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Ruins Preservation Guide

Aztec Ruins National Monument

Active Working Edition
Stephen E. Adams
Archeologist
National Park Service
Navajo Lands Group
February, 1979

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Introduction

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Aztec Ruins National Monument was established so that preservation of the ruins would be ensured. Preservation requires effective management which can only be realized when the area staff, particularly maintenance personnel, is thoroughly familiar with the resources. This guide should function to help personnel become more knowledgeable about specific details of the ruins. However, this guide should not be misconstrued as a substitute for first-hand knowledge. Rather, it should be used as a "map" to direct the reader toward a more intimate cognizance of the cultural resources.

Secondarily, but just as importantly, this guide should serve as a repository for information pertinent to preservation or management of the ruins. Examples of such information are: building materials sources (stone, dirt, etc.); sources for rare or exotic equipment or supplies; special preservation techniques you have used; outstanding workers; etc. Such information is always valuable and is sometimes critical to successive managers and maintenance personnel. Therefore, to be effective, this guide must be continually added-to, updated, and used.

To facilitate proper upkeep, this manual should be maintained in a looseleaf binder. This allows simple introduction or deletion of material and permits removal of specific informational items for short-term field use.

Much of the information is a compendium of portions of management or other documents. This serves as background material to assist the reader in understanding and appreciating related information presented in narrative or list style.

To simplify the search for specific data, this text is divided into a number of subject categories (see "Contents"). A short introduction is provided for each subject section to guide the reader in its use.

For convenience, a list of contents is furnished for each section.

II. STATEMENT FOR MANAGEMENT

A. PURPOSE OF THE PARK

The presence near the town of Aztec, in northwestern New Mexico, of a massive pueblo and other significant archeological features, and a unique blending of prehistoric architectural styles representing the great Chaco Canyon and Mesa Verde cultures of the American Southwest, prompted President Warren G. Harding to establish Aztec Ruins National Monument by Presidential Proclamation No. 1650 of January 24, 1923 (42 Stat. 2295), "...with a view to the preservation of said ruin for the enlightenment and culture of the Nation..."

B. SIGNIFICANCE OF RESOURCES

Of primary significance at Aztec are the remains of a massive, unified-design, terraced pueblo, covering 2 acres (0.8 hectares) standing three stories high, extending seven rooms wide at the base and four and five rooms wide across the wings, and containing 500 rooms averaging 10 feet (3 m) by 12 feet (4 m) in dimensions. A partially-restored "great kiva" dominates the pueblo's enclosed patio.

The nearby Hubbard Ruin, acquired in 1948, has been excavated, and adds to the archeological significance of Aztec Ruins National Monument, as do numerous unexcavated archeological sites in other parts of the monument.

Also of significance, the ruins are a unique blending of architectural styles, representing, in initial construction, Chaco Canyon-related peoples (northwestern New Mexico) between A.D. 1111 and 1115: and representing, in later remodeling and enlargement, Mesa Verde-related peoples (southwestern Colorado), who abandoned the pueblo in the late 13th century. This architectural blending offers significant insights into social relationships between Chaco Canyon and Mesa Verde, and into the cultural history of, and eventual abandonment of, the Four Corners region.

Because of its unique historical significance in the prehistory of our Nation, the monument is listed on the National Register of Historic Places.

C. LAND CLASSIFICATION

All 27.14 acres (11 hectares) of monument lands are listed in the National Register of Historic Places, and will be classified and managed as a historic zone, in accordance with National Park Service Management Policies (1975), which stipulate that "... physical development...shall be the minimum needed to preserve, protect, and interpret historical ... values."

D. MANAGEMENT OBJECTIVES

1. To protect, stabilize where appropriate, and maintain the historical integrity of the major ruin and its Great Kiva, and other archeological features significant to the monument story.

2. To provide visitors with opportunities for interesting, enjoyable, and enlightening monument experiences, and to enable them to gain insights into the archeological values, through well-researched, varied, balanced, and well equipped interpretive programs, emphasizing the Aztec ruins as a reflection of cultural change resulting from cultural diffusion into the region from the Chaco Canyon and Mesa Verde locales.

3. To maintain liaison and close cooperation with, and offer assistance to, other Federal, state, county, city, and other entities that have an interest in the monument and its surroundings, in order to achieve the monument's purpose, and to in general promote the most harmonious integration possible of activities inside and outside the monument boundaries.

Addendum to Statement for Management
B. Significance of resources

The term "significance", in the archeological context, is a measure of the importance of a particular artifact, site, complex, or region as a link in understanding relationships between such archeological resources. The understanding of relationships is what generates data material for interpreting particular resources to the visiting public.

To reiterate, Aztec Ruins is important in that it has provided information which has been of value in determining relationships between early cultures of the larger Four Corner's region.

The Park Service has the responsibility of preserving its archeological resources and much legislation has been passed to ensure that preservation: Antiquities Act of 1906; Historic Sites Act of 1935, Historic Preservation Act of 1966; National Environmental Policy Act of 1969.

The primary reason for the area, therefore, is the preservation of the archeological resources for the public enjoyment and use.

III. ANNOTATED MANAGEMENT CONSTRAINTS

All management, planning, and development decisions and actions relating to Aztec Ruins National Monument must comply with current National Park Service Management Policies (1975) and Activity Standards (1972); with the park's establishing legislation (Presidential Proclamation No. 1650, January 24, 1923, 42 Stat. 2295, appended); and with subsequent boundary-expansion legislation (Presidential Proclamation No. 1840, July 2, 1928, 45 Stat. 2954, appended; Presidential Proclamation No. 1928, December 19, 1930, 46 Sts. 3040, appended; and Presidential Proclamation No. 2787, 62 Sts. 1513, May 27, 1948, appended). All decisions and actions must also comply with the provisions of the Antiquities Act of 1906; the National Park Service Organic Act of 1916; the Historic Sites Act of 1935; the National Historic Preservation Act of 1966; the National Environmental Policy Act of 1969; Executive Order 11593 of May 13, 1971; and the Archeological and Historic Data Preservation Act of 1974.

An easement dated March 1948 allows 20 feet (6 m) adjacent and parallel to the park's western boundary for public-road use only. The road is not liable to upkeep and maintenance by the National Park Service, and the easement becomes null and void if travel across it becomes hazardous, or if the road use is abandoned.

With the acquisition of 1.8 acres (0.7 hectares) of land from the American Museum of Natural History in 1930 (see appended Presidential Proclamation of 1930) came "one sixteenth (1/16) of one share in running space in the Farmers' Ditch, a community ditch existing under the laws of the State of New Mexico." This amounts to approximately 4.8 acre-feet (5,900 cubic meters) of water per year, and together with the domestic water furnished by the City of Aztec, is deemed sufficient for present and future park use.

In 1958, Lloyd A. Hubbard donated to the United States an easement for approximately 357 feet (109 m) of underground transite cement asbestos pipe across his land from the Farmers' Union Ditch to the northwestern corner of the monument, which includes rights of ingress and egress to install, maintain, and repair the pipe.

A 20-year special-use permit was issued on March 1, 1971, to San Juan County, New Mexico, for the construction (it has been constructed) and maintenance of a county road across 0.15 acres (0.06 ha) of land in the southeastern corner of the monument.

The National Park Service exercises proprietary law-enforcement jurisdiction over the monument, which means that monument staff are limited to enforcing only Federal codes within the boundaries. Local, city, state, and county law-enforcement agencies also exercise jurisdictional enforcement authority within the monument.

The indenture of March 28, 1928 involves the right to drains and drainage across land described. And, indenture of May 15, 1947 contains an easement for a public road along the west boundary.

These constraint documents are available at Aztec, New Mexico, 87401, the Navajo Lands Group, Farmington, New Mexico, and the Southwest Regional Office, Santa Fe, New Mexico.

IV. RESOURCE MANAGEMENT PROGRAM

For the purpose of clarity, all the actions included in the project discussions will be divided into five Natural Types and two Historic (Cultural) Types.

The five Natural Types are:

1. Those actions whose implementation will have a significant and measurable effect on the natural environment. (Significant Action)

2. Those actions whose implementation will continue existing maintenance of the natural environment. (Continuing Maintenance)

3. Those actions which will initiate new maintenance of the natural environment. (New Maintenance)

4. Those actions which entail research into the natural environment. (Research)

5. Those actions which do not have an effect on the natural environment. (No Effect-Natural)

The two Historic (Cultural) Types are:

A. Those actions whose implementation will have an effect on the historic resources. (Effect)

B. Those actions which will not have an effect on the historic resources. (No Effect-Historical)

AZRU
EARU

RUINS MAINTENANCE DESCRIPTION

NAME: East Ruin

DESCRIPTION: A partly excavated, 16 feet high, 400 X 180 feet mound, with 24 excavated and partly excavated, roofed rooms.

USE: Not open to the public.

	PRESENT	ACCEPTABLE
MAINTENANCE STANDARD:	B	B
PROTECTION STANDARD:	C	C

SIZE: 24 excavated and partly excavated roofed rooms.

Linear feet of Stabilized Wall: 720 (220m)

Square feet of Stabilized Wall: 5,040 (469m^2)

SPECIAL PROBLEMS: Roofed rooms.

LAST CYCLIC MAINTENANCE: 1965

PERIOD FOR CYCLIC MAINTENANCE: 10 years

MAN-DAYS FOR CYCLIC MAINTENANCE: 30 man-days

MAN-DAYS FOR ANNUAL MAINTENANCE: 5 man-days

Revised 7/75

AZRU
HURU

RUINS MAINTENANCE DESCRIPTION

NAME: Hubbard Ruin

DESCRIPTION: A specialized tri-wall structure, moderately well constructed of varying masonry types.

USE: Moderately heavy. A secondary interpretive feature. Entered on a self-guided trail.

	PRESENT	ACCEPTABLE
MAINTENANCE STANDARD:	B	B
PROTECTION STANDARD:	B	B

SIZE: 22 rooms, 2 kivas and several fragmentary rooms.

Linear feet of stabilized wall: 1,100 (334m)

Square feet of stabilized wall: 7,700 ($716m^2$)

SPECIAL PROBLEMS: Drainage and water seepage.

LAST CYCLIC MAINTENANCE: 1965

PERIOD FOR CYCLIC MAINTENANCE: 5 years

MAN-DAYS FOR CYCLIC MAINTENANCE: 30 man-days

MAN-DAYS FOR ANNUAL MAINTENANCE: 10 man-days

Revised 7/75

AZRU
WERU

RUINS MAINTENANCE DESCRIPTION

NAME: West Ruin

DESCRIPTION: A very large ruin with cored walls standing to three stories. Twenty-one rooms exist with intact ceilings. It is largely excavated.

USE: The major interpreted site. Entered by the visitor on a self-guiding trail.

	PRESENT	ACCEPTABLE
MAINTENANCE STANDARD:	B	B
PROTECTION STANDARD:	B	B

SIZE: 185 ground-floor rooms, 14 kivas, and a restored great kiva.

Linear feet of stabilized wall: 6,790 (2,071m)

Square feet of stabilized wall: 72,800 (6,770m^2)

SPECIAL PROBLEMS: Twenty-one rooms with intact ceilings covered by modern, protective roofs. Long internal drainage lines. High water table and rotting of basal masonry.

LAST CYCLIC MAINTENANCE: 1976

PERIOD FOR CYCLIC MAINTENANCE: 10 years

MAN-DAYS FOR CYCLIC MAINTENANCE: 120 man-days

MAN-DAYS FOR ANNUAL MAINTENANCE: 50 man-days

Revised 7/75

United States Department of the Interior

NATIONAL PARK SERVICE
SOUTHWEST REGION
P.O. Box 728
Santa Fe, New Mexico 87501

IN REPLY REFER TO:
N22(SWR)CR

APR 27 1977

RECEIVED
NAVAJO LANDS GROUP
HEADQUARTERS
APR 28 1977

Memorandum

To: General Superintendent, Navajo Lands Group

From: Deputy Regional Director, Southwest Region

Subject: Aztec Ruins Resource Management Plan Revision

I approve of the revised cultural resources project number 3, Preservation of Ruins, of the Aztec Ruins Resources Management Plan.

cc:
Supt., AZRU

REVOLUTION BICENTENNIAL AME 1776-1976

United States Department of the Interior
NATIONAL PARK SERVICE
Navajo Lands Group
Box 539
Farmington, N. M. 87401

IN REPLY REFER TO:
N22

April 11, 1977

Memorandum

To: Regional Director, Southwest Region

From: General Superintendent, Navajo Lands Group

Subject: Aztec Ruins Resource Management Plan Revision

I approve of the enclosed revision of cultural resources project number 3, Preservation of Ruins, of the Aztec Ruins Resources Management Plan, and request your approval.

Arthur H. White

Enclosure

cc: Supt., AZRU

REVOLUTION BICENTENNIAL AMERICA 1776-1976

United States Department of the Interior
NATIONAL PARK SERVICE
Aztec Ruins National Monument
P. O. Box U
Aztec, New Mexico 87410

IN REPLY REFER TO:
N22

April 11, 1977

Memorandum

To: General Superintendent, Navajo Lands Group

From: Superintendent, Aztec Ruins National Monument

Subject: Aztec Ruins Resource Management Plan Revision

The enclosed revision of cultural resources project number 3, Preservation of Ruins, of the Aztec Ruins Resources Management Plan has been prepared with the assistance of the Navajo Lands Group Ruins Stabilization Specialist and has been reviewed by cultural resources personnel at the Southwest Cultural Resources Center and Western Archeological Center. Their comments have been included in this revision.

I approve this revision and request your approval and that of the Regional Director.

Clarence N. Gorman

Clarence N. Gorman

Enclosures

3. Project: Preservation of Ruins

There are three (3) excavated or partly excavated ruins, one (1) excavated and reconstructed prehistoric great kiva, and ten (10) unexcavated ruins at Aztec Ruins National Monument.

a. The West (or Main or Aztec) Ruin, LA45b, is a very large, massive, largely excavated, stabilized, prehistoric, masonry Pueblo Ruin consisting of 185 ground floor rooms including 21 rooms with intact, original ceilings, 14 kivas, and rubble core masonry walls standing up to the third story.

The West Ruin suffers extensive moisture damage to its sandstone masonry and adobe mortar walls from accumulations of surface moisture from summer rains and winter snow and ice, and from subsurface moisture which percolates through walls or rises by capillary action into wall bases. This damage is aggravated by an inefficient and inadequate drainage system; by long, wide, flat wall caps; and by the use of incompatible and unesthetic, tinted Portland Cement mortar. In addition, the 21 original ceilings are covered by old (1938), deteriorating, leaking, inadequately designed protective roofs; exposed wooden construction members suffer damage by being exposed to alternating cycles of wetness and dryness, insect infestation and rot, and only sporadic application of preservatives; and ruins maintenance is carried out largely by means of large and small rehabilitation and cyclic stabilization projects rather than by an adequately funded, staffed, trained, and directed annual ruins maintenance program. Also, most preservation treatment is symptom oriented and not aimed at attacking the causes of deterioration.

b. The Hubbard Ruin, LA45c, is an excavated, stabilized, prehistoric, masonry Pueblo ceremonial structure consisting of 22 rooms, two (2) kivas, and moderately-well to poorly constructed walls standing up to eight (8) feet (2.4m).

The Hubbard Ruin has most of the same preservation problems as the West Ruin plus the fact it has been stabilized so extensively that its structural integrity is in question to the point that its main value lies in its worth as an interpretive display rather than as an archeological resource. The extensive cement plaster on this ruin provides an ideal medium for capillary action which causes very heavy stone deterioration, gives little protection to wall cores and veneers, masks interior defects, and has an unaesthetic color and texture.

c. The East Ruin, LA45a, is a largely unecavated, 16 feet (5m) high, 400 (91m) by 180 feet (55m), prehistoric masonry Pueblo mound containing 24 excavated or partly excavated, stabilized rooms, some with intact, original ceilings.

Relatively little wall is exposed, but what is exposed is subject to the same problems as the West Ruin, although not as severely. Vegetation is helping to check erosion of the mound. The protective roofs covering the intact, original ceilings are of a different design than those of the West Ruin and are providing good protection.

d. The Great Kiva is a large, excavated, prehistoric, reconstructed, masonry Pueblo, ceremonial structure in the plaza of the West Ruin.

The Great Kiva has an inadequate and incomplete drainage system. Parts of the structure have settled more than others and wall cracks have developed along mortar joints. The adobe mortar has eroded to the point where there are deep voids in the joints. Exterior wood roof members are well exposed and severely decayed. The interior, plaster simulation paint is of an inaccurate color and texture.

e. The ten (10) unexcavated ruins at the monument are, with one exception, static and require no preservative treatment. The one exception is Mound F that has one exposed room and an intrusive modern storage cellar.

These unexcavated ruins are densely covered with vegetation that checks erosion and should, except for trees, be retained. There is a potential wildfire threat. In the event of a burn, it is to be controlled from peripheral areas without any equipment allowed on the ruins.

ACTION: Research and Maintenance

a. Rehabilitate West Ruin: (5. No Effect - Natural. A. Effect - Historical).

Complete the ruins stabilization rehabilitation of the West Ruin. (Package 110 - FY77 and Package 111 - FY78 and FY79). Use these funds to begin an annual ruins maintenance program. (106 statement has been completed).

b. Design and Install Comprehensive Surface Drainage System for West Ruin including Great Kiva. (3. New Maintenace. A. Effect - Historical). A consultation in compliance with Section 106 of the National Historic Preservation Act will be required. (Draft 10-238 enclosed).

c. Design and Install Protective Roofs - West Ruin. (5. No Effect - Natural. A. Effect - Historical). A consultation in compliance with Section 106 of the National Historic Preservation Act will be required. (Draft 10-238 enclosed).

d. Complete Historic Structures Report for West Ruin. (5. No Effect - Natural. B. No Effect - Historical). Report to be written by NALA Ruins Stabilization Specialist. No additional funds required.

e. Complete Ruins Preservation Guide for West Ruin (5. No Effect - Natural. B. No Effect - Historical). Guide to be written by NALA Ruins Stabilization Specialist. No additional funds required.

f. Rehabilitate Hubbard Ruin: (5. No Effect - Natural. A. Effect - Historical).

Package 115, Rehabilitate Hubbard Ruin, includes complete restabilization of ruin (along with removal of the cement plaster), design and installation of an adequate drainage system, and completion of an Historic Structures Report and Ruins Preservation Guide. The project will be supervised by the NALA Ruins Stabilization Specialist. A consultation in compliance with Section 106 of the National Historic Preservation Act will be required.

g. Revise Cyclic Maintenance Paint Job Specifications for Great Kiva interior to include proper paint color and plaster texture. (5. No Effect - Natural. B. No Effect - Historical).

h. Mound F. Backfill one exposed room and remove modern storage cellar and backfill resulting cavity. (5. No Effect - Natural. B. Effect - Historical). Funds for this work are available. A consultation in compliance with Section 106 of the National Historic Preservation Act will be required.

i. Complete Historic Structures Report for East Ruin (5. No Effect - Natural. B. No Effect - Historical). Report to be written by NALA Ruins Stabilization Specialist. No additional funds are required.

j. Complete Ruins Preservation Guide for East Ruin (5. No Effect - Natural. B. No Effect - Historical). Guide to be written by NALA Ruins Stabilization Specialist. No additional funds are required.

k. Request Southwest Cultural Resources Center and Western Archeological Center to initiate research into the development of new preservation techniques and materials designed to attack, where possible, the causes of deterioration. Of particular importance to Aztec Ruins is research leading to the development of a better mortar, to the prevention of sandstone deterioration, to the preservation of original wall plaster, and the preservation of in-place wood. (5. No Effect - Natural. B. No effect - Historical).

NOTE: All new materials are to be laboratory and field tested on non-original fabric before application to original fabric. Prior to application to original fabric, a National Historic Preservation Act 106 Statement may be required.

l. Ruins Maintenance: (5. No Effect - Natural) (B. Effect - Historical).

It is estimated that 520 man days per year will be required to maintain the Aztec Ruins at standard. This is an initial estimate only and will be revised on the basis of data generated by the monument Ruins Preservation Guides. A third estimate is possible upon completion of the first full year of the program at standard. At present 15 man days per year are allotted to ruins maintenance. An additional 83 man days is to be allotted in FY1979. A 10-237 requesting 1.5 man years in FY1980 is to be submitted.

Details of housekeeping procedures, maintenance practices, and ruins maintenance program review and appraisal will be outlined in the West Ruin Preservation Guide.

See enclosed Resource Requirements Data and draft 10-237.

NATIONAL PARK SERVICE

DEVELOPMENT/STUDY PACKAGE PROPOSAL

PACKAGE NO. | REVISION NO.

PKG NO	PARK (OR OTHER ORIGINATOR)	DEVELOPED AREA NAME	DA CODE	REG'N
	Aztec Ruins National Mon.	West Ruin & Great Kiva	WR	SW

STATE	STATE CODE	COUNTY(S)	CONGRESSIONAL DISTRICT
New Mexico		San Juan	

PACKAGE TITLE: Modify drainage Systems

STUDY PACKAGE ☐
NEW CONSTRUCTION B ☒
REHABILITATION A ☐

NEW PACKAGE ☒
REVISION ☐

CRITERIA (INSERT X's)	PARK PRIORITY	DATE	REG'N PRIORITY	DATE

PROGRAM THRUST, STATUS AND OTHER INFORMATION

WILL ADDITIONAL OPERATING FUNDS AND POSITIONS BE NEEDED UPON COMPLETION OF THIS PACKAGE?
(IF 'YES' EXPLAIN NEEDS IN SECTION XI OUTLINE OF PLANNING AND MANAGEMENT REQUIREMENTS)
YES ☐
NO ☒

FULL PACKAGE DESCRIPTION

Modify and improve the drainage systems in the West Ruin and the Great Kiva. Current systems will be redesigned and expanded.

PACKAGE JUSTIFICATION/CONSEQUENCES:

Existing drainage systems in these two cultural resources are inadequqte and inefficient. They are failing to control moisture from snow, ice, and rain and are thus contributing to wall stone and mortar erosion. Increased deterioration demands increased maintenance. A modified drainage system will effectively control moisture and will result in a substantial decrease in ruins maintenance requirements.

Failure to improve the drainage system will maintain the currently high cost vs. benefits ratio, will result in further ruin deterioration, and will cause a decrease in the archeological and interpretive value of the sites.

PLANNING AND MANAGEMENT REQUIREMENTS: *(Follow instructions and outline provided in Program Formulation Guideline)*

System must be effective in each unit being drained and must be easily maintainable. System should be designed and installed by a professional engineer. Design must be approved by the Southwest Region and installation must be monitored by a professional archeologist.

ORIGINATOR (Signature and Title)	DATE	CONCURRENCE (Signature of Superintendent or Equivalent Official)	DATE

APPROVAL (Signature of Regional Director or Equivalent Official) | DATE

U.S. GOVERNMENT PRINTING OFFICE: 1976-634-968/401

UNITED STATES DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE

PACKAGE ESTIMATING DETAIL

PAGE ___ OF ___ FOR THIS PACKAGE

PACKAGE NO

REVISION NO.

ORG	PARK NAME	DEVELOPED AREA NAME	D.A. CODE	REGION
	Aztec Ruins National Mon.	West Ruin & Great Kiva	WR	SW

PACKAGE TITLE: Modify Drainage Systems

NET CONSTRUCTION — DETAIL OF ESTIMATES

CLASS OF ESTIMATE

☐ A— WORKING DRAWINGS ☐ B— PRELIMINARY DRAWINGS ☒ C— SIMILAR FACILITIES

THIS ESTIMATE VALID TO: (DATE) FY78

ITEM	QUANTITY	COST (NET AMOUNT—THOUSANDS) PLANNING AND CONSTRUCTION	ROAD CONSTRUCTION
Labor	200 wd	7800	
Support costs, supplies and materials		26200	
(If additional space is required—use plain paper and attach)	TOTALS	$ 34,000	$

NET CONSTRUCTION — COST BY PROJECT TYPE AND FUND SOURCE

PROJ TYPE	PROJECT TITLE	COST BY FUND SOURCE (THOUSANDS OF DOLLARS) PWE	PLAN./CONST	PWE	ROAD CONST.
52	MUSEUM EXHIBIT PRODUCTION				
55	WAYSIDE EXHIBIT PRODUCTION				
57	ACQUISITION OF ARTIFACTS AND GRAPHICS				
62	AUDIOVISUAL ARTS PRODUCTION				
89	RUINS STABILIZATION	300	34,000		
91	CONSTRUCTION				
91	CONSTRUCTION				
92	UTILITY CONTRACTS				
	TOTALS		$ 34,000		$

ESTIMATE PREPARED BY: (Signature)	TITLE	DATE
ESTIMATE APPROVED BY: (Signature)	TITLE:	DATE

NATIONAL PARK SERVICE

DEVELOPMENT/STUDY PACKAGE PROPOSAL

PACKAGE NO.
REVISION NO.

ORG NO	PARK (OR OTHER ORGANIZATION)	DEVELOPED AREA (NAME)	D A CODE	REG'N
	Aztec Ruins National Mon.	West Ruin	WR	SW

S1	STATE	STATE CODE	COUNTY(S)	CONGRESSIONAL DISTRICT
	New Mexico		San Juan	

PACKAGE TITLE: Replace Protective Roofs

STUDY PACKAGE ☐
NEW CONSTRUCTION B ☒
REHABILITATION A ☐

NEW PACKAGE ☒
REVISION ☐

CRITERIA (INSERT X s)

PARK PRIORITY	DATE	REG'N PRIORITY	DATE

PROGRAM THRUST, STATUS AND OTHER INFORMATION

WILL ADDITIONAL OPERATING FUNDS AND POSITIONS BE NEEDED UPON COMPLETION OF THIS PACKAGE?
(IF 'YES' EXPLAIN NEEDS IN SECTION XI OUTLINE OF PLANNING AND MANAGEMENT REQUIREMENTS)
YES ☐
NO ☒

FULL PACKAGE DESCRIPTION:

Remove old protective roofs and replace with new and better designed ones. New roofs will apply current methodology and improved materials.

PACKAGE JUSTIFICATION/CONSEQUENCES:

The old protective roofs are supported by the original roofs - additional weight which these 800 year old roofs were not designed to bear. Also, the old protective roofs were poorly designed. They do not compensate for expansion and contraction of materials and are exerting mechanical strain on the original wall and roof fabrics. Furthermore, they do not effectively control moisture and so original roofs and room interiors suffer damage from which they are supposed to be protected.

Failure to replace the old roofs will lead to continued deterioration or original roofs and room interiors.

PLANNING AND MANAGEMENT REQUIREMENTS: *(Follow instructions and outline provided in Program Formulation Guideline)*

New protective roofs must bear their own weight and be separate from original roofs. Materials must be effective in all weather conditions. New roofs must allow for access to protected rooms when no other access is available. System to be designed and installed by professional engineer after approval of design by Southwest Region. Insallation to be monit red by professional archeologist.

ORIGINATOR (Signature and Title)	DATE	CONCURRENCE (Signature of Superintendent or Equivalent Official)	DATE

APPROVAL (Signature of Regional Director or Equivalent Official) | DATE

U.S. GOVERNMENT PRINTING OFFICE: 1976-634-968/401

UNITED STATES DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE

PACKAGE ESTIMATING DETAIL

PAGE ___ OF ___ FOR THIS PACKAGE

PACKAGE NO

REVISION NO

ORG	PARK NAME	DEVELOPED AREA NAME	D.A. CODE	REGION
	Aztec Ruins National Mon.	West Ruin	WR	5

PACKAGE TITLE: Replace Protective Roofs

NET CONSTRUCTION — DETAIL OF ESTIMATES

CLASS OF ESTIMATE

☐ A— WORKING DRAWINGS ☐ B— PRELIMINARY DRAWINGS ☒ C— SIMILAR FACILITIES

THIS ESTIMATE VALID TO: (DATE) FY 78

ITEM	QUANTITY	COST (NET AMOUNT—THOUSANDS) PLANNING AND CONSTRUCTION	ROAD CONSTRUCTION
Labor	150 wd	6750	
Support costs, supplies and materials		8250	
(if additional space is required—use plain paper and attach)	TOTALS	$ 15,000	$

NET CONSTRUCTION — COST BY PROJECT TYPE AND FUND SOURCE

PROJ TYPE	PROJECT TITLE	COST BY FUND SOURCE (THOUSANDS OF DOLLARS) PWE	PLAN./CONST	PWE	ROAD CONST
52	MUSEUM EXHIBIT PRODUCTION				
55	WAYSIDE EXHIBIT PRODUCTION				
57	ACQUISITION OF ARTIFACTS AND GRAPHICS				
62	AUDIOVISUAL ARTS PRODUCTION				
89	RUINS STABILIZATION	300	15,000		
91	CONSTRUCTION				
91	CONSTRUCTION				
92	UTILITY CONTRACTS				
	TOTALS		$ 15,000		$

ESTIMATE PREPARED BY: (Signature)	TITLE	DATE
		Feb. 77
ESTIMATE APPROVED BY: (Signature)	TITLE:	DATE

IDENT.	CODE
PARK NO	IN N. A

ID	FISC. YR.	DEV. AREA	STATE	PKG.	PRG	CAT	PRIORITIES PARK	PRIORITIES REGION
1	80		NM					

United States Department of the Interior
NATIONAL PARK SERVICE

Page ____ of ____

DETAIL OF ANNUAL OPERATING REQUIREMENTS

CONCISE DESCRIPTION & JUSTIFICATION	LINE 1	CONCISE DESCRIPTION & JUSTIFICATION	LINE 2
Bring Ruins Maintenance Program To		Standard	
	LINE 3		LINE 4
	LINE 5		LINE 6

ITEM	ACT	PWE	NET AMOUNT	R/N	PERM. POS.	MY OTHER	PAY PLAN	GRADE	POSITION TITLE/COST COMPONENT	INC. REF.
01	A	300	19412	R		15	WG		Masonry Worker	
02	A	300	4588	R					Support Costs-Supplies and Materials	

FULL DESCRIPTION AND JUSTIFICATION *(Typewritten)*

Aztec Ruins National Monument is responsible for administration, interpretation, and preservation of fourteen excavated and unexcavated, prehistoric, masonry Pueblo ruins.

The above additional operating requirements would allow the establishment of an adequate ruins maintenance program and would improve cost vs. benefit by allowing a continuity of employment for qualified personnel rather than a continual turnover caused by an insufficiently long work season.

Failure to provide these positions will drastically restrict the preservation of unrenewable resources and will result in their further deterioration with a concomitant reduction in archeological integrity and interpretive image.

PARK OR OFFICE:	SUPERINTENDANT OR OFFICE CHIEF *(Signature & title)*	DATE	REGIONAL DIRECTOR APPROVAL *(Signature & title)*	DATE

CULTURAL RESOURCES
MAINTENANCE

ACTIVITIES AND 5-YEAR PROGRAMMING SHEET

Pkg. No.	Area Priority	RMP Ref. No.	Project Title	Year 1 NPS M.Y.	Year 1 Cost/ $1000	Year 2 NPS M.Y.	Year 2 Cost/ $1000	Year 3 NPS M.Y.	Year 3 Cost/ $1000	Year 4 NPS M.Y.	Year 4 Cost/ $1000	Year 5 NPS M.Y.	Year 5 Cost/ $1000	Date Subm: 10-237 10-
	1	C31	Ruins Maintenance	.05	.75	.05	.75	.4	4.0	2.0	20.8	2.0	20.8	
	2	C2	Museum Collection	.2	3.0	.1	1.0	.1	1.0	.1	1.0	.1	1.0	
110/111	3	C3a	Rehabilitate West Ruin	.5	30.0	.5	30.0	.5	30.0					
115	4	C3f	Rehabilitate Hubbard Ruin			.7	50.0							
	5	C3b	Design and Install Drains-West Ruin					.8	34.0					
	6	C3c	Design and Install New Protective Roofs-West Ruin							.6	15.0			

CULTURAL RESOURCES
RESEARCH

ACTIVITIES AND 5-YEAR PROGRAMMING SHEET

Pkg. No.	Area Priority	RMP Ref. No.	Project Title	Year 1 NPS M.Y.	Year 1 Cost/ $1000	Year 2 NPS M.Y.	Year 2 Cost/ $1000	Year 3 NPS M.Y.	Year 3 Cost/ $1000	Year 4 NPS M.Y.	Year 4 Cost/ $1000	Year 5 NPS M.Y.	Year 5 Cost/ $1000	Date Submitt 10-237 10-23
	1	C1	Archeological Assessment	0.1	2.0									
	2	C3d	Historic Structure Report-West Ruin	0.1	2.0									
	3	C3e	Ruins Preservation Guide-West Ruin	0.1	2.0									
115	4	C3f	Historic Structure Report-Hubbard Ruin			0.1	2.0							
115	5	C3f	Ruins Preservation Guide-Hubbard Ruin			0.1	2.0							
	6	C3i	Historic Structures Report-East Ruin					0.1	2.0					
	7.	C3j	Ruins Preservation Guide-East Ruin					0.1	2.0					
	8.	C3k	New Preservation Techniques and Methods											

(Form 1)

AREA: Aztec Ruins National Monument

COST ACCOUNT: _____

DATE: February, 1977

ACTIVITY: Ruins Maintenance

ACTIVITY STANDARDS -RESOURCE REQUIREMENTS DATA

PWE NO.	ELEMENTS OF ACTIVITY	PERIOD OF OPERATION	WORK LOAD FACTORS	REQUIREMENTS TO MEET STANDARDS OF OPERATION
300	1. West Ruin	April to October	250,000 sq ft wall surface 9,000 lin ft wall top 20,700 sq ft wall cap	420 wd
			5,000 sq ft wood members	5 wd
			1,000 lin ft drainages	15 wd
			107,828 sq ft ground surface (vegetation control)	15 wd
			5,120 sq ft ruin trail surface	10 wd
				465 wd
	2. Hubbard Site	April to October	1,100 lin ft wall 11,000 sq ft wall 6,900 sq ft ground surface 30 lin ft trail drainage negligible wood members negligible	25 wd
	3. East Ruin	April to October	720 lin ft stab. wall 5,040 sq ft stab. wall 900 sq ft wood members	15 wd
	4. Great Kiva	April to October	240 lin ft wall 2,880 sq ft wall 3,888 sq ft wood members	15 wd 520 wd total requirement

Maintenance
Management

Maintenance Management

Introduction

Form 10-577, example

Resource Requirements Data, example forms

Activity Standards:

Maintenance of Physical Facilities
Historic Structure Preservation Guide

Navajo Lands Group Ruins Stabilization Program

10-237, example

10-238, examples

Cyclic Maintenance Proposal, examples

Maintenance Management

Preservation of prehistoric cultural resources is an expensive and ubiquitous process. Under the Park Service adopted policies and philosophies of Zero Base Budget and Management by Objective, the need for and the costs of preservation must be justified. Once monies have been justified and appropriated they should be efficiently expended.

To justify and spend funds properly, a manager must know every facet and physical aspect of the resources being managed. For maintenance, of which preservation is a part, this knowledge includes such things as: what is the resource constructed of; how many square and lineal feet are represented; what materials are needed for repair of the defects and what is the current cost of these materials; how much manpower is required to effect repairs; what other costs are involved; what are the defects and what Activity Standard are they covered under; and what repair work is to be done and who is to do it. Maintenance divisions in the National Park Service have utilized the 10-577 Job Order Request to organize their basic resources data successfully for a number of years. Instructions for the use of this form are included on the back side and an example is included in this section. Man day estimates should reflect manpower needs to correct all structural defects. This will quantify the discrepancy beyween actual needs and what is currently available, limited by operating funds. The 10-577 also serves as a data base to justify operating funds you are currently receiving - a very important bargaining tool under zero base budgeting.

A separate 10-577 should be prepared for each zero base Primary Work Element. Some of these elements will require annually updated 10-577's. Aztec Ruins maintenance preservation will utilize the following PWE's:

145 Exhibits - maintenance of existing facilities

252 Cultural Resources Maintenance and Operations

276 Trails

286 Water Systems - drainage

292 Electric Systems

298 Turf, Tree, Shrub and Ground Care

Primary Work Element 252 will require several different 10-577's: one for repair of masonry walls and features; one for repointing of eroded mortar joints; one for wall top capping; one for repair and/or preservative treatment of roofs, roof members, or other structural wood; and one for control of insect and/or animal pests.

Data for all 10-577's must be compiled during physical inspection of the resources. Two in-Group forms - Resource Requirements Data and Resource Requirements Data Tally Sheet - were developed to aid in the compilation of 10-577 data. Example specimens of these two forms are provided in this section. For task time requirements, see "Inspection Schedules" section.

Some of the ruins maintenance will have to be accomplished on a cyclic basis. Under ZBB all cyclic maintenance (such as resurfacing protective roofs) will be handled by SWRO personnel. For your information, however, examples of Cyclic Maintenance Proposals are included in this section. For further information on cyclic maintenance involving archeological resources contact the NALA Ruins Preservation Specialist. For information on other cyclic maintenance, contact the NALA Facilities Manager or the Regional Civil Engineer (who currently manages cyclic maintenance funds).

Presently, these positions are filled by:

NALA Ruins Preservation Specialist
Stephen E. Adams (Steve)

NALA Facilities Manager
Sheldon L. Smith ("Smitty")

Regional Civil Engineer
Dustin Aughenbaugh ("Dusty")

For assistance on ruins maintenance or any other preservation activity, especially emergency conditions, contact the NALA Ruins Preservation Specialist. For your information, some 10-238 Development Package Proposals have been included in this section as examples of those types of projects which are initiated by the Preservation Specialist for the Group areas.

Also included in this section are pertinent portions of the National Park Service Activity Standards, the Navajo Lands Group Ruins Preservation Program, and the Outline for Historic Structures Preservation Guides (SWCRC).

Form 10-577
(March 1970)

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

JOB ORDER REQUEST *Example*

(See Instructions on Reverse)

JOB ORDER NO. _____ FY _____

JOB DESCRIPTION	LOCATION	DISTRICT
Replace Deteriorated Stone, Eroded Mortar	A2RU - West Ruin	

PROPOSED START DATE	TARGET COMP. DATE	NO. OF UNITS	UNIT OF MEASURE	EST. COST PER UNIT	ACT. COST PER UNIT
4/15	9/30	# sq. ft.	sq. ft.		

STANDARD AND LEVEL PROPOSED

B&U (Ruins): General 10; Foundation & Exterior Walls 5a

STATEMENT OF WORK PROPOSED

Replace all deteriorated stone threatening or affecting the structural or aesthetic integrity of the West Ruin; reset all loose stone, including capstones; replace all eroded mortar.

Work to be performed by area maintenance personnel, seasonal day labor.

PERSONAL SERVICES

POSITION, TITLE, GRADE AND SURNAME	EST. M/DAYS	DAILY RATE	EST. COSTS	ACT. M/DAYS	ACTUAL COSTS
Masonry Worker Leader WL-7	100	60.37	6037.00		
Masonry Worker WG-8	100	57.82	5782.00		
Masonry Helper WG-5	100	49.37	4937.00		
Masonry Helper WG-5	100	49.37	4937.00		
Masonry Helper WG-5	100	49.37	4937.00		

EQUIPMENT RENTAL

TYPE OF EQUIPMENT	EST. HRS./MIS.	RATE	EST. COSTS	ACT. HRS/MIS.	ACTUAL COSTS
1/2 Ton Pickup (Mo. Rent 70.00)	1200	0.10	540.00		

MATERIALS AND OTHER COSTS

ITEM	EST. COSTS	ACTUAL COSTS
Miscellaneous Supplies & Materials @ 4.00/m.d.	2000.00	

COST ACCOUNT	PERSONAL SERVICES	EQUIPMENT RENTAL	SUPPLIES AND MATERIALS	OTHER	TOTAL
300	26,630.00	540.00	2000.00		29,170.00

REQUESTED BY (Title & Signature)	CONCURRED BY (Title & Signature)	APPROVED BY (Title & Signature)
Joe Smith, Maintenance Foreman		

COMPLETED BY	DATE COMP.	INSPECTED BY	DATE INSPECTED

Resource Requirements Data

Site: West Ruin Area: AZRU Room: _____ Kiva: _____ Other: _____

Ceiling area: _____ (2) is used only on rooms that have complete roofs. (1) is used as a total on unroofed rooms.

North wall or quadrant:

	Length	Height	Width	Drainage
(1) int.:	M	M	M	M
(1) ext.:	M	M		M
(2) int.:	M	M		M
(2) ext.:	M	M		M

	Wood	Rebuild	Grout	Cap	Void fill
(1) int.:	sqM	sqM	sqM	sqM	sqM
(1) ext.:	sqM	sqM (Repoint)	sqM		sqM
(2) int.:	sqM	sqM	sqM		sqM
(2) ext.:	sqM	sqM	sqM		sqM

Other: _____

South wall or quadrant:

	Length	Height	Width	Drainage
(1) int.:	M	M	M	M
(1) ext.:	M	M		M
(2) int.:	M	M		M
(2) ext.:	M	M		M

	Wood	Rebuild	Grout	Cap	Void fill
(1) int.:	sqM	sqM	sqM	sqM	sqM
(1) ext.:	sqM	sqM	sqM		sqM
(2) int.:	sqM	sqM	sqM		sqM
(2) ext.:	sqM	sqM	sqM		sqM

Other: _____

East wall or quadrant: (1) int.: Length _____ M Height _____ M Width _____ M Drainage _____ M
(1) ext.: _____ M _____ M _____ M
(2) int.: _____ M _____ M _____ M
(2) ext.: _____ M _____ M _____ M

(1) int.: Wood _____ sqM Rebuild _____ sqM Grout _____ sqM Cap _____ sqM Void fill _____ sqM
(1) ext.: _____ sqM _____ sqM _____ sqM _____ sqM
(2) int.: _____ sqM _____ sqM _____ sqM _____ sqM
(2) ext.: _____ sqM _____ sqM _____ sqM _____ sqM

Other: _____

West wall or quadrant: (1) int.: Length _____ M Height _____ M Width _____ M Drainage _____ M
(1) ext.: _____ M _____ M _____ M
(2) int.: _____ M _____ M _____ M
(2) ext.: _____ M _____ M _____ M

(1) int.: Wood _____ sqM Rebuild _____ sqM Grout _____ sqM Cap _____ sqM Void fill _____ sqM
(1) ext.: _____ sqM _____ sqM _____ sqM _____ sqM
(2) int.: _____ sqM _____ sqM _____ sqM _____ sqM
(2) ext.: _____ sqM _____ sqM _____ sqM _____ sqM

Other: _____

Special history: _____

Special instructions: _____
_____

Research: _____

Resource Requirements Data Tally Sheet No. __ of __ pages

Room/Kiva	Wall Area	Cap Area	Drainage	Wood/Ceiling	Rebuild	Repoint	Cap	Void fill	Other
Totals this page									

ACTIVITY STANDARDS: Excerpts

MAINTENANCE OF PHYSICAL FACILITIES

Physical facilities maintenance will be considered to be satisfactory when:

Buildings, Utilities, and Other Facilities

General

1. All buildings...are neat, clean, and free of debris, exposed surfaces are sound and properly finished,.....

4. Adequate operating and maintenance logs and records are current and available.

7. Maintenance procedures assure detection and correction of nonoperational or hazardous conditions.

9. All roofing and flashing prevent water or moisture from entering building.

10. Structures are free of differential settlement, cracking, spalling, loose joints, leaks, and encroaching vegetative growth.

Buildings

2. Drainage.....
   a. Are free of obstructions and all openings clear.

3. Electrical (Wiring, Lighting, etc.)

   c. Lamps and appliances are operating properly

5. Foundation and Exterior Walls

   a. Are structurally sound and support the superimposed loading.

   b. Are free of differential settelement or lateral, vertical or longitudinal displacement.

8. Interior Surfaces

   a. Are free of damage attributal to accumulated moisture.

   c. Are...free of....excessive wear

10. Roofs

a. Are free of deterioration that would affect structural qualities.

c. Are free of displacement or warping.

d. Have snow load removed before the critical depth is reached.

e. Structures or parts of roof structures are not jeopardized by adjacent vegetation.

Grounds

2. Grounds Cover

b. Cover is attractive, of sufficient length and density to protect the soil and free of erosion and debris. In areas where poisonous or dangerous animals or insects are not compatible with use, ground cover shall be controlled to minimize hazards.

3. Trees and Shrubs

b. Areas of use are free of defective and/or potentially hazardous trees.

10. Graded Drainage Areas

a. Are free of trash, debris, erosion and standing water.

Historic Structures

(A historic structure is a work of man, either prehistoric or historic, consciously created to serve some form of human activity. Besides buildings of various kinds, the term includes engineering works such as dams, canals, bridges, stockades, forts and associated earthworks, nautical vessels, Indian mounds, gardens, historic roads, millraces, and ponds.)

1. Housekeeping and maintenance do not change or adversely affect the fabric or historic appearance of the structure and are done in accordance with the area's Historic Resource Management Plan or a specifically applicable Historic Structure Preservation Guide.

2. All projects involving specialized housekeeping, repair, rehabilitation, or replacement of structural components and projects involving techniques for arresting or slowing deterioration of the historic fabric and its historic environment are conducted under the direction of a Historical Architect or Archeologist as appropriate.

3. Routine housekeeping which will not affect the historic fabric and maintenance of equipment and facilities located within the structure but not themselves of historical significance are maintained in accordance with the applicable maintenance standards for that type of equipment or facility.

Historic Structure Preservation Guide

The Historic Structure Preservation Guide is a reference document, tailored to the individual needs of a restored or reconstructed structure, from which park management may obtain guidance for continuing normal maintenance and minor repairs. It is ordinarily prepared at the conclusion of a development project as part of the construction supervision (identified as such on Form 10-238), but for completed projects lacking such a guide may also be programmed in the annual professional services program.

A Historic Structures Preservation Guide will be considered satisfactory when it:

1. Documents new historical, archeological, and architectural data learned in the process of construction and not included in a Historic Resource Study or Historic Structure Reports.

2. Includes all drawings, technical specifications, and change orders used to carry out the project. Drawings may be reduced to letter size.

3. Provides detailed specifications for expendable items such as roof coverings so they may be replaced in material, design and texture as in the original.

4. Contains a schedule of paint colors related to a color standard such as the Munsell Color System and a suggested program for paint maintenance and repainting, giving formulas where special materials and textures are required.

5. Provides formulas and specifications for mortars, waterproofing, floor finishes, glazing, and any item not found in the normal market.

6. Provides manufacturers recommendations for maintenance where available.

7. Provides a schedule of periodic inspection to assure proper preservation.

NAVAJO LANDS GROUP

RUINS STABILIZATION PROGRAM

Revised July 1975

INTRODUCTION

Ruins maintenance is an area responsibility and as presently designed annual and cyclic maintenance is funded from the area's operating funds. Supervisory, Technical and Professional assistance in ruins maintenance can be received upon request from the Navajo Lands Group Ruins Stabilization Unit and Southwest Region.

Annual ruins maintenance is performed by the area maintenance staff and includes an inspection of each ruin at least one a year, maintenance of drains and drainage systems, removal of weeds, trash and wind-blown or water-borne sand, and minor structural repairs.

Ayclic ruins maintenance is performed by the area maintenance staff and is usually performed under the supervision of a ruins stabilization specialist. Besides involving all the activities performed during annual ruins maintenance major structural repairs are made.

For both annual and cyclic ruins maintenance, records of the work accomplished, number of man-days expended, and costs incurred are kept for each ruin.

Only man-day estimates are listed. Dollar estimates may be made by computing the labor costs plus 10% for fringe benefits plus 20% to 40% for supplies, materials and equipment, etc.

JUSTIFICATION

Ruins maintenance is the key to Ruins preservation, as is the maintenance of any structure the key to its preservation. Some believe that Ruins require little or no maintenance once they are initially stabilized. It is granted that a Ruin requires less work than modern structures, for the Ruins usually have no roofs, no floors, no heating or cooling systems, no utilities, etc., but they do require maintenance and frequently more maintenance, unit for unit, than modern structures. Ruins are usually open to the weather, they were constructed with impermanent materials and contain many structural faults. Also, their stabilization and maintenance involve conflicting objectives - authenticity (the preservation of irregular and relatively primitive construction), permanence (the requirements of sound building practice), and safety. Ruins are usually entered by people little acquainted with their nature, who frequently assume that they are as safe or safer than modern structures when, in fact, the Ruins are dangerous and when, in fact, the visitor's very actions actually increase their danger.

Drainage

In most Pueblo sites, surface water within rooms is absorbed into the soil and presents little difficulty. Problems are encountered where adjacent rooms or small areas are at widely varying levels, and the problem is either surface washing from one level to another or moisture penetration through a wall.

To maintain a drainage system, the drains must be kept free and open. Obstructions must not be placed, or allowed to accumulate, at the entrance to drains, weeds which accumulate in the Ruins, especially Russian Thistle, must be removed annually, and the drainage gradient must be maintained. Settling basins and dry barrels must be cleaned periodically. Wind borne sand can accumulate against walls, and alter the drainage surface.

Housekeeping

In addition, the accumulation of weeds, water and wind borne soil and trash covers Ruins features, and creates an unsightly mess.

Structural Repairs

During initial Ruins stabilization, major structural faults are repaired or strengthened, wall tops are re-set in tinted cement mortar and loose wall faces are respalled and grouted with tinted cement. Usually, repairs to initial stabilization, and later occurring major work and deficiencies, are performed only during cyclic or periodic major Ruins maintenance when a trained stabilization foreman or archeologist is present to supervise and record the work. However, minor problems will arise from time to time. Small sections of wall caps may come loose, wall surfaces, especially about doorways and drains, loosen, and erosion may cause soil to bleed from beneath walls. These minor deficiencies, if left untended, will enlarge. They should be repaired annually with materials that match the materials used during initial stabilization or construction. Adobe mortar, made from local matching soil, is the mortar of first choice. Tinted cement, never untinted, is the mortar of second choice or is to be used where strength is required.

Safety

Ruins were not built to be national monuments, to survive forever. Safety engineering was unknown at the time of their construction. The visitor seldom recognizes these facts. Yet, the National Park Service must make sure that the Ruins are safe for and from the visitor.

Unsafe conditions must be corrected, immediately. Where this cannot be done without seriously compromising the authenticity of the Ruin, that section must be closed. Where it can be done without compromising the authenticity of the Ruin, it must be done.

Remember, one loose rock that falls on one visitor's head may result in a tort claim settlement, equal to or greater than the budget for Ruins maintenance.

Keep the Ruins safe for the visitor, but also keep the Ruin safe from the visitor. We have to preserve both.

PROGRAM STANDARDS

The standard of maintenance for a ruin is set at the time of its initial stabilization and is detailed in the initial stabilization report. In addition, two (2) sets of program standards have a bearing on the preservation of ruins. They are (1) standards for ruins maintenance stabilization, and (2) standards for ruins protection. These standards are defined as:

Standards for Ruins Maintenance Stabilization

Standard A: Maintenance which is required to protect the ruins from natural and human erosion.

Standard B: Maintenance which is required to protect the ruins from natural erosion and human vandalism.

Standard C: Ruins which are naturally protected. Maintenance, if required, is limited to maintaining the natural protection.

Standards for Ruins Protection

Standard A: Ruins of such a fragile nature that it is necessary to assure protection through immediate visual and verbal contact.

Standard B: Ruins of such a nature that adequate protection can be provided by self-guide interpretation and ranger patrols.

Standard C: Ruins closed to all visitation because they are either unsafe for the visitor or the visitor will irreparably damage the ruin by entering it.

...NT.	CODE
...RK NO	IN... N.
	A

ID	FISC. YR.	DEV AREA	STATE	PKG	PRG	CAT	PRIORITIES PARK	PRIORITIES REGION
1	80		NM					

United States Department of the Interior
NATIONAL PARK SERVICE

Page ____ of ____

DETAIL OF ANNUAL OPERATING REQUIREMENTS

CONCISE DESCRIPTION & JUSTIFICATION	LINE 1	CONCISE DESCRIPTION & JUSTIFICATION	LINE 2
Bring Ruins Maintenance Program To		Standard	
	LINE 3		LINE 4
	LINE 5		LINE 6

...EM	ACT	PWE	NET AMOUNT	R/N	PERM. POS.	MY OTHER	PAY PLAN	GRADE	POSITION TITLE/COST COMPONENT	INC. REF.
1	A	300	19412	R		15	WG		Masonry Worker	
2	A	300	4588	R					Support Costs-Supplies and Materials	

FULL DESCRIPTION AND JUSTIFICATION *(Typewritten)*

Aztec Ruins National Monument is responsible for administration, interpretation, and preservation of fourteen excavated and unexcavated, prehistoric, masonry Pueblo ruins.

The above additional operating requirements would allow the establishment of an adequate ruins maintenance program and would improve cost vs. benefit by allowing a continuity of employment for qualified personnel rather than a continual turnover caused by an insufficiently long work season.

Failure to provide these positions will drastically restrict the preservation of unrenewable resources and will result in their further deterioration with a concomitant reduction in archeological integrity and interpretive image.

PARK OR OFFICE:	SUPERINTENDANT OR OFFICE CHIEF *(Signature & title)*	DATE	REGIONAL DIRECTOR APPROVAL *(Signature & title)*	DAT...

NATIONAL PARK SERVICE

DEVELOPMENT/STUDY PACKAGE PROPOSAL

PACKAGE NO.
REVISION NO

	Aztec Ruins National Mon.	West Ruin & Great Kiva	WR / SW
STATE: New Mexico	STATE CODE	COUNTY(IES): San Juan	CONGRESSIONAL DISTRICT

PACKAGE TITLE: Modify Drainage Systems

STUDY PACKAGE ☐
NEW CONSTRUCTION B ☒
REHABILITATION A ☐

NEW PACKAGE ☒
REVISION ☐

CRITERIA (INSERT X s)	PARK PRIORITY	DATE	REGION PRIORITY	DATE

PROGRAM THRUST, STATUS AND OTHER INFORMATION

WILL ADDITIONAL OPERATING FUNDS AND POSITIONS BE NEEDED UPON COMPLETION OF THIS PACKAGE? (IF 'YES' EXPLAIN NEEDS IN SECTION XI OUTLINE OF PLANNING AND MANAGEMENT REQUIREMENTS)
YES ☐
NO ☒

FULL PACKAGE DESCRIPTION

Modify and improve the drainage systems in the West Ruin and the Great Kiva. Current systems will be redesigned and expanded.

PACKAGE JUSTIFICATION/CONSEQUENCES:

Existing drainage systems in these two cultural resources are inadequqte and inefficient. They are failing to control moisture from snow, ice, and rain and are thus contributing to wall stone and mortar erosion. Increased deterioration demands increased maintenance. A modified drainage system will effectively control moisture and will result in a substantial decrease in ruins maintenance requirements.

Failure to improve the drainage system will maintain the currently high cost vs. benefits ratio, will result in further ruin deterioration, and will cause a decrease in the archeological and interpretive value of the sites.

PLANNING AND MANAGEMENT REQUIREMENTS: *(Follow instructions and outline provided in Program Formulation Guideline)*

System must be effective in each unit being drained and must be easily maintainable. System should be designed and installed by a professional engineer. Design must be approved by the Southwest Region and installation must be monitored by a professional archeologist.

ORIGINATOR (Signature and Title)	DATE	CONCURRENCE (Signature of Superintendent or Equivalent Official)	DATE

APPROVAL (Signature of Regional Director or Equivalent Official) | DATE

U.S. GOVERNMENT PRINTING OFFICE: 1976-634-968/401

UNITED STATES DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE

PACKAGE ESTIMATING DETAIL

FOR THIS PACKAGE

PACKAGE NO

REVISION NO

ORG	PARK NAME	DEVELOPED AREA NAME	D.A. CODE	REG.
	Aztec Ruins National Mon.	West Ruin & Great Kiva	WR	SW

PACKAGE TITLE: Modify Drainage Systems

NET CONSTRUCTION — DETAIL OF ESTIMATES

CLASS OF ESTIMATE

☐ A— WORKING DRAWINGS ☐ B— PRELIMINARY DRAWINGS ☒ C— SIMILAR FACILITIES

THIS ESTIMATE VALID TO: (DATE) FY78

ITEM	QUANTITY	COST (NET AMOUNT—THOUSANDS) PLANNING AND CONSTRUCTION	ROAD CONSTRUCTION
Labor	200 wd	7800	
Support costs, supplies and materials		26200	
(If additional space is required—use plain paper and attach)	TOTALS	$ 34,000	$

NET CONSTRUCTION — COST BY PROJECT TYPE AND FUND SOURCE

PROJ TYPE	PROJECT TITLE	COST BY FUND SOURCE (THOUSANDS OF DOLLARS) PWE	PLAN./CONST	PWE	ROAD CONST.
52	MUSEUM EXHIBIT PRODUCTION				
55	WAYSIDE EXHIBIT PRODUCTION				
57	ACQUISITION OF ARTIFACTS AND GRAPHICS				
62	AUDIOVISUAL ARTS PRODUCTION				
89	RUINS STABILIZATION	300	34,000		
91	CONSTRUCTION				
91	CONSTRUCTION				
92	UTILITY CONTRACTS				
	TOTALS		$ 34,000		$

ESTIMATE PREPARED BY: (Signature)	TITLE	DATE
ESTIMATE APPROVED BY: (Signature)	TITLE:	DATE

NATIONAL PARK SERVICE

DEVELOPMENT/STUDY PACKAGE PROPOSAL

PACKAGE NO.
REVISION NO.

ORG. NO.	PARK OR OTHER ORIGINATOR	DEVELOPED AREA NAME	DIR. CODE	
	Aztec Ruins National Mon.	West Ruin	WR	EW

ST	STATE CODE	COUNTY(S)	CONGRESSIONAL DISTRICT
New Mexico		San Juan	

PACKAGE TITLE: Replace Protective Roofs

STUDY PACKAGE ☐
NEW CONSTRUCTION B ☒
REHABILITATION A ☐

NEW PACKAGE ☒
REVISION ☐

CRITERIA (INSERT X's)

PARK PRIORITY	DATE	REG'N PRIORITY	DATE

PROGRAM THRUST, STATUS AND OTHER INFORMATION

WILL ADDITIONAL OPERATING FUNDS AND POSITIONS BE NEEDED UPON COMPLETION OF THIS PACKAGE?
(IF YES EXPLAIN NEEDS IN SECTION XI OUTLINE OF PLANNING AND MANAGEMENT REQUIREMENTS)

YES ☐
NO ☒

FULL PACKAGE DESCRIPTION

Remove old protective roofs and replace with new and better designed ones. New roofs will apply current methodology and improved materials.

PACKAGE JUSTIFICATION/CONSEQUENCES:

The old protective roofs are supported by the original roofs - additional weight which these 800 year old roofs were not designed to bear. Also, the old protective roofs were poorly designed. They do not compensate for expansion and contraction of materials and are exerting mechanical strain on the original wall and roof fabrics. Furthermore, they do not effectively control moisture and so original roofs and room interiors suffer damage from which they are supposed to be protected.

Failure to replace the old roofs will lead to continued deterioration or original roofs and room interiors.

PLANNING AND MANAGEMENT REQUIREMENTS: *(Follow instructions and outline provided in Program Formulation Guideline)*

New protective roofs must bear their own weight and be separate from original roofs. Materials must be effective in all weather conditions. New roofs must allow for access to protected rooms when no other access is available. System to be designed and installed by professional engineer after approval of design by Southwest Region. Insallation to be monit red by professional archeologist.

ORIGINATOR (Signature and Title)	DATE	CONCURRENCE (Signature of Superintendent or Equivalent Official)	DATE

APPROVAL (Signature of Regional Director or Equivalent Official) | DATE

☆ U.S. GOVERNMENT PRINTING OFFICE: 1976-634-968/401

UNITED STATES DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE

PACKAGE ESTIMATING DETAIL

FOR THIS PACKAGE

PACKAGE NO

REVISION NO

ORG	PARK NAME	DEVELOPED AREA NAME	D.A CODE	REGION
	Aztec Ruins National Mon.	West Ruin	WP	5

PACKAGE TITLE: Replace Protective Roofs

NET CONSTRUCTION — DETAIL OF ESTIMATES

CLASS OF ESTIMATE: ☐ A— WORKING DRAWINGS ☐ B— PRELIMINARY DRAWINGS ☑ C— SIMILAR FACILITIES

THIS ESTIMATE VALID TO: (DATE) FY 78

ITEM	QUANTITY	COST (NET AMOUNT—THOUSANDS) PLANNING AND CONSTRUCTION	ROAD CONSTRUCTION
Labor	150 wd	6750	
Support costs, supplies and materials		8250	
(if additional space is required—use plain paper and attach)	TOTALS	$ 15,000	$

NET CONSTRUCTION — COST BY PROJECT TYPE AND FUND SOURCE

PROJ TYPE	PROJECT TITLE	COST BY FUND SOURCE (THOUSANDS OF DOLLARS) PWE	PLAN./CONST	PWE	ROAD CONST
52	MUSEUM EXHIBIT PRODUCTION				
55	WAYSIDE EXHIBIT PRODUCTION				
57	ACQUISITION OF ARTIFACTS AND GRAPHICS				
62	AUDIOVISUAL ARTS PRODUCTION				
89	RUINS STABILIZATION	300	15,000		
91	CONSTRUCTION				
91	CONSTRUCTION				
92	UTILITY CONTRACTS				
	TOTALS		$ 15,000		$

ESTIMATE PREPARED BY: (Signature)	TITLE	DATE
		Feb. 77
ESTIMATE APPROVED BY: (Signature)	TITLE	DATE

CYCLIC MAINTENANCE PROPOSAL

Region	Professional Office	Park (or Other Originator)	Developed Area
	NALA	Aztec Ruins National Monument	Park General

Project Title: Clean Drainage System

FY	Priority	Cycle
77	1	3 years

	Date Built	Date-Previous Repair
[X] New Proposal	1945	1957
[ ] Addition to an existing Proposal		
[ ] Revision to an existing Proposal		

Project Description Clean out 8" perforated Orangeburg interceptor drainage system, 1440 feet long with 9 manholes. Will require approximately 60 man days day labor.

Project Justification This system, designed to carry excess sub-surface water around and away from the ruins, has become completely plugged with leaves, trash, and soil. Consequemtl water is not adequately drained and is accumulating around, under, and in ruins structures, thereby adversely affecting structural fabric by eroding mortar and sandstone building materials and accelerating ruins deterioration and adding an increasing burden on the ruins maintenance program. If not cleaned out, the drainage system will continue its indirect adverse effect on these non-renewable resources.

Management Requirements Cost estimate based on Drawing Number NM-AZT 2303, May, 1966 by W.P. Jensen:

60 man days labor at $43.00 each	= 2580
Supplies and materials	= 120
	2700

Originator Signature, Title	Date	Approving Signature (Supt. or other orig.)	Date
Stephen E. Adams Ruins Stab. Spec.	04/01/77		4/1/77
Approved for estimating by Professional office(s)		Signature, Title	Date
Disapproved for reasons stated in transmittal memo and returned to originator			

CYCLIC MAINTENANCE PROPOSAL

Originating (Professional Office)	Park (or Other Originator)	Developed Area
~~NALA~~	~~Aztec Ruins National Monument~~	~~Park General~~

Project Title: Repair Protective Roofs

FY	Priority	Cycle
77	2	10 years

	Date Built	Date-Previous Repair
[X] New Proposal	1918 (Est.)	1937 1953
[ ] Addition to an existing Proposal		
[ ] Revision to an existing Proposal		

Project Description Modify present protective roofs to conform to current technology and improved materials in a design that will increase protection and reduce structural strain on the prehistoric roofs..

Justification As designed, the protective roofs are subject to leaking because of expansion and contraction of materials. This leaking is causing substantial moisture damage to interior wall cores and veneers. Furthermore, the current roofs are heavy and this weight is being born by 900-year-old timbers that were never designed to bear that weight. These two factors contribute to increased maintenance requirements and also threaten the safety of visitors touring the roofed rooms. If the protective roofs are not repaired, wall fabric damage and original roof damage will continue, resulting in increased maintenance costs, a worsening visitor safety situation, and an irretrievable commitment of resources.

Management Requirements Cost estimates determined from similar facilities are:

Labor 7.5 md/unit @$45.00 = 337.50, 20 units = 6750
Supplies & Materials 412.50/unit, 20 units = 8250
$15000.00

Originator's Title	Date	Approving Signature (Supt. or other originator)	Date
Stephen E. Adams Ruins Stab. Spec.	04/01/77	Arthur M. Nitsch	4/1/77

Approved for estimating by Professional office(s) — Signature, Title — Date

Disapproved for reasons stated in transmittal memo and returned to originator

CYCLIC MAINTENANCE PROPOSAL

Professional Office	Park (or Other Originator)	Developed Area
NALA	Aztec Ruins National Monument	Park General

Project Title Emergency Cyclical Maintenance Hubbard Site

FY	Priority	Cycle
77	3	5 years

	Date Built	Date-Previous Repair
☐ New Proposal		
☒ Addition to an existing Proposal	A.D. 1075 Stabilized 1954	1965
☐ Revision to an existing Proposal		

Project Description Strip off cement plaster from ruin walls, replace rotted stone, regrout mortar joints, replaster walls with soil plaster.

Justification The ruin was plastered with cement in order to protect the walls from moisture. However, cement is porous to water and therefore does not keep moisture off walls. Furthermore, it provides an optimum medium for capillary action. Therefore, walls and wall cores are continually exposed to moisture. When the plaster peels off it also peels off wall fabric. In addition, white Portland cement turns purple when fully cured, as at Hubbard. If the cement, which is accelerating ruin deterioration, is not removed ruin maintenance costs will increase, severe damage to the fabric will recur, and the ruin will continue to be an eyesore to the interpretive program.

Management Requirements Cost estimate based on 10-802, Package #115 are:

Labor: 156 md @ $48.00 = 7488
Supplies & Materials: = 2512.
Total $10000.00

Name & Title	Date	Approving Signature (Supt. or other orig.)	Date
Stephen E. Adams/Ruins Stab. Spec.	04/01/77	Arthur H. Smith	4/1/77
Approved for estimating by Professional office(s)		Signature, Title	Date
Disapproved for reasons stated in transmittal memo and returned to originator			

CYCLIC MAINTENANCE PROPOSAL

Originating (Professional Office)	Park (or Other Originator)	Developed Area
~~NALA~~	~~Aztec Ruins National Monument~~	Park General

Project Title Repaint Interior Of Great Kiva

FY 77	Priority 6	Cycle 5 years

	Date Built	Date-Previous Repair
[X] New Proposal	1933-34	1974
[ ] Addition to an existing Proposal		
[ ] Revision to an existing Proposal		

Project Description Sand-blast interior wall surfaces, repaint with historically accurate colors. Match paint textures with texture of prehistoric plaster.

Project Justification The Great Kiva, as a major interpretive focus, was reconstructed to provide the visitor a more meaningful historic experience in this large and archeologically important group of resources. The Service is committed to providing the most accurate representations possible of the lifeways and architecture of the Anasazi who dwelt here. The current paint scheme is historically inaccurate and has a glossy, cement-like texture. As long as this erroneous paint job is displayed, the park visitor will continue to be puzzled by this incongruous, intrusive, modern artifact which tarnishes his ephemeral journey through the fascinating halls of prehistory.

Management Requirements Cost estimate based on previous contract bids:

$2,000.00 on contract.

Originator (Name & Title)	Date	Approving Signature (Supt. or other orig.)	Date
Stephen E. Adams Ruins Stab. Spec.	04/01/77	[signature]	4/1/77

[ ] Approved for estimating by Professional office(s)
[ ] Disapproved for reasons stated in transmittal memo and returned to originator

Signature, Title

Date

SWR-OM-6(10/78)

CYCLIC MAINTENANCE PROGRAM

SOUTHWEST REGION

Aztec Ruins National Monument (Park)

Originator _____ Approved By Virginia Vulgamore (Superintendent) Date 11/29/78

PRIORITY	PROJECT TITLE - AREA	FACILITY DESCRIPTION		DATE OF PREVIOUS WORK(FY)	CYCLE FREQUENCY	DUE FISCAL YEAR	OFFICE IN CHARGE	DAY LABOR OR CONTRACT	ESTIMATED COST	ACTION TAKEN
		UNITS	TYPE (Surface-Material)							
1	CLEAN INTERCEPTOR DRAIN	1,400 LF	Perforated Tile	1978	5 Years	1984	SWR	DL & Contract	$ 5,000	
2	RUINS MAINTENANCE - EAST RUIN	720 LF	Masonry	1965	5 Years	1979	SWR	DL	2,000	
2	RESURFACE PROTECTIVE ROOFS - EAST RUIN	1,500 SF	Paper	1957	10 Years	1979	SWR	DL	6,500	
3	REPAINT INTERIOR VISITOR CENTER	4,146 SF	Plaster	1974	5 Years	1979	SWR	Contract	1,500	
4	CHIP & SEAL PARKING AREAS & TRAILS	70,000 SF	Asphalt	1976	3 Years	1979	SWR	Contract	2,550	
5	RECARPET MUSEUM LOBBY	925 SF	Cement	1969	10 Years	1979	SWR	Contract	1,100	
6	REHABILITATE MUSEUM EXHIBITS	23 Each	Various	1964	5 Years	1978	SWR	Cpntract	2,300	
7	RESURFACE PROTECTIVE ROOFS - WEST RUIN	3,000 SF	Epoxy	1979	20 Years	1999	SWR	Contract	10,000	
8	REPAINT VISITOR CENTER EXTERIOR WALLS	20,845 SF	Stucco	1974	10 Years	1984	SWR	Contract	2,000	
9	REPAINT GREAT KIVA	3,014 SF	Plaster	1978	5 Years	1983	SWR	Contract	4,000	
10	REPAINT SHOP BUILDING	13,901 SF	Stucco	1975	10 Years	1985	SWR	Contract	7,700	
12	REHABILITATE SEWER LIFT STATION	50 LF	Various	1976	10 Years	1986	SWR	DL & Contract	4,500	
11	HUBBARD RUIN MAINTENANCE	1,100 LF	Masonry	1978	10 Years	1988	SWR	DL	2,000	
13	REROOF SHOP BUILDING COMPLEX	2,000 SF	Asphalt	1978	10 Years	1988	SWR	Contract	2,000	
14	REROOF VISITOR CENTER	4,694 SF	Asphalt	1977	10 Years	1978	SWR	Contract	5,663	
15	RECARPET VISITOR CENTER LOBBY/OFFICE	1,226 SF	Cement	1978	10 Years	1988	SWR	Contract	1,430	
16	RUINS MAINTENANCE - WEST RUIN	6,790 LF	Masonry	1978	5 Years	1983	SWR	DL	8,000	

SWR-OM-6(10/78)

CYCLIC MAINTENANCE PROGRAM

SOUTHWEST REGION

Aztec Ruins National Monument
(Park)

Originator _____ Approved By _____ (Acting Superintendent) Date 11/29/78

PRIORITY	PROJECT TITLE - AREA	FACILITY DESCRIPTION		DATE OF PREVIOUS WORK(FY)	CYCLE FREQUENCY	DUE FISCAL YEAR	OFFICE IN CHARGE	DAY LABOR OR CONTRACT	ESTIMATED COST	ACTION TAKEN
		UNITS	TYPE (Surface-Material)							
17	REROOF GREAT KIVA	4,300 SF	Asphalt	1974	10 Years	1984	SWR	Contract	$ 2,750	

Inspection Schedules

Inspection Schedules

Inspection schedules are one of the most important resource management tools. They are simple to set up and provide exact guidelines on what to inspect, how, how often, and, preferably, when. Any thing that can be damaged, broken, or deteriorated should be inspected according to a regular schedule. For ruins resources, this includes everything - walls, roofs, protective roofs, surface and sub-surface drainages, doorways, ventilators, lintels, electrical systems for lighting, trails ~~themselves~~, stairs, transparent doorway sealers, interpretive displays, and trail markers. This also applies to the Great Kiva which is an historic structure.

Included in this section is an inspection schedule for the AZRU cultural resources. Inspection rates should naver be made more infrequent. However, if you believe a particular rate should be made more frequent, make this change in the schedule. In any case, adhere to this schedule as you have it set up.

Bear in mind that any alterations to prehistoric or historic structures (for instance, moving trail lighting from one part of a wall to another) requires prior clearance by Regional and NALA Cultural Resources Management personnel.

Ruins Inspection Schedule:

Item	Inspection Rate	Approximate Date(s)	What To Look For	Treatment
Walls, foundations, doorways, etc.	Biannual	Oct. 15 & Apr. 1 And after heavy snow/rain	Eroded, deteriorating stone, loose stone, voids, cracks, eroded mortar joints	See "Masonry Struc
Roofs, ceilings, and other wood members	Biannual	Apr. 1 & Oct. 1 And after heavy snow/rain	Insect activity, rotten, broken, or warped members, leaks, undue stress or strain	"Weather & Biologics" See "Protective Roofs"
Protective Roofs	Biannual	Mar. 15 & Oct. 1 And after heavy snow/rain	Leaks, cracks	See "Protective Roofs"
Orangeburg drainage	Annual	Oct. 7	Clogged system	See "Drainage"
Other drainage	Biannual	Mar. 15 & Nov. 30	Clogged system, broken sections	See "Drainage"
Interpretive displays and trail markers	Biannual	Apr. 1 & Sep. 30	Cracks, splinters, breaks, insects, dry rot	See "Utilities & Trail Appurtenances"
Electrical systems	Monthly	1st of month	Loose, broken, or missing hardware, loose, broken, or burned out bulbs, loose exposed wire.	See "Utilities & Trail Appurtenances"
Trails	Monthly	1st of month	Cracks, broken areas, abraded areas, surface debris.	See "Utilities & Trail Appurtenances"
Stairs	Bi-monthly during peak season Monthly	1st & 15th of month 1st of month	Loose, broken steps, loose railings, splinters, surface debris	See "Utilities & Trail Appurtenances"
Trail doorway sealers	Bimonthly during peak season, otherwise monthly	1st & 15th of month 1st of month	Cracks, breaks, dirt & grime, film	See "Utilities & Trail Appurtenances"
Grounds	Monthly during warm months	1st of month	Intrusive weeds, shrubs, tree, overgrown plants	See "Grounds"

Task Time Requirements

(based on an average, trained crew familiar with resources; time includes support activities)

Task	Time Required
Replace eroded stone	1 sq. ft./hr.; 8 sq. ft./day
Reset loose stone	1 sq. ft./hr.; 8 sq. ft./day
Repoint fine to medium mortar joints	1¼ sq. ft./hr.; 10 sq. ft./day
Wood treatment	1 sq. ft./min.; approx. 3 md/year
Clean 8" interceptor drain (1425')	5 mandays/year
Other drains (approx 251')	1 lineal ft./minute
Replace wood sign	3 man hours
Replace wood trailer marker	1.5 man hours
Replace bulb in trail light	15 minutes
Sweep visitor trail	2 man hours
Snow removal	5 man days/year
Replace wood stair step	30 minutes
Clean doorway sealer	10 minutes
Remove intrusive vegetation	4 man days/year
Trim over grown vegetation	1 man day /year
Clear roof drainage, West Ruin (20 roofs)	15 minutes/roof
Clear Kiva N drainage (7 flush caps, approx. 220 ft. of pipe)	15 minutes/flush cap
Clear Great Kiva roof drainage (5 spouts)	10 minutes/spout
Clear East Ruin roof drainage (1 pipe currently exposed)	15 minutes

Task time requirements are based on the experiences of a few project supervisors. Once you begin performing these tasks, you may find that requirements vary from those listed. When this happens, document the actual time you expend. If your figures recur consistently, substitute them for the figures listed in the task time requirements. On your seasonal crews you will have individuals who exceed the rates and others that perform below the rates. It is the average rate of the crew as a whole that you must be concerned with.

When reviewing time requirements, take into consideration support activities: collection and transport to the work site of materials and tools; making of replacement items such as new trail signs; difficulty of access to the work site (i.e. is a ladder needed); temperature and precipitation conditions; etc.

It should be emphasized that unless tasks are scheduled and the schedule adhered to as closely as possible, it will be virtually impossible to either keep track of time requirements or to accomplish the tasks. Organization is the key to timely execution. Organization also allows you to shift task schedules in order to circumscribe unforeseen circumstances that would otherwise delay and confuse your maintenance program.

The more information you compile, the broader the base for your organization will be. Therefore, it is imperative that you keep accurate records. Not only will this help you, it will also prove invaluable to your successor. The more information he/she has, the more quickly and better the job will be performed.

Weather And
Biology

Weather and Biologics

Introduction

Weather Summary, 1976

Common Fauna

Common Flora

Resources Management Plan, Project 4: Noxious Plants and Animals

Insects and Diseases of Evergreens in New Mexico
Pub. of U.S.D.A.

Aztec Ruins, at 5600+ feet, lies within the Pinyon-Juniper Belt, or Upper Sonoran Zone. Pinyons and Junipers are virtually non-existent on the monument, however, other characteristics of this belt are applicable:

> "The terrain is usually dry and rocky or gravelly, and characterized by limited moisture. The annual average precipitation is between 10 and 20 inches. Summer days are often hot (but not so hot as in the drier desert immediately below). Winters are relatively long and see some snowfall. Rainfall throughout this belt is scanty, thereby restricting the plants mostly to drought-resisting species." (Elmore, 1976:13)

The weather does somewhat limit preservation activities. Most repair work is accomplished from about mid-April to mid-October. From July to September, thundershowers will occasionally interrupt the work schedule.

It is during winter that perhaps the greatest structural and fabric damage occurs (see Ruins Management Plan) from moisture. Snow and ice clog drains, provide soaking moisture over a relatively long period of time, and cause added structural stress to roofs through increased weight. A mild winter can cause a great deal of damage and a moderate winter can cause severe, extensive damage. In other words, winter can be a critical factor in ruins preservation. Facts on winter precipitation are available in the area weather file. Unusually mild or severe winters should be recorded in this section along with any other weather facts you believe pertinent. The temperature/precipitation chart in this section will give you general indications of what to expect and when and will enable you to better plan work activities.

For your information, lists of common fauna (see also "Safety") and common flora (see "Grounds") have been included here. Project: Noxious Plants and Animals from the Resources Management Plan outlines action to be taken to eradicate some of the more prevalent plant and animal pests. You may find the USDA pamphlet on evergreen insects and diseases helpful in the control of insects and diseases affecting wood structural members in the ruins.

CITADEL® NO. 641 - SCIENCE - 10 SQUARES TO CENTIMETER

	Temperature														Precipitation									
Month And Year	Average Maximum	Average Minimum	Average Departure From Normal	Highest	Date	Lowest	Date	Degree Days	MAX # of Days 90° or >	MIN # of Days 32° or <	MIN # of Days 32° or <	MIN # of Days 0° or <	Total	Departure From Normal	Greatest Day	Date	SNOW, ICE Total	SNOW, ICE Maximum Depth On Ground	SNOW, ICE Date	# of Days .10 or >	# of Days .50 or >	# of Days 1.00 or >
JAN 76	43.9	10.6	27.3	-1.8	56	18	-8	2	1162	0	4	31	4	.03	-.72	.03	6	2.0			0	0	0
FEB 76(M)	56.1	20.0	38.1	2.8	67	29	8	21	775	0	0	25	0	1.21	.57	.80	14				3	1	0
MAR 77(M)	56.9	20.1	38.5	-2.5	69	23	7	30	816	0	0	29	0	.11	-.60	.05	9	.0	0		0	0	0
APR 76	69.0	30.3	49.7	-.4	76	29+ 19	11	6	452	0	0	20	0	.42	-.28	.21	19	.0	0		3	0	0
MAY 76(M)	72.8	34.6	53.7		87	16 15	27	13		0	0	3	0	.61		.36	6	.0	0		2	0	0
JUN 76(M)	76.4	37.7	57.1		99	28	27	15		6	0	2	0	T			30	.0	0		0	0	0
JUL 76(M)	94.0	54.1	74.1	-.3	101	10	42	17	0	28	0	0	0	1.21	.34	.56	27	.0	0		3	1	0
AUG 76(M)	89.3	51.5	70.4	-1.7	95	1	42	24	0	12	0	0	0	.51	-.78	.25	21	.0	0		1	0	0
SEP 76(M)	82.6	46.7	64.7	.0			37	29	58		0	0	0	2.21	1.31	1.40	27	.0	0		3	1	1
OCT 76(M)	66.6	28.6	47.6	-6.1			15	18	536	0	0	21	0	.10	-1.07	.05	22	.0	0		0	0	0
NOV 76(M)	56.6	16.8	36.7	-3.3	69	8	-5	28	816	0	1	29	2	.05	-.49	.05	27	.5	0		0	0	0
DEC 76(M)	47.3	8.7	28.0	-2.9	54	17	0	28	1139	0	0	31	1	.05	-.84	.05	31	2.5	1	31	0	0	0

/ = no data or not applicable T = Trace

M = One or more days missing; if average is entered, less than 10 days record is missing. Degree day data adjusted to represent the value for a full month.

National Oceanographic & Atmospheric Administration
Environmental Data Service, National Climatic Center

Fauna

Striped Skunk

Porcupine (occasional)

Mule Deer (small herd)

Blue Jay

Magpie Jay

Woodpecker

Sparrows

Bats

Rabbit (cottontail)

Jackrabbit

Squirrel

Field Mice
(Need faunal inventory)

Insects

Arachanids

- Tarantulas
- Black Widow
- Brown Recluse?

Common Shrubs and Trees

Aztec Ruins National Monument

Woods Rose----------Rosa woodsi

Black Sagebrush----------Artemisia tridentata Nova

Fremont Cottonwood----------Populus fremontii

Rubber Rabbit Brush----------Chrysothammu- nauseosus

Pinyon Pine----------Pinus edulis

Fourwing Saltbrush----------Atriplex canescens

Prickleypear cactus----------Opuntia polycantha

Narrow Leaf Yucca----------Yucca augustissima

Velvet Ash----------Fraxinus velutina Torr.

Arroyo Willow----------Salix lasiolepis

Russian Olive----------Elaeagnus angustifoluis

Chinese Elm----------Ulmus parvifolia

Black Greasewood or Chico Bush--------Sarcobatus vermiculatus

.....

Less Common

Mormon tea (Green Ephedra)----------Ephedra viridis

Bee plant----------Cleome serrulata

Cholla----------Opuntia imbricata

4. Project: Noxious Plants and Animals

Vegetative cover within the monument was originally and typically that of the Upper Sonoran Zone but has been drastically altered by several hundred years of occupation. Many exotic trees have become part of the scene and are presently affording shade for visitors and food and cover for animals. However, they are exotic in nature and, upon their death, will be replaced with vegetation more compatible to the historic nature of the resource. Plants such as Russian thistle and wild morning glory pose a serious threat to the ruins, walkways and other man-made objects by expediting deterioration of walks, black-top, etc. Puncture-vine presents a hazard to visitors with thin-soled shoes or bare feet.

Ground squirrels burrow in and under the walk of the ruins causing structural damage and erosive potential.

Action: Maintenance (2. Continue Maintenance-Natural B. No Effect-Historical)

Control of Russian thistle, morning glory and puncture-vine will continue where needed to prevent deterioration of historic ruins and other man-made objects and to prevent injury to visitors. Russian thistle and punture-vine can be controlled through physical removal but an herbicide is needed for the eradication of the morning glory. The herbicide "Bromacil" (5-bromo-3-sec-butyl-6-methyluracil) is currently recommended and has been approved for this purpose.

Ground squirrels should be controlled within the ruins areas by methods which are selective to the pest controlled.

INSECTS AND DISEASES OF EVERGREENS IN NEW MEXICO

PREPARED COOPERATIVELY BY:

NEW MEXICO DEPT. OF AGRICULTURE
FOREST SERVICE — U.S. DEPT. OF AGRICULTURE
NEW MEXICO DEPT. OF STATE FORESTRY
COOPERATIVE EXTENSION SERVICE
— U.S. DEPT. OF AGRICULTURE

1977

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INTRODUCTION

Cities grow, suburbs expand, and the demand for greenbelts, parks, ornamental and shade trees increases greatly each year. People have learned that trees and other green plants are a vital part of their life-support system. Green, healthy vegetation supplies oxygen, filters dust from city air, reduces noise pollution, lowers the temperature along urban streets by 10 or more degrees, serves as a windbreak, and increases the quality of life in many other ways. Planting native evergreen trees and shrubs can create a more natural landscape, save money, or reduce the costs of maintenance and water use.

Evergreens in New Mexico are not easily transplanted. Their root systems are extensive and spread out several feet from the tree. Generally, few of these roots remain intact when the tree is dug up; consequently, a high percentage of trees fail to survive transplanting. Survival rate can be more than doubled by root-pruning 12 months or more before digging. Root-pruning is accomplished by cutting the roots with a narrow-pointed shovel from 1 to 3 feet out from the tree to a depth of 12 to 18 inches. Root-pruning should be done in November, December, or January, and is most easily done immediately following a rain or snowmelt. Evergreens must be moved with a ball of soil held firmly intact around their roots. The ball of soil should be wrapped with burlap and tied tightly to prevent the soil from crumbling away from the roots during transporation and handling. It is not necessary to remove the burlap wrapping when resetting the plant in the ground because it will rot away within a few weeks.

Whenever a tree is transplanted, it must adjust to a new set of living conditions, some of which are subtle, while some are abrupt. Without man's help, most trees will have a rough time adjusting to the new conditions, many of which are too harsh for its normal development or too extreme for its survival. In urban areas throughout New Mexico, evergreen trees will need supplemental watering in the windy spring months and at other dry times of the year. At these times, normal rainfall will be inadequate to maintain tree health and vigorous growth. The failure of the tree to adjust brings about distress symptoms. Symptoms are produced from two general sources: the living agents (biotic), and the physical environment (abiotic). The biotic agents are insects, animal pests, plant pathogens, and plant parasites. Abiotic agents are soil, climate, weather conditions, and man-modified atmospheric and soil conditions. All of these factors must be taken into account to diagnose tree problems. In this publication we will deal exclusively with insects and diseases.

This publication has been prepared to help homeowners and forest landowners identify insect and disease pests of New Mexico evergreen trees. The insects and diseases included are the most common ones attacking ornamental and forest trees. Prompt identification and treatment of these pests are essential to minimize the loss of valuable shade and forest trees. This is particularly important in the Southwest where the extreme dry and windy seasonal conditions place extra stress on the trees and make them highly susceptible to attack. The prevention of attack is greatly enhanced by keeping the trees in a healthy,

TREE SPECIES, BY POINT OF ATTACK

Insect species	Pinyon	Ponderosa	Other pines	White fir	Douglas-fir	Blue spruce	Engelmann spruce	Juniper (cedars)
Pitch nodule moth	ST, BR, LI	ST, BR, LI	ST, BR, LI					
Pine tip moth	BU, ST	BU, ST	BU, ST					
Bark moth and pitch moth	BR, LI, TR	BR, LI, TR	BR, LI, TR	LI, TR	LI, TR			
Ips bark beetles	UB	UB	UB		UB			
Dendroctonus bark beetles		UB	UB	UB	UB	UB	UB	
Pine needle scale	NE	NE	NE		NE			
Pinyon needle scale	NE							
Conifer aphids	LI, TW, BR	LI, TW, BR	LI, TW, BR	LI, TW, BR	LI, TW, BR	LI, TW, BR	LI, TW, BR	LI, TW, BR
Cooley spruce gall aphid					NE, TW	BU	BU	
Douglas-fir tussock moth				NE	NE	NE	NE	
Tiger moth	NE	NE	NE					
Mistletoes	BR, LI, TR	BR, LI, TR	BR, LI, TR	BR, LI	BR, LI	BR, LI	BR, LI	BR, LI, TR
Broom rusts-			BR, LI	BR, LI	BR, LI	BR, LI		
Non-infectious diseases	WH	WH	WH	WH	WH	WH	WH	WH

BU = Buds; NE = Needles; TW = Twigs; ST = Shoots and Tips; BR = Branches; LI = Limbs; TR = Trunk; UB = Under bark; WH = Whole tree.

The following pages include descriptions of pests, pictures of damage, and pictures of the damage-causing organism where possible. Recommended chemical control methods are not included because changes frequently take place in chemical registration and chemical-use regulations. Pest control is a growing field and changes in its technology develop rapidly. New pesticides are being made available constantly which quickly replace older materials. For recommended chemical controls, contact your county Agriculture Extension Agent or the Cooperative Extension Service at New Mexico State University. Other advice may be obtained by contacting the New Mexico Department of Agriculture; New Mexico Department of State Forestry; or U.S. Forest Service, Region 3, Forest Insect and Disease Management, Albuquerque, New Mexico.

For their assistance in the preparation of this publication, we wish to credit personnel of the New Mexico Department of Agriculture, New Mexico Department of State Forestry, U.S. Forest Service, and Cooperative Extension Service. We hope that you will find this publication useful in maintaining your evergreen trees.

State law prohibits the removal of any plant within 300 feet of a public thoroughfare. The law also requires that a written permit be obtained from the landowner or land manager for any plants removed. Additionally, persons digging and selling plants on a commercial basis must apply for a Collected Plant Inspection Certificate and/or a Dealers License from the New Mexico Department of Agriculture. You are advised to observe these laws and regulations.

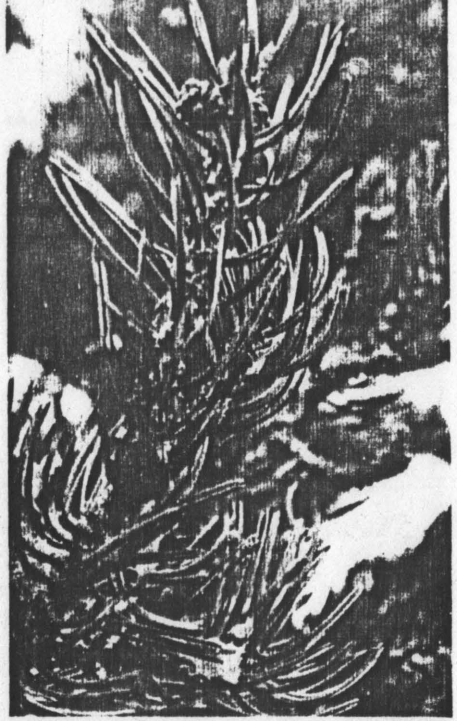
PITCH NODULE MOTH

Petr sp.

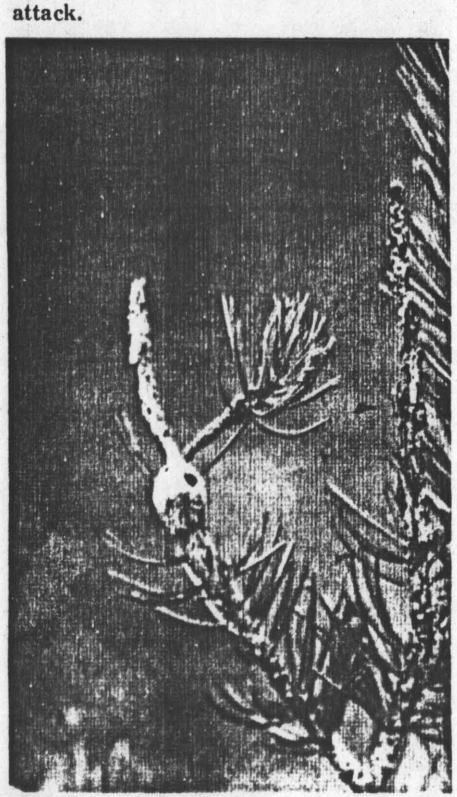
he pitch nodule moth attacks primarily inyon, but may also attack other pines n New Mexico. The most conspicuous vidence of attack by this insect is fadng branch tips associated with the haracteristic "pitch nodule." The pitch odules are hollow balls of pitch, about ½ ch in diameter, formed at the points of ttack on branch tips. The tips soon die nd turn light brown. Dead needles may ersist for several months, but eventualy fall off. The barren twigs, with the rying pitch nodules, remain for a year r more, after which they fall off, leaving he tree deformed and unsightly.

he larvae do not attack buds, but sually bore into new twigs just below he tips and kill the tips by tunneling own the twigs. Old growth branches nd stems are occasionally attacked, but ot often in New Mexico. The larvae sually bore into the bark at nodes or vhorls of branches and the point of ttack is always characterized by a pitch odule. Mature larvae are dirty-white to rown and about ½ inch long. Pupation akes place inside the pitch nodule from arly to mid-summer. The pupae move o the surface just before adult emergence and the moths escape through mall holes in the pitch nodules.

here are no registered insecticides to ontrol this insect. In the forest nvironment, tip-killing is rarely mportant. On ornamentals of high value, the insect may be controlled by pruning the infested tips as they fade and disposing of them in May or June before the adult moths emerge. On branches and stems, the larvae may be destroyed by crushing them within the pitch nodule.



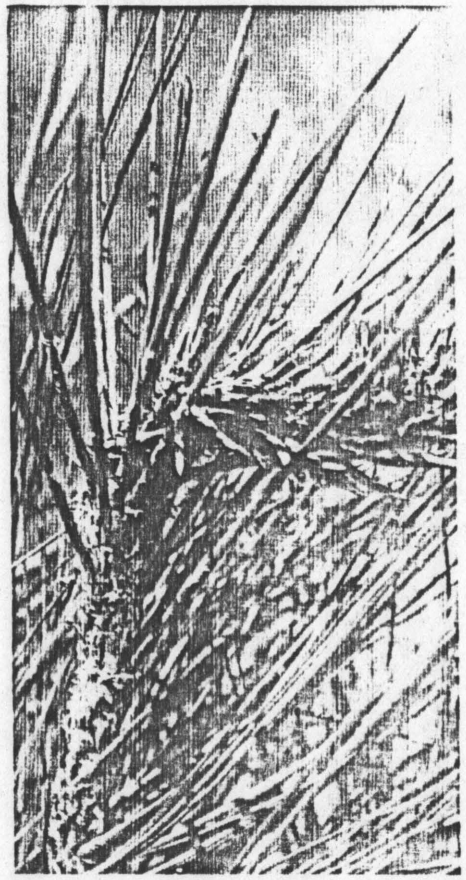
Characteristic reddish-brown "pitch nodule" on green twig indicates new attack.



Dead tips and old "pitch nodule" with adult exit hole.

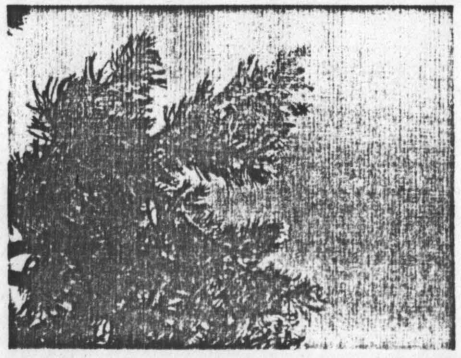
Rhyacionia spp.

These insects primarily attack very young ponderosa from 6 inches to 6 fe Although mortality is rare, heavily infested trees may be severely stunted deformed. Generally, ponderosa pines grow out of the susceptible stage withi few years, but the branch tips of pinyon are susceptible to attack for many yea Repeated attacks over several years can weaken trees and predispose them attack by other insects. The adult insect develops in May and June, and damage evident in early summer. Tips, twig laterals, and terminals turn a straw color, and needles fall off in late fall.



Eggs are laid on new shoots or needl near terminal buds in May or early Ju The newly-hatched larvae bore in buds, laterals, and terminals, and mi out the pith from the tip down to base of the shoot. The point of attack marked by a small flow of resin, but "pitch nodule" is formed. The larvae yellow to orange to brown and are ¾ inches long when full grown. moths over-winter as pupae in the tips shoots of infested trees, in bark crevic or in the litter below the tree. There one generation each year in N Mexico.

In the forest environment, chemi control measures are rarely necessa except in young plantations. Heav attacked ornamentals may require insecticide for control. For a few sm trees, the best home method to con this damaging insect is to prune infes tips and shoots in May or June when needles begin to yellow and dest them by burning or burying.



Ponderosa pine terminal and pinyon tips killed by tip moth larvae. These tips and shoots can be pruned for successful control.

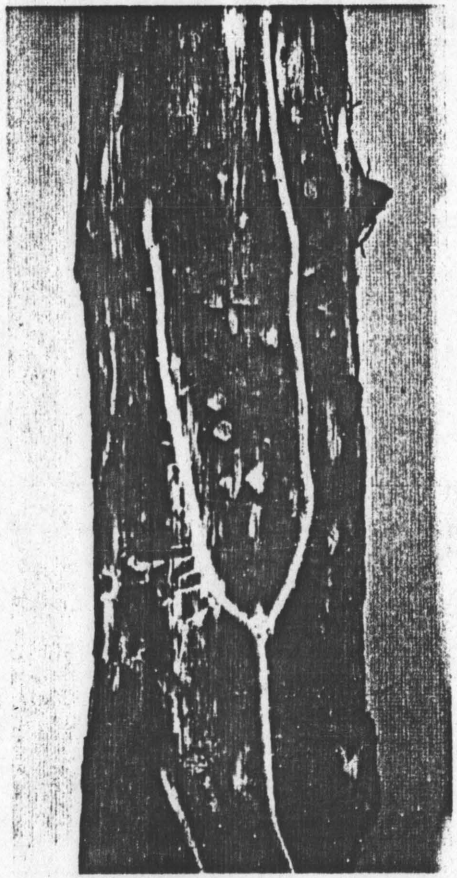
IPS ENGRAVER BEETLES

Ips spp.

Ips beetles attack both ponderosa and pinyon pines. Usually they attack trees weakened by drought, lightning strikes, root disturbances, soil compaction, and changes in soil depth around the tree. These insects will also attack fresh slash left on the ground from such activities as road and home construction, logging operations, and land-clearing projects.

Trees that are attacked are rapidly girdled by the adults as they construct their egg galleries in the inner bark. Girdling is also done by the young larvae as they feed outward from the egg gallery. Adult beetles introduce a blue stain fungus into the tree during attack and tunnel construction. Growth of the fungus blocks the flow of water and nutrients in the tree. This blockage, combined with the girdling by the adult and young beetles, causes death of the tree.

Small reddish-white pitch masses and reddish boring dust are the first signs of beetle attack. Removal of the bark from an infested tree will reveal typical "Y" tuning fork or H-shaped tunnels with short larval feeding galleries extending perpendicularly from either side of the egg galleries. The Y- or H-shaped galleries are always clear of boring dust and other debris. Fading of the needles in the top third of the crown is also an early sign of *Ips* beetle attack. In ponderosa pine, the needles first turn to a light straw color and then to a dark reddish brown. In pinyon, the needles on the entire tree turn to a deep reddish brown.

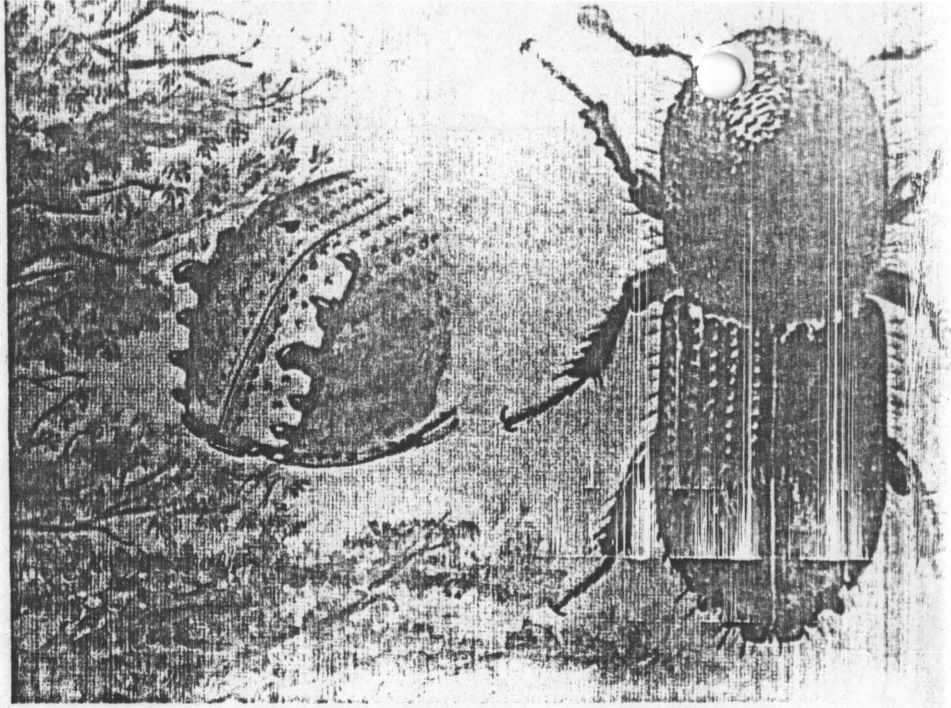


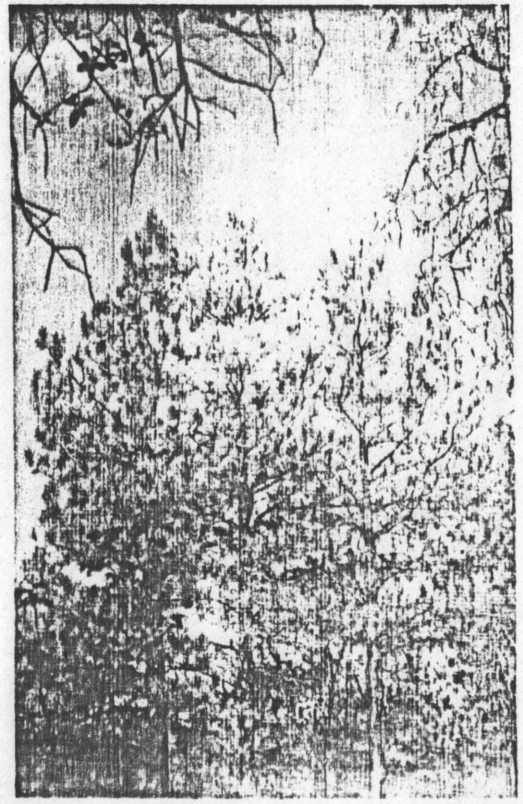
Typical clean "tuning fork" gallery of *Ipps*.

Ips beetles are easily recognized by their "scooped out" posterior which is surrounded by varying numbers of spine-like projections. It takes only 3 to 5 weeks to complete their life cycle from egg to adult beetles. The short life cycle allows beetle populations to increase rapidly from spring through fall seasons.

The best method of control is the immediate removal and use of infested trees. Clear plastic sheeting may be used to cover infested firewood and slash piles. The sun creates high, lethal temperatures under the covering and kills the beetles and larvae in the infested material in 2 or 3 weeks.

When digging native evergreens in the wild near land-clearing projects or in other areas of ground or tree disturbance, extreme care must be used in examining and selecting trees for digging and removal to be sure that they are not infested with *Ips* beetles.





Adult *Ipps* bark beetle. Note the ir rear end and spines at the edge of in tion.

Fading ponderosa pine, characteri *Ipps* bark beetle attacks at top o stem.

BARK BEETLES

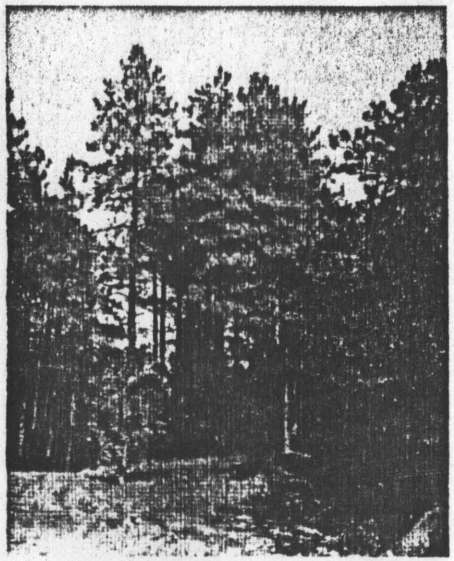
Dendroctonus spp.

This group of bark beetles attacks medium to large ponderosa pine, blue spruce, Engelmann spruce, and Douglas-fir trees in New Mexico. In contrast to the *Ips* engraver, these insects are usually not a problem in new ornamental plantings, but occasionally cause extensive damage and tree mortality in natural forested areas and in heavily forested urban communities. Drought, lightning strikes, overstocked stands, and other factors that cause low tree vigor contribute to buildup and help maintain damaging beetle populations. Man-made disturbances in natural stands, such as tract development, road construction, and logging, where trees and slash are supplied on a continuing basis, contribute to rapid increases in beetle populations. Also, windthrow is an especially serious problem in spruce stands.

Adult beetles in this group are about the size of the head of a wooden match. They bore directly through the bark, mate, and the female excavates egg galleries. Removal of the bark from an infested tree will reveal straight, slightly curved, or S-shaped galleries. The galleries are filled with boring dust, frass, and other debris, while *Ips* galleries are clean and clear.

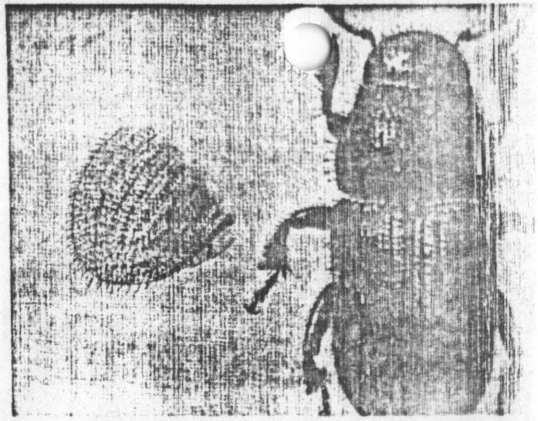
First outward signs of beetle attack are pitch tubes and boring dust. Pitch tubes are a mixture of pitch or resin and boring dust exuded through the attack hole. The tubes may be clear to cream colored or dark red. Fading of all needles throughout the crown is a sign of beetle attack by species of this group. Needle-fade may occur from 2 months to a year after successful attack in ponderosa pine. The usual color change is from yellow-green to straw to brown. Dead needles usually drop soon after browning, depending on weather conditions. In Douglas-fir, needle-color change is from yellow to reddish brown. Fading of spruce needles usually begins 10 to 15 months after attack. Needle-color change is to light yellow-green, to light brown, to reddish-orange. Dead needles may remain on spruce for a year after color change begins or about 2 years after successful attack.

Bark beetles of this group have a rounded posterior and spines are not present. Most species in this group, except the spruce beetle, take 1 year to complete their life cycle from egg to adult beetle. The spruce beetle takes 2 years, but has a flight and brood produced each year. The beetles of this group carry the blue stain fungus and introduce the fungus into the trees upon attack. Growth of the fungus blocks the flow of water and nutrients. The blockage, combined with the girdling by the adult and young beetles, causes death of the tree.

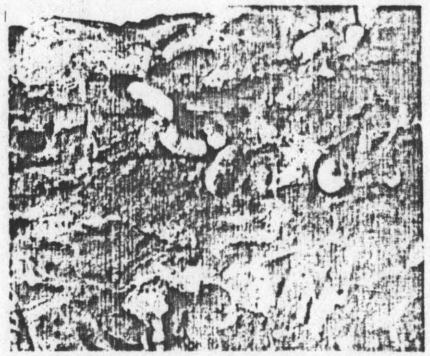


Groups of ponderosa pine killed by *Dendroctonus* bark beetles. Beetle attack in lower trunk causes entire tree to fade and die.

methods. Homeowners should remove any infested trees at once to prevent emerging adults from attacking adjacent trees. Infested trees are hazard trees and the emerging adult beetles will attack trees nearby and possibly kill a group of trees or a whole stand of trees.



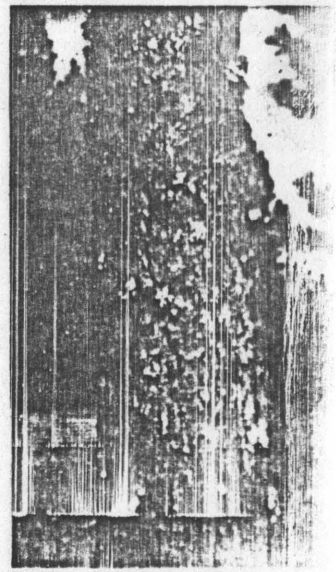
Adult *Dendroctonus* bark beetle. Note rounded rear end.



Larvae and pupae, two of the four life-stages of *Dendroctonus* bark beetles, in bark.

Typical debris-filled gallery of *Dendroctonus* bark beetles. Eggs are laid by the female adult at edge of gallery.

Clear plastic-covered piles of beetle-infested wood. The sun generates temperatures lethal to the beetles infesting the wood.

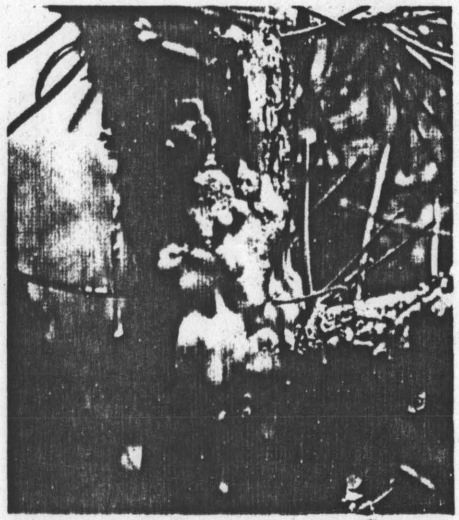


Small flows of pitch on the trunk indicate attack by bark beetles.

Dioryctria spp. and *Vespamima* spp.

These two insect[illegible] listed together because their habits and effects on trees are very similar. The moths attack the larger branches, limbs, and trunks of young ponderosa and pinyon. Occasionally, Douglas-fir and the true firs are also attacked. The most severe damage is to trees under 20 feet, especially in urban areas. The insects are rarely a problem on larger trees or in the forest environment. The main difference between the two insects is in the length of their life cycle. The pitch moths (*Vespamima* spp.) require 2 years for one generation and overwinter as larvae each winter, while the bark moths (*Dioryctria* spp.) require only 1 year for a generation and overwinter as eggs or larvae.

Eggs are laid in bark crevices or near mechanical wounds on the bark. The newly-hatched larvae tunnel under the bark, forming irregular tunnels and tunneled-out areas, or they simply extend the bark wounds near where the eggs are laid. Larvae feed on pitch which flows from the tree in response to their tunneling. Great masses of pitch, 1 to 3 inches in diameter, form around the entry holes and conceal the larvae and their destructive tunneling from view. Generally, there is only one larva under each pitch mass. Full grown larvae are from ¾ to 1 inch long and are dirty white, yellow, reddish yellow, light green, or light brown.



Typical pitch masses on pinyon trunks and branches formed in response to larval tunneling.

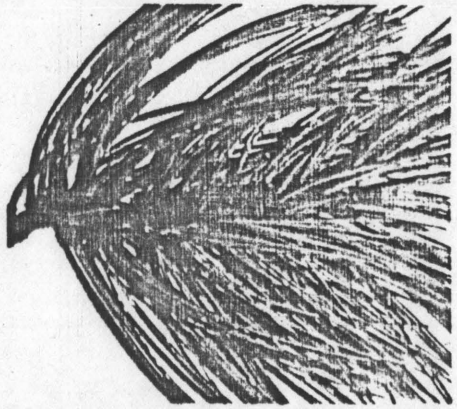
There are no insecticides registered for use on these insects. The only effective control is the simple removal of the larvae from the pitch masses with a knife or similar tool.

Phenacaspis pinifoliae

The pine needle scale is a common pest of most species of [illegible]s and occasio[illegible] spruce and Douglas-fir. The scale insects feed on evergreens by piercing needles with their mouthparts and sucking the sap from the needles. Early si[illegible] of feeding injury are spotting and yellowing of the needles. Infested branc[illegible] suffer needle loss and slowly wither as the scales continue to feed for 2 or 3 ye[illegible] Heavy infestations cause the trees to appear yellowish or grayish and unheal[illegible] Continued feeding gradually kills the branches and the tree may die if it rema[illegible] untreated.

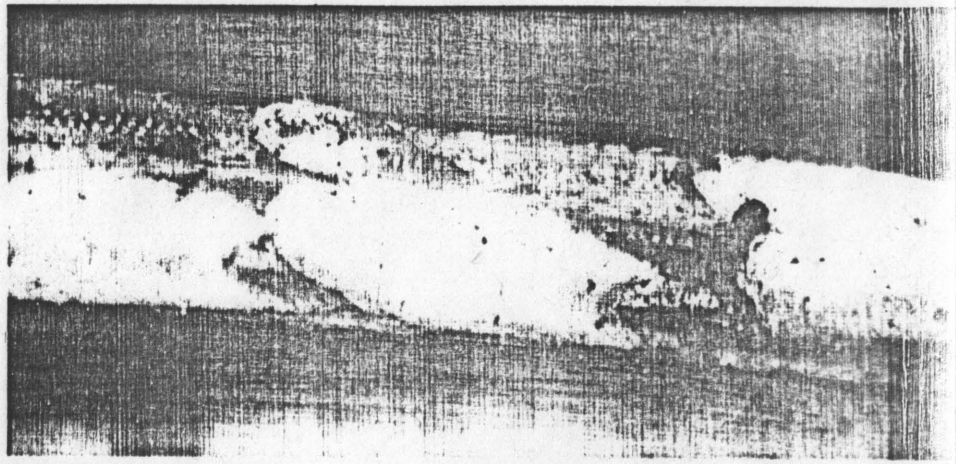
Generally, there are two generations each year and both dead and living s[illegible] can be seen on the needles all year. The mature female scale is white, sie[illegible] flattened, and about ⅛ inch long. Mature males are about half as large as fem[illegible] Eggs are laid in the fall and remain under the dead female scale-covering d[illegible] the winter. The eggs hatch when new needles appear in the spring, a[illegible] nymphs crawl to green needles and begin feeding. By mid-July, the scales [illegible] and new clusters of eggs are laid. Scales of this new generation mature b[illegible] fall and lay the eggs which overwinter.

Damage is most troublesome on ornamental trees and is often noticed along d[illegible] roads where people are likely to dig small trees to transplant in the home y[illegible] Anyone who plans to dig or [illegible] evergreens to transplant should ins[illegible] the needles carefully for the presenc[illegible] scales or signs of their feeding. Cutt[illegible] and burning infested trees is the [illegible] effective cultural control alternative[illegible] chemical pesticides. Lady beetles [illegible] certain wasps are the important nat[illegible] controls of this insect.



Ponderosa pine needles infested with scales. Note the yellowing and spotting injury.

Enlarged view of fem[illegible] scales on a single needle.

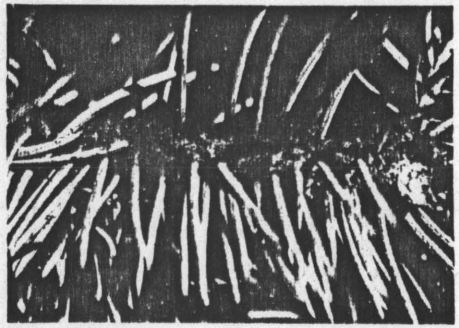


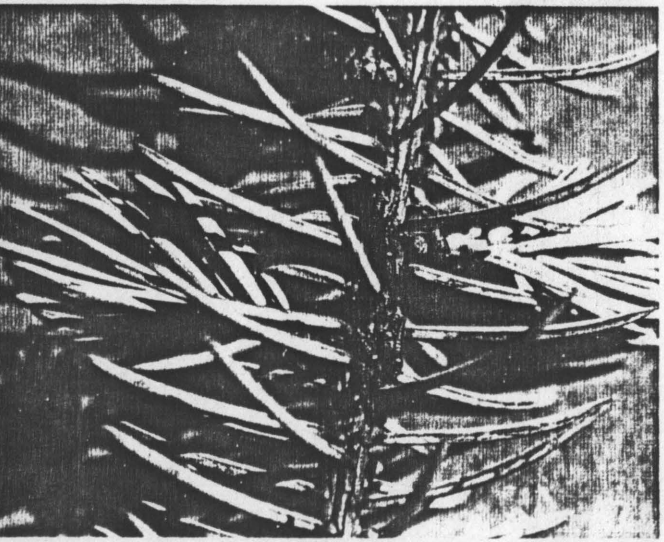
here are more t 35 species of conifer aphids found in the western States. Many of these sp es occur in New Mexico and attack the pines, true firs, Douglas-fir, and spruces. Conifer aphids are rarely a problem in the forest, but re often annoying pests on ornamentals and shade trees around homes. Frequently, trees are so weakened that they die in a few seasons or become ubject to attack by other insects.

Most of the conifer aphids are quite large, up to ¼ inch, and are generally dark olored. They are long-legged and have naked bodies or are lightly covered with a owdery wax. There are a number of generations produced each year with both winged and wingless forms.

Damage is caused primarily by aphids feeding on the branches and twigs. They ierce the bark of the branch and suck out great quantities of sap. Needle growth s reduced, twigs dry, and heavy defoliation occurs with excessive feeding. Since he aphids cannot utilize all of the liquid portion of the sap, they expell the excess rom their bodies. The expelled liquid is called "honeydew" and contains sugars nd other compounds which are sweet and very sticky. The honeydew rains down n lower branches, the ground, and other objects directly below the feeding phids and turns the objects into a sticky mess. A black "sooty-mold fungus" often rows on the honeydew and thus the bjects become covered with a black lime. Sometimes it appears as though he tree and adjacent area were sprayed ith crude oil.

There are several chemical pesticides which are effective in the control of onifer aphids. The timing of spray pplication or other chemical control neasure is not critical to the success of ontrol efforts.



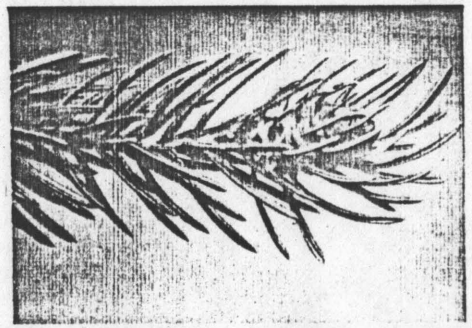


Wingless aphids feeding on spruce branch.

Winged aphids feeding and reproducing on spruce branch.

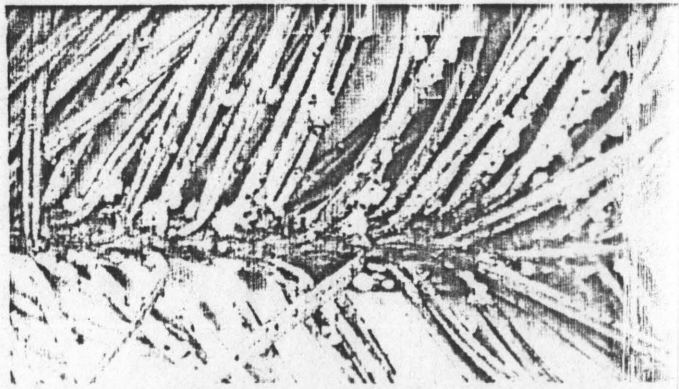
There are several kinds of spruce gall aphids which form cone-shaped galls on t terminal twigs of various species of spruce. The most common one in New Mex is the Cooley spruce gall aphid which is not usually considered an important p in the forest. However, it is often troublesome on ornamental spruce and Christmas tree plantations where the young trees may be aesthetically dama by large numbers of unsightly galls. The life history of this insect is quite comp and involves two different host trees and at least five different winged wingless forms.

Generally, winged females migrate from Douglas-fir to spruce where they lay e at the bases of newly forming buds in early spring. Nymphs hatch from these e and begin to feed at the bases of the very young needles. The nymphs soon beco enclosed in the rapidly developing galls. The galls are an abnormal growth respo to the feeding by the nymphs. Young galls vary from green to purple, while ol galls are purplish or reddish brown. By mid-July, the galls are from 1 to 3 inc long and contain from 50 to 350 maturing nymphs. At this time, the galls begi dry and open, allowing the mature nymphs to crawl out to the needles. The nym transform to winged adults and fly back to Douglas-fir. The adults on Douglas lay eggs which hatch and produce a generation of "woolly aphids." The insects l like little fluffy balls of cotton clinging to the needles. Occasionally, Douglas-fir be so heavily attacked that it looks as though snow had fallen on the tree. Fee by the insect produces yellow spots on the needles and occasionally produces and distorted needles. Eventually another winged form is produced on Dougla and it migrates to spruce again completing the life cycle.



There are insecticides to suppress aphid; however, the timing of s application is difficult to determine effective control. On small ornamen the galls may be pruned off and disp of before the release of the nym which become winged and migrat Douglas-fir. It may also help to pl spruce or Douglas-fir exclusive instead of planting both tree spec together.

Mature gall on spruce twig. Note openings from which winged adults emerge.



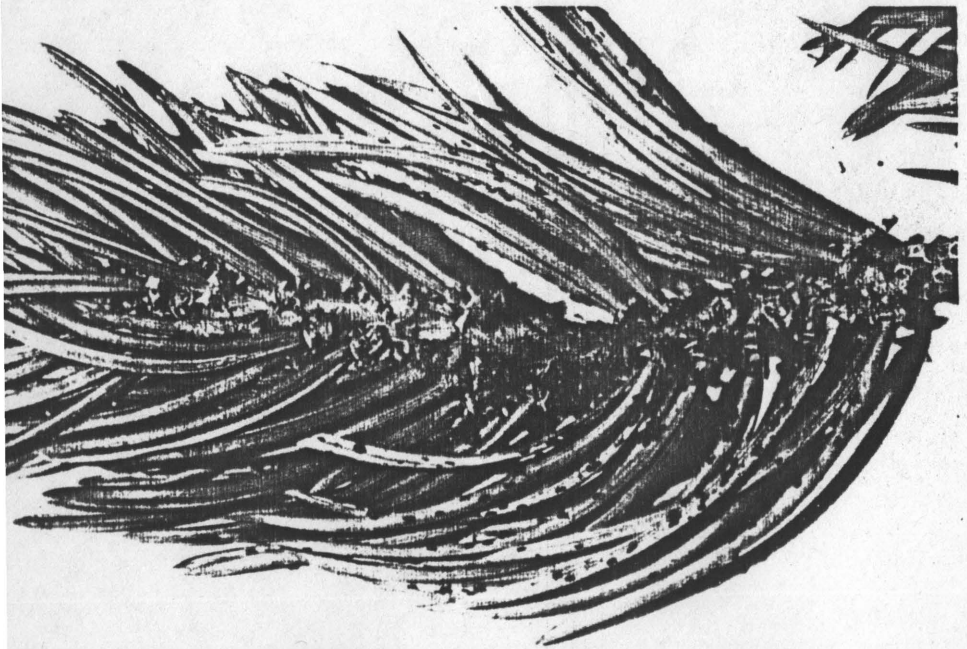
Alternate life-stage or "woolly aphid" on Douglas-fir.

Matsucoccus acalyptus

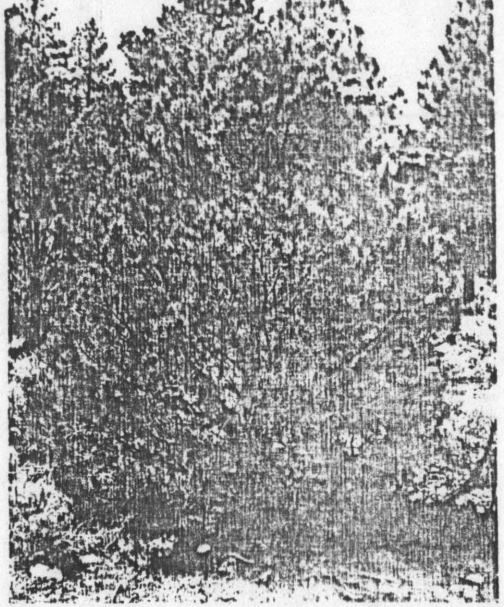
he pinyon needle scale is a tiny sap-sucking insect which can cause extensive jury to pinyon pines in the forest condition or when used as ornamentals. The ales infest 1-year-old needles and greatly weaken the trees by their feeding. eeding causes reduced needle growth or needle loss. Heavy infestations often ave the branches with only a few stunted needles clustered at the tips. Small ees frequently die, while weakened larger trees become susceptible to attack by her insects, especially bark beetles, which can kill trees.

arly signs of attack are easily seen with the naked eye. During mid to late April, ewly-emerged females lay clusters of yellow eggs held together in loose, white, ttony webbing. The egg masses and webbing are found on the undersides of rge limbs, in crotches of large branches, in rough bark cracks, and around the ot collar at the base of the tree. From these eggs develops a tiny crawler stage. he crawlers move to the ends of branches and settle on the needles in early June. a day or so, the settled scales cover themselves with a waxy substance and turn ack. At this point, they are about 1/16 inch in length, bean-shaped, and otionless. They feed through most of the growing season.

secticides are available to control this insect on ornamental trees, but timing e spray application is critical for effective control. An inexpensive and effective ltural control alternative has been developed. The procedure is to wash down e tree with a garden hose to dislodge the eggs and webbing. Next, the dislodged gs, webbing, litter, and debris on the ground under the tree are raked up and gged. Finally, the bagged materials are disposed of by burning or burying. This ethod of control should be accomplished before eggs hatch. In New Mexico, pending on weather, the time to wash down trees will be between the first of pril and mid-May.

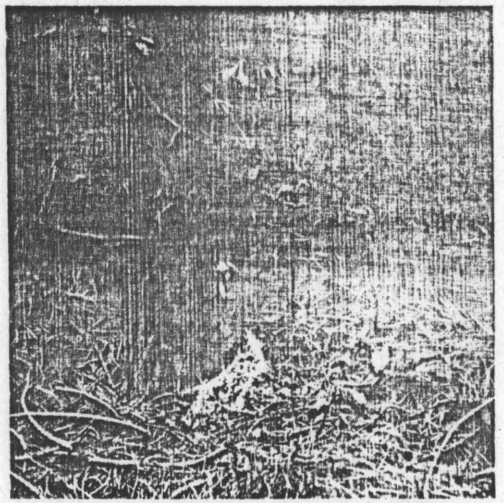


cales infesting one-year-old needles.

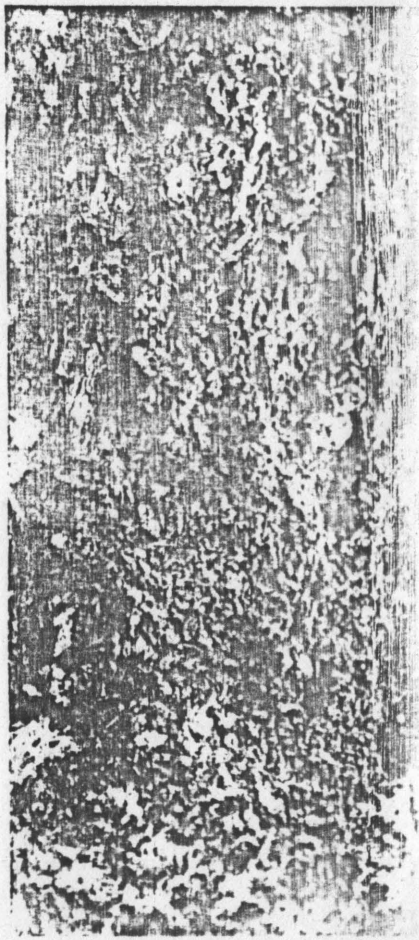


Heavily infested and damaged p
yon. Only the new growth r
green.

Cottony webbing and e
laid on rough trunk bark



Cottony webbing and eggs laid at base of tree trunk.



Orgyia pseudotsugata

Douglas-fir tuss[illegible] moth is one of the most destructive forest insects on amentals in the Southwest. In New Mexico, it has been a persistent pest of uce, white fir, and Douglas-fir planted as ornamentals or shade trees.

vae hatch in the spring and feed on the new foliage, causing it to turn brown shrivel. As they continue to grow, they feed on both new and older foliage er in the crown and farther back on the branches. Heavy feeding causes ere defoliation and the tree begins to turn a reddish brown starting at the top advancing down to progressively lower limbs during the year or in successive rs. Repeated defoliation may cause top-kill or tree mortality. Fully grown vae are grayish to light brown and are from 1 to 1¼ inches long. The body is ered with a variety of short to long hairs arranged in a distinctive pattern. The st conspicuous hairs occur in two forms: four dense, buff-colored tussocks or mps of hairs are located forward along the middle of the back; and three long, sh-like tufts form hornlike structures, two of which are located just behind the d, with the third brush on the tail end. Except for the head and legs, the rest the body is covered with short hairs growing out from reddish button-like ts. Many people are sensitive or allergic to the hairs which can irritate the skin l may produce an itchy rash or blisters.

e tussock moth produces one generation each year. Adult moths emerge from e July to early September. Their cocoons are attached to the underside of bs, branches, and foliated twigs. After mating, the wingless female clings to cocoon and lays white eggs in a mass about the size of a dime on its surface. ile laying the eggs, she glues her body hairs to the egg mass and they erwinter in a brownish woolly mass.

e removal and destruction of the egg masses, cocoons, and larvae will control s insect on very small home-planted ornamentals. Larger infested trees will quire the use of an insecticide for control. A microbial insecticide, *Bacillus uringiensis*, is a bacterium that produces a toxin, lethal to many kinds of moth vae. *B. thuringiensis* has been tested in New Mexico on the Douglas-fir ssock moth and was found to give satisfactory control. Because this insecticide specific to insects, it is safe to use, is biodegradable, and is a logical alternative chemical insecticides in use.

ature larva feeding on new edles. Note tussocks on ck.

Wingless female laying eggs in a mass on twig.

Severe defoliation causes browning and top kill.

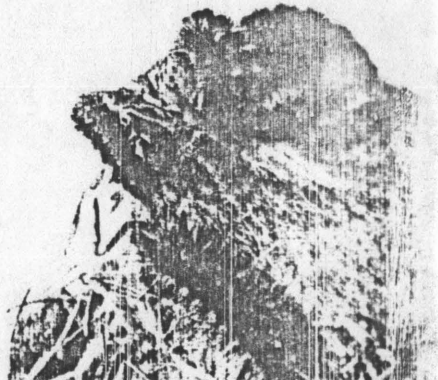
Halisidota ingens

The natural parasites of this moth prevent it from becoming erious forest pest although it may be damaging to young ponderosa or pinyon pines in commercial plantations. The webbing and defoliation of branches by the larvae are very unsightly on ornamentals.

The tiger moth produces one generation each year. Adult moths emerge from mid-July to late August, and light green eggs are laid in clusters on twigs and needles of the host trees. The eggs hatch in 3 to 6 weeks, producing small gregarious larvae which are dark brown to black and quite hairy. Groups of young larvae feed on the current needles and form webs or tents enclosing a portion of the branch. Feeding continues through the fall and the larvae overwinter within the tents. The tents are usually located in the topmost branches or on the south and west sides of the trees. When temperatures are warm, the larvae may continue to feed outside the webbing and return to the tent before nightfall. By early spring, the tents are large, conspicuous, and filled with masses of dead needles.

The caterpillars no longer feed in groups as they approach their full growth, but feed alone away from the tent, often migrating to another tree. Full-grown caterpillars are about 1½ inches in length and are covered with light yellow-brown to dark brown poisonous hairs which can produce rashes and blisters on the skin of people who are sensitive to them. Pupation occurs in June and the mature caterpillars spin brownish cocoons made of silk and body hairs. Cocoons are attached to branches, limbs, and trunks of the host trees, and occasionally to debris on the ground.

Insecticides are available for control, but are not generally necessary. An inexpensive cultural control method consists of pruning the branches with tents and burning them while the small larvae are inside.



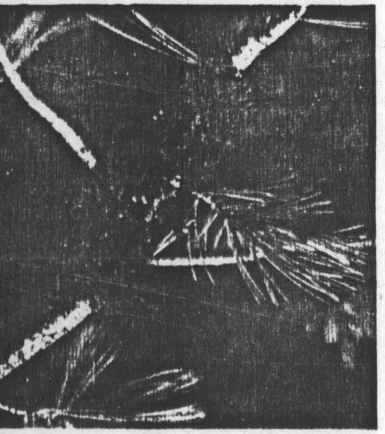
Some webbing and nearly full-grown caterpillars.

Typical tent as it appears in early spring along with defoliated tips.

Arceuthobium spp. and *Phoradendron* spp.

mistletoes are pa sitic plants that cause injury to their woody hosts. The types of mistletoe found in New Mexico are dwarf mistletoes and true letoes. Dwarf mistletoes live on conifers only, while true mistletoes occur on fer and hardwood trees and shrubs. The parasitic mistletoes withdraw ntial nutrients and water from their host, resulting in injury and sometimes mortality.

New Mexico, dwarf mistletoes attack ponderosa pine, southwestern white , pinyon, Douglas-fir, Engelmann spruce, and blue spruce, while true letoes are found on several species of juniper, numerous species of oak, and r hardwoods. The mistletoe plant varies in color from green to red-green. rf mistletoe plants vary in size from an inconspicuous bud-like structure ruding through the tree bark to shoots nearly a foot long. True mistletoe ts vary in size from several inches to several feet in length. Symptoms of letoe infection include swelling at infection sites and the formation of witches' ms.



nderosa pine branches heavily in- ted with dwarf mistletoe. Note nch swelling and disfiguration.

Dwarf mistletoes are spread by explosive fruits which shoot seeds 20 to 30 feet into the surrounding area. True mistletoes are spread by birds that feed on the mistletoe berries. The seeds from the berries pass through the bird unharmed and are thus spread in the bird feces.

Branches on mistletoe-infected trees may be pruned to reduce damage to the trees and to reduce further spread of the parasite. No chemical or biological controls are available for mistletoe control.

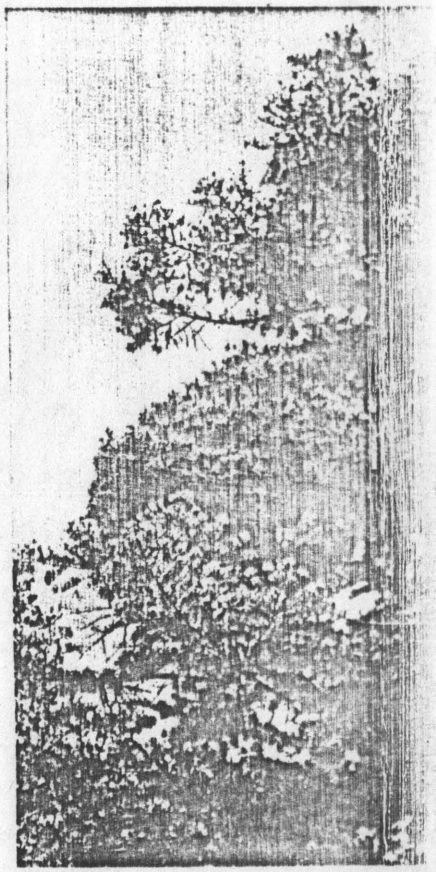
True mistletoe infecting juniper, a common sight in New Mexico.

Two of the most important broom rusts in New Mexico are s e broom rust fir broom rust. The host trees for spruce broom rust are E mann spruce a blue spruce, while the hosts for fir broom rust are alpine fir and white fir. Br om rust fungi require an alternate host to complete their life cycle, and the alternate host plants must be present in the area for successful spread of broom rust. Kinnikinnick is the alternate host for spruce broom rust, and chickweed is the alternate host for fir broom rust.

Trees infected by broom rust are easily recognized by the witches' brooms that form from infected branches. Witches' brooms are dense masses of branches that are conspicuous in infected trees. Generally, they are large and yellow. Needles of the brooms are often stunted and drop off in the fall each year. Other fungi and disease agents may cause the formation of witches' brooms, but only broom rusts cause yellowing of broom foliage and annual needle drop.

Broom rusts cause reduction in tree growth, top-kill, and some mortality. Rusts may create entry points for decay fungi. Witches' brooms may be pruned from trees with only a few branch infections if the infections are not too close to the tree trunk. Trunk infections are recognized by swelling of the trunk and cracks in the bark at infection sites.

There are no chemical or biological controls available for the control of broom rusts.



Large, dense witches broom in white fir.

Close-up of broom showing stunted, yellow needles.

ENVIRONMENTAL AND MAN-CAUSED

erous non-infectious diseases cause injury to trees or death of trees. Two d categories of non-infectious diseases are "environmental" and n-caused." Any factor that causes a change in the tree's "normal" living and ing processes may cause injury. Injuries to trees can result from too much as as too little of any basic requirement for tree growth.

ENVIRONMENTAL FACTORS

Injury

y or late frosts often cause damage to tree buds, foliage, or flowers. Sudden s in temperature during the dormant season can cause cracking of the bark. -injured trees often have reddened or rust-colored foliage and may suffer nature leaf drop.

Injury

tissues may be injured when they are exposed to temperatures above the imum to which they are acclimated. Sunscald is one kind of heat injury which lts from overheating and drying of the bark, and is characterized by lening of the bark followed by canker formation. Premature leaf drop also rs on heat-injured trees.

er Injury

tage of available water may result in drying of foliage and twigs, with tual mortality. Drought injury may cause foliage to turn yellow or brown and e prematurely cast. Flooding of trees also causes injury by cutting off the gen available to the root system. Trees injured by excess water often have olored leaves and spongy bark.

rient Injury

nort supply of essential nutrients may cause injury or death of trees and an ess of nutrients may be toxic to the tree. Nutrient abnormalities are acterized by foliage discoloration and frequently by distortion of twigs and es.

ther Injury

h winds often cause branch, limb, or trunk breakage and the uprooting of s. Heavy snows cause limb breakage from excessive weight. Hail may cause nding or death of buds, leaves, twigs, and branches. Lightning strikes on s frequently cause breakage or formation of large cracks and burns in the k.

mal Injury

ls or rodents feeding on or under tree bark can injure trees. Small trees and bs around the home are often injured by dog urine, and the injury is acterized by localized discoloration of the foliage. Trees are also wounded by "sharpening" their claws on the thin bark of small trees.

Soil Compaction

Trampling of soil around trees by animals or compaction by machine traf reduces soil aeration and percolation, resulting in yellowing of foliage, prematur leaf drop, and death of the tree.

Mechanical Wounds

Wounding often results from use of machinery such as lawn mowers or fr individual attacks on trees by children banging into them with bikes, wagons, other toys. Excavation around trees may cause injury to the root systems.

Air Pollution

Toxic substances in the air surrounding trees may result in injury or death certain trees and shrubs. Air pollution injury is characterized by discoloration foliage and formation of spots or blotches on leaves. The most common a pollutants causing plant injury are sulfur dioxide, PAN, and ozone. Air pollut problems result most often from industrial emissions and vehicle exhaust.

Salt Injury

When roots take in water contaminated with sodium or chloride from highwa treated with deicing salt, the result is often injury or tree mortality. Salt spra from passing vehicles also may cause injury to trees near treated highway Salt-injured trees may have yellow, red, or brown needles. In the case of s spray, injury occurs on one side of the tree only.

As indicated by the previous descriptions, many non-infectious diseases ha similar symptoms. Thus, the diagnosis of disease problems is very often a di fic task even for trained personnel.

Masonry
Structures

Masonry Structures

Introduction

Defects: Treatments

- Eroded Stone
- Eroded Mortar
- Loose Stone
- Small Voids
- Large Voids
- Unsupported Sections
- Effluorescing Salts

Artificial Foundations - West Ruin

- Concrete - Hydropel

Masonry Structures

Approximately 95% of all ruins maintenance involves the repair of masonry walls. One of the most important things to remember in ruins maintenance is that there are different masonry styles and types from room to room and one room may represent several distinctive styles. This is certainly true of the Aztec Ruins where styles range from fine, banded Chacoan to coarse laid Mesa Verdean. There are also different wall bond types and some unbonded wall corners. When repairing walls you must first be aware of the masonry style of the particular wall you are working on and then you must be sure that your repaired portion matches the original. One common fault is the alteration of features through repair. A typical example is the elimination of doorway jamb lines in a doorway which was filled-in by the original occupants. The filled-in portion will often be of a different masonry style and workers will sometimes forget the different style and even obliterate jamb lines when repairing eroded stone. To guide repair work and to help eliminate sloppy replication of masonry styles, "before" photos must be taken and working prints made. Such photos are required to document walls and features as they were before the repair work was undertaken.

There are also different colors of mortar in the ruins. These too should be matched as closely as possible. A Munsell soil color chart (see "Supply Sources") is a valuable matching tool. In fact, a Munsell or similar instrument is required by Activity Standards, Part IV Professional Services, Section 2, Historic Structure Preservation Guide: 4. The Munsell is also of considerable help in the field search for stone and soil sources.

Moisture is the foremost damaging agent in the Aztec Ruins. The most common defect is eroded stone, particularly at wall bases where capillary processes are most active. Such erosion should be repaired when it begins to detract from the mood of the interpretive scene. It must be repaired when it has advanced to the point of adversely affecting structural integrity.

The second most prevalent defect is mortar joint erosion. It, too, is caused mostly by moisture. Mortar is critical to bonding and supporting building stones. It also helps protect wall interiors by providing a moisture barrier at joints. In rubble core walls, such as those at Aztec, it provides the matrix for the rubble core. When this interior matrix is eroded, voids result and, if large enough, will seriously weaken wall sections in which they occur. Therefore, mortar must be replaced when it has eroded to the point that it is not providing proper protection.

Loose veneer and capstones are the third most common defect at Aztec. Loose capstones are more prevalent because there is no weight bearing on them and because wall tops receive more soaking moisture than veneer surfaces (except for wall bases). Loose stones, particularly capstones, are a major safety hazard for maintenance crewmen and unauthorized visitor traffic. They can also affect support of other wall stones and break the moisture barrier created by bonds between mortar and stone.

Another serious defect, fortunately not common at Aztec, is unsupported or undercut wall sections. Small such areas with little or no overburden (wall above) do not significantly affect structural integrity. The critical defect of this type, and probably the most common, is a collapsed doorway jamb with a large or heavy overburden of wall section. This particular defect usually isn't long lasting because tremendous pressures from the overburden cause early collapse. When such a section falls, it usually causes collapse of a large area of wall. This, in turn, often makes other immediate wall sections unstable.

To reiterate an earlier point, there are "artificial" defects that are very common and involve the alteration, obliteration, or removal of architectural features or building materials (wall or roof fabric). Examples are: removal of rotted wood members without replacement by a new members, sometimes subsequent filling of the seats or sockets with stone and mortar; and removal of wood or stone to provide easier access to a room. Once you become intimately familiar with the ruins you will begin to notice these and other such defects. Once you find an apparent defect of this kind and you have architectural, photographic, or written proof of its existence and cause, it should be programmed for restoration to its proper condition. However, since this type of defect does not usually adversely affect structural integrity, it will remain a fairly low priority for repair.

A minor defect very prevalent in the Aztec ruins is the accumulation of a whitish, powder deposit on wall surfaces. This occurs in capillary action as dissolved salts are carried up into and through walls and changed from a crystalline state to a powdery state on exterior wall surfaces where the water medium evaporates. This deposit can sometimes be removed, in light or moderate cases, with a stiff wire brush. If a brush is used, care must be taken to avoid deep scoring of the soft sandstone. Heavy deposits can be removed but this usually results in damage to the underlying wall stones. It is best to practice preventive maintenance on situations that facilitate efflorescence. This process can be controlled for the most part by keeping snow away from walls, picking up leaves and other debris around walls, and keeping drainage systems clear and functioning. If you have severe efflorescence problems that cannot be effectively controlled through maintenance, contact the group Ruins Preservation Specialist for assistance.

Procedures for repair of other defects discussed above are found in this section. If you are not familiar with the basic techniques

involved in these recommendations, do not attempt repair - contact NALA: the recommendations are submitted as guidelines and not as substitution for experience in or knowledge of basic stabilization techniques.

Several different mortars have been used in the Aztec Ruins during its history of preservation: regular cement mortars, both tinted and untinted; soil-bitumen mortars; fortified soil mortars; and unmodified soil mortars. The use of these mortars reflects changes in the philosophy of stabilization over the years. Each different mortar has its advantages and disadvantages, its good points and its bad. Cement mortars are very strong and long lasting but they are porous to moisture and are usually unaesthetic (witness the infamous "purple" cement of the RSU years). Soil-bitumen mortars are aesthetic and provide some moisture barrier but are weak. Soil-cement mortars can be made virtually as strong or weak as desired but color control is difficult and capillary potential is increased with its use. Fortified soil mortars can be made quite strong but are expensive and relatively difficult to work with. Unmodified soil mortars usually provide the best color match but are often very weak and easily weathered unless there is a sufficient clay content.

The NALA Ruins Preservation Specialist recommends the following: for all basic mortar, use an unmodified soil, leaving a one-inch deep mortar joint which you will point with a fortified soil mortar; for wall sections or caps that receive heavy pressure or heavy foot traffic, your basic mortar should be a soil-cement overpointed one inch with a fortified soil mortar.

The unmodified soil mortar and the fortified pointing mortar should be color matched to the original. To obtain a color match, you may have to mix soils of different colors, so plan to do tests well in advance of the start of the work season. For testing, simply make small test mixes, add water to the mixture to form a workable mud, make flat patties, and leave these to completely dry in the sun (remember to record what each mix is and mark each patty for ready identification). Obtain a dry sample of mortar you are matching and compare it to your test patties. Select the closest match. If there is no close match, make more test patties until you obtain a match. To fortify the mortar for overpointing, add 13 oz. cup of latex modifier (concrete adhesive) to each gallon, by volume, of soil. The unmodified basic mortar is mixed in the plaster mixer in large volumes. The overpointing mortar is mixed in two gallon quantities by hand. The latex modifier should be added to the water and the water then mixed with the dry soil. The amount of water used will vary from different soils. The point to remember is that the mix should be dry as possible with only enough water to make the mixture workable. The fortified soil will set fairly rapidly and must be used quickly (within about 25 minutes), thus it is mixed by the bucket.

You will be using very little soil-cement at Aztec. It should only be used on wall tops which are immediately accessible to the public. For this limited application, use at least a 5:1 mix, that is, 5 parts soil to 1 part cement. The cement should be Phoenix Type I or the equivalent. The use of white Portland cement in ruins resources is forbidden by WASO directive. The local sandy soils you will be using usually preclude the addition of sand in the mortar mix. Again the mix should be wet enough

to be workable and no more. A one-inch deep line should be maintained in the mortar joints for pointing with fortified soil.

A list of concrete-hydropel foundations of the West Ruin has been included for information and as an inventory. Also, it would be a good idea to observe walls with these foundations and compare them with those walls without such foundations, over a period of several years, to determine the effectiveness of the artificial foundations.

Defect: Eroded Stone

Tools required for repair: Rock hammer; cold chisels; pointing trowel,caulking trowels (1/8", 1/4", 1/2"); whisk brooms (2); steel buckets (2).

Safety gear: Hard hat; steel toe boots; chipper's goggles; gloves.

Materials: Dry, uneroded stone; mortar; water.

Procedure: Remove eroded stone and attendant mortar; brush dirt off exposed rock surfaces; dress fresh stone to size (custom fit), one course at a time; wet in-situ rocks surfaces; lay-in mortar; wet and lay-in stone; repeat process until all stone replaces; dress mortar joints to remove trowel marks.

Clean up: Brush or pick mortar off exterior rock surfaces; remove and dispose of old stone and mortar.

Remarks: Work in sections small enough to avoid structural stress; brace large areas if you must use this method (see RSU Handbook); be sure to match masonry type and soil and stone color.

Defect: Eroded Mortar

Tools required: Pointing trowel; caulking trowels (1/8", 1/4", 1/2"); whisk brooms (2); steel buckets (2).

Safety gear: Hardhat; steel toe boots; chipper's goggles; dust mask, gloves.

Materials: Mortar; water; additives (if any).

Procedure: Remove old mortar; brush out dirt and dust; wet mortar joint; caulk joint with mortar; dress joint to remove trowel marks.

Clean up: Brush or pick excess mortar off exterior rock surfaces remove and dispose of old mortar.

Remarks: Mortar should be dry as possible yet still workable; mortar should be packed in joints as tightly as possible.

Defect: Loose Stone

Tools required: Rock hammer, cold chisels; pointing trowel; caulking trowels (1/8", 1/4", 1/2"); whisk brooms (2); steel buckets (2).

Safety gear: Hard hat; steel toe boots; chipper's goggles; gloves.

Materials: Mortar; water.

Procedure: Remove loose stone(s) and attendant mortar; brush off rock surfaces; wet rock surfaces; lay-in mortar; wet and lay-in stone(s); dress mortar joints to remove trowel marks.

Clean up: Remove excess mortar from exterior rock surfaces; remove and dispose of old mortar.

Remarks: Capstones should be laid in a fairly strong mortar such as a soil cement (see Materials Data section) so that traffic will be safer. On major recapping, avoid flat wall tops which catch and retain rain and snow moisture - a slant to one or both sides is preferred.

Defect: Small Voids

Tools required:	Rock hammer; cold chisels; pointing trowel; caulking trowels; whisk brooms (2); steel buckets (2); heavy duty caulking gun.
Safety gear:	Hard hat; steel toe boots; gloves
Materials:	Mortar; water
Procedure:	Clean out loose stone and loose or deteriorated mortar; brush area clean as possible; wet all surfaces involved; trowel - in mortar or use caulking gun; dress surface of mortar.
Clean up:	Remove excess mortar off surfaces; remove and dispose of old mortar and rock (if any).
Remarks:	Mortar should be workable but dry as possible.

Defect: Large Voids

Tools required: Rock hammer; cold chisels, pointing trowel; caulking trowels; whisk brooms (2); steel buckets (2); rope oakum; knife or heavy duty scissors; slurry pump; large hand scoop (example - sugar scoop).

Safety gear: Hard hat; steel toe boots; goggles; gloves

Materials: Mortar or mortar slurry; water; small stones (fist-sized)

Procedure 1 (no bulge ~~to~~ in veneer exterior to void): Remove several stones from veneer at top of void, enough to be able to fit small stones into void; pump in small amount of slurry; plug flowing holes with oakum as they appear; begin filling void with small amounts of slurry with small stones thrown in to add strength and binding, the end result when the void is filled should be a mortar slurry matrix with interspersed small stones - this replicates the rubble core of the wall; when slurry has hardened, remove oakum and caulk and dress mortar joints.

Procedure 2 (veneer bulges, or if you are, for some reason, unable to form a slurry-rock core): Remove bulged section of veneer; clean out bottom of void; rebuild veneer; form rubble core behind veneer as you work upward; dress mortar joints.

Clean up: Remove excess mortar or dried slurry from exterior surfaces; remove and dispose of any trash rock or mortar.

Remarks: If you can form a rubble core in the void, Procedure 1 is preferred; if not, use Procedure 2; Procedure 2 is also more applicable to void areas creating <u>severe</u> structural stress; be sure to work with areas small enough to handle when you have to remove and rebuild veneer.

Defect: Unsupported Sections

Repair techniques, tools, etc. are the same as repair for eroded stone. For suggestions on reinforcement and bracing, see RSU Handbook.

Defect: Effluorescing Salts

Tools required: Pointing trowel, caulking trowels, whisk brooms (2), paint brush (2" - 3"), steel brush (fine), spray applicator (trigger pump type is the most convenient), steel bucket.

Safety gear: Hard hat; steel toe boots; chipper's goggles; gloves.

Materials: Water; distilled vinegar.

Procedure: Remove as much salt as possible by brushing and scraping (take care not to score the stones); dilute vinegar 50% with water, mix and pour in spray applicator; spray small section of wall (one square foot) with diluted vinegar; wash off section with clear water (splashed on with whisk broom) immediately after the diluted vinegar ceases reacting; work in small sections until finished. Several applications may be required --let area dry completely between applications.

Clean up: Sweep excess salts (that have been brushed or scraped off) away from walls. If there is a substantial amount, collect it and dispose of it where it will do no damage to ruin walls.

Remarks: Mortar soil sources at Wupatki are high in salt content. These sources should be avoided. Locate and establish a borrow (must receive clearance from NALA and SWR) with low salt content. For assistance, contact NALA Archeologist.

Concrete - Hydropel Foundations (WERU)

Rooms with artificial foundations, N, S, E, W walls: 16, 17, 18, 20, 26, 27, 28, 29, 30, 33, 35, 37, 38, 39, 40, 41, 42, 43, 44 (probably), 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 64, 65, 66, 70, 71, 72, 73, 74, 75, 76, 77, 78, 80, 81, 82, 83, 84, 90, 91, 92, 93, 94, 95, 99, 100, 101, 111, 112, 115.

Rooms with artificial foundations, N, E, W walls: 67, 69, 96, 120

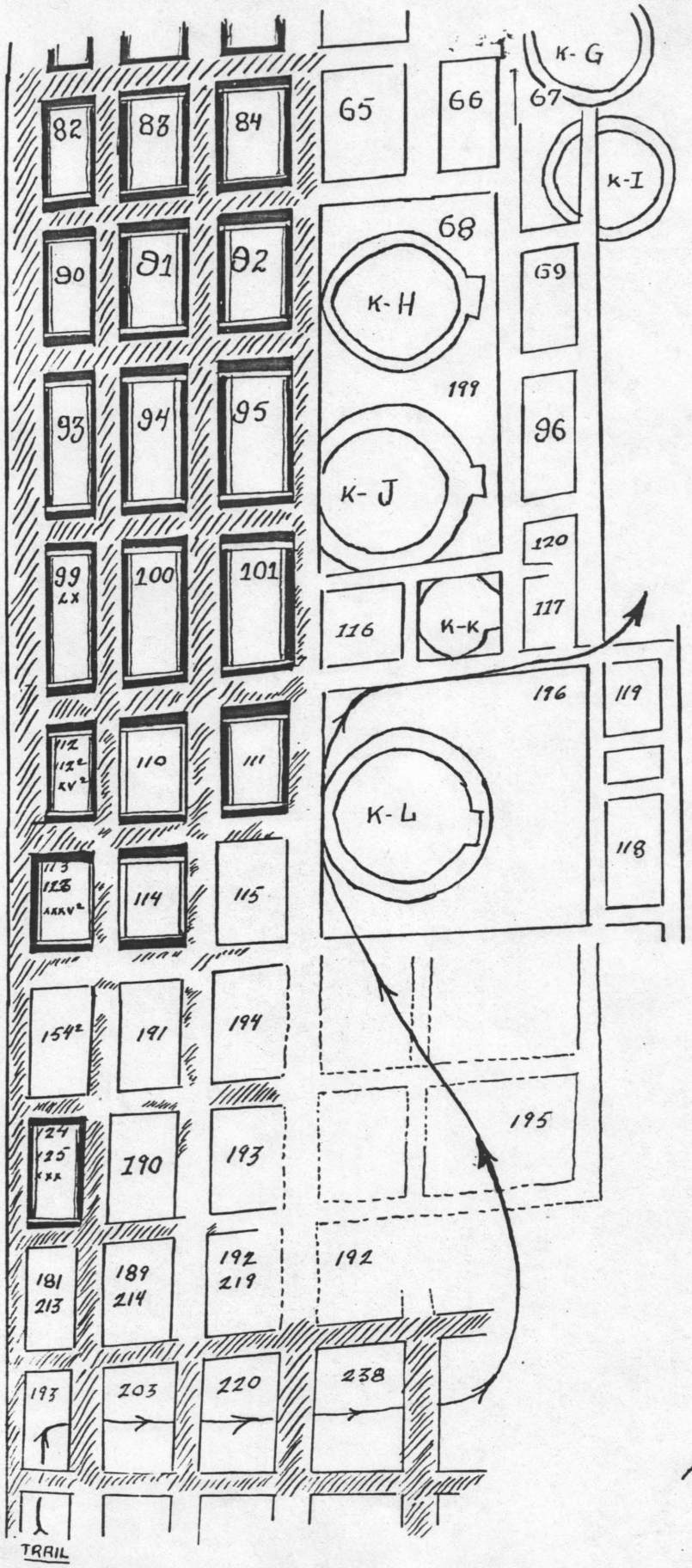
Room with artificial foundations, N, S, E walls: 113

Room with artificial foundations, E, W walls: 114

Room 120: North exterior wall treated with hydropel and backfilled (see Shiner, 1959: 3-6)

Original cobblestone foundations - West Ruin

Room 16: east wall
18: east wall



Middle House Block-

— Legend —

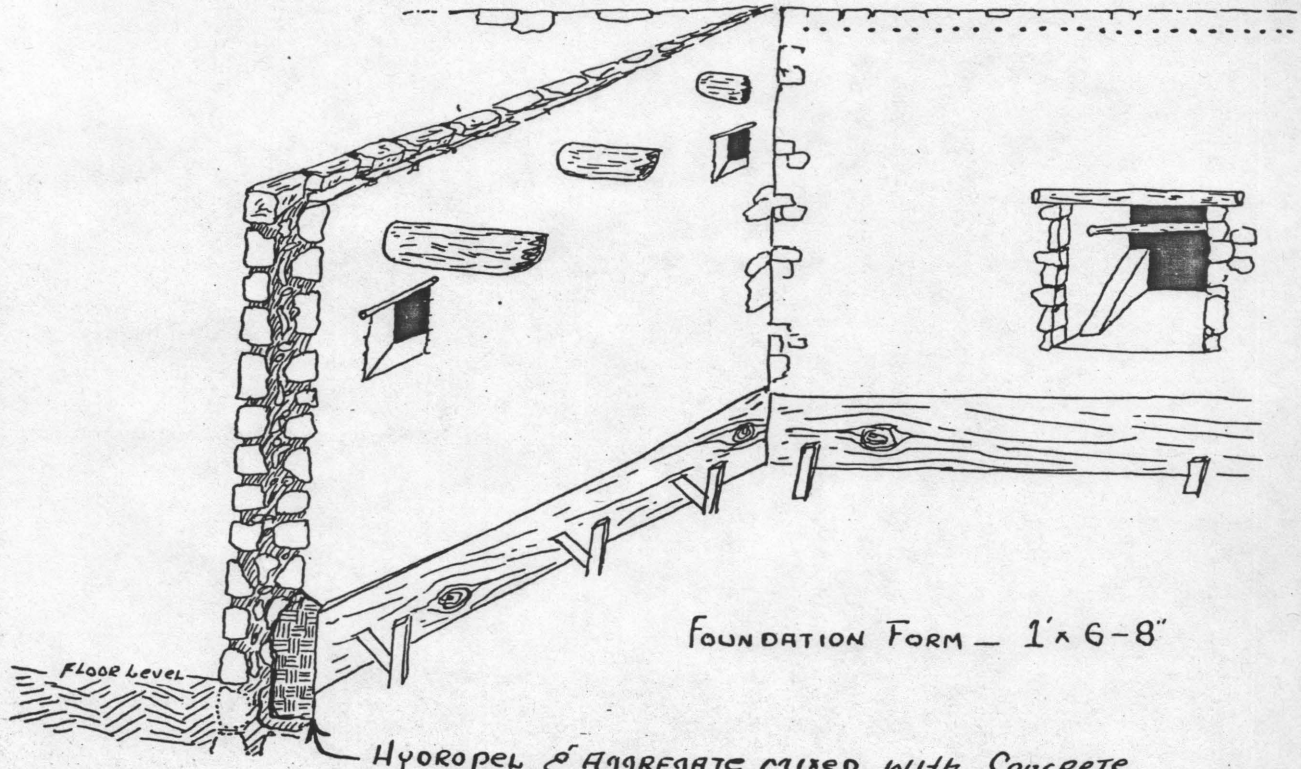
Guide Trail

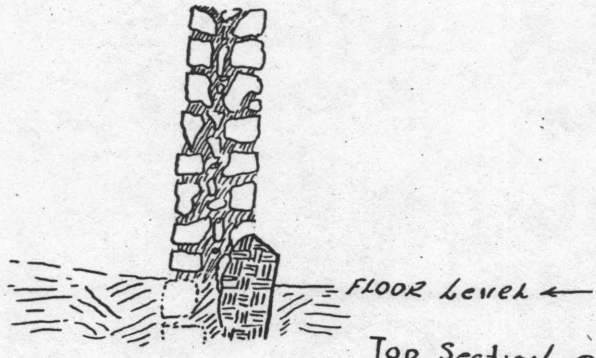
— Capping of Bitumuls Mortar & Masonry

— Non excavated Walls-

— formed Concrete foundations of Hyoropeb-

From Vivian & Rixey, 1950:3





From Vivian & Rixey, 1950: 5

Drainage
Systems

Drainage Systems

Introduction

Narrative on 8" Interceptor Drainage

Farm Drainage Ditch
w/map

East Ruin Roof Drainages

West Ruin Surface Drainage Systems
w/additional drainage notes

Map References
West Ruin Plaza Drainage
Great Kiva Floor Drainage

Kiva N Subsurface Drainage
w/detail

Map of West Ruin Surface Drainage Systems

West Ruin Roof Drainages

Drainage Systems

There are several different types of drainage systems at AZRU: one major underground system to intercept water from the aquafer running north-south beneath the monument (see excerpts from Richert, 1953, this section); a series of room surface drains; a custom fitted kiva drainage system (see "Kiva N Drainage", this section); a few room dry-barrels; and roof drains.

To function properly, these systems must be kept clean and unobstructed. Therefore, you must know where they are and how to clean them. Locations of these systems and procedures for cleaning them are discussed by system in the latter part of this section. First, however, it is important that you know the background information - why these drains are needed and how they can become obstructed.

Moisture, whether from direct processes such as rain or snow, or from indirect processes such as capillary action, weakens soil mortar and the soft sandstone building material of the ruins. Weakening of mortars and stones occurs through physical processes such as rainfall erosion and chemical processes such as efflorescence of minerals through capillary action. Mortar performs the function of bonding and supporting stone. Stone constitutes the main wall fabric and acts to support other stone within the wall, giving the structure stability. Therefore, mortar and stone, particularly in an exposed ruin structure, must be kept sound enough to remain functional.

Since it is neither practical nor aesthetic to build a shelter over the ruins, we seek to control moisture through other means - various drainage systems.

Drainage systems can and do become fouled or obstructed, thus limiting or eliminating their function. For instance, the 8" Orangeburg underground along the north part of the monument, designed to intercept and channel water from the aquafer away from the ruins, is easily fouled from roots growing into the pipe through the perforations. Control of the roots should be an annual task. Roof drains at AZRU become obstructed during the winter with snow and ice. This results in leaks into the rooms below. Surface drains catch leaves in the fall, snow in the winter (insulated by the leaves), and dirt year round (blown and washed in). They become blocked and so are unable to carry away surface moisture.

When most of the leaves have fallen in the fall, they should be collected and disposed of. Large garbage bags are very handy for collecting. At the same time, clean dirt and other obstructions out of the drains. A long piece of garden hose plugged at one end makes a good, flexible closed-drain (pipe) cleaner. This cleaning should be done before the first snowfall because snow and ice complicate and impede the cleaning procedures.

When winter arrives roof drains will become plugged and they should be cleared. The chisel end of a rock hammer makes a good ice tool. However, use such a tool with caution to avoid damage to the drain and the roof. More than likely, you will need to clear the drains several times during the winter. It does not take long and, considering the damage that results when drains aren't cleaned, the effort is well worthwhile. When checking roof drains for snow and ice, also check roof surface drains and clear them when needed. A little bit of preventative maintenance will go a long way in preserving the ruins.

The following excerpts from Richert's 1953 West Ruin Stabilization report explains the importance of the 8" Orangeburg aquafer interceptor. Since it was built, the system has not been well maintained. Time between cleaning has ranged from 5 to 10 years. The system must be cleaned annually to be effective. It should be cleaned in the fall when most root growth has slowed or stopped - about October 7. You may wish to schedule this slightly earlier, before the end of the fiscal year, so that your seasonal employees can help clean the drain.

The system is to be cleaned during the FY 1978 stabilization season with a power auger and mild root acid.

The system is approximately 1425 feet long and has nine man holes for inspection and facility of cleaning. Vegetation around the man holes should be kept low to ease access.

Addendum

An attempt was made to clear and clean the 8" interceptor using the methods described above. However, several sections of pipe were discovered to have been, in effect, crushed. These were replaced with new materials.

Towards the middle of the system, Cottonwood root growth has severely clogged and damaged the pipe. Many of these trees were cut down. However, this section of pipe requires major rehabilitation (expected completion FY1979) to repair root damage.

"...the 1933-34 project accomplished mainly the resotration of the Great Kiva but sub-projects included drainage of the ruins court, patching, capping and repair of walls, and protection of original ceilings. Of the latter two items - that of actual repair and capping of walls, and protection of ceilings - much of the planned work had to be dropped due to insufficient funds.

The all-important drainage work involved laying of tile drains in trenches, some as much as 17 feet deep, with connecting drains from the Great Kiva roof and the edges of Kivas E and I, and possibly one or two others. Interestingly enough, deeply buried archeological features were frequently encountered in the court during trenching, testifying to deeply buried structures and hence, earlier occupations. As we shall see later this elaborate drainage system never functioned properly and the deep kivas remained damp." (Richert, 1953: 8 & 9)

"In 1944 many studies and investigations by various National Park Service officials were made to determine the exact nature and source of a relatively high water table and to recommend economically feasible means of relieving the problem. A drainage and soils expert of the Soil Conservation Service, Albuquerque, New Mexico, was asked to conduct a study and make a report of his findings. This very excellent report by the Soil Conservation Service, based on thorough technical investigations involving test holes and soil analyses, confirmed earlier beliefs that the source of sub-surface water was from the north and northeast of the ruin. It also showed that the ruin was apparently located near the termination of an alluvial fan formed by a small drainage from the north. Soils north of the project are very stratified and contain numerous lenses of sand, gravel and cobble. These continue northward to the foot of the mesa a quarter of a mile away which is traversed by a large, modern irrigation ditch, intensively used. Hence, the result of these studies showed that watertable slope, topography, and soil conditions were chiefly responsible for sub-surface water seepage from the irrigation ditch.

Of several means proposed to releive the watertable problem, one seemed most practicable and was eventually adopted and carried out in 1945. It consists of a deep drain along the north side of the ruin, tapping the ground water reservoir accumulating in that section and which formerly kept the adjoining area waterlogged.

To the best of my knowledge, this is a 14-inch tile drain installed at a depth of 20 ft., placing the bottom of the drain some 2 - 3 ft. below the bottom level of the deepest kiva in the ruin and therefore intercepts sufficient sub-flow to completely relieve the former waterlogged condition. The drain extends from west to east some 1000 ft. along the north side of west Ruin and has several suitable manholes for periodic

inspection and provision for flushing the line. During the 1953 stabilization project, I inspected on of these manholes and, since the system is quite deep, by use of artificial light I could see a rather sizeable stream of water being conducted along the drain tile - this despite the fact that the Aztec vicinity had received no appreciable precipitation for months, bearing ample testimony to the presence of a high watertable. Without checking the system further in detail, I believe the water is conveyed by drain tile to the east side of the ruin, thence southeastward down the natural drainageway perhaps to a waste ditch south of the Monument where it eventually empties into the Animas River.

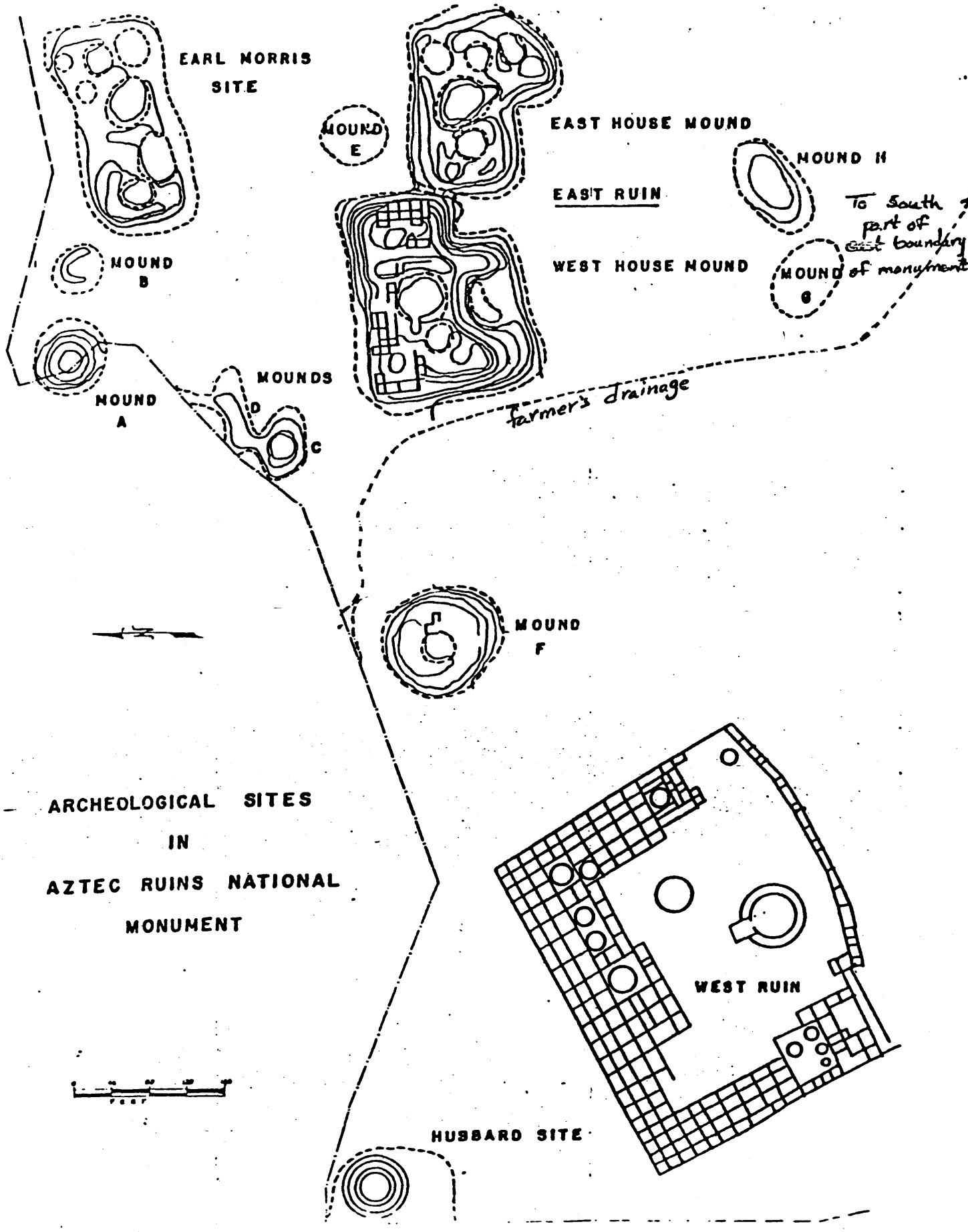
Built in 1945 - 46 at a cost of approximately $10,000, this drainage system has, in my opinion, proved effective in maintaining a lowered watertable under the ruins and will provide a permanent solution of the problem so long as the line is periodically inspected and maintained. The implications of this fact are tremendous. For 9 years now the plaza with its deep kivas has remained free of water with the exception of normal surface runoff during periods of precipitation. Capillary action to surface structures with its usual, rapid erosion of soft sandstone building blocks is greatly diminished, and has, in fact, been brought to a complete halt in a majority of rooms in the north and east wings where waterproof cement foundations were installed in 1950-51 by Mr. Raymond Rixey, then Archeologist Aide." (Richert, 1953: 13, 14, & 15)

Farm Drainage Ditch

The owner of the land north of the monument has legal easement to drain his property across the monument. This drainage consists of a simple, shallow ditch running onto the monument just NNE of Mound F, east toward the East Ruin, south along the west wall of the East Ruin, south to the west of Mound G, curving southeast, south of Mound G toward the southeast part of the monument. The ditch stops in the stand of trees and bushes just northeast of Residence Building 9 (Superintendent's Residence).

It is recommended that this ditch be converted to pipe drainage within the foreseeable future. A 10-238 will be required (will be initiated at NALA).

The land owner does not maintain his ditch on NPS property. Therefore, it is up to you to inspect it at least twice yearly and ensure that water flow will not be obstructed.


EARL MORRIS SITE
MOUND E
EAST HOUSE MOUND
MOUND H
EAST RUIN
To South part of East boundary of monument
WEST HOUSE MOUND
MOUND G
MOUND B
MOUNDS D
MOUND A
C
Farmer's Drainage
MOUND F
ARCHEOLOGICAL SITES IN AZTEC RUINS NATIONAL MONUMENT
WEST RUIN
HUBBARD SITE

East Ruins Roof Drainage

Currently, there is only one roof drain pipe exposed - from Room 11 to the partial roof over Room 24. The other pipes are buried (see roof drainage list).

The buried pipes should be located, exposed, and left exposed so that they can be cleaned periodically. There is no access to the upper ends of the drains so they will have to be cleaned from the lower ends.

There is no cleaning tool available on the monument for this job. The following is suggested: take a section of the hand rotated pipe cleaner (located in the stabilization tool shed) and weld onto the male end a steel cup about 2" in width, the cup opening should face the female end of the section; attach several other sections of rod and insert the cup end (cup on top) into the drain, push it in as far as it will readily go; rotate the rods so that the cup is directly centered on the bottom half of the pipe and proceed to scrape the pipe outwardly; repeat until you have removed built-up sediments. Since the system is enclosed on the upper end, you will not have to worry about leaves.

Roof Drainage - East Ruin

Room 1: drains off surface toward southeast.

2: roof sloped to west toward low area (unexcavated kiva).

2: drains off surface to east

4: same as Room 2.

6: drains off surface to north, east, and west.

7: same as Room 6.

8: drains through east wall to Rm 12. (bituminized fiber pipe)

9: bituminized fiber pipe through south wall onto roof of Rm 11.

11: b.f. pipe through south wall onto partial roof of Rm 24.

12: b.f. pipe through east wall to exterior. (below surface)

13: same as Rm 12.

14: same as Rm 12.

Room Surface Drainage

There are three types of artificial room surface drainage in the West Ruin: ceramic, petroleum product, on synthetic pipe; rock lined trough; whole and split ceramic pipe trough.

For cleaning the troughs, you will need only a small scoop (the split ceramic pipe troughs are about 6" I.D.,) gloves, and plastic trash bats. Simply clear the troughs of debris and put this debris in the garbage bags for easy disposal.

the rock-lined troughs about 12" I.D.

For the various kinds of pipe, different cleaning methods will have to be used. For the larger, straight pipes, use the scoop you made out of a steel cup and pipe cleaner rod (see East Ruin Roof Drainage narrative). For small or angled pipes use a length of garden hose (about 10' long) plugged at one end. In all the pipes, leaves will accumulate.

The troughs and pipes should be cleaned after all the leaves have fallen in the fall but before the winter rains and snows begin. In other words, around November 30. They should be cleaned again about March 15 to remove sediments accumulated over the winter.

Room Surface Drainage - West Ruin

Room NN2: longitudinally-split ceramic tile, 2' long, in south end of west wall, through wall into Rm 175.

NN3: ceramic tile, 2' long, in south end of east wall, through wall into Rm 187.

NN5: ceramic tile drain, 4½' long, in center of south wall, down and into and through wall into the west center of the north wall, at mid-height, of Rm 118.

119: west half of room drains through a 1' long hole in the south part of the center wall dividing the two room halves, into the east half and out the south doorway.

138: ceramic tile, 4' long, in the center of the north half of the west wall, through the wall into the drain system of Rm 229.

154: rock-lined, surface trough, 10' long, oriented south to north in the east center of the room, connects to 2½' long ceramic tile in east center of north wall, through wall to exterior.

182: ceramic tile, 3½' long, in west center of north wall, through wall to exterior.

184: ceramic tile, 3' long, in west center of north wall, through wall downward to Rm 183.

191: rock-lined trough, 10' long, oriented south to north, in the east center of the room, connects to 2½' long ceramic tile in east center of north wall, through wall to trough in Rm 154.

194: rock-lined hole connected to 6½' of ceramic tile, in the center of the south wall, downward and then through wall into Rm 218.

195: ceramic tile, 3½' long, in south part of west wall, through the wall into Rm 242 underground, connects underground to PVC pipe (up to 12' long) and surfaces along the south wall line of Rm 242, approximately in the center of that line.

196: ceramic tile, 4½' long, in west center of south wall, down and then through wall into the northwest part of Rm 119.

197: (East) ceramic tile, 2½' long, in center of south wall into northwest part of Rm 69.

197: (West) ceramic tile with top screen and concrete apron, 6' long, in top west part of south wall, down to 2' long ceramic tile through wall into center of north wall of Rm 96.

Rooms 203, 213, 220 & 238: drain north on visitor trail to ceramic tile, 2½' long in center of north wall of Rm 213, through wall into large, wood lined drain box on exterior.

Rooms 211 & 233: longitudinally split ceramic tiles laid along west wall north to south, 18' long, through west end of south wall in 1½' ceramic tile into drain system of Rm 235.

Room 214: ceramic tile, 3' long, in east center of north wall, through wall into drain system of Rm 191.

216 & 218: ceramic tile, 4' long, in south center of east wall, down and through wall into rock-lined trough oriented west to east across Rm 186, to under center of east wall and out onto plaza.

225: metal drain through west wall under west doorway into Rm 202, spout of drain about 1' long.

226: ceramic tile, 3' long, in center of south wall, downward through wall to Rm 227.

227: ceramic tile, 4' long, in center of south wall, downward through wall to Rm 130.

228: ceramic tile, 5' long, in center of south wall, downward through wall to Rm 138.

229: rock-lined trough, 15' long, from north center of east wall downward and across to the middle of the west wall, south along west wall, through wall in south corner of west wall, in ceramic tile, 4' long, to exterior.

230: longitudinally split ceramic tile, 17' long, from south to north along west wall, through west end of north wall in 3' long ceramic tile, into drain system of Rm 229.

234: longitudinally split ceramic tile, 17' long, along west wall collects water and drains it through a 4' long ceramic tile through the west wall in the south end, and downward to Rm 233.

235: split ceramic tile, 14' long, south to north along west wall, downward through wall to exteri or.

236: ceramic tile, 4' long, through center of west wall downward to Rm 235.

237: rock-lined hole, 1½' long, through bottom part of the south center of the west wall into Rm 236.

239: ceramic tile, 2' long, in west center of the south wall, onto plaza.

Room 242: ceramic tile, 2' long, in center of west wall, through wall to exterior and southward to plaza.

Kiva F: area around kiva drains toward southwest corner to cement-lined trough on top of wall running east-west just south of F, down to northwest corner of area around kiva G.

Kiva G: area around kiva drains toward southwest corner onto cement-lined trough on top of north half of west wall of Rm 58, south to doorway then through wall to exterior and onto plaza.

Kiva N: see kiva N details, this section.

Kiva V: ceramic tile, 3' long, in center of west wall, downward through wall to Rm 174.

Kiva W: ceramic tile, 2' long, in south wall of "keyhole", downward through walls to Rm 184.

Additional Drainage Notes

" A drain was constructed across the floor from an outlet on the north wall to one on the south wall. Used tinted cement and made drain overall width of about seven inches with an internal gutter about 4 (inches)."
(Shiner, 1959-60:42)

"Constructed a double drain of colored cement across the floor from two outlets at base of north wall to single outlet on the south wall".
(Shiner, 1959-60:62)

Drainage Systems

West Ruin plaza drainage

NM - AR - 3112 - A, June 1967

Great kiva floor drainage

NM - AZT - 4958, December 1935

(Maps on file at AZRU)

Drainage Installation in a Portion of the South Wing of the Aztec Ruins, 1977

Submitted by:
Larry V. Nordby
Supervisory Archeologist
SWCRC

March, 1978

Drainage Installation

Introduction: Periodic project work in the West Ruin at Aztec had been done on Kivas N, O, V, and W. According to prior stabilization records (Voll and Mayer, 1965; Laudeman, 1973), these kivas had been subjected to extensive masonry repairs in 1964 and 1973. Generally these repairs consisted of relaying decayed masonry in tinted portland cement mortar, using fresh stone as replacement, or repointing wall faces with portland cement grout. Rebar keying was also used behind the wall. The area was also a focal point along the interpretive trail, with stops providing an overview of the pueblo's plan, and an explanation of Mesa Verde style kiva architecture. For this reason, the area had been covered with an emulsified asphalt trail.

The Problem: Consultations between the project supervisor and Southwest Cultural Resources Center personnel recognized that in spite of the previous preservation work on the kivas, deterioration was continuing. This deterioration resulted from lateral movement of ground water to the kiva walls as shown in Figure 1. Evaporation of this moisture was concentrating soluble salts on the stone of the kiva wall surfaces, and the combination of mechanical and chemical impacts was deleterious to the stabilized fabric. Augmenting the stone breakdown was the use of less permeable portland cement mortar, which forced water transmission through the stone. Periodic reworking of the masonry was treating the symptom of the problem, but not attacking it at its source: presence of ground-water and soluble salts.

Two additional factors tended to aggravate the deterioration. The first of these consists of the slope east of the wall separating the kiva

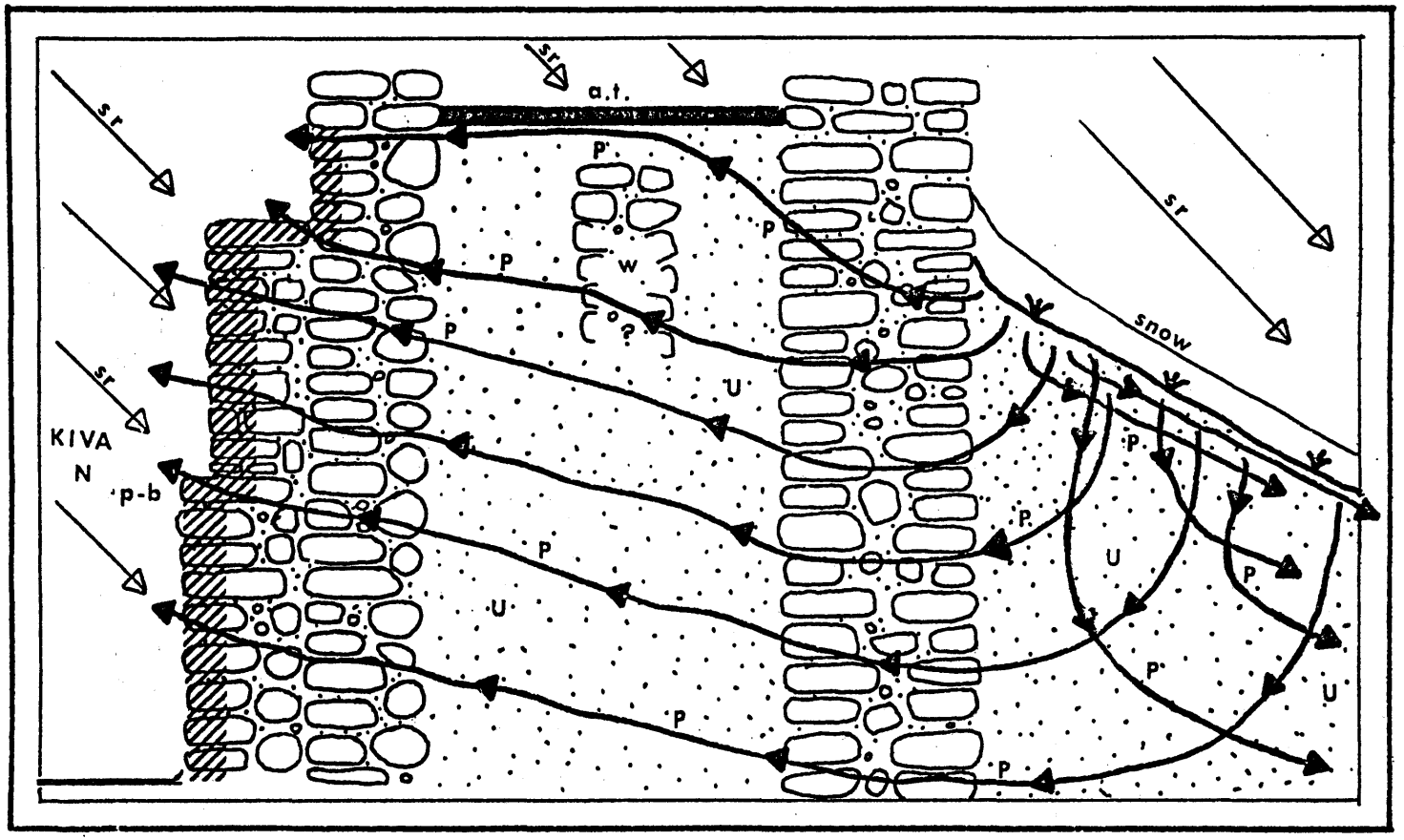


Figure 1: Schematic cross section of area between Kiva N and Aztec Ruins main plaza, showing ground water movement and area of salt deposition in Kiva N. Key:SR:Sun's rays; p-b, Kiva N pilaster-banquete; U: Unexcavated fill; W: wall encountered during drainage excavation; a.t.: emulsified asphalt trail; ←P— : water percolation route; ▨ : salt deposition zone.

N/O/V/W enclosure from the main Aztec Ruins plaza. This slope is protected from the winter afternoon sun by the aforementioned wall, and also enjoys a low angle of incidence to the winter sun's rays (Fig. 1). Consequently, snow sits on this area, and upon melting thoroughly saturates the ground. Because of the change in level between this slope and the kiva floor, much of this moisture is drawn toward the heated kiva wall where it evaporates, leaving salt concentrations on the surface.

Secondly, the emulsified asphalt trail permits no evaporation of this moisture before it reaches the kiva walls. Upon removal of the asphalt during drainage installation, the soil within ca. ten centimeters below it was saturated.

The Solution: The proposed solution consisted of installing a method of ground-water control. The system selected has two basic components: a method of moisture collection and a method of moisture transport. Another selection factor was that the system not be visible, since the area was crossed by the interpretive trail.

As shown in Figure 2, system components are completely buried. A water-proof membrane functions as a moisture collection agent for recently fallen precipitation as well as for percolating ground water entering the system from below it. Moisture collected on either side of the membrane then enters one of two perforated plastic sewer and drain pipes via the perforations adjacent to it. The pipes are both four inches in diameter. The water is then transported away from the area through the pipes, which are laid at a consistent grade wherever possible.

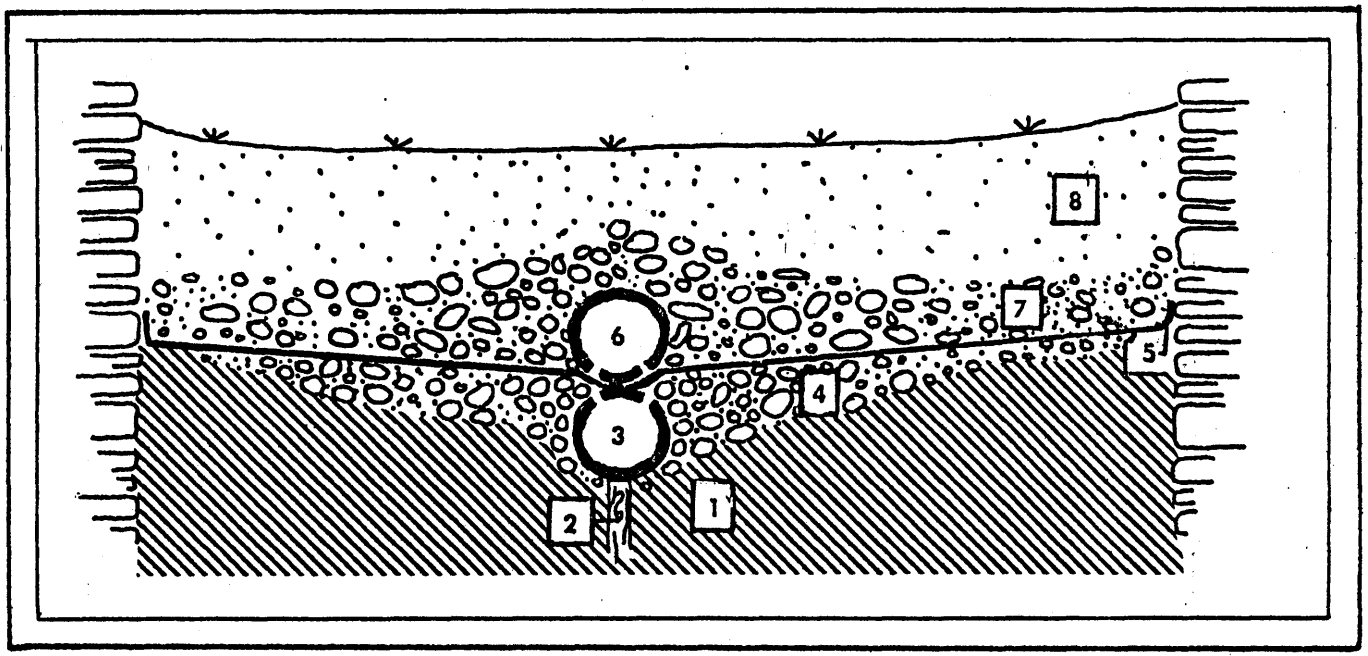


Figure 2: Schematic cross-section of drainage components.

Key:

1....unexcavated fill
2....stake
3....lower pipeline
4....mixed gravels
5....polyethylene sheeting
6....upper pipeline
7....mixed gravels
8....refilled soil

Variably-sized gravels are used to keep the drain system from silting, and cleanouts are installed at each upstream end of individual upper drain lines. Construction of these cleanouts is shown in Figure 3.

Implementing the Solution: Once the problem had been identified and a theoretical solution had been devised, the remaining aspect of the work lay in simply doing it. The first step was to make certain that the superintendent did not mind having the interpretive trail disrupted for a long enough period to do the work, as well as assuring Section 106 compliance. Only after explanation of the plan to the Superintendent and legal compliance was the work begun.

Crewmen consisted of Steve Adams of NALA, and Larry Nordby, Dave Battle, Doug Hicks, and Bruce Panowski of SWCRC. Mary Thul also assisted in the excavation. They began by stripping off the old asphalt trail covering the area to be drained using pick, shovel, doublejack sledge hammer, and pitchfork. Slabs and fragments of asphalt were removed, exposing a muddy soil; these pieces were then transported to the Aztec City Dump.

Excavation of the area was done under direction of Supervisory Archeologist Nordby and this phase of the work is described as Appendix A. As the work was done, materials were collected and recorded in congruence with archeological practices. Most noteworthy are architectural deviations from Morris' site map, which caused alterations in the original pipe layout necessitating additional drainage components.

Digging was done in order to permit laying the pipe at the desired grade of 1/8 of an inch per foot wherever possible. Sometimes external constraints, such as the slope of the ground surface or the presence of

archeological features required vertical drops in layout. In order to install all components of the system, a minimum of 18 inches (45 cm) in depth below ground surface is required. Since the ground surface slope exceeded 1/8 of an inch per foot, excavation of the upslope ends of the pipelines had to be deeper than 18 inches (see Fig. ___, Appendix A). When an adequate depth was obtained, stakes were driven into the trench bottom to mark the line and help establish the desired grade.

Then the pipe for the lower line was cut and fitted. Cutting was done with a hacksaw, and pieces were joined with couplings as needed. After preliminary fitting, pieces were marked with an indelible marker for correct alignment, and disassembled. A polyvinyl chloride solvent/cleaner was applied to clean each joint which required gluing; when the solvent/cleaner had dried (ca. 30 seconds), polyvinyl chloride cement was applied. During fitting of the bottom line, it is important to remember that the perforations face upwards toward the membrane. Once glued, the pipe cannot be separated. The upstream end of the lower pipeline was capped.

After installation of the lower line, the top line was cut and the preliminary fitting and alignment marking of sections was done. Sections were also numbered to keep them in order when they were stacked out of the way pending final fitting and gluing.

The next step in the installation process consisted of filling the area around the lower pipeline with gravels, as shown in Figure 2. Both pea and 1½ inch-average-diameter sized gravels were used. Care was taken to cover the pipeline holes, while still permitting the top part of the pipe to lie tangent to the underside of the plastic sheeting.

Since the pipe perforations are larger than the pea gravel, obviously the coarser gravel was used close to the pipe. Grading of this lower gravel bed was designed to cause the plastic membrane which would be installed later to be at its lowest elevation above the pipe.

Next, the waterproof membrane was installed. Six-mil polyethylene sheeting was cut from a roll in widths sufficient to cover the desired area. Installation of these sheets was done from the bottom end of the line, so that each piece would receive runoff from the one upstream. Approximately one foot (30 cm) of overlap was left between adjacent sheets, and seams were not sealed.

After this had been done, the top pipeline was laid into position and the joints were glued. Installation was with perforations facing downward. Care was taken while walking on the polyethylene to keep from puncturing it, but some small holes undoubtedly occurred. At the upstream end of each top line, cleanouts of the type shown in Figure 3 were installed (for exact locations, refer to Fig. 5).

The upper and lower pipes were joined where shown in Figure 5. A "y"-type fitting was cut with a hacksaw to the configuration shown in Figure 4, and the pipes were necked together. The bottom line was established to complete transport of water away from the area into the old flagstone-lined drain box east of Room 208. At the downstream end of the pipeline, galvanized steel window screen was attached with wire to prevent rodents from entering the pipe and building a nest.

A second layer of variably sized gravels was then placed atop the polyethylene sheeting and around the pipe. A minimum of four inches was

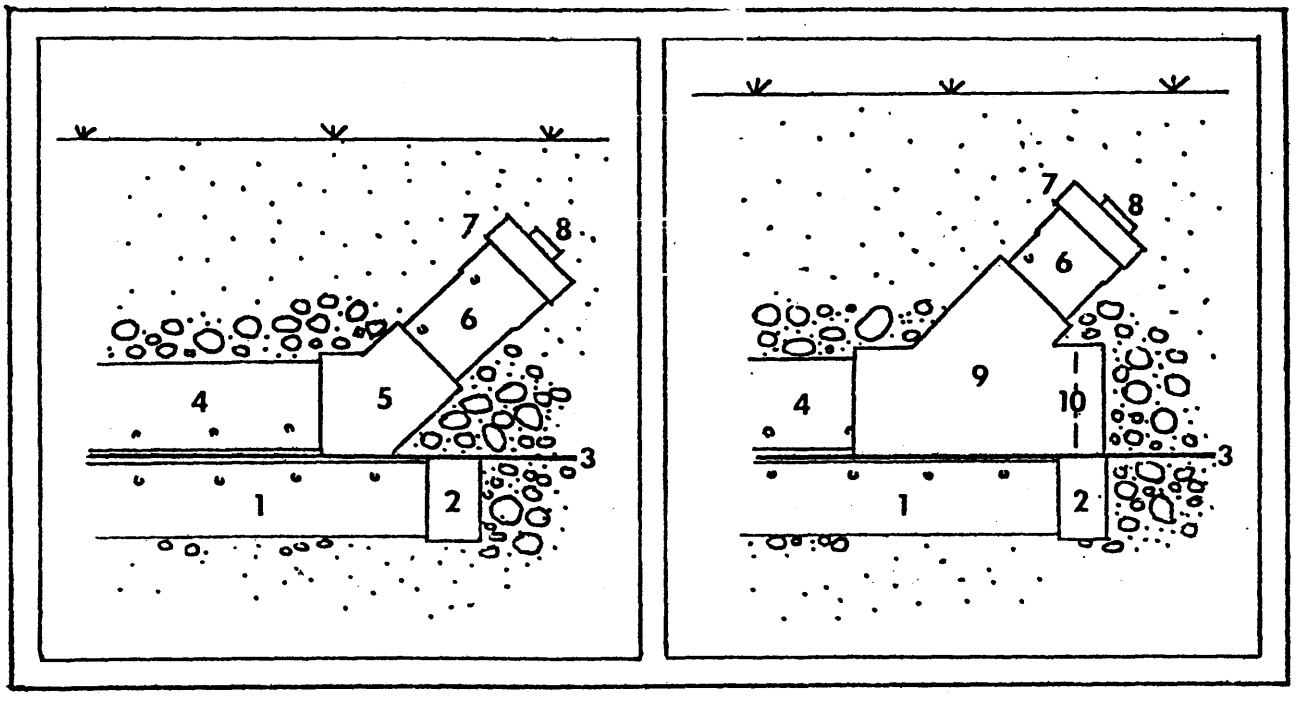


Figure 3: Cleanout types installed at upstream pipeline ends.

Key:
1....lower pipeline
2....slip-on cap
3....polyethylene sheeting
4....upper pipeline
5....45° "L" fitting
6....Section of pipe with belled end
7....Slipin cleanout adaptor
8....Screw in cleanout plug
9...."Y" fitting
10....slip in cap made from section of pipe

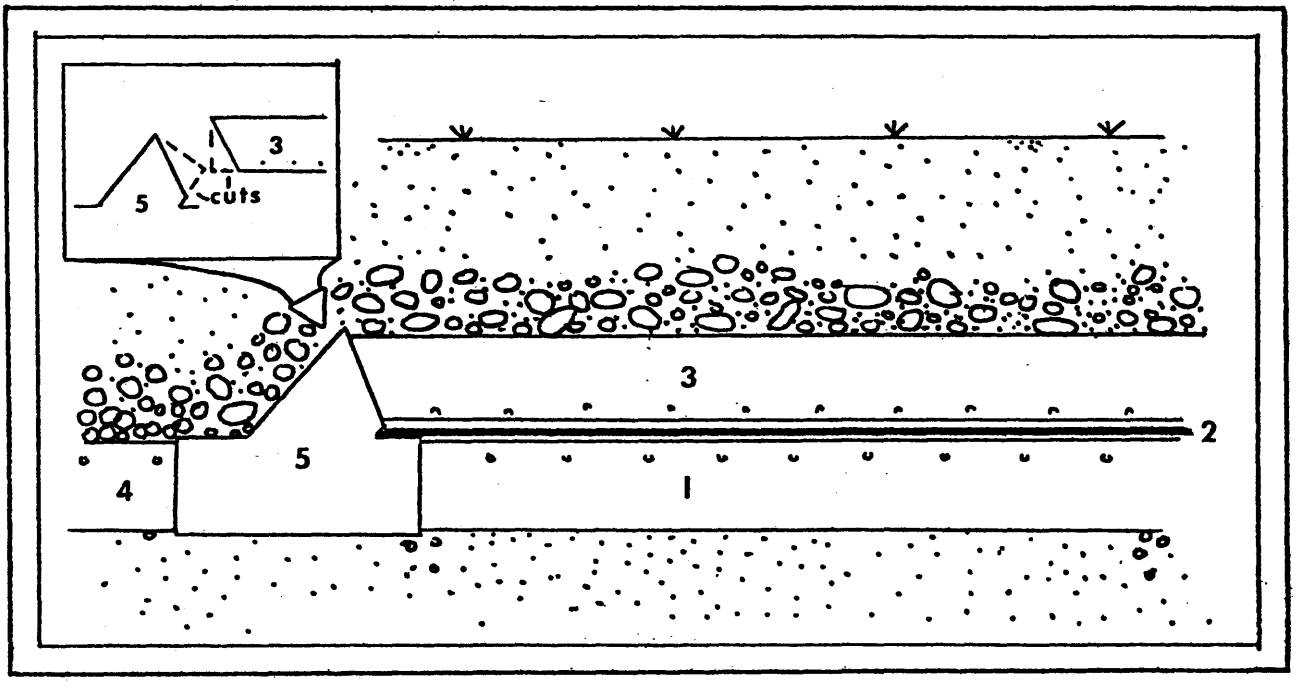


Figure 4: Method of joining upper and lower pipes. Inset shows parts of pipe and fitting to be cut off, glued and taped over with duct tape.

Key:
1. lower pipeline
2. polyethylene sheeting
3. upper pipeline
4. pipe carrying joined flow from both upper and lower lines
5. cut Y fitting.

installed, and the immediate vicinity of the top pipeline received approximately two additional inches. Atop the gravel, the original fill soil was then replaced until it approximated the original ground surface level. Interpretive signs were reinstalled at this time. This soil was manually tamped as it was being replaced, and eventually the pipeline, gravels, and cleanouts became totally buried.

Later, the step along the interpretive trail between Kivas N and O was reset using semi-ashlar stone set in a Lumnite brand calcium aluminate cement. This mixture used only the cement; no soil was added. During the remainder of the project work, the masonry kiva walls were again reset and repointed with adobe mortar fortified with ~~Duraweld~~ Wilhold brand concrete adhesive. This fact should supply us with an assessment of how well this drainage system will work at Aztec, since the wall condition can be monitored during the next few years, and compared with pre-drainage stone replacement cycles.

Manpower and Materials Expenditures. The following breakdown of the man days was spent during various phases of the drainage installation:

Task	Man Hours
Removing asphalt:	12
Transport of asphalt to city dump	1½
Excavating to grade, including archeological recording	122½
Acquiring needed job materials	12
Pipe fitting, gluing, installing	16
Refilling, installing gravel	128
Total Field Time	292
Drainage report preparation	24
Archeological Analysis	32
Archeological report preparation (Appendix A)	16
Total Documentation Time	72
Total Man Hours	364

Tools and equipment were provided by the Aztec stabilization project. Materials consisted chiefly of drainage components. Polyethylene sheeting was purchased from the G.S.A. schedule. Other materials, including the gravels, were purchased locally:

Item	Used	Unit Cost	Total Cost
*Polyethylene sheeting	2 100-foot rools (10 feet wide)		
Ten-foot joints of sewer and drain pipe	25	4.50	112.50
Cleanout adaptors	5	2.11	10.55
Cleanout plugs	5	1.57	7.85
"Y" Fittings	10	3.54	35.40
**45° "L" Fittings	29	1.31	37.99
22½° "L" Fittings	6	2.60	15.60
End caps	3	1.25	3.75
Pea gravel	5 cu. yds.	14.50	72.50
1½" gravel	10 cu. yds.	8.86	88.60
PVC solvent	1 pint	3.00	3.00
PVC cement	1 quart	7.00	7.00
Lumnite cement	1 bag	10.80	10.80
		Total cost of components	405.54

*Actual usage approximated 1.5 rolls, but two rolls were purchased.

**Several of these fittings were manufactured in the shop, using a hacksaw and two-inch wide duct tape.

Future Maintenance: Maintenance of the drainage system consists of inspecting the downstream mouth of the pipeline, located in the old drain box east of Room 208, to determine if any siltation is occurring. Silt will be caught on the inside of the window screen. This screen should also be kept in position. Periodic examination of the masonry will assist in determining the efficiency of the system; any breakdown should be noted. In addition, the level of the trail should be kept well above the gravel layer. Soil should be added as needed, to prevent system

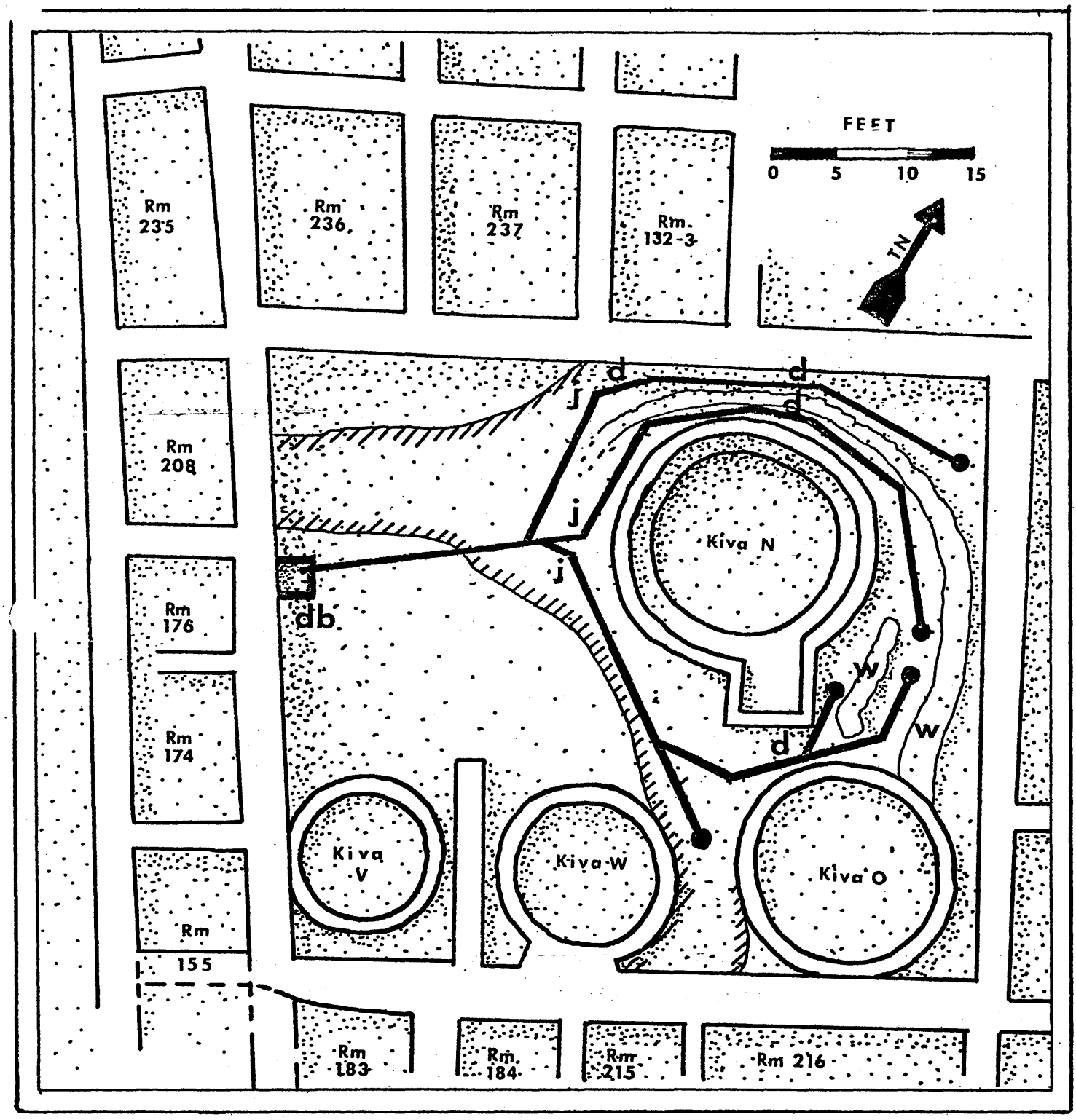


Figure 5: Plan of drained area, showing pipeline layout.

Key:

● - cleanout
d - drops in grade
w - walls encountered during excavation
j - points at which upper and lower lines are joined
db - drain box
/// - edge of former asphalt trail

components from becoming exposed.

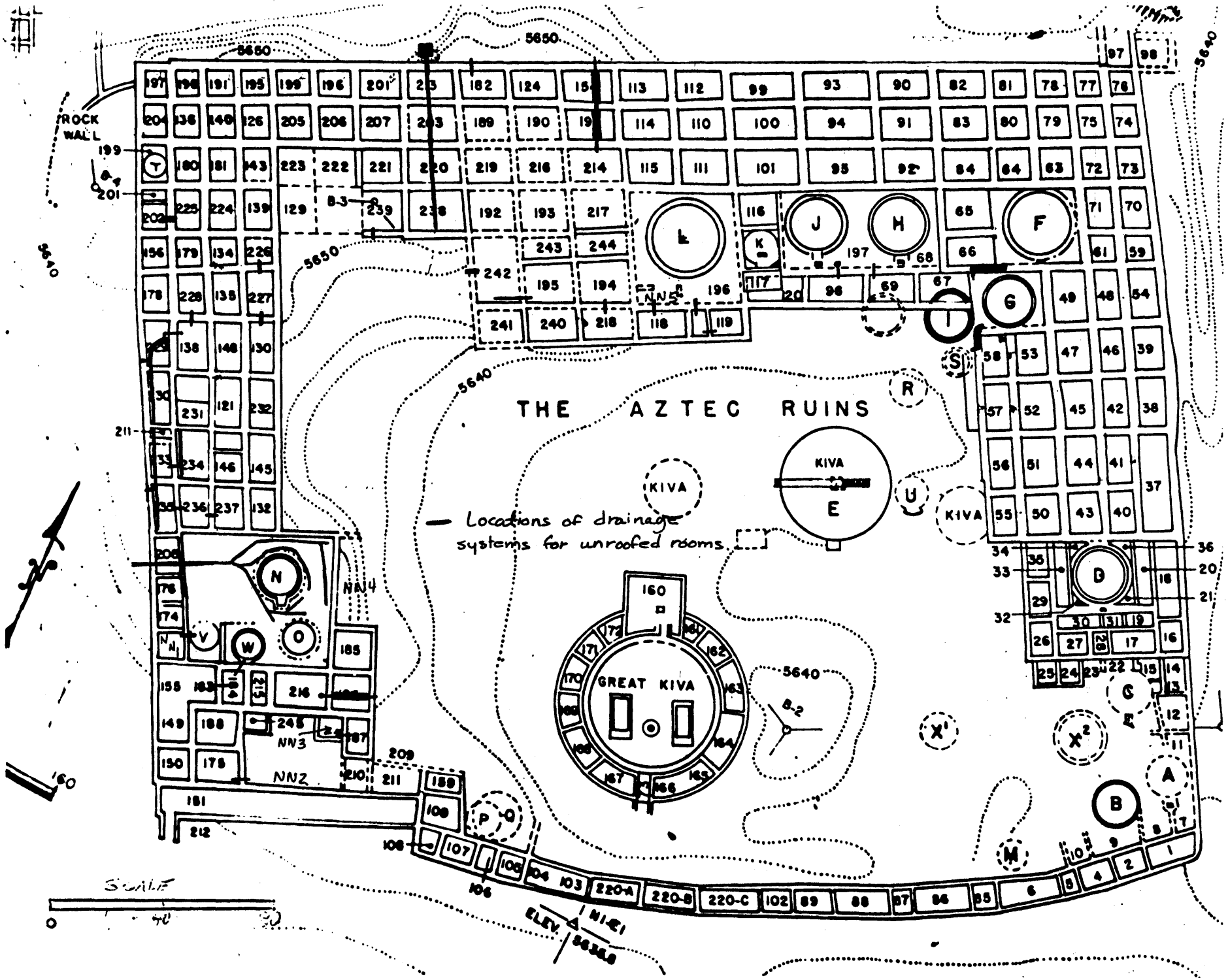
The pipeline should also be cleaned out periodically, at least annually. This is accomplished by reference to Figure 5 in order to locate the cleanouts. Maintenance personnel must then re-excavate around the cleanouts and unscrew the cleanout cap. About fifty gallons of water should then be dumped by bucket or hose into each cleanout, and the exposed downstream end examined to see that the water is transmitted. Running water through the pipe should continue until it has no sediment load (is not "muddy"). Then the cap is replaced and the cleanout hole refilled. A schedule for these activities is:

Activity	Frequency or Date	Time required
Siltation inspection	April, August, December	5 minutes
Masonry inspection	April, August, December	10 minutes
Trail inspection	Bi-monthly	5 minutes
Trail maintenance	As needed	1 hour maximum
Flushing pipeline	April, August, and December, if possible	2 hours

As will be noted, only about ten man hours per year are required to maintain this system. If this schedule is implemented, this drainage system will remain functional for at least 15 years.

Addendum

Because of an unusually wet winter, the trail surface around kiva N became very muddy. This created a visitor safety hazard and increased housekeeping needs in the visitors' center and on the trail. Pea gravel was spread over the exposed trail to provide a cleaner, safer walking surface. This surface should be periodically checked to ensure that enough gravel is present.


THE AZTEC RUINS
ROCK WALL
KIVA
GREAT KIVA
Locations of drainage systems for unroofed rooms
5650
5640
SCALE
0
40
80
ELEV.
NN2
NN3
NN4
NN5
B-2
B-3

Roof Drainage - West Ruin

Roof drain spouts and pipes become clogged with leaves in the fall. This is a minor problem, however, because the roofed rooms aren't very close to trees and not many leaves accumulate. Those leaves that do accumulate should be removed. Leaves in pipes can be pushed out with a garden hose section.

The major problem withroof drainage is ice. Ice accumulates in the drain pipes and spouts and prevents melted ice and snows from exiting. This moisture then often times leaks through the protective roof to the original roof and room below, causing structural damage.

During icy and snowy weather, keep the pipes and spouts clear. You will probably have to clear pipes with a steel rod (something you can batter the ice with). For spouts, chip the ice out with the chisel end of a rock hammer. Be careful not to damage the spout with the hammer. When snow plugs spouts, scoop or sweep it out.

When you are on icy or snowy roofs, be extremely careful. Do not approach roofs on wall tops, use a ladder.

Roof Drainage - West Ruin

Room 59: metal drain through center of east wall to exterior

61: ceramic tile through bottom center of east wall to roof of Rm 59.

112: metal drain through center of north wall to exterior.

113: same as Rm 112.

121: surface tile to buried metal pipe, east to plaza.

132: ceramic tile through north part of east wall, east to plaza.

134: ceramic tile through west wall to roof of Rm 179.

140: metal drain through north wall to roof of Rm 191.

143: metal drain through north wall down to dry barrel of Rm 126.

146: ceramic tile through southeast corner to roof of Rm 132.

156: surface metal drain in west wall to exterior, rock lined drain box below exterior spout.

178: surface metal drain in west wall to exterior.

179: ceramic tile through west wall to roof of Rm. 156.

191: metal drain through north wall to exterior.

195: same as Rm 191.

196: " " " "

197: metal drain through north wall, east corner, to exterior

198: metal drain through northwest corner to metal drain in Rm 197.

199: metal drain through north wall to exterior.

201: surface metal drain in north wall to exterior.

117 (partial roof): roof slanted down to south into Rm 120.

Kiva B: surface drain to north, south, east, and west.

Great kiva: Metal lined wood surface drains in exterior walls of rooms - 160 (spout over steel grated, concrete drain box) north wall; 162 east wall; 164 north part of east wall; 165 south wall; 169 west wall.

Protective
Roofs

Protective Roofs

Introduction

Roofed Rooms, East and West Ruins

East Ruin Roofed Rooms Accesses

West Ruin Roofed Rooms Accesses
w/additional notes

Roof work, East and West Ruins - References

East Ruin Roof and/or Wall Braces

East Ruin Miscellaneous Roof Details

West Ruin Roof and/or Wall Braces

West Ruin Miscellaneous Roof Details

Detail - Custom Braces for East Ruin Roof Beams

Details (2) - East Ruin Protective Roofs

Description of Protective Roofs, West Ruin

Protective Roofs

There are thirty-three rooms at AZRU with whole or partial protective roofs built over the originals (see list, this section). It is important that you know where these are and what they look like so that you may properly assess whether or not they are providing adequate protection.

Within this section you will find other basic information such as where and how to get into these rooms, where they are vented, etc. This data will help make your inspections quicker and more efficient.

There is also a list herein of roof and wall braces in the ruins. This list will help you in your inspections of the braces. By inspecting the braces you will also be exposed to various methods of supporting weakened or broken wall or roof fabric.

*Present protective roofs will be replaced during FY 1978 because they are poorly designed and do not provide adequate protection. Details on the new roofs will be included in this section upon completion of the roofing project.

Note that there are no accesses to Rooms 178 and 179. When the new roofs are installed, accesses will be established through the roofs, if practicable.

*Ten roofs were replaced in 1978. Ten more are to be replaced during the 1979 field season.

Roofed Rooms

East Ruin

Ruin with protective roofs: 1, 2, 4, 8, 9, 11, 12, 13, 14, 24 (roof is partial)

Rooms with undisturbed original roofs: 3, 6, 7

West Ruin

Rooms with protective roofs: 59, 61, 112, 113, 121, 132, 134, 140, 143, 146, 156, 178, 179, 191, 195, 196, 197, 198, 199, 201, Kiva B, Great Kiva, and 117 (partial)

East Ruin

Rooms vented through ceiling and roof: 1, 8, 9, 11, 12, 13, 14

Rooms vented through doorway(s) and/or ventilators: 2, 3, 4, 6, 7, 24

West Ruin

Rooms vented through ceiling and roof: 132 (1 in roof, 1 surfacing along east wall of Room 237), 146 (2), 191.

Rooms vented through doorway(s) and/or ventilators: 59, 61, 112, 113, 121, 134, 140, 143, 156, 178 (ventilators only), 195, 196, 197, 198, 199, 201, Great Kiva.

Room with no apparent ventilation: 179

Room vented through fire ventilator: Kiva B

Access to Roofed Rooms

East Ruin

Room 1: doorway in north half of west wall.

2: doorway in north wall.

3: through east wall of Room 2. Must enter Room 2.

4: through south wall of Room 2. Must enter Room 2.

6: down into Room 24 from east wall, through locked doorway in south exterior wall of Rm. 14, through north doorway of 14 into 13, through west doorway of 13 into 9, through north doorway of 9 into 8, through north doorway of 8 into 7, through west doorway of 7 into 6.

7: E 24 → S 14 → N 14 → W 13 → N 9 → N 8

8: E 24 → S 14 → N 14 → W 13 → N 9 →

9: E 24 → S 14 → N 14 → W 13

11: E 24 → S 14 → N 14 → W 13 → S 9

12: E 24 → S 14 → N 14 → N 13

13: E 24 → S 14 ↔ N 14

14: E 24 → S 14

24: E 24. Partial roof over this room has a built-in ladder on southeast corner.

Access to Roofed Rooms

West Ruin

Room 59: 8 foot ladder required. E 54→ N54

61: 12 foot ladder required. N 77→ S 77 → S 75 → S 72→ S 71

112: 14 foot ladder required. S111 → N 111 → N 110

113: 8 foot ladder required. S115 → N 115 → N 114

121: 14 foot ladder required. E 145 → W 145 → N 146

132: through ventilator shaft. Remove ventilator shaft cover on protective roof. Room has its own wood ladder.

134: S 135 → N 135

140: S 135 → N 135 → N 134 → N 224 → N 181

143: 14 foot ladder required. S 139 → N 139

146: 14 foot ladder required. E 145 → W 145

156: Walk north on top of west wall of pueblo, down wood stair-steps on west wall of Rm 202 to doorway in S wall. Doorway is locked.

178: no current access. Access to be made when protective roof replaced (tentative FY 1978).

179: same as above

191: reach through visitor trail

195: " " " "

~~196:~~ " " " "

~~197:~~ " " " "

~~198:~~ " " " "

~~199:~~ " " " "

~~201:~~ " " " "

~~Kiva B:~~ requires 14 foot ladder. Access through covered, square hole in center of roof. Cover is nailed down - requires claw hammer. Hasp and padlock should be installed.

~~Great Kiva:~~ entered ~~through visitor~~ trail.

Access to Roofed Rooms

West Ruin page 2

Room 196: reach through visitor trail

197: " " " "

198: " " " "

199: " " " "

201: " " " "

Kiva B: requires 14 foot ladder. Access through covered, square hole in center of roof. Cover is nailed down - requires claw hammer. Hasp and padlock should be installed.

Great Kiva: entered through visitor trail

Room 117: not entered. Open across south end (wire covers opening).

Additional notes

Rooms 112 and 113: there is a large pot-hole between the two rooms which allows mutual access.

Room 143: can also be entered through the north wall by going through the pot-hole in the east wall of Rm 140 into Rm 126 and through south doorway of 126.

Room 59: can also be entered by walking on east wall of pueblo to Rm 54 and down the east wall of Rm 54 and into 59. East wall of 54 is about 6½' high.

Roofs and Roof Work

Shiner	1959 - 1960	West Ruin
Richert	1957 (w/drawings)	East Ruin (See Graphics section)
Richert	1956	West Ruin
Richert	1953	West Ruin
Richert	1953	East Ruin
Vivian	1949	East Ruin
Vivian	1939-1941	West Ruin
Smith	1978	West Ruin (see Fact File)

Artificial Foundations

Shiner 1959-1960 West Ruin

Concrete-hydropel shield poured around wall base, three to four inches thick, extending eighteen inches to two feet below and four to six inches above the floor.

Rooms with this type artificial foundation:

51	120
52	(also has dry barrel)
53	(" " " ")
56	
58	(dry barrel, too)
66	
67	
69	
96	(drainage)

Roofs and/or Wall Braces

East Ruin

Room 1: custom made supports for middle 7 beams. Steel braces cup-shaped, held to bottom of beams by bolts from protective roof above original roof (see drawing, this section).

2: integral wood members in west wall supported by 3" X 6" on top of 6" X 6" on top of vertical 8" X 8".

3: viga supported by short 3" X 6" on top of adjustable "perma-jack".

4: roof and beams held up by 2" X 8" on top of two 8" vertical posts (juniper?).

9: north viga supported by two single-cup braces with bolts from protective roof.

12: north viga badly cracked. It is supported by two single-cup braces with bolts from protective roof.

14: west end of south viga supported by single-cup brace with bolts from protective roof

Miscellaneous Roof Details (EARU)

Room 24: wood roof members stored under partial protective roof in this room.

Roof and/or Wall Braces (WERU)

Room 59: center viga cracked, held up by adjustable "perma-jack" on sandwiched (one each) 2" X 12" and 2" X 8" short, horizontal, wood pieces. East-center part of room.

61: two cracked vigas, held up by two short, sandwiched pieces of 2" X 12" on top of vertical, 6" log pole. Center of room.

121: three north vigas supported from protective roof with bolts from roof, through vigas and attached to steel grader blade pieces underneath.

132: three north vigas supported from protective roof with bolts to channel iron braces (forms cradle for vigas); east and west walls braced by mid-height, horizontal 4" X 4" abutting a 3" X 12" vertical board at each of the east and west walls; ventilator shaft from exterior of filled-in west doorway to ground surface at the interior east wall of Room 237 is lined with wood boards.

134: horizontal 6" X 6" supported by vertical 6" X 6" braces east against west wall, abuts horizontal 2" X 12" on east wall.

140: central viga cracked, supported directly by one 8" log pole and one 5" log pole, also supported by short section of 2" X 8" atop adjustable "perma-jack" between the two log poles.

146: three north vigas badly cracked, supported by bolts through vigas and attached to steel plates (pieces of grader blade) on the underside of the vigas, also supported by 3" X 12" board on top on two juniper logs, one 7" diameter, the other 5"; three south vigas supported by sandwiched, short 2" X 12" boards on top of single, 5" diameter juniper post.

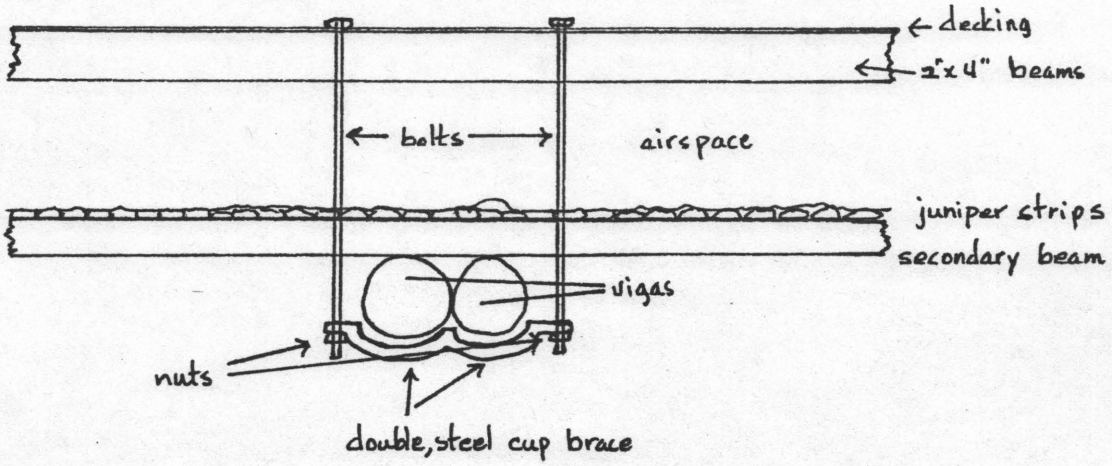
Miscellaneous Roof Details (WERU)

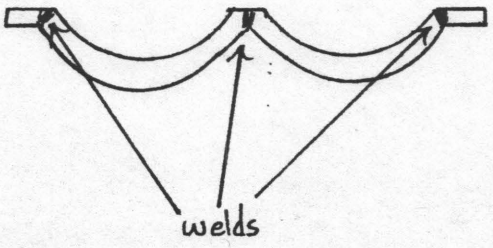
Great kiva: skylight in south center part of roof, glass with integral wire in metal frame.

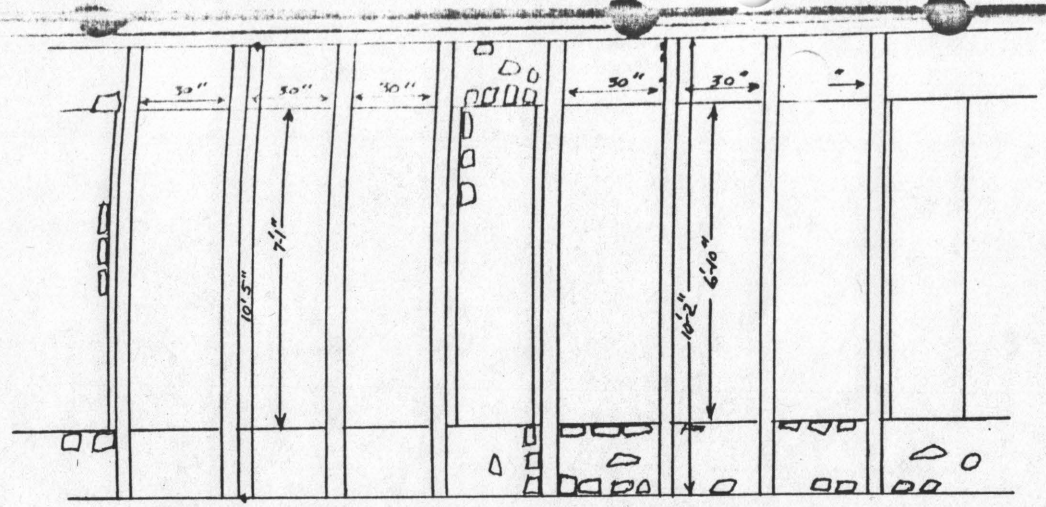
Room 117: protective roof made from 4" X 4" members frame, with 1" X 14" boards covered by asphalt felt.

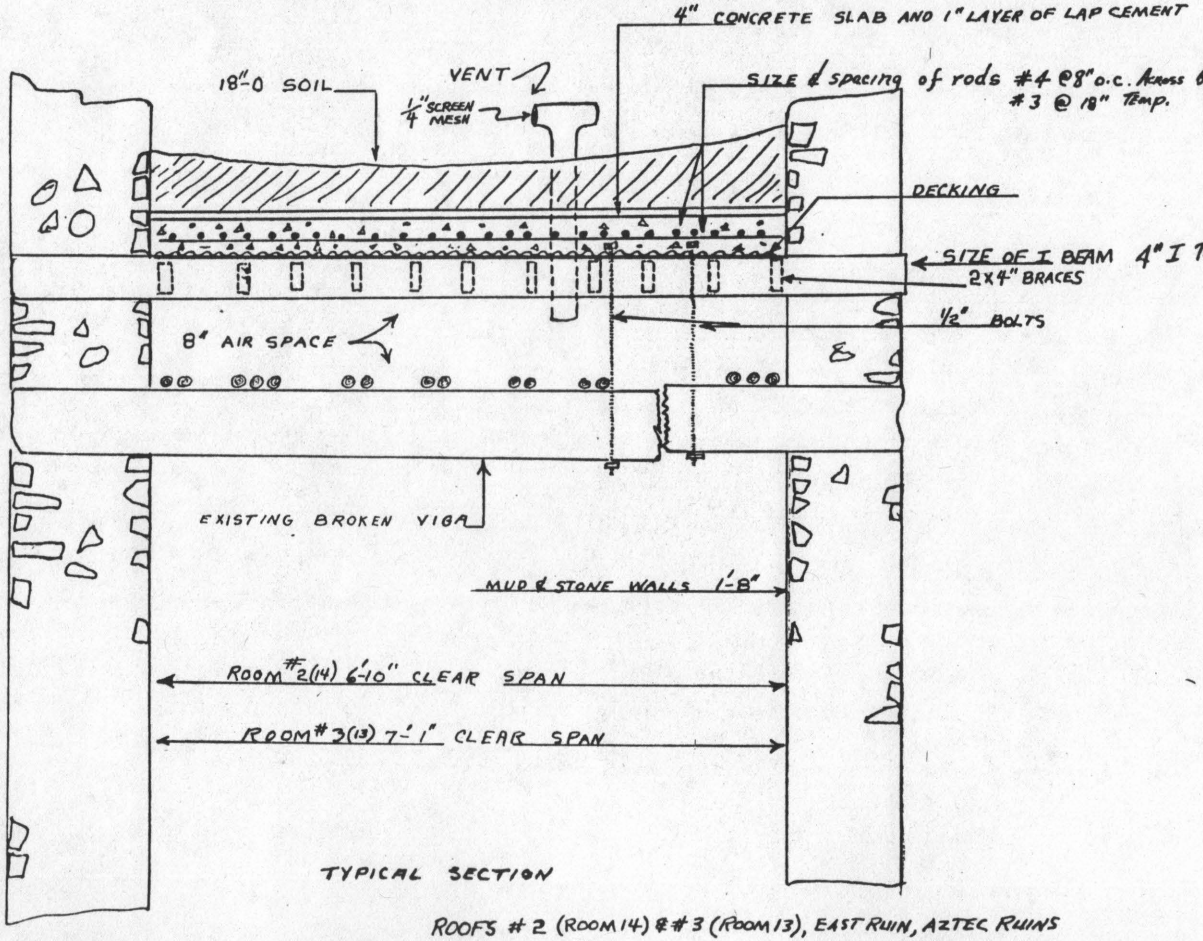
Room 124: west viga badly cracked. Propped up at center by a wood vertical.

Custom Braces - East Ruin Roof Beams







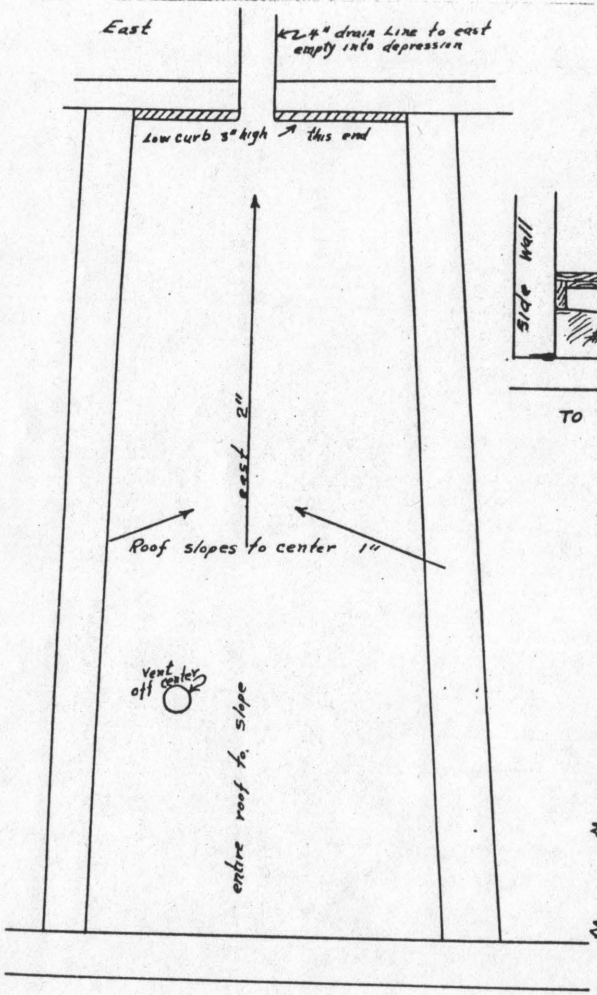


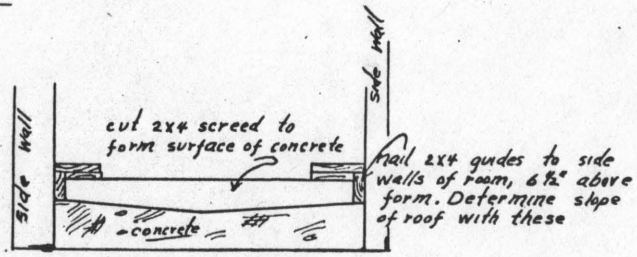
TWO ROOFS- (1) 7'-1" (+3'-4") x 7'-8"
(2) 6'-10" (+3'-4") x 7'-7"

REQUIRED:
SIZE & SPACING REINFORCING RODS
SIZE OF I BEAMS
FORM CANNOT BE SUPPORTED FROM INTERIOR

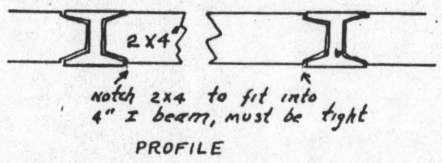
ROOFS #2 (ROOM 14) & #3 (ROOM 13), EAST RUIN, AZTEC RUINS

FIG. 2

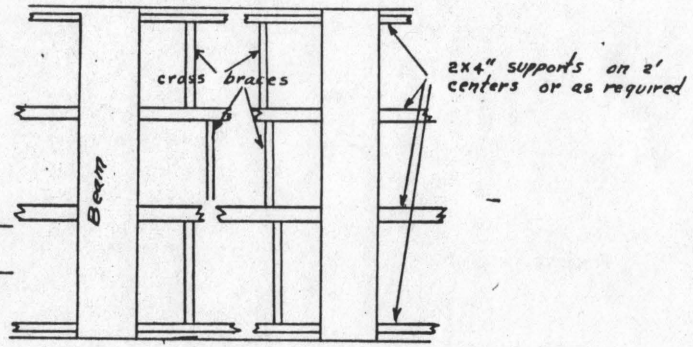




TO FORM SURFACE OF CONCRETE

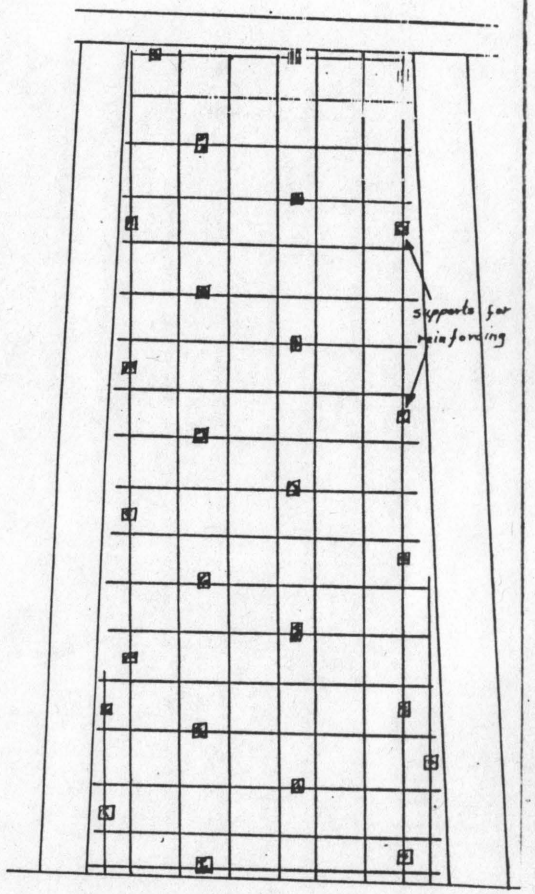


PROFILE



PLAN

TO SUPPORT FORM FOR CONCRETE



5/8" reinforcing - place on 1' centers, support reinforcing 2½" above form on precast blocks "chairs" about 3" square

Room or ~~House~~ No. 156 - 157[2]

RUINS STABILIZATION RECORD (Second Sheet)

Condition on date when work started

Ancient masonry: Fair. Considerable clay mortar eroded from facing of E wall. South jamb of door in E wall extremely loose. 1st floor room has been damaged by water leaking through roof and having streaked the original plaster. Roofing placed in 1953 is generally good, except that leaks occur at clogged drains for lack of maintenance.

Repair or reconstruction previous to this work: All walls capped with bitumuls. Concrete slab roof constructed by Morris in the 1920's; this had cracked by 1938, was plated with tar or bitumuls in 1939-40, replated with thick adobe in 1945. Vitreous tile drain installed in west wall 1938, drains Rooms 156, 178, 179 and 134. In 1953 Richert removed the several fractured layers of bitumuls and tar, repaired the concrete slab, and resurfaced the roof with 3 layers of 30# asphalt felt, mopped with 190° tar, sides flashed with asphalt impregnated cloth, final coat of tar rolled with chat.

Materials, construction, and technique in making repairs or accomplishing job:

Upper wall areas were tightened by grouting and pointing.

All of the old tar and asphalt felt layers were removed. The non-functional vertical tile drain in the west wall was plugged and replaced with a galvanized metal outlet box 8" wide. Since the concrete slab installed by Morris was badly cracked, a half inch layer of Hydropel treated cement was trowelled over the old surface and damp cured. Three layers of 30# asphalt felt were then mopped on with 190° tar. A final tar application was covered with rolled chat. Asphalt impregnated cotton fabric strips 9" wide were flashed to the sides and corners.

Reference to drawing:

Work authorized by R. Richert
Archeologist

Date work started: May 20, 1960

Date work finished: June 1, 1960

(Note: Place "before" and "after" pictures on blank bond sheets, caption, and keep with these record sheets. Include "during" pictures to show interesting or important details or technique. Use additional sheets for any heading if necessary).

Room or ~~Area~~ No. 178 - 192^2

RUINS STABILIZATION RECORD (Second Sheet)

Condition on date when work started

Ancient masonry: The roof of Room 178 (and former floor of 192^2) was generally in good condition. However, water stands at the northwest corner where a drain pipe extends between the common wall of Upper Rooms 192^2 and 157^2. Apparently this area leaks badly; the drainage seeps down into the south wall of Room 156 and is damaging the unique dado.

Repair or reconstruction previous to this work: Concrete slab roof built in the 1920's by Morris. At that time drainage was thru west wall. Slope of roof was changed in 1938 by building up a plating of bitumuls and drain thru north wall, then into a common drain in west wall of Room 157. All walls capped with bitumuls. In 1953 the fractured bitumuls plating was removed and replaced with veneer of cement, resurfaced with 3 layers of 30# asphalt felt mopped with 190° tar, and chat rolled onto top, tarred layer.

Materials, construction, and technique in making repairs or accomplishing job: Upper wall areas were tightened by grouting and pointing. All of the old tar and asphalt felt layers were removed. A galvanized metal outlet box 8" wide was installed in the west wall. Since the roof sloped sharply to the old drain in the northwest corner, the drainage was changed to slope from a level line along all four walls both to center of room and to the west, at ½" to the foot. This was accomplished by building up a Hydropel treated layer of concrete (sand and ¼" gravel, or chat) screeded to slope. After damp curing, three layers of 30# asphalt felt were mopped on with 190° MP tar. A final layer of tar was covered with rolled chat. Asphalt impregnated cotton fabric strips 9" wide were flashed to the sides and corners.

Reference to drawing:

Work authorized by R. Richert
Archeologist

Date work started: May 20, 1960

Date work finished: May 31, 1960

(Note: Place "before" and "after" pictures on blank bond sheets, caption, and keep with these record sheets. Include "during" pictures to show interesting or important details or technique. Use additional sheets for any heading if necessary).

Room ~~or Area~~ No. 191

RUINS STABILIZATION RECORD (Second Sheet)

Condition on date when work started
Ancient masonry:

O.K. but water is seeping down to room 142 below on north interior wall. Either the roof leaks or water is getting into the wall.

Repair or reconstruction previous to this work:

Materials, construction, and technique in making repairs or accomplishing job:

Wall tops in immediate area capped and new mortar (cement) pointed in between stones on wall faces.

Old roofing tar and felt pulled off down to boards. Chopped hole through wall on north side and installed galvanized drain 8" square, cemented wall all around drain and nailed flanges to floor and wall. Laid 3 layers of 30# felt over 190° melt tar, installing asphalt impregnated cloth all around as flashing, over another layer of hot tar, scattered a layer of pea gravel.

Reference to drawing: Work authorized by R. Richert
Archeologist

Date work started: 5/16/60

Date work finished: 6/7/60

(Note: Place "before" and "after" pictures on blank bond sheets, caption, and keep with these record sheets. Include "during" pictures to show interesting or important details or technique. Use additional sheets for any heading if necessary).

49779

FORM 10-7141 (APRIL 1964)

PURCHASE ORDER

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
Navajo Lands Group
P. O. Box 539
Farmington, New Mexico 87401

(ISSUING OFFICE)

REQUISITION NO.

THIS NUMBER MUST APPEAR ON ALL PACKAGES AND PAPERS RELATING TO THIS ORDER

DATE OF ORDER: 04/02/76

ORDER NO.: PX738060022

ACCOUNTING CLASSIFICATION: J7380 300 N 2500 $995.00

VENDOR'S NAME AND ADDRESS:
Goodrich Roofing Co., Inc.
Rt 3 65 B
Farmington, N M 87401

SHIP TO: (Consignee and Address:)
Superintendent
Aztec Ruins National Monument
P. O. Box U
Aztec, N M 87410

CONTRACT NO.: Quote 3/31/76

DISCOUNT TERMS: ---

SHIP VIA: ---

DELIVERY: F.O.B. / SHIPPING POINT: destination

TIME FOR DELIVERY: May 15, 1976

GOVT. B/L NO.: ---

ITEM NO.	ARTICLES OR SERVICES	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT	
	Reroof approximately 839 sq. ft. of roofing on seven (7) prehistoric rooms at Aztec Ruins National Monument in accordance with the attached specifications.	1	job		995	00

Find to SWRO
4-21-76
[illegible]

RECEIVED
APR 05 1976
FINANCE
SWRO

RECEIVED
AZRU
APR 6 1976

ACT		INT	DATE
	SUPT.	[illegible]	6
	ADMIN.		
	RANGER		
	PARK TECH.		
	MAINT.		
	FILE		

Request for Quotes sent to:

Gilmer S. J. SupplyCo. — no response
D. J. Williams Roof Co. — " " "
Cortez Roofing — " " "

TOTAL 995 00

SIGNATURE

NAME AND TITLE: Lydia G. Babos — Supply Tech. PURCHASING OFFICER

6. MEMORANDUM COPY

STATEMENT

Goodrich Roofing Co.

A CORPORATION

NO JOB TOO LARGE OR TOO SMALL

Farmington 327-3577
PHONE 345-1854
3401 VASSAR N.E.

ALBUQUERQUE,
NEW MEXICO 87107

U.S. Dept of the Interior
Aztec Ruins
P.O. Box U.
Aztec, New Mexico

April 15, 1976

Everything In Roofing – Sheetmetal

BALANCE DUE

Reroof 7 Prehistoric Rooms at Aztec Ruins as per Order No. Px738060022

$995.00

Please remit to:

Goodrich Roofing Co. Inc.
Route 3, Box 65B
Farmington, N. Mex. 87401

GOODRICH ROOFING CO.

Job No. F-76-59

Date April 15,1976

Maintenance Guarantee

Name United States Dept. of Interior
Aztec Ruins

Address P.O. Box U.

Town Aztec, State N. Mex.

Roof Applied At 7 Prehistoric Rooms
Aztec Ruins National Mon.

Town Aztec, State N. Mex.

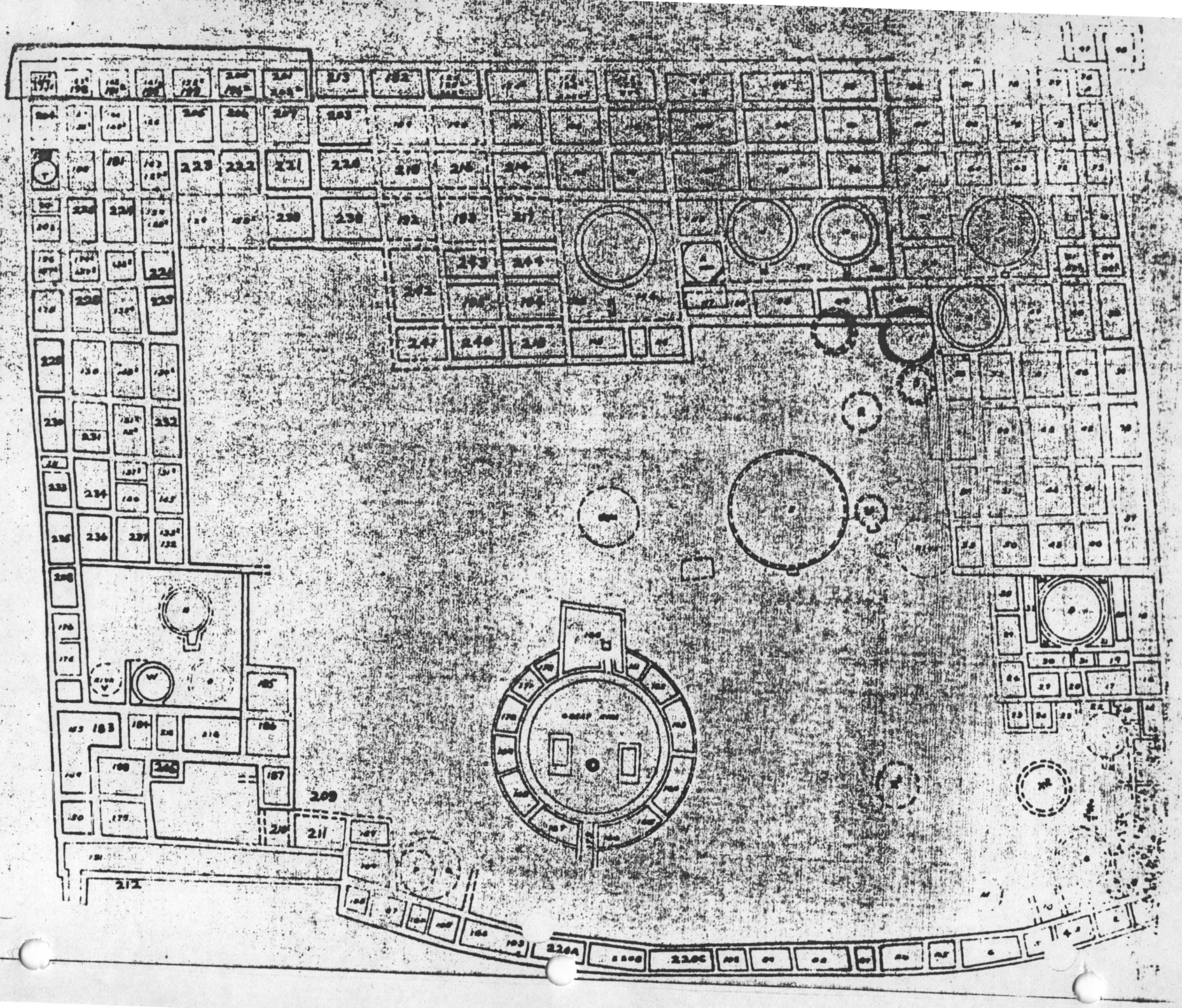
Type of Roof Built-up Gravel Roof

For Value Received We Guarantee to repair any leaks on above roof against any defects of workmanship or material for a period of two years from date of completion thereof, barring leaks caused by sheathing nails installed by others, acts of God or accidents over which we have no control. In the event of leaks caused by workmanship or material we shall be promptly notified at once at Albuquerque, New Mexico, and after such notice if repairs be needed because of fault of workmanship or materials, such repairs will be made during the life of this guarantee without charge but should such repairs be needed through no fault of material or workmanship reasonable charges will be made for repairs. The permitting of any repairs by any other concern than ourselves during the life of this guaranty for any reason whatsoever shall void this agreement. This guaranty is limited to workmanship and material and shall not apply to defects caused by improper construction of the building or base upon which the roof is laid. Nothing in this guaranty shall be construed to cover any damages to building or contents thereof. Guaranty not valid until work covered is paid in full.

GOODRICH ROOFING CO., ALBUQUERQUE, N. M.

By Patrick Montoya

Farmington Phone 327-3577



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220C

Great Kiva

The Great Kiva

Introduction

Miscellaneous Data, Ancillary Rooms

Plan of Original Roof

Plan Map, House of the Great Kiva

The Great Kiva

The Great Kiva was reconstructed in 1934, and so, is fairly new. However, it is an historic structure and a primary theme resource for the area. Therefore, it must be properly maintained. Fortunately, this structure, being a modern reconstruction, has few of the problems associated with the original rooms of the Aztec Ruins. Most of the maintenance of this building is concerned with the roof surface and the visitor trail and its appurtenances.

The roof must be resurfaced every few years to keep it sound and leak-proof. Your area maintenance files should give the history of roof resurfacing for the Great Kiva. This data should be compiled and entered in this manual for convenience and because of the value of the information. Sometime in the near future, the roof will be re-surfaced with a soil-tinted covering to make the roof appear more original. There are also plans to lower the sky light to make it less obtrusive to the interpretive scene.

The electrical system for the trail lights and the lights themselves must be periodically checked to ensure they are functioning properly.

There are both wood stairs and rock stairs in the Great Kiva and both have wood railings. These must be maintained and kept clean and sound so that a visitor does not trip, fall, or otherwise injure him/herself. The chains across the south end of Room 160 must be checked to see that they are secured and in good condition.

The floor of the kiva and its ancillary rooms should be kept clear of debris and trash as this detracts from the interpretive scene.

Occasionally, bats and birds and bird nests must be removed from the interior, especially the kiva room itself. If you encounter a non-poisonous snake in the ceiling beams, leave it. They are harmless and they help keep birds and mice out of the ceiling. Under no circumstances should you kill any animal on the monument (even poisonous snakes) unless you have direct permission from the superintendent. Otherwise, contact the Regional Biologist (currently Dr. Milford Fletcher). Remember, this area is an unofficial government wildlife refuge.

For further architectural details on the Great Kiva, see the Earl Morris book Aztec Ruins, Part II, "The House of the Great Kiva".

For details on where trail lights are located and information on stairs, see Utilities and Trail Appurtenances, this manual.

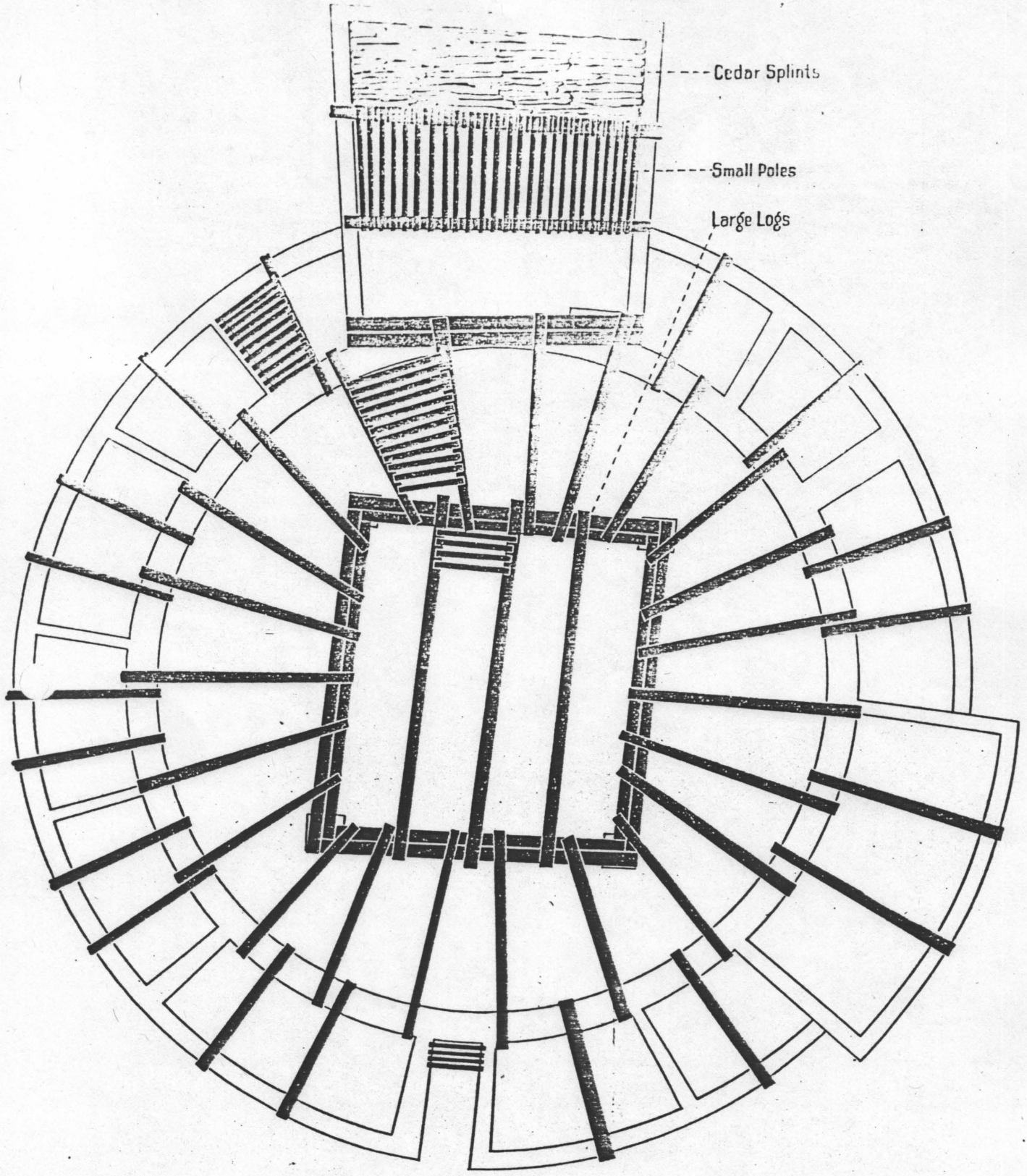
Room Number	Length at Center	Width at Center
161	8 ft. 6 in.	5 ft. 9 in.
162	8 " 3 "	6 "
163	17 " 3 "	6 " 6 "
164	19 "	10 " 4 "
165	9 " 3 "	6 " 6 "
166	12 " 7 "	7 "
167	15 " 3 "	6 " 8 "
168	12 " 6 "	6 " 3 "
169	11 " 6 "	6 " 5 "
170	13 " 6 "	6 " 3 "
171	9 " 3 "	6 " 3 "
172	8 " 4 "	6 "

The foundations of dismantled walls, bounded by dotted lines in the plan, lie beneath Rooms 163, 164, 167, 168, 170. When these were functional they divided the area of the twelve secondary chambers into fifteen rooms of more nearly uniform size, whose dimensions were as follows:—

Room Number	Length at Center	Width at Center
I	8 ft. 6 in.	5 ft. 9 in.
II	8 " 3 "	6 "
III	7 " 9 "	6 " 6 "
IV	8 " 3 "	6 " 6 "
V	8 " 9 "	6 " 6 "
VI	8 " 3 "	6 " 6 "
VII	9 " 6 "	6 " 6 "
VIII	9 " 0 "	6 " 6 "
IX	8 " 9 "	6 " 9 "
X	8 " 6 "	6 " 3 "
XI	11 "	6 " 2 "
XII	11 " 8 "	6 " 4 "
XIII	12 "	6 " 5 "
XIV	11 " 3 "	6 " 3 "
XV	8 " 4 "	6 "

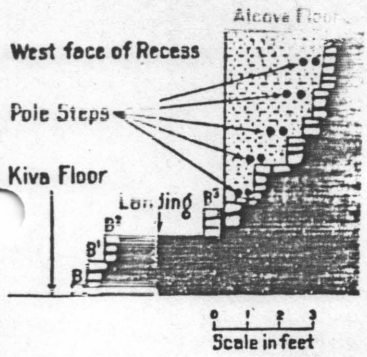
In the outer wall of each of the primary series there was a doorway (Y to Y^{13}) which gave access to or from the court.[1] In width, they varied less than one inch from 1 foot 10¾ inches. The sills were about 10 inches from the floors. In no place do the walls stand to a sufficient height to reveal their vertical dimension.

[1]This statement is made on the assumption that during the process of remodeling, the groundplan of the building was not materially altered. However, when the débris beyond what is here considered the outer wall is removed, the foundations of other chambers, perhaps of a complete second ring, may be found.

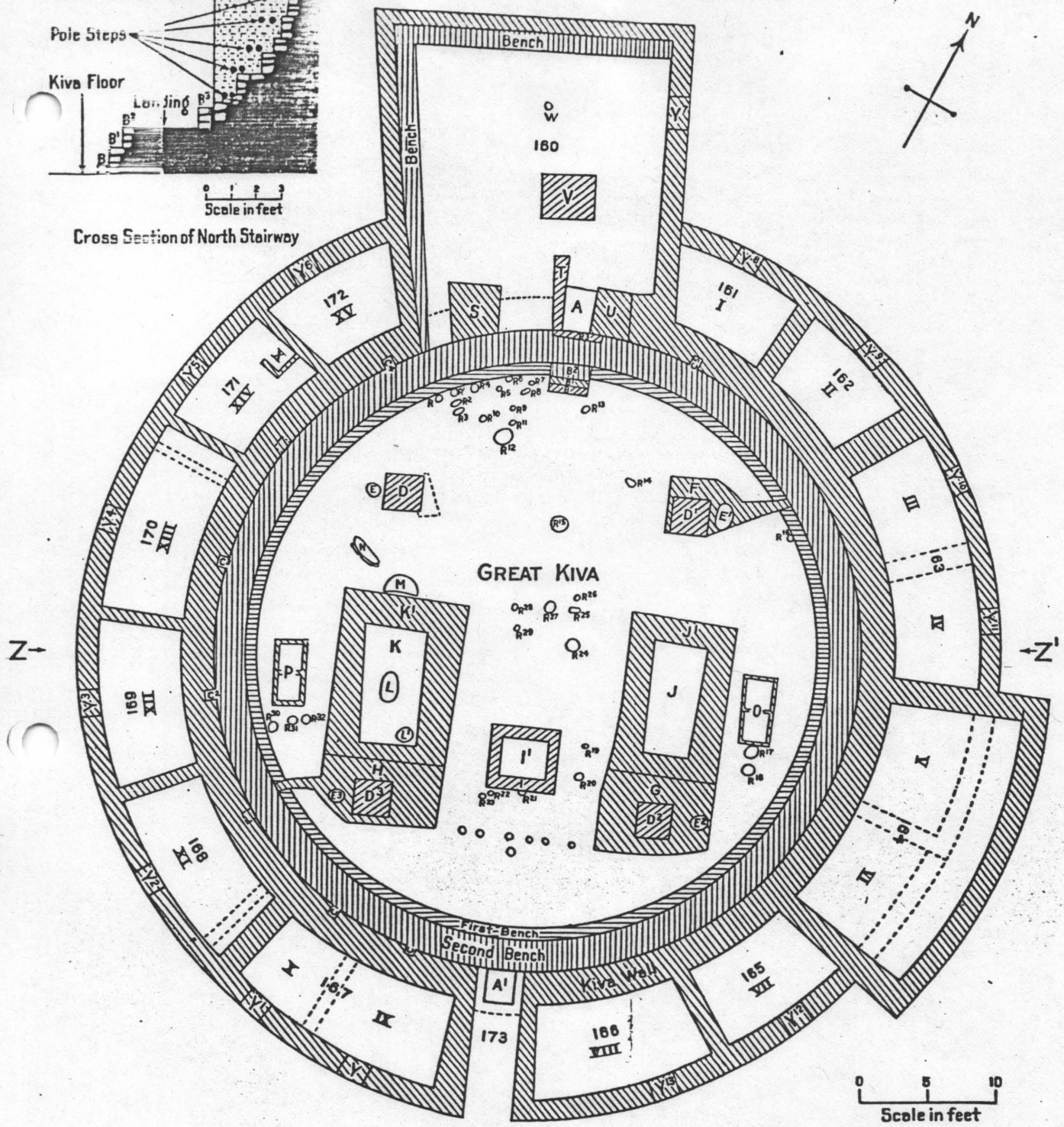


Probable Plan of Roof, House of the Great Kiva

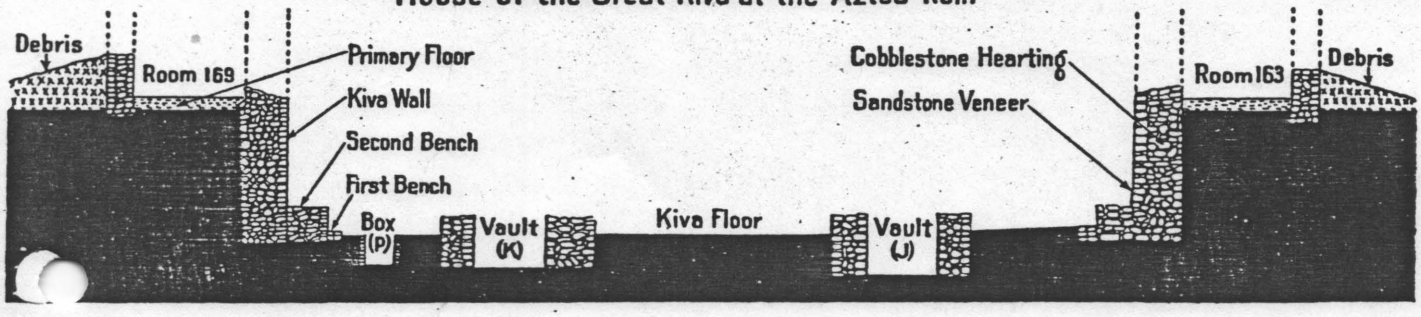
Fig. 3



Cross Section of North Stairway



House of the Great Kiva at the Aztec Ruin



Cross Section, House of the Great Kiva from Z to Z'

Fig 2

FORM 10-131
(APRIL 1964)

PURCHASE ORDER

*Remark [illegible] 12/74

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

Navajo Lands Group
P. O. Box 539
Farmington, New Mexico 87401

(ISSUING OFFICE)

REQUISITION NO.	THIS NUMBER MUST APPEAR ALL PACKAGES AND PAP RELATING TO THIS ORDE
DATE OF ORDER: June 14, 1974	ORDER NUMBER: PX738040042

ACCOUNTING CLASSIFICATION: 7380 260 N 2500 $585.00

VENDOR'S NAME AND ADDRESS:
Guy Lanham
Rt 1, Box 301
Farmington, N M 87401

SHIP TO: (Consignee and Address;)
Superintendent
Aztec Ruins National Monument
P. O. Box U
Aztec, N M 87410

CONTRACT NO.	DISCOUNT TERMS	SHIP VIA
Quote 6/9/74	--	--

DELIVERY: F.O.B. SHIPPING POINT	TIME FOR DELIVERY	GOVT. B/L NO.
destination	June 30, 1974	none

ITEM NO.	ARTICLES OR SERVICES	QUANTITY ORDERED	UNIT	UNIT PRICE	AMOUNT
	Paint interior of Great Kiva at Aztec Ruins National Monument (approximately 4,400 sq. ft.) with a high quality paint. Color and type of paint to be decided upon by Superintendent or his representative.	1	Job		585.00
	Time of painting to be by mutual agreement between contractor and Superintendent				
	* In reviewing work. painting and roof on Maint. building w/contractor, he agreed to repaint KIVA and redo roof.				
	Review of remarks disclosed that it still is not up to standard, but will not call them back again.				
	Other quotes received:				
	Manuel C. Hastings Paint Sales, Farmington, N M — $1,163.00				
	Industrial Coating Inc., Farmington, N M — 1,263.00				
				TOTAL	585.00

NOTE: No FUTURE WORK TO BE AWARDED TO LANHAM BY NAVAJO LANDS GROUP. Joe Moyer 8/5/74

THE ARTICLES OR SERVICES LISTED WERE RECEIVED ON 6/25/74 (DATE)
AND ACCEPTED ON 6/28/74 (DATE) RECEIVING REPORT NO:
SIGNATURE: [signature]

SIGNATURE: Donald M. Kitts

NAME AND TITLE: Donald M. Kitts
Administrative Officer

PURCHASING OFF.

2. A. RECEIVING REPO[illegible]

IDARD FORM [illegible] JULY 1966
ERAL SERVICES ADMINISTRATION
PROC. (41 CFR) 1-16.201

REQUEST FOR QUOTATIONS
(THIS IS NOT AN ORDER)

PAGE 1 OF 3

EQUEST NO.	2. DATE ISSUED	3. REQUISITION/PURCHASE REQUEST NO.	4. CERTIFIED FOR NATIONAL DEFENSE UNDER BDSA REG. 2 AND/OR DMS REG. 1 RATING:
	9/9/74		

UED B

Navajo Lands Group
P.O. Box 539
Farmington, New Mexico 87401

INFORMATION CALL (Name and tel. no.) (No collect calls) D Kitts 325-5036

6. DELIVER BY (Date)
October 15, 1974

7. DELIVERY
[X] FOB DESTINATION
[ ] OTHER (See Schedule)

O NAME AND ADDRESS

eet, City,
te and
Code)

9. DESTINATION (Consignee and address including ZIP code)

Superintendent
Aztec Ruins National Monument
P.O. Box U
Aztec, NM 87410

. PLEASE FURNISH QUOTATIONS TO THE ISSUING OFFICE ON OR BEFORE CLOSE OF BUSINESS 9/25/74 (Date) SUPPLIES ARE OF DOMESTIC ORIGIN

ILESS OTHERWISE INDICATED BY QUOTER. THIS IS A REQUEST FOR INFORMATION, AND QUOTATIONS FURNISHED ARE NOT OFFERS. IF YOU ARE UNABLE TO IOTE, PLEASE SO INDICATE ON THIS FORM AND RETURN IT. THIS REQUEST DOES NOT COMMIT THE GOVERNMENT TO PAY ANY COSTS INCURRED IN THE PREP- ATION OR THE SUBMISSION OF THIS QUOTATION, OR TO PROCURE OR CONTRACT FOR SUPPLIES OR SERVICES.

SCHEDULE

11. EM NO.	12. SUPPLIES/SERVICES	13. QUANTITY	14. UNIT	15. UNIT PRICE	16. AMOUNT
1	Furnish all labor, supplies, materials, tools, equipment, and incidentals to reroof the Great Kiva at Aztec Ruins National Monument, Aztec, NM. Refer to attached drawings for special dimensions and details. Work to be done: Remove all existing roofing to wood sheathing. Replace sheathing that is rotten or damaged from moisture as directed by contracting officer. Replace roofing using manufactures specifications to apply 4 layers of 15 lb. felt and cover with clean crushed stone as final coating. Use 20 lb. felt for 3 layers on the up-slope to top of parapet wall as shown on drawing. Area around Kiva will be kept clean and all waste and existing material will be removed from Park by contractor. Install 2 new drains as shown on plans. Time for completion - 15 days. Barricades, signs and warning devices will be placed for visitor protection as directed.	1	Job		

PRICES QUOTED INCLUDE APPLICABLE FEDERAL, STATE, AND LOCAL TAXES.

OR PROMPT PAYMENT ____% 10 CALENDAR DAYS. ____% 20 CALENDAR DAYS. ____% 30 CALENDAR DAYS. ____% ____ CALENDAR DAYS.

NOTE: Reverse must also be completed by the quoter.

18. NAME AND ADDRESS OF QUOTER (Street, city, county, State, including ZIP Code)	19. SIGNATURE OF PERSON AUTHORIZED TO SIGN QUOTATION	20. DATE OF QUOTATION
	21. SIGNER'S NAME AND TITLE (Type or print)	22. TELEPHONE NO. (Include area code)

REPRESENTATIONS AND CERTIFICATIONS

The Quoter represents and certifies as part of his quotation that: (Check or complete all applicable boxes or blocks.)

1. SMALL BUSINESS

He ☐ is, ☐ is not, a small business concern. A small business concern for the purpose of Government procurement is a concern, including its affiliates, which is independently owned and operated, is not dominant in the field of operation in which it is quoting on Government contracts, and can further qualify under the criteria concerning number of employees, average annual receipts, or other criteria, as prescribed by the Small Business Administration. (See Code of Federal Regulations, Title 13, Part 121, as amended, which contains detailed industry definitions and related procedures.) If the quoter is a small business concern and is not the manufacturer of the supplies offered, he also represents that all supplies to be furnished hereunder ☐ will, ☐ will not, be manufactured or produced by a small business concern in the United States, its possessions, or Puerto Rico.

2. REGULAR DEALER-MANUFACTURER (Applicable only to supply contracts exceeding $10,000.)

He is a ☐ regular dealer in, ☐ manufacturer of, the supplies offered.

3. CERTIFICATION OF INDEPENDENT PRICE DETERMINATION (Applicable only to quotations in excess of $2,500.)

(a) By submission of this quotation, the quoter certifies, and in the case of a joint quotation, each party thereto certifies as to its own organization, that in connection with this procurement:

(1) the prices in this quotation have been arrived at independently, without consultation, communication, or agreement, for the purpose of restricting competition, as to any matter relating to such prices with any other quoter or with any competitor;

(2) unless otherwise required by law, the prices which have been quoted in this quotation have not been knowingly disclosed by the quoter and will not knowingly be disclosed by the quoter prior to opening in the case of an advertised procurement or prior to award in the case of a negotiated procurement, directly or indirectly to any other quoter or to any competitor; and

(3) no attempt has been made or will be made by the quoter to induce any other person or firm to submit or not to submit a quotation for the purpose of restricting competition.

(b) Each person signing this quotation certifies that:

(1) he is the person in the quoter's organization responsible within that organization for the decision as to the prices being quoted herein and that he has not participated, and will not participate, in any action contrary to (a)(1) through (a)(3) above; or

(2)(i) He is not the person in the quoter's organization responsible within that organization for the decision as to the prices being quoted herein but that he has been authorized in writing to act as agent for the persons responsible for such decision in certifying that such persons have not participated, and will not participate, in any action contrary to (a)(1) through (a)(3) above, and as their agent does hereby so certify; and (ii) he has not participated, and will not participate, in any action contrary to (a)(1) through (a)(3) above.

(c) This certification is not applicable to a foreign quoter submitting a quotation for a contract which requires performance or delivery outside the United States, its possessions, and Puerto Rico.

(d) A quotation will not be considered for award where (a)(1), (a)(3), or (b) above, has been deleted or modified. Where (a)(2) above, has been deleted or modified, the quotation will not be considered for award unless the quoter furnishes with his quotation a signed statement which sets forth in detail the circumstances of the disclosure and the head of the Agency, or his designee, determines that such disclosure was not made for the purpose of restricting competition.

CORTEZ ROOFING COMPANY

Owner;
FERNAN CORTEZ
Phone 505/327-9063
2328 East 13th Street
FARMINGTON, NEW MEXICO 87401

NAVAJO LANDS GROUP
ATTENTION: SUPERINTENDENT
AZTEC RUINS NATIONAL MONUMENT
P. O. BOX U
AZTEC, NEW MEXICO 87410

3/30/74 19___

PROJECT Garage, work shop and maintenance shop.

LOCATION Aztec Ruins National Monum

OWNER _____

ARCHITECT _____

WE PROPOSE TO FURNISH ALL LABOR AND MATERIALS NECESSARY FOR THE COMPLETION OF THE

removal of old roofing and install 72 sq. ft. of tongue and groove decking. Re-roof 2,012 sq. ft. with one base, three solid mop 15# layers gravel stop, then flood and gravel.

ON THE ABOVE NAMED PROJECT ACCORDING TO THE PLANS AND SPECIFICATIONS, FOR THE SUM OF:

++++Seven Hundred Seventy Nine & 20/100+++ $ 779.20

ALTERNATES & EXCEPTIONS:

ANY CHANGE IN CONSTRUCTION, NECESSITATING EXTRA WORK, MADE WHILE THIS CONTRACT IS IN PROGRESS, SHALL BE AT YOUR EXPENSE, FOR AN AMOUNT AGREED UPON IN ADVANCE.

THIS PROPOSAL IS LIMITED TO THIRTY DAYS ACCEPTANCE UNLESS OTHERWISE AGREED.

NO ORAL STATEMENT SHALL BE CONSIDERED A PART OF THIS CONTRACT.

WE ARE NOT LIABLE FOR DAMAGE TO ANY BUILDING OR CONTENTS THEREIN RESULTING FROM STORMS, HAIL, TORNADO, FIRES, STRIKE, LOCKOUTS, CAR DELAYS, EMBARGOES, NOR FOR ACCIDENTS AND CONDITIONS BEYOND OUR CONTROL, NOR FOR LEAKS DUE TO STRUCTUAL CHANGES, NOR ANY DAMAGE TO OUR WORK BY OTHERS OCCURRING WHILE WORK IS UNDER WAY OR AFTER WORK IS COMPLETED. EVERY REASONABLE PRECAUTION TO PREVENT DAMAGE WILL BE EXERCISED BY US.

TERMS:

YOUR ACCEPTANCE OF THIS PROPOSAL CONSTITUTES

_____ 19___

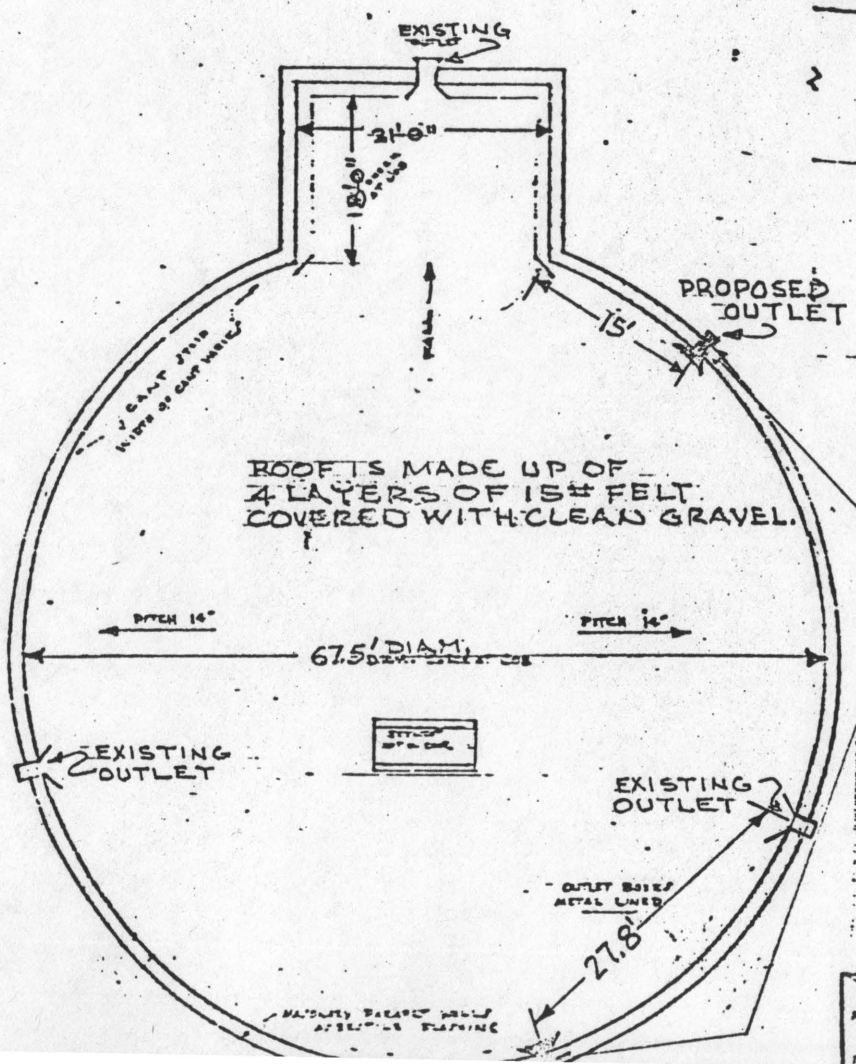
_____ ACCEPT THE ABOVE PROPOSAL.

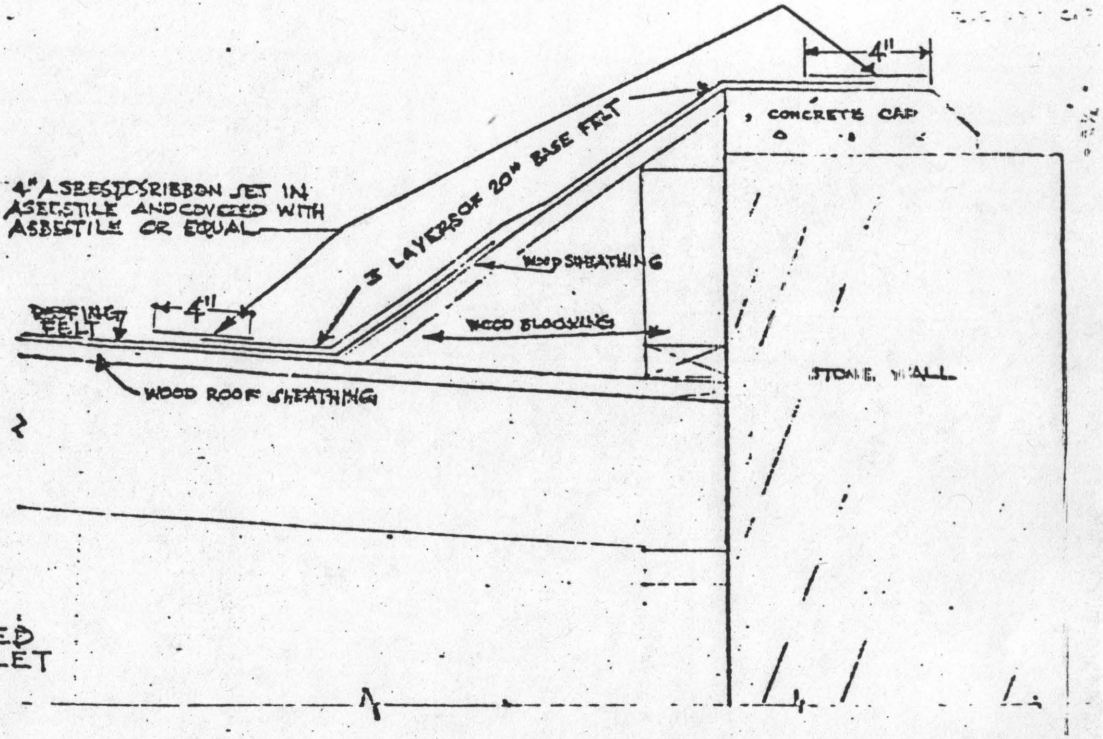
_____

RESPECTFULLY SUBMITTED:

CORTEZ ROOFING COMPANY

BY _____





PARAPET WALL SECTION
SCALE 3" = 1' or 1/4" = 1'

SEE ATTACHED DETAIL SHEET FOR ROOF DRAINS

NOTE — ALL MATERIAL TO BE PLACED IN ACCORDANCE TO SPECIFICATIONS OF MANUFACTURER.
DESIGN, INSTALLATION AND COLOR TO MATCH THE ROOF AS IT EXISTS.

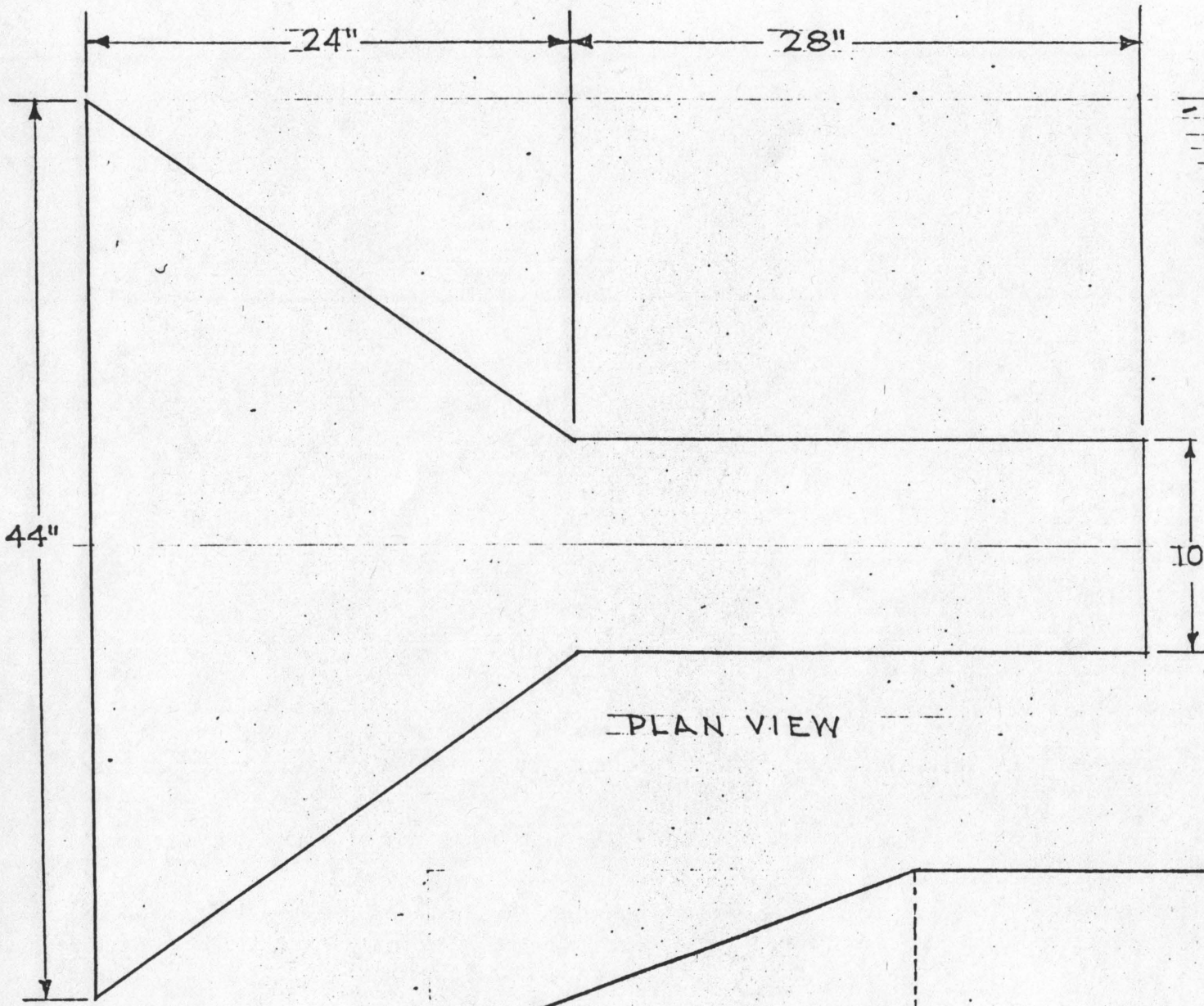
RE-ROOF - GREAT KIVA
AZTEC RUINS NATL. MON'T.
1 OF 2

HALF-SIZE REPRODUCTION

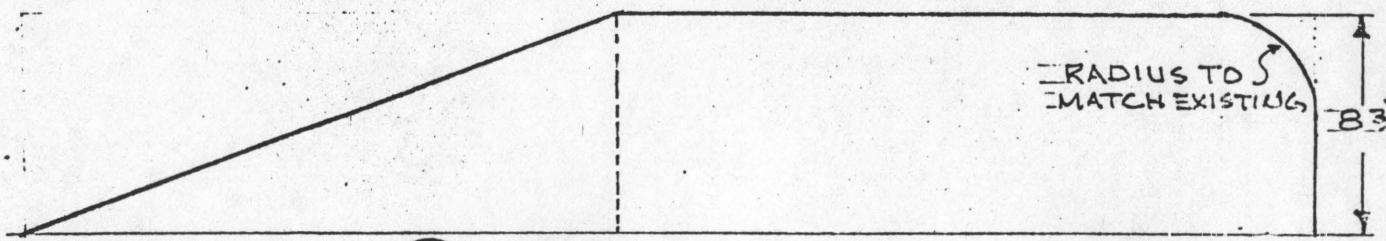
1954 REPRODUCTION
ACTUAL SIZE
SCALE

RECOMMENDED _____ DATE _____
RECOMMENDED _____ DATE _____

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
ARCHITECTURAL DIVISION
REGION 3, SANTA FE, N.M.



PLAN VIEW



SIDE VIEW

ROOF DRAINS-
GREAT KIVA
AZTEC NATL. MON.
SCALE: ⅛" = 1FT.
ALL MATERIALS & DESIGNS
TO MATCH EXISTING DRAIN
8/26/74 JM

Form 10-768
(Rev. 8/64)

U.S. DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

INDIVIDUAL BUILDING DATA

are in duplicate. Send original to Regional Office. Retain one copy in park office.

Building Name	Bldg. No.
Great Kiva	

Location in Park: West Ruins

Park, Monument, Etc.: Aztec Ruins Nat'l. Mon.

1. GENERAL

Use and Occupancy	Owned By	Operated By	
Public use	National Park Service	N.P.S.	
Maintained By	**Constructed By**	**Year**	**Drawing No.**
N.P.S. (1412)		~~1934~~	
Remodeled By		**Year**	**Drawing No.**
PW Project		1934	

2. VALUE		3. TYPE			4. SIZE (Sq. Footage)			
Original Cost	Present Value	No. Stories	No. Rooms	Basement	Overall	Basement	1st Floor	2nd Floor
$	$	1	15		4052		4052	

5. CONSTRUCTION

Construction Type	Foundation	Walls, Exterior	Walls, Interior	Floor	Roof
Rock Wall	Rock	sand Rock	Plaster	soil	Felt & gravel

6. INTERIOR FINISH

Walls	Floors	Ceilings	Trim
Plaster-sand Rock	soil	open-Vigas	

7. UTILITIES

Water	Electric	Gas	Sewer	Telephone	Other
	Farmington Elec				

8. MECHANICAL EQUIPMENT

Plumbing	Heating	Fuel	Electric	Hot Water	Other

9. EXISTING CONDITION (Indicate Excellent, Good, Fair, Poor - If New Building Leave Blank)

of (Date)	Structural	Mechanical	General State of Repair
11-20-74	Good		Good

10. FIRE PROTECTION			Extinguishing Equipment		
No. Hydrants	Size	Distance	Mechanical	Hand	Other
1	1½	150 ft.			

11. PHOTOGRAPHS. Furnish 8 x 10½" photographs or smaller photographs mounted on 8 x 10½ sheets. Attach to photograph: Name of park, location in park, and name and number of building.

12. SKETCH PLAN. Furnish legible sketch on separate sheet including over-all dimensions, names and sizes of rooms, scale, and date drawn. Use double line to indicate walls of building.

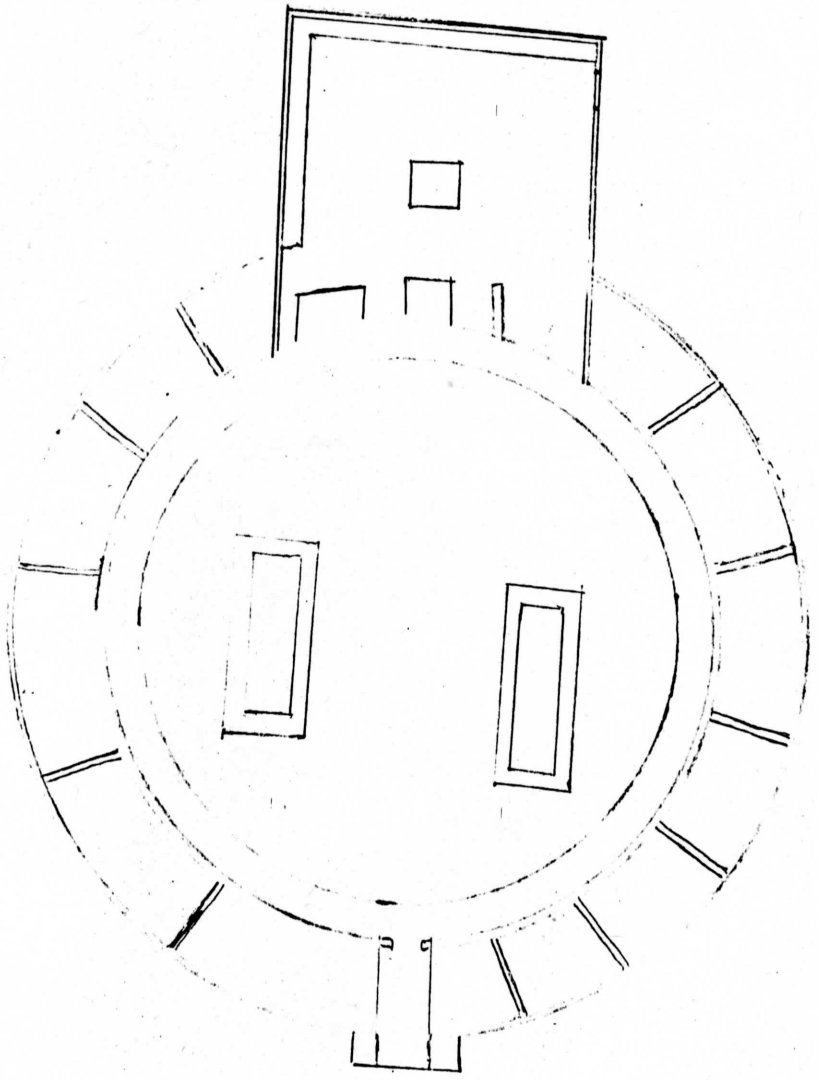
13. REMARKS (Furnish any other pertiment data to complete record)

~~Roof was~~ Kiva was roofed on Nov. 1974 by Gilmer Construction by striping old felt to bare wood & New Felt & gravel roof was installed at a cost of $1995.00 & 2 Two New drains where also " at " " of $280.00 ea.

Prepared By	Date	Approved By	Date
Felizonio Velasquez	11-20-74	Clarence N Gorman	11-20-74

Grotte Kiva

Roof: 4052 sq. ft.
Interior Walls: 4408



NOT TO Scale.

Area: AZTEC RUINS NATIONAL MONUMENT

Building _____: GREAT KIVA

Floor Area: 2,830 sq. ft.; type soil;
last date replaced N.A.; every ____ years cycle; contract
_____ or day labor _____; cost $_____.

Roof: ~~3,630~~ 4,052 sq. ft.; type Felt + Bummise Rub.;
last date replaced ~~1959~~ 1966; every 10 years cycle; contract
CONTRACT or day labor N.A.; cost $1,089.00.

Exterior Walls: N.A. sq. ft.; last date painted _____;
every ____ years cycle; contract _____ or day labor
_____; cost $_____.

Interior Walls: 4,408 sq. ft.; last date painted 1970;
every 5 years cycle; contract Contract or day labor
_____; cost $~~538.00~~ $529.00.

REMARKS:
.30 (cents) per. Sq. Foot Roofing
.12 (cents) Per. Sq. Foot Painting.

Est. 82
in 74

Grounds

Grounds

Grounds care and maintenance is another important part of ruins preservation. Intrusive weeds, bushes, and trees can alter site surface and subsurface drainage, affect structural integrity, and hide defects. They can also be unsightly, disrupt the scenic view, and limit access to some ruin areas. Falling leaves clog drain pipes and can accumulate against ruin walls where they can insulate snow and ice and thus help provide soaking moisture which is particularly devastating to ruins. Accumulating snow is devastating by itself (see Weather & Biology) and is a safety hazard to visitors.

Leaves should be raked away from walls, picked from drains, gathered, and disposed of. High or noxious weeds should be pulled out by the root rather than chopped. Intrusive bushes and trees should be removed by the same method. Overgrown but unobtrusive bushes and trees should be cut back yearly, enough that they not affect the scenic view. Obviously, trash and debris should be picked up and discarded.

Snow must be kept off trails for visitor safety. Unfortunately, it is usually shovelled off the walk and up against ruin walls. This and other (drifted) snow causes most of the moisture related damage to the ruins (see Ruins Management Plan). Snow must not be shovelled against walls! Since it can't remain on the trail either, a compromise must be reached. If you must pile trail snow, pile it between the trail and the wall. In many areas, with a little effort, the snow can be thrown clear of rooms where it will do less harm when melting. The walls affected most by unwisely shovelled snow are the interior walls of Room 151.

Snow is also a major problem in drains, on roofs, and along the exterior north wall of the West Ruin. The same applies to ice. At this time it is not practical to clear roofs after every snow. However, it takes relatively little effort to make sure the snow or ice is not blocking drainages. The snow that accumulates along the exterior north wall of the West Ruin is causing extensive damage to the interior. It melts slowly and saturates the surface and sub-surface. This snow should be either shovelled or blown (AZRU has a snow blower machine) away from the wall.

For the time being, little can be done to snow accumulating on wall tops. However, when capping a wall, you can put a slight slant to the cap which will reduce snow accumulation.

Open areas, such as the land around the ruins and the West Ruins plaza, are particularly susceptible to intrusive vegetation because of more available sunlight. Kivas, usually being larger, have more intrusive vegetation than secular rooms. The secular rooms, however, particularly the large, north-south oriented ones, do have this problem.

The open areas north, south, and west of the West Ruin have zones of dense, overgrown brushes, and trees. Black sage is particularly thick and overgrown.

The other ruins within the monument have even denser and taller vegetation covers. This vegetation must not be disturbed because it provides some erosion protection and it serves as an important refuge for various wildlife in the immediate area.

Trail And
Appurtenances

Trail and Appurtenances

Introduction

Trail Appurtenances, West Ruin

- Stairs/steps
- Markers
- Signs
- Doorway sealers
- Electrical
- Miscellaneous

Electric System Diagram, Great kiva
(from fact files)

The Trail and its Appurtenances

The visitor tral and its appurtenances are, for the purposes of maintenance, considered to be part of the cultural resources. Therefore, this section has been included in the Preservation Guide. You must know the trail and the appurtenances so that you will know what you are to maintain. Lists of stairs and steps, trail markers and signs; interpretive signs, trail lights, and visitor control doorway sealers have been provided for quick and handy reference.

Stairs and steps should be kept clean and sound. Sweep them at least twice a month during the park visitor season. Replace eroded or broken stone and reset loose stones in cement. Replace rotted, broken, or splintered boards and secure them properly.

Trail and interpretive markers and signs should be clean and legible. Repaint when necessary. Wood rots fairly quickly underground so replace signs when they become unstable or unaesthetic. Treat new signs with wood preservative. For metal surfaces that are dirty, a damp cloth is usually sufficient to remove the dirt.

Trail lights do burn out. It is a simple, quick task to remove protective hardware, replace the bulb, and reinstall the hardware.

Doorway sealers are transparent to partially satisfy the curiosity of the visitor. They collect dust, dirt, grime, grease, air pollutants, and body oils. Dry, clean paper towels and industrial window cleaner should be used to clean them. Replace cracked sealers promptly as they are a safety hazard. Check the wood frames for soundness and repair where necessary. Replace frames rotted below ground surface.

Trail Appurtenances

Stairs/steps: 6 rock steps with one wood railing, at interior east wall of Room 151

2 rock steps, southeast exterior of Room 187

2 rock steps, southwest corner of Room 216

2 rock steps, northwest corner of Room 216

2 rock steps, east exterior of kiva W

1 rock step, southeast exterior of kiva N

7 rock steps, east wall of Room 205

9 rock steps, west exterior of Room 205

7 wood stair steps with the two wood railings and platform with wood railing situated in Rooms 6 & 15A

2 concrete steps and 4 wood stair steps with one wood railing, west interior of Room 197

1 concrete step, east doorway of Room 197

2 concrete steps, one in each of east and west doorways, Rm 198

2 concrete steps, one in each of east and west doorways, Rm 191

2 concrete steps, one in each of east and west doorways, Rm 195

2 concrete steps, one in each of east and west doorways, Rm 199

2 concrete steps in west doorway, 1 in east doorway, Rm 196

1 concrete step in west doorway, 2 in east doorway, Rm 201

10 rock steps, southeast corner of Rm 196

1 rock step, west exterior wall of Room 58

3 concrete steps in east doorway of Room 160

13 wood stair steps with two wood railings on north wall of Great Kiva.

8 wood stair steps with two wood railings at lower part of south exit of the Great Kiva.

6 rock steps with two wood railings at upper part of south exit of the Great Kiva

Other stairs/steps: 12 wood stair steps down into Room 202

2 concrete steps, one on either side of the north doorway of Room 156

Trail Appurtenances (WERU)

Markers (wood, unless otherwise noted)

Room 151: Exterior southwest, also interior northwest

211: Exterior of east wall (steel marker)

NN4: Exterior of west wall

205: Ext. of west wall

202: Ext. of west wall

197: Ext. of west wall (2 markers), also interior at east wall

220: Int. of west half of room

238: Marker on west side of trail south of this room

118: South exterior

120: South exterior

196: Northwest corner

58: West exterior

kiva E: East exterior

160: by northeast corner of altar

Great kiva : by northeast exterior of west "foot drum"

105: north exterior

107: north side of trail south of this room

212: south side of trail south of this room

Wood markers (unless otherwise noted) -

Covered rooms on or along visitor trail

Room 197: northeast corner of room

191: by northeast corner
195: on wall on east side of south doorway
199: at bottom center of north wall
196: on east wall of south doorway

Trail signs (wood, unless otherwise noted)

Room 151: trail sign by exterior of west wall

NN4: interpretive sign by exterior of west wall

Kiva N : by exterior of west wall (interpretive)

197: by exterior of west wall (trail sign)

Int. sign : on east side of trail between WERU and Hubbard

Int. sign : by south exterior of the cobble kiva south of Hubbard

238: metal trail sign in wouthwest corner

119: by southeast exterior (metal interpretive sign)

Kiva L : by north exterior

57: by southwest exterior (metal trail sign)

160: by east exterior (metal trail sign)

212: interpretive sign on north side of trail south of the southeast exterior corner of this room; int. sign in same location but on south side of trail; int. sign on south side of trail south of the southwest ext. corner of this room.

East Ruin: warning sign on west side of ruin by foot path up to Room 1.

Sealers for doorways (leading off trail (WERU)

Room 197: 3' X 3' glass with metal frame mounted with wall screws over south doorway

198: 3' X 5' glass with wood frame sealing south doorway exteriorally

191: same as 198

195: " " "

199: " " "

196: " " "

201: " " "

47: " " "

Trail Appurtenances

Electrical (WERU)

Room 197: electrical conduit integral with west wall

198: trail light in center of north wall

191: same as above

195: " " "

199: " " "

196: " " "

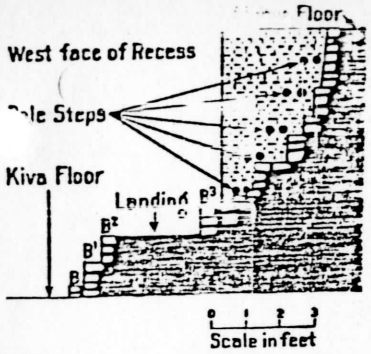
160: trail light on east wall south of the doorway; music button for kiva music, mounted on wood pedestal in southeast corner of the room.

Great kiva: see diagram

Miscellaneous (WERU)

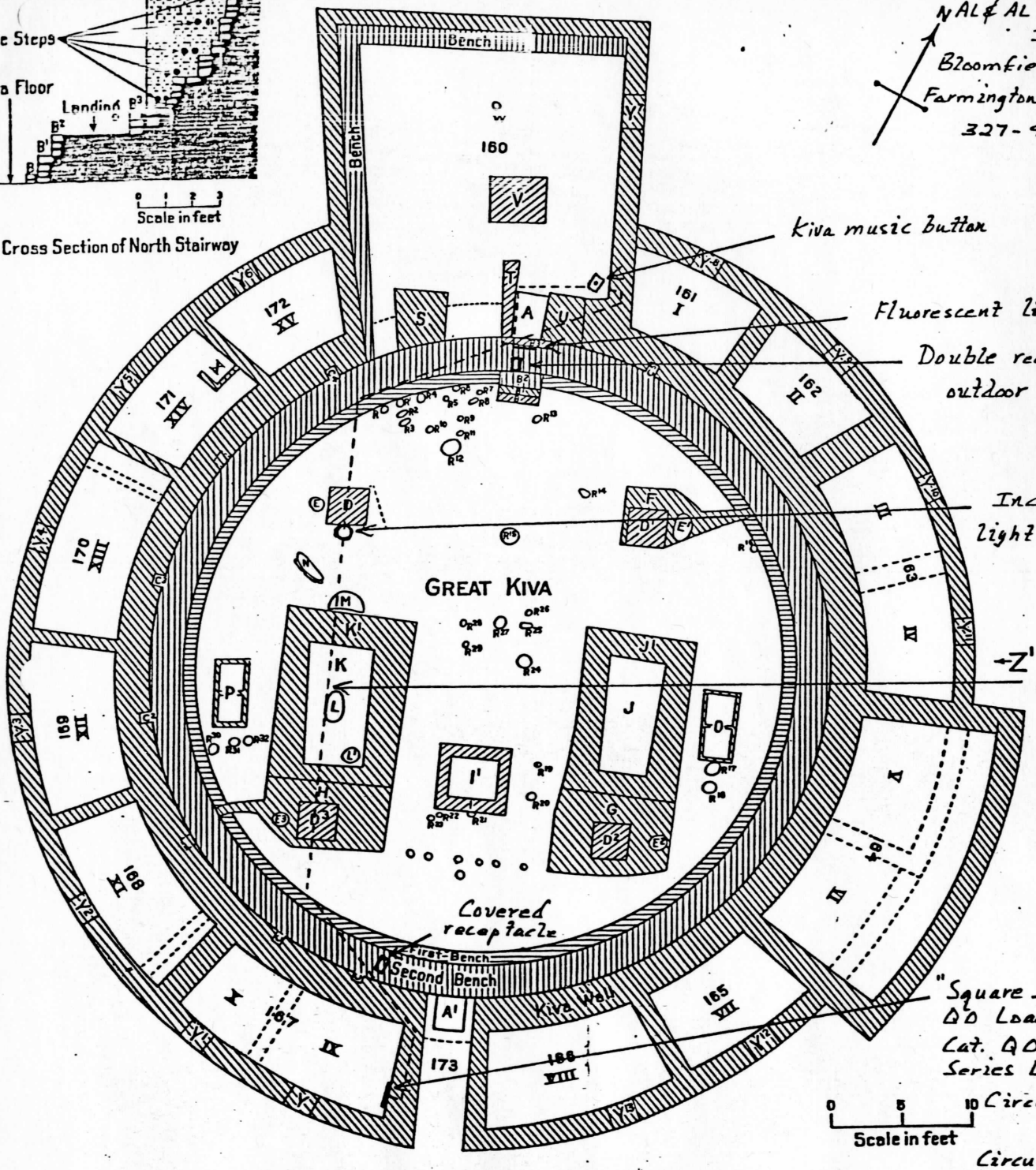
Room 160: 3 chains between pilasters on south end of room.

Great Kiva Wiring System
(as installed, August, 1978)



Cross Section of North Stairway

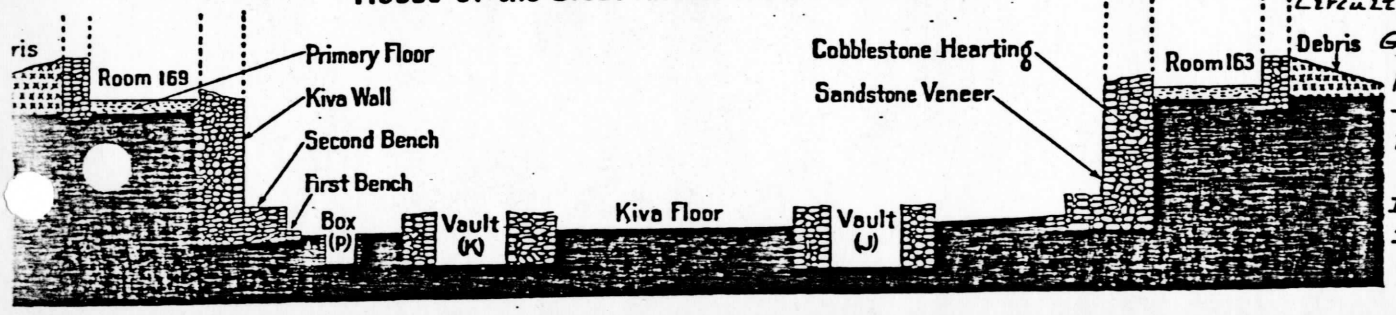
Contractor:
NAL & AL Electric Co. Inc.
Bloomfield Highway
Farmington, NM 87401
327-9175



House of the Great Kiva at the Aztec Ruin

Circuit 4 = South plug
Circuit 5 = Lights
Circuit 6 (with Debris GFCI) = North Plug

Mains 100 Amp. Max. 120/220 V 1ph. 3 W.



Cross Section, House of the Great Kiva from Z to Z'

Materials
Sources

Materials Sources

Introduction

Examples of BLM Borrow Permits

Graywacke - possible source description of graywacke

Source For Gray - Green Sandstone

Materials Sources

As far as color is concerned, the ideal soil for stabilization at AZRU comes from the monument itself. However, and necessarily, recent legislation makes borrowing on the monument difficult if not impossible. Therefore, you must go elsewhere for soil. The same applies to stone acquisition. The easiest and most convenient source for soil and stone is local government land. Most of this land is administered by the Bureau of Land Management, Farmington Resource Area, 900 La Plata Highway, Farmington, NM, 87401. Their telephone number is 325-3581. The current person to contact at BLM is Fred Anderson. He is familiar with the needs for stone and soil for preservation activities at AZRU.

Information on soil types and their locations is available from the Soil Conservation Service, 424 North Mesa Verde Avenue, Aztec, New Mexico, 87410; phone number - 334-9437.

Free use permits from the BLM require potential borrow areas to have archeological clearance in accordance with Section 106 of the Historic Preservation Act of 1966. The Navajo Lands Group Ruins Preservation Specialist can initiate this process. Contact this person when you are looking for potential borrow areas.

Included in this section are copies of correspondence between NALA and the BLM and the resulting permits.

There is also a source description (from a recent stabilization report) for the grayish-green sandstone needed for parts of the Aztec ruins. As yet, a source for the dark-green graywacke sandstone has not been located. The NALA Preservation Specialist will continue the search for the graywacke.

Materials should be stockpiled fairly close to the work and out of site as much as possible. Rock is usually stockpiled outside the east (north half) wall of the West Ruin. Soil is stockpiled outside the north (east half) wall of the West Ruin. Materials to be used on the East Ruin can be stockpiled in the "boneyard" (but away from Mound F). Mixing operations can be set up either at the exterior of the northeast corner of the West Ruin or at the north exterior of the visitors center library. For the East Ruin, set up mixing operation in the boneyard.

For work near the visitors center, water can be obtained from the spigot in the broom closet on the back porch of the visitors center. For other work you will have to run either a long hose, or, preferably, obtain a surplus water tank trailer (contact NALA Administrative Officer) and fill it at the fire hydrant located just northwest of Building 9 (Superintendent's Residence).

United States Department of the Interior
NATIONAL PARK SERVICE

IN REPLY REFER TO:

L3035

May 9, 1977

To : Al Park, Bureau of Land Management

From : Archeologist, National Park Service,
Navajo Lands Group

Subject : Borrow Pit

In response to your correspondence (2920) dated April 25, 1977, I checked with your office regarding locations of BLM lands on the Conger Mesa. According to your records, the NE 1/4 of the SE 1/4 of Section 8 (USGS La Plata Quadrangle, New Mexico - Colorado, 7.5 Minute Series, Topographic, 1963) is currently under BLM administration. This morning, I surveyed the center portion of that area and located an ideal borrow pit site which is devoid of artifacts and cultural features. The site is located at approximately UTM 4088580N, 747720E.

The general area east of the borrow pit site is fairly flat mesa top with sparse grass cover and scattered Black Sage. A few Juniper trees are strung along the mesa edge. The land west of the site drops gradually into Little Barker Arroyo. The biotic community in this transition zone consists mostly of widely disbursed Black Sage.

The borrow pit area is a good supply location for reddish, sandy loam (28% clay). I would like to obtain approximately 30 cubic yards of this material for the 1977 ruins stabilization season at Aztec Ruins National Monument.

A borrow pit 24' x 24' x 1.5' should supply enough soil for the full season. Very little vegetation would be disturbed by borrow operation and, as the pit will be a maximum of 18 inches deep (in order to avoid underlying calcium intrusions),

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the landscape will not be substantially altered. Furthermore, the area would be policed and smoothed after each borrow to partially mitigate the impact on the natural environment.

Should any features or artifacts be encountered during borrow operations, work will immediately cease and the pit will be cleaned up and closed.

Stephen E. Adams

Form 5510-1
(' 972)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

FORM APPROVED
OMB NO. 42-R0875

Permit Number

Expiration Date 8/15/77

District NM-1(F)77-8

FREE USE APPLICATION AND PERMIT
VEGETATIVE OR MINERAL MATERIAL

APPLICATION

Name of applicant
NATIONAL PARK SERVICE
NAVAJO LANDS GROUP

Address *(include zip code)*
BOX 539
FARMINGTON, N.M.

Kind of material
COMMON BORROW

Estimated quantity
96 CUBIC YARDS

Give legal land description

TOWNSHIP	RANGE	SECTION	SUBDIVISION
31 N	13W	8	NE¼ SE¼

Materials are to be used for INDIAN RUINS STABILIZATION

I HEREBY AGREE TO COMPLY WITH the special conditions as set forth below. I CERTIFY That the: (a) materials removed are to be used for the purpose noted above; (b) none of the materials removed are to be sold or bartered; noval of materials can begin only upon receipt of an approved copy of this permit; and, (d) the authorized officer is to be notified upon completion of removal.

I CERTIFY That I am twenty-one years of age or older, a citizen of the United States, and resident of the State of

I FURTHER CERTIFY That the statements made by me in this application are true, complete, and correct to the best of my knowledge and belief and are made in good faith.

5/11/77
(Date)

Stephen E. Adams
(Signature of Applicant)

Title 18 U.S.C. Section 1001, makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious, or fraudulent statements or representations as to any matter within its jurisdiction.

PERMIT

SPECIAL CONDITIONS

This permit is hereby issued for the materials applied for but may be canceled if it appears that this permit was issued erroneously or the terms or conditions contained herein are not observed. It shall be subject to the following special conditions:

1. THE SITE WILL BE SMOOTHED AFTER REMOVAL OF THE MATERIAL

2 THE SITE WILL BE SEEDED DURING LATE AUGUST.

(Special Conditions continued on reverse)

APPLICANT

Conservation practices must be practiced as provided by 43 CFR 5511.1–1(b), .2–3(c), and .3–3;

Equipment, personal property, and improvements must be removed within ninety (90) days after expiration date (43 CFR 3621.3(c) or 5511.3–5);

Any use of the surface of the lands involved in this permit shall be such as not to interfere with any mining claim subject to the provisions of Section 4 of the Act of July 23, 1955 (30 U.S.C. 613);

The permittee shall clean up all work areas and shall remove or dispose of all refuse resulting from the permittee's operations;

This permit is issued under the Act of July 31, 1947, as amended, and 43 U.S.C. 2 and 1201.

5/25/77
(Date)

(Signature of Authorized Officer)

Form 5510-1
(May 1972)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

FORM APPROVED
OMB NO. 42-R0875

Permit Number FU NM-1(F) 77-9
Expiration Date 9/24/77
District ALBUQUERQUE

FREE USE APPLICATION AND PERMIT
VEGETATIVE OR MINERAL MATERIAL

APPLICATION

Name of applicant
NATIONAL PARK SERVICE
NAVAJO LANDS GROUP

Address *(include zip code)*
BOX 539
FARMINGTON, N.M.

Kind of material
BUILDING STONE

Estimated quantity
5 CUBIC YARDS

Give legal land description

TOWNSHIP	RANGE	SECTION	SUBDIVISION
32 N	13 W	15	E½ SE¼ NE¼ NE¼

Materials are to be used for RUINS STABILIZATION

I HEREBY AGREE TO COMPLY WITH the special conditions as set forth below. I CERTIFY That the: (a) materials to be removed are to be used for the purpose noted above; (b) none of the materials removed are to be sold or bartered; (c) removal of materials can begin only upon receipt of an approved copy of this permit; and, (d) the authorized officer is to be notified upon completion of removal.

I CERTIFY That I am twenty-one years of age or older, a citizen of the United States, and resident of the State of

I FURTHER CERTIFY That the statements made by me in this application are true, complete, and correct to the best of my knowledge and belief and are made in good faith.

June 24, 1977
(Date)

Stephen E. Anderson
(Signature of Applicant)

Title 18 U.S.C. Section 1001, makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious, or fraudulent statements or representations as to any matter within its jurisdiction.

PERMIT

SPECIAL CONDITIONS

This permit is hereby issued for the materials applied for but may be canceled if it appears that this permit was issued erroneously or the terms or conditions contained herein are not observed. It shall be subject to the following special conditions:

THE SITE WILL BE LEFT IN A CLEAN CONDITION UPON COMPLETION OF THE WORK

(Special Conditions continued on reverse)

APPLICANT

Conservation practices must be practiced as provided by 43 CFR 5511.1–1(b), .2–3(c), and .3–3;

Equipment, personal property, and improvements must be removed within ninety (90) days after expiration date (43 CFR 3621.3(c) or 5511.3–5);

Any use of the surface of the lands involved in this permit shall be such as not to interfere with any mining claim subject to the provisions of Section 4 of the Act of July 23, 1955 (30 U.S.C. 613);

The permittee shall clean up all work areas and shall remove or dispose of all refuse resulting from the permittee's operations;

This permit is issued under the Act of July 31, 1947, as amended, and 43 U.S.C. 2 and 1201.

6/12-4/77
(Date)

(Signature of Authorized Officer)

United States Department of the Interior
NATIONAL PARK SERVICE

IN REPLY REFER TO:

L3035

June 30, 1977

Memorandum

To: Mr. Fred Anderson
Geologist, Bureau of Land Management

From: Archeologist
National Park Service

Subject: Borrow Pit

The 28% red clay soil I have obtained from BLM land is too dark and does not match the color of the original mortar in the Aztec Ruins. The red soil needs to be toned by adding lighter colored soil.

I have located a good borrow pit area on BLM land NE of Aztec Ruins. This area has been greatly disturbed by previous borrow operations for soil and rock. It is also currently being used as a soil dump. The area is immediately accessible by County Road 44 and is located in T31N, R11W, Section 23, NW¼ of NW¼ of SE¼ (UTM 4085900N, 236250E, Aztec Quadrangle, NM, 15 Minute Series, Topographic, 1959). I would like to obtain approximately 30 cubic yards of light colored soil from this area for use at Aztec Ruins National Monument.

Though previous disturbance has destroyed or masked any archeological features and artifacts present, should any such features or artifacts be encountered, borrow operation will cease and the area will be policed and closed.

Stephen E. Adams

CONSERVE AMERICA'S ENERGY

Save Energy and You Serve America!

Form 5510-1
(M 1972)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

FORM APPROVED
OMB NO. 42-R0875

Permit Number FU NM1(F)-77-12
Expiration Date 9/20/77
District Albuquerque

FREE USE APPLICATION AND PERMIT
VEGETATIVE OR MINERAL MATERIAL

APPLICATION

Name of applicant: National Park Service
Navajo Lands Group

Address *(include zip code)*: 111 North Behrend Ave.
Farmington, NM 87401

Kind of material: Common Borrow

Estimated quantity: 30 cu. yds.

Give legal land description

TOWNSHIP	RANGE	SECTION	SUBDIVISION
31N	11W	23	NW¼NW¼SE¼

Materials are to be used for
ruins stabilization

I HEREBY AGREE TO COMPLY WITH the special conditions as set forth below. I CERTIFY That the: (a) materials to be removed are to be used for the purpose noted above; (b) none of the materials removed are to be sold or bartered; (c moval of materials can begin only upon receipt of an approved copy of this permit; and, (d) the authorized officer is to be notified upon completion of removal.

I CERTIFY That I am twenty-one years of age or older, a citizen of the United States, and resident of the State of

I FURTHER CERTIFY That the statements made by me in this application are true, complete, and correct to the best of my knowledge and belief and are made in good faith.

8/8/77
(Date)

Stephen E. Adams
(Signature of Applicant)

Title 18 U.S.C. Section 1001, makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious, or fraudulent statements or representations as to any matter within its jurisdiction.

PERMIT

SPECIAL CONDITIONS

This permit is hereby issued for the materials applied for but may be canceled if it appears that this permit was issued erroneously or the terms or conditions contained herein are not observed. It shall be subject to the following special conditions:

1. The subject site will be left in a clean and smoothed condition.
2. Confine all activities to the area covered by the archeological survey.

(Special Conditions continued on reverse)

APPLICANT

Conservation practices must be practiced as provided by 43 CFR 5511.1-1(b), .2-3(c), and .3-3;

Equipment, personal property, and improvements must be removed within ninety (90) days after expiration date (43 CFR 3621.3(c) or 5511.3-5);

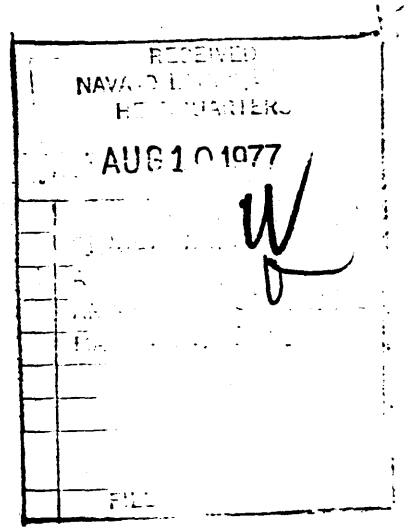
Any use of the surface of the lands involved in this permit shall be such as not to interfere with any mining claim subject to the provisions of Section 4 of the Act of July 23, 1955 (30 U.S.C. 613);

The permittee shall clean up all work areas and shall remove or dispose of all refuse resulting from the permittee's operations;

This permit is issued under the Act of July 31, 1947, as amended, and 43 U.S.C. 2 and 1201.

8/8/77
(Date)

Willis M. Reid Jr.
(Signature of Authorized Officer)



July 2, 1955

Information on Green Sandstone

Read from the Geologist

The source of the Green sandstone shown by the Geologist - North Westn. Southwest of Bondad

The green sandstone is found in thin beds inter-bedded with shale

Difference in color from ferrous oxide (green) instead of ferric oxide (red)

Aztec Ruin Green Sandstone

On July 21, 1954 Mr. Harold Miller, A.-T.-S.-C. Camp, Shiprock, New Mexico reported that green sandstone like that in the west wall of Aztec Ruin is found six to eight miles southwest of the Cove Day School in the Carrizo Mountains of Arizona. H. H.

Green sandstone may be upper member of the Morrison formation according to Mr. Jack Slaton, Sept 1954.

Roger C Green

Aztec Ruin — ~~Green Sandstone~~

In a letter dated Sept. 13, 1954 the following information was supplied by John S. Baker, 609 Tulane Drive, N. E. Albuquerque, N. M. The information is from "Rocks and Minerals" by Louis V. Pirson, Page 251. Graywacke Graywacke is a sandstone-like rock, generally gray and sometimes greenish or black, which, in addition to quartz and feldspar, containsrounded or angular bits of other rocks, such as fragments of shale, slate, chert, quartzite, granite, felsite, and basalt. It is in reality a strongly indurated, impure sandstone. By increase in size of some of the component particles it grades into fine-grained conglomerate. The cement, as in sandstone, is generally small in amount and is generally argillaceous (clayey), but in somegraywackes it is siliceous or calcareous. Graywackes, if fine-grained and compact and largely complsed of feldspatic material, may be difficult to distinguish from some feldsites in the hard specimen, but close examination with a good lens generally shows their detailed nature.

Graywacke occurs in the Mariposa formation in the Sierra Nevada and in the Francisca formation of the California Coast Range. It forms a belt 1000 miles long that extends along the Alaskan coast from Sitka to Cook Inlet. In the Sitka region the graywacke forms massive beds hundreds of feet thick and entirely devoid of stratification, so that it closely resembles an igneous rock. In Ontario and Quebeck graywacke is common in many formations of pre-Columbian age.

Mr. Baker had added the following at the end of the above information: "All kidding aside, it is the opinion of us here in the Skelly Oil Company Office in Albuquerque that when the Indians came across the Siberian land bridge into North America, they brought this graywacke with them from the Alaskan coast in order to spruce up the south wall of their Aztec pueblo."

H. H. September, 1954

A suitable rock for stabilization at the West Ruin was to be found approximately 4.5 miles north-east of the Monument, on private property reached from a spur road leading off the Cedar Hill Road. The property belongs to Mr. Arlo T. Robb, who donated an unlimited amount of stone for stabilization purposes. Kelley's Backhoe of Farmington was contacted to load, haul and deliver the stone to the work area. Enough rock was stockpiled to complete the remainder of the four-year stabilization program at West Ruin. According to an old report in the Monument fact file, the area quarried is in the vicinity of the original prehistoric quarry.

An area on the northeast corner of the West Ruin, beside the service road, was cleared for the work trailer and supply storage.

The plaster mixer, water tank trailer and sand supply were set up directly behind the north exterior wall of the ruin, near the east corner. This area was chosen because of its proximity to the main room blocks scheduled to be worked on and because it was hidden from the view of visitors.

The water tank trailer was filled at a fire hydrant in the residential area of the Monument. Sand was contracted from and delivered directly to the work site by Alcora Materials of Bloomfield, New Mexico. All other supplies and materials were purchased in Farmington. (Chambers and Trussell, 1974: 3 & 4.)

Supply Sources

Supply Sources

Introduction

Miscellaneous Items and Sources

GSA Items Commonly Used in Stabilization

Federal Schedule Items

Items Purchased Through Bid

Supply Sources

Most of the supplies you order will come form either GSA or Federal Schedule. Questions on these two sources should be directed to your Procurement Clerk or the NALA Purchasing Agent.

Some of the supplies you will need are not on GSA or Federal Schedule. Included in this section is a list of such items and their sources. You should add items to the list as you encounter them. Remember, this document is not only for you but for your successor as well, so write it down even if you know the source well.

Item	Source
Caulking trowels	Goldblatt Tool Company 511 Osage Kansas City, Kansas 66110 (913)621-3010
Heavy duty caulking guns	Goldblatt Tool Company
Sand	By bid, see NALA Purchasing Agent
Concrete adhesive	Available locally
Calcium Alumnate Cement	Contact Ruins Preservation Spec. Southwest Cultural Res. Center Santa Fe, New Mexico
Soil Color Chart	Munsell Color MacBeth Division of Kollmorgen Corp. 2441 N. Calvert Street Baltimore, Maryland 21218 (301)243-2171
Ground Fault Circuit Interrupter	Kabo Electronics (FCS) Department M P.O. Box 477 Natick, MA 01760
Mortar Color (not recommended for use - weakens mortar)	Tamms Industries Company 9920 Flora Vista Avenue Bellflower, CA 90706 (213)925-2206

GSA Items Commonly Used

Rock hammer

Cold chisels

Pointing trowels

Galvanized metal buckets

Shovels

Mortar hoes

Rakes, garden and road

Forks, spading

Dust masks

Whisk brooms

Garden hose

Electrical extension cords

Federal Schedule

Portable electric generators

Scaffolding

Items Purchased on Bid or Open Market

Mortar boxes

Plaster mixers

Personnel

Personnel

Introduction

Employee Information Contacts

Outstanding Personnel

Position Descriptions

- ~~WG~~ L-7
- WG-8
- WG-5
- WG-3

Personnel

Traditionally, Navajo workers have been employed in stabilization at AZRU. Most of these live around Chaco Canyon National Monument. The worker pool for AZRU has been reduced by the increased maintenance activities at Chaco. However, there are usually a few experienced Navajos who apply every year at AZRU.

Your crew will be small for stabilization work and will usually consist of one WL-5 masonry worker leader and several WG-5 masonry worker helpers. There have been WG-3 laborer and WG-8 masonry workers employed in the past on large rehabilitation projects but they are not needed on a small maintenance crew at AZRU.

Navajo Lands Group is currently attempting to add another position to the AZRU staff. It will be a subject-to-furlough, split position: WL-5 during the stabilization season, WG-5 during the remainder of the year.

As a WL-5, this person will be responsible for leading the masonry worker crew by assigning job tasks, checking work, notifying the project supervisor or foreman when supplies are needed, and in general ensuring the smooth operation of the annual ruins maintenance. During the rest of the year, this person will assist the area maintenance worker in his/her duties.

Position descriptions for WL-5 Masonry Worker Leader, WG-5 Masonry Helper, and WG-3 Laborer are included in this section to give you an idea what workers in these positions are supposed to do.

Also included in this section is a list of outstanding workers. You should add to this list when appropriate. For information on other applicants you should contact supervisors who have employed these persons in the past. A list of contacts is provided herein.

For employment procedures, contact the personnel clerk or administrative officer at Navajo Lands Group in Farmington.

Employee Information Contacts

Stephen E. Adams
Ruins Preservation Specialist
Navajo Lands Group
P.O. Box 539
Farmington, NM 87401
325-5036

Martin T. Mayer
Supervisor, Ruins Stabilization Unit
Western Archeological Center
P.O. Box 49008
Tucson, AZ 85717
(602) 792-6501

Charles B. Voll
I & RM Specialist
Navajo Lands Group
P.O. Box 539
Farmington, NM 87401
325-5036

Archie Werito
Maintenance Foreman
Chaco Canyon National Monument
Star Route 4, Box 6500
Bloomfield, NM 87413
(505)786-5384

Cecil Werito
Ruins Maintenance Foreman
Chaco Canyon National Monument
Star Route 4, Box 6500
Bloomfield, NM 87413
(505) 785-5384

Outstanding Personnel Ratings

1975:	James D. Brown	WG-5
	Daniel Harrison	WG-5
	Charles Lanell	WG-5
	Willie P. Yazzie	WG-8

1977:	James D. Brown	WG-5
	Willie P. Yazzie	WG-8

(received 10-year service pin 1977; has worked seasonally in stabilization since 1946)

Optional Form 8
July 1959
U.S. CIVIL SERVICE COMMISSION
FPM Ch. 295
5008-104

POSITION DESCRIPTION

1. Check one: Dept'l ☐ Field ☒
2. Official headquarters: Aztec Ruins NM
4. Agency position No.
3. Reason for submission:
(a) If this position replaces another (i. e., a change of duties in an existing position), identify such position by title, allocation (service, series, grade), and position number
5. C. S. C. certification No.
6. Date of certification
8. CLASSIFICATION ACTION
(b) Other (specify) Establish new position
7. Date received from C. S. C.

ALLOCATION BY	CLASS TITLE OF POSITION	CLASS Service	CLASS Series	CLASS Grade	INITIALS	DATE
a. Civil Service Commission						
b. Department, agency, or establishment	Should be re-written to					
c. Bureau	WL-5 level					
d. Field office	✓ ✓ ✓	WL	3603	07	[illegible]	[illegible]
e. Recommended by initiating office	Masonry Worker Leader	WL	3603	07		

9. Organizational title of position *(if any)*
10. Name of employee *(If vacancy, specify V-1, 2, 3, or 4)*

11. Department, agency, or establishment: Interior
a. First subdivision: National Park Service
b. Second subdivision: Southwest Region
c. Third subdivision: Navajo Lands Group
d. Fourth subdivision: Aztec Ruins National Monument
e. Fifth subdivision

12. This is a complete and accurate description of the duties and responsibilities of my position
(Signature of employee) (Date)

13. This is a complete and accurate description of the duties and responsibilities of this position
(Signature of immediate supervisor) (Date)
Title: General Superintendent

14. Certification by head of bureau, division, field office, or designated representative
(Signature) (Date)
Title: Personnel Management Specialist

15. Certification by department, agency, or establishment
(Signature) (Date)
Title:

16. Description of duties and responsibilities

Primary Duties:

His work involves the maintenance, repair and restoration of prehistoric structures and surfaces built of stone and adobe. He mixes soil-cement mortar and earth mortar (adobe). He removes damaged portions of walls, partitions or other similar structures in preparation for repair of damage. He caps, resets, respalls, grouts, and reinforces prehistoric walls so that the repaired portion closely matches the original, undamaged portion of the structure.

He loads and unloads soil and stone; stacks and handles stone building materials and supplies; and loads and unloads tools and equipment on trucks for movement from one job location to another within the area.

Uses hand tools (shovel, ax, hoe, pick, rake, etc.) in digging, raking, backfilling small excavations, shoveling earth mortar (adobe) and soil cement. Loads

If more space is required, use the other side and additional pages size 8 x 10½

GPO: 1964—O-722-787

and pushes wheelbarrows, moves rock and cuts brush. He also uses hand hammers, hand saws, chisels and crowbars to remove portions of walls and in preparing damaged areas for repair.

Skills and Knowledge Required:

The incumbent must have the skill to closely match or duplicate [redacted], the original appearance of the prehistoric structure. To accomplish this, he must have a basic knowledge of the principles and procedures involved in laying a variety of block, stone and adobe. In completing repairs, he must have the skill necessary to spread mortar; set block; select, dress and set native stone; and finish joints so that the repaired section closely matches the original portion.

The incumbent must be skilled in the use of the trowel in spreading mortar, in the tuck pointing trowel in grouting, and in the rock hammer in dressing native stone. In mixing mortar, he must insure that the proper proportions of [redacted] and water are used to obtain the desired consistency and color.

Responsibility:

General work assignments and plans are provided by the archeologist in charge of he project. The incumbent [redacted] the work of duplicating materials and fabricati masonry or adobe closely resembling that used in the original construction.

Leading Others:

The incumbent usually leads a crew of from 5 to 10 skilled or semi-skilled Masonry Workers and Laborers ranging in grade from WG-8 to WG-3.

He is responsible for passing on the instructions of the supervisor and setting an example in regard to the amount and quality of work accomplished.

He provides on-the-job training in regard to work methods and procedures, and advises the supervisor as to additional training needed.

He is responsible for seeing that necessary tools, equipment and supplies are available to his work crew.

He keeps his supervisor informed as to work progress and problems encountered.

He insures that crew members observe safety rules and good housekeeping practices.

Physical Effort and Working Conditions:

Physical effort is moderate in that he occasionally lifts objects weighing over 50 pounds. He is frequently required to stand while working and must [redacted] sometimes

climb ladders and scaffolds of six to 30 feet. The work requires bending, stooping, climbing and working in awkward positions.

He is exposed to a variety of spring, summer and fall weather conditions while working outdoors. He is subject to danger of falling when working from ladders and scaffolds. He is exposed to dust and dirt while mixing mortar, removing damaged portions of walls, and while handling various masonry materials.

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POSITION DESCRIPTION

3. Reason for submission:
(a) If this position replaces another (i.e., a change of duties in an existing position), identify each position by title, allocation (service, series, grade), and position number

5. C. S. C. certification No.

6. Date of certification

8. CLASSIFICATION ACTION

(b) Other (specify) Establish new seasonal position

7. Date received from C. S. C.

ALLOCATION BY	CLASS TITLE OF POSITION	CLASS Service	CLASS Series	CLASS Grade	INITIALS	DATE
a. Civil Service Commission	Fair Labor Standards Act Vacant 6/4/74 & Not applicable					
b. Department, agency, or establishment	Overtime Provisions ( ) Exempt					
c. Bureau	(X) Nonexempt					
d. Field office	Masonry Worker	WG	3602	05	[illegible]	[illegible]
e. Recommended by initiating office	Masonry Worker	WB	3602	04	CBV	5/3/7[illegible]

9. Organizational title of position (if any)

10. Name of employee (If vacancy, specify V-1, 2, 3, or 4)

11. Department, agency, or establishment
Interior

a. First subdivision
National Park Service

b. Second subdivision
Southwest Region

c. Third subdivision
Navajo Lands Group

d. Fourth subdivision
Aztec Ruins National Monument

e. Fifth subdivision

12. This is a complete and accurate description of the duties and responsibilities of my position

(Signature of employee) (Date)

13. This is a complete and accurate description of the duties and responsibilities of this position

Charles B. Voll 5/3/73
(Signature of immediate supervisor) (Date)

Title: Charles B. Voll
Acting General Superintendent

14. Certification by head of bureau, division, field office, or designated representative

Emil J. Mattic 5/21/73
(Signature) (Date)

Title: Personnel Management Specialist

15. Certification by department, agency, or establishment

(Signature) (Date)

Title:

16. Description of duties and responsibilities

Primary Duties:

His work involves assisting the Masonry Worker in the maintenance, repair and restoration of prehistoric structures and surfaces built of stone and adobe. He participates in archeological excavations incidental to this work. He mixes cement mortar, soil-cement mortar and earth mortar (adobe). He removes damaged portions of walls, partitions or other similar structures in preparation for repair of damage. He caps, resets, respalls, grouts, and reinforces prehistoric walls so that the repaired portion closely matches the original, undamaged portion of the structure. His work includes the application of chemical compounds as preservative treatment on wood, stone and adobe.

He loads and unloads cement, soil and stone; stacks and handles stone building materials and supplies; and loads and unloads tools and equipment on trucks for movement from one job location to another within the area.

If more space is required, use the other [illegible] additional pages [illegible]

[illegible]—O 722 797

Uses hand to[illegible]el, ax, hoe, pick, rake, etc.) in digging, raking, backfillin small excava[illegible]noveling concrete, earth mortar (adobe) and soil cement. Load. and pushes wi[illegible]rows, moves rock and cuts brush. He also uses hand hammers, hand saws, chi[illegible]and crowbars to remove portions of walls and in preparing damaged areas for repair.

Skills and Knowledge Required:

The incumbent must acquire the skill to closely match or duplicate without the use of gauge line, spirit level and plumb bob, the original appearance of the prehistoric structure. To accomplish this he must learn the basic knowledge of the principles and procedures involved in laying a variety of block, stone and adobe. In completing repairs, he must acquire the skill necessary to spread mortar; set block; select, dress and set native stone; and finish joints so that the repaired section closely matches the original portion.

The incumbent must acquire skill in the use of the trowel in spreading mortar, in the tuck pointing trowel in grouting, and in the rock hammer in dressing native stone. In mixing mortar, he must insure that the proper proportions of sand, lime, cement, mortar color and water are used to obtain the desired consistency and color.

The incumbent generally performs the most typical tasks of a Masonry Worker. Occasionally he performs more difficult work under close supervision.

Responsibility:

A supervisor or higher grade worker assigns the incumbent to specific work locations, and he is given specific, detailed instructions by the supervisor or higher grade worker who closely supervises his work for accuracy and adherence to standards. The incumbent selects the proper tools and uses materials called for by instructions.

He keeps his tools clean and in safe operating condition. He works in a safe manner for protection of self and fellow workers, particularly when working on high standing walls which require the use of six to 30 feet of scaffolding.

Physical Effort and Working Conditions:

Physical effort is moderate in that he occasionally lifts objects weighing over 50 pounds. He is frequently required to stand while working and must frequently climb ladders and scaffolds of six to 30 feet. The work requires bending, stooping, climbing and working in awkward positions.

He is exposed to a variety of spring, summer and fall weather conditions while working outdoors. He is subject to danger of falling when working from ladders and scaffolds. He is exposed to dust and dirt while mixing mortar, removing damaged portions of walls, and while handling various masonry materials.

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POSITION DESCRIPTION

1. Check one: Dept'l ☐ Field ☒

2. Establishment: Aztec Ruins National Monument

3. Reason for submission:
(a) If this position replaces another (i. e., a change of duties in an existing position), identify such position by title, allocation (service, series, grade), and position number

(b) Other (specify) Establish new seasonal position

4. Agency position No.

5. C. S. C. certification No.

6. Date of certification

7. Date received from C. S. C.

8. CLASSIFICATION ACTION

ALLOCATION BY	CLASS TITLE OF POSITION	CLASS Service	CLASS Series	CLASS Grade	INITIALS	DATE
a. Civil Service Commission						
b. Department, agency, or establishment						
c. Bureau						
d. Field office	✓	✓	✓	✓	JAB	8/14/72
e. Recommended by initiating office	Laborer	WG	3502	03	ARW LWC	8/1/72 8/1/72

9. Organizational title of position *(if any)*

10. Name of employee *(If vacancy, specify V-1, 2, 3, or 4)*

11. Department, agency, or establishment: Interior

a. First subdivision: National Park Service

b. Second subdivision: Southwest Region

c. Third subdivision: Navajo Lands Group

d. Fourth subdivision: Aztec Ruins National Monument

e. Fifth subdivision

12. This is a complete and accurate description of the duties and responsibilities of my position

(Signature of employee) (Date)

13. This is a complete and accurate description of the duties and responsibilities of this position

Leslie W. Cammack 8/1/72
(Signature of immediate supervisor) (Date)
Leslie W. Cammack
Title: Superintendent

14. Certification by head of bureau, division, field office, or designated representative

(sgd) J. S. Bullion 8-14-72
(Signature) (Date)
Title: Personnel Management Specialist

15. Certification by department, agency, or establishment

(Signature) (Date)
Title:

16. Description of duties and responsibilities

PRIMARY DUTIES

Is responsible for the movement of freight, furniture, machinery or other items by lifting or use of hand trucks and other moving equipment.

Digs ditches and trenches with pick and shovel, leveling sides and bottom of trench to grade, assuming responsibility for maintaining slopes and grade.

Maintains picnic grounds by doing minor repair work on tables, such as, painting them, pulling out protruding nails with a claw hammer, or replacing worn or missing bolts; keeps tables clean by washing them and the grounds free of trash and other litter; by mowing grass around picnic sites with a power mower.

Mixes mortar and concrete by operating a tilter mixer; or, by hand with hoe, adds compontents according to instructions. Empties mixed concrete into wheelbarrow, wheels concrete to point where it is to be used, and cleans area after work has been completed.

If more space is required, use the other side and additional pages size 8 x 10½

GPO: 1964—O-722-797

Mows and waters lawns and clips hedges, using hand and/or self-propelled power lawn mowers and hedge clippers. Makes simple adjustments to cutter mechanisms and periodically oils and cleans tools and equipment used. Shovels snow from walks and building entrances.

Repairs walks, roads and parking areas by cleaning areas to be patched. Removes broken or damaged paving materials with pick and shovel or jackhammer, fills with asphalt, hot mix, concrete, cinders, gravel, coral, or other materials, smooths and rakes material and tramps into place.

Cuts trees using axe, hand or power saw and performs related duties involving comparable responsibility. Loads pickup with debris to be hauled to the dump.

SKILLS AND KNOWLEDGE REQUIRED

The incumbent must be able to operate, control and clean power equipment, such as, power mowers, jackhammers and chain saws. Must be able to complete tasks or processes which require remembering directions and/or sequences.

RESPONSIBILITY: Is responsible for completing work after receiving initial oral or written instructions.

PHYSICAL EFFORT AND WORKING CONDITIONS

The incumbent exerts heavy physical effort, such as, frequently lifting and moving objects weighing over 50 pounds, pushing heavy wheelbarrow loads and running power mowers on grades.

Works outside in all kinds of weather and inside in areas that may be dusty or drafty. The equipment, tools and tasks involved at this level frequently require special care to avoid serious injury.

Materials Data

Introduction

Soil, Soil Cement, and Stone Test Results
(from Soil Scientist, WAC)

"Initiatory Report, Adobe Preservation Research, Fort Bowie National Historic Site " (from Soil Scientist, WAC)

"Initial Report, Mud Plaster Preservation Research, Bent's Old Fort National Historic Site" (from Soil Scientist, WAC)

"Second Report, Mud Plaster Preservation Research, Bent's Old Fort National Historic Site" (from Soil Scientist, WAC)

"The Solidification of Cement" (article from Scientific American)

Latex Modified Mortar

"Third Annual Report, Chemical Stabilization of Prehistoric Structures at Chaco Canyon National Monument" (from Regional Chief Scientist, Western Region).

Research Data

This section is included to keep you up to date with the findings of various research tests involving stabilization. Most of the data will be from Western Archeological Center Soil Scientist's test projects. As you receive additional data of this kind, forwarded to you by the NALA Preservation Specialist, study it and then put it in with this section.

If you have any questions, contact the NALA Preservation Specialist.

NPS AREA: Aztec Ruins National Monument

SOIL: Aztec

LOCATION: Aztec

I. SOIL TEST RESULTS

A. Particle Size Characterization

1. Total

Texture Class: Sandy Loam

% Sand (2mm-.05mm)	65.5
% Silt (.05mm-.002mm)	25.0
% Clay (less than .002mm)	9.5
Total	100.0%

2. Sand Sieve Analysis (2mm-.05mm)

% 1.0mm-2.0mm (very coarse)	1.11
% 1.0mm-0.5mm (coarse)	9.25
% 0.5mm-0.25mm (medium)	17.46
% 0.25mm-0.10mm (fine)	30.73
% 0.10mm-0.05mm (very fine)	41.45
Total	100.00%

B. Chemical Characterization

1. General

pH of Soil Paste	8.10
Calcium Carbonate (Lime) Equivalent %	3.48
Cation Exchange Capacity (me/100g)	14.36

2. Analysis Of Soil Water Extract (1:5 Soil To Water)

Electroconductivity (mmho/cm)	0.22
Soluble Salts (parts per million)	323.00
pH	7.30

Calcium (milligrams/liter*)	20.0
Magnesium (milligrams/liter*)	1.3
Sodium (milligrams/liter*)	3.5
Chlorine (milligrams/liter*)	25.0
Sulfate (milligrams/liter*)	216.0
Bicarbonate (milligrams/liter*)	53.7
Carbonate (milligrams/liter*)	0.0
Nitrate (milligrams/liter*)	3.45

*Milligrams/liter is approximately equal to parts per million.

C. Clay Minerology

Clay Type	Tendency To Crack	Relative Proportion Present In This Soil None (0) to Dominant (5)
Montmorillonite	high	5
Mica (illite)	low	3
Vermiculite	medium	2
Chlorite	low	0
Kaolinite	low	2
Interstratified	low to medium	0-1

II. SOIL CEMENT TEST RESULTS

A. Strength

Soil-Cement Ratio	Unconfined Compressive Strength (psi)
4:1	576
6:1	213
10:1	119

2. Effects Of Sand Additions On A 6:1 Soil-Cement

Sand Type	% Sand Added	Unconfined Compressive Strength (psi)
Clean silica	0	213
	20	214
	40	195
	60	174

B. Capillary Water Rise

1. Various Soil-Cement Ratios

Soil-Cement Ratio	Capillary Rise (Ft)
1:0	8.9
10:1	15.8
6:1	16.6
4:1	19.9

2. Effects Of Sand Additions On A 6:1 Soil-Cement

Sand Type	% Sand Added	Capillary Rise (Ft)
Clean Silica	0	16.6
	20	9.5
	40	7.5
	60	7.0

III. STONE TEST RESULTS

A. Source: Aztec Ruins

B. Description: Coarse grained, friable graywacke

C. Compressive Strength (psi): 1130

D. Estimated Capillary Rise Potential (ft.): 33.4

E. Comments: This stone is a weak, porous stone that readily transmits water.

IV. EVALUATION OF RESULTS

A. Use Of Soil In Soil-Cement Mixes

1. Compressive Strength Comparison (psi)

a. Stone sample: 1130

b. 4:1 soil-cement: 576

c. 6:1 soil-cement: 213

d. 10:1 soil-cement: 119

e. Comment: Any soil-cement used should be weaker than the stone. The soil meets this criteria for all soil cement ratios tested. The 6:1 and 10:1 ratios are weak, however, and the 4:1 soil-cement should be used.

2. Capillary Rise Comparisons (ft)

a. Stone sample: 33.4

b. 4:1 soil-cement: 19.9

c. 6:1 soil-cement: 16.6

d. 10:1 soil-cement: 15.8

e. Comment: Any soil-cement used should have a higher capillary potential than the stone to ensure that destructive moisture is drawn out of the stone into the mortar. The soil fails this criteria for all soil-cement ratios tested. The moderately high capillary potential of the stone makes it difficult for any soil to meet the criteria in this case.

3. Addition Of Sand To 6:1 Soil-Cement

a.

% Sand Added	Compressive Strength (psi)
0	213
20	214
40	195
60	174

b. Comments: Sand should <u>not</u> be added to the soil in making soil-cement.

B. Use Of Soil As Unamended Mud Mortar Or Plaster

1. Particle Size Distribution: Optimum soil is a sandy loam with a particle size distribution of 20-25% clay, 60-70% sand, and 0-10% silt. Silt is not desirable since it does not bind as well as clay, and does not provide strength as does coarse sand. This soil is too high in silt and low in clay. It will make a good mortar, but the resulting strength and erosion resistence will be low.

2. Sand Size Distribution: Coarse sand is much superior to fine sand because fine sand is similar to silt in properties. The sand in this soil is over 72% fine and very fine, which is not conducive to optimum mortar strength.

3. Clay Mineral Composition: Some clay types exhibit extreme shrinking and swelling upon absorption or desorption of water. This causes cracking and the mortar will deteriorate faster than mortars with more stable clay types. This soil contains:

____ Acceptably low level of swelling clays
____ Moderate level of swelling clays
__X__ Excessive level of swelling clays.

4. Soluble Salts: Soils used for unamended mortars should have a soluble salt level lower than 1000 parts per million. Excessive salts weaken the mortar, attract hygroscopic moisture, and form harmful salt efflorescence and subflorscence. This soil contains:

__X__ Acceptably low salt content
____ Excessively high salt content.

5. Liquid Limit (% Water): 25 %. This is the percent by weight water at which the soil will have the most workable and satisfactory consistency.

6. Summary Comments: This soil has only 9% clay, but most of it is of the shrinking and swelling type that cracks badly upon drying. This, coupled with the high silt content, makes this soil unsuitable for a routine ruins maintenance mud-mortar or plaster.

Documentation

INITIATORY REPORT

ADOBE PRESERVATION RESEARCH

FORT BOWIE NATIONAL HISTORIC SITE

By

Dennis B. Fenn

Research Scientist

Western Archeological Center

October 18, 1976

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INTRODUCTION

The problem of preserving exposed historic and prehistoric adobe walls is a complex and difficult one for the National Park Service. Research in this area has been largely ineffective because most projects were conducted by interested individuals with little financial support. Often, no more than one chemical treatment was studied at a time and no long-term followup and monitoring was conducted. This, however, was the best that conditions would allow. The result has been that each National Park Service unit possessing adobe structures has tended to develop its own "favorite" treatment with little scientific evidence to support the contention and little or no communication with other areas with similar concerns.

The recent emphasis by top-level Park Management on developing an improved ruins preservation program has created an atmosphere conducive to the conduct of a thorough adobe preservation research project.

The objectives of this project are to study a selected variety of potential waterproofing chemicals for their effectiveness as spray coatings on adobe walls and as integral mix materials for producing stabilized adobe. Factors such as durability, effectiveness, color stability, hardness and treatment penetration will be monitored.

Selection of Chemicals

Twenty-four chemicals were selected for this first phase of the project. Of these 24 products, 12 were tested in a thorough laboratory weathering

study for the National Park Service by the National Bureau of Standards in 1974 (1, 3, 4). The remaining 12 products were selected because of their current or former use in the NPS system (5) or because of their potentially favorable properties. Each chemical product is listed below.

National Bureau of Standards Tested Chemicals

1. Adobe Seal Formula 325. A sodium methyl siliconate at 31% solids in water solvent, purchased from Research and Development Laboratories, P. O. Box 4561, Tucson, Arizona 85717. Telephone No. 602/795-1092.

2. Soil Seal Concentrate. A plastic emulsion at 46% solids in water. Purchased from Soil Seal Corporation, 600 S. Harvard, Los Angeles, California 90005.

3. Rhoplex E-330. An acrylic resin emulsion at 47% solids in water. Purchased from Rohm and Haas Company, 1930 S. Tubeway, Commerce, California 90040. Telephone No. 213/722-5434.

4. Thompson's Water Seal. A copolycarvitol at 10% solids in aniline solvent. Purchased from E. A. Thompson Company, Inc., 1333 Gough, San Francisco, Californai 94109. Telephone No. 415/346-8610.

5. Versacryl "E" No. 90, Transparent Exterior Sealer. A methyl methacrylate emulsion at 20% solids in water. Purchased from Applied Polymers of America, R-210 Delaware Avenue, Clifton, New Jersey, 07014. Telephone No. 201/473-4640.

6. K & E Penetrating and Hardening Mineral Sealer. An aqueous solution of inorganic mineral salts at 30% solids. Purchased from K & E Chemical Company, 16810 Miles Avenue, Cleveland, Ohio 44128. Telephone No. 216/751-9233.

7. Mo-Clear Natural Clear Coating. A modified acrylic at 15% solids in aromatic solvent. Purchased from National Coatings Corp., Ohio and Murray Avenues, Atlantic City, New Jersey 08401. Telephone No. 609/345-2186.

8. Acriseal. A methyl methacrylate at 15% solids in Xylol and mineral spirits solvent. Purchased from Aztec Sales Associates, P. O. Box 6608, Bridgewater, New Jersey 08807. Telephone No. 201/526-8990.

9. Linseed Oil. Commercial grade. Purchased at common hardware store.

10. Raylite D-36. A polyisobutyl methacrylate at 36% solids in aromatic solvent. Purchased from Raylite Company, P. O. Box 7218, Wilmington, Delaware 19803. Telephone No. 302/652-3904.

11. R-20 Silicone. Sodium Methyl Silonate at 20% solids in water. Purchased from Union Carbide Corp., 1 University Plaza, Hackensack, New Jersey, 07601. Telephone No. 201/646-1111, Ext. 303.

12. Re-280 Silicone. A methyl silicone emulsion at 40% solids in water. (Same source as 11.)

Additional Chemicals Selected

13. Pencapsula. A polyurethane resin at 90% solids in mineral spirits. Purchased from Texas Refinery Corp., 1019 Pampas Drive S.E., Albuquerque, New Mexico 87018. Telephone No. 505/256-0666.

14. Acryl 60. An acrylic emulsion at 28% solids in water. Purchased from Standard Dry Wall Products, Inc., Newark, California 94560. Telephone No. 415/796-9911.

15. Thoro-Clear 777. A silicone at 5% solids in organic solvent. (Same source as 14.)

16. Concrete Hardener and Sealer No. 10. An acrylic at 16% solids in aromatic solvent. Purchased from Camp Company, 9300 S. Sangamon Street, Chicago, Illinois 60620. Telephone No. 312/779-4900.

17. Aqua-Pel. A silicone at 5% solids in aromatic solvent. (Source same as 16.)

18. Daraweld-C. A high polymer resin emulsion at 51% solids in water. Purchased from W. R. Grace & Company, Construction Products Division, Cambridge 40, Massachusetts.

19. Okon Adobe Mix and Waterproofing. A new experimental acrylic resin in water. Purchased from Okon, Inc., 6000 W. 13th Ave., Lakewood, Colorado 80214. Telephone No. 303/232-3571.

20. Okon W-2. An acrylic resin emulsion at 10% solids in water. (Source same as 19.)

21. Okon S-2. A blend of waterproofing resins in hydrocarbon solvent at 10% solids. (Source same as 19.)

22. Durak. Basic material is Rhoplex E-330 (product #3) plus additives. An aqueous emulsion with 47% solids. Purchased from Masonry Systems International, 600 S. Cherry, Denver, Colorado 80222. Telephone No. 303/320-5800.

23. Sarabond. A saran latex emulsion at 47% solids in water. (Source same as 22.)

24. TACSS T-060. A water reactive grout system that can be spray-applied and will polymerize upon contact with soil water. Purchased from Air Frame Manufacturing and Supply Company, Inc., 7407 Fulton Avenue, North Hollywood, California 91605. Telephone No. 213/875-2094.

Treatment Plot Design

Figure 1 shows the configuration of the test walls built under the supervision of Mr. George Duran of the Fort Bowie maintenance staff and the treatment plots assigned to the 24 selected chemicals in this first phase of the study. The walls were built on a concrete foundation. All adobe blocks were handmade at the site by Mr. Duran and staff. The stabilized adobe were made by using the selected chemical at a dilution of 10%

solids to mix the mud. Tap water was used in making the untreated adobe. The mortar used to lay up both the treatment and untreated walls was unamended.

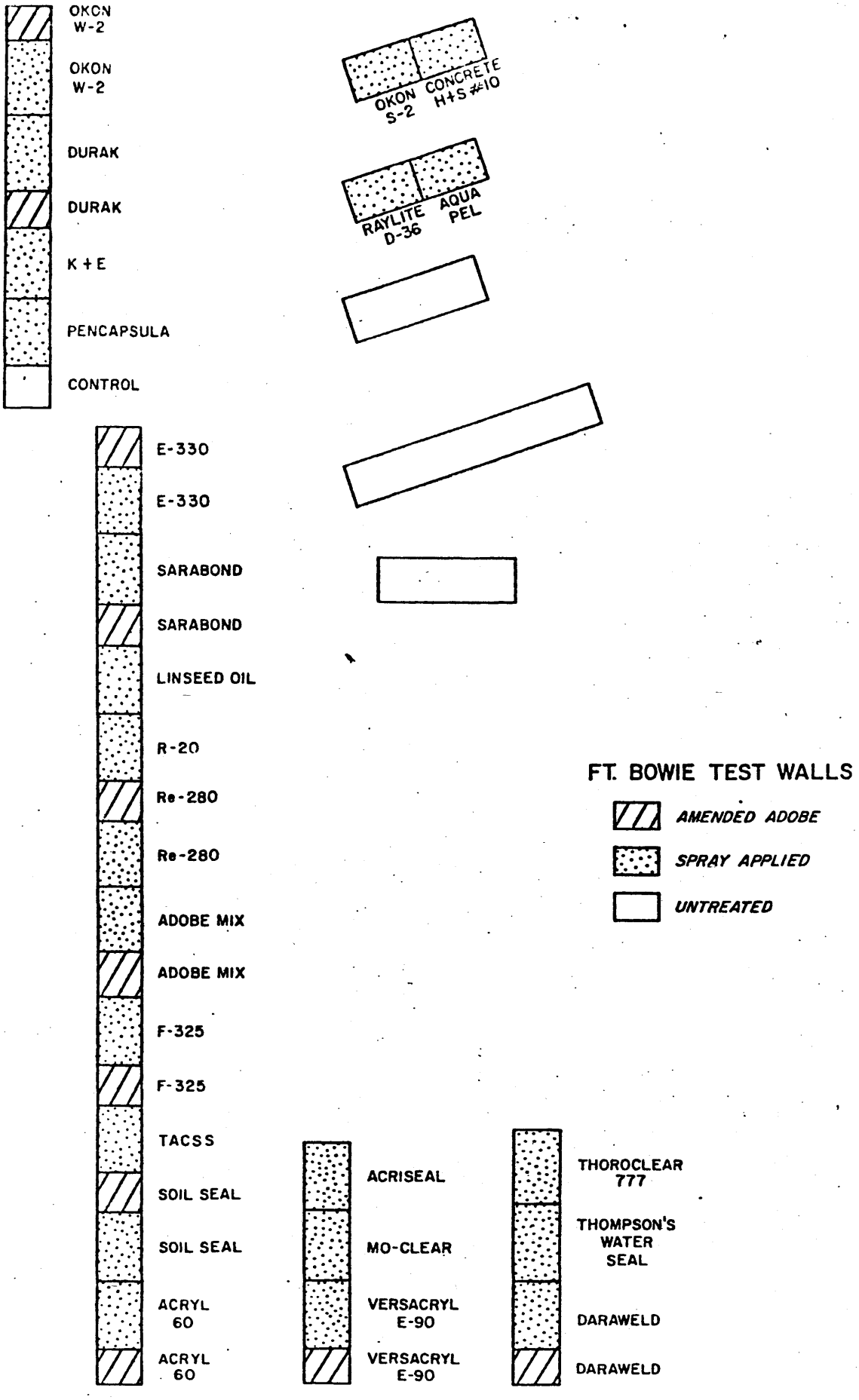

FIGURE 1: ADOBE TEST WALLS

Eleven of the chemicals were used to make stabilized adobe. The locations of the wall sections built from the stabilized adobe for each chemical are shown in Figure 1. All 24 chemicals were spray-applied to treatment plots on the walls. Both faces and the top of the wall were sprayed. A total of three gallons of chemical at 10% solids miximum (some chemicals are marketed at only 5% solids) was spray-applied to each treatment plot.

Observations

Amended Adobe

Earlier work in Chaco Canyon National Monument has shown that hydrocarbon solvent based materials do not form stable, binding mortar or adobe. (2) The organic solvent molecules cause the clay particles to flocculate and settle out of suspension rather than coating the sand particles and forming a stable bond upon drying. Therefore, only the 13 water-based products were selected for making stabilized adobe, with the addition of pencapsula, which was also utilized for amended adobe production based upon the manufacturers' recommendation.

Three of the products tested failed to produce a stable adobe block, namely Union Carbide R-20, which produced a badly-cracked and unstable block; K & E Penetrating and Hardening Mineral Sealer, which produced a very soft, granular, friable block that could be easily crushed; and pencapsula, which formed a badly cracked and unstable block. The remaining 11 products produced workable adobe blocks and test plots were constructed from each, as outlined in Figure 1 and shown in Figures 2 - 12.

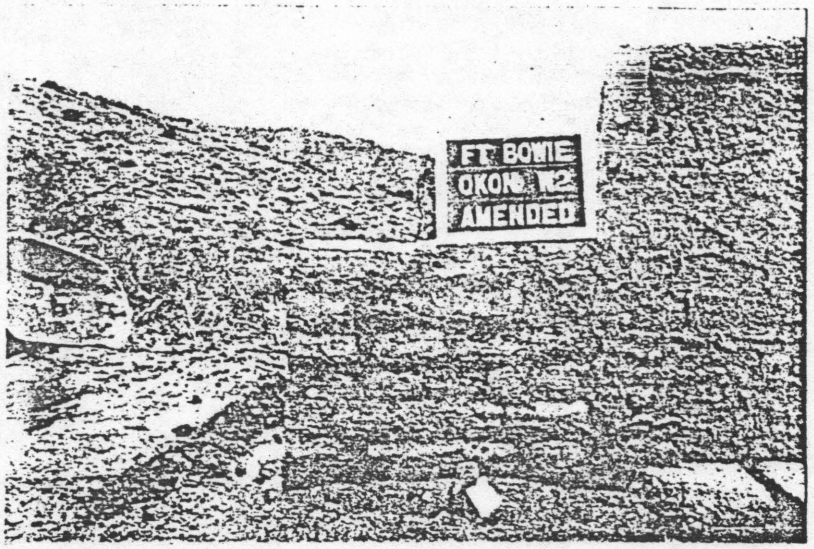

Figure 2: Okon W-2 amended adobe

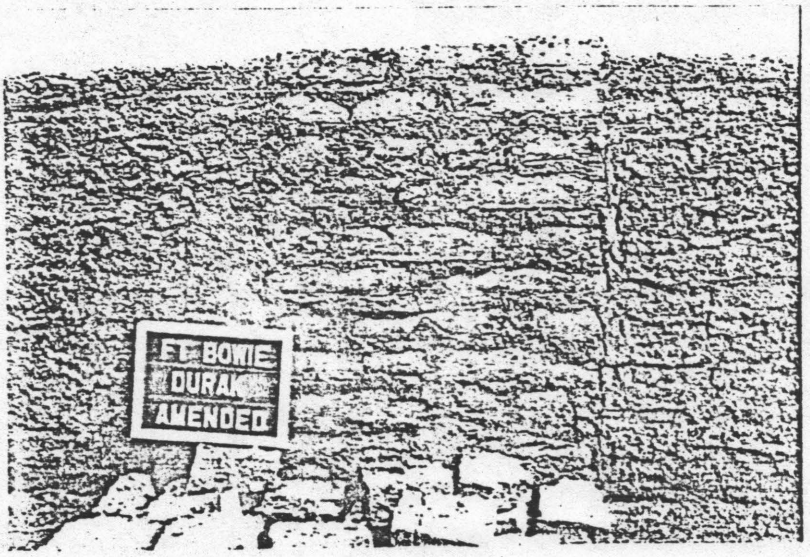

Figure 3: Durak amended adobe

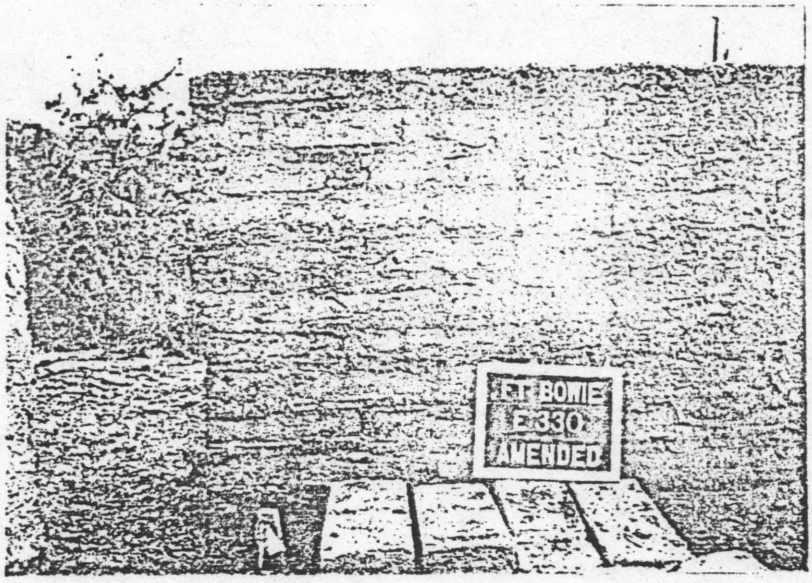

Figure 4: Rhoplex E-330 amended adobe

Figure 5: Sarabond amended adobe

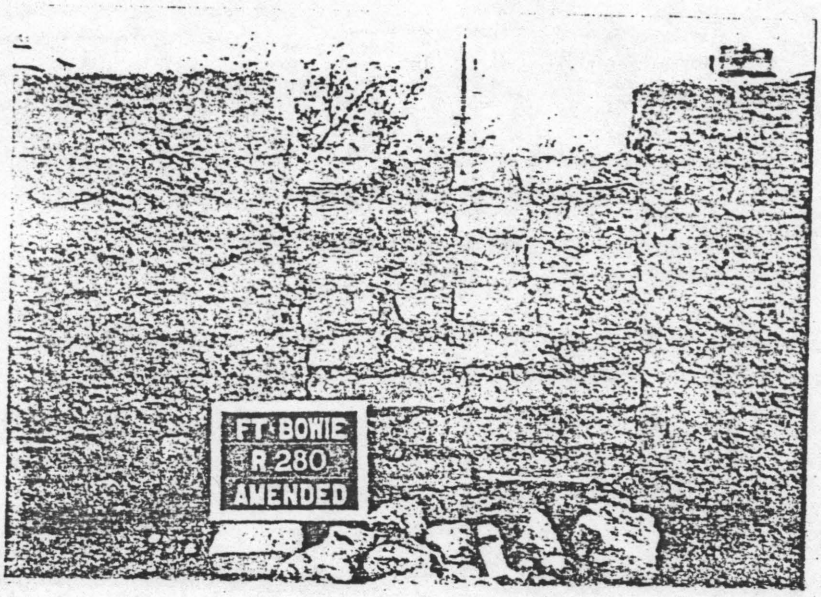

Figure 6: Union Carbide Re-280 amended adobe

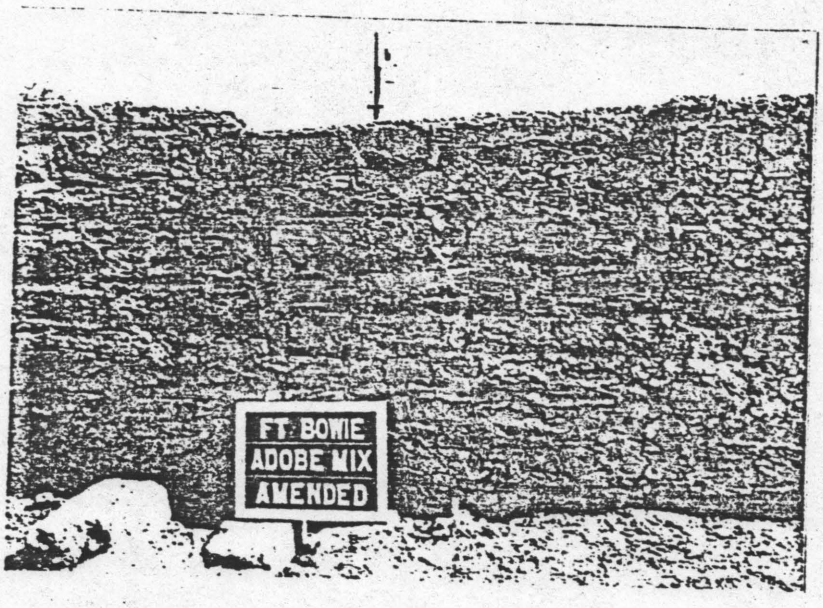

Figure 7: Okon adobe mix amended adobe

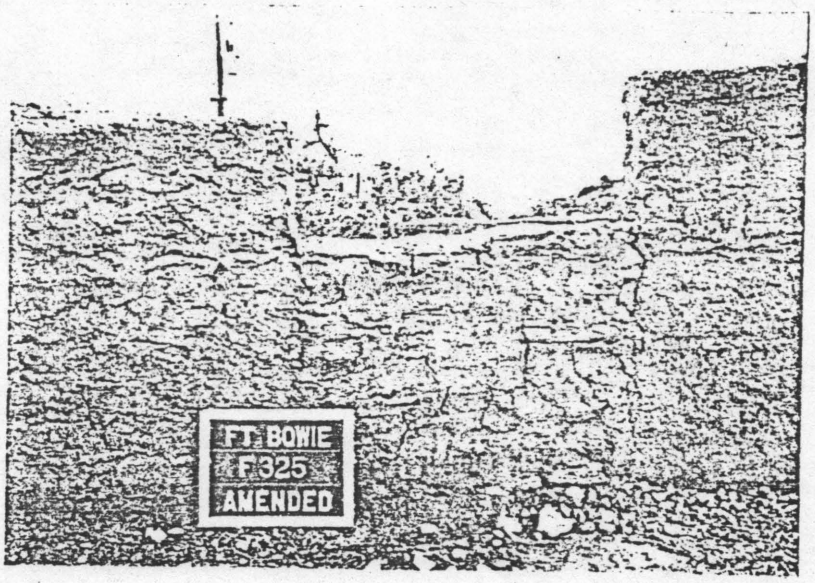

Figure 8: Adobe seal F-325 amended adobe

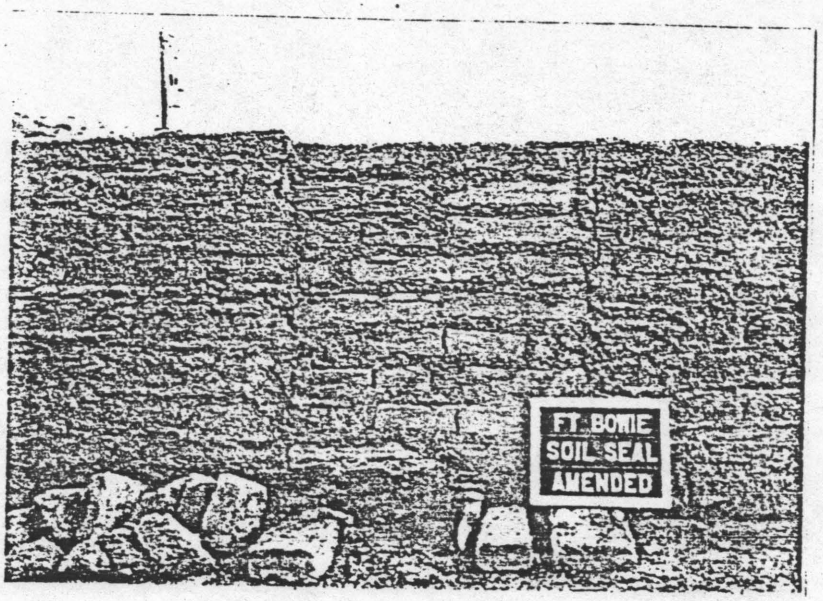

Figure 9: Soil seal amended adobe

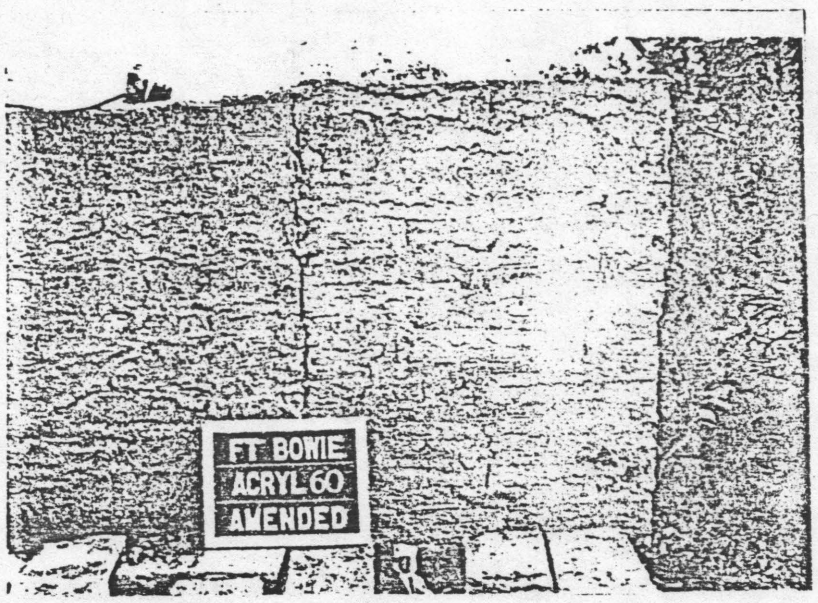

Figure 10: Acryl 60 amended adobe

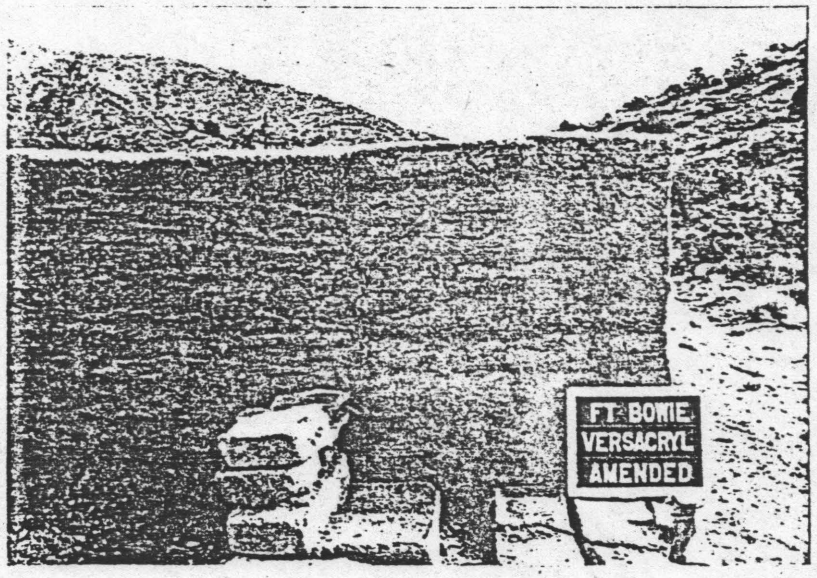

Figure 11: Versacryl "E" No. 90 amended adobe

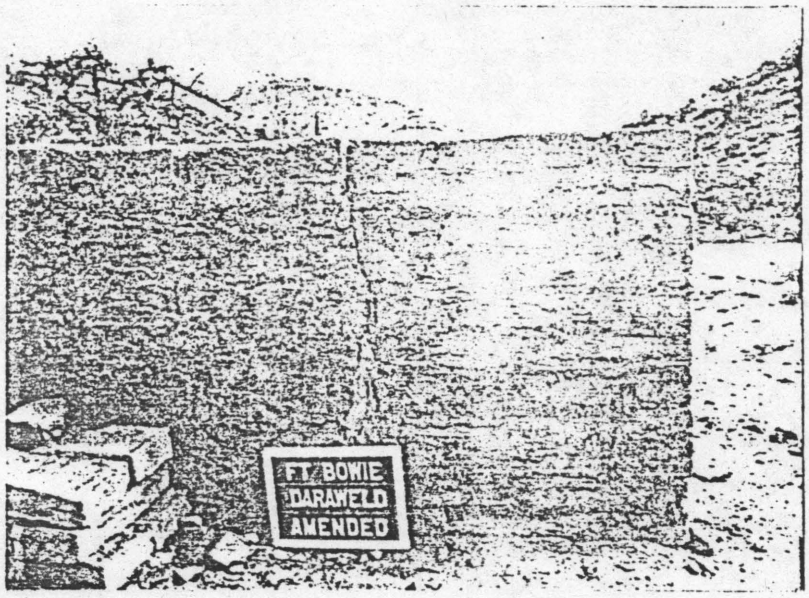

Figure 12: Daraweld amended adobe

Spray Treatments

Most of the chemicals caused a darkening of the adobe when spray-applied. The degree of darkening varied greatly from chemical to chemical. Badly discoloring the adobe were Pencapsula, TACSS, linseed oil, Sarabard, Soil Seal, Acryl 60, Acriseal, Thompson's Water Seal and Raylite D-36. Moderate, asthetically unacceptable darkening occurred with Okon W-2, Durak, K & E, E-330, Re-280, Adobe Mix, Versacryl "E" 90, Mo-Clear, Daraweld, Thoro-Clear 777, Okon S-2. Slight discoloration occurred with Aqua-pel. No noticeable discoloration occurred with Concrete Hardener and Sealer #10. Figures 13 - 15 demonstrate the relative degrees of darkening ranging from serious (Fig. 13) to moderate (Fig. 14) to no discoloration (Fig. 15).

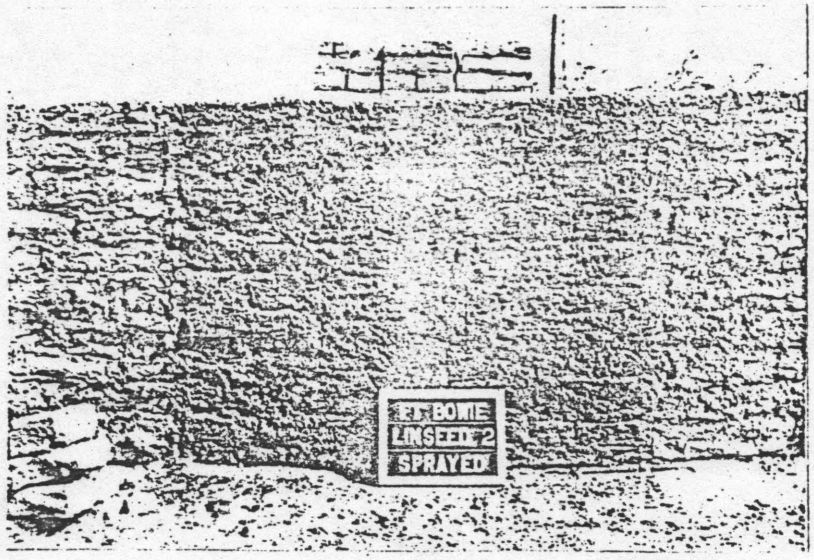

Figure 13: Serious discoloration of adobe by treatment

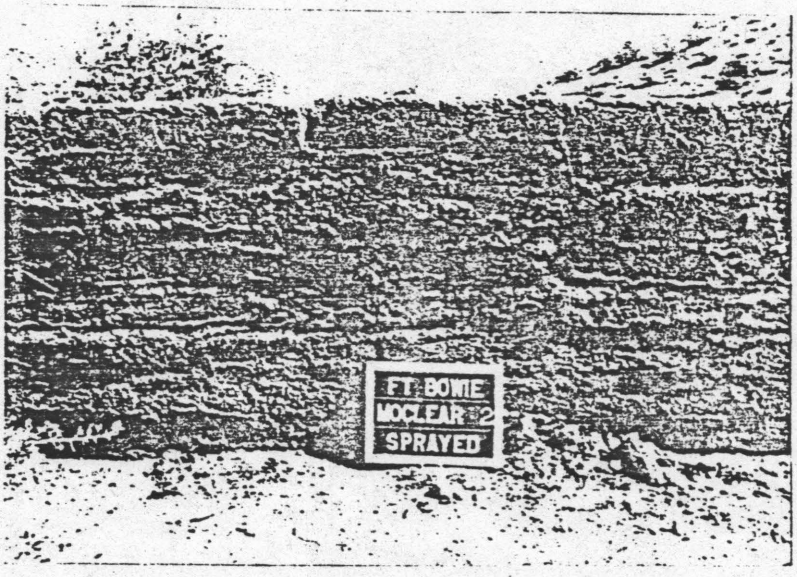

Figure 14: Moderate discoloration of adobe by treatment

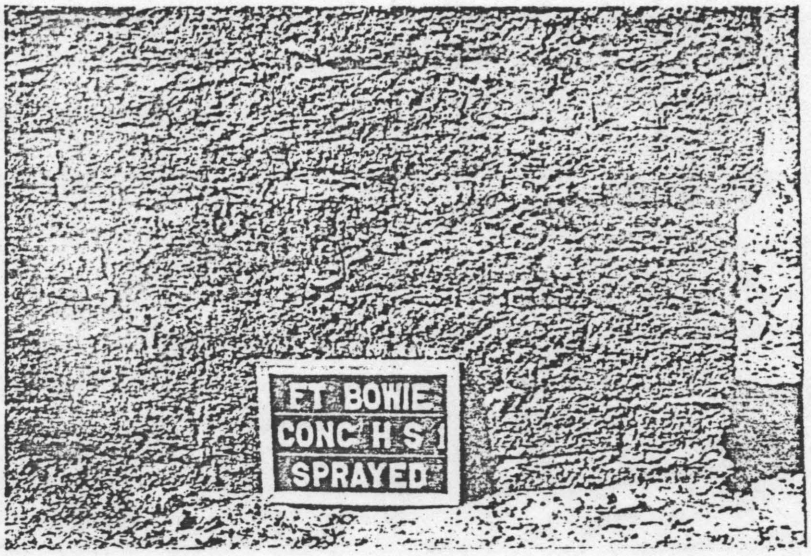

Figure 15: No discoloration of adobe by treatment

The depth of penetration of the products was tested after the spray plots had dried. It was found that most of the products formed a thin surface film on the adobe blocks. Penetration was about 1mm. Figures 16 and 17 graphically illustrate this fact. In Figure 16, the thin surface film is clearly shown. Figure 17 shows the surface film pealed away and the untreated adobe just below the surface. The lack of penetration is an indication that these spray treatments will have a relatively short effective life.

Future Work

Work to be done in the near future includes the installation of a complete environmental monitoring station to gather supporting data for the study.

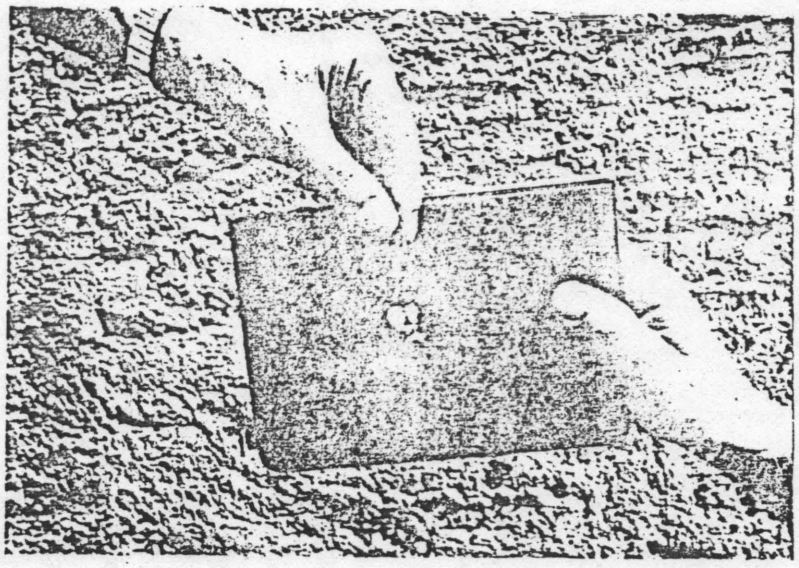

Figure 16: Thin surface film formed by spray treatment

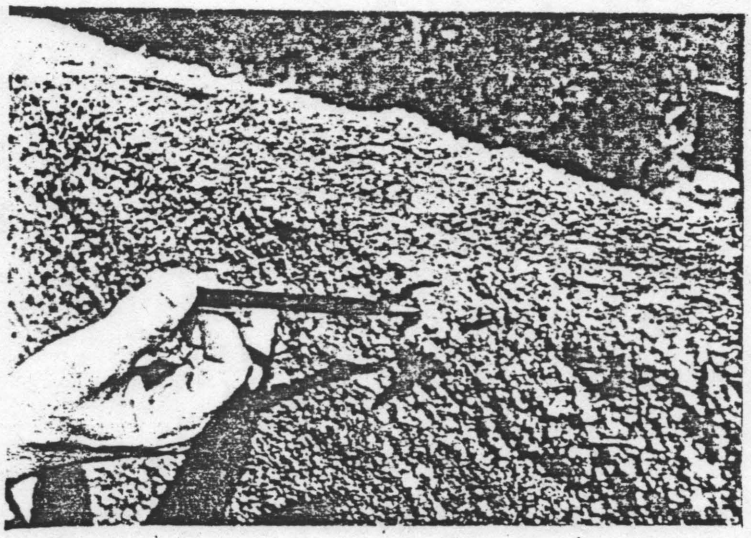

Figure 17: Untreated adobe just beneath surface film

This station, manufactured by Weather Measure Corporation, will monitor air temperature, rainfall, solar radiation, wind velocity, wind direction and relative humidity.

Forty linear feet of untreated wall remain at the site and will be used to expand the study as new products are developed or come to our attention.

The treatment areas will be monitored over the coming months for durability and effectiveness. Laboratory research will be conducted at the Western Archeological Center to support the field trials.

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1. Clark, E. J., P. G. Campbell and G. Frohnsdorff. 1975. Waterproofing Materials for Masonry. National Bureau of Standards, Washington, D.C. 78 p.

2. Fenn, D. B. 1976. First Annual Report: Chemical Stabilization of Prehistoric Structures at Chaco Canyon National Monument. Unpublished National Park Service Report. Western Archeological Center, Tucson, Arizona. 27 p.

3. Sleater, G. A. 1976. Stone Preservatives: Methods of Laboratory Testing and Preliminary Performance Criteria (draft). National Bureau of Standards, Washington D.C. 77 p.

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Initial Report

Mud Plaster Preservation Research

Bent's Old Fort National Historic Site

by

Dennis B. Fenn

Research Scientist

Western Archeological Center

July 15, 1977

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INTRODUCTION

Bent's Old Fort was totally reconstructed in 1975-76 utilizing local soil sources in the manufacture of adobe blocks and surface plaster. The local soils contain a high percentage of very fine sand and silt as is common throughout the plains region. This fine textured soil is very susceptable to erosion and has a low sheer strength when moist. These properties combined with the frequent high winds, hard rains, and dust storms that strike the Bent's Fort region, produce heavy erosion damage to the Fort exterior.

The high cost of maintenance labor and the speed at which the mud plaster deteriorates on the Fort walls made it very important that a research project be initiated to find suitable, economical methods of reducing the erodibility of the mud plaster. A coordinated project involving practical adobe experience, field study, and laboratory research seemed to be the most promising approach.

The objectives of this study are to investigate the usefulness of selected chemical plaster amendments in reducing surface erosion, to compare the effectiveness of surface spray applications versus integral amendment techniques, and to determine the important procedures and methods to utilize in successfully applying chemical methods of plaster preservation.

Selection of a Soil Source

Eleven Bent's Fort area soils were sampled and analyzed for particle size distribution and sand sieve separates. Tables 1 and 2 list the analysis results. An optimum adobe soil should have about 65-70% sand, 20-25% non-swelling clay, and 5-15% silt.

None of the soils tested proved to be satisfactory for use in the field study. Sample number 7, the material used in the reconstruction of the Fort, contains nearly optimum levels of sand, silt, and clay, but as Table 2 shows, its sand fraction is mostly medium fine to very fine in size. A good adobe soil should contain predominately medium to very coarse sized sand particles.

After studying the analytical results shown in Tables 1 and 2, it was decided to manufacture a "soil" for use in this research. Mr. John R. Vincent of the New Mexico Arts Commission, a well known practical adobe and mud plaster artison, was vitally involved in the development of a suitable soil source for this Bent's Fort project.

The "soil" finally chosen for use in this study was manufactured on site by the mixing of washed masonry sand and refined kaolin clay materials. The recipe used was 9.9 pounds Valley Concrete Company masonry sand, 8.4 pounds A. P. Green Refactory Company Apache red No. 9 clay, 8.4 pounds A. P. Green Refactory Company fireclay, 4.3 pounds Georgia Kaolin Company kaolnite, 0.4 pounds Smith No. 1505 brown mortar color, 0.8 pounds wheat straw, and 0.1 pounds Ivory Snow soap flakes.

The "soil" recipe developed for this study was also recommended for use in the cyclic maintenance program at Bent's Old Fort and is being used to repair erosion damage on the exterior of the Fort.

TABLE 1: Particle size analysis of selected Bent's Fort area soils.

Sample	Description	% Sand	% Salt	% Clay
1	Arroyo 5.9 miles east of La Junta out 6th Street	42	33	25
2	Wash east of Pueblo, east of fountain, south of highway	1	49	50
3	East of La Junta, west of Arroyo where 1 was taken	13	37	50
4	Access road, west side of historic area of Bent's Old Fort	39	33	28
5	Original adobe material taken from wall remnant, Bent's Old Fort	64	25	11
6	Old river channel, 120 yards south of old stone arch, Bent's Old Fort	26	34	40
7	Sample of adobe soil used on Bent's Old Fort walls during reconstruction	62	18	20
8	Interior plaster used during reconstruction of Bent's Old Fort	77	8	15
9	Strasburg Adobe Block	68	15	17
10	Reed Adobe Block	44	21	35
11	Flood plain of Arkansas River east of Bent's Old Fort	100	0	0

TABLE 2: Sand sieve analysis, selected Bent's Fort area soils.

Sample	% Of Soil Larger Than Sieve Number						
	10	18	20	35	120	140	<140
1	0	0.2	0.1	1.4	30.8	3.3	6.2
2	0	0	0	0	.8	.2	0
3	0	0.1	0.1	0.3	2.4	0.9	9.2
4	4.4	1.8	0.5	2.4	15.8	2.6	11.5
5	3.0	2.9	1.1	6.0	25.4	5.8	19.8
6	0	0.4	0.2	1.0	7.1	1.8	15.5
7	1.4	1.2	0.2	4.0	36.8	3.4	15.0
8	8.2	13.2	4.0	15.0	36.1	2.1	0
9	2.5	6.1	3.3	17.2	35.4	1.4	2.1
10	6.6	6.1	2.4	9.3	19.2	1.4	0
11	9.7	28.8	9.7	28.7	22.8	0.1	0.2
Sand size class	very coarse	coarse	medium	medium	medium fine	fine	very fine

HEMICALS SELECTED

Thirty-three different chemical products were selected for testing in this project. Twenty-one products were water based emulsions, and twelve products were organic solvent based resins. Each chemical is listed below.

1. Petroset SB. Rubber emulsion at 68% solids in water. Phillips Petroleum Company, P. O. Box 3090, Borger, Texas 79007 (Telephone 918/661-6197).

2. Sonocrete. Polyvinyl Acetate resin emulsion at 50% solids in water. Sonneborn-Contech, Inc., 7711 Computer Avenue, Minneapolis, Minnesota 55435 (Telephone 612/835-3434).

3. Aerospray 70. Polyvinyl Acetate resin emulsion at 60% solids in water. American Cyanamid Company, Industrial Chemicals and Plastics Division, Wayne, New Jersey 07470 (Telephone 201/831-1234).

4. Aerospray 52. Alkyde resin emulsion at 48% solids in water. Same source as No. 3.

5. Versacryl "E" No. 90. A methyl methacrylate emulsion at 20% solids in water. Applied Polymers of America, R-210 Delaware Avenue, Clifton, New Jersey 07014 (Telephone 201/473-4640).

6. R-20 Silicone. Sodium Methyl Silonate at 20% solids in water. Union Carbide Corp., 1 University Plaza, Hackensack, New Jersey 07601 (Telephone 201/646-1111, Ext. 303).

7. Rhoplex E-330. Acrylic resin emulsion at 47% solids in water. Rohm and Haas Company, 1930 S. Tubeway, Commerce, California 90040 (Telephone 213/722-5434).

8. Rhoplex AC-61. Acrylic resin emulsion at 47% solids in water. Same source as No. 7.

9. Rhoplex AC-634. Acrylic resin emulsion at 47% solids in water. Same source as No. 7.

10. Rhoplex SS-521. Acrylic resin emulsion at 50% solids in water. Same source as No. 7.

11. Rhoplex MC-76. Acrylic resin emulsion at 47% solids in water. Special small molecule formulation of E-330 for use in spray applications. Same as No. 7.

12. Okon W-2. Acrylic resin emulsion at 10% solids in water. Okon, Inc., 6000 W. 13th Avenue, Lakewood, Colorado 80214 (Telephone 303/232-3571).

13. Okon Adobe Mix and Waterproofing. Experimental acrylic resin at 40% solids in water. Same source as No. 12.

14. Acryl 60. Acrylic emulsion at 28% solids in water. Standard Dry Wall Products, Inc., Newark, California 94560 (Telephone 415/796-9911).

15. Soil Seal Concentrate. Plastic emulsion at 46% solids in water. Soil Seal Corporation, 600 S. Harvard, Los Angeles, California 90005.

16. Daraweld-C. A high polymer resin emulsion at 51% solids in water. W. R. Grace and Company, Construction Products Division, Cambridge, Massachusetts 02140.

17. Sarabond. Saran latex emulsion at 47% solids in water. Masonry Systems International, 600 S. Cherry, Denver, Colorado 80222 (Telephone 303/320-5800).

18. Durak. Basic material is Rhoplex E-330 (product #3) plus additives at 47% solids in water. Source same as No. 17.

19. Rhoplex E-1141. Experimental acrylic resin emulsion at 37% solids in water. Source same as No. 7.

20. Primal 863. Acrylic resin emulsion at 35% solids in water. Source same as No. 7.

21. Acryloid A-21. Acrylic ester resin at 30% solids in toluene. Same source as No. 7.

22. Thompson's Water Seal. Copolycarvitol at 10% solids in aniline. E. A. Thompson Company, Inc., 1333 Gough, San Francisco, California 94109 (Telephone 415/346-8610).

23. Acriseal. Methyl methacrylate at 15% solids in Xylol and mineral spirits. Aztec Sales Associates, P. O. Box 6608, Bridgewater, New Jersey 08807 (Telephone 201/526-8990).

24. K & E Penetrating and Hardening Mineral Sealer. A solution of inorganic mineral salts at 30% solids in water. K & E Chemical Company, 16810 Miles Avenue, Cleveland, Ohio 44128 (Telephone 216/751-9233).

25. Okon S-2. A blend of waterproofing resins at 10% solids in hydrocarbon solvent. Source same as No. 12.

26. Mo-Clear Natural Clear Coating. Modified acrylic at 15% solids in aromatic hydrocarbon solvent. National Coatings Corp., Ohio and Murray Avenues, Atlantic City, New Jersey 08401 (Telephone 609/345-2186).

27. Pencapsula. Polyurethane resin at 90% solids in mineral spirits. Texas Refinery Corp., 1019 Pampas Drive S.E., Albuquerque, New Mexico 87018 (Telephone 505/256-0666).

28. Concrete Hardener and Sealer No. 10. Acrylic resin at 16% solids in aromatic hydrocarbon solvent. Camp Company, 9300 S. Sangamon Street, Chicago, Illinois 60620 (Telephone 312/779-4900).

29. Aqua-Pel. Silicone resin at 5% solids in aromatic hydrocarbon solvent. Source same as No. 28.

30. Thoro-Clear 777. Silicone resin at 5% solids hydrocarbon solvent. Source same as No. 14.

31. Adobe Seal Formula 325. Sodium methyl siliconate at 31% solids in water. Research and Development Laboratories, P. O. Box 4561, Tucson, Arizona 85717 (Telephone 602/795-1092).

32. Hydrozo Special Clear. Hydrozite gum at 15% solids in mineral spirits. Hydrozo Coatings Company, 855 West Street, Lincoln, Nebraska 68501 (Telephone 402/477-6981).

33. Linseed Oil. Commercial grade. Purchased at common hardware store.

Treatment Plot Design

The west-facing, exterior wall of the corral at the rear of Bent's Old Fort was chosen as the location of the test plots. The six foot high wall runs north-south and is 163 feet and 3 inches in length. The location was chosen because of its ideal size and lack of visibility from on or within walls of the Fort.

Table 3 gives the specific location of each treatment plot on the wall. All measurements were taken from a standard reference point located at the southern most edge of study wall.

Treatment Plot Establishment

Figure 1 shows the method used to establish the treatments on 34 of the plots. These plots are all chemically amended mortar plots.

TABLE 3: Location of treatment plots, measured from south end of study wall.

Plot No.	Treatment, % Solids	Plot Location
1	Control No. 1,	0 - 3'7"
2	Petroset SB, 10%	3'7" - 6'6"
3	Sonocrete, 10%	6'6" - 9'7"
4	Aerospray 52, 10%	9'7" - 12'9"
5	Aerospray 70, 10%	12'9" - 15'6"
6	Versacryl E #90, 10%	15'6" - 19'1"
7	R-20, 10%	19'1" - 22'
8	Rhoplex E-330, 10%	22' - 25'
9	Rhoplex AC-61, 10%	25' - 27'7"
10	Rhoplex AC-634, 10%	27'7" - 31'
11	Rhoplex SS-521, 10%	31' - 34'
12	Rhoplex MC-76, 10%	34' - 37'
13	Okon W-2, 10%	37' - 39'9"
14	Okon Adobe Mix, 10%	39'9" - 42'8"
15	Acryl 60, 10%	42'8" - 46'3"
16	Soil Seal, 10%	46'3" - 49'
17	Daraweld-C, 10%	49' - 52'
18	Sarabond, 10%	52' - 54'8"
19	Durak, 10%	54'8" - 58'
20	Control No. 2	58' - 60'9"
21	Rhoplex E-1141, 10%	60'9" - 63'9"
22	Primal 863, 10%	63'9" - 67'3"
23	Spray, Acryloid A-21, 10%	67'3" - 70'3"

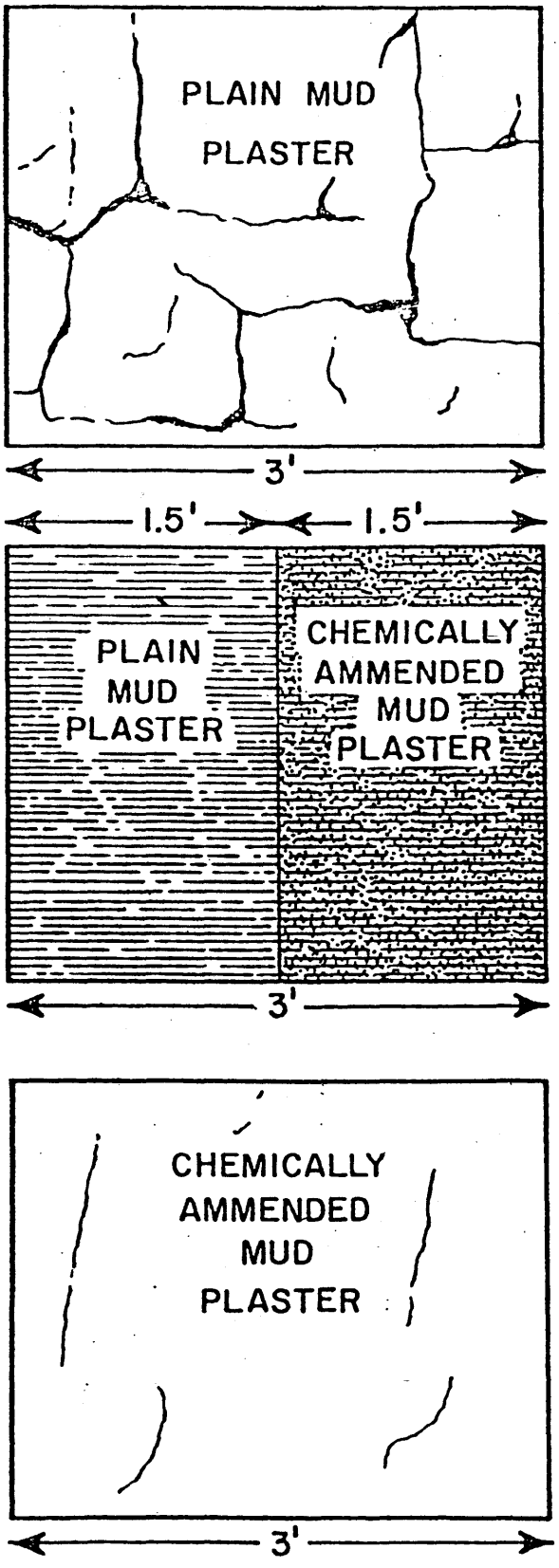
TABLE 3 (Continued-Page 2)

Plot No.	Treatment, % Solids	Plot Location
24	Spray, Thompson's Water Seal, 10%	70'3" - 73'3"
25	Spray, Acriseal, 10%	73'3" - 76'3"
26	Spray, K & E Mineral Sealer, 10%	76'3" - 79'3"
27	Spray, Okon S-2, 10%	79'3" - 82'3"
28	Spray, Mo-Clear Natural Clear, 10%	82'3" - 85'3"
29	Spray, Pencapsula, 10%	85'3" - 88'3"
30	Spray, Concrete Hardener and Sealer No. 10, 10%	88'3" - 91'3"
31	Spray, Aqua-Pel, 5%	91'3" - 94'3"
32	Spray, Thoroclear 777, 5%	94'3" - 97'3"
33	Spray, Adobe Seal F-325, 8:1 dilution	97'3" - 100'3"
34	Spray, Hydrozo Special Clear, 10%	100'3" - 103'3"
35	Spray, Linseed Oil-Turpentine, 1:2 dilution	103'3" - 106'3"
36	Spray, Acryloid A-21, 2%	106'3" - 109'3"
37	Spray, Rhoplex MC-76, 5%	109'3" - 112'3"
38	Spray, Concrete Hardener and Sealer No. 10, 5%	112'3" - 115'2"
39	Control No. 3	115'2" - 118'2"
40	Petroset SB, 5%	118'2" - 121'4"
41	Sonocrete, 5%	121'4" - 124'4"
42	Aerospray 70, 5%	124'4" - 127'3"
43	Aerospray 52, 5%	127'3" - 130'2"
44	Versacryl E #90, 5%	130'2" - 133'4"

TABLE 3 (Continued - Page 3)

Plot No.	Treatment, % Solids	Plot Location
45	Rhoplex E-330, 5%	133'4" - 136'1"
46	Rhoplex AC-61, 5%	136'1" - 139'1"
47	Rhoplex SS-521, 5%	139'1" - 142'1"
48	Rhoplex MC-76, 5%	142'1" - 145'2"
49	Okon Adobe Mix, 5%	145'2" - 148'2"
50	Acryl 60, 5%	148'2" - 151'2"
51	Soil Seal, 5%	151'2" - 154'1"
52	Daraweld-C, 5%	154'1" - 157'1"
53	Durak, 5%	157'1" - 160'4"
54	Control No. 4	160'4" - 163'3"

FIGURE 1: System of applying plaster treatments to Plots 2-19, 21-22 and 40-53.



STEP 1 — REPAIR WALL EROSION

STEP 2- BASE COAT

STEP 3- FINISH COAT

Step 2 of Figure 1 was included in the design to test for ability of a chemically amended plaster to adhere to a previously treated plaster. Some researchers have reported problems with getting plaster to adhere to an older, chemically treated plaster. By splitting the base coat into two parts, one plain mud and the other chemically amended mud, allowing the plot to dry and harden, and then applying the finish coat of Step 3, Figure 1, we can study the ability of a chemically amended plaster to adhere to chemically treated plaster versus plain mud plaster.

This information could be very important in the event that a chemical method of erosion control is adopted for the entire Fort. A method would have serious drawbacks if it should prove difficult to repair patches of erosion on the treated walls at a later date because of poor adhesion.

Treatment plot numbers 23-38 were established differently than the previously discussed plots. With these sixteen plots, only plain mud plaster was applied utilizing three steps similar to those shown in Figure 1. After the finish coat was applied and allowed to dry, the respective chemical treatment for each plot was sprayed onto the wall.

Plots 1, 20, 39, and 54 are control plots. The plaster was applied as with plots 23-38, but no chemical treatments were used. These plots will serve as references for comparing the effectiveness of each chemical treatment in slowing plaster erosion.

Figure 2 shows an overall view of the completed study wall. As can be readily seen, each treatment shows a slightly different color, with some chemicals imparting an unacceptably dark color to the plaster.

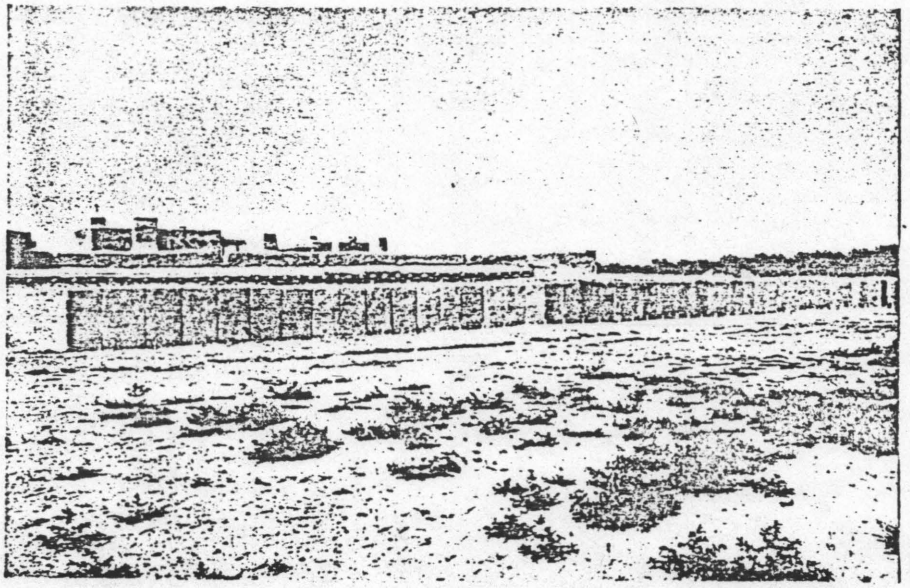


Figure 2: Study wall after completion of treatment applications.

Treatment Observations

Each of the solvent-based spray treatment plots readily absorbed 2.5 gallons of chemical material. No erosion of the plaster was noted with the solvent-based spray treatments.

Three water based chemicals were also sprayed onto treatment plots. Rhoplex MC-76 at 5% solids and Adobe Seal F-325 diluted 1:8 parts both caused serious erosion of the plot surface and only 1.25 gallons of each were applied to the respective plots. K & E Mineral Sealer caused no erosion and 2.5 gallons were readily absorbed by the plot.

The plaster color was affected by most treatments. The majority of the chemicals caused only slight, unobjectionable color shifts. Several, however, dramatically altered the plaster color.

Linseed oil in turpentine, Okon S-2, and Thompson's Water Seal all resulted in a serious darkening of the plaster when sprayed on the wall. Hydrozo caused a moderate darkening of its treatment plot.

With the amended plaster treatments, Union Carbide R-20 at 10% solids caused a very dark brown color as can be seen near the right (south) end of the wall in Figure 2, and also in the close-up of Figure 3.

Aerospray 52 at 10% solids caused a moderate brown color. Petroset SB at 10% solids dried a yellowish brown color. Primal 863 at 10% solids, as shown in Figure 4, caused a serious cracking in the plaster upon drying. The plot was also yellowish in color.

The 5% solids amended mortar treatments were all lighter in color and a closer match to the control plots than the 10% solids treatments. This can be seen in the left (north) end of the wall in Figure 2.

Future Plans

The field plots have now been established, and the effects of weathering will now be monitored over the next year. Any treatments that appear effective after one year's exposure may then be expanded and studied in more detail. Treatments that show rapid failure will be eliminated from consideration.

A thorough laboratory study is being conducted on the effects of the treatments on compressive strength, freeze-thaw resistance, capillarity and erosion resistance. This data will support the results of the field study.

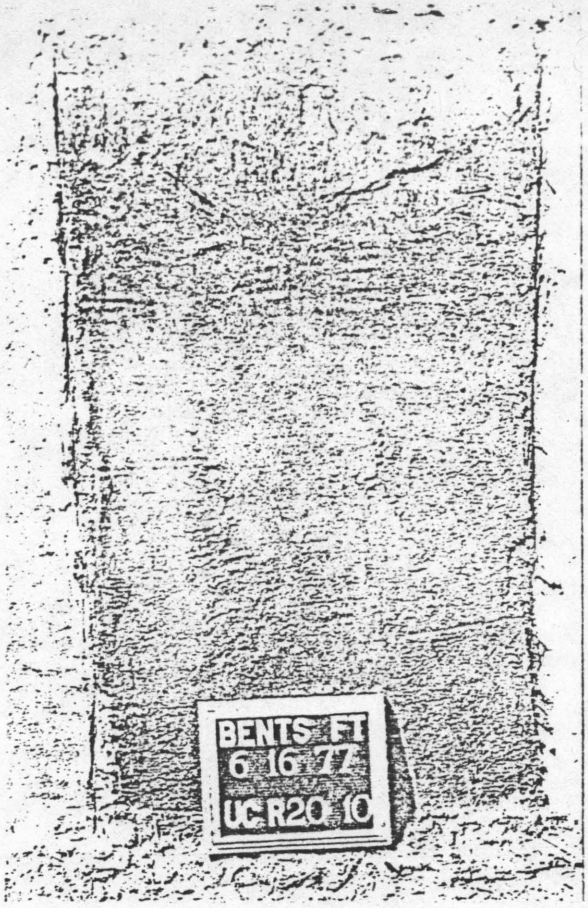


Figure 3: Union Carbide R-20, 10% solids, amended plaster.

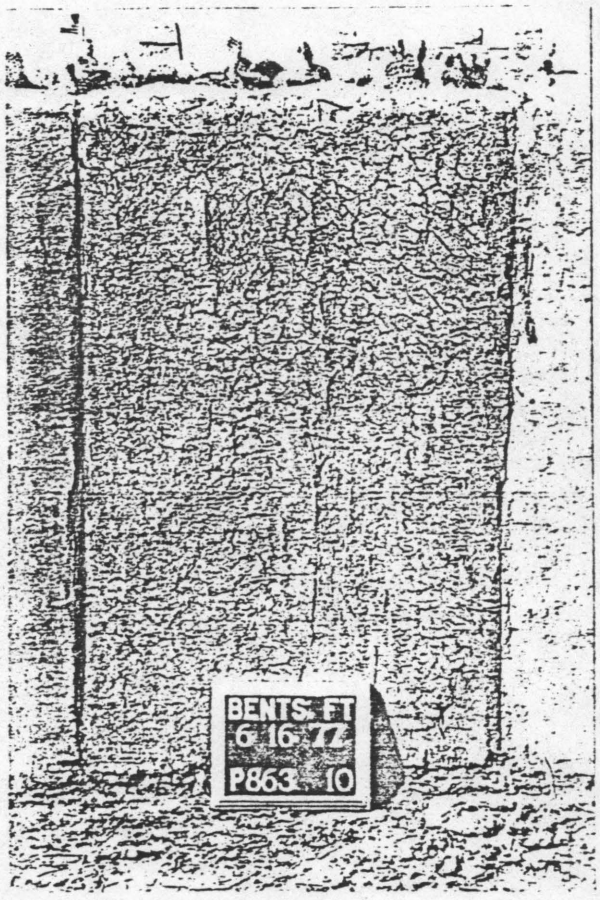


Figure 4: Primal 863, 10% solids, amended plaster.

Second Report

Mud Plaster Preservation Research

Bent's Old Fort National Historic Site

by

Dennis B. Fenn

National Park Service

Western Archeological Center

November 1, 1977

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INTRODUCTION

This research project was initiated during the week of June 13, 1977, in response to the pressing need for a solution to the serious mud-plaster erosion problem that exists at Bent's Old Fort National Historic Site.

The objectives of this study are to investigate the usefulness of selected chemical plaster amendments in reducing surface erosion, to compare the effectiveness of surface spray applications versus integral amendment techniques, and to determine the important procedures and methods to utilize in successfully applying chemical methods of mud-plaster preservation.

The research plots were revisited on October 1, 1977, and each treatment was critically evaluated as to its erosion resistance during the first three and one-half months of exposure.

The erosive potential that existed during the three and one-half months of exposure is demonstrated by the rainfall record for August, 1977. August 5, 0.83 inches; August 10, 1.23 inches; August 11, 0.24 inches; August 16, 0.15 inches; August 17, daylong drizzle; August 8, daylong drizzle; August 19, 2.26 inches with 50-mile per hour winds; and August 20, 0.36 inches, totaling 5.13 inches in the first three weeks of August. This amount of rainfall is well above the normal for August at Bent's Old Fort and provided a severe test of treatment effectiveness.

For a complete description of the treatment design and information on each chemical, please refer to the initial report on this study (Fenn, 1977).

Treatment Observations

Black and white photographs were taken and visual observations recorded during the visit to Bent's Old Fort. For the purposes of qualitative analysis, several terms are used herein to describe the erosion status of the plots. "Very little erosion" and "little erosion" refer to treatments that are performing satisfactorily after three and one-half months exposure. "Moderate erosion" refers to treatments that are showing definite erosion, but are still resisting complete failure. The terms "serious erosion" and "very serious erosion" refer to badly eroded plots where the treatments have failed. Figures 1-5 show examples of each erosion status designation.

The four control plots (Nos. 1, 20, 39, and 54) all show very serious erosion losses. This is a good indication of the erosive forces that have been active since the treatment plots were established. These control plots serve as the baseline for determining if any of the chemical treatments have been effective in rendering mud plaster more erosion resistant.

Table 1 summarizes the observations of each plot. By noting the erosion status of each treatment and comparing that status with the appropriate Figure (1-5), one can get an idea of the appearance of the treatment plot on October 1, 1977.

In determining treatment effectiveness it is assumed that plots with an erosion status of "very serious" or "serious" have performed unsatisfactorily. Eleven plots (four control and seven chemicals) showed this result. Plots with an erosion status of "moderate" have performed marginally and will likely fail after a few months of additional exposure. Eleven chemicals showed this result. Plots with an erosion status of "little"

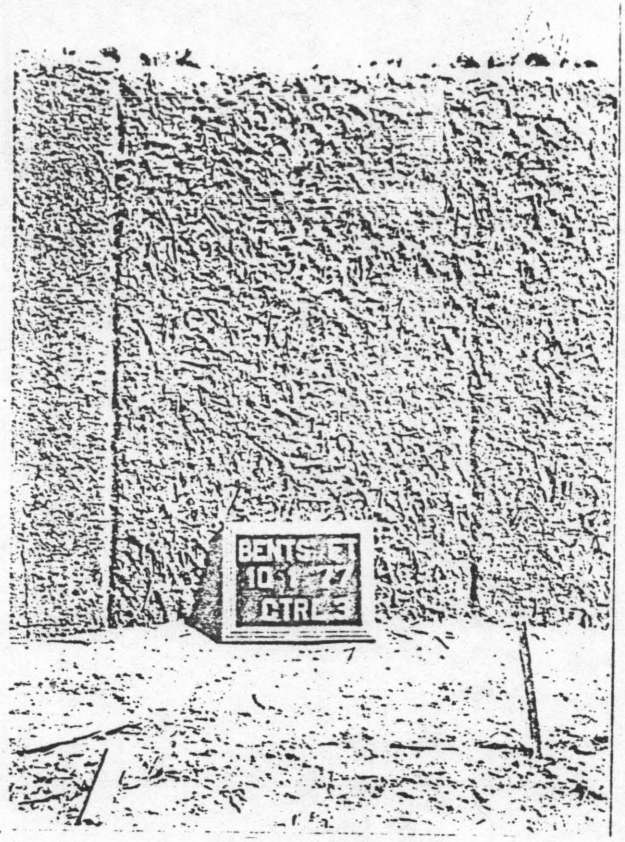


Figure 1: Example of "very serious erosion." Plot 39, Control No.3.

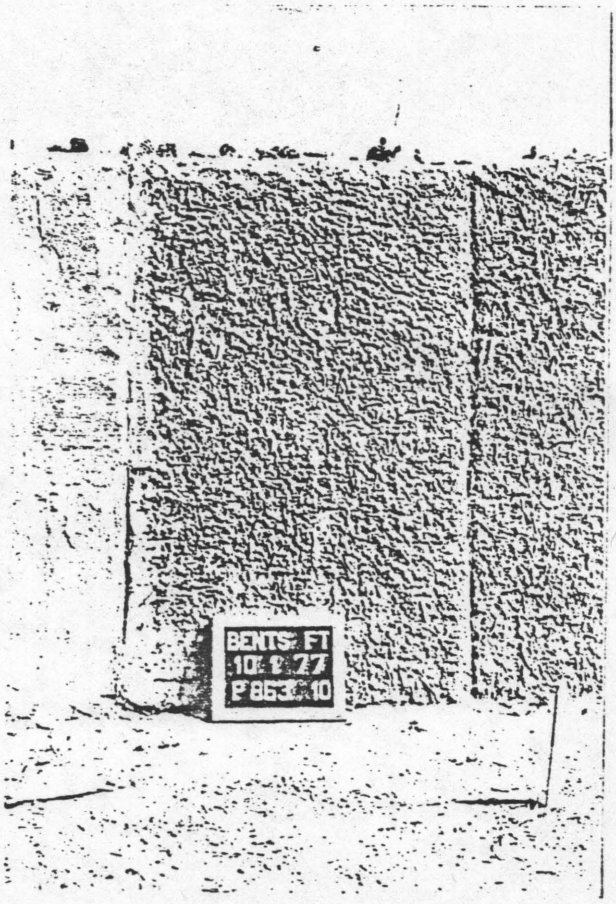


Figure 2: Example of "serious erosion." Plot 22, Primal 863, 10% solids.

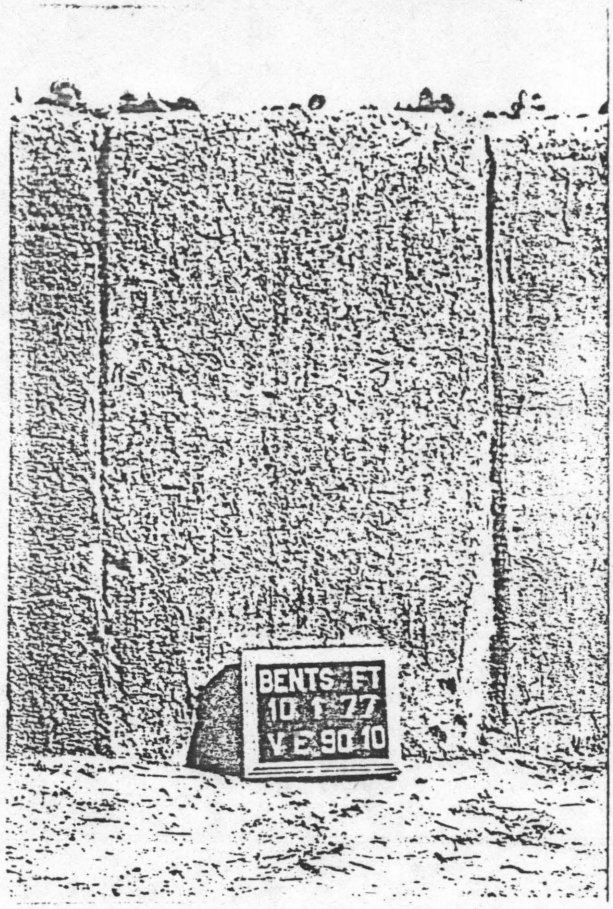


Figure 3: Example of "moderate erosion." Plot 6, Versacryl E No. 90, 10% solids.

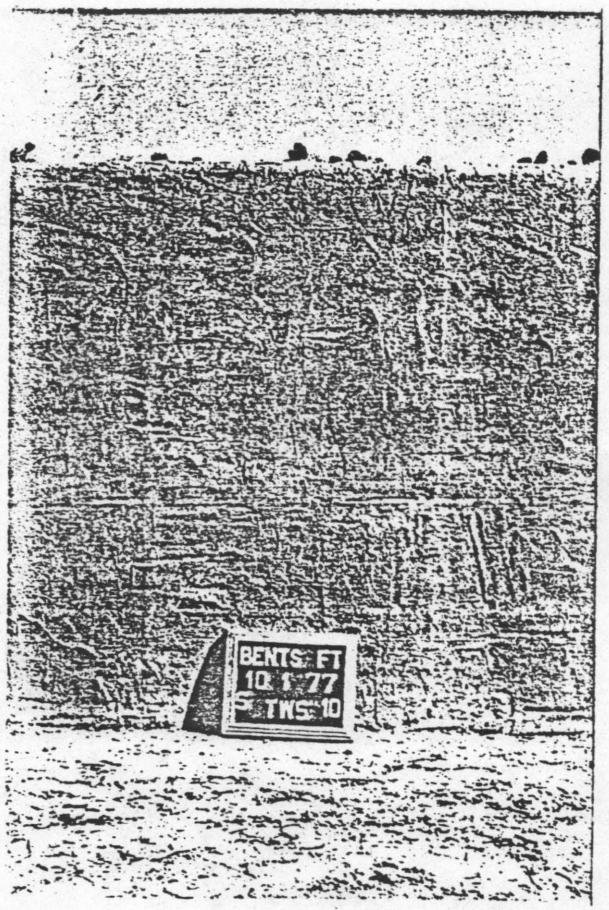


Figure 4: Example of "little erosion." Plot 24, Thompson's Water Seal, 10% solids, spray applied.

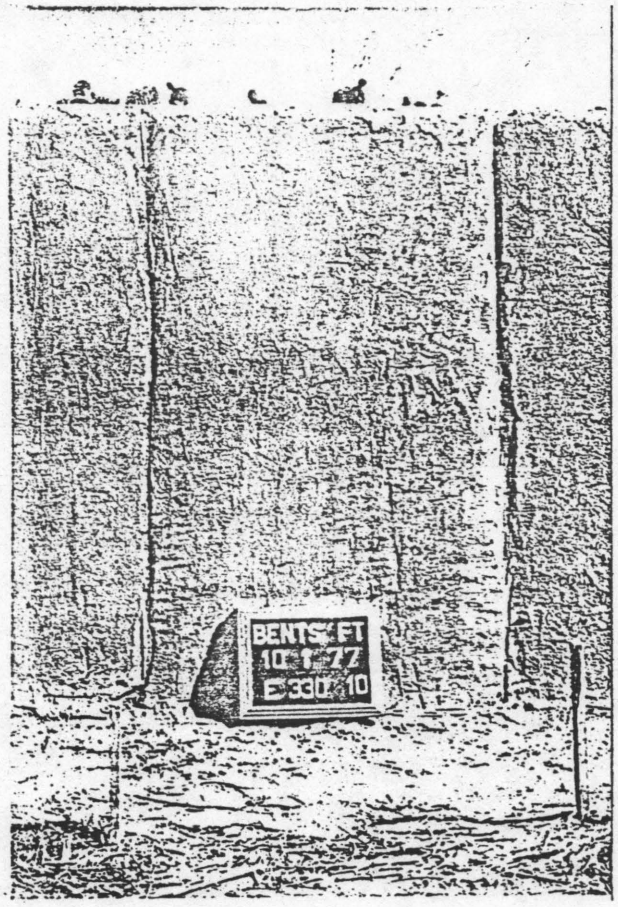


Figure 5: Example of "very little erosion." Plot 8, Rhoplex E-330, 10% solids.

or "very little" have performed satisfactorily and remain resistant to erosive degradation. Thirty-two chemical treatments showed this result. These results are listed by treatment plot in Table 1.

Plot Nos. 23-38 are treatments where the walls were plastered with unamended mud, allowed to air dry, and then the chemical treatment spray applied. Such treatments have not proven too successful on adobe materials in past studies. Thus far in this study, however, only two chemicals are showing any significant erosion, namely, Adobe Seal F325 and Concrete Hardener and Sealer No. 10 at 5% solids. The remaining 14 spray chemicals are still performing well. The exposure time on these treatments is very short, however, and in the past, spray treatments have reportedly held up well for several months or even a few years before suddenly beginning to fail. These plots will be watched with interest over the next several months.

In Figure 1 of the Initial Report (Fenn, 1977), we described the design of the treatment plots to test the ability of the chemically amended mud plaster to adhere to an undercoat of chemically amended plaster. Thus far in this study, there is no evidence of any failure of the plaster due to lack of adhesion of the surface coat to a chemically amended base coat. This result is encouraging if it continues to hold true. If the Fort were treated with chemically amended plaster and later required patching and repair, one would desire the assurance that the repair plaster would adhere to the older amended plaster. The freeze-thaw effects of the winter months could provide a severe test of the interlayer adhesion properties of each amended plaster. This factor will also be watched with interest over the next several months.

Table 1: Observations on the erosion resistance of plots after three and one-half months of exposure.

Plot No.	Treatment, % Solids	Erosion Status
1	Control No. 1 *	Very serious erosion
2	Petroset SB, 10% **	Moderate erosion
3	Sonocrete, 10%	Very little erosion
4	Aerospray 52, 10%	Very little erosion
5	Aerospray 70, 10%	Very little erosion
6	Versacryl E #90, 10% **	Moderate erosion
7	U. C. R-20, 10% **	Moderate erosion, dark color
8	Rhoplex E-330, 10%	Very little erosion
9	Rhoplex AC-61, 10%	Very little erosion
10	Rhoplex AC-634, 10%	Very little erosion
11	Rhoplex SS-521, 10% *	Serious erosion, cracking
12	Rhoplex MC-76, 10%	Very little erosion
13	Okon W-2, 10%	Little erosion
14	Okon Adobe Mix, 10%	Very little erosion
15	Acryl 60, 10%	Very little erosion
16	Soil Seal, 10%	Very little erosion
17	Daraweld-C, 10%	Very little erosion
18	Sarabond, 10% *	Serious erosion
19	Durak, 10%	Little erosion
20	Control No. 2 *	Very serious erosion
21	Rhoplex E-1141, 10% *	Serious erosion

Table 1. Continued

Plot No.	Treatment, % Solids	Erosion Status
24	Spray, Thompson's Water Seal, 10%	Little erosion
25	Spray, Acriseal, 10%	Very little erosion
26	Spray, K & E Mineral Sealer, 10%	Very little erosion
27	Spray, Okon S-2, 10%	Very little erosion, dark color
28	Spray, Mo-Clear Natural Clear 10%	Very little erosion
29	Spray, Pencapsula, 10%	Very little erosion
30	Spray, Concrete Hardener and Sealer No. 10, 10%	Very little erosion
31	Spray, Aqua-Pel, 5%	Very little erosion
32	Spray, Thoroclear 777, 5%	Very little erosion
33	Spray, Adobe Seal F-325,** 8:1 dilution	Moderate erosion, dark color 1
34	Spray, Hydrozo Special Clear, 10%	Very little erosion
35	Spray, Linseed Oil-Turpentine, 1:2 dilution	Very little erosion, dark color
36	Spray, Acryloid A-21, 2%	Very little erosion
37	Spray, Rhoplex MC-76, 5%	Very little erosion[1]
38	Spray, Concrete Hardener and Sealer No. 10, 5% *	Very serious erosion
39	Control No. 3 *	Very serious erosion
40	Petroset SB, 5% **	Moderate erosion
41	Sonocrete, 5%	Little erosion
42	Aerospray 70, 5%	Very little erosion

Table 1. Continued

Plot No.	Treatment, % Solids	Erosion Status
43	Aerospray 52, 5% **	Moderate erosion, cracking
44	Versacryl E #90, 5% **	Moderate erosion
45	Rhoplex E-330, 5%	Little erosion
46	Rhoplex AC-6	Moderate erosion
47	Rhoplex SS-521, 5% *	Serious erosion
48	Rhoplex MC-76, 5%	Little erosion
49	Okon Adobe Mix, 5% **	Moderate erosion
50	Acryl 60, 5% **	Moderate erosion
51	Soil Seal, 5%	Little erosion
52	Daraweld-C, 5% **	Moderate erosion
53	Durak, 5% *	Serious erosion
54	Control No. 4 *	Very serious erosion

[1]Most of the erosion occurred during spray application treatment on June 16, 1977. Some additional erosion has occurred during exposure.

*Products that did not resist erosion and are not recommended for use.

**Products that performed marginally and are not recommended for use.

Conclusions

The three and one-half months exposure time thus far in this study is much too short to allow final conclusions to be drawn as to which chemical products, if any, will satisfactorily improve mud plaster erosion resistance. Some conclusions can be drawn, however, as to which chemical products definitely do not perform satisfactorily. The treatment failures are marked by an * in Table 1. Those products that had a "moderate erosion" status are marginal and are not recommended for use. They are marked by a ** in Table 1.

In general, chemicals used at the 5% solids level in water have performed only marginally well. It can be concluded from these tests that an amended mud plaster will require the chemical to have a concentration of at least 10% solids in water if adequate erosion protection is to be realized.

The treatment plots will be allowed to weather over the winter months and in the spring we will once again visit the site and evaluate the appearance of each plot. Those plots that show complete treatment failure will be replaced by new chemical treatments in a second generation effort to solve this difficult problem of mud plaster erosion protection. A third report will be prepared at that time.

Literature Cited

Fenn, Dennis B., 1977. Initial Report, Mud Plaster Preservation Research, Bent's Old Fort National Historic Site. Unpublished Report. Western Archeological Center, Tucson, Arizona. 10p.

The Solidification of Cement

What happens after water is added to cement to transform it from a soft slurry to a rock-hard mass? Chemical reactions give rise to a system of interlocking particles that knit the material together

by D. D. Double and A. Hellawell

In its commonly accepted sense cement can be described as a finely powdered, calcareous material that, when it is mixed with water, forms a plastic paste that sets and eventually hardens to a rocklike consistency. This much is commonly taken for granted, but what is perhaps not so well appreciated is that the development of strength is the result of chemical reactions between the cement constituents and the added water. The consolidation process occurs by the formation of a rigid interlocking matrix of hydration products, which gradually replace the water between the cement grains and finally bind the composite cement mass together. The processes involved in hydration are quite complex. The purpose of this article is to describe some recently acquired knowledge in this field based on our own studies at the University of Oxford and those of workers elsewhere.

To gain perspective one might recall that the use of cement as an adhesive filler between bricks and stones in the construction of buildings and engineering works is by no means new. Its origins can be traced back to early Egyptian and Greek times. The use of cement reached a high level of expertise during the Roman period.

These early cements would now be more accurately described as lime mortars, that is, mixtures of quicklime (calcium oxide, or CaO) and sand. They depended for their development of strength and their long-term durability not so much on the initial slaking reaction—written $CaO + H_2O \rightarrow Ca(OH)_2\downarrow$ to show that on the addition of water, calcium hydroxide precipitates out and forms a colloid, a system in which fine particles of the material are dispersed in the water—as on the subsequent aging process by which the colloidal hydroxide was slowly converted to calcium carbonate by reaction with atmospheric carbon dioxide [$Ca(OH)_2 + CO_2 \rightarrow CaCO_3$]. The high quality of Roman cements, which is evident in the num- to the added discovery that lime mixed with reactive siliceous material (in the form of crushed tiles or volcanic ash) gave a cement that developed superior strength and water resistance. "Roman cement" made in this way enjoyed wide prestige and retained its popularity with little improvement or development until the end of the 18th century.

Although there is some dispute about it, the invention of portland cement as it is now known is usually attributed to Joseph Aspdin, a builder from Leeds who took out a patent in 1824 for "a cement of superior quality resembling Portland stone." His cement was prepared by sintering fixed proportions of limestone or chalk (calcium carbonate) with clay (aluminosilicates) in a kiln at very high temperatures. This is the basis of the manufacturing method that is still in service today. In the course of firing, the raw materials combine to produce clinkers (small rounded lumps that are subsequently ground to yield the cement powder), which contain reactive calcium silicates. The silicates give the cement its hydraulic character, that is, the property of hardening by reaction with water. Unlike the original lime-based cements, Aspdin's type of cement would harden under water and also be resistant to water for a long time. One of its first large-scale uses was in the construction of the Thames Tunnel from 1825 to 1843 by Marc Isambard Brunel and his son Isambard Kingdom Brunel.

Ordinary portland cement is still by far the most important cement in terms of the quantity used for construction purposes. In its most widespread form it is mixed with inert filler material (sand and graded aggregates) to produce concrete. A number of variations in type have been developed to meet specific requirements (such as rapid hardening, low evolution of heat and resistance to sulfates), but they involve relatively minor modifications in composition or method of preparation.

A notable exception in this context is different in its chemical composit and hydration characteristics. For t reason it provides an interesting co parison with portland cement. High-al mina cement, which was developed France and came on the commer market after World War I, is manuf tured by firing limestone with baux (hydrated aluminum oxide).

Unlike portland cement, which arrived at more or less by trial and er high-alumina cement was specific designed to resist sulfates. Indeed proved successful in overcoming a nu ber of construction problems in en ronments where portland cement unsuitable because of its vulnerabi to corrosive attack by sulfates. Anot advantage that quickly came to be preciated was that high-alumina cem has a very rapid rate of hardening. T latter quality has made it an attra ive alternative to the slower-harden portland cement in such applications rapid repair work and the fabrication precast units, where a higher product rate provides an economic advant that outweighs a relatively higher co

Nevertheless, the accumulation of perience with concretes made fr high-alumina cement has shown t it can be defective in its long-te strength. As a result the use of this ment in any load-bearing capacity come to be regarded as a highly qu tionable practice. Most countries n avoid using high-alumina cement structural purposes, and some of th have imposed prohibitions or restr tions to this effect. Frequently these tions have followed incidents in wh structural members and even ent buildings containing high-alumina ment have collapsed, primarily beca of the deterioration of the concrete

In this article the main features the hydration and development strength of portland cement and h alumina cement are described in te of a comparison between the two t

much different in appearance from the one that forms on portland cement. After a short incubation period the coatings are broken by ridges that grow rapidly into faceted crystals with hexagonal or acicular (needlelike) outlines. These crystals can be identified with the first products of hydration: it is by their complex interlocking that the cement achieves its rapid rise in strength.

Under the contrived aging conditions the sample undergoes a rapid transformation, and within 14 days it exhibits the stabler form of a hydration product: the hexahydrate in a nearly spherical form with faceted polyhedrons. Since faceted crystals are characteristic of growth from solution, the conclusion is that the change to the stable hydrate must take place in this way. In other words, the change involves a recrystallization from an aqueous solution. Evidently, then, free water is present in the microstructure of the cement, since it would be needed to provide the medium in which the stable phase could nucleate and grow. This conclusion suggests why a high ratio of water to cement in the original mix can facilitate the loss of strength in high-alumina cement.

One is tempted to ask what can be done about this problem. Can the transformation be inhibited, or could the stable product be made to form preferentially in the first place? It is difficult to see how the change could be prevented except by the accepted practice of making the mix relatively dry, so that the amount of water available to promote the undesirable transformation would be at a minimum. Perhaps if the initial hydration were carried out at a sufficiently high temperature, the stable hydrate might develop more rapidly. The necessary temperatures are probably impractically high, however, and in any case it is unlikely that a cement matrix composed of faceted polyhedrons would develop the interpenetrating network that seems to be a requirement for high strength.

In structural member, such as a beam of prestressed concrete, there are further practical problems. Although it is accepted that the best approach is to use a minimum of water during mixing of the cement, how uniform can such a mixture be in a section from 25 to 30 centimeters across and from five to 10 meters in length? It is instructive to consider an example.

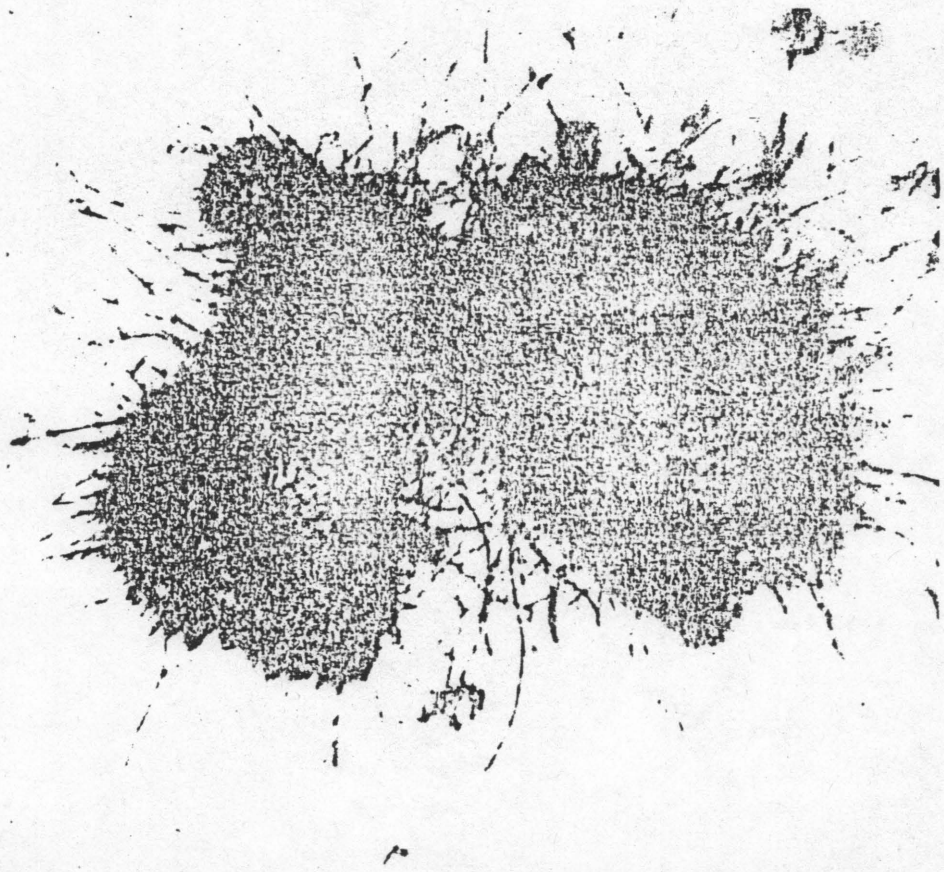
A cross section two centimeters thick was cut from a six-meter beam of high-alumina cement. The beam had a wood insert at the bottom, presumably so that objects could be nailed to the beam. The cross section was then cut into smaller pieces and the relative conversion (from metastable to stable compound) was determined for each piece by a thermochemical analysis.

As one might expect from such an inhomogeneous structure, the distribution was variable, with a few regions of low conversion near the surfaces and around the wood insert, where the concrete had been locally dried by absorption of the water. Inevitably one must assume that variations in the other dimension, along the length of the beam, would show a larger amplitude. The practical problems of ensuring homogeneity of such a material, within precise limits and over large dimensions, can be appreciated. These variations in the conversion values must also be reflected in variations of the mechanical strength of the concrete from point to point. Ultimately the strength of a given beam will depend on its weakest part.

One of the characteristic features of cements (and concretes in general) is that they can develop a large compressive strength during hydration, whereas their tensile strength remains relatively very low. For this reason it is usually necessary to reinforce concrete beams or to subject them to prestressing or poststressing in compression by the inclusion of stretched steel wires or rods. In general the engineering design of a building has to be such that the concrete is not subject to an undue tensile stress. Clearly any improvement that could be achieved in the tensile properties of a cement or a concrete would have far-reaching and universal importance in building practice.

If the setting and hardening processes depend on the interpenetration and interlocking of gelatinous fibrils or faceted crystals, as the recent findings we have described suggest, it is reasonable to ask whether the tensile strength could be improved by somehow emphasizing the development of the interlocking features, perhaps by causing the growth products to interweave or interlock more closely. Modification of the microstructure of metals has been fundamentally important in metallurgical technology and is also well known in the solidification of many alloys, but it has not been tried with cement.

With the well-developed crystalline hydrates of high-alumina cement the prospects for useful modification are uncertain. With the irregular fibers of portland cement, however, some improvement might be expected if, for example, the fibers could be made less regular and more intricately woven. It is instructive to consider the long, thin and densely interwoven fibrils that grow from crystals of ferrous sulfate. Clearly it would be valuable to find out if something similar can be achieved with port



IMPROVED STRUCTURE that might be sought for portland cement is suggested by the fine and densely interwoven network of tubular fibrils visible in this micrograph. Crystal seen here

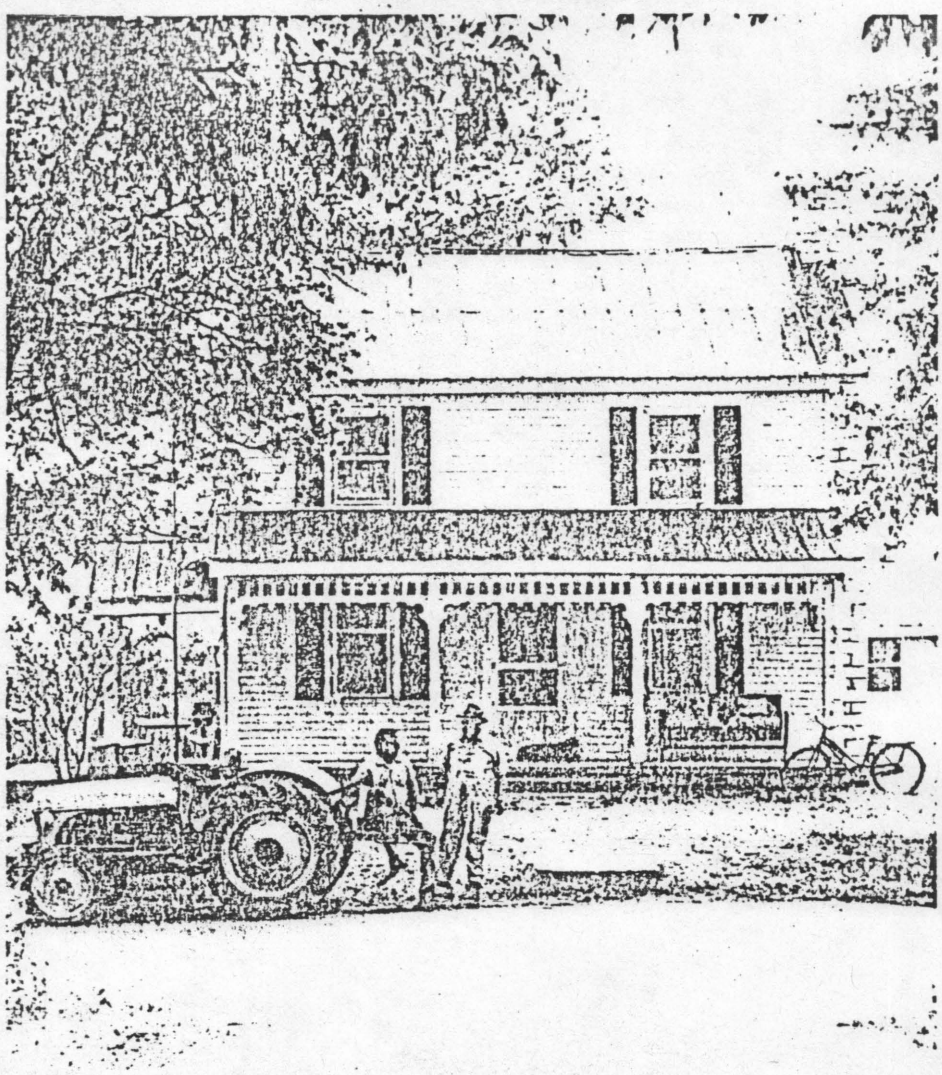
fundamental nature of this material can be obtained.

The hydration products of high-alumina cement are more conventional crystalline forms. As we have indicated, the principal anhydrous constituent of high-alumina cement is monocalcium aluminate ($CaO \cdot Al_2O_3$, written CA), and the development of strength of the cement is derived primarily from the hydration products of this compound. Under normal conditions at room temperature the main product is the decahydrate phase CAH_{10}, which is usually associated with smaller quantities of octahydrate C_2AH_8 with alumina gel, which eventually ages to crystalline gibbsite, AH_3. The relative amounts of CAH_{10} and C_2AH_8 present in the cement paste are dependent on the temperature of hydration and the composition of the cement itself. These crystalline hydrates provide the matrix that binds the paste together. Their early production gives rise to the rapid increase in strength that is characteristic of the material.

Conversion occurs because the initial hydrates CAH_{10} and C_2AH_8 are metastable and tend to change spontaneously to the stabler hydrate C_3AH_6, with water and further gibbsite as by-products. The process is accompanied by a change in the crystal structure of the hydrates (CAH_{10} and C_2AH_8 have well-defined hexagonal crystal structures and C_3AH_6 is cubic) and, because of differences in their densities, by a substantial decrease in the volume of solids. The change amounts to about 50 percent for CAH_{10} and some 30 percent for C_2AH_8.

These changes are the basis of the problem with the long-term strength of high-alumina cement. They lead to a loss in cohesion of the microstructure and an increase in the porosity of the hardened cement paste. At room temperature and lower temperatures the rate of change is slow, particularly in dry conditions, and the effects may not be evident for years. At higher temperatures and in a moist environment the changes can occur within a few weeks or even days. In the end the result is a marked reduction in strength and an increased susceptibility to corrosive attack. High-alumina cement lasts longest when it is mixed fairly dry and is in a cold environment. The reverse combinations are disastrous for the long-term stability of the material.

The reactions can be followed by examining with the scanning electron microscope samples of cement paste at various stages of hydration. Our samples, which were made with a high ratio of water to cement, were artificially aged by being stored in a humid environment at a fairly high temperature (40 degrees Celsius, or 104 degrees Fahrenheit). Initially the cement [illegible]



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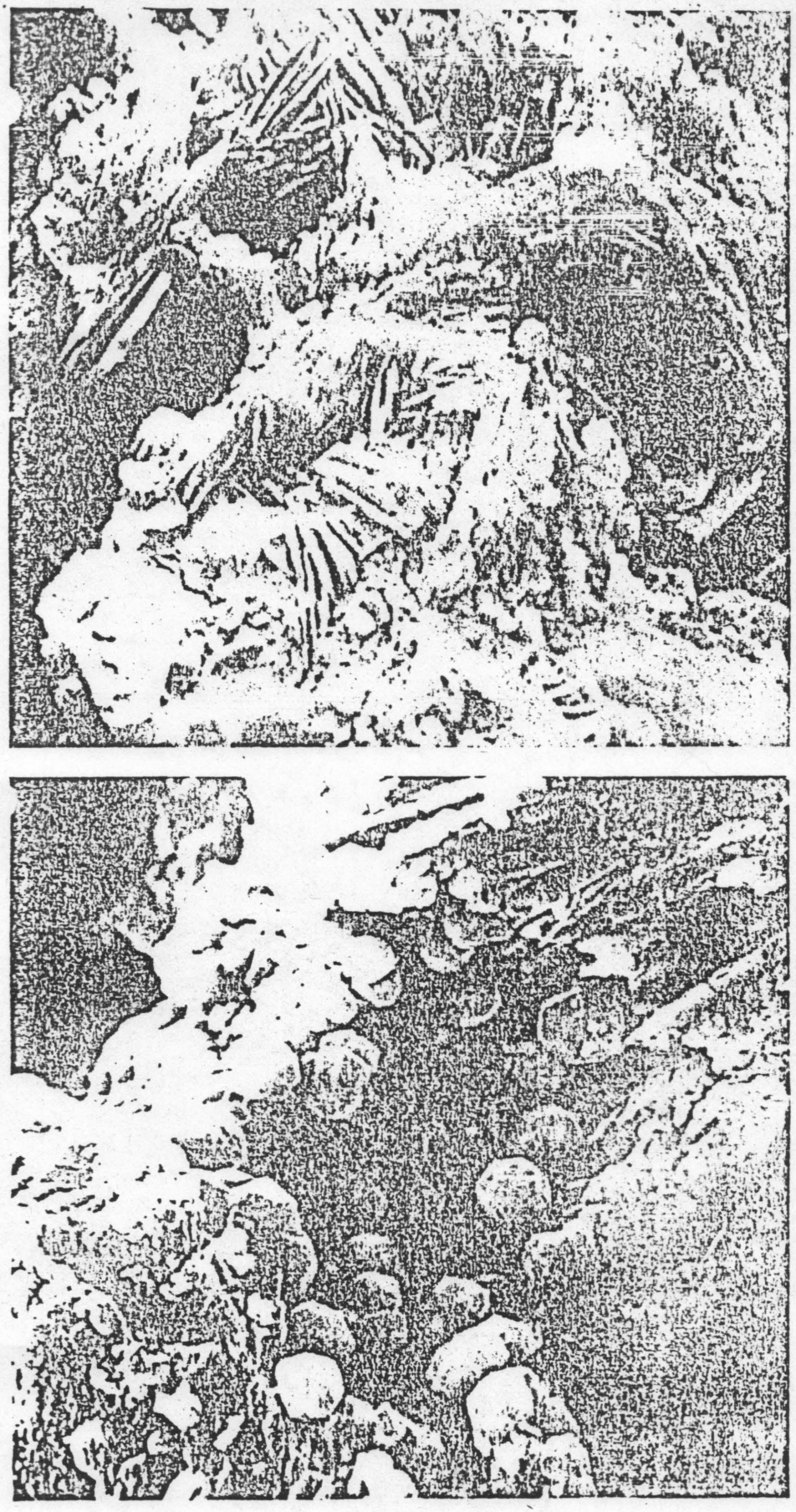


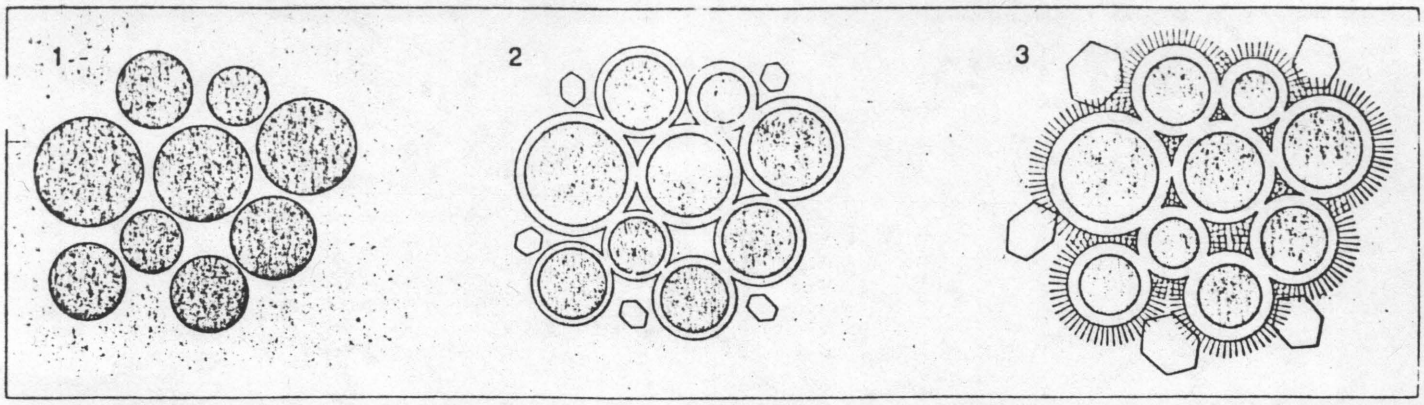
DEVELOPING MICROSTRUCTURE of hydrated high-alumina cement paste is seen in the scanning electron microscope. The paste was made with a high ratio (60 percent) of water to cement and stored at a high temperature (40 degrees C., or 104 degrees F.) in order to study the conversion process that often gives rise to the failure of load-bearing members made of high-alumina cement. The top micrograph shows the paste after one day; the needlelike crystals of

duce fine tubular growth forms with a radiating fibrillar appearance. In spite of certain obvious differences between the hydration of portland cement and the growth of a silica garden (in the scale of growth and the nature of the chemical constituents) the parallel between the two processes is so close that it suggests a similar growth mechanism operates in both cases.

The growth mechanism for the silica garden has been shown to depend on osmotic pressure. As the salt crystals come in contact with the aqueous silicate solution, they begin to dissolve and simultaneously precipitate a gelatinous silicate-hydrate envelope. This envelope is colloidal and acts as a semipermeable membrane. Because of the concentration difference in the solutions across the membrane (a concentrated solution of the metal salt inside and a dilute solution of the silicate outside) water diffuses preferentially into the envelope, causing continued dissolution of the salt crystal. The internal pressure slowly builds up, and eventually the envelope bursts, ejecting jets of salt solution into the silicate solution. There is a spontaneous reaction between the two with the precipitation of the insoluble silicate material as a continuously growing tubular wall. The initial membrane acts as an osmotic pump, the salt solution flowing up the tube and precipitating at the tip by an almost steady-state process.

So far there is little quantitative data bearing on this mode of growth, but it is likely that it is relatively common whenever the initial reaction product between two solutions is a continuous semipermeable membrane. Both the initial envelope and the tubes that grow from it are amorphous and gelatinous, although when they are extracted from solution they prove quite hard and strong. In any given system the rate of growth is proportional to the measured diameter of the tube: smaller tubes are the result of slower growth. This finding is in the right direction qualitatively to support the analogy between silica gardens and the hydration products of portland cement. A wide variety of metal-ion salts show this type of growth. It is reassuring that calcium salts are among them, since calcium-silicate-hydrate gel is the principal hydration product of portland cement.

Using the silica garden as a model it is possible to explain the essential features of the hydration of portland cement and in particular the growth of the fibrillar calcium-silicate-hydrate gel material that is such an important factor in the development of strength. The implication of the analogy is that osmosis provides the driving force for the hydration of portland cement. Further de-



STAGES IN HYDRATION of portland cement are depicted schematically. The process begins (*1*) with the addition of water, which surrounds the individual grains of cement. Soon the coating of gel appears around the grains (*2*), and angular crystals of calcium hydroxide that develop as a by-product of the hydration of the silicates in the mix become evident. Finally the tubular fibrils develop (*3*). The interlocking of these fibrils as hydration proceeds eventually binds the cement and other components of the mix into a hard mass.

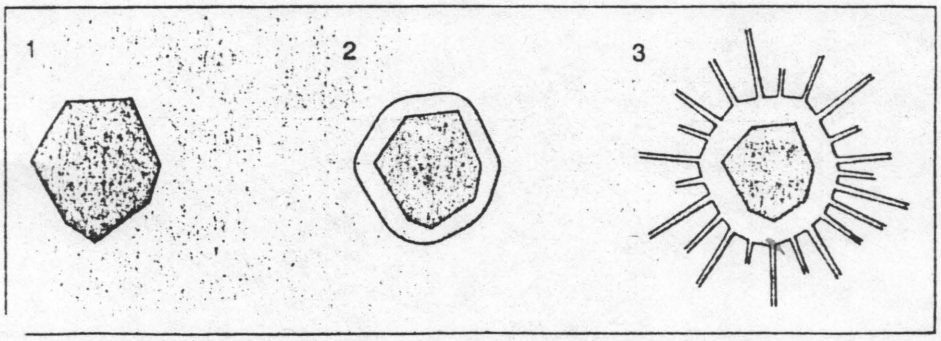
the surface area of the cement powder, that is, to how finely the cement powder has been ground. Variations in the ratio of water to cement in the range from 30 to 50 percent (which is typical of ordinary practice) do not significantly alter the pattern of hydration.

Although the heat-evolution curves give information about the extent and rate of hydration, they tell little about the structure of the material and are not necessarily related in any simple way to the development of strength. It is true that under normal conditions the setting period occupies approximately the interval of time between the dormant stage and the second peak and that the hardening reaction follows thereafter, but the setting and hardening processes are clearly dependent on the detailed development of the microstructure of the paste. Because of the fine scale of the hydrates involved the microstructure has been most usefully studied by electron microscopy.

The micrographs show that within two hours the originally angular and crystalline grains of cement become coated with a gelatinous envelope of hydrate material. The grains are bridged at their points of contact by these coatings. The network of relatively weak bonds thus formed accounts for the loss of plasticity of the paste at this time, that is, for the setting effect. The structure can be broken up easily but will quite quickly set again as the cement grains recoagulate.

The irreversible development of strength during the hardening period, which begins after some three to five hours, is associated with a distinct change in the microstructure of the cement. The initial gel coatings develop fine surface protuberances. Over a period of time they grow into thin, densely packed fibrils radiating like porcupine quills from the individual grains of cement. This fibrillar development is the calcium-silicate-hydrate gel product of the reaction between the cement silicates and water. At the same time calcium hydroxide (portlandite) precipitates as a by-product and forms the large angular crystals that are so prominent in the microstructure. As hydration proceeds the gel fibrils gradually interpenetrate in the region between the adjacent cement grains. The interwoven meshwork thereby created eventually consolidates to form a rigid matrix that effectively binds the composite mass: the residual grains of unreacted cement, the crystalline products of hydration and, in a concrete, the sand and the aggregate material.

Although the secondary growth of the fibrils of calcium-silicate-hydrate gel is clearly of importance in the development of strength of the cement-water paste, its detailed morphology and mechanism of growth have hitherto remained obscure. Recent studies by our research group at Oxford making use of transmission electron microscopy have provided some new insight into this problem. What these pictures show is that the fibrils do not resemble the faceted regular shapes one might expect from the growth of solid crystals from aqueous solution and that the individual fibrils are not solid but appear to consist of fine hollow tubes. This information presents an entirely new aspect of the problem.



SILICA "GARDENS" provide an analogy to the growth of tubular fibrils in portland cement. A silica garden forms when water-soluble salts of certain metals are put in a solution of sodium silicate. In this example, from a crystal of cobalt nitrate, the salt crystal begins to dissolve (*1*) and a shell of insoluble silicate forms around it (*2*). Since the membrane is permeable to water, the crystal continues to dissolve. Finally osmotic pressure ruptures the membrane (*3*), causing the growth of precipitated silicate in the form of fine hollow tubes similar to those

In the context of the precipitation of solids from aqueous solution the concept of a tubular morphology is perhaps rather unusual. It turns out, however, that such growth forms are commoner than might have been expected. A familiar example of tubular growth is to be found in the silica "gardens" that develop when water-soluble salts of metals, which themselves form insoluble silicates, are placed in a dilute aqueous solution of sodium silicate. The growth pattern of a silica garden provides a striking visual analogy with what happens during the hydration of portland cement. A gelatinous silicate-hydrate envelope is first precipitated around the salt crystal. After a dormant period the

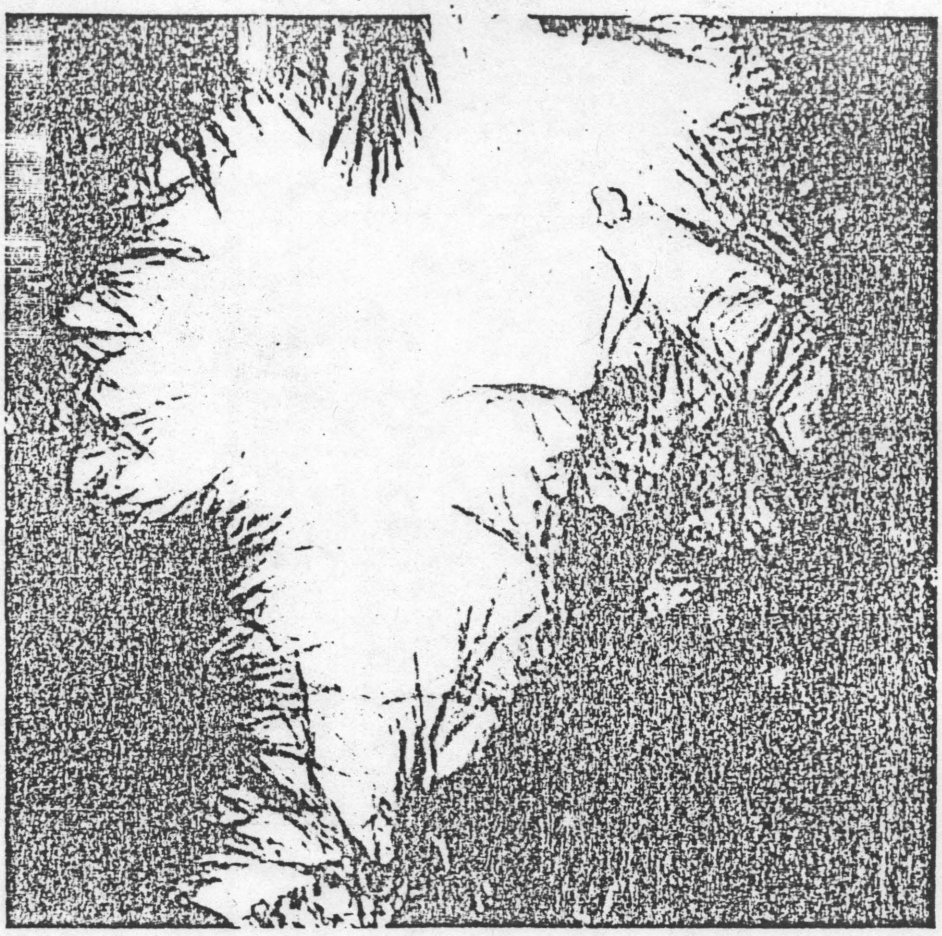
ously broken up to expose fresh reactive surfaces, as, for example, by continuous agitation of the paste in a ball mill, can complete hydration be achieved in a reasonable length of time.

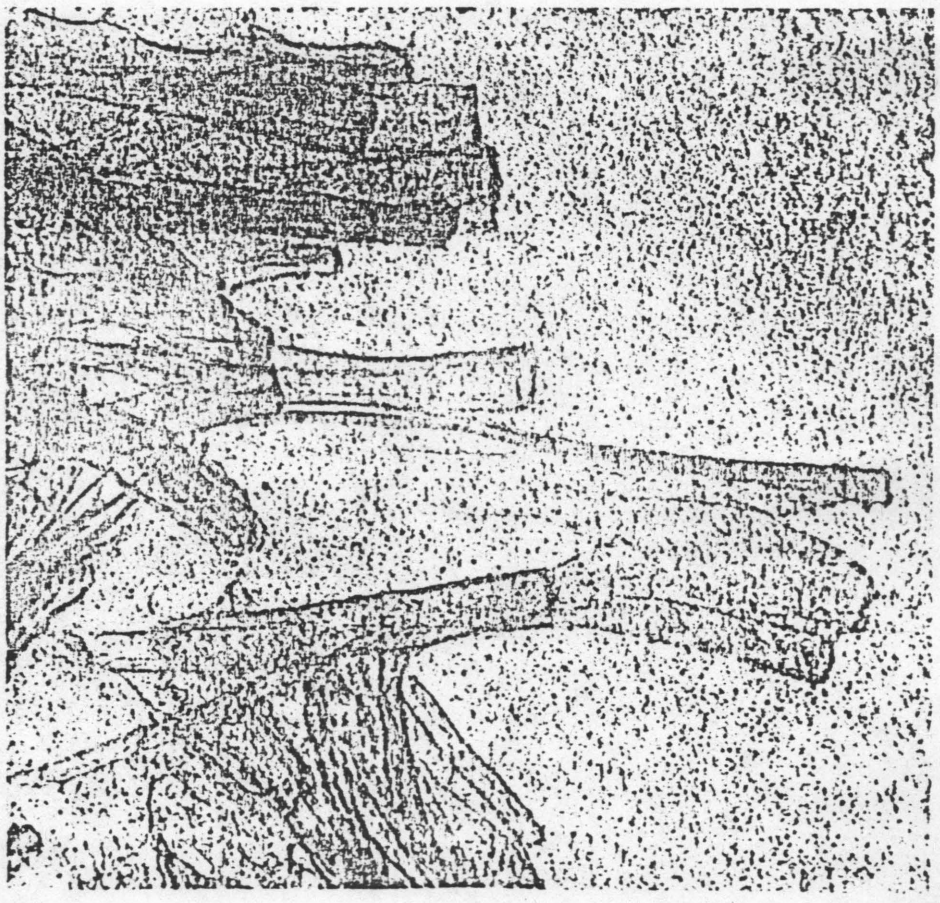
The presence of unreacted clinker material can have some interesting effects. For example, if the cement is ground up and mixed again with water, it will set a second time and develop a degree of strength that, although it is inferior to the strength of the first setting, can nonetheless be substantial. It is even possible that if fine microcracks develop in a cement structure, they can heal themselves by renewed hydration.

The reaction between cement and water is exothermic; under typical conditions the temperature of a paste may rise by tens of degrees. This phenomenon can present quite a problem in laying concrete structures of large section. It is sometimes necessary to cool the material during the setting and hardening period to prevent cracking through thermal expansion and contraction. The heat evolved is directly related to the degree of hydration of the various constituents of the cement. Because of the physical nature of the reaction, the heat-evolution rate tails off exponentially at long time intervals. Under normal conditions, however, some 50 percent of the total heat available (100 to 150 calories per gram) is liberated within the first three days of mixing and some 30 percent is liberated within the first day.

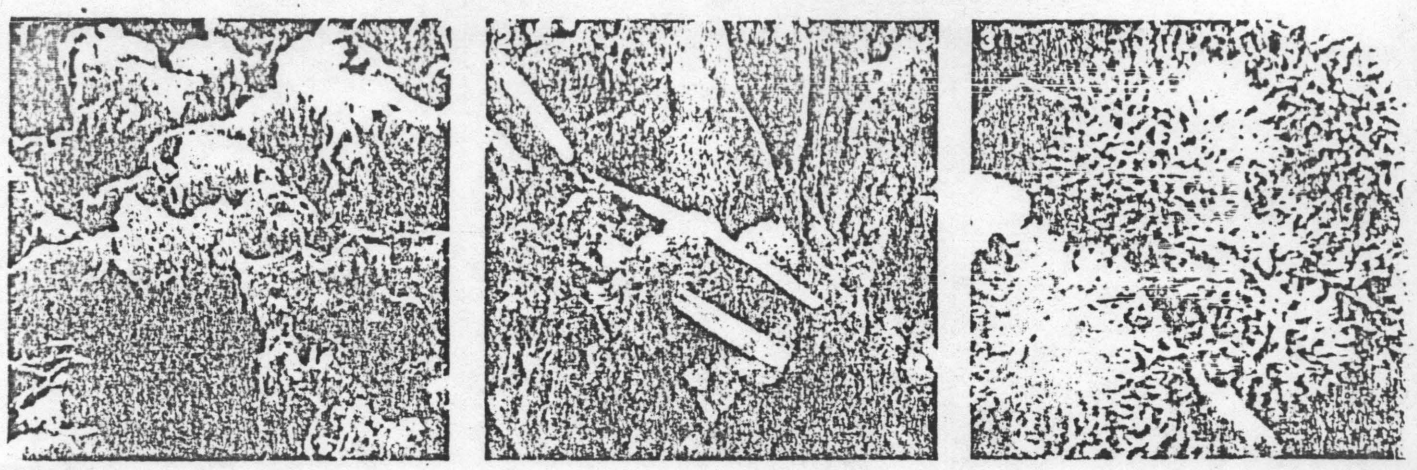
If the evolution of heat is plotted as a curve, it shows two peaks [*see bottom illustration on opposite page*]. One peak is sharp, reflecting highly exothermic processes. It reaches a maximum within 10 minutes of mixing and is mainly due to the hydration of free lime and the dissolution of other impurities that are always present in small quantities in commercial portland cement. After the first peak the rate of reaction drops rapidly to a low value, where it remains for an hour or two. This is the "dormant" or "induction" period. It is thought to be brought about by the inhibition of hydration as the cement grains become coated with the initial gelatinous products. This picture is confirmed by observations with the electron microscope.

Later the coatings apparently become ineffective, because the reaction rate begins to increase again and reaches a second (but much lower) peak in from eight to 10 hours. Thereafter it decreases gradually over a much longer period. The form of the peak is largely determined by the hydration of the major constituent of the cement, tricalcium silicate. The curve has a form that is characteristic of many phase transformations occurring by a process of nucleation and growth. As one might expect,





HYDRATED PORTLAND CEMENT is seen in microstructure in the transmission electron microscope. The top micrograph shows a wet sample of cement after some two days of hydration; one can see a well-developed fibrillar network of silicate gel surrounding the cement grains

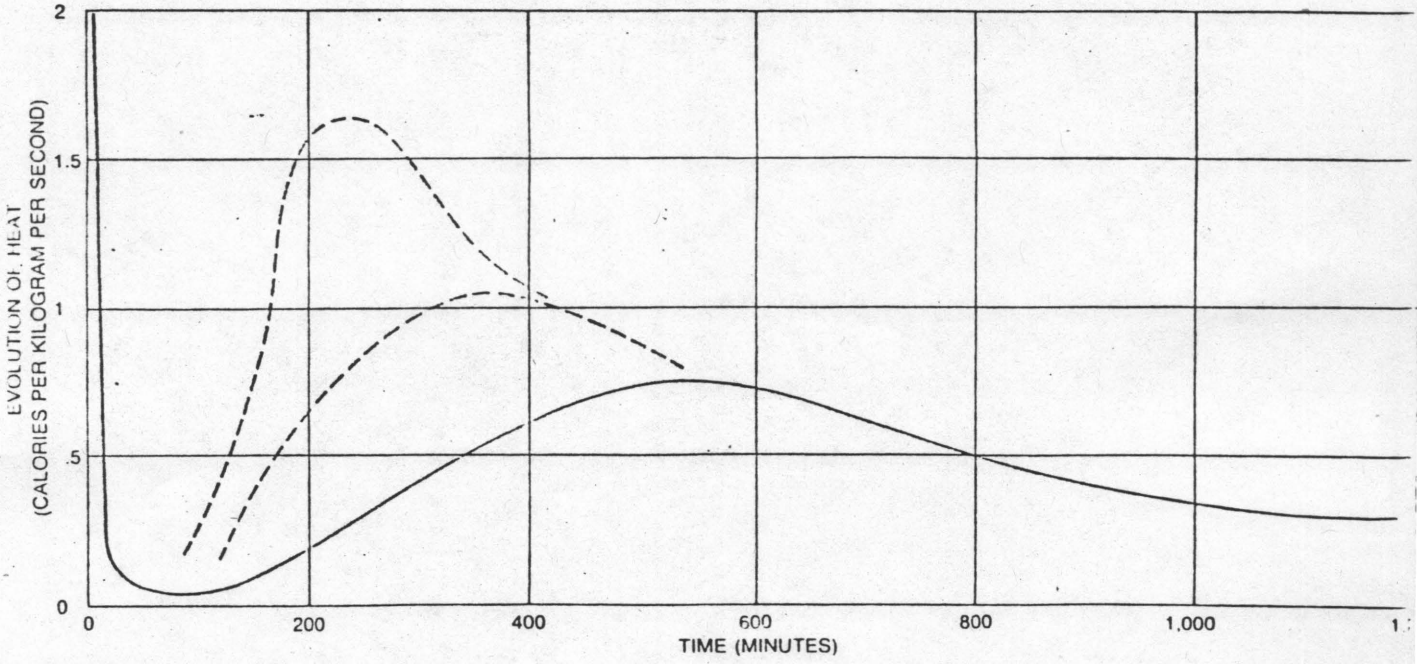


PASTES OF PORTLAND CEMENT appear in scanning electron micrographs made at various stages of hydration, that is, at various times after water was mixed with the cement. After two hours (*1*) the initial gel coatings are visible around the cement grains. After a month (*2*) the fibrils are evident, as are large platelike crystals of calcium hydroxide. Detail of same sample (*3*) shows the interlocking fibers.

cement as that given above, it is appropriate to consider what is known about the products of hydration and their proportions in the hardened paste. As might be expected, the hardening reaction in a cement-water paste is principally associated with the hydration of the two silicate compounds, C_3S and C_2S. In the anhydrous clinker they occupy about 75 percent by weight of the total; they finally provide the bulk of the hydrated material. The reaction rates of C_3S and C_2S differ appreciably, but the final product in both cases is thought to be the same: a colloidal calcium-silicate-hydrate gel of rather indefinite composition and structure. In a hardened cement this gel, in a finely divided and largely amorphous form, occupies about 70 percent by volume of the hydrated material and thus forms the main bonding agent between the residual grains of unreacted cement and the other crystalline products of hydration. The major part of the other crystalline products consists of calcium hydroxide (portlandite), the rest being composed of various complex aluminum hydrates and other minor substances.

Of the two silicates, C_3S is primarily associated with the hardening reaction that takes place during the early stages of hydration, within the first few days and weeks. The slower-reacting C_2S is probably responsible for the longer-term and continuous development of strength, which can extend for periods of months or even years. The contribution to the strength from the aluminate compounds is uncertain, but it is probably relatively small.

In a cement paste under normal conditions the hydration reaction does not usually go to completion. Even after several years a typical microstructure will show residual grains of unreacted cement embedded in a matrix composed mainly of calcium-silicate-hydrate gel. The reason for this state of affairs is that during hydration the reaction products form coatings around the cement grains and the coatings progressively inhibit the access of water to the anhydrous material. Only if these coatings are continu

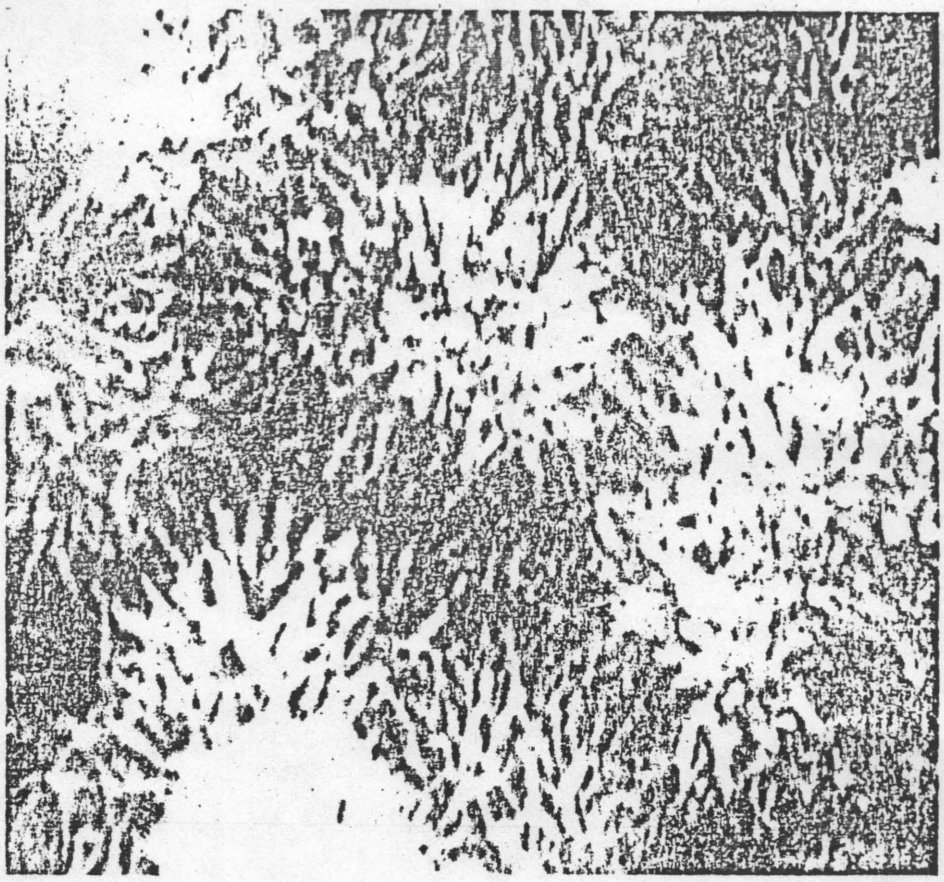


EVOLUTION OF HEAT as portland cement sets and begins to harden is charted. The sharp first peak represents rapid heat-generating processes, including the hydration of free lime and the dissolution of impurities in the cement. The trough thereafter represents the "dormant" or "induction" period, which probably results from the in- cement grains. The coatings eventually become ineffective, because the reaction rate soon rises to a second peak. At a hydration temperature of 20 degrees Celsius (68 degrees Fahrenheit) the rate of reaction is represented by the lowest curve. The broken-line curves above it show the effect on the form of the second peak of increasi-

aluminum ($CaO–SiO_2–Al_2O_3$). Commercial cements tend to vary in composition over a small range and also contain a number of impurities, notably iron oxides (less than 10 percent in portland cement, up to 20 percent in high-alumina cement), and to a much lesser extent free lime and associated oxides. The impurities do not, however, substantially affect the basic properties of the cements.

Portland cement is basically a calcium silicate mixture predominantly containing tricalcium and dicalcium silicates, which can be written in abbreviated form as C_3S and C_2S. (We employ here a simplified notation wherein oxides of calcium, silicon, aluminum and iron are represented respectively by C, S, A and F and water is represented by H. Whereas dicalcium silicate would normally be written $2CaO \cdot SiO_2$, for example, in the simplified system it is C_2S.) In addition there are also present smaller proportions of tricalcium aluminate (C_3A) and a calcium aluminoferrite approximating the formula C_4AF. Typical weight proportions in an ordinary portland cement are 50 percent C_3S, 25 percent C_2S, 10 percent C_3A, 10 percent C_4AF and 5 percent other oxides. High-alumina cement, as its name suggests, contains mainly monocalcium aluminate ($CaO \cdot Al_2O_3$, written CA) and relatively little silicate material. A variety of less well specified compounds are also present, but CA is the main reactive ingredient.

In both cements the principal anhydrous constituents show hydraulic properties: in a finely divided form they react with water to yield a paste that sets and eventually hardens. Moreover, because the cements are chemically dissimilar, the way and the rate at which their strengths develop are different. Both cements can achieve about the same ultimate strength, but high-alumina cement initially hardens much faster than portland cement. In practice high-alumina cement can develop in a day about the same strength that a comparable portland cement would achieve in a month. The advantages of high-alumina cement in this context are obvious. It is the long-term strength of high-alumina cement that is the problem. Depending on the ambient temperature and the environment, the cement may deteriorate by a process known as conversion in such a way that the strength shows a sudden dramatic decrease. The conditions that accentuate this behavior are a high-temperature environment and too high a content of water in the cement. Although these factors would also tend to reduce the strength of portland cement at all ages, the effects are much less marked, and there is no sudden drop in strength comparable to that displayed



MICROSTRUCTURE OF PORTLAND CEMENT in the early stages of the reaction with water is revealed in this scanning electron micrograph at an enlargement of 6,000 diameters. Individual grains of cement have begun to develop fibers of the silicate-gel reaction product.

HIGH-ALUMINA CEMENT, which was designed to resist attack by sulfates and which hardens faster than portland cement, is portrayed at the same magnification as the micrograph at the top of the page. The reaction products are crystalline aluminates with an interlocking

Latex Modified Mortar

The sandy soils in this area do not make good exterior pointing mortars because they contain relatively little clay and wash out quickly. The addition of latex modifier (concrete adhesive) in the basic soil mortar will give sandy soil enough cohesive strength to be used in pointing. A small amount of modifier per bucket is needed to attain this strength. Therefore, the relatively high cost of the modifier is offset by the volume of mortar it will strengthen.

A 32 to 1 ratio has been used successfully at AZRU, that is 8 oz. of modifier to 2 gallons of soil. However, it is recommended that this ratio be reduced to 10 to 1 (26 oz. modifier to 2 gallons of soil) to increase the maintenance cycle interval.

The best method of mixing is as follows: in a 2½ gallon steel bucket, pour 16 oz. (one pint) of water; add 26 oz. of latex modifier and stir well; slowly stir in 2 gallons of soil, mix well; add more water if needed but add slowly in small amounts - too much water weakens the mortar. The mortar should be stiff but workable.

Use the mortar within 20 - 25 minutes. If you cannot use a full "batch" before it dries out, halve or quarter the "recipe". Once the mortar begins drying out, the bonds begin forming. Remixing will break the bonds and they won't reform. When the mortar becomes unworkable, dispose of it and mix a fresh batch.

The modified mortar is usually trowelled into joints. It can also be used in a heavy duty caulking gun. Be sure to clean the gun thoroughly between or after loads. For application of caulking mortars, see Masonry Structures section.

Latex modifiers are generally available at hardware and builders supplier stores.

Third Annual Report

Chemical Stabilization of Prehistoric Structures

at

Chaco Canyon National Monument

by

Dennis B. Fenn
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Western Region

and

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December 20, 1978

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We also express our appreciation to Al Fehrman, Dennis Byrnes, Jon Thomas, Larry Morse, Marcia Petta, Craig Christensen, and Gary Hancock of the Western Archeological Center for all their assistance in the field and laboratory work in this project.

The faithful support and encouragement of Carla Martin, Center Chief and George Cattanach, Chief of the Division of Adobe/Stone Conservation, at the Western Archeological Center is also gratefully acknowledged.

Management Recommendations

Based upon the results of this study, which has been ongoing since July 1975, and upon observations of other in-park research that was initiated in Chaco Canyon in 1972, several recommendations can be made for consideration by the cultural resource manager in designing a cyclical ruins maintenance program in Chaco Canyon and other National Park Service areas containing stone-mud mortar ruins.

Negative Recommendations

1. That chemical products having a hydrocarbon solvent base such as toluene, xylene, petroleum distilates, benzene, etc., not be used to make amended mud mortar.

2. That the water-based products Primal 863, Rhoplex E-1141, Rhoplex SS-521, Aerospray 52, Union Carbide RE-280, K & E Mineral Sealer, and Okon W-2 not be used to make amended mud mortar.

3. That spray applications of chemical products not be used, at least at today's level of technology, as the sole method for stabilizing exposed pithouse walls.

4. That chemical products used to make amended mud mortar not be any less than 10% chemical solids in the water solution used to make the mortar.

Positive Recommendations

1. That Rhoplex E-330 be used to make amended mud mortar for capping walls and repointing joints.

2. That Rhoplex E-330 as purchased from the supplier be diluted to one part E-330 to two and one-half parts water by volume. This diluted E-330 solution will contain approximately 13% chemical solids by weight. This diluted solution should then be used to mix the mortar.

3. That every effort be made to utilize a soil that contains little or no bentonite clay and therefore, low cracking potential. The soil should have about 70% sand, 20% clay and less than 10% silt for best results. This texture can vary, however, and still yield acceptable mortars.

4. That this Chaco Canyon research project continue at a monitoring level for five more years. Two purposes will be served by continuation: (a) This extra time will be important in determining maintenance cycles necessary with amended mortars; and (b) ten products in addition to Rhoplex E-330 are showing preliminary positive results. This additional monitoring time will allow for a thorough evaluation of these products and potentially provide the National Park Service with several optional chemical mortar amendments that equal or exceed the performance of Rhoplex E-330.

5. That an economic analyses be conducted to evaluate the hypothesis that the cost of Rhoplex E-330 will be recovered several times over by the labor costs saved by extending the maintenance cycle from the current three to four years to eight or ten years with the amended mortars.

6. That pithouse wall stabilization research be given a high priority and that a research project be funded to investigate several promising new techniques in this area.

INTRODUCTION

This study was initiated in July 1975 at the request of Walter P. Herriman, Superintendent of Chaco Canyon National Monument. The objective of the study was to investigate the usefulness of organic polymers in developing improved, cost-effective, and resource-compatible ruins stabilization repointing mortars, stone preservation treatments and pithouse wall erosion prevention treatments.

The initial repointing mortar field research plots in this study were established on July 31, 1975, at Site Bc-236. This site is located on the edge of the still widening and downcutting Chaco Wash and is therefore threatened with eventual collapse due to stream bank undercutting. Zoro Bradley conducted a salvage archeological operation on the site in 1958 (1). Parts or all of the several walls on the northern edge of the ruin have collapsed due to stream bank erosion since the 1958 excavation. Site Bc-236, therefore, was not a part of the Monument development and preservation plan and could be used as a research site. Three organic polymer products were tested as repointing mortar additives in the initial trial.

The chemically amended test mortars at Site Bc-236, and in all subsequent test locations, were made by diluting the test chemicals with water or the appropriate organic solvent to produce solutions containing 10% chemical solids by weight. These diluted solutions were then individually mixed with soil to produce mud mortars of easily workable consistency. The mortars were then applied to the appropriate test plots by traditional hand-and-trowel techniques.

The lone exception to this procedure was Bakelite VMCH Vinylite at Site Bc-236. With this test product, the mortar joints were repointed with untreated mud mortar and allowed to dry. Then the VMCH was spray-applied to the dried mortar in a steady, low-pressure stream until the mortar was saturated. The organic solvent then evaporated leaving behind a dry, VMCH-coated mortar.

On October 9, 1975, the study was expanded to include six additional chemical products. Site Bc-236 was not large enough to accomodate repointing mortar test plots for the six new chemical products, so Site SS-1912, also known as Lizard House, was selected for use as a test ruin. Lizard House, like Bc-236, is located on the edge of an arroyo and threatened with eventual undercutting and collapse. J. C. Maxon conducted a salvage archeological operation on this ruin in 1960 (2).

The initial pithouse wall erosion protection studies were established at Site SS-299 on October 12, 1975. The site, located near the northwest base of Fajada Butte, is a Basketmaker III pithouse dating from the early 600's A.D. It was excavated in the summer of 1973 by Richard Loose of the Chaco Center (Dr. Robert H. Lister, personal communication). Nine chemical products were spray-applied to test plots along the northeastern half of the pithouse.

It soon became obvious from the experiences gained in initiating this project that the limited availability of prehistoric wall area for use in stabilization materials research and the variability in directional exposure and plot size made it necessary to find a suitable testing alternative.

It was decided that the best long-term solution to this problem was to design and build a stone test "ruin" that would allow for uniform plot sizes and exposure faces. It was determined, in consultation with Superintendent Herriman and the Monument staff, that the most convenient and suitable location for such a structure was near the sewage lift station, 200 yards east of the visitors' center. Construction was started on July 13, 1976. Due to a shortage of time, the test "ruin" was only 75% completed when construction was halted on July 19, 1976.

Fourteen new chemical products were tested on the newly constructed test "ruin" on July 20-21, 1976. For the first time in this study the use of chemical products as stone preservation treatments was also tested. The chemical assigned to each test plot was spray-applied to the stone walls. After 24 hours of drying, the chemically-amended, repointing mortar was then applied to the wall joints. Hence, each plot was used to simultaneously test for stone preservation effectiveness and repointing mortar durability.

On August 11, 1977, construction of the test "ruin" was completed and the original design modified by the addition of a one-foot-high stone wall around the perimeter of the structure. The 18-inch-wide space between the perimeter wall and the "ruin" wall was lined with PVC plastic, drip irrigation hoses installed, and the space backfilled with soil. Water is added to this soil through the drip irrigation hoses for four hours each week producing a condition where moist soil is continually in contact with the ruin wall. This promotes the movement of capillary moisture into the stone and provides a good test of each chemical's effectiveness

in resisting stone decay. This also provides a stringent test of each chemical's potential as a repointing mortar additive.

Also on August 11, 1977, Dr. William J. Burke of the Arizona State University, Department of Chemistry, utilized the former east facing control plot in Room D of the "ruin" (see Figure 10) to establish a field test of his in situ polymerization of methyl methacrylate stone preservation method (3). Dr. Burke and his doctoral student, Mr. Richard L. Bradshaw, prepared a mixture of methyl methocrylate monomer, reaction initiators and catalysts and gently sprinkled this solution onto the stone and mortar, attempting to achieve saturation. The polymerization reaction then occurred within the stone and mortar (in situ) forming a long chain organic polymer that coats the stone and soil particles yielding a water-proof protective film. This treatment plot will be monitored overtime for its protective effectiveness.

On August 3, 1978, two new chemical products and 5:1 soil-cement by volume were placed in test plots at the "ruin." These new tests were established in plots where the initial chemical products had failed after two years of exposure testing.

The soil used in this study to make repointing test mortars and to build the test "ruin" was taken from the spoil bank of the sanitary landfill in the Monument. Fenn and Chambers (4) report that this soil has good texture and adhesive properties, but also has an excessive level of bentonitic clays that produce a tendency to crack upon drying. Cracking was indeed noted with this soil, but no particular problems were caused by it.

The research plots established to date in this study were revisited on May 9-10, 1978; photographs were taken, and visual observations made of the individual treatment plots. These observations are presented in this report along with an update of the August 3, 1978, work on the test "ruin".

Chemicals Tested

The National Bureau of Standards' Center for Building Technology, Materials and Composites Section, conducted a comprehensive laboratory stone weathering study for the National Park Service in 1973 and 1974 (5, 6). They studied more than 95 chemical materials marketed for use as weatherproofing agents. Thirteen of these products performed satisfactorily enough in the laboratory to warrant further study in the field.

The Western Archeological Center, Division of Adobe/Stone Conservation, developed a list of 21 additional products that showed sufficient promise to also merit field testing.

The final product selected thus far for testing was Dr. William J. Burke's in situ methyl methacrylate system, as described in the introduction.

Listed below is a complete summary of the 35 chemical products tested thus far in this study. Chemical Numbers 1-24 are all water-based emulsions. Chemical Numbers 25-35 are hydrocarbon solvent-based resins.

1. Rhoplex E-330. Acrylic resin emulsion at 47% solids in water. Rohm and Haas Company, 1930 S. Tubeway, Commerce, California 90040. Telephone 213/722-5434.

2. Rhoplex AC-61. Acrylic resin emulsion at 47% solids in water. Same source as No. 1.

3. Rhoplex AC-634. Acrylic resin emulsion at 47% solids in water. Same source as No. 1.

4. Rhoplex SS-521. Acrylic resin emulsion at 50% solids in water. Same source as No. 1.

5. Rhoplex MC-76. Acrylic resin emulsion at 47% solids in water. Special small molecule formulation of E-330 for use in spray applications. Same source as No. 1.

6. Rhoplex E-1141. Experimental acrylic resin emulsion at 37% solids in water. Same source as No. 1.

7. Primal 863. Acrylic resin emulsion at 35% solids in water. Same source as No. 1.

8. Primal 826. Acrylic resin emulsion at 35% solids in water. Same source as No. 1.

9. Acryl 60. Acrylic emulsion at 28% solids in water. Standard Dry Wall Products, Inc., Newark, California 94560. Telephone 415/796-9911.

10. Subind. Inorganic sulfur formulation containing a soil stabilizer at 29% solids in water. Chevron Chemical Company, Sulfur Products Division, 575 Market Street, San Francisco, California 94105. Telephone 415/894-0400.

11. Suferm. Inorganic sulfur formulation plus laxex polymers at 32% solids in water. Same source as No. 10.

12. Soil Seal Concentrate. Plastic emulsion at 46% solids in water. Soil Seal Corporation, 600 S. Harvard, Los Angeles, California 90005. Telephone 213/487-0251.

13. Daraweld-C. A high polymer resin emulsion at 51% solids in water. W. R. Grace and Company, Construction Products Division, Cambridge, Massachusetts 02140.

14. Sarabond. Saran latex emulsion at 47% solids in water. Masonry Systems International, 600 S. Cherry, Denver, Colorado 80222. Telephone 303/320-5800.

15. Durak. Acrylic emulsion at 47% solids in water. (Basic product is Rhoplex E-330 plus additives.) Same source as No. 14.

16. Petroset SB. Rubber emulsion at 68% solids in water. Phillips Petroleum Company, P. O. Box 3090, Borger, Texas 79007. Telephone 918/661-6197.

17. Sonocrete. Polyvinyl Acetate resin emulsion at 50% solids in water. Sonneborn-Contech, Inc., 7711 Computer Avenue, Minneapolis, Minnesota 55435. Telephone 612/835-3434.

18. Aerospray 70. Polyvinyl Acetate resin emulsion at 60% solids in water. American Cyanamid Company, Industrial Chemicals and Plastics Division, Wayne, New Jersey 07470. Telephone 201/831-1234.

19. Versacryl "E" No. 90. A methyl methacrylate emulsion at 20% solids in water. Applied Polymers of America, R-210 Delaware Avenue, Clifton, New Jersey 07014. Telephone 201/473-4640.

20. R-20 Silicone. Sodium Methyl Silonate at 20% solids in water. Union Carbide Corp., 1 University Plaza, Hackensack, New Jersey 07601. Telephone 201/646-1111, Ext. 303.

21. RE-280 Silicone. Silicone resin emulsion at 40% solids in water. Same source as No. 20.

22. K & E Penetrating and Hardening Mineral Sealer. A solution of inorganic mineral salts at 30% solids in water. K & E Chemical Company, 16810 Miles Avenue, Cleveland, Ohio 44128. Telephone 216/751-9233.

23. Okon W-2. Acrylic resin emulsion at 10% solids in water. Okon, Inc., 6000 W. 13th Avenue, Lakewood, Colorado 80214. Telephone 303/232-3571.

24. Okon Adobe Mix and Waterproofing. Experimental acrylic resin at 40% solids in water. Same source as No. 23.

25. Okon S-2. A blend of waterproofing resins at 10% solids in hydrocarbon solvent. Source same as No. 23.

26. Acryloid A-21. Acrylic ester resin at 30% solids in toluene. Same source as No. 1.

27. Hydrozo Special Clear. Hydrozite gum at 15% solids in mineral spirits. Hydrozo Coatings Company, 855 West Street, Lincoln, Nebraska 68501. Telephone 402/477-6981.

28. Thompson's Water Seal. Copolycarvitol at 10% solids in aniline. E. A. Thompson Company, Inc., 1333 Gough, San Francisco, California 94109. Telephone 415/346-8610.

29. Raylite D-36. Butyrate resin at 36% solids in mineral solvents. Raylite Company, P. O. Box 7218, Wilmington, Delaware 19803. Telephone 302/652-3904.

30. Wendex Silicone Clear Water Repellent (Masury). Silicone resin in xylene solvent at 5% solids. Masury Paint Company, Division of Conchemco Inc., Baltimore, Maryland 21330. Telephone 301/837-2960.

31. Unelko Water Repellent. (Chemical nature unknown), 10% solids in mineral spirits. Unelko Corp., 727 E. 110th St., Chicago, Illinois 60628. Telephone 312/468-1700.

32. White Roc Clear Masonry Sealer. (Chemical nature unknown), 6-10% solids in xylene solvent. Mohawk Distributors, 2916 S. 40th St., Phoenix, Arizona 85040. Telephone 602/268-8861.

33. Drylock Silicone. Silicone resin at 5% solids in mineral spirits solvent. United Gilsonite Laboratories, Scranton, Pennsylvania 18501. Telephone 717/344-1202.

34. Bakelite VMCH Vinylite. Carboxylated vinyl resin at 100% solids. To use, dissolve in methyl ethyl ketone or acetone solvent. Union Carbide Corporation, Coatings Materials, 270 Park Avenue, New York, New York 10017. Telephone 212/551-4641.

35. Methyl Methacrylate, in situ polymerization. Experimental system developed by Dr. William J. Burke, Department of Chemistry, Arizona State University, Tempe, Arizona 85281. Telephone 602/766-3266.

Results and Discussion

Site Bc-236

Figure 1 shows an outline of Bc-236 and locates those wall areas where repointing mortar test plots were established on July 31, 1975. An untreated control mortar and three chemically-treated mortars were utilized at this site. Each mortar treatment was used in four plots yielding exposures facing east, west, north, and south in an attempt to ascertain the effects of solar radiation and prevailing wind conditions on treatment life. This site was revisited on May 9, 1978, and observations made of the treatment plots after 33 months of exposure. The percentages of erosion loss reported are based on visual estimates only.

Control Plots

The mortar joints in the control plots were all repointed with untreated mud mortar on July 31, 1975. The control plots provide a baseline measure of the rate at which untreated mortar erodes and allows a visual evaluation of the relative effectiveness of a chemical treatment in reducing this erosion rate.

The four control plots all showed considerable erosion when viewed on May 9, 1978. The capping mortar was almost entirely gone and the repointing mortar in the joints was from 60-100 percent eroded away in all four plots. Figure 2 shows the appearance of the north facing control plot on this date.

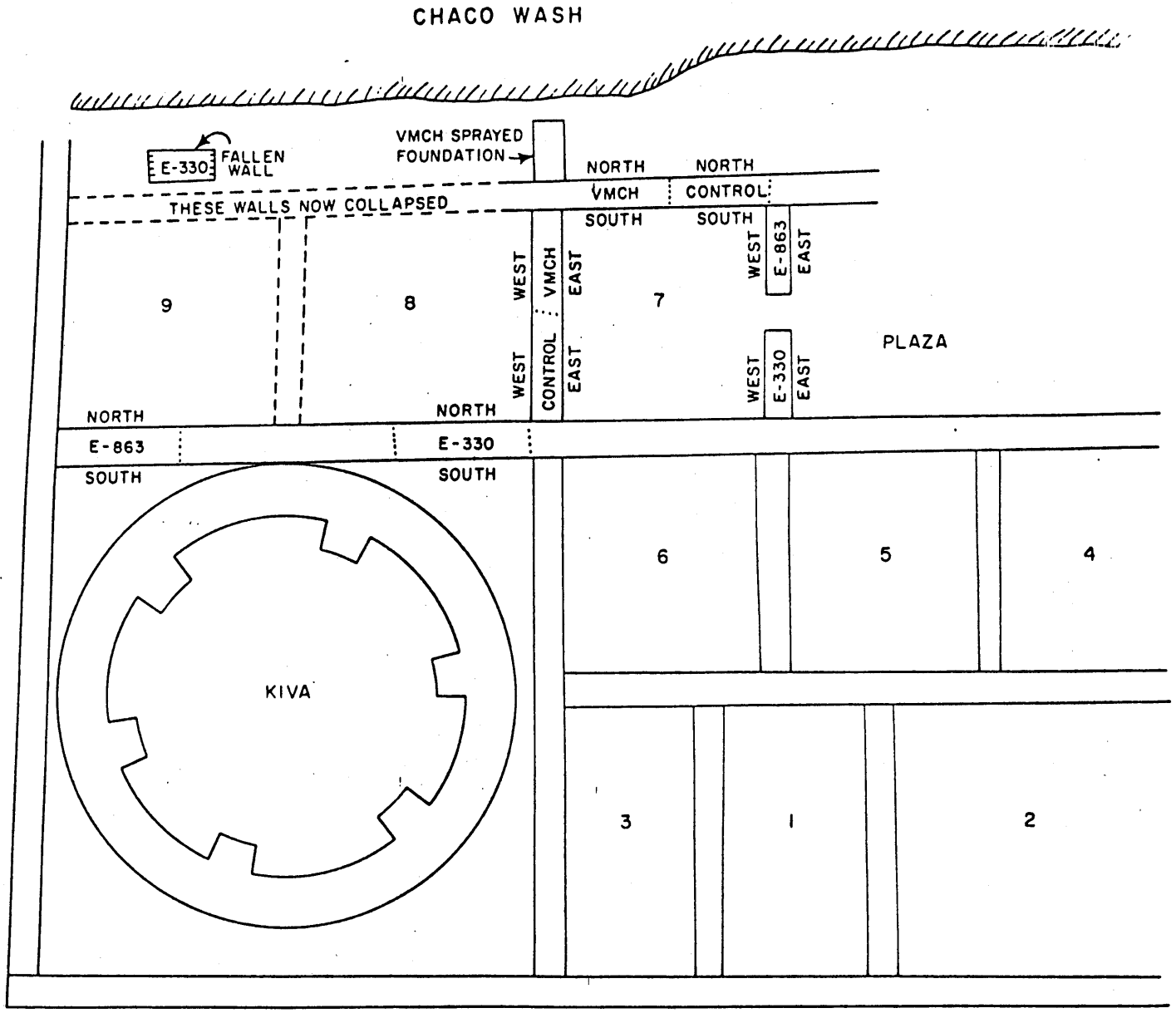


FIGURE I: SITE Bc-236

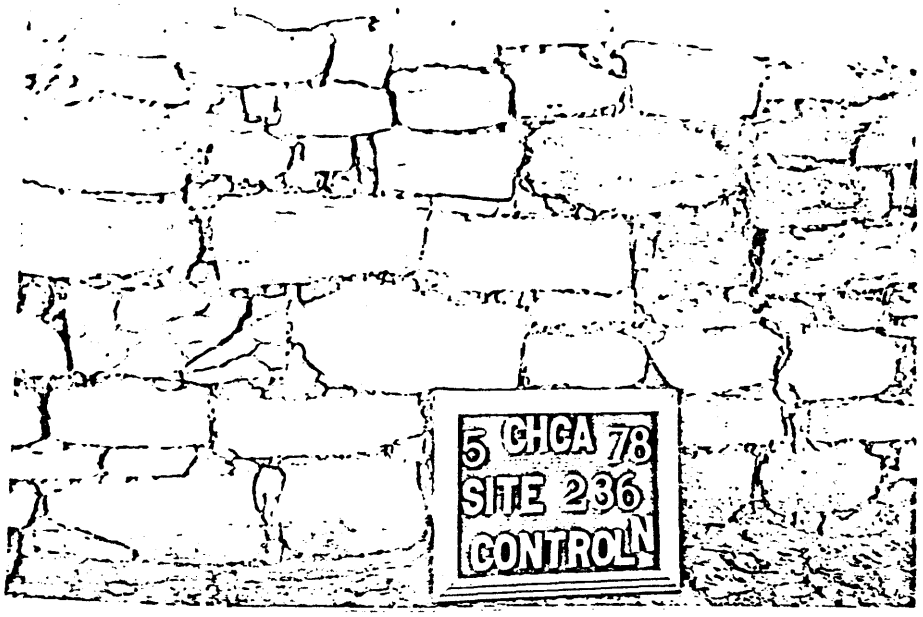


Figure 2: North Facing Control Plot at Site Bc-236 after 33 months of exposure.

Bakelite VMCH Vinylite Plots

The Bakelite VMCH Vinylite treatment, as reported earlier by Fenn (7, [illegible]) proved unsatisfactory. Within three months of the treatment application, the VMCH had started to turn a dark maroon color due to the influence of ultraviolet solar radiation.

When the VMCH plots were observed on May 9, 1978, much of the discolored VMCH had faded or peeled away and the mortar looked reasonably good. The discoloration that initially occurs is unsatisfactory, however, and VMCH was eliminated from further consideration as a mortar treatment.

Primal AC-33 Plots

The Primal AC-33 plots are all showing signs of significant erosion. Up to 50 percent or more of the treated repointing mortar placed in the joints has eroded away. This material is an improvement over the control plots, but does not appear to be sufficiently effective to prove economical and satisfactory for use on a large scale.

Rhoplex E-330 Plots

The Rhoplex E-330 plots are beginning to show some signs of minor erosion. The capping mortar has eroded smooth and no brush marks are showing. The mortar joints are still resisting erosion well, however, with many surfaces still bearing the finishing brush marks from the time application 33 months earlier.

Figure 3 shows the north facing Rhoplex E-330 plot as it appeared on May 9, 1978. A close examination of Figure 3 reveals that many of the mortar joints still show the finishing brush marks as mentioned earlier. The mortar shows considerable cracking due to the bentonite clay present in the soil. This cracking, however, has not affected the durability of the test mortars in the E-330 plots.

Figure 3: North facing Rhoplex E-330 plot at site Bc-236 as it appeared after 33 months of exposure.

In a severe test of erosion resistance, a 2.5 x 6.0 foot section of intact wall that had fallen over earlier due to basal erosion was repointed with E-330 treated mortar on July 31, 1975. The mortar joints in this plot have been exposed to direct vertical rainfall for over 33 months. Figure 4 shows the plot's appearance on May 9, 1978. Except for a small hole that has eroded near the right center of the plot, the E-330 mortar is still intact. The surface is beginning to erode, however, and about 1/4" of the mortar has been lost. This degree of erosion resistance shows that the Rhoplex E-330 has a promising potential as a repointing mortar additive.

Figure 4: Rhoplex E-330 treated wall (note wall is lying horizontal on ground) at Site Bc-236 after 33 months of exposure.

Site SJ-1912, Lizard House Ruin

Figure 5 is a schematic diagram of Lizard House Ruin and shows the locations of the treatment plots used in this study. Each treatment consisted of capping the top of the wall and repointing all of the joints in the face of the wall down to ground level. The wall height varied from seven feet in Room 12 down to two feet along the south wall of Room 17.

Eight Rhom and Haas chemicals are being tested at Lizard House, namely: Rhoplex E-330, Rhoplex E-1141, Rhoplex AC-61, Rhoplex AC-634, Rhoplex SS-521, Acryloid A-21, Primal 863, and Primal 826. It was not possible to get complete cardinal direction exposures for all eight chemicals used at Lizard House due to a lack of suitable walls.

Lizard House was revisited on May 9, 1978, and observations made of the treatment plots after 31 months of exposure. The reported percentages of erosion loss are visual estimates only.

Control Plots

The three control plots are all showing significant erosion. Up to 75% of the untreated repointing mortar placed in the plots on October 9, 1975, has been eroded away.

Acryloid A-21 Plots

The three Acryloid A-21 plots show very little erosion except for a slight smoothing of the capping mortar. Finishing brush marks are still clearly evident on the mortar joints. The results achieved with most solvent-based chemicals in this study have been very unsatisfactory. The Acryloid A-21 is an exception to this result. It is performing very

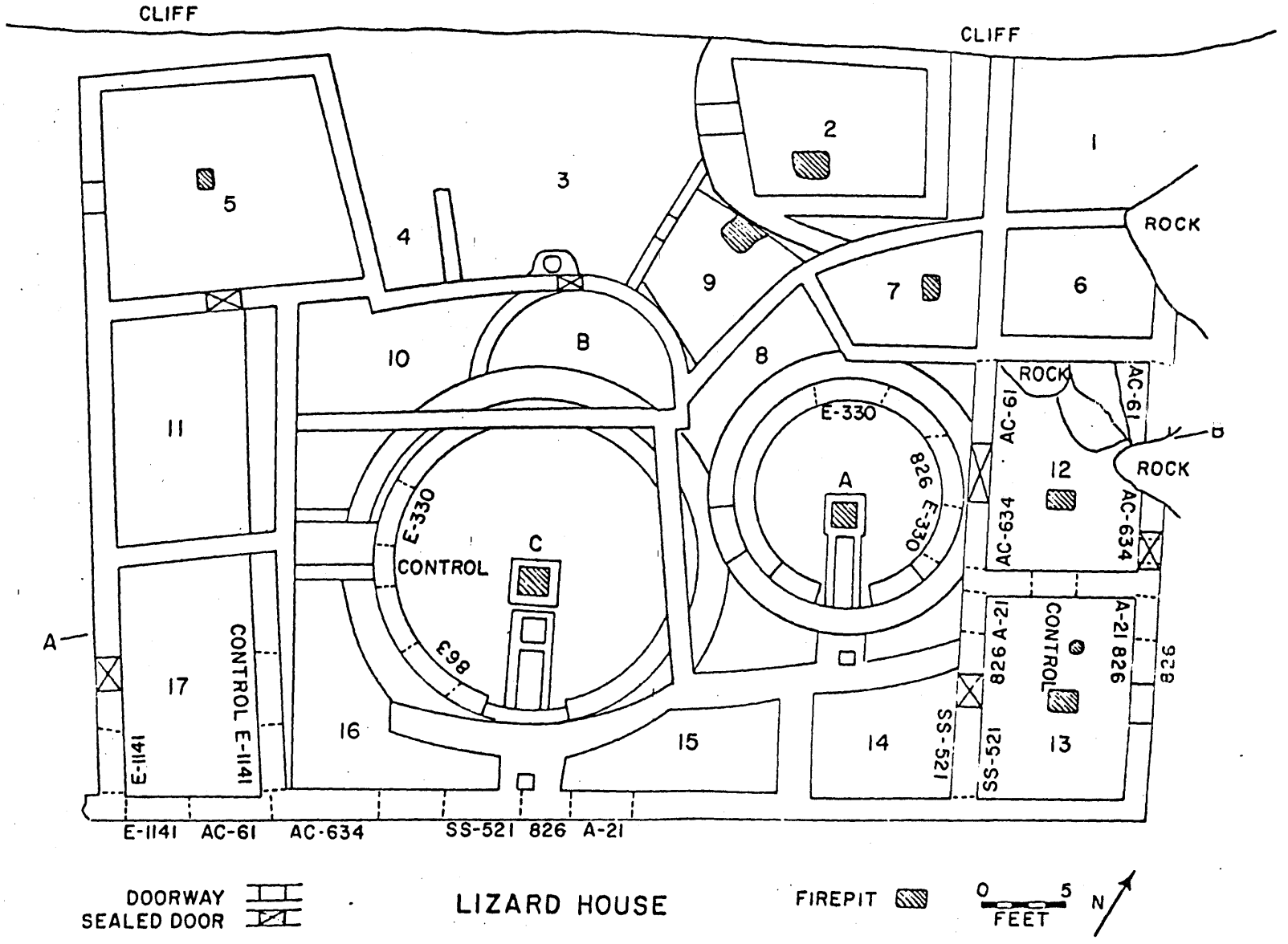


FIGURE 5: SITE SJ-1912

well after 31 months of exposure. Less than 5% of the treated mortar applied in 1975 has thus far been eroded away.

Primal 826 Plots

The five Primal 826 plots have eroded smooth on the caps and some of the joints are also showing a slight erosion of the finishing brush marks. This material remains strong and intact overall. Less than 10% of the mortar applied in 1975 has been eroded away.

Primal 863 Plot

The one Primal 863 plot is beginning to show some minor erosion. The finishing brush marks on the mortar are beginning to erode smooth in the joints and the capping is eroded smooth. Approximately 10% of the original test mortar has been eroded.

Rhoplex E-330 Plots

The three E-330 plots show a slight smoothing of the brush marks on the capping. The mortar joints show very little erosion. Less than 5% of the original test mortar applied in 1975 has eroded away.

Rhoplex SS-521 Plots

The three Rhoplex SS-521 plots are showing slightly more erosion than the other Rhoplex products. The capping is very smooth and some of the mortar joints have also eroded smooth. It is estimated that 10-15% of the original test mortar has eroded away.

Rhoplex AC-61, AC-634, E-1141 Plots

The Rhoplex AC-61, Rhoplex AC-634, and Rhoplex E-1141 plots are all performing similarly with a smoothing of the capping mortar and very little

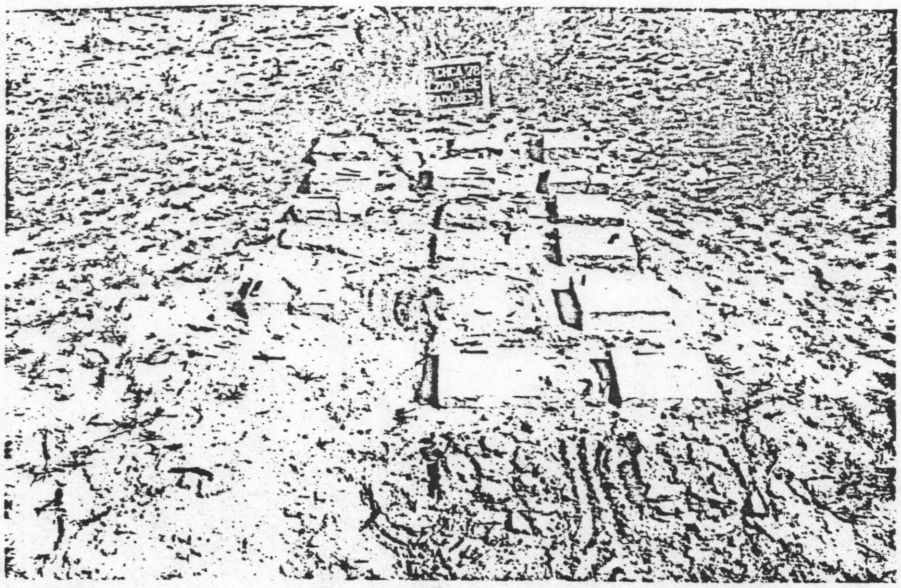


Figure 6: Appearance of test adobes at Lizard House Ruin after 31 months of exposure. (See Figure 7 for identification of chemicals used.)

erosion of the joints. Less than 5% of the original test mortar has been eroded away.

Test Adobe Blocks

In a severe test of erosion resistance, each chemically treated mortar was also formed into two 1' x 1' x 3.5" adobe test blocks and set out on the ground across the arroyo from Lizard House. Figure 6 shows the appearance of these adobe blocks after 31 months of exposure. Figure 7 shows the identification of the chemical used in each adobe test block.

As can be seen in Figure 6, several of the products have not withstood the 31 months of exposure. The two control adobes show considerable erosion and are barely intact. The two Primal 863 adobes and one of the Rhoplex SS-521 adobes have completely disintegrated. The two Rhoplex E-1141 adobes are intact, but an estimated 50% of the original volume of both have eroded away, as is the case with the one Rhoplex SS-521 adobe still intact. The Acryloid A-21 adobes show some erosion, but are intact.

The blocks showing the least damage after 31 months of exposure are the Rhoplex E-330, H_2Out, Primal 826, Bakelite VMCH Vinylite, Rhoplex AC-634, and Rhoplex AC-61 adobes. The Rhoplex E-330 adobes appear overall to be the best of the samples tested.

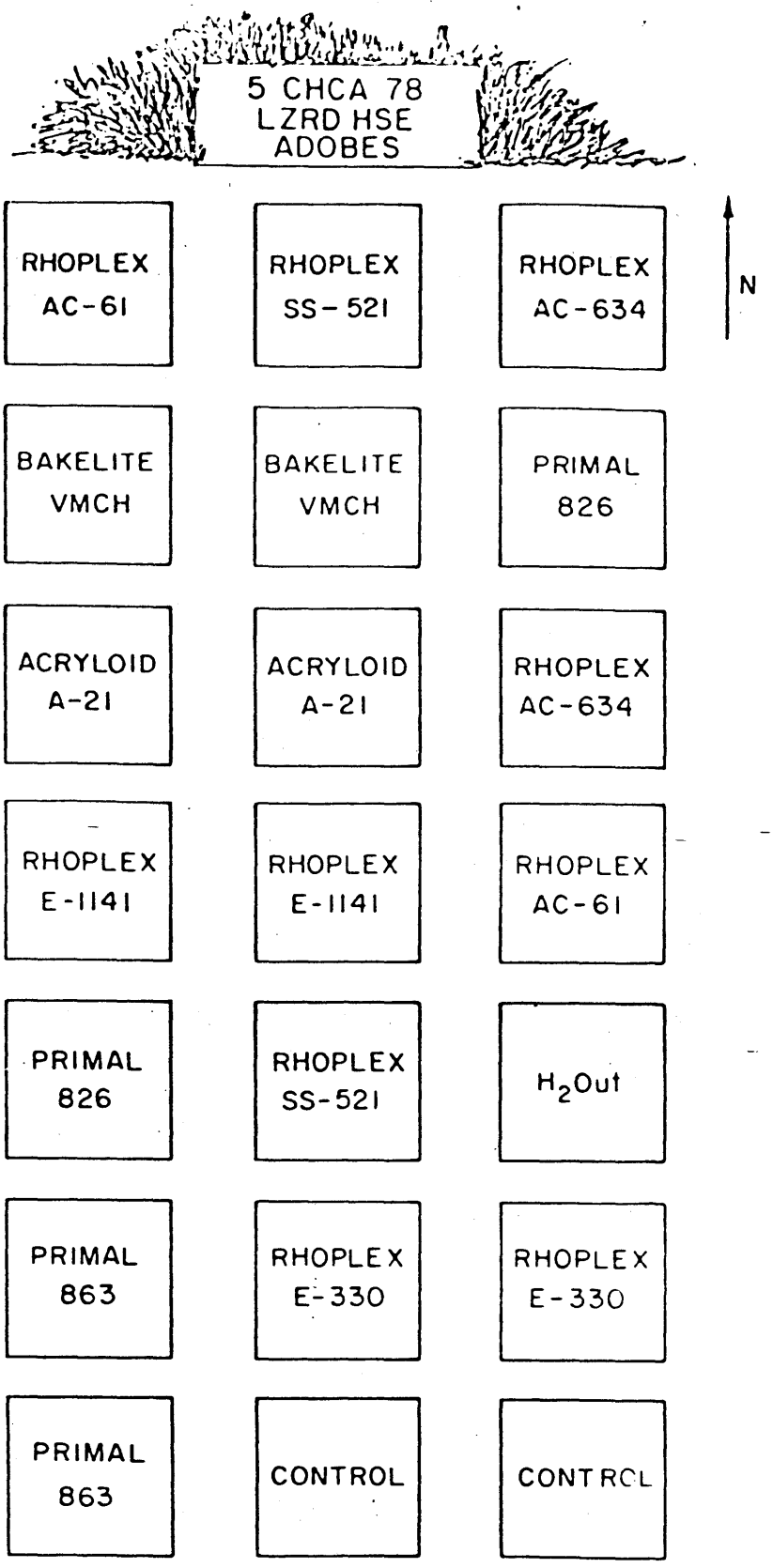


FIGURE 7: IDENTIFICATION OF CHEMICAL PRODUCTS USED IN MAKING ADOBE TEST BLOCKS AT LIZARD HOUSE RUIN ON OCTOBER 11, 1975

Pithouse Site SJ-299

The study plots at this site were terminated on August 13, 1977, due to the complete failure of the spray treatments to resist pithouse wall erosion.

Quoting from the Second Annual Chaco Canyon Research Report (8): "The results of this study demonstrate that the surface spray application of waterproofing chemicals to an exposed soil bank is not an effective long-term treatment. The surface soon cracks and moisture and wind get in behind the treatment and cause spalling and exfoliation of the surface. Erosion then is accelerated in the exposed areas of the surface."

"Because of the serious damage occurring to the pithouse due to the failure of the treatments, it was decided to terminate this study. The pithouse has been backfilled to prevent further damage."

The plans for digging a test "pithouse" and initiating a new series of pithouse wall stabilization tests during the summer of 1978 did not materialize. The transfer of the principal investigator to the Western Regional Office and the shortage of funds at the Western Archeological Center were the principal reasons for the lack of progress in this regard.

This important area of research should be given a high priority for Southwest Region research funds in the near future.

Modern Test "Ruin"

Figure 8 shows a photograph of the modern test "ruin" as it appeared on May 10, 1978. The perimeter wall is clearly visible as is the continuously recording weather station and the sewage lift station. Also visible to the right (west) of the ruin are the adobe test blocks as shown in more detail in Figures 13 and 15. North is at the bottom of the photograph.

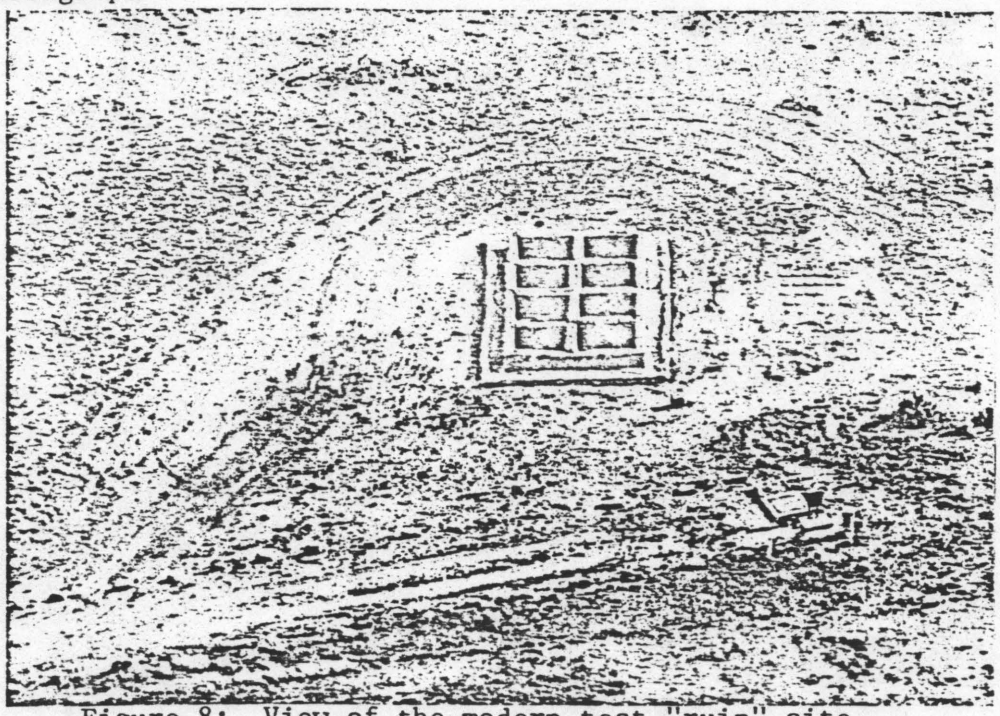


Figure 8: View of the modern test "ruin" site on May 10, 1978.

Figure 9 shows a schematic outline of the test "ruin" and the chemical product tested in each plot at the time of original construction in July 1976.

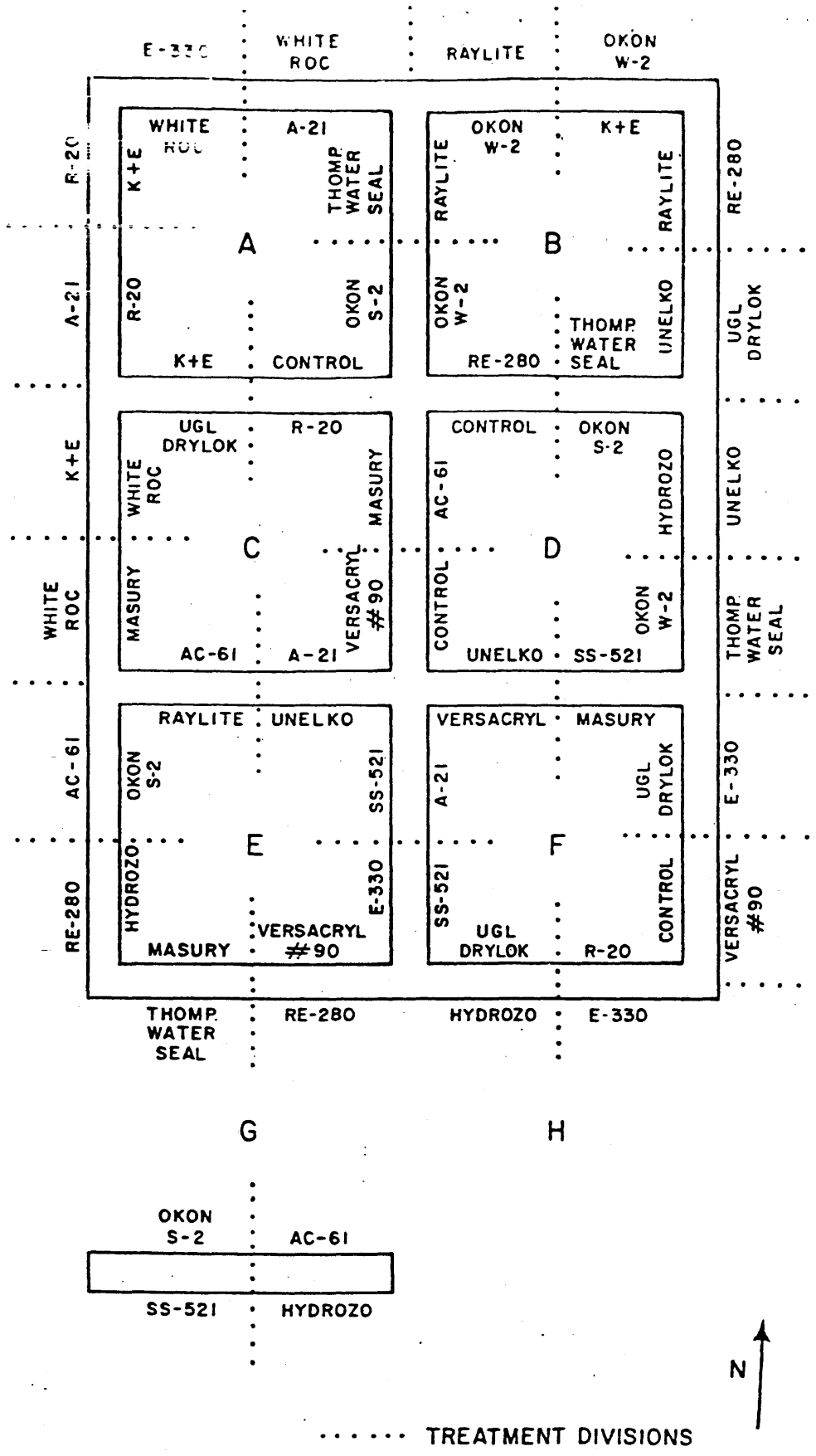


FIGURE 9: MODERN TEST "RUIN", JULY 21, 1976

The test plots are 4' long and 3½' high. An average of 11 layers of Cliff House sandstone (9, 10) were used to construct each wall. The chemical products were assigned to each plot by a random-draw procedure and each treatment has a plot facing east, west, north, and south. An error in assignment, however, resulted in Hydrozo having two south exposures and no north exposure and AC-61 having two north exposures and no south exposure.

During construction of the test "ruin," the mortar between the layers of stone was intentionally left out of the exterior two inches of the wall on both sides. This then provided the space for repointing the joints with treated test mortar.

The treatments were applied to the test plots on July 20 and 21, 1976. The chemicals were first sprayed onto the stone in each respective test plot and allowed to dry. The organic solvent-based materials were absorbed by the stone at a faster rate than the water-based chemicals. The one exception to this was the water-based K & E Penetrating Mineral Sealer which was absorbed by the stone at the fastest rate of all the 17 chemicals tested at that time.

Most of the chemicals caused a slight darkening of the stone. This effect was most noticeable when adjacent to an untreated control plot. The effect was indistinguishable when the entire length of a wall had been treated with chemicals. The most serious discoloration occurred with Rhoplex SS-521 and Acroloid A-21. Both of these chemicals, rather than darkening the stone, however, formed a chalky-white surface. When the site was revisited on May 10, 1978, most of the treatment plot colors had faded to closely match the central plots during the 22 months of exposure.

After the stone treatments had been completed and allowed to dry, the repointing mortar treatments were applied. The same chemical sprayed on the stone in a given plot was used to prepare the amended repointing mortar for that plot. This allows for a direct contrast to be made between a chemical's effectiveness as a mortar amendment and as a stone preservative.

Figure 10 shows a schematic of the modern test "ruin" as it appeared following the completion of the structure and the addition of the 18-inch-high perimeter wall on August 11, 1977.

Figure 11 shows the location of all treatment plots after the replacement of several failed treatments with 5:1 soil-cement, Subind and Suferm test plots on August 3, 1978. Figure 11, therefore, shows the current configuration of the modern test "ruin" in Chaco Canyon National Monument. The percentage erosion loss figures given are based upon visual estimates only.

Solvent-Based Chemical Plots

Most of the hydrocarbon solvent-based chemicals tested on the modern "ruin" performed very poorly as mortar additives. The mud mortars prepared with organic solvent-based chemicals in almost every case were difficult to work with because of a lack of adhesive and cohesive properties. Also, when the subject mortars dried, instead of forming hard adobe, they formed loose-grained powders that quickly crumbled out of the mortar joints.

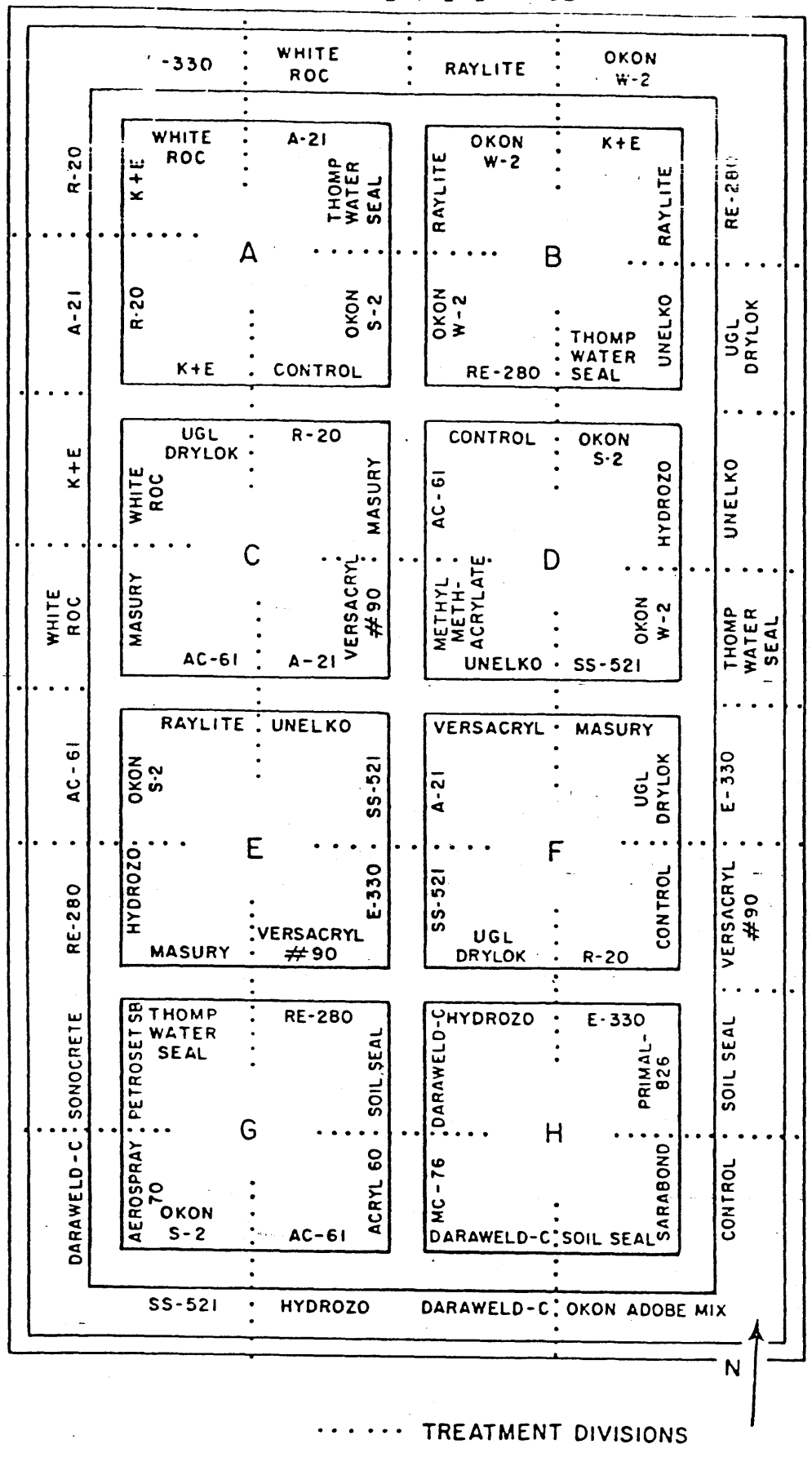


FIGURE 10: MODERN TEST "RUIN", AUGUST 11, 1977

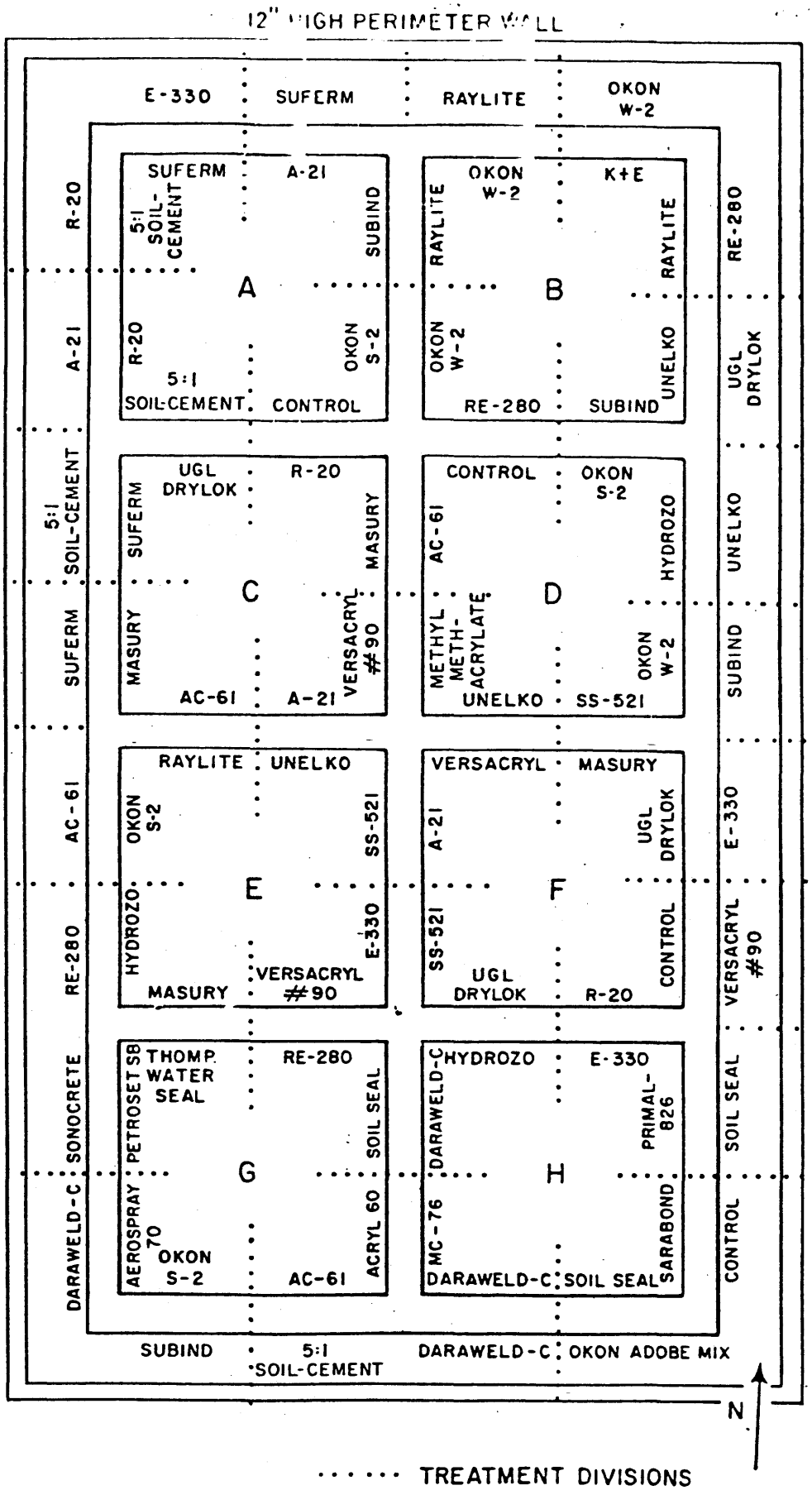


FIGURE II: MODERN TEST "RUIN", AUGUST 3, 1978

The cause of this failure is the fact that organic solvents flocculate the clay mineral fraction of a soil, thus interfering with the bonding interaction between the sand and clay particles. This then prevents the formation of a uniform, bonded, stable adobe mortar upon drying.

The organic solvent-based chemicals that failed as mortar additives in this study were as follows: White Roc Clear Masonry Sealer, Thompson's Water Seal, Hydrozo Special Clear, Drylock Silicone (UGL), Okon S-2, Wendex Silicone Clear Water Repellent (Masury), and Acryloid A-21.

The authors are unable to explain why Acryloid A-21 failed quickly in tests on the modern "ruin," but is performing very well in tests on Lizard House ruin.

The one exception to this organic solvent chemical failure occured with Raylite D-36. This product produced a hard, stable mortar that still showed good erosion resistance in three out of four test plots after 22 months of exposure. The east facing Raylite D-36 plot, however, showed considerable erosion with an estimated 75% of the original mortar gone on May 10, 1978.

It is recommended, based upon these results, that organic-based solvent chemicals not be used in making chemically amended repointing mortars. The properties of these products are simply incompatible in most cases with this particular usage.

Control Plots

The three control plots established in July 1976 are all showing considerable weathering, with 100% of the original mortar eroded away in the

south and east facing plots. The north facing plot, as shown in Figure 12, has lost approximately 80% of its original test mortar. This shows that considerable erosion can occur to an exposed ruin in a relatively short time and further demonstrates the need for an effective mortar amendment.

Figure 12: North facing control plot in modern test "ruin" after 22 months of exposure.

The east facing control plot was replaced by a methyl methacrylate in situ polymerization test plot on August 11, 1977. A new east facing control plot was placed in the newly built section of the "ruin" at that time, and it shows only minor erosion after nine months of exposure.

Water-Based Chemical Plots: Failures

Three water-based chemical products tested on the "ruin" have clearly failed to provide adequate protection and stabilization to the repointing mortar. These products are as follows: Union Carbide R-20,

K & E Mineral Sealer, and Rhoplex SS-521. These products suffered a loss of 85-100% of the original repointing test mortar in a period of less than 22 months.

Water-Based Chemical Plots: Moderate Effectiveness

Four water-based chemical products tested on the "ruin" have thus far been moderately effective in reducing mortar erosion. These products are as follows: Rhoplex AC-61, Versacryl E No. 90, Okon W-2, and Union Carbide RE-280. These products are all showing some erosion, but are still largely intact and losses have been less than 20% of the original mortar applied.

Water-Based Chemical Plots: Very Effective

Eleven chemical products have thus far proven to be very effective in resisting erosion in amended mortar tests on the "ruin." These products are Rhoplex E-330, Primal 826, Acryl 60, Okon Adobe Mix, Soil Seal, Daraweld-C, Petroset SB, Sarabond, Aerospray 70, Sonocrete, and Rhoplex MC-76. These products are all showing little or no erosion in their test plots.

It should be noted herein that only the Rhoplex E-330 has been exposed to weathering for 22 months. The other 10 treatments have only been in place for 12 months. Additional time will be needed before any definite conclusions can be drawn about the long-range effectiveness of these 10 promising products. It could be significant, however, that in mud plaster tests at Bent's Old Fort National Historic Site (11, 12, 13), Acryl 60, Aerospray 70, Daraweld-C, and Soil Seal have all performed very well in resisting erosion.

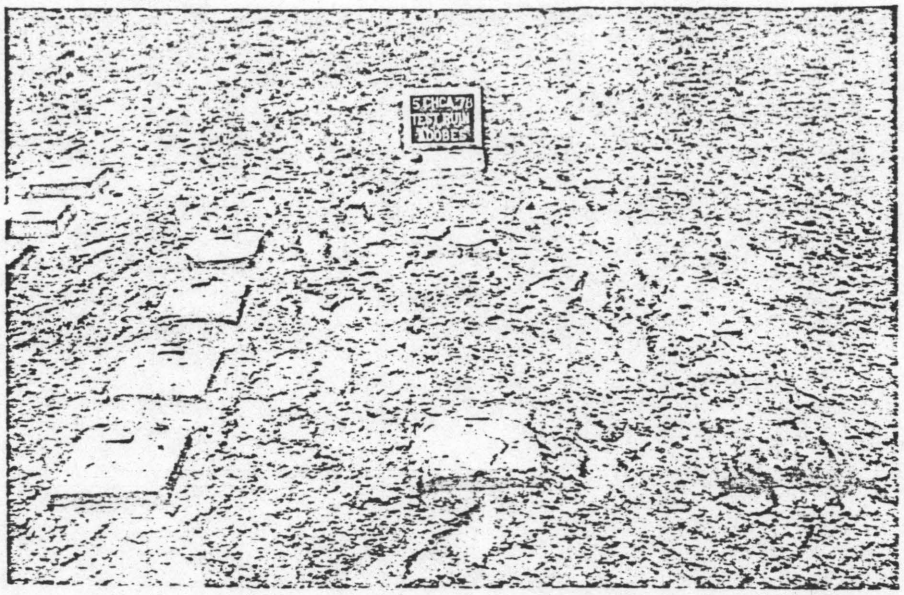


Figure 13: Appearance of test adobe blocks at modern "ruin" on May 10, 1978 after 22 months of exposure (see Figure 14 for identification of chemical products used in each adobe block).

Test Adobe Blocks

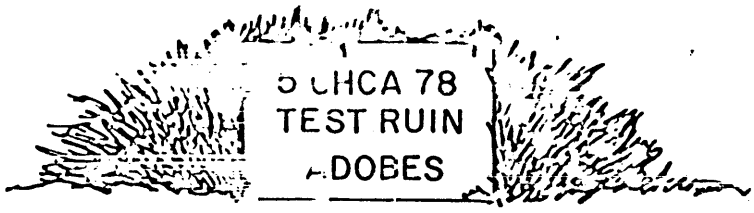
In a test similar to that performed at Lizard House, adobe blocks were made of amended mortar for each chemical product tested on the modern "ruin." These blocks were then placed on the ground just west of the "ruin" and allowed to weather. Figures 13 and 15 show the adobe blocks as they appeared on May 10, 1978. The adobe blocks in Figure 13 had undergone 22 months of weathering, and the blocks in Figure 15 had been weathering for nine months at the time the photos were taken on May 10. Figures 14 and 16 identify the chemical products being tested in the adobe blocks of Figures 13 and 15 respectively.

As can be seen in Figure 13, the following products have failed to survive the 22 months of exposure: K & E Mineral-Sealer, Okon W-2, White Roc, Hydrozo, Thompson's Water Seal, Okon S-2, and UGL Drylock Silicone.

Several amended adobe blocks are still intact, but showing considerable erosion, namely: Union Carbide R-20, Masury Wendex Silicone Clear Water Repellent, Versacryl E No. 90, and Rhoplex AC-61.

The chemical products that appear to be performing well in the adobe block weathering test include Raylite D-36, Union Carbide RE-280, Rhoplex E-330, and Unelko.

The degree of erosion potential existing is demonstrated by the amount of erosion that has occured with the untreated control adobe block. This block, as seen in Figure 13, is intact but badly eroded. Almost 50% of the original volume of the block has been eroded away in the 22 months of exposure.



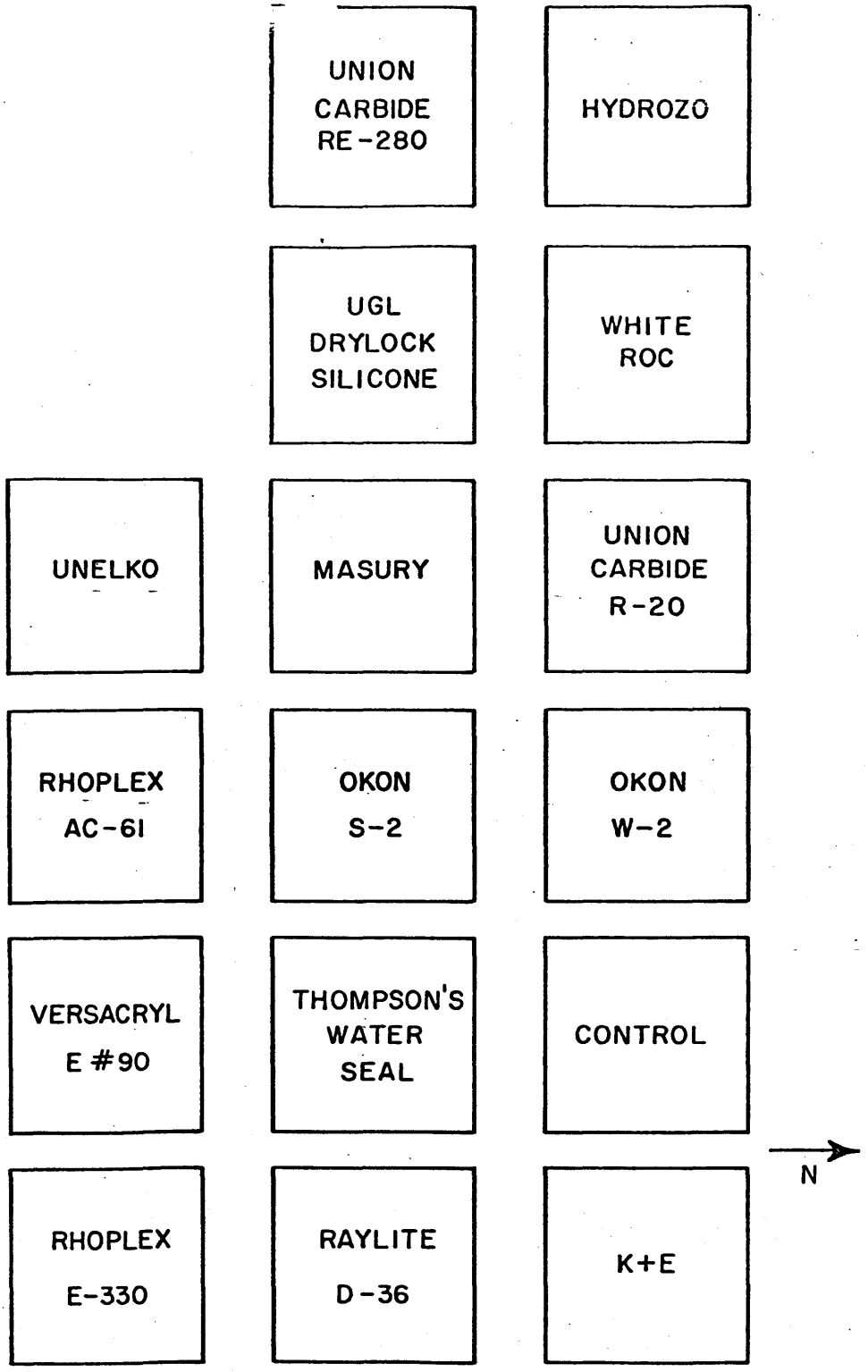


FIGURE 14: IDENTIFICATION OF CHEMICAL PRODUCTS USED IN MAKING ADOBE TEST BLOCKS AT MODERN "RUIN" ON JULY 22, 1976.

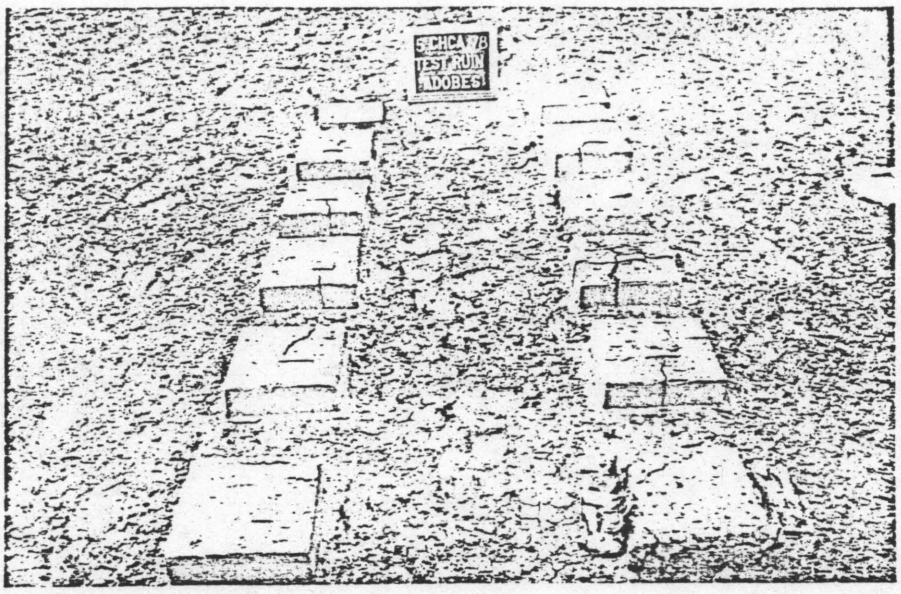


Figure 15: Appearance of test adobe blocks at modern "ruin" on May 10, 1978 after 9 months of exposure (see Figure 16 for identification of chemical product used in each adobe block).

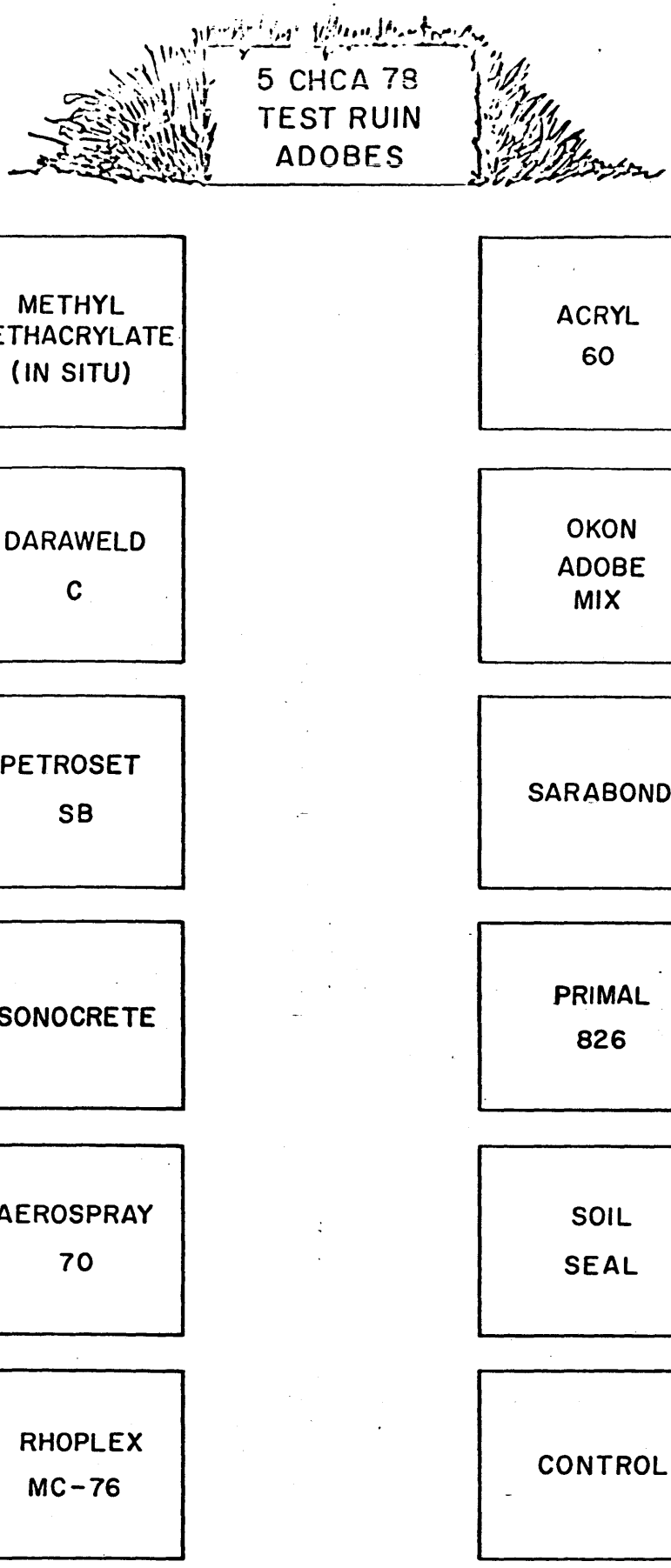


FIGURE 16: IDENTIFICATION OF CHEMICAL PRODUCTS USED IN MAKING ADOBE TEST BLOCKS AT MODERN "RUIN" ON AUGUST 13, 1977.

Figure 15 shows 12 additional chemically amended adobe blocks that were made on August 13, 1977. They had, therefore, been weathering for nine months when the photograph was taken on May 10, 1978. The unamended control block is beginning to erode badly.

Only the Sarabond block of the treated adobes is showing much erosion. The Primal 826 block is badly cracked and several other adobes also show cracks. This cracking, however, is due to the bentonitic soil and to handling during production of the adobes and is therefore not due to the chemical treatments themselves.

Both sets of adobe blocks, those made in 1976 and those made in 1977, should be monitored over the next several years. This severe erosion resistance test is a very effective method for determining how long a chemical product can provide mortar erosion protection.

Laboratory Analysis

During the winter and spring of 1978, a thorough laboratory analysis of wet and dry unconfined compressive strength and soaking stability of the chemically amended mortars was conducted.

Each of the 23 water-based chemical products tested in this study (Primal 863 and Union Carbide RE-280 were deleted) were mixed with Chaco test soil to produce mortars with a chemical content of 1%, 2½%, or 5% on a weight replacement basis in the final dried mud. These mortars were then placed in standard 1.25-inch diameter by 2.5-inch long cylindrical test molds and compacted to a standard dry density of 100 lbs/ft^3. After drying for 24 hours, the molds were removed and the samples allowed to cure for at least 30 days under laboratory atmospheric conditions.

After curing, duplicate mortar cylinders for each chemical product were tested to failure on the unconfined compression testing instrument in the laboratory. Two additional mortar cylinders were submerged in water for one hour and then tested to failure on the unconfined compressive testing instrument. A fifth sample for each chemical product was submerged in water and soaked for seven days with the physical condition of the sample noted every 24 hours.

Air-Dry Unconfined Compressive Strength

Table 1 shows the results of the unconfined compressive strength analysis for the air-dried samples following a minimum of 30 days curing time. Oven-dried moisture determinations of the failed samples showed a percent moisture content of less than 1.5% in all samples tested.

Table 1: Results of unconfined compressive strength testing of chemically amended mortar 1.25-inch diameter by 2.5-inch long cylinders after a minimum of 30 days curing under laboratory conditions.*

Chemical Product	% Chemical solids by weight in air-dried mortar		
	1%	2½%	5%
	Unconfined Compressive Strength, PSI**		
Aerospray 52	162	200	452
Aerospray 70	593	957	1008
Subind	140	76	94
Suferm	91	100	96
Rhoplex E-1141	174	230	318
Rhoplex E-330	592	898	1075
Rhoplex MC-76	616	854	882
Rhoplex AC-634	560	551	722
Rhoplex AC-61	526	522	569
Rhoplex SS-521	456	363	205
Primal 826	356	268	727
Sonocrete	516	720	953
K&E Mineral Sealer	72	130	85
Acryl 60	688	764	862
Durak	543	702	1026
Daraweld-C	578	604	890
Versacryl E No. 90	155	300	-
Okon W-2	170	372	-
Okon Adobe Mix	518	586	510
Union Carbide R-20	494	638	849
Soil Seal	467	687	884
Sarabond	326	300	174
Petroset SB	165	130	75
Control (100 lbs/ft^3)	307***		
Control (105 lbs/ft^3)	277***		

*Cylinders were ground to make ends approximately flat and parallel. No capping was used.

**Average from two cylinders

***0% Chemical solids

Two chemicals, namely, Aerospray 52 and Durak, were included in the laboratory tests and the results are shown in Table 1. These two products, however, have not yet been placed in test plots for field testing in Chaco Canyon. The Aerospray 52 performed so poorly in the laboratory tests that it will not be placed under field testing.

The 1% chemical solids mortar in Table 1 corresponds roughly to using a 3.8% solids by weight solution of chemical to make a mortar of workable consistency.

The 2½% chemical solids mortar corresponds closely to the result of using an 8.9% solids by weight solution of chemical to make a mortar. Therefore, most of the field tests conducted at BC-236, SJ-1912, and the "ruin" relate closely to this value of 2½% chemical solids by weight in the air-dried mortar.

The 5% chemical solids mortar would be closely approximated by using a chemical solution containing 16% solids by weight to make a suitable mortar.

Examining the 2½% chemical solids column of Table 1, which corresponds closely to the mortar mixes placed in field test in Chaco Canyon to date, and using a minimum compressive strength criteria of 600 psi, there are nine products that look promising. These products are: Aerospray 70, Rhoplex E-330, Rhoplex MC-76, Sonocrete, Acryl 60, Durak, Daraweld-C, Union Carbide R-20, and Soil Seal.

Wet Unconfined Compressive Strength

Since water is the main erosive agent of concern to the ruins stabilizer, and because wet soils (even chemically amended soils) have less erosion

resistence and lower shear strength than dry soils, it was necessary to evaluate the compressive stength of moist samples as well as dry. Table 2 shows the results of this study. It is quite obvious that the performance of most of the chemical products is dramatically altered by being submerged in water for one hour. As seen in the 2½% chemical solids column, none of the products meet the 600 psi criteria. In the 5% chemical solids column, only Rhoplex E-330 and Union Carbide R-20 meet the criteria, with Acryl 60 and Durak coming very close to meeting it.

This wet unconfined compressive strength test was performed under conditions much more stringent than is likely to be encountered under normal field conditions. It does, however, give a good indication of the limits of the stabilizing potential of organic polymers.

Seven-Day Soaking Test

In another severe laboratory test of treatment effectiveness, one test cylinder for each chemical product was placed in a 500 ml. breaker full of water. The effect of this submergence on the appearance and stability of the test cylinders was monitored periodically over a seven-day period. The cylinders were not agitated or moved during the soaking period. The results of this test are summarized in Table 3.

The following chemical products failed to withstand the soaking test at any of the three percentage chemical solids levels: Subind, Rhoplex E-1411, Rhoplex SS-521, Okon Adobe Mix, and Sarabond.

Several products showed good soaking stability at 5% chemical solids but disintegrated at 1% and 2½% chemical solids. These products

Table 2: Results of unconfined compressive strength (psi) testing of chemically amended mortar 1.25-inch diameter by 2.5-inch long cylinders after a minimum of 30 days curing under laboratory conditions and then soaking in water for one hour, and the percentage moisture absorbed during the one-hour submersion.*

Chemical Product	% Chemical solids by weight in air-dried mortar					
	1%		2½%		5%	
	psi**	% H_2O**	psi**	% H_2O**	psi**	% H_2O**
Aerospray 52	14	16.6	18	18.6	50	13.3
Aerospray 70	24	14.7	111	9.3	290	6.8
Subind	0	***	0	***	20	15.3
Suferm	6	19.8	17	17.7	23	18.5
Rhoplex E-1141	12	17.4	0	***	0	***
Rhoplex E-330	13	15.0	20	12.9	696	2.1
Rhoplex MC-76	82	9.9	94	7.3	366	4.1
Rhoplex AC-634	127	7.5	95	9.5	177	7.6
Rhoplex AC-61	14	14.9	14	17.6	16	19.7
Rhoplex SS-521	0	***	0	***	0	***
Primal 826	24	10.8	18	19.8	25	12.3
Sonocrete	345	4.3	496	3.4	444	2.1
K&E Mineral Sealer	0	***	0	***	11	17.1
Acryl 60	50	12.0	322	6.0	564	4.6
Durak	62	9.9	113	7.9	558	4.2
Daraweld-C	17	15.1	30	11.0	28	14.3
Versacryl E No. 90	0	19.7	15	19.4	***	***
Okon W-2	16	15.4	176	16.0	***	***
Okon Adobe Mix	61	9.6	22	13.2	310	4.5
Union Carbide R-20	303	2.3	469	2.1	869	2.0
Soil Seal	82	8.7	242	6.9	29	9.5
Sarabond	0	***	0	***	0	***
Petroset SB	20	12.2	20	11.4	16	12.2
Control (100 lbs/ft^3)	No chemicals used. Cylinders disintegrated within 2 minutes. Unconfined compressive strength of zero. No % H_2O readings possible.					
Control (105 lbs/ft^3)						

*Cylinders were ground to make ends approximately flat and parallel. No capping was used.

**Average from two cylinders

***Samples disintegrated. No % H_2O readings possible.

Table 3: Appearance of test cylinders after seven days submerged in water and percent moisture absorbed by selected samples during submersion.

Chemical Product	% Chemical Solids in Water	Soaking Test Results	% H_2O Absorbed
Aerospray 52	1%	Sample disintegrated within 36 hours of submersion	
	2½%	Sample showed minor damage after 7 days of submersion	20.7% H_2O
	5%	Sample showed no damage after 7 days of submersion	17.0% H_2O
Aerospray 70*	1%	Sample not tested	
	2½%	Sample not tested	
	5%	Sample not tested	
Subind	1%	Sample disintegrated within 2 minutes of submersion	
	2½%	Sample disintegrated within 2 minutes of submersion	
	5%	Sample showed major damage after 7 days soaking	
Suferm	1%	Sample showed major damage after 7 days soaking	
	2½%	Sample showed minor damage after 7 days soaking	20.0% H_2O
	5%	Sample showed minor damage after 7 days soaking	21.0% H_2O
Rhoplex E-1141	1%	Sample showed major damage after 7 days soaking	23.0% H_2O
	2½%	Sample disintegrated within 30 minutes of submersion	
	5%	Sample disintegrated within 48 hours of submersion	
Rhoplex E-330	1%	Sample disintegrated within 8 hours of submersion	
	2½%	Sample disintegrated within 96 hours of submersion	
	5%	Sample showed no damage after 7 days of submersion	14.0% H_2O

Table J Con't

Chemical Products	% Chemical Solid in Water	Soaking Test Results	% H_2O Absorbed
Rhoplex MC-76	1%	Sample disintegrated within 4 hours of submersion	
	2½%	Sample disintegrated within 7 days of submersion	
	5%	Sample showed no damage after 7 days of submersion	19.0% H_2O
Rhoplex AC-634	1%	Sample showed no damage after 7 days of submersion	
	2½%	Sample showed minor damage after 7 days of submersion	
	5%	Sample showed no damage after 7 days of submersion	
Rhoplex AC-61	1%	Sample disintegrated within 8 hours of submersion	
	2½%	Sample disintegrated within 96 hours of submersion	
	5%	Sample showed minor damage after 7 days of submersion	
Rhoplex SS-521	1%	Sample disintegrated within 2 hours of submersion	
	2½%	Sample disintegrated within 4 hours of submersion	
	5%	Sample disintegrated within 24 hours of submersion	
Primal 826	1%	Sample showed no damage after 7 days of submersion	23.6% H_2O
	2½%	Sample showed no damage after 7 days of submersion	22.9% H_2O
	5%	Sample showed no damage after 7 days of submersion	24.4% H_2O
Sonocrete	1%	Sample showed no damage after 7 days of submersion	17.9% H_2O
	2½%	Sample showed no damage after 7 days of submersion	18.5% H_2O
	5%	Sample showed no damage after 7 days of submersion	16.5% H_2O

Table 3 Con't

Chemical Product	% Chemical Solid in Water	Soaking Test Results	% H_2O Absorbed
K&E Mineral Sealer	1%	Sample disintegrated within 2 minutes of submersion	
	2½%	Sample disintegrated within 24 hours of submersion	
	5%	Sample showed minor damage after 7 days of submersion	19.0% H_2O
Acryl 60	1%	Sample disintegrated within 6 hours of submersion	
	2½%	Sample showed minor damage after 7 days of submersion	20.5% H_2O
	5%	Sample showed no damage after 7 days of submersion	20.1% H_2O
Durak*	1%	Sample not tested	
	2½%	Sample not tested	
	5%	Sample showed no damage after 7 days of submersion	23.0% H_2O
Daraweld-C	1%	Sample disintegrated after 5 days of submersion	
	2½%	Sample showed no damage after 7 days of submersion	
	5%	Sample showed no damage after 7 days of submersion	
Versacryl E No. 90	1%	Sample disintegrated within 8 hours of submersion	
	2½%	Sample showed minor damage after 7 days of submersion	26.0% H_2O
	5%	Sample not tested	
Okon W-2	1%	Sample showed major damage after 7 days of submersion	23.0% H_2O
	2½%	Sample showed no damage after 7 days of submersion	21.0% H_2O
	5%	Sample not tested	
Okon Adobe Mix	1%	Sample disintegrated within 7 days of submersion	
	2½%	Sample disintegrated within 5 days of submersion	
	5%	Sample showed major change after 7 days of submersion	24.2% H_2O

Table 3 Con't

Chemical Product	% Chemical Solids in Water	Soaking Test Results	% H_2O Absorbed
Union Carbide R-20	1%	Sample disintegrated within 7 days of submersion	
	2½%	Sample showed no damage after 7 days of submersion	11.6% H_2O
	5%	Sample showed minor damage after 7 days of submersion	12.4% H_2O
Soil Seal	1%	Sample showed minor damage after 7 days of submersion	21.9% H_2O
	2½%	Sample showed no damage after 7 days of submersion	19.8% H_2O
	5%	Sample showed no damage after 7 days of submersion	21.4% H_2O
Sarabond	1%	Sample disintegrated within 15 minutes of submersion	
	2½%	Sample disintegrated within 15 minutes of submersion	
	5%	Sample disintegrated within 15 minutes of submersion	
Petroset SB	1%	Sample showed minor damage after 7 days of submersion	20.8% H_2O
	2½%	Sample showed minor damage after 7 days of submersion	19.6% H_2O
	5%	Sample showed no damage after 7 days of submersion	19.1% H_2O
Control (100 lbs/ft^3)		Sample disintegrated within 2 minutes of submersion	
Control (105 lbs/ft^3)		Sample disintegrated within 2 minutes of submersion	

*Aerospray 70 inadvertently overlooked in this study at all three chemical solids levels. Durak inadvertently overlooked at 1% and 2½% chemical solids level.

were: Rhoplex E-330, Rhoplex MC-76, Rhoplex AC-61, and K & E Mineral Sealer.

Aerospray 52, Suferm, Rhoplex AC-634, Acryl 60, Daraweld-C, Versacryl E No. 90, Okon W-2, and Union Carbide R-20 all performed very well at the 2½% and 5% chemical solids levels, but failed at 1% solids.

Five products resisted soaking damage at all three percentage chemical solids levels tested, namely: Rhoplex AC-634, Primal 826, Sonocrete, Soil Seal, and Petroset SB.

It is interesting to note that several of the products that resisted disintegration during the submersion still allowed the absorption of more than 20% water by oven-dry weight. Of the samples that performed well, the 5% chemical solids samples of Union Carbide R-20 and Rhoplex E-330 only absorbed 11.6% and 14% moisture respectively. The remaining intact samples absorbed 16-26% moisture while still retaining their cylindrical shape.

Summary

Site Bc-236

The results of 33 months of testing at Site Bc-236 have shown that chemical amendments can be effective in providing mortar erosion protection and can greatly extend the time between cyclic maintenance repairs. The results also show, however, that the decision to use such products should be carefully researched. One product, Bakelite VMCH Vinylite, quickly suffered ultraviolet discoloration and another product, Primal 863, was not very effective in resisting erosion. Rhoplex E-330 and Primal 826 are both performing well after this prolonged exposure.

Site SJ-1912

The rapidly weathering control plots at Lizard House show the erosive forces that work against a ruin. Even so, most of the products in test in this ruin are performing well in the mortar joints. However, when made into adobe blocks and placed out in direct exposure to weathering, several products such as Primal 863, Rhoplex SS-521, Rhoplex E-1141, and Acryloid A-21 have not fared so well. Rhoplex E-330, Primal 826, Rhoplex AC-634, and Rhoplex AC-61 adobe blocks all are in good shape after 31 months of exposure.

Pithouse Site SJ-299

This study evaluated the potential effectiveness of spray applications of various chemical products in providing erosion protection to pithouse walls. Rhoplex E-330, E-1141, AC-61, AC-634, and SS-521, as well as Primal 826, Primal 863, Bakelite VMCH Vinylite, and Acryloid A-21 were tested.

All of the treatment plots failed and began to erode badly within a few months of application. This study was terminated and the pithouse backfilled to prevent further erosion damage.

This particular aspect of ruins stabilization needs more research funding and should be given a high priority for future work. It is recommended that a modern test "pithouse" be dug at a suitable location for this research.

Modern Test "Ruin"

Research efforts at the test "ruin" have shown that hydrocarbon solvent-based chemicals should not be used for making amended mortar. The organic solvent flocculates the clay particles in the soil and interferes with the clay-sand binding properties. The result is a loose, powdery soil rather than a hard mortar upon drying. Therefore, product Nos. 25-35 in the "chemicals tested" section of this report should not be used for repointing mortar amendments.

Several water-based chemicals are performing very well thus far at the "ruin" in both repointing mortar and adobe block weathering tests. These products are Rhoplex E-330, Primal 826, Soil Seal, Daraweld-C, Aerospray 70, Acryl 60, Sarabond, Rhoplex MC-76, Okon Adobe Mix, Sonocrete, and Petroset SB.

Most of the tests at the "ruin" are still of too short a duration to draw definitive conclusions, however, and these plots will be monitored over the next several years for effectiveness.

Laboratory Tests

A series of wet and dry unconfined compressive strength and soaking tests were conducted in the Western Archeological Center laboratory.

The products which performed best in these laboratory tests were Primal 826, Soil Seal, Rhoplex E-330, Aerospray 70, Durak, Daraweld-C, Rhoplex MC-76, Union Carbide R-20, Acryl 60, and Sonocrete.

Future Studies

The study plots established thus far in this study should be maintained and monitored over the next five years. The results thus far show that chemical amendments can be effective in slowing the erosion of repointing mortar. This monitoring should be carried on in order to get a good estimate of the actual length of time amended mortars will last. This information will be useful to the manager in estimating maintenance cycles needed.

This monitoring time is also needed in order to fully answer the concerns about ultraviolet stability of these chemical products.

As mentioned earlier, studies are also needed on effective means of controlling pithouse wall erosion problems. This cultural stage of occupation in Chaco Canyon is currently not interpreted for the visitor due to the lack of technology to protect the exposed pithouse without unduly intruding upon the prehistoric scene.

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APPENDIX A

LABORATORY ANALYTICAL METHODS USED

Soils when used as an unamended mortar will develop dry densities of 100 to 110 lbs/cu ft. A compaction test (moisture-density relationship) was done on a sample of the Chaco soil to be used for test cylinder.

Consistency limits tests for the Chaco soil were run. The liquid limit was found to be 22% moisture. The liquid limit is the moisture content at which a soil will begin to flow (liquify), and is comparable to the consistency that a soil is used at in the field as a mortar. Based on the compaction test and the liquid limit, 100 lbs/cu ft was chosen as the appropriate dry density for the test cylinders.

Compressive strength for a given soil will vary directly with density (unit weight). It is therefore important that the densities for all test cylinders remain the same so that changes in compressive strength are related only to the additives used. It was found that more uniform cylinders were produced by raising the moisture content to 25%, and the unit wet weight to 125 lbs/cu ft respectively. A set amount of material was put into the cylinder and compacted to a set volume, thus holding density constant.

The cylinders, after curing as listed in the body of the report, were tested for compressive strength on a Soil Test Versa Tester 1000.

The seven-day soaking test was used as developed by Dr. Hassan A. Sultan, College of Engineering, University of Arizona.

All test procedures at the Materials Laboratory, Western Archeological Center, are based on ASTM (American Society of Testing and Materials) standards as applicable.

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APPENDIX B

SANITARY LANDFILL SPOIL BANK
SOIL ANALYSIS

Data Taken From

Fenn, D. B., and Chambers, G. J. 1978. Laboratory Assessment of Soil-Cement Mortars Used in Prehistoric Ruins Stabilization in the National Park Service. Unpublished report. National Park Service, Western Archeological Center, Tucson, Arizona. 175 pp.

NPS AREA: Chaco Canyon National Monument

SOIL: Trash pit soil

LOCATION: Trash pit

I. SOIL TEST RESULTS

A. Particle Size Characterization

1. Total

Texture Class: Sandy loam

% Sand (2mm-.05mm)	74.0
% Silt (.05mm-.002mm)	11.0
% Clay (less than .002mm)	15.0
Total	100.0%

2. Sand Sieve Analysis (2mm-.05mm)

% 1.0mm-2.0mm (very coarse)	1.33
% 1.0mm-0.5mm (coarse)	6.40
% 0.5mm-0.25mm (medium)	18.45
% 0.25mm-0.10mm (fine)	62.19
% 0.10mm-0.05mm (very fine)	11.60
Total	100.00%

B. Chemical Characterization

1. General

pH of Soil Paste	8.1
Calcium Carbonate (Lime) Equivalent %	1.78
Cation Exchange Capacity (me/100g)	9.14

2. Analysis Of Soil Water Extract (1:5 Soil To Water)

Electroconductivity (mmho/cm)	0.26
Soluble Salts (parts per million)	111.26
pH	7.3

Calcium (milligrams/liter*)	27.0
Magnesium (milligrams/liter*)	5.3
Sodium (milligrams/liter*)	11.2
Chlorine (milligrams/liter*)	6.0
Sulfate (milligrams/liter*)	6.0
Bicarbonate (milligrams/liter*)	53.7
Carbonate (milligrams/liter*)	0.0
Nitrate (milligrams/liter*)	2.0

*Milligrams/liter is approximately equal to parts per million.

C. Clay Minerology

Clay Type	Tendency To Crack	Relative Proportion Present In This Soil None (0) to Dominant (5)
Montmorillonite	high	4
Mica (illite)	low	3
Vermiculite	medium	4
Chlorite	low	0
Kaolinite	low	3
Interstratified	low to medium	1

II. SOIL CEMENT TEST RESULTS

A. Strength

Soil-Cement Ratio	Unconfined Compressive Strength (psi)
4:1	380
6:1	286
10:1	145

2. Effects Of Sand Additions On A 6:1 Soil-Cement

Sand Type	% Sand Added	Unconfined Compressive Strength (psi)
Chaco, Big Wash	0	286
	20	282
	40	250
	60	201

B. Capillary Water Rise

1. Various Soil-Cement Ratios

Soil-Cement Ratio	Capillary Rise (Ft)
1:0	17.4
10:1	16.7
6:1	17.4
4:1	

2. Effects Of Sand Additions On A 6:1 Soil-Cement

Sand Type	% Sand Added	Capillary Rise (Ft)
Chaco, Big Wash	0	16.7
	20	11.4
	40	7.9
	60	4.8

III. STONE TEST RESULTS

A. Source: Rock Pit
Chettro Kettle
Pueblo Alto

B. Description: Rock Pit: Relatively friable, fine grained sandstone
Chettro Kettle: Well indurated (cemented) sandstone
Pueblo Alto: Friable, fine grained sandstone

C. Compressive Strength (psi):
Rock Pit: 2210
Chettro Kettle: 17,790
Pueblo Alto: 1290

D. Estimated Capillary Rise Potential (ft.):
Rock Pit: 63
Chettro Kettle: 5.4
Pueblo Alto: Greater than 70

E. Comments:
The Chettro Kettle stone is very hard, strong sandstone that resists moisture movement. The Rock Pit and Pueblo Alto stone are very similar friable, fine grained sandstone that readily transmit water by capillary action.

IV. EVALUATION OF RESULTS

A. Use Of Soil In Soil-Cement Mixes

1. Compressive Strength Comparison (psi)

a. Stone sample: Rock Pit, 2210; Chettro Kettle, 17,790; Pueblo Alto, 1,290

b. 4:1 soil-cement: 380

c. 6:1 soil-cement: 286

d. 10:1 soil-cement: 145

e. Comment: Any soil-cement used should be weaker than the stone. This soil meets this criteria at all soil-cement ratios tested and for all three stone types.

2. Capillary Rise Comparisons (ft)

a. Stone sample: Rock Pit, 63; Chettro Kettle, 5.4; Pueblo Alto, >70

b. 4:1 soil-cement: 17.4

c. 6:1 soil-cement: 16.7

d. 10:1 soil-cement: 15.7

e. Comment: Any soil-cement used should have a higher capillary potential than the stone to ensure that destructive moisture is drawn out of the stone into the mortar. This soil meets this criteria for Chettro Kettle at all soil-cement levels tested. This soil fails to meet the criteria for Rock Pit stone and Pueblo Alto. These two stones have such a high capillary potential that few soils could meet the criteria.

3. Addition Of Sand To 6:1 Soil-Cement

a.

% Sand Added	Compressive Strength (psi)
0	286
20	282
40	250
60	201

b. Comments: This soil contains 74% sand naturally. It is recommended that sand not be added when making a soil-cement mix.

B. Use Of Soil As Unamended Mud Mortar Or Plaster

1. Particle Size Distribution: Optimum soil is a sandy loam with a particle size distribution of 20-25% clay, 60-70% sand, and 0-10% silt. Silt is not desirable since it does not bind as well as clay, and does not provide strength as does coarse sand.
This soil is slightly high in silt and low in clay, but is close enough to still be suitable.

2. Sand Size Distribution: Coarse sand is much superior to fine sand because fine sand is similar to silt in properties.
The sand in this soil is 74% fine or very fine. This is not good for yielding maximum strength.

3. Clay Mineral Composition: Some clay types exhibit extreme shrinking and swelling upon absorption or desorption of water. This causes cracking and the mortar will deteriorate faster than mortars with more stable clay types. This soil contains:

____ Acceptably low level of swelling clays
____ Moderate level of swelling clays
__X__ Excessive level of swelling clays.

4. Soluble Salts: Soils used for unamended mortars should have a soluble salt level lower than 1000 parts per million. Excessive salts weaken the mortar, attract hygroscopic moisture, and form harmful salt efflorescence and subflorscence. This soil contains

__X__ Acceptably low salt content
____ Excessively high salt content.

5. Liquid Limit (% Water): 20%. This is the percent by weight wate at which the soil will have the most workable and satisfactory consistency.

6. Summary Comments: This soil only contains 15% clay, but most of the clay is the swelling and shrinking type. This will most likely cause cracking problems which will shorten the lifetime of any mortar treatments. A test adobe should be made to test for cracking potential. An alternative soil source should be found if too much cracking occurs.

Documentation

Introduction

Activity Standards: Working Drawings and Specifications for Historic Structures

Ruins Stabilization Record Sheet

Documentation

Whenever you repair a wall, backfill a room, remove or install a utility or drainage system, or perform any such alteration, it is critical that you make photographic, graphic (drawings), and written records of your work. Documentation of any work affecting cultural resources is required by law. Alteration of utility or drainage systems that affect cultural resources must be documented because of preservation laws and is dictated by the needs of proper management.

Whenever you perform such work, be sure to do the following:

Make a complete photographic record of the wall or the other architectural item or utility, or drainage system, or trail before you begin work.

Compile a complete written record of the item to be affected before you begin work (for an example, see the Ruins Stabilization Record sheet, this section).

Make photo and written records of work "in progress" for all but routine maintenance stabilization.

When work is completed, compile complete photo and written records or work as it is when finished. Include drawings and written records of systems in this manual. File extra photos (see your Park Ranger).

All your photos, drawings, and written records must be contained in a completion report which you will retain at the area.

If you have darkroom expertise, the NALA darkroom at AZRU is available for your use. Otherwise, make arrangements with the NALA Preservation Specialist. He/she can also help you in the planning and construction of your completion report.

Activity Standards

Working Drawings and Specifications for Historic Structures

Working drawings and specifications for the preservation, restoration, or reconstruction of historic structures shall be considered satisfactory when, in addition to meeting other applicable standards, they:

1. Record conditions existing prior to preservation, restoration, or reconstruction.

2. Document all known proposed changes to the structure.

3. Specify materials that will be compatible with the original fabric.

4. Specify craftsmanship as well as material and design to assure that surface textures are compatible with the original fabric.

5. Provide for recovery and ownership of artifacts.

6. Provide for protection of historic resources, including grounds and historic setting, during construction.

7. Provide for changes due to unforeseen structural problems or new evidence of historic appearance, and such changes are recorded as an addition to the original documents.

8. Provide for the qualifications of contractors when special skills are required.

9. Insure installation of adequate fire detection and suppression system.

10. Provide humidity and temperature control when the historic fabric and contents of the building warrant.

11. Insure that modern utilities and structural reinforcement do not intrude on the historic scene.

December 21, 1971

Ruins Preservation Record

National Monument _____ Date _____
Structure _____ Room ____ Kiva ____ Other _____
Repair involves: Wall N S E W ; Roof _____ Floor _____
Last prior repair (Report Author, date): _____

Architecture: Standing stories _____ Smoked _____
_____ Burned _____
Standing roof _____ Masonry ____ Jacal ____ Other (Specify)
_____
Room plan _____ Long axis ____ Foundation _____
Room situated _____
_____
Room/Kiva N _____ S _____ E _____ W _____

Other notes: _____
_____
_____
Roof type: Pueblo (primary & secondary beams, etc.) _____
Other _____ Unknown _____
Floor type: Adobe ____ Flagstone ____ Other _____
Unknown ____

General condition of this unit prior to this repair (critical, very poor, poor, average, good, very good, excellent) _____
Preservation materials, technique: Fresh stone ____ Site stone _____
Soil mortar, ____ Fortified soil mortar _____
Soil plaster ____ Fortified soil plaster _____
Soil cement _____
Other _____
_____
Standard masonry techniques ____ Special techniques _____
_____
_____
_____
_____

Further notes: _____
_____
_____
Work started _____ Finished _____
Approximate work days ____

Defects: North wall: basal stone erosion (extreme, severe, heavy, medium, moderate, light)_____

veneer stone erosion_____

mortar erosion_____

other _____

South wall: basal stone erosion_____

veneer stone erosion_____

mortar erosion _____

other _____

East wall: basal stone erosion_____

veneer stone erosion _____

mortar erosion _____

other _____

West wall: basal stone erosion_____

veneer stone erosion _____

mortar erosion _____

other _____

Other notes, defects: _____

Architectural Details
(doorways, ventilators, lintels, etc.)

North wall:

South wall:

East wall:

West wall:

Safety

Safety

Introduction

Safety Tips for Tools and Equipment

Safety Tips for Personal Safety Gear

Environmental Factors

Insects, Arachnids, and Animals

Safety Rules for Use of Pesticides

Accidents

Safety

Safety, for discussion here, can be broken into 4 major categories: Proper use and care of tools and equipment; personal gear, use and care; materials; dangerous insects and animals.

For details, see Supervisor's Safety Manual.

Proper Use and Care of Tools and Equipment

OSHA, the Occupational Safety and Health Act, governs the use and care of tools and equipment used by employees. Following is a list of tools and equipment and safety tips for them. These are drawn from the book, Supervisors Safety Manual.

hammers: replace brittle, cracked, splintered, or broken handles. Be sure head is secure. Inspect often for signs of potential metal splinters.

chisels: repair burred heads by grinding off burred areas. Safe-end tools when possible.

electric cords: keep away from heat, sharp objects, and petroleum oils. Check for exposed or unconnected wires.

generators: install ground fault interrupter and test weekly. Install proper ground rod.

mortar mixers: forbid employees to reach into the mixing drum with hands or tools until the mixing paddles are disengaged from the engine and have completely stopped.

scaffolding: make sure that braces are on properly, that the system is complete (all components in use), that it is level with proper feet and leveling jacks, and that guard rails have been installed.

ladders: be sure they are in good repair, select the right length for the job, and set it up properly with feet firmly planted and ladder at about 75 degree angle to wall.

Ladder Length Required

Wall Height	Ladder Length
0-9 ft.	16 ft.
10-13	20
14-17	24
18-21	28
22-25	32
26-28	36
29-32	40

(From Chambers, 1976:33)

Personal Safety Gear

OSHA also requires certain safety gear for certain jobs. The following list describes applications for and care of personal safety gear. Whatever safety gear you require, you must provide or pay for.

goggles:	use goggles whenever there is the potential of eye damage or irritation - dusty areas, when working with mortar slurries, and especially when hammering or chipping. For stabilization work, choose goggles that give all-round protection (e.g. chipper's goggles). Clean goggles with mild soap and water. Do not allow extra ventilation holes to be cut into goggles.
footgear:	stabilization work requires steel toes. Boots are preferred because they provide lower leg protection and extra support for ankles.
hard hats:	must be OSHA approved type. Hat shell must be sound, without cracks, punches, or breaks. Cradles and headbands must be kept in good condition. Clean shell and cradle at least once per month. Allow no holes to be drilled for ventilation.
respiratory protection :	use disposable dust masks in areas of low dust. In very dusty conditions use filter respirators.

Environmental Factors

Two factors are potentially hazardous in ruins maintenance work - heat and dust.

Heat is a problem usually only in the hot summer months of June, July, August, and early September. Stabilization work is 99% outside work and most of this is done in sunlight. Adjust the work schedule so that you avoid heavy duty chores. Save them for cooler hours of the day. You can also adjust the work procedure so that, by working on east and south walls in the morning and north and west walls in the afternoon, you can take advantage of available shade. When the temperature exceeds 100° it is suggested you find some interior work or give your crew administrative leave.

AZRU does not receive much precipitation and dust is a persistent problem. Low dust levels can cause irritation of eyes, mouth, nose, throat, and lungs. Continual exposure can lead to infection. Moderate and high dust levels are more irritative and increase chances of infection. Coccidioidomycosis, commonly referred to as "Valley Fever", is a relatively common disease among people working in dry, dusty conditions in ruin areas. The effects of this disease range from mild irritation to debilitation. Require filter respirators for crewmen working in moderate or high dust levels.

Insects, Arachnids, and Animals

There are a number of insects, spiders, and animals at AZRU that are potentially harmful to humans. The most numerous pest is the ant. There are hundreds of ant hills in and around the ruins and they contain literally millions of individuals. Reaction to ant bites ranges from mild to quite severe. It is difficult to work around these insects. Nests at or near workers should be treated with an approved insecticide.

Velvet ants, been, hornets, and, especially wasps are numerous in some parts of the ruins. Individually, they are a nuisance. Collectively, they are a definite danger. Destroy any nests you find (remember to wear proper protective gear while doing this).

Black Widows are occasionally found in the ruins. They are more numerous in the "bone-yard" where there are lumber piles, unused machinery and other such hiding places. Use caution around these areas. Destroy any Black Widows you find.

Tarantulas have been sighted at AZRU. A few have been found in voids inside ruin walls. They are not poisonous to humans. They can, however, inflict painful bites. When you find a tarantula, capture it, transport it somewhere out of the monument away from the ruins and release it. Use caution when working around void areas. Use gloves!

From time to time, bats move into the Great Kiva. Considering the number and virility of diseases bats can carry, this poses a serious health hazard to individuals. Sick bats are sometimes found on the floor. They have become sick from eating insects from the local orchards that have been sprayed with insecticides. Any such bats you find should be destroyed and disposed of (buried).

Skunks are present on the monument but, for the most part, they stay deep in the brush away from areas patrolled by humans. However, use caution in the East Ruin where skunks frequently range.

You should familiarize yourself with Poisonous Dwellers of the Desert by Natt N. Dodge. Also, learn first-aid treatments for bites and stings.

Before you use pesticides or herbicides, check with the Regional Safety Officer or the Safety Technician to ensure authorized use.

A traditional pesticide - wood preservative at AZRU is pentachlorophenol. Use of this product has been banned within the Park Service. The ideal pesticide - wood preservative would be one which was odorless, stainless, effective, easily applied, and safe to use without exotic protective gear. Unfortunately, that is an elusive product. Until such a product is developed, creosote (lightly brushed on) is recommended.

SAFETY RULES FOR USE OF PESTICIDES

1. Read entire label before using product.
2. Observe all precautions each time a material is used.
3. Store chemicals under lock and key out of reach of children and pets, away from food and feed.
4. Keep chemicals in their original containers.
5. Dispose of unused chemicals and empty containers in such a way that they are no longer hazardous.
6. Follow directions pertaining to residual tolerances on edible plants; allow the specified time interval between last application and harvest.
7. Use chemicals only on plants specified and at the correct rate and schedule.
8. Do not eat or smoke while applying pesticides.
9. Wear protective clothing and masks when directed on the label.
10. Bathe and change to clean clothing right after spraying or dusting. Wash clothing before reuse.
11. If chemicals are spilled on the skin or clothing, change clothing immediately and wash thoroughly.
12. If illness develops during or after a spraying or dusting operation, call a physician or take patient to hospital immediately.
13. Avoid chemical injury to plants; use separate equipment for herbicides.
14. Rates of application have been carefully computed; do not use more than recommended.
15. Do not spray or dust on a windy day; avoid drift that would injure plants on adjacent property.

Use Pesticides Safely

FOLLOW THE LABEL

PESTICIDE SAFETY

Pesticides, predominately organic chemicals, are toxic to various pests (insects, weeds and causal organisms of plant disease, etc.). Many are toxic also to nontarget organisms including man. Safe and proper use depends partly on knowledge of toxic properties and a respect for the potential hazards associated with their use. Misuse of pesticides may cause or create problems not only for the applicator but for others as well. Potential problems include poisoning the applicator or others from mishandling and poor storage, drifting onto susceptible crops, pesticide residues in excess of established tolerance, carry-over effects, etc.

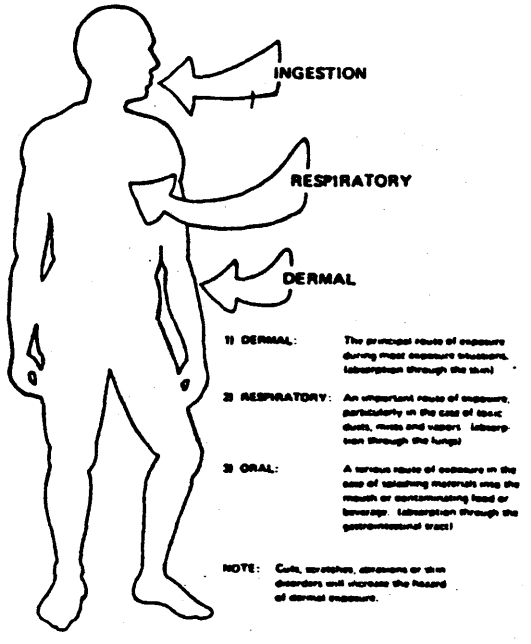
Proper handling, use, storage and disposal; recognition of local environmental situations and poisoning symptoms and procedures to follow in the case of pesticide poisoning are each essential elements of safe use.

The importance of the product label as an information source is a key element of safe use. Precautionary statements; hazards to man, domestic animals and the environment; reentry statements and storage and disposal information, all a part of the label, are guides to safe use.

Remember, few safety recommendations cover all situations. There are, however, some general guidelines that, if followed along with the information on the product label, are beneficial when using pesticides. Some points worth remembering include the following information:

Chemicals used as pesticides are poisonous and one must exercise care in their handling and use to avoid accidental poisoning; damage or irritation to the skin or eyes and damage to crops, livestock and the environment. Safe pesticide use begins with purchase, continues through proper use and is complete with proper disposal of waste and the used container.

The key to preventing accidental poisoning is an awareness of the route by which pesticides may enter the body. Use hazards depend on a product's toxicity and degree of exposure. Safety instructions on the label and from other sources become more meaningful if one understands the reasons for the instructions.



Pesticides may enter the body through the skin, lungs or mouth. Entry through the skin is the most likely source of poisoning during handling and use of a pesticide. Pesticides contact the skin through spills, spray droplets, dust or from equipment.

Mixers, loaders and flaggers are subject to relatively high levels of skin exposure. Indoor spraying can be extremely hazardous because of the

possibility of increased skin exposure. Poisoning from contact with treated plant surfaces has occurred. Hand harvesting, thinning, cultivating, irrigating and insect scouting can result in sufficient skin exposure to cause poisoning. Additional exposure may result from contact with the contaminated surfaces of equipment.

Skin exposure is minimized by using protective equipment. No safety recommendations cover all situations. Check the label for specific recommendations for protective clothing and equipment.

As a general rule, use clean clothing daily and cover up before exposure, not afterward. Covering contaminated skin increases absorption of some pesticides. A long sleeved shirt and full length trousers or coverall-type garment made of closely woven material are minimum requirements. A wide brimmed hat, preferably waterproof, offers protection from downward drift for face and neck areas. Plastic "hard hats" also are useful. Contaminated hatbands can be a source of exposure. Use disposable hatbands or hatbands of a material that can be cleaned readily.

Wear unlined, natural rubber gloves for best protection. Prevent contamination of the inside of the gloves. Loose long sleeves should cover the gauntlet of the glove to keep pesticides from running down into the glove. For some pesticides, such as methyl bromide, gloves are not to be used. This is one more reason to consult the product label before using a pesticide.

If exposure to the lower trunk and legs is anticipated, such as in mixing and loading, a waterproof apron is essential. Waterproof shoes or boots are preferred. Leather shoes crack after a few wettings and, thus, are penetrated

easily. Canvas shoes offer little protection. Contaminated shoes or boots are another source of exposure. Wear trouser legs over boots to keep pesticides from running down the trousers into the boots.

Shield the eyes to avoid exposure, particularly if splashing may occur, such as in mixing and loading. Goggles or a face shield provide protection.

If clothes become wet with spray or if pesticide is splashed onto clothing or the skin, remove the clothing and wash immediately. Decontamination of the skin is more efficient if done promptly. Destroy heavily contaminated clothing. Do not store or wash contaminated clothing with the family laundry.

Proper care of protective clothing is essential. Test gloves for leaks. Wash gloves, boots, hat, goggles and face shield following each day's use and more often if necessary due to excessive contamination.

Pesticides also may enter the body through the lungs. The mouth is another point of entry followed by absorption through the gastrointestinal tract. While exposure through these routes generally is less likely than skin exposure, the pesticide is absorbed much more efficiently through these routes.

Various types of respirators can provide respiratory protection. Most respirators are air purifying and remove contaminants from air by filtering or chemical action.

Filters remove particles by physical trapping as air is inhaled. Mechanical filters do not provide protection against gases, vapors or oxygen deficiency.

A respirator is characterized by a cartridge or canister which contains a chemical that removes gases or vapors.

Read the label. If a respirator is required, the information will appear on the label. In fumigation or applying highly toxic pesticides in confined spaces, a respirator with a special compressed air supply tank is suggested.

No matter how well a respiratory device is designed and made, unless it is maintained properly, it may fail to provide protection. The most common problems are failure to occasionally wash the face piece with soap and water and neglecting to change the filter cartridges. Check the face piece for cracks, hardening and elasticity of straps. A good seal is essential.

Change filters twice a day and whenever breathing becomes difficult. Change cartridges after 8 hours of actual use and whenever any pesticide odor is detected.

Remove filters and cartridges and wash the face piece with soap and water after use. Rinse thoroughly to remove traces of soap. Dry with a clean

loth that is not contaminated with the pesticide and place the face piece in a well-ventilated area to dry. Store the respirator, filters and cartridges in a clean, dry place, preferably a tightly closed paper or plastic bag.

Accidental splashing or transfer of pesticides to the mouth through wiping one's face on the sleeve, cuff or hand are likely ways pesticides can enter the mouth. Other possibilities include food handled with contaminated hands; food exposed to pesticide spray, dust or spills; contaminated drinking utensils and attempting to clear nozzles by blowing through them.

Check the label for special instructions or warnings regarding exposure. Never eat, drink or smoke while spraying or dusting. Wash thoroughly with soap and water before eating or drinking. Do not touch lips to contaminated objects or surfaces.

Do not wipe the mouth with hands, forearm or clothing. Do not expose lunch, lunch container, beverage or drinking vessel to pesticides. If involved in operations that may result in splashing pesticides, wear a full-face shield.

Information regarding signs and symptoms of poisoning often is a part of the pesticide label. Signs and symptoms of organophosphorus poisoning may include fatigue, headache, dizziness, blurred vision, excessive sweating, nausea and vomiting, stomach cramps and diarrhea. Repeated exposures over a brief period of time may result in poisoning, all the more reason for minimizing exposure.

Signs and symptoms of moderate organophosphorus poisoning include inability to walk, weakness, chest discomfort, muscle twitches and constriction of the pupils of the eye.

Severe organophosphorus poisoning results in unconsciousness, severe pupil constriction, muscle twitches, secretions and breathing difficulty.

Signs and symptoms of carbamate poisoning are similar to those of organophosphorus poisoning. These include feelings of discomfort, excessive sweating, light-headedness, nausea, blurred vision and excessive salivation and vomiting.

Toxicity of organophosphorus and carbamate pesticides relate primarily to their function as cholinesterase inhibitors. Acetycholinesterase is an enzyme involved in the normal function of certain nerves. Regulation of vital body processes such as breathing, pulse rate and function of the gastrointestinal tract, for example, are controlled by nerves. Following a nerve impulse, the nerve or junction is returned to the normal state in the presence of an enzyme (acetylcholinesterase) and is again capable of carrying an impulse. The enzyme (acetylcholinesterase) prevents persistent "activation" of the nerve or junction. Certain chemicals including organophosphorus and many carbamate pesticides block the enzyme action (acetylcholinesterase) causing a nerve malfunction.

Failure of the affected nerves to function properly causes:

. Constriction of the pupil of the eye (miosis)
. Tightness of the chest

- Increased bronchial (respiratory tract) secretions
- Sweating
- Tearing (lacrimation)
- Rapid pulse rate initially followed by a decrease in the pulse rate
- Nausea, vomiting, abdominal pain and diarrhea
- Involuntary urination
- Muscle twitching
- Cramps
- Increased salivation

A lethal dose of a cholinesterase-inhibiting organophosphorus compound is reported to produce death from respiratory failure (asphyxia).

Clinically, poisoning from cholinesterase-inhibiting organophosphorus or carbamate pesticides is confirmed by measuring the cholinesterase activity of the blood plasma or red blood cells (erythrocytes). Persons working with organophosphorus or carbamate pesticides which interfere with normal nerve functions (inhibitors of the enzyme acetylcholinesterase) should consult a physician concerning the possibility of measuring blood cholinesterase activity as an estimate of exposure. Specific antidotes, available to the medical profession, are effective in countering organophosphorus and carbamate pesticides.

Although the symptom-producing effect of organophosphorus poisoning results from blocked activity of the enzyme at the nerve or nerve ending, the enzyme also exists in tissues and blood. This enzyme serves as a buffer or reserve "tying up" much of the toxic material even though some affects the enzyme at the nerve or nerve ending. Thus, reduction of blood and tissue enzyme by repeated exposure to the poison reduces the reserve, and the critical enzyme at the nerve and nerve junctions is affected more readily.

Exposure of a significant nature is likely to produce less severe poisoning if the reserve is not depleted. Thus, even in the absence of noticable effects, always attempt to minimize exposure.

Toxicity to man and other warm-blooded animals varies greatly within a given group or class of compounds, particularly those used as insecticides. For example, some organophosphorus insecticides are direct inhibitors of acetylcholinesterase, while others are inactive *per se* but are changed in the body of man and other organisms to one or more toxicants that are inhibitors of acetylcholinesterase. The net toxic effect depends on a combination of factors including the rates of activation and/or detoxification, penetration to the site of action and the affinity of the toxicant for acetylcholinesterase.

Signs and symptoms of chlorinated hydrocarbon pesticide poisoning vary but may include nausea, mental confusion or semiconsciousness, jerking of the legs and arms, dizziness, drowsiness, weakness and loss of appetite.

Signs and symptoms of fumigant and solvent poisoning include poor coordination, slurred speech, confusion and sleepiness. Become familiar with the signs and symptoms of poisoning produced by the products you use and with the "statement of practical treatment" or first aid on the pesticide products you use. This

information may save your life or the lives of others. A statement of practical treatment, first aid or other appropriate practical treatment is a part of most pesticide labels. Before using a pesticide, become familiar with specific first aid information on the product label.

Some pesticide labels will include information regarding signs and symptoms of poisoning. Pesticide poisoning signs may appear like brain hemorrhage, heat stroke, heat exhaustion, low blood sugar, gastroenteritis, asthma and pneumonia. If you should become ill or experience any signs or symptoms, seek medical help immediately.

Criteria for cataloging pesticide products by toxicity established by federal regulation include the following categories based on the acute oral LD_{50} of the product:

Highly toxic	LD_{50} - 50 mg/kg or less
Moderately toxic	LD_{50} - Between 50-500 mg/kg
Low order toxicity	LD_{50} - 500-5000 mg/kg
Comparatively free from danger	LD_{50} - 5000+ mg/kg

A product with an acute dermal LD_{50} of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours to the bare skin of rabbits is considered highly toxic to man.

LC_{50} is the term used to identify a product's concentration in air that is fatal to 50 percent of the test animals when administered by continuous inhalation for 1 hour to both male and female rats or in some cases other species. A pesticide that exhibits an acute LC_{50} value of 2,000 micrograms or less of dust or mist per liter of air or 200 parts per million or less by volume of gas or vapor is considered highly toxic to man.

In each case, the acute oral LD_{50}, dermal LD_{50} and LC_{50} is evaluated on the basis of death produced in 50 percent of the test animals within 14 days of the challenge.

LD_{50} values have become a universally accepted means of expressing toxicity. Acute oral LD_{50} values provide a means of comparing one chemical to another and thus a means of evaluating the relative toxicity of chemicals when administered orally. Many people are tempted to use the values in an absolute sense, i.e., direct extrapolation of LD_{50} to man even to the point of calculating the LD_{50} dose for man. Relevance of these animal values to man is questionable. Further assumption could lead to serious consequences. One should assume in the absence of information to the contrary, that the chemical is at least as toxic to man as it is to the most sensitive test animal. Effects of pesticides on the eye and skin also are considered criteria in cataloging pesticide products by toxicity.

Of the various work activities associated with pesticide use, the loading operation is considered one of the more hazardous parts of the spraying or dusting cycle. Obviously, many factors are involved that determine the degree

of hazard of any operation. Mixing and loading pesticides generally results in exposure to higher concentrations and greater quantities (i.e., spills, splashes, etc.). Although not minimizing the importance of protective measures during all work activities, the mixing and loading operation warrants special attention and care.

Consider the following general safety instructions during mixing and loading:

- Never work alone when handling hazardous pesticides.
- Mix chemicals outside where there is adequate ventilation.
- Following the label carry out calculations for required dilution and obtain proper equipment, including protective clothing, proper respirator, if required, and first aid equipment. A waterproof apron is especially useful in protecting the lower trunk and legs.
- Check all figures and calculations for each load.
- Have clean measuring and transfer containers available. Transfer containers must have a spout for pouring the concentrate and separate openings for fill and venting. All measuring and transfer containers should be galvanized or of stainless steel for safety unless plastic or other containers are specified on the product label. Many pesticides are corrosive or react with other chemicals, water or some metals. Paint all mixing and loading containers a bright orange and label "Danger - Poison" to prevent their use for other purposes.
- Carefully open original concentrate containers. Open sacks with a knife rather than tearing. Always stand upwind when mixing or loading pesticides.
- Pour concentrate into the measuring container. Touch the spout of the concentrate container to the edge of the measuring container before pouring the liquid. Replace the lid on the concentrate container.
- Pour the concentrate from the measuring container into the transfer container. Touch the spout of the measuring container to the edge of the opening of the transfer container before pouring the liquid. Repeat the two preceding steps for each load using a separate transfer container for each load.
- Replace the lids tightly on the transfer containers.
- Rinse measuring containers. Return concentrates, empty containers and clean measuring containers to the chemical storage room.
- With the transfer containers in position for emptying into the spray tank, remove the spout lid, loosen the outer lid so it will function as a vent and carefully pour the concentrated pesticide into the tank without splashing. If the spray tank is elevated, do not allow others in the immediate vicinity at ground level.
- As concentrate containers are emptied in the process of measuring, allow them to drain in a vertical position for 30 seconds.
- As concentrate containers are emptied and drained, use water or other diluting material to rinse the container. Rinse three times allowing 30 seconds for cleaning after each rinse. (Use 1 quart for each rinse of a 1-gallon can or jug, a gallon for each 5-gallon can and 5 gallons for either 30- or 55-gallon drums.)
- Tighten both lids (spout and vent) of transfer containers before returning the container to ground level. Thoroughly rinse transfer containers before they are returned to the locked chemical storage room.

Be sure to:

. Always mix outside in open air.
. Handle carefully to minimize splashing.
. Remove the screen on the spray tank before adding the concentrate.
. Slurry wettable powders before adding to the spray tank.
. Do not mix chemicals unless specified by label directions.

Back-siphoning, which occurs through pumps commonly used to deliver liquids, results in water contamination. In this manner pesticides can be back-siphoned from the spray or mixing tank to the nurse tank, ponds, streams, wells and other water systems.

When delivering water to spray or mixing tanks, use an air gap and a check valve to prevent back-siphoning. The distance between the hose and the top of the tank should be two times the diameter of the hose.

Always store pesticides in original containers with a legible label. Keep storage unit away from food, feed or clothing; away from living quarters and in an area not subjected to temperature extremes or high moisture conditions.

Proper storage protects the health and well-being of people, pets and livestock; protects against environmental contamination and often extends a chemical's shelf life. Take special care to handle and store pesticides to prevent fire hazards and explosion. Fires involving pesticides present uncommon hazards, for example, highly toxic and phytotoxic fumes, toxic runoff and toxic ash or other residues.

When storing pesticides place in a well-ventilated area preferably in a separate building. Do not locate storage near food, feed or seed. Post signs at each entry and on all sides of the storage building. Keep the storage area locked when not in use; keep a log of pesticides and the amount of each in storage. Fireproof the area to the extent possible; check containers periodically for corrosion, leaks, breaks and tears and store "empty" containers in the storage area pending proper disposal.

Use the rinse and drain procedure to decontaminate "empty" pesticide containers and to minimize waste. For a pesticide costing $70 a gallon, the dollar loss from unremoved material amounts to $3.50 per 5-gallon can and up to $17.50 per 55-gallon drum. An empty pesticide container that has not been rinsed is far from being empty. This results in increased hazards to the environment, humans and animals, plus additional material cost and less efficient pest control.

When following label directions for disposal such as burning paper or cardboard containers where permitted, stay out of smoke. Do not allow smoke to drift onto crops or onto areas occupied by humans or animals. Suggested safety procedures are not intended as a substitute for specific information appearing on each pesticide product label. Few safety recommendations cover all situations so always read the label.

Using pesticides in ways other than directed on the label can:

. Injure plants and animals

. Leave illegal residues
. Create greater pest problems
. Damage wildlife and fish

Insure that pesticide use does not create environmental problems.

Pesticides become problems when they move off target. This may mean drifting out of the target area as a mist or dust; moving through runoff and erosion; leaching through the soil; being carried out as residues in crops, livestock or livestock products or evaporating and moving with air currents.

To minimize drift, use the largest droplet spray consistent with effective pest control, and avoid spraying upwind from sensitive crops or pastures. Avoid spraying during high wind or air stagnations. Conditions that hold smoke close to the ground (a warm air ceiling near ground level) allows drifting small droplets to remain close to the ground; slowly settling droplets may concentrate on nearby crops.

Most fish and other aquatic organisms can survive only slight environmental changes. Very small amounts of many pesticides harm them or destroy the food they eat. They may die immediately or change effects may exist which make them more susceptible to prey or interfere with normal reproduction.

Pesticides may reach water directly through application, drift, spills or incorrect disposal methods and indirectly through runoff, leaching and air cleansing rains.

Proper pesticide selection, handling, use and disposal minimizes pesticide problems in the environment.

Accidents

Theoretically, you should report and fill out paperwork for any accident you or your workers have, whether very minor or not. Contact the NALA Personnel Clerk for information and details.

For your own records, you should keep details of accidents so that you will be able to detect trends or particular problem areas. When you know where and what the problem is, you can begin corrective measures or procedures. For ideas on this aspect of safety, see Chapter 2, Supervisors Safety Manual.

As a supervisor, you should be thoroughly attuned to safety and thoroughly familiar with safety requirements that apply to ruins preservation. In as much as ruins preservation is a type of construction work, practically all safety aspects applying to construction are applicable to ruins work. If you have no safety training, contact the Regional Safety Officer and discuss training opportunities.

Tools And Equipment
Maintenance

Tool and Equipment Maintenance

Introduction

Suggested Maintenance for Various Tools and Equipment

End of Season Activities

Tool and Equipment Maintenance

Tools and equipment are expensive to purchase and usually more expensive to replace. A little care goes a long way and ultimately is a time saver because it helps avoid delays caused by broken or poorly functioning equipment.

Included in this section are a few tips that will help you keep your tools and equipment in operating condition.

For maintenance of safety gear, see Safety section, this manual.

Rock hammers and other hammers:

Keep them as clean and dry as possible - don't leave them in water. Replace handles when cracked or broken; fiberglass handles last longer and are harder to break than wood ones, if you use fiberglass, the head will slip off more often than on a wood handle, coat the tip of your fiberglass handle with epoxy glue, set the hammer head on and let it dry for at least 24 hours; wood handles tend to dry out and become brittle, when they start to dry out, rub (don't soak) in a generous amount of pure, boiled linseed oil, wipe off excess and replace head; keep a few extra handles around and also (spare) complete hammers to replace those you have to repair or treat.

Cold chisels:

Keep them clean and dry as possible, never put them in water. Keep them blunt-sharp with a grinder or file and they will cut well. Remove rust with metal sandpaper. Keep the head dressed to provide a strong, uniform striking surface.

Trowels:

Keep them clean and dry. Crewman tend to leave them in water buckets and the wood swells and breaks, and the steel rusts. Keep rust off with metal sandpaper. Treat dry handles with rubbed-in linseed oil.

Buckets:

This is the favorite throw-around of maintenance crews. They can be bent and dented fairly easily and the more battered they are, the harder they are to clean. You will occasionally have to admonish your crew not to drop, throw or kick the buckets. When using cement or any sort of modified mortar, the bucket should be thoroughly rinsed between mortar loads. A 55-gallon drum filled with water and a stiff brush will make this task quite easy. When soil mortar is used, the buckets should be thoroughly cleaned at the end of the work day, as should all other tools.

Mortar boxes:

These boxes are designed for hand mixing with a mortar hoe. They can also be used to store different soils at the plaster mixer when you must mix soils to obtain the proper color. If you mix mortar in the boxes, the same cleaning suggestions for buckets apply. Dry the boxes at the end of the mixing by leaving them up - they rust easily.

Scaffolding:

This equipment is a major investment and should be treated accordingly. Require that it be set up properly - bent parts do not straighten easily. The common problem for scaffolding is mud, especially on open leg bottoms. Mud blocks or makes difficult the insertion of scaffold feet and screw jack leveler are difficult to turn when dirty or when rusty. Clear your plugged ends and once a week check all your scaffolding. A wire brush will quickly clean off dirt and rust from your scaffold feet and leveler. Keep your leveler threads well greased for rust protection and easy operation. A ½" caulking trowel works well for clearing plugged ends. A natural fiber brush will usually remove most of the dirt and mud from the scaffold pieces, braces and guard rails. Keep your safety locks clean for easy assembly or disassembly of the scaffolding.

Plaster mixer:

This piece of equipment is faster, more thorough, and produces a larger volume than hand mixing. Consequently, it sees some fairly extended use. It is a relatively simple machine and therefore is easily maintainable, with proper servicing. When using cement, clean the mixing drum, paddles, and hardware thoroughly after each mix, otherwise plan to spend a lot of time with a hammer and cold chisel chipping out the dried remnants. If you are using soil mortar, give the drum and hardware a good rinse after each mix and clean it thoroughly at the end of the day. Dried soil will come off fairly easily if you don't clean between mixes. However, this makes the machine work harder and increases the chance for breakdown. Do not use concrete adhesive in the plaster mixer. At the end of each work week when your machine has seen heavy or moderate use, change the engine oil, clean the air filter, check for and secure loose nuts, bolts, screws, parts, etc., and check the mixing drum gear and all belts. Repair when necessary. Do this early enough on the last work day of the week so that you can order or purchase any parts you might need. This will save delay in the work at the beginning of the next work week.

Shovels, hoes, rakes forks:

Keep them out of water except for cleaning. Remove rust with steel brush. Treat drying handles with rubbed-in linseed oil. Replace brittle or cracked handles.

Water hose:

Keep coiled when not in use. Drain before coiling at end of day. Repair kits are available for bent, broken or otherwise unuseable hardware. Avoid kinks and don't run machinery over hose.

At the End of the Season

Clean all tools and equipment thoroughly. Be sure to remove dust.

Repair everything that needs it.

Give all wood parts a thorough rubbing with linseed oil. Wipe off excess.

Give all exposed metal parts on tools a light coat of linseed oil.

Empty all water hoses, allow them to dry as much as possible before recoiling.

Motorized equipment: clean all parts including air filter, change the oil, top-off the gas tank, check and adjust tire pressures.

Store all tools and equipment neatly in a clean and dry, covered and enclosed area; in this case, the maintenance stabilization tool shed on the concrete pad in the "boneyard".

Graphics

Graphics

Introduction

Map References

Base Map: East Ruin
(also shows roofed rooms)

Base Map: West Ruin
(also shows roofed rooms)

Base Map: West Ruin
(also shows how ruin is divided into "wings")

Base Map: Aztec Ruins National Monument

Base Map: Hubbard Site

Sketch Map: Great Kiva Electrical System

Metric Conversion Card

Photographs and Caption Sheet

Map References

Photogrammetric panel layout, AZRU
Gordon Herkenhoff & Associates, Inc.
Drawn by "B.M.", dated 4-27-78, on
file at AZRU and NALA.

Aerial photogrammetric imagery, AZRU
Thomas R. Mann & Associates, Inc.
Dated 2-15-78
On file at AZRU and NALA

Graphics

This section is for maps, drawings, and photographs.

There have been several different archeological base maps of the ruins and this becomes confusing when you look through some of the old documents. For the purposes of standardization, the maps were included in this section to show which ones have been used recently as references. These, too, will change somewhat when the photogrammetrical studies of AZRU are completed in FY 1978. For the present, use these maps for reference and for your work records. Copies of the maps drawn from aerial photos will be forwarded to you, when complete, by NALA. They should be entered in this section.

The maps provide other valuable information - where the drainage systems are, and, for the purposes of description, what part of (wing) the ruin rooms are located in.

Drawings of utilities in the ruins should be included here so that you and your successors will know what existing systems are and any changes or alteration that are made.

Also include any photographs you believe will be of special interest or provide important visual information. Anything else that will help you, such as mathematical tables, metric conversion, etc., should be included, too.

THE EAST RUIN
AZTEC RUINS NATIONAL MONUMENT

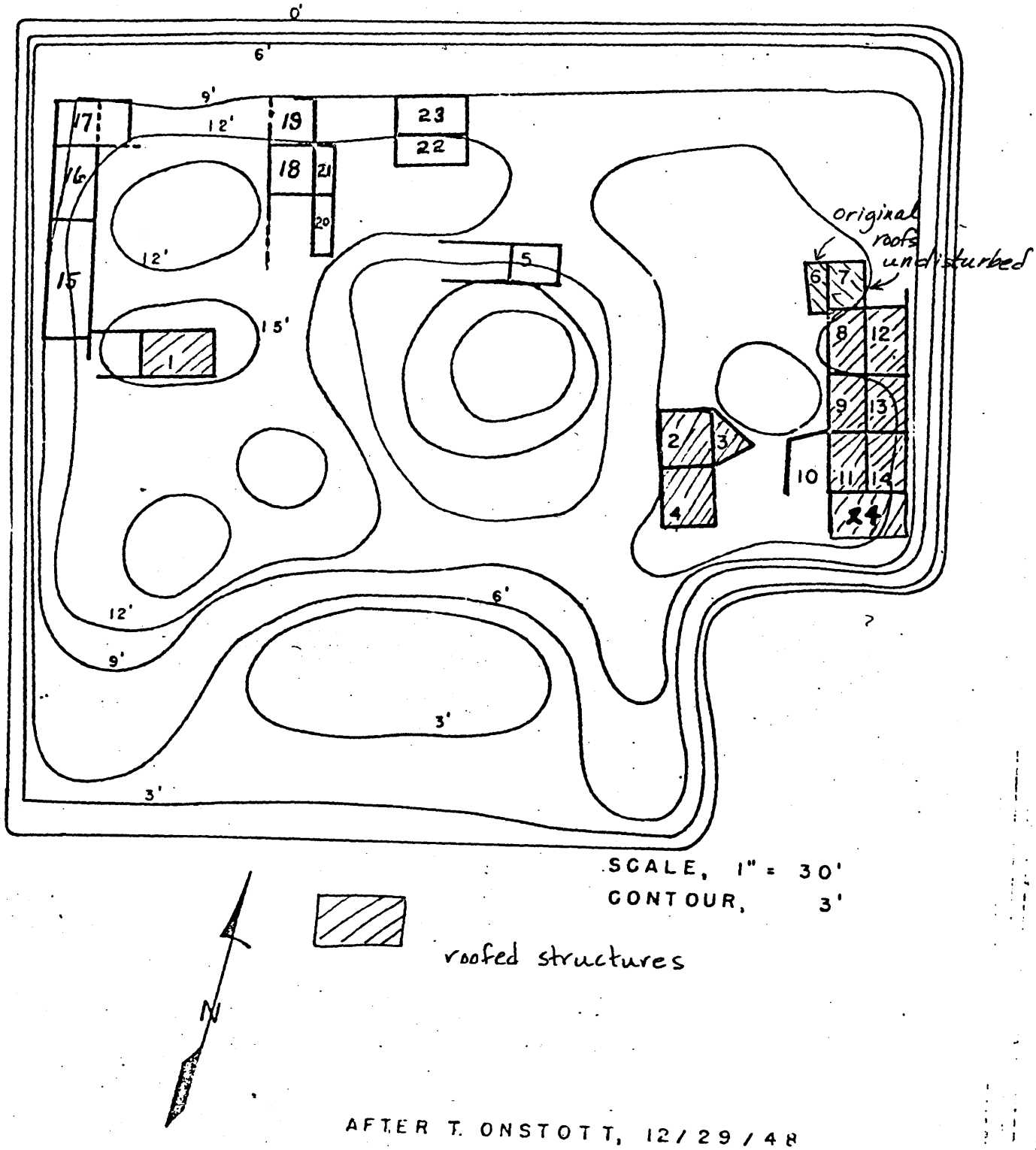
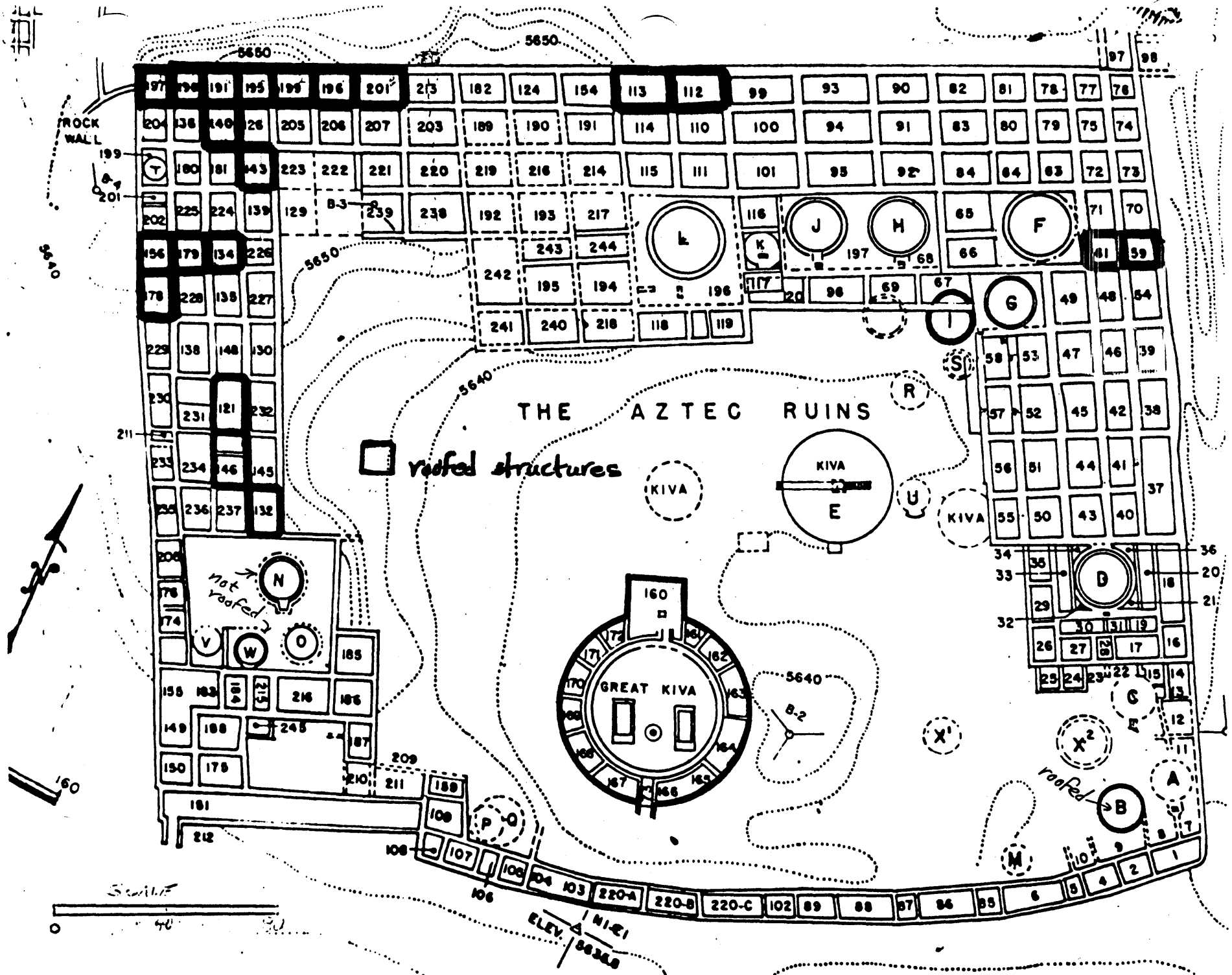


FIG. 1


THE AZTEC RUINS
roofed structures
ROCK WALL
KIVA
GREAT KIVA
not roofed
roofed
5650
5640
ELEV.
N1-E1
B-2
B-3
B-4
SCALE
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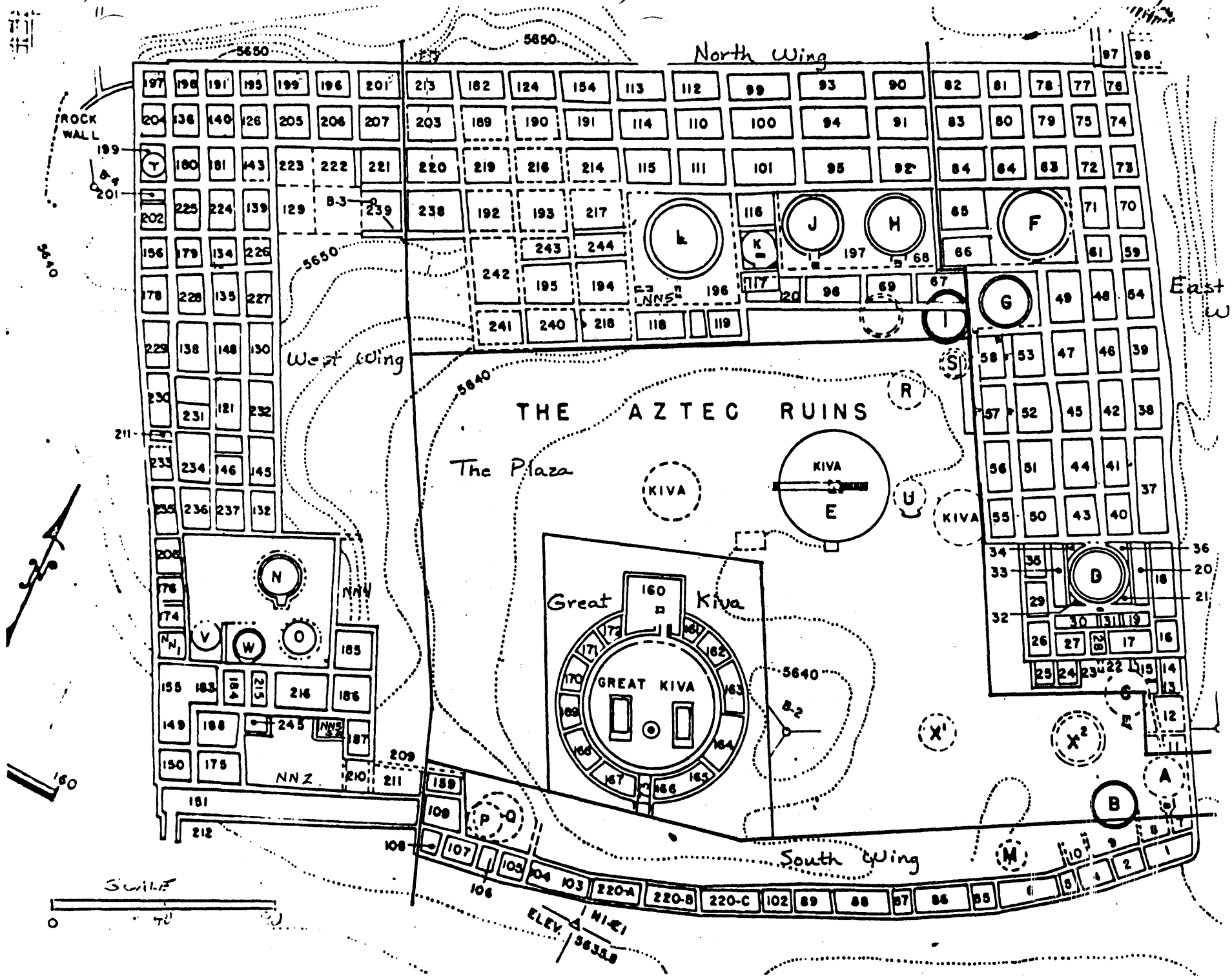
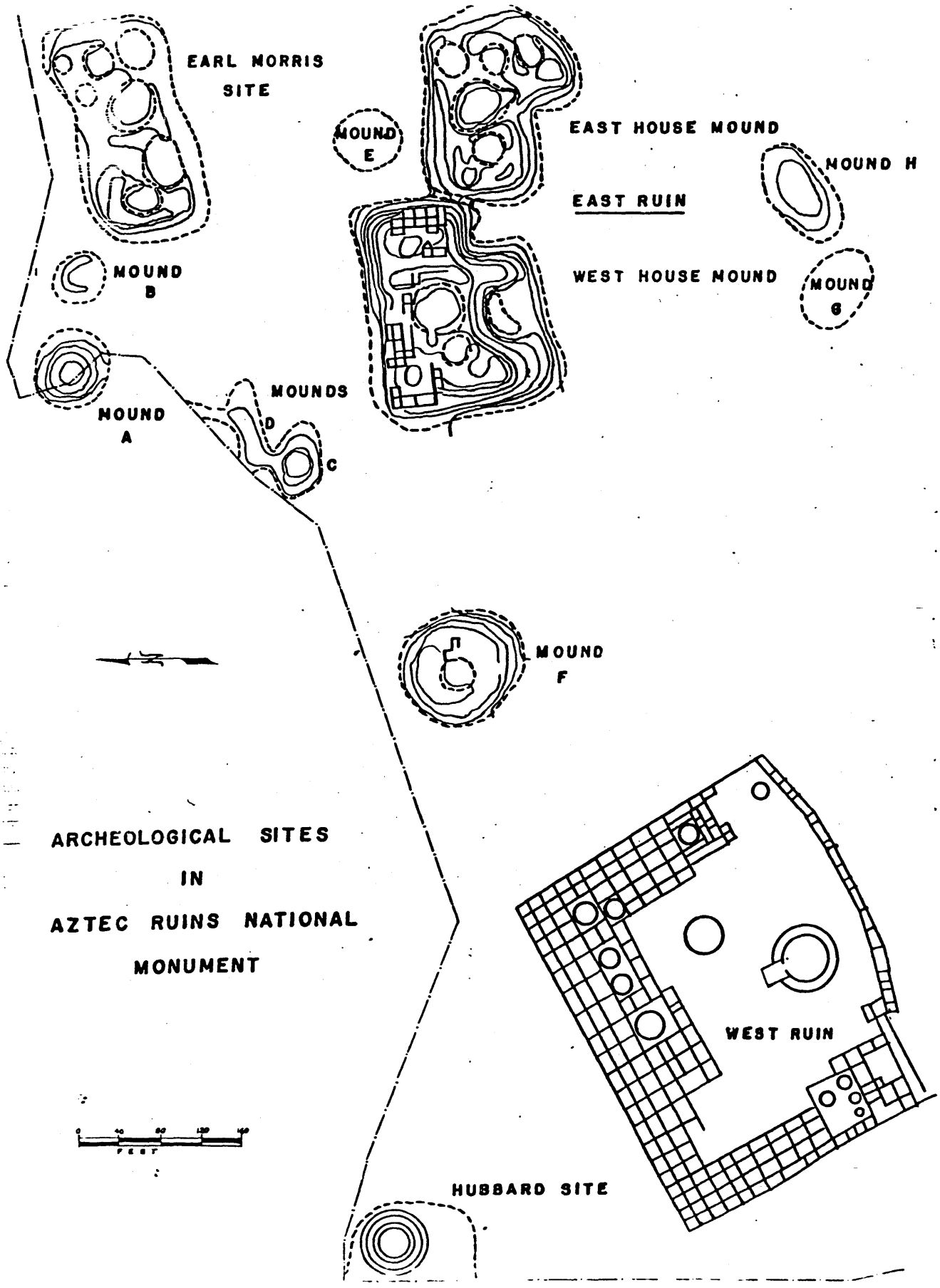
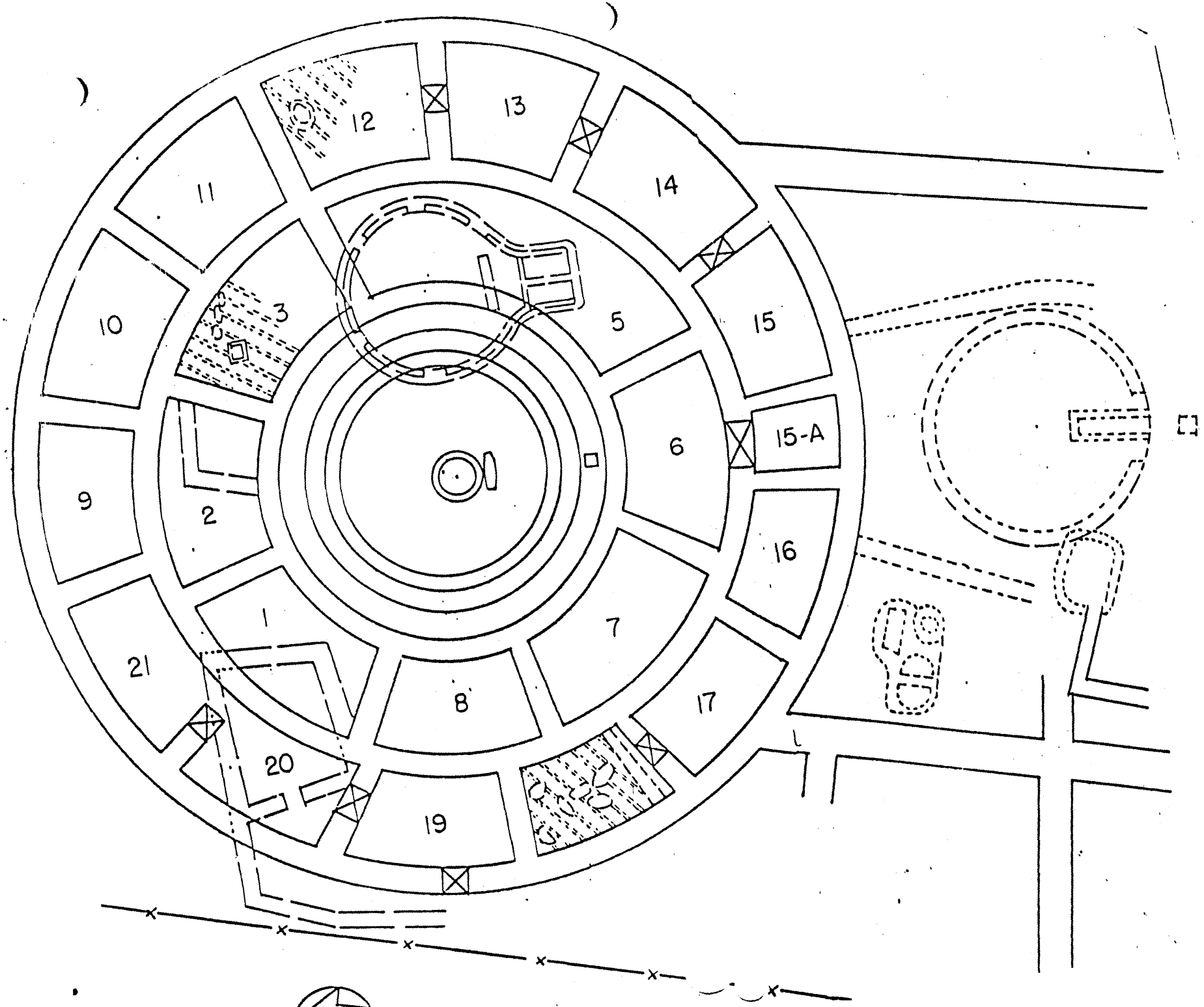
40
80



North Wing
East Wing
West Wing
South Wing
THE AZTEC RUINS
The Plaza
Great Kiva
GREAT KIVA
KIVA
ROCK WALL
5650
5640
ELEV. 5635.8
SCALE


EARL MORRIS SITE
MOUND E
EAST HOUSE MOUND
MOUND H
EAST RUIN
MOUND B
WEST HOUSE MOUND
MOUND G
MOUNDS D
MOUND A
C
MOUND F
ARCHEOLOGICAL SITES IN AZTEC RUINS NATIONAL MONUMENT
WEST RUIN
HUBBARD SITE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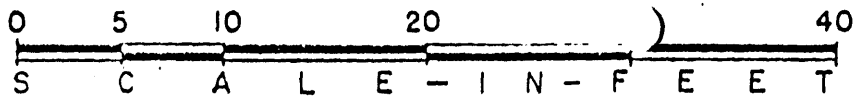


LEGEND

(FOR HUBBARD RUIN ONLY)

Note: Numbers indicate room numbers

——————— Late masonry, tri-wall and adjacent walls

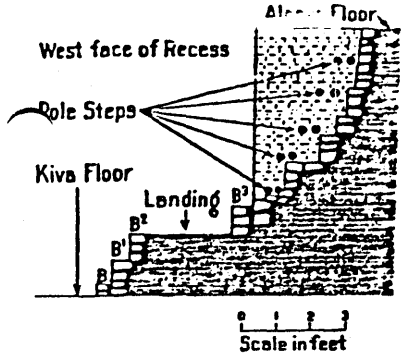
——— ——— ——— Adobe walls, lowest level below other walls

- - - - - - - - - - - - Masonry, mid. level walls and floor surfaces

Blocked doorways

-x———x— Fence

Great Kiva Wiring System
(as installed, August, 1978)



Cross Section of North Stairway

Contractor:
NAL & AL Electric Co. Inc.
Bloomfield Highway
Farmington, NM 87401
327-9175

Kiva music button

Fluorescent light fixture

Double receptacle, outdoor type

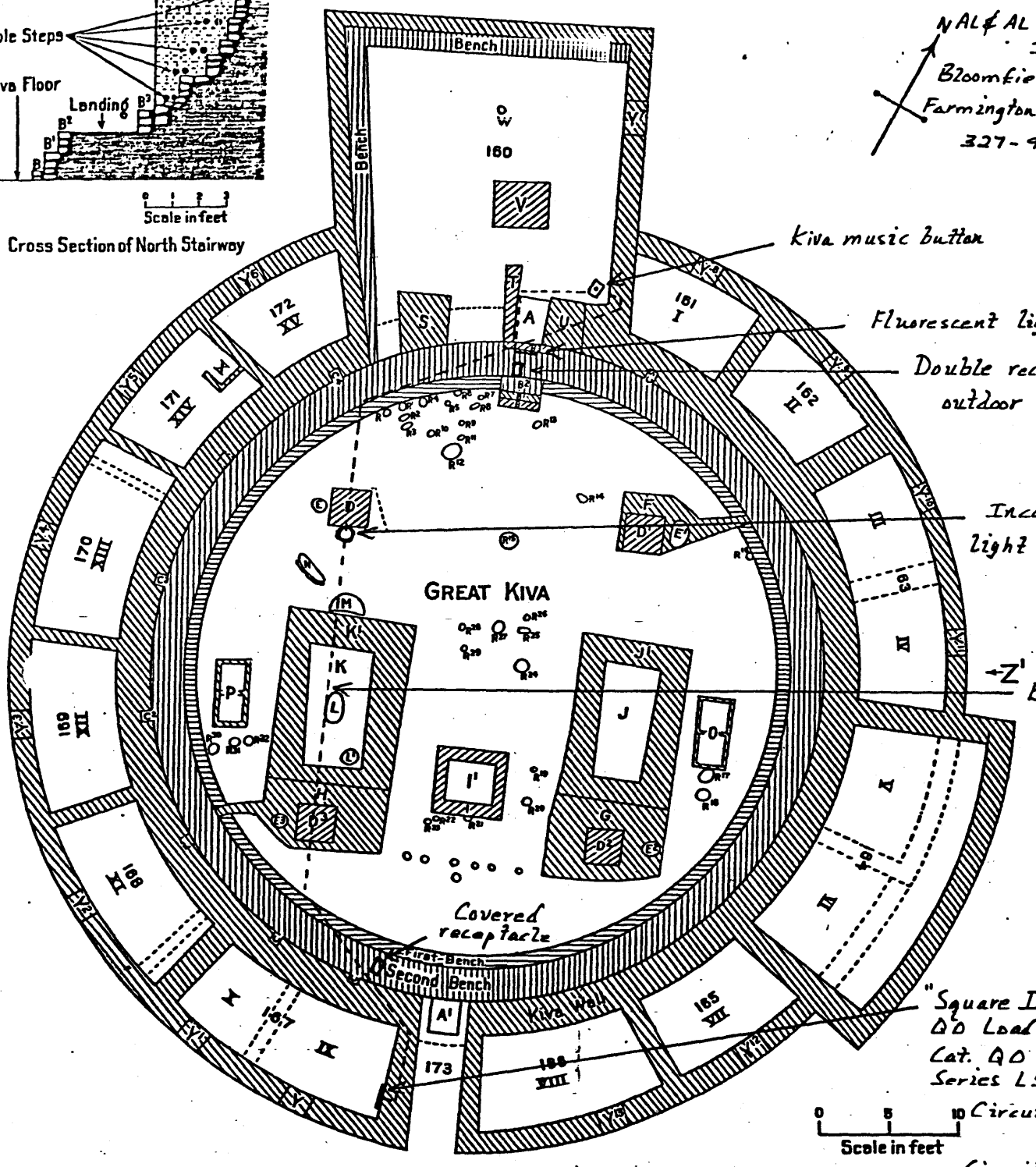
Incandescent light fixture

Electrical cable

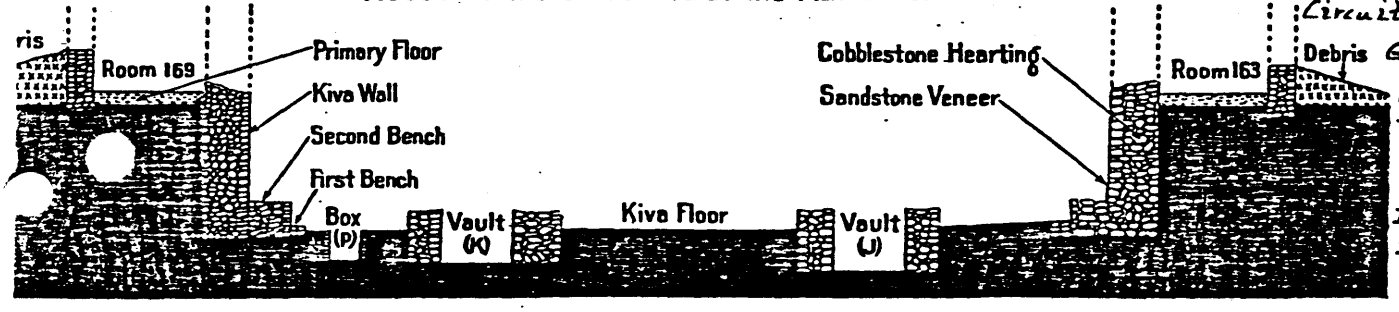
"Square D"
QO Load Center
Cat. QO 6-12
Series L5

Circuit 4 = South plug
Circuit 5 = Lights
Circuit 6 (with GFCI) = North Plug

Mains 100 Amp. Max.
120/220 V.
1ph. 3 W.



House of the Great Kiva at the Aztec Ruin



Cross Section House of the Great Kiva from Z to Z'

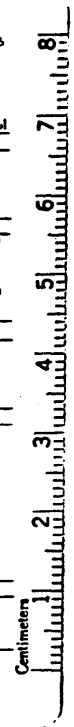
U. S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

NBS Special Publication 365
Revised November 1972

METRIC CONVERSION CARD

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

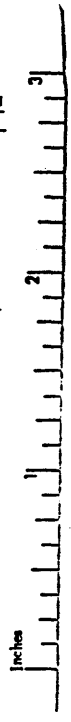


Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price 20 cents domestic postpaid, or 10 cents GPO Bookstore. Stock Number 0303-0168. Catalog No. C13.10: 365/2.

☆ U.S. GOVERNMENT PRINTING OFFICE : 1973—O-495-957



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Photograph Captions

1. Shows high amount of water on walls from slowly melting snow.

2. Shows mixed leaves and snow against ruin wall. Leaves insulate the snow, allow slower melting, and increase wall moisture retention.

3. Shows heavy mortar erosion. There is an extensive formation of voids behind the veneer. These voids must be filled prior to surface pointing.

4. Shows medium erosion of veneer stone and honeycomb effect of cement mortar.

5. Shoes older type of drainage. This type should be replaced, as allowable, with a more contemporary system.

6. Shows heavy basal stone erosion.

7. Shows overgrowth of vegetation obscuring the interpretive view. Vegetation should be periodically trimmed.

8. Shows snow removed from trail for visitor safety.

9 & 10. Show differences in masonry styles and point out the need to match the original when repairs are made.

11. Shows decorative band of whitish stone.

12. Shows decorative bands of dark green graywacke stone.

13. Shows split-tile drain after removal of dirt, leaves, and snow.

14. Shows weed buildup. This is unsightly and helps insulate snow.

15. Shows mortar erosion from slowly melting snow. The constant freeze-thaw cycle hastens deterioration.

Fact File

Fact File

Use this section to record unusual events, important new information, obscure but relevant facts, special projects, etc. In other words, anything which you think will be of use now on at any future date. Examples are included in this section.

Facts File

Shiner, 1959 - 1960:71

Room 106 "Entire west partition wall torn down and rebuilt using cement instead of mud:"

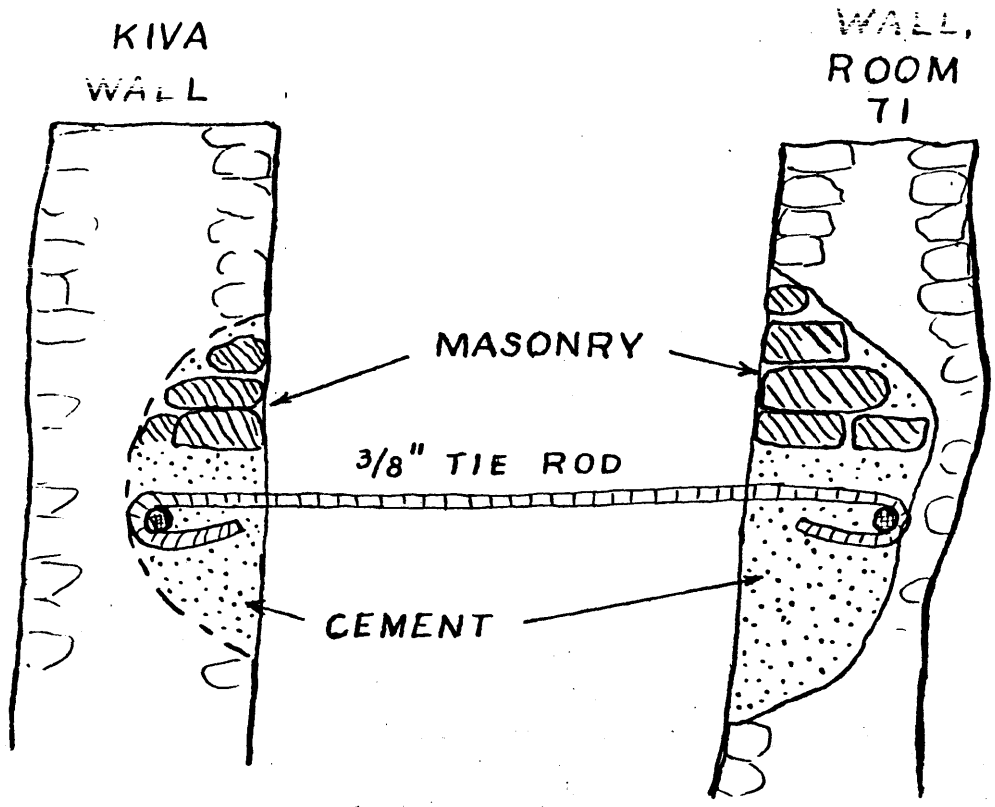
:73

Room 107 "Southwest corner of room (mainly exterior) was taken down and relaid in cement mortar."

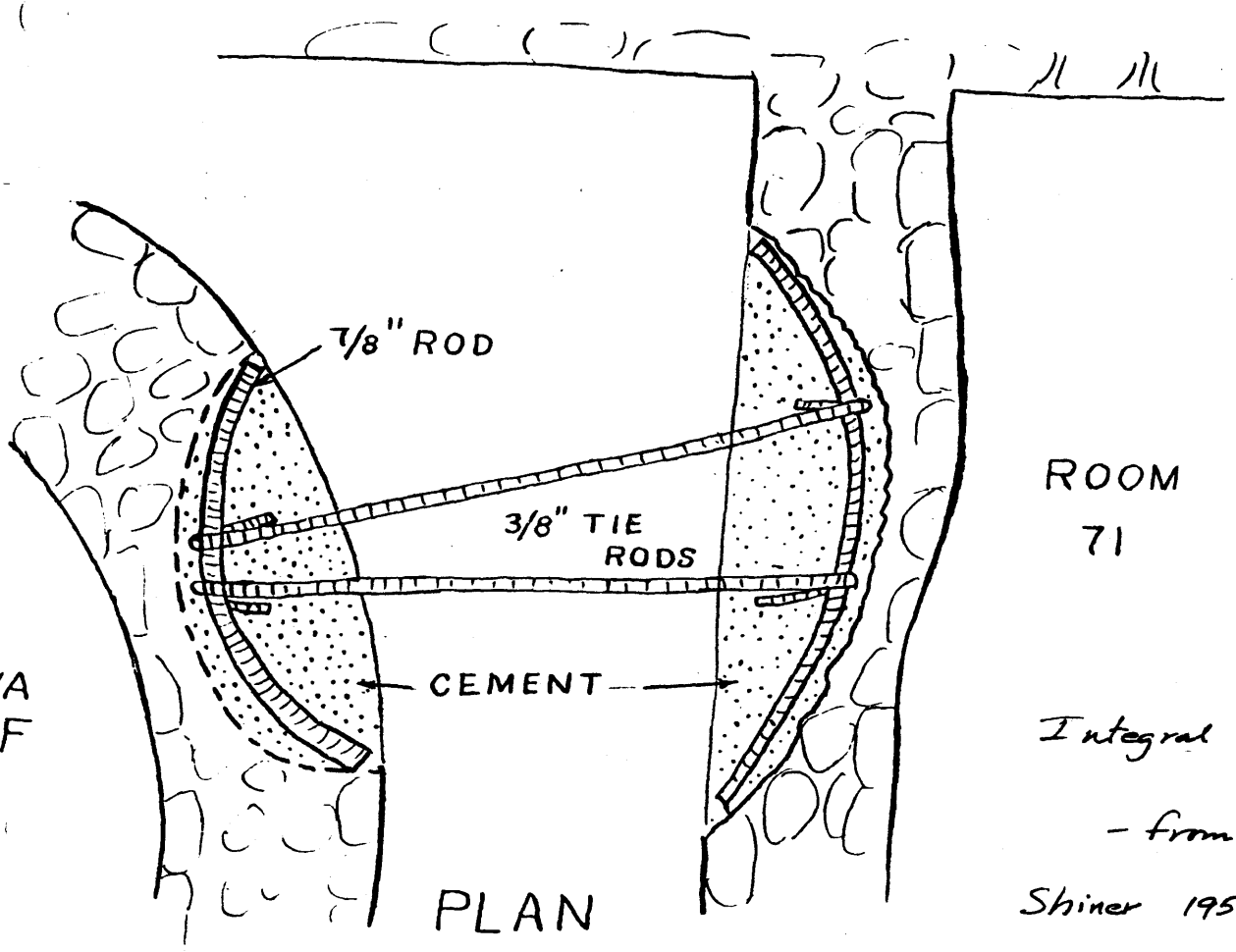
:77

Room 117 "North exterior of room...wall was plastered with cement containing "hydropel"... (and) given a coat of tar."

Fiscal year 1977: root cellar on northeast edge of Mound F removed by Adams, et al., because the cellar was obtrusive to the resource (part of the hole extended into the mound). Hole to be filled in and graded to mound slope during FY 1978 - after aerial photogrammetry completed.



PROFILE



PLAN

Integral Members

- from -

Shiner 1959-60 : 48

United States
Department of the Interior
National Park Service
Aztec Ruins National Monument

Completion Report
Day Labor Project

Construction Package Number 110

Title: Stabilize West Ruin

Prepared by: Stephen E. Adams
Ruins Preservation Specialist

Date: December 12, 1977

Form 10-174
(June 1962)

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

FACE SHEET FOR COMPLETION REPORT

Park: Aztec Ruins National Monument	Region: Southwest	Work Order No.
Location in Park: West Ruin	State(s): New Mexico	Fund Symbol
☐ Contract and/or ☒ Day Labor	County or Counties: San Juan	Year Programmed
Work Order Title: Stabilize West Ruin		PCP No.: Package No. 110
		Master Plan No.
		Master Plan Corrected By
		As Built Drawings By
		Date Started: May , 1977
		Date Completed: September , 1977

DESCRIPTION OF FIXED ASSETS (For completion by employee in charge of project)	TOTAL COSTS (For completion by FFO)
305 Ruins Stabilization	
1. Ruin Structural Fabric: Replacement of eroded stone, capping of loose wall tops, repointing of eroded mortar joints. This stabilized ruin walls. Units stabilized: Forty-four rooms and kivas representing approximately 45,000 square feet of masonry.	$29,911.75
TOTAL	$ 29,911.75

DISTRIBUTION No.	To

THE FIXED ASSET DESCRIBED ABOVE HAS BEEN COMPLETED IN ACCORDANCE WITH APPROVED DRAWINGS, SPECIFICATIONS, AND AUTHORIZED CHANGES

Submitted By: Stephen E. Adams	Title: Ruins Stabilization Spec.	Date: 12/12/77
Approved By: Charles B. Voll	Title: Acting Gen'l. Supt.	Date: 12/12/77
COSTS VERIFIED BY	Title:	Date:

Form 10-174A
(June 1962)

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

COMPOSITION OF COST FOR COMPLETION REPORT

Work Order Number	
Fund Symbol	

Park	Region	Year Programmed
Aztec Ruins National Monument	SW	

Location in Park
West Ruin

Work Order Title
Stabilize West Ruin

COMPOSITION OF COST

COSTS CHARGED TO FUNDS ALLOTTED TO FIELD FINANCE OFFICE		
(1) Personal Services	$25,225.23	
(2) Travel		
(3) Contract Work		
(4) Supplies and Materials and Capitol Acquisitions	4,166.44	
(5) Other Direct Expenses Printing & Reproduction	51.32	
(6) Operation of Equipment		
(7) Depreciation of Equipment		
(8) Purchase of Construction Equipment		
(9) Purchase of Other Accountable Equipment		
(10) Other Costs: GSA	468.76	
(11) TOTAL COST CHARGED TO FFO FUNDS	xxxxxxxxxx	$ 29,911.75
OTHER COSTS:		
(12) PS&S, AP, and/or Facilitating Services @ ____ %	$	
(13) Inventory and Other Non-Fund Costs		
(14) GROSS WORK ORDER COSTS	xxxxxxxxxx	$
LESS:		
(15) Residual Value of Construction Equipment on Line 8	$	
(16) Other Credits		
(17) NET COST OF FIXED ASSETS	xxxxxxxxxx	$ 29,911.75

ntify other costs and other credits by line item entry, on an attached schedule, or explain in narrative.

Narrative To Accompany Project Completion Report,
Package Number 110, Stabilize West Ruin
Aztec Ruins National Monument

Although Aztec Ruins National Monument has been in the Park Service system since 1923, preservation has been unable to keep abreast of ruins deterioration. Therefore, the goal of bringing the Aztec Ruins to maintenance status has not yet been realized.

By far, the prevalent problem at Aztec is erosion caused by ground and surface moisture which reaches its most damaging form in capillary action on ruin walls.

Standard preservation techniques have been mostly ineffective. Special techniques, though they have helped, have not been adequate because of the massive sizes of the resources.

Ruins stabilization in the past here has been dependent on a large scale cyclical maintenance projects. This is a result of a misdirected preservation thrust and a lack of adequate funding and staffing for a maintenance program. Beginning in 1973, a six-year rehabilitation project was implemented, the goal being maintenance status for the West Ruin by the end of the sixth year. Definite progress has been made but even by this, the 5th year, we are still far short of maintenance status.

The 1977 project was directed and supervised by Stephen E. Adams, NALA Ruins Preservation specialist. Crewmen were: Masonry Worker Willie P. Yazzie; and Masonry Helpers James D. Brown, Kato Tsosie, and Steve E. Wilson. Masonry Helper Clifford Werito was on the project for a short time during May and June, 1977.

Work began May 9 with an authorized plan of $30,000.00 under Account Number 7371-1001-305. Work under this plan was completed September 30. The field season continued through November 18 on a new account number (new fiscal year). Details for the October 1 through November 18 activities will be included in the 1978 fiscal year completion report.

Forty-four rooms (including 4 kivas) were worked on and approximately 3200 square feet of wall surface was stabilized. Three hundred sixteen (316) work days were spent on actual stabilization, 7.18 per room. Seventy two (72) work days were used in support activities such as soil and stone acquisition and mortar mixing. The total project work day expenditure was 398.

This season's activities were concentrated on repairing basal erosion, the prominent defect this year. Standard masonry techniques were used to replace eroded stone and mortar with freshly dressed, dry stone and fortified mortar. The soil mortar was fortified with a latex base modifier, "Wilhold" concrete adhesive. The stone and soil used were acquired from BLM land through contact with the Farmington District Office. This was done to avoid further digging in the monument around archeological resources. Supplies and materials were purchased from GSA and a local builders supplier, Construction Supply Company (Farmington).

Other standard work performed consisted mostly of repointing of eroded mortar joints with fortified soil mortar. Where possible, loose, purple cement was removed and replaced with fortified soil mortar.

There were two special projects, both dealing with kivas. A bulge in the upper SW quadrant of Kiva L had developed into an emergency status defect over the previous winter. An attempt was made to remove enough rock to clean out the material settled in the bottom of the bulge and then push the wall back into place and stabilize it there. However, during the cleaning process, the bulge collapsed. Standard techniques were used to replace the fallen stone flush with the rest of the wall. The second project was the installation of a double drainage system to intercept moisture that was causing severe damage, through capillary action, to Kiva N walls. Details on this project will be available in the report to be written by Larry Nordby of the Southwest Cultural Resources Center.

A photogrammetry project for Aztec was initiated by Adams and planned by Dr. Lyons of the Chaco Research Center Remote Sensing Laboratory. It is to be implemented this winter and details will be supplied in the Field Season 1978 completion report.

Because Southwest Region has acquired its own stabilization expertise, the Western Archeological Center stabilization equipment, though purchased largely with SWR project funds, is no longer available for use in the Southwest Region. Therefore, the crew had to be completely outfitted with new equipment. Small hand tools, miscellaneous tools, supplies, and equipment, a large storage building, a plaster mixer, and scaffolding were purchased from project funds already severely affected by inflation and high labor costs.

As far as visitation is concerned, this year's work had a positive effect. Because the crew was small and unobtrusive, the interpretive scene was not affected to any significant degree. Furthermore, the crew activities generated a lot of visitor interest in the form of questions about the techniques, theory, and history of stabilization at Aztec. This well points out the need for interpreting preservation projects that are visible to a curious public.

Stephen E. Adams
Ruins Preservation Specialist

Hubbard Site

FY 1978 Ruins Stabilization

Scope of Work Statement

The Hubbard Mound was excavated in 1953 and stabilization was begun in October of that year. Most walls were capped with freshly dressed stone to help hold up the eroded and somewhat loose wall tops. The wall tops and upper sides were then plastered with a tinted, 2 to 1 soil cement. Minor repairs, such as patching eroded wall holes, were also performed. An unsuccessful attempt was made to preserve plaster, in place, with the use of an ethyl silicate solution. Some drainage work was done to protect the site from water from irrigated fields close by. A trench 2 - 2½ feet deep was dug around the north half of the exterior part of the wall and filled with gravel.

In 1960, the soil cement and the remaining original plaster was removed, eroded areas were patched, and all wall tops and surfaces were replastered with tinted cement laid over chicken wire nailed onto the walls. Some repair work was done on the interior wall of kiva 1. The space between the kiva wall and the room walls around the kiva was levelled and then graded to direct water to a drainage tile which channels the water into a dry barrel installed in Room 4. "Urea-bor", a weed killer, was spread in all rooms and kivas. Also, at this time, the cobble wall structures and features adjacent to the tri-wall were reset in tinted cement.

Cyclic maintenance of a minor nature was performed in 1965. Most of this work involved patching of caps and small, eroded areas on walls.

The major preservation problem is the cement plaster. It is providing an ideal medium for capillary action and furnishes no real moisture protection to ruin walls. It masks interior defects and is unpleasantly textured and colored. Another significant problem is drainage, particularly in kiva 1 below surface level. Much of the moisture in this kiva comes from snow which, when melted, has no place to drain.

All rooms and the kiva require preservative treatment and all wall surfaces will be worked on. The project is planned to proceed as follows:

a. remove wooden steps in Room 6.

b. strip all wall surfaces and wall tops of cement plaster.

c. repair all structural defects - eroded or loose stone, eroded mortar joints, etc.

d. rebuild north wall of Room 15A, including filled-in doorway (most of the wall was removed to provide access to the wooden steps placed in Room 6 for interpretive display of the ruin).

e. replaster Rooms 6, 15, 15A, and 16.

f. space between kiva 1 outer wall and wall formed by rooms surrounding the kiva: fill top with water-proof or water repellent material graded to drain into Room 4 ~~dry-barrel.~~

delete g. remove Room 4 dry-barrel, clean out, and re-install.

h. install dry-barrel in floor of kiva 1.

i. line east walls of Rooms 7 and 17, and west walls of Rooms 5 and 15 with waterproof materials, also line all exterior walls of central kiva (kiva 1).

j. backfill; Rooms 1-5, 7-14, and 17-21; all cobble wall features and structures (including kiva 2); and backfill, to graded slope, around ruin to recreate a mounded site. Visqueen to be laid out under graded slope, with small drain holes through walls where necessary to drain toward exterior.

All stone work will be done with freshly dressed, dry stone. Walls will be capped with a tinted soil cement strong enough to stand up reasonably well to foot traffic. All other mortar will be an unmodified soil mortar. Plaster work will be done with a soil mortar fortified with concrete adhesive (latex modifier).

Kiva
Room floor surfaces will be sloped toward dry-barrels. Dry-barrels will be filled with coarse gravel on the bottom 2/3, smaller-graded toward the top (to slow dirt fill-in). The barrels should be 2 - 2½ feet wide and 3 - 4 feet deep.

Some original fabric and unexcavated deposits will be affected by stabilization when eroded sections are removed and rebuilt with fresh materials and when the dry-barrel is installed in kiva 1. There will be no major structural changes or fabric removal. Minor changes will be small drain holes through walls at graded surface level.

The waterproofing activities in Rooms 5, 7, 14, and 17 will not affect cultural deposits and will not affect wall fabrics because materials will be so placed as to be independent of (i.e. not applied to) wall fabric.

Backfilling, of course, will preserve rather than impact any features or structures.

Scope of Work Statement

Protective Roofs - West Ruin

Aztec Ruins National Monument

Stephen E. Adams
Ruins Preservation Specialist
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The history of the protective roofs in the West Ruin is rather confusing. Many of the older records and files have been thrown away or transferred. However, there is enough information in stabilization records to give a general idea of what kinds of roofs have been used, the problems associated with these roofs, and what kinds of attempts were made to solve the problems.

Phase I of the roofing history begins with Dr. Earl Morris. Morris attempted the protection of ceilings and room interiors by pouring concrete slabs over the original roofs. In addition to failing to protect (the cement being porous to water), the slabs caused further damage by adding tremendous weight to already weak and unstable roofs. Use of concrete slabs continued at least until 1934. In the 1933-34 season, Hamilton installed reinforced concrete slabs over Rooms 202 and 196. The concrete was turned up on the wall at the edges to create evaporative pans. These pans had no drain outlets.

Apparently, the winter of 1936-37 was quite severe and damaged the ruins extensively. Thus began Phase II of the history. In 1937, Custodian T.C. Miller installed protective roofs over seven rooms. Miller recognized the ineffectiveness of concrete protective roofs and decided to use tar paper with tin flashing. He also recommended that concrete roofs no longer be built in the ruins.

From 1938 to 1941, Gordon Vivian made repairs to some protective roofs. On Rooms 156,178,134, and 179 a two inch plating of bitudobe was laid over the cement slabs installed during Phase I. A large drainage tile to drain the four rooms was installed in the west wall of Room 156. This tile drained into a six inch tile that ran to 28 feet west of the pueblo and ended and surfaced at that point. In 1939, Vivian applied a wood and tar paper roof over the concrete slab of Room 132 (record is contradictory: the room sheet indicates that the new roof was applied over the slab; a photo caption says the slab was removed and replaced with bitumulus plating). In September, 1938, a drain tile was set in the north wall of Room 113 and the concrete slab was cleaned off and given a plating of soil-bitumen. In August of that year, the slab of Room 137 was cleaned and plated with soil-bitumen. The same repair was accomplished on the roof of Room 112. In 1939, the concrete slab over the roof of Room 121 was covered with a wood and tar paper roof. It received a thin top layer of bitumulus and drainage was made through the east wall. Also, the slab of the roof of Room 61 was sealed and covered with a thin plating of stabilized mortar (probably bituminized).

Richert, et al., were concerned with roof protection during the 1953 season. Although he was aware of the damage caused by concrete roofs, Richert was reluctant to remove them, fearing that this would cause even more damage (the concrete would have to be sledge-hammered and picked-out). Therefore, he removed the overburden from the slabs, patched gaps, cracks, and breaks, installed cant strips, and applied three layers of #30 asphalt felt mopped with 190 degree melt tar. Asphalt impregnated, 9" wide cotton fabric was flashed onto felt/cant joints and mopped with hot tar. The roof was given a final coat of tar

and chat gravel was rolled on. The roofs were sloped toward large, galvanized metal drain troughs. Sixteen rooms received this treatment: 59; 61; 112; 113; 143; 198; 197; 196; 201; 121; 132; 134; 146; 156; 178; and 179. Also, a partial protective roof was built over Room 117. This roof was built of asphalt paper over wood.

In 1956, Richert gave the roofs of Rooms 140, 195, 191, and 199 new coats of tar and new impregnated fabric flashings. He also re-surfaced the protective roof over Room 117. The new surface was mineral surfaced asphalt felt which was painted to blend with the surrounding masonry. The overlaps were sealed with tar, and galvanized tin was placed along the east edge of the roof.

Shiner treated two roofs in 1960. The tar and asphalt roofs of Rooms 156 and 178 were removed. The vertical tile on the west wall of 156 was plugged and an 8" wide galvanized tin drain box was installed over it. An identical drain outlet was installed in the west wall of Room 178. On both roofs, Shiner laid a Hydropel treated concrete layer over the old concrete slabs. The cement was covered with asphalt, felt, tar, and flashing via the "Richert method". In Room 191, Shiner "Chopped hole through wall on north side and installed galvanized drain 8" square...". The roof was finished with the Richert method.

In 1965, Voll and Mayer repaired roofs in Rooms 132, 146, 156, 197, 198, 141 (195), 199, 196, 201, 113, 112, 61, and 59. Repair involved reflashing and filling cracks and gaps (Voll, personal communication).

A contract was let in 1976 for reroofing of Rooms 197, 198, 191, 195, 199, 196, and 201. Roofs were stripped to the decking, some decking was replaced, and the roofs then relaid by the Richert method.

There are several disadvantages to the tar and asphalt roofs. There is inadequate airspace and ventilation; the maintenance cycle is relatively short; and the roofing process is messy and has an immediate adverse impact on the masonry around the roof edges. In some rooms, tar is splattered halfway up the walls. The roofs are prone to slow leakage and have failed to provide enough protection. Some have been built directly over the old Morris era cement slabs and have thus increased the weight on the original roofs.

In 1978, we are approaching Phase III, in which an attempt will be made to solve several problems involved with protective roofs. The ideal roof is one which: (1) will have little or no adverse effect on the resource; (2) is light but strong and durable; (3) is designed to support itself; (4) is designed to allow proper ventilation; (5) is easily removeable for maintenance; and (6) is designed to be relatively maintenance-free.

Newly designed protective roofs are to be installed in Rooms 178, 179, 197, 198, 191, 195, 199, 196, and 201.

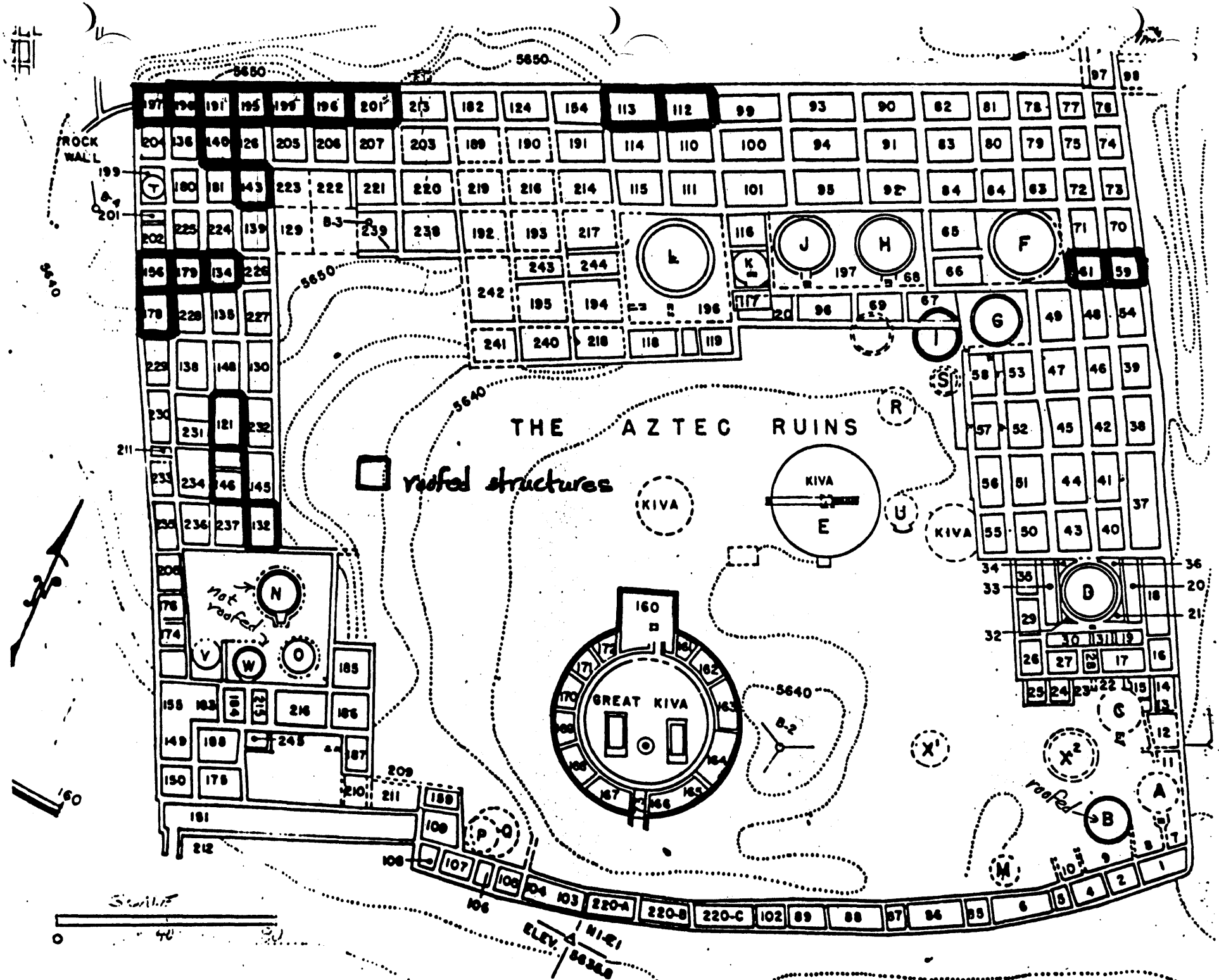
Expected installation procedure is as follows (per room): remove protective roof; remove old decking, cant strips, and concrete slabs (where possible); police the area, install 4"x4" lattice decking, bottom of decking to be at least 6" above surface of original roff; on this decking, lay sections of 1.8" urethane combination board glued together with epoxy glue and edges custom fitted to wall

rock contours; between the urethane edges and the walls, polyethylene film will be placed; ~~an eyebolt will be installed near the middle of the shooting, with 1/4" steel plates on either side of the sheet for reinforcement;~~ a 4" bituminized fiber vent will be installed near center to ventilate the airspace (in Rooms 178 and 179, access hatches will be installed at this point); over the urethane will be placed a 1/4" layer of epoxy grout; a thin layer of dirt will be applied to the grout surface while curing to give the grout a natural dirt finish; the polyethylene film will be cut off from around the edges; white, pliable latex sealer will be applied around the roof edges; dirt will be thrown on the sealer in a thin layer to naturalize it; and excess dirt will be allowed to blow off.

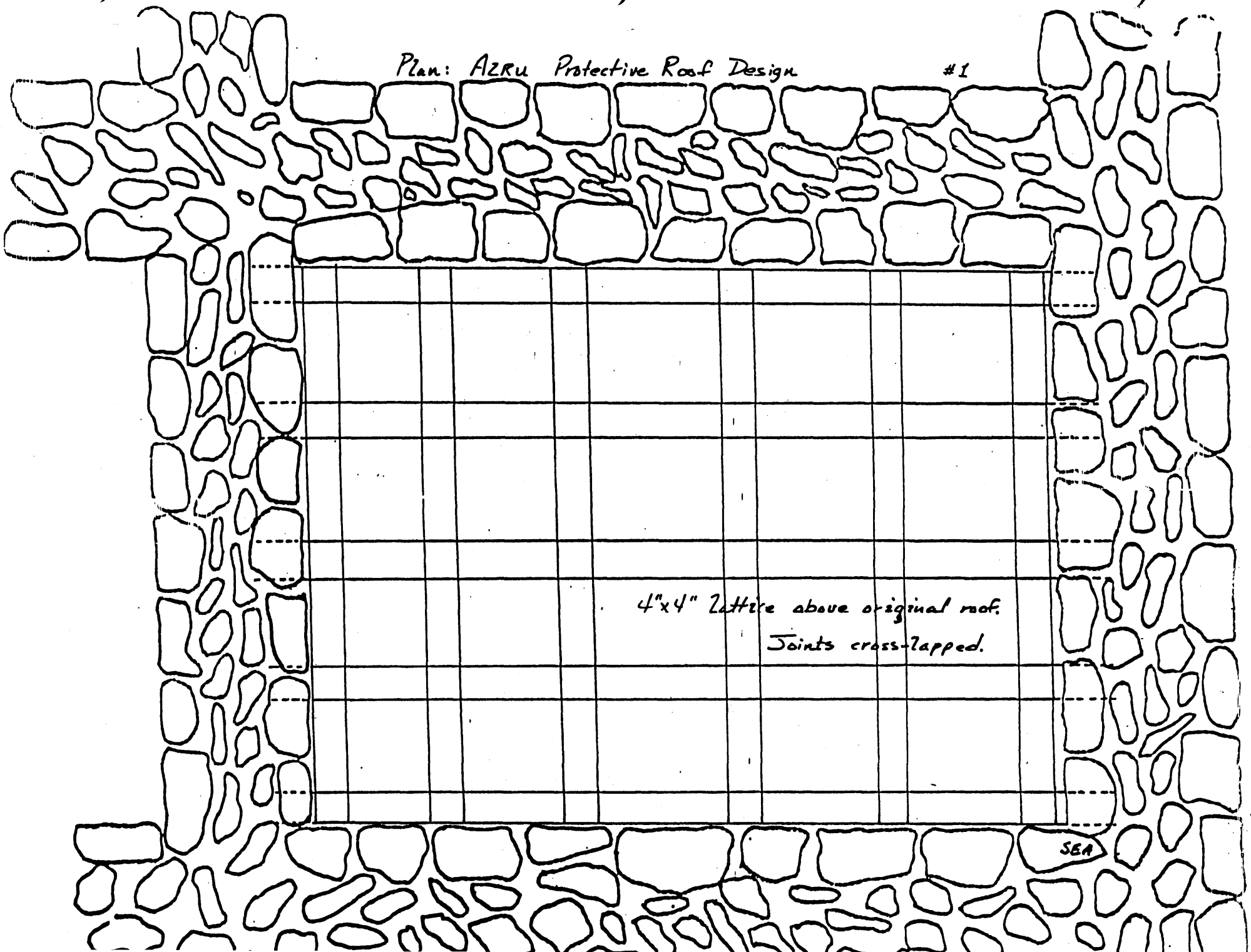
Impact on the resources will be minor: a few stones will have to be removed for placement of the 4"x4" decking; pliable latex sealer will be applied on rock around the edges of the new roof. Many of the stones around the roof edges have either cement or tar smeared on them. Removal of some of these stones and application of the sealer is not expected to significantly affect the archeological or architectural integrity of the ruin.

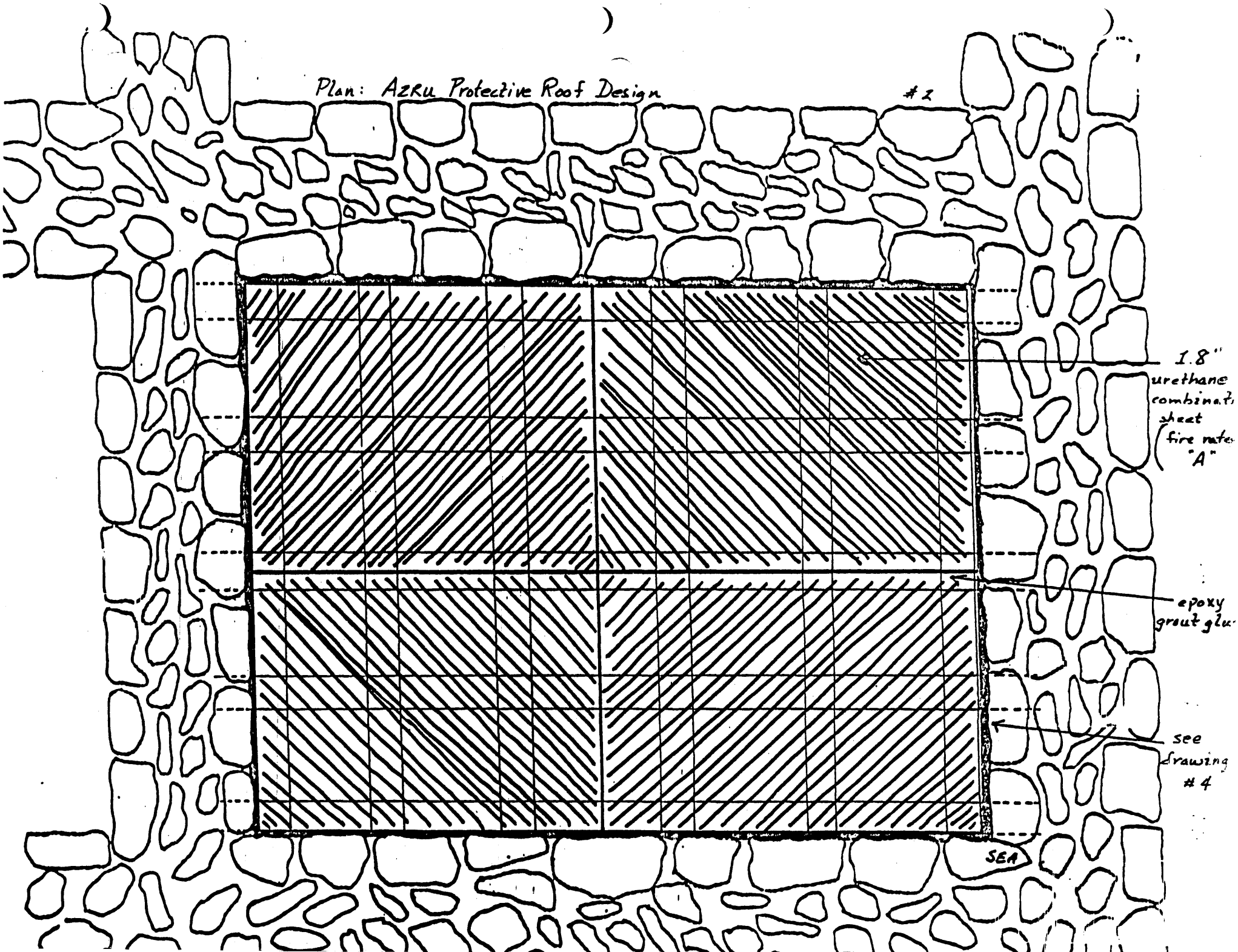
Because of all previous stabilization activities on the roofs, disturbance of the original roof surface will not be adverse. Of course, care will be taken throughout the installation process to ensure that no undue stress is created on either the walls or original roofs. Mitigation of 4"x4" installation will consist of thorough photo and written documentation of walls affected.

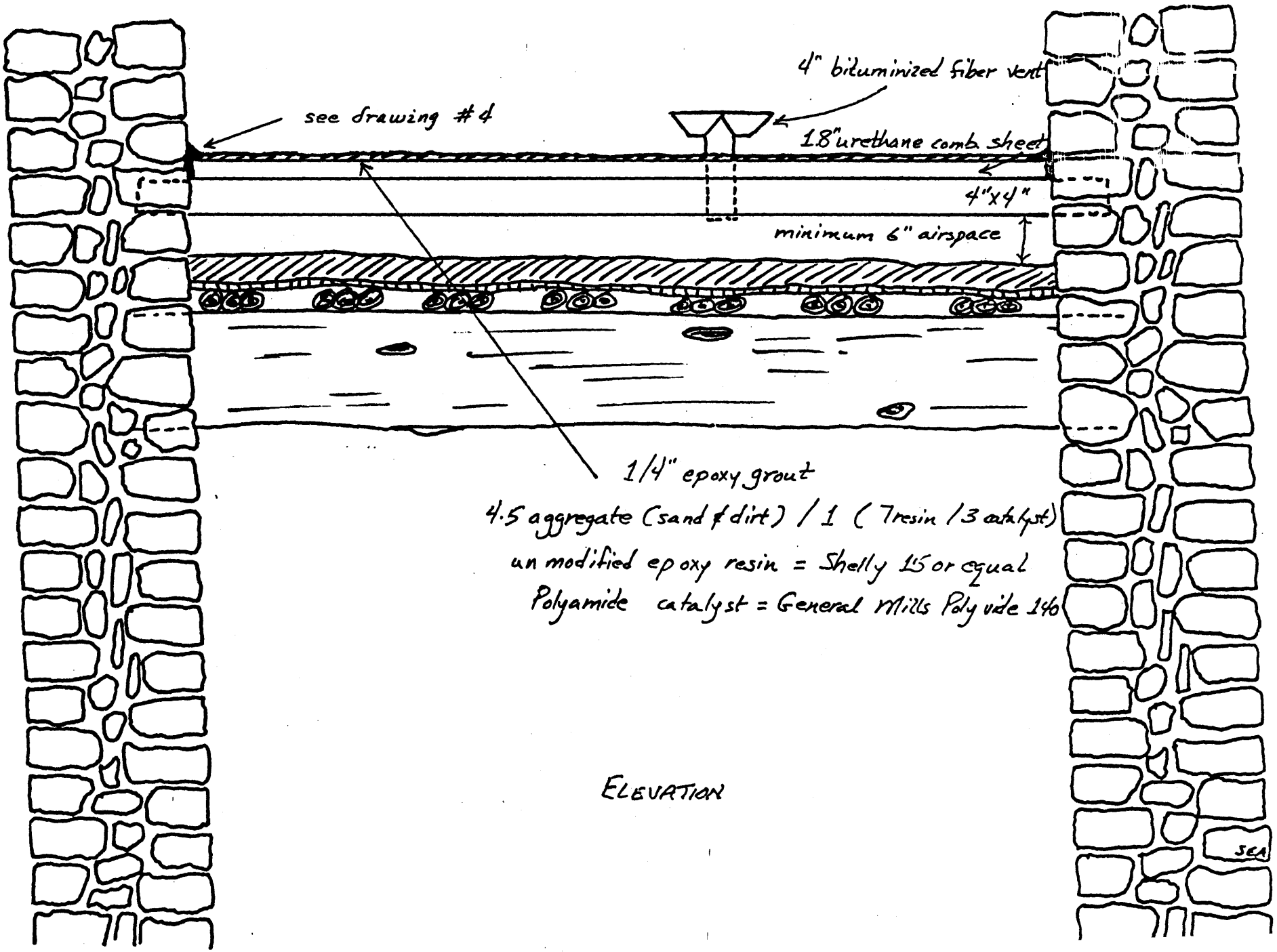
Two rooms, 178 and 179, may require more extensive mitigative actions. At this time, there are no lateral entranceways into these rooms. According to the stabilization records, it seems no one has entered these rooms since 1953 an d, possibly, since the early 1920's. It is not known whether or not there are roof accesses. If not, they should be established so that the rooms can be inspected and worked on, when needed. This would necessitate the removal of a section of the original roof. This section would have to be at least 2 1/2' x 2 1/2', and would be wood lined. The wood lining would extend upwards one to two inches above the roof level (see fourth drawing) and would be covered with a hinged, lockable hatch. Mitigation would consist of overburden excavation and photo and written recording of excavation and hatch installation activities. Installation of the hatches would have immediate and adverse impact on the resources. However, this seems minor considering the alternative of allowing the rooms to collapse due to lack of maintenance.


THE AZTEC RUINS
roofed structures
ROCK WALL
GREAT KIVA
KIVA
not roofed
roofed
5650
5640
ELEV.
N1-E1
B-2
B-3
B-4
Scale
0
40

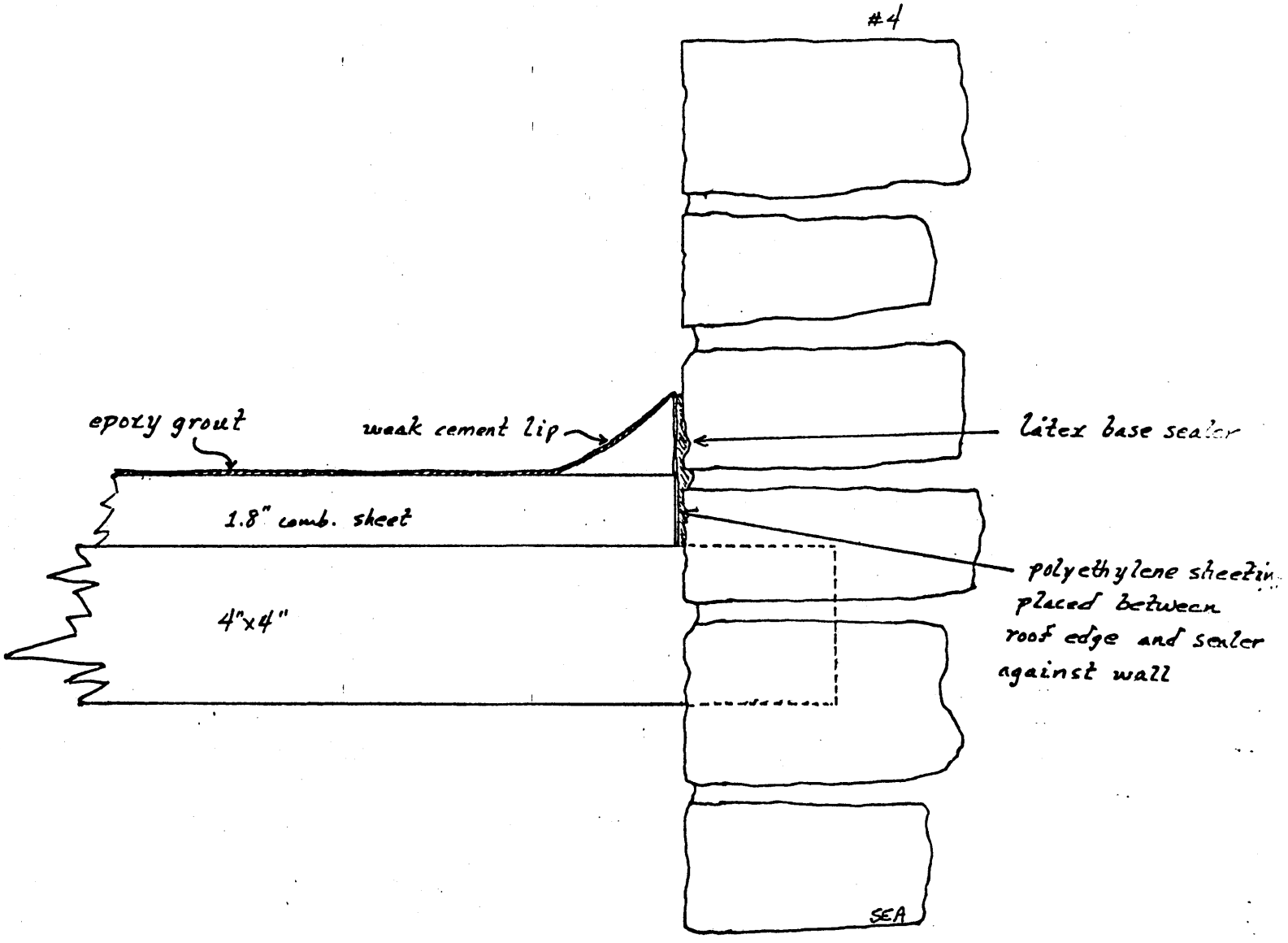
Plan: AZRU Protective Roof Design #1




Plan: AZKU Protective Roof Design
#2
1.8"
urethane
combinat
sheet
fire rate
"A"
epoxy
grout glu
see
drawing
#4
SEA


4" biluminized fiber vent
see drawing #4
1.8" urethane comb. sheet
4"x4"
minimum 6" airspace
1/4" epoxy grout
4.5 aggregate (sand & dirt) / 1 (7 resin / 3 catalyst)
un modified epoxy resin = Shelly 15 or equal
Polyamide catalyst = General Mills Polyvide 140
SEA

ELEVATION


#4
epoxy grout
weak cement lip
latex base sealer
1.8" comb. sheet
4"x4"
polyethylene sheeting placed between roof edge and sealer against wall
SEA

Bibliography

Bibliography

Use this section as a reference guide for the history of stabilization at AZRU and as reference for other subjects in this manual.

When you find a new reference source, list it under "new entries" with the date of entry and your name. Include any references which you think will be helpful in the preservation of the ruins.

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n.a.

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COMPLETED MAJOR RUINS STABILIZATION

Reports of major stabilization work carried on at Aztec Ruins National Monument are on file in the monument library.

The stabilization reports for the West Ruin are:

1938 - 1946:	Steen, Charlie R., et. al.
1939 - 1941:	Vivian, R. Gordon
1950:	Vivian, R. Gordon, and Raymond Rixey
1951:	Rechert, Roland
1959, 1959 - 1960 and 1961:	Shiner, Joel
1965:	Voll, Charles B., and Martin T. Mayer
1967:	Mayer, Martin T.

The stabilization reports for the East Ruin are:

1949:	Vivian, R. Gordon
1953 and 1956:	Richert, Roland
1957:	Vivian, R. Gordon, and Roland Richert
1960:	Shiner, Joel L.
1965:	Voll, Charles B., and Martin T. Mayer
1967:	Mayer, Martin T.

The stabilization reports for the Hubbard Mound are:

1954:	Vivian, R. Gordon, and Tom Mathews
1960:	Shiner, Joel
1965:	Voll, Charles B., and Martin T. Mayer
1978:	Schart, William L.

Rehabilitation Projects, West Ruin

1973 Sudderth, W.E. and Peter Laudeman

1974 Chambers, G. and M. Trussell

1975 Chambers, G. and Stephen E. Adams

1977 Adams, Stephen E.

1978 Schart, William L.