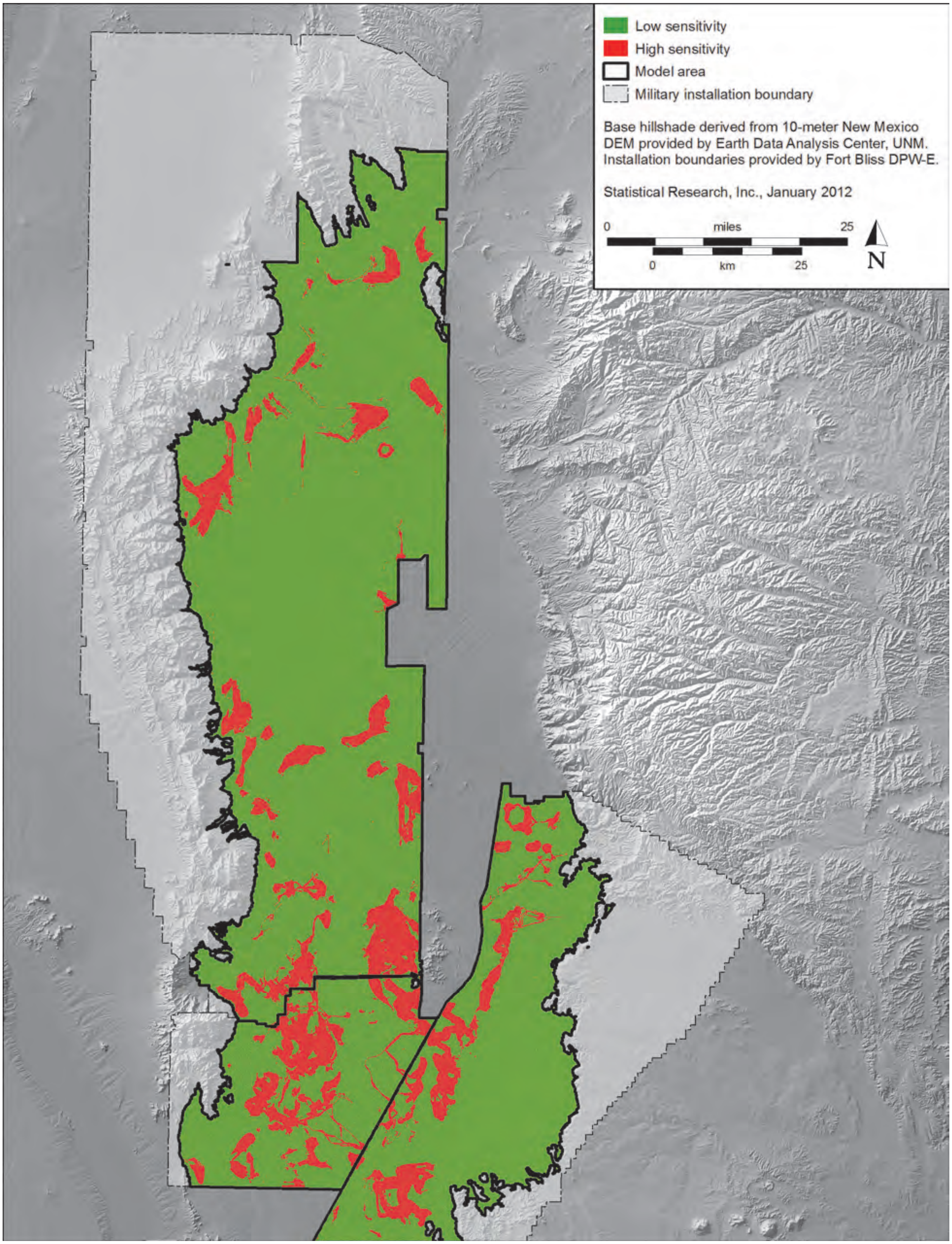

Figure A.4. Predictive model of Early Formative residential site locations on Fort Bliss and WSMR.

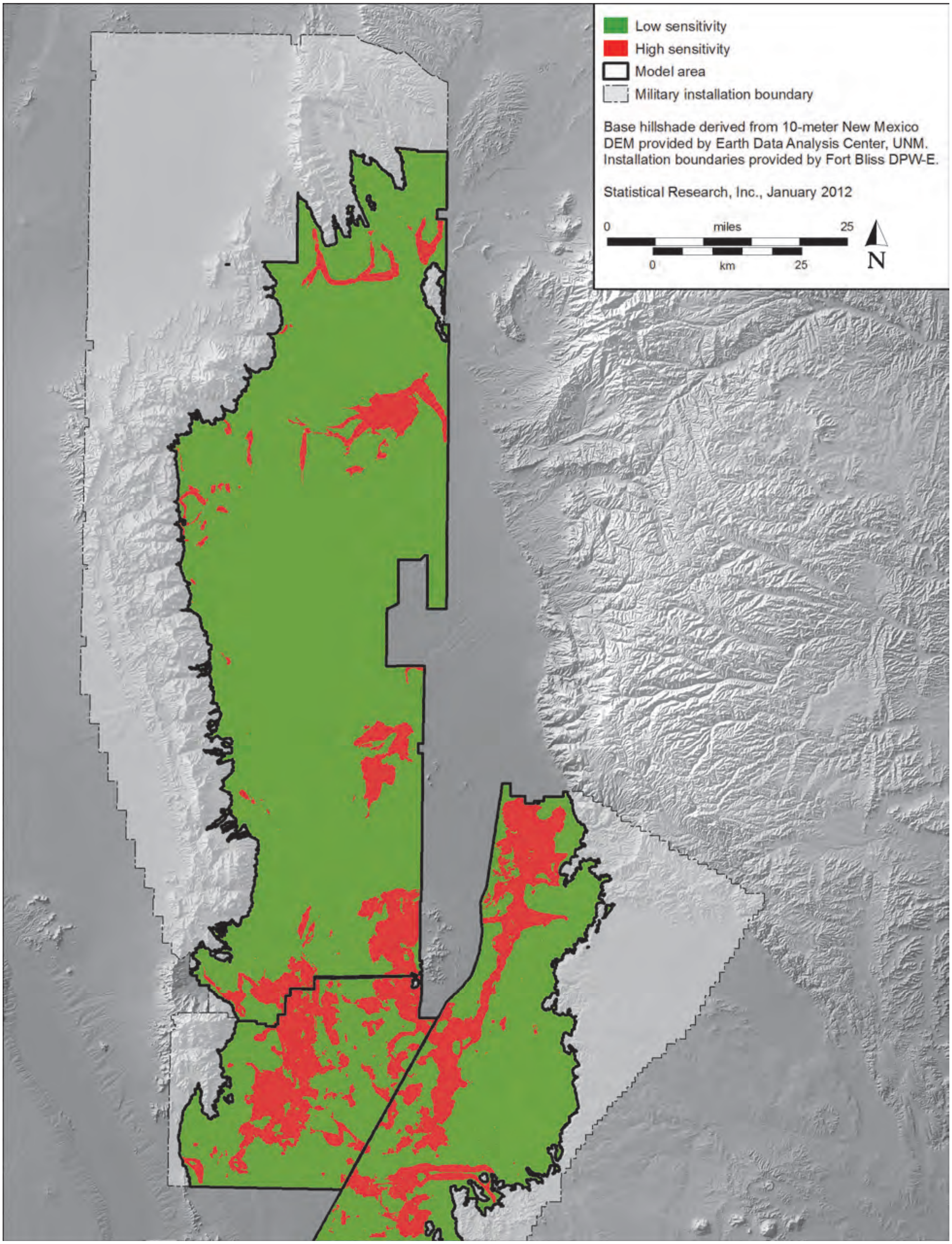

Figure A.5. Predictive model of Late Formative nonresidential site locations on Fort Bliss and WSMR.

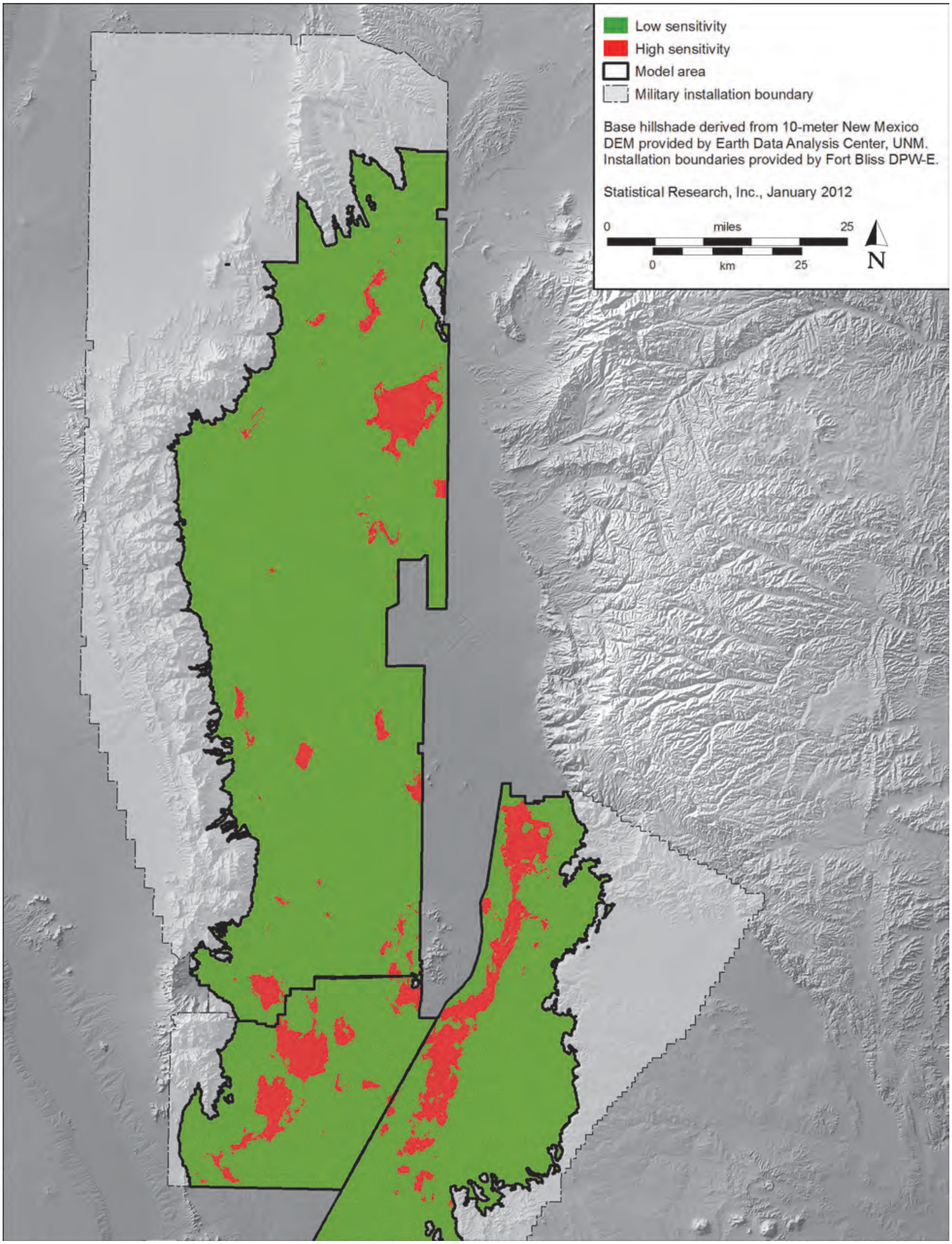

Figure A.6. Predictive model of Late Formative residential site locations on Fort Bliss and WSMR.

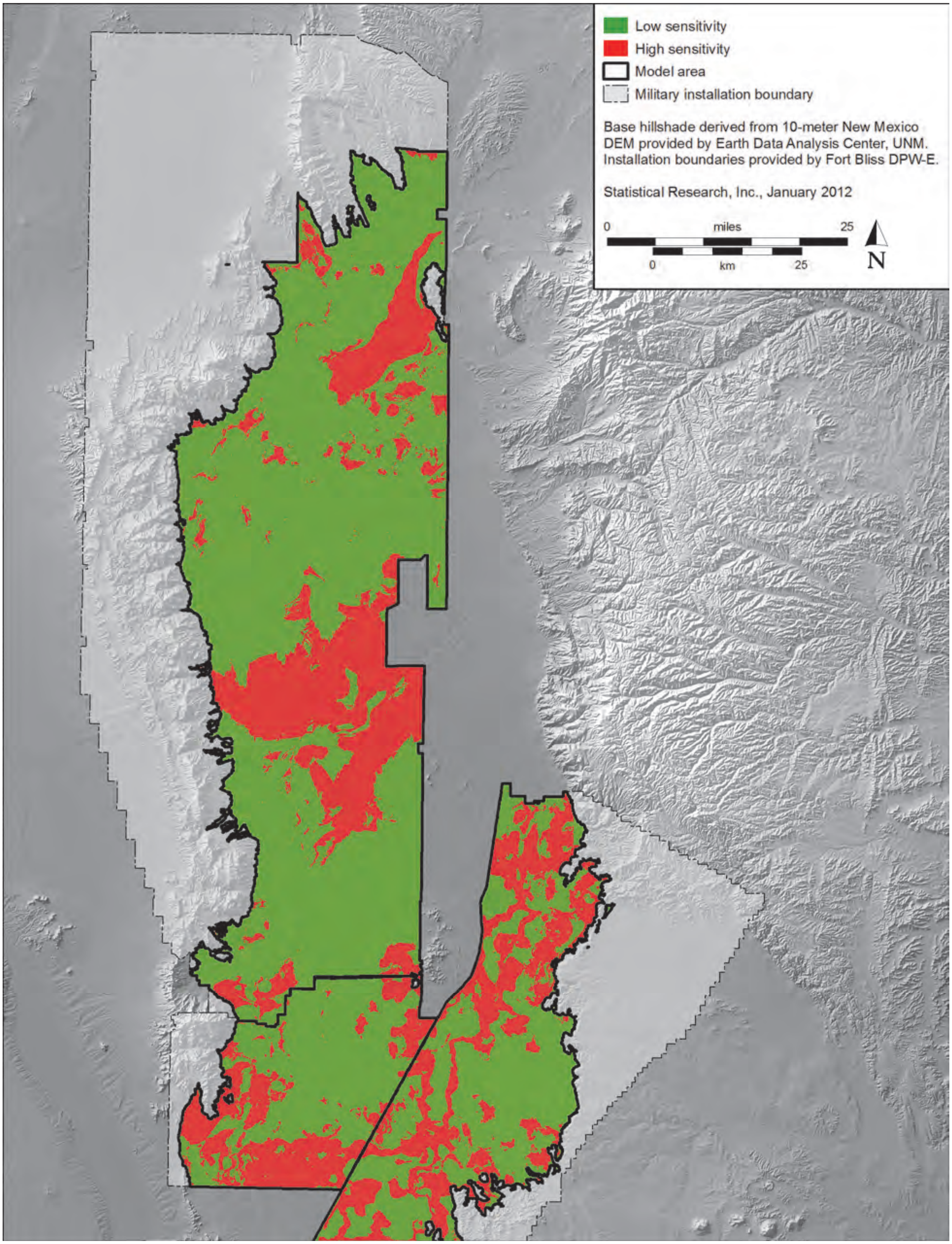

Figure A.7. Predictive model of historical-period site locations on Fort Bliss and WSMR.

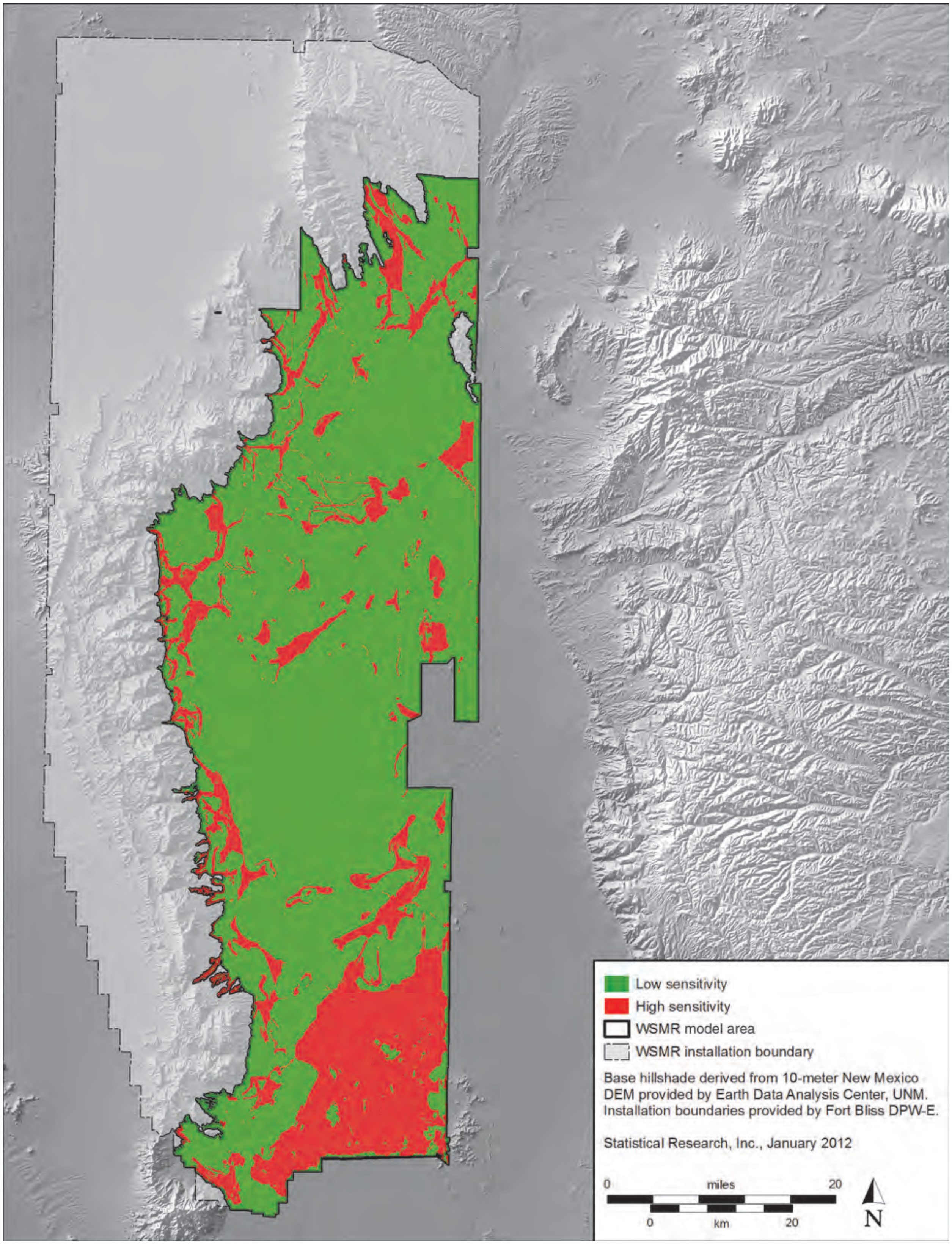

Figure A.8. Predictive model of the location of sites of undetermined type on WSMR.

APPENDIX B

White Sands Missile Range Significance Model Sorting Algorithms

Sorting Algorithms for WSMR Significance Model

First Sort *assigns site data potential to sites containing rare component types and removes these sites from the sorting process before the assemblage-size cutoffs*

For all sites where site data potential = [blank]:

If culture type_1 **or** culture type_2 **or** culture type_3 **or** culture type_4 **or** culture type_5 = Apache, **then** site data potential = high

If culture type_1 **or** culture type_2 **or** culture type_3 **or** culture type_4 **or** culture type_5 = Paleoindian, **then** site data potential = high

Second Sort *assigns sites with special cultural and religious significance to Indian tribes to a special management category*

For all sites where site data potential = [blank]:

If feature type_1 **or** feature type_2 **or** feature type_3 **or** feature type_4 **or** feature type_5 = petroglyph, **then** site data potential = high cultural significance

If feature type_1 **or** feature type_2 **or** feature type_3 **or** feature type_4 **or** feature type_5 = pictograph, **then** site data potential = high cultural significance

If feature type_1 **or** feature type_2 **or** feature type_3 **or** feature type_4 **or** feature type_5 = shrine, **then** site data potential = high cultural significance

If feature type_1 **or** feature type_2 **or** feature type_3 **or** feature type_4 **or** feature type_5 = burial/grave, **then** site data potential = high cultural significance

Third Sort *assigns site data potential to tiny and huge sites and removes them from the sorting process, leaving the "assemblage size = 10s or 100s" sites for further sorting*

For all sites where site data potential = [blank]:

If site assemblage size = 0 **or** site assemblage size = 1s, **then** site data potential = low

If site assemblage size = 1000s **or** site assemblage size = 10,000s, **then** site data potential = high

If site assemblage size = [unknown], **then** site data potential = insufficient data

Fourth Sort *assigns Archaic components of sites where assemblage size = 10s or 100s to **component-based** data-potential categories. The sites of which these components are a part remain in future sorts so that other site components can be assigned to a component-based data-potential category. In the final step of the model, these component-data-potential assignments are used to sort the sites into **site**-data-potential categories.*

For all sites where site data potential = [blank]:

If culture type_1 = Archaic

and early period_1 = Early Archaic

and late period_1 = Early Archaic, **then** component data potential_1 = high

Repeat for culture types 2–5

If culture type_1 = Archaic

and early period_1 = Early Archaic

and late period_1 = Middle Archaic, **then** component data potential_1 = high

Repeat for culture types 2–5

If culture type_1 = Archaic
and early period_1 = Early Archaic
and late period_1 = Late Archaic, **then** component data potential_1 = medium
Repeat for culture types 2–5

If culture type_1 = Archaic
and early period_1 = Middle Archaic
and late period_1 = Middle Archaic, **then** component data potential_1 = high
Repeat for culture types 2–5

If culture type_1 = Archaic
and early period_1 = Middle Archaic
and late period_1 = Late Archaic, **then** component data potential_1 = medium
Repeat for culture types 2–5

If culture type_1 = Archaic
and early period_1 = Late Archaic
and no_obs_1 ≥ 0
or site assemblage size = 100s, **then** component data potential_1 = high
Repeat for culture types 2–5

If culture type_1 = Archaic
and early period_1 = unspecified
and no_obs_1 ≥ 0
and site assemblage size = 100s, **then** component data potential_1 = medium
Repeat for culture types 2–5

Fifth Sort *assigns Mogollon components from sites where assemblage size = 10s or 100s to* ***component-based*** *data-potential categories. The sites of which these components are a part remain in future sorts so that other site components can be assigned to a component-based data-potential category. In the final step of the model, these component-data-potential assignments are used to sort the sites into* ***site****-data-potential categories.*

For all sites where site data potential = [blank]:
If culture type_1 = Mogollon **and** early period_1 = Early Pithouse **or** Late Pithouse
and late period_1 = Early Pithouse **or** Late Pithouse
and no_obs_1 ≥ 0, **then** component data potential_1 = high
Repeat for culture types 2–5

If culture type_1 = Mogollon **and** early period_1 = Early Pithouse **or** Late Pithouse
and late period_1 = Early Pithouse **or** Late Pithouse
and no_obs_1 = [blank]
and site assemblage size = 100s, **then** component data potential_1 = medium
Repeat for culture types 2–5

If culture type_1 = Mogollon **and** early period_1 = Early Pueblo **or** Late Pueblo
and late period_1 = Early Pueblo **or** Late Pueblo
and no_obs_1 ≥ 0, **then** component data potential_1 = high

Repeat for culture types 2–5

If culture type_1 = Mogollon **and** early period_1 = Early Pueblo **or** Late Pueblo
and late period_1 = Early Pueblo **or** Late Pueblo
and no_obs_1 = [blank]
and site assemblage size = 100s, **then** component data potential_1 = medium
Repeat for culture types 2–5

If culture type_1 = Mogollon **and** early period_1 = Early Pithouse or Late Pithouse
and late period_1 = Early Pueblo or Late Pueblo
and no_obs_1 ≥ 0, then component data potential_1 = medium
Repeat for culture types 2–5

If culture type_1 = Mogollon **and** early period_1 = Unspecified Jornada Mogollon or Unspecified Mimbres Mogollon
and no_obs_1 ≥ 0, **then** component data potential_1 = medium
Repeat for culture types 2–5

Sixth Sort *assigns Anasazi and mixed Anasazi/Mogollon components from sites where assemblage size = 10s or 100s to* ***component-based*** *data-potential categories. The sites of which these components are a part remain in future sorts so that other site components can be assigned to a component-based data-potential category. In the final step of the model, these component-data-potential assignments are used to sort the sites into* ***site****-data-potential categories.*

For all sites where site data potential = [blank]:
If culture type_1 = Anasazi
and no_obs_1 ≥ 0, then component data potential_1 = medium
Repeat for culture types 2–5

If culture type_1 = Mixed Anasazi/Mogollon
and no_obs_1 ≥ 0, **then** component data potential_1 = high
Repeat for culture types 2–5

If culture type_1 = Mixed Anasazi/Mogollon
and no_obs_1 = [blank], **then** component data potential_1 = medium
Repeat for culture types 2–5

Seventh Sort *removes Historical period components of sites where assemblage size = 10s or 100s from consideration in the process of determining the site data potential for those sites.*

For all sites where site data potential = [blank]:
If culture type_1 = Anglo, **then** component data potential_1 = N/A
Repeat for culture types 2–5

If culture type_1 = Unknown
and early period_1 = Unspecified/Other Historic, **then** component data potential_1 = N/A
Repeat for culture types 2–5

Eighth Sort *assigns prehistoric Unknown components from sites where assemblage size = 10s or 100s to* ***component-based*** *data-potential categories. The sites of which these components are a part remain in future sorts so that other site components can be assigned to a component-based data-potential category. In the final step of the model, these component-data-potential assignments are used to sort the sites into* ***site****-data-potential categories.*

For all sites where site data potential = [blank]:

If culture type_1 = Unknown
and early period_1= Unknown **or** Unspecific/Other Prehistoric
and no_obs_1 ≥ 0, **then** component data potential_1 = medium
Repeat for culture types 2–5

If culture type_1 = Unknown Aboriginal
and no_obs_1 ≥ 0, **then** component data potential_1 = medium
Repeat for culture types 2–5

Ninth Sort *assigns site data potential based on an evaluation of the component-data-potential scores derived in previous steps in the model. This runs three times on the sites with data potential still blank. The last run codes all remaining "site data potential" blanks as "low."*

For all sites where site data potential = [blank]:

If component data potential_1 = high, **then** site data potential = high
Repeat for component data potential 2–5

If component data potential_1 = medium, **then** site data potential = medium
Repeat for component data potential 2–5

If site data potential = [blank], **then** site data potential = low

Comparison between the Significance-Model Results and Available Records of Determinations of Eligibility (DOEs) for Listing in the National Register of Historic Places from the New Mexico Cultural Resource Information System (NMCRIS) and the White Sands Missile Range (WSMR) Database

There are 531 recorded DOEs for WSMR sites in NMCRIS and 2,124 recorded DOEs in the WSMR database. There are 199 cases in which the same site has a DOE record in both databases.

For sites that the model categorizes as having *high cultural significance*,
- only 4 of the 24 sites have DOE information.
  - WSMR undetermined = 2
  - WSMR not eligible = 1
  - WSMR undetermined/NMCRIS eligible = 1

For sites that the model categorizes as having *high data potential*,
- 208 of the 483 sites have DOE information in one or both databases.
  - DOE information in both databases:
    - Eligible = 25 (66 percent)
    - Not eligible = 2 (5 percent)
    - Undetermined = 4 (11 percent)
    - Conflicting information = 7 (18 percent)
      - WSMR eligible/NMCRIS undetermined = 1
      - WSMR not eligible/NMCRIS eligible = 3
      - WSMR undetermined/NMCRIS eligible = 3
  - DOE only in NMCRIS:
    - Eligible = 58 (66 percent)
    - Not eligible = 5 (6 percent)
    - Undetermined = 25 (28 percent)
  - DOE only in WSMR:
    - Eligible = 14 (17 percent)
    - Not eligible = 6 (7 percent)
    - Undetermined = 62 (76 percent)

For sites that the model categorizes as having *medium data potential*,
- 144 of the 270 sites have DOE information in one or both databases.
  - DOE information in both databases:
    - Eligible = 8 (53 percent)
    - Not eligible = 1 (7 percent)
    - Undetermined = 0
    - Conflicting information = 6 (40 percent)
      - WSMR not eligible/NMCRIS eligible = 2
      - WSMR not eligible/NMCRIS undetermined = 3
      - WSMR undetermined/NMCRIS not eligible = 1
  - DOE only in NMCRIS:
    - Eligible = 49 (80 percent)
    - Not eligible = 4 (7 percent)
    - Undetermined = 8 (13 percent)
  - DOE only in WSMR:
    - Eligible = 7 (10 percent)
    - Not eligible = 13 (19 percent)
    - Undetermined = 48 (71 percent)

For sites that the model categorizes as having *low data potential*,
- 457 of the 907 sites have DOE information in one or both databases.
  - DOE information in both databases:
    - Eligible = 13 (21 percent)

Not eligible = 21 (34 percent)
Undetermined = 14 (23 percent)
Conflicting information = 14 (22 percent)
WSMR eligible/NMCRIS undetermined = 1
WSMR not eligible/NMCRIS eligible = 5
WSMR not eligible/NMCRIS undetermined = 3
WSMR undetermined/NMCRIS not eligible = 5

DOE only in NMCRIS:
Eligible = 55 (38 percent)
Not eligible = 22 (15 percent)
Undetermined = 67 (47 percent)

DOE only in WSMR:
Eligible = 20 (8 percent)
Not eligible = 36 (14 percent)
Undetermined = 195 (78 percent)

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