

VANISHING TREASURES PROGRAM
&
HISTORIC PRESERVATION PROJECTS
INTERMOUNTAIN OFFICE-SANTA FE

ARCHITECTURAL CONSERVATION REPORT

MASONRY STABILIZATION
AT TYUONYI PUEBLO (LA 00082)
2007



Bandelier National Monument

Architectural Conservation Report

Masonry Stabilization at Tyuonyi Pueblo, 2007

**Bandelier National Monument
New Mexico**

**Vanishing Treasures Program
Bandelier National Monument
Los Alamos , New Mexico**

And

**Historic Preservation Projects
Intermountain Regional Office-Santa Fe**

National Park Service

**U. S. Department of the Interior
Washington, DC**

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The following report is a summary of the stabilization activities at Tyuonyi Pueblo conducted by the Vanishing Treasures Program and the Historic Projects Program (HPP)-Intermountain Regional Office-Santa Fe during the field season of 2007 at Bandelier National Monument. Masonry stabilization in Tyuonyi Pueblo in 2007 is a continuation of documentation and condition assessment conducted in 2001, and stabilization efforts commenced in 2002. For information on methodologies, research and findings of the documentation, assessment and stabilization of Tyuonyi, refer to “Bandelier National Monument Architectural Conservation Reports:” *Tyuonyi Pueblo Documentation, Condition Assessment and Stabilization 2001-2002*, *2003 Stabilization Field Report: Tyuonyi Pueblo Stabilization and Stabilization Mortar Test Walls*, and *Masonry Stabilization at Tyuonyi Pueblo, 2004* on file at Bandelier National Monument.

Section A: Tyuonyi Pueblo Map

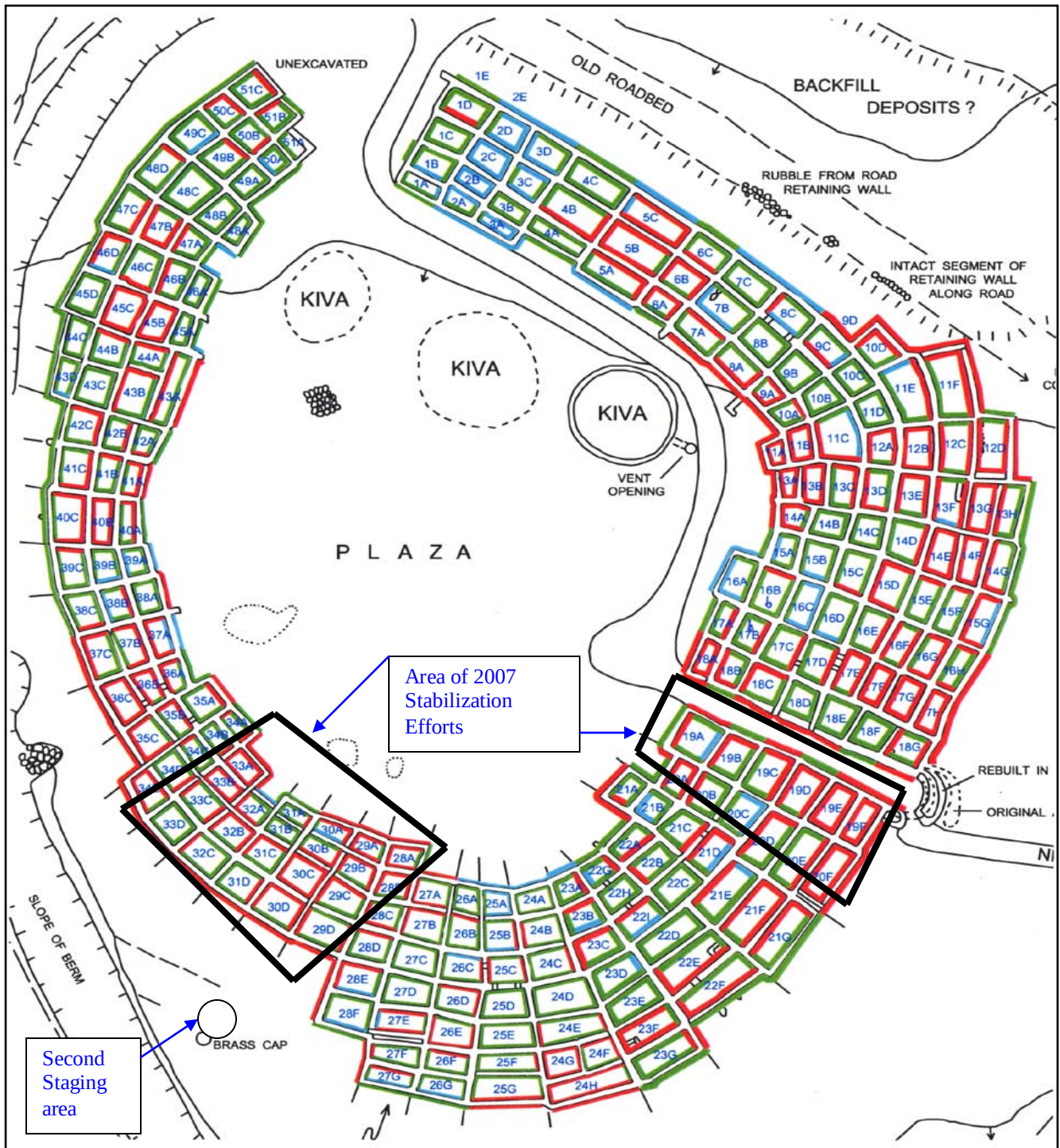


Figure 1: Tyuonyi Pueblo (LA 82) wall numbers and priority

Section B: Project Summary

As in previous years, the primary objective of masonry stabilization at Tyuonyi Pueblo in 2007 is to reinforce the stone walls by replacing deteriorated and/or poorly applied mortar.

Mortar was removed by hand using hammers and chisels and loose mortar was cleaned and washed out to allow for re-pointing with modified earthen mortar. In many cases, mortar was totally deteriorated or detached from stones, necessitating the complete replacement of bedding and pointing mortar. Walls deemed unstable were partially or completely disassembled and reassembled. The stabilization mortar, an acrylic-modified earthen material, was applied and finished to resemble an eroded surface. This was accomplished by recessing the mortar from the stone faces and texturing it with a sponge.

The Historic Preservation Projects (HPP) crew was a major change from previous year's efforts when masonry workers were hired and trained by Bandelier Staff. Already experienced masons, the HPP crew quickly adapted to the acrylic-modified mortar mix and the documentation procedures in place.

Masonry stabilization was conducted in Tyuonyi Pueblo from July 25 until September 25, during which time 97 wall faces, representing approximately 119 square meters of stone masonry, were treated. In total, 75 high priority, 20 medium priority, and 2 low priority wall faces were treated and stabilized.

Stabilization work at Tyuonyi was documented using written, graphic, and photographic techniques. Before any stabilization was performed on a wall face, the worker made sure that a condition assessment form had been completed. Digital images of the wall faces taken in 2001, as part of the documentation and condition assessment, were printed and placed in transparent acetate sleeves and stabilization work was graphically recorded on the acetate overlays using colored permanent markers.

In addition, photographs taken during the 1947-48 excavation and stabilization were used to determine whether wall configurations had changed over the past 56 years; where appropriate, wall configurations were returned to the 1947-48 appearance.

Project Agreement*For the production of a***Masonry Stabilization at Tyuonyi Pueblo***In***Bandelier National Monument****FY2007**

By the

Division of Facility Management

Historic Preservation Projects

Intermountain Regional Office - Santa Fe

National Park Service

June 21, 2007

Scope of the Project

The scope of this project is to stabilize the masonry walls Tyuonyi Pueblo as prioritized by BAND in the 2004 Tyuonyi LA 82 diagram (attached). The primary objective of this project is to continue the stabilization of those walls designated “high priority” in the 2001 conditions assessment report of Tyuonyi Pueblo. Previous work on the walls of the pueblo took place in 2002, 2003 and 2004 with the main objectives being the following:

1. Accurate photographic and written documentation of the existing walls prior to any stabilization work being initiated.
2. Comparison of existing wall configurations with 1947-48 photographs of the same.
3. Removal of inappropriate existing concrete based mortar from those masonry walls identified as high priority, and in most cases, complete rebuilding of the same walls (to their c.1948 configuration if different from their existing form), with an acrylic based mortar.
4. Minor re-grading of the soil at the stabilized wall including firm compaction of the material at the base of the stabilized wall and slight drainage towards the middle of the room space.
5. Photographic, graphic and narrative documentation of the stabilization of each wall using pre-established methodology.

As the scope of work for this project has already been established, the main objective of the 2007 work will be to continue where the 2004 crew left off using their same methodology. Further, materials and mix ratios for the 2007 work will follow the 2004 crews established techniques which are outlined in the *Masonry Stabilization at Tyuonyi Pueblo, 2004* report and the “2005 Long House Report.”

In reviewing the 2004 report for the site, and in discussions with Park personnel who previously worked on the project, it appears that in most cases the walls that were stabilized at that time were taken down to the foundation stones. The primary reason for this is that the 90% of the walls in the pueblo are only one wythe thick and if a wall is listed as high priority then there is a good chance that much of the wall material has either deteriorated to the point where complete rebuilding is necessary, or removal of any concrete mortar from the stones cannot be accomplished without weakening the wall to the point where rebuilding is the only option. As such, in most cases it should be assumed that those walls worked on as part of the 2007 rehabilitation will need to be accurately documented, disassembled and reconstructed. The one exception to this is where the walls are in highly visible areas along the trail where disassembly should be kept to minimum.

Section C: Project Context

Tyuonyi Pueblo (LA 00082) is a stabilized 14th to 16th century masonry pueblo located at the bottom of Frijoles Canyon in Bandelier National Monument. The walls of Tyuonyi have been subjected to many preservation treatment attempts in the past with varying degrees of success. Following is an abbreviated history of treatment strategies compiled by Mary Slater, Architectural Conservator, Bandelier National Monument:

At Bandelier National Monument, early stabilization efforts utilized soil amended with charcoal and ashes as a binder. This stabilization mortar eroded relatively quickly, and the park decided to use Portland cement as a soil amendment in stabilization. This practice continued until the 1980's, when calcium aluminate (a refractory cement) was substituted for Portland cement. Calcium aluminate carries fewer soluble salts than Portland cement and its color minimizes the need for added colorants. However, calcium aluminate mortars have many of the same drawbacks as Portland cement mortars, including short working time of the mortar paste and brittleness of the cured material. Mortar hardness presents a problem at stabilized sites at Bandelier, mainly due to ground subsidence and wall movement, and calcium aluminate mortars appear to be at least as hard if not harder than Portland cement mortars. Additionally, inappropriate application of these materials, particularly smearing of mortar over stone faces, has led to deterioration of original stones.

Soil cement was the material of choice in Tyuonyi for 50 years. Differing colors, textures, and application techniques marked different stabilization campaigns. The earliest soil cements seemed to be grey with a thin wash of soil, while later campaigns appeared to be shades of brown (indicating the use of pigments) or even pink (signifying calcium aluminate as the cement). Earthen mortar was also observed, if sporadically; it could not be visually determined whether the earthen mortars had been amended. While some of the earthen mortars were in relatively good condition, most soil mortars were completely disintegrated to a powdery texture.

An important characteristic of mortar typology is mortar profile. Mortar that is applied over the face of surrounding stones (described as an "obscuring" profile) is often associated with localized detachment of stone material, while recessed and flush mortar joints have no negative effect on the stones. An obscuring mortar profile was indicative of earlier stabilization campaigns, while more recent work tended to be flush or recessed from the stones.

TYUONYI TIMELINE: PREVIOUS STABILIZATION EFFORTS

1880's: Adolph Bandelier working through Archaeological Institute of America, measured caves and ruins, collected artifacts, took notes (no excavation).

1896-1903: Edgar Hewett conducts preliminary reconnaissance of Pajarito Plateau sites, sporadic work.

1908-09: Hewett's excavation of Tyuonyi.

1933-34: Paul Reiter working with Civil Works Administration Program in Tyuonyi and elsewhere in Frijoles Canyon and Tsankawi: cleaning, mapping and excavation of 2 rooms in Tyuonyi, painted plaster panel restoration in Group D. Stones at Tyuonyi were replaced without mortar because of cold weather. Makes recommendations for stabilization of Tyuonyi walls (disassemble and reconstruct each wall, lay in cement, point w/ mud, plaster w/ mud).

1937-38: Jerome Hendron's stabilization using CCC labor: re-pointing w/ mud mortar, plastering. (Mortar: valley soil mixed with loess from 15 miles away, ashes and charcoal added as binder. Plaster: not specified.)

1940': Removal of "Hewett's Dump" (backfill from excavation), test trench of pile. Stabilization by Eden: mortar 2/3 adobe, 1/3 sand. Early letters suggest that doorways should be plugged and walls plastered.

1942: Clay and water mixture "painted" onto stones, water brushed into joints to seal cracks.

1947-48: Thomas Onstott's stabilization: original foundations and floors identified by trenching. Re-pointing with 5:1 soil:cement (although foreman Cordero mentions using 7:1 ratio), mud mortar sometimes used.

1950: John Turney's stabilization: repointing w/ soil cement. Notes previous stabilization mortar (Onstott's) "flaking off."

1961: Repointing w/ soil cement (7:1?). Use of tints in mortar?

1975: Repointing w/ 14:1 soil:cement. (Experimented w/ 13:1 soil:Ready-Mix at Big Kiva.)

1977: Soil-cement study by WACC. Makes recommendations for use of soils in cement mixtures as mortars (based on physical and chemical properties of soil samples from Bandelier).

1978: Larry Nordby's Proposed Ruins Maintenance Program: makes recommendations for vegetation control, grading, etc.

1980: Repointing w/ soil cement (Sweetland).

1982: Repointing w/ soil cement, Sweetland mentions soil cement ratio recommended by WACC study.

1988: Scope of Work by Santa Fe Office: Identifies deterioration conditions, recommends stabilization and documentation methodologies. Refers to test walls at Sterile House where different soil amendments (Rhoplex, calcium aluminate cement, lime) are tested in mortars. Stabilization by Joe Griego assisted by YCC Crew: 4:1 and 5:1 soil:"Lumnite." The work of the YCC crew is generally of poor quality.

1994: Stabilization of 140 walls by Santa Fe Office: 5:1:1 sand:local dirt:calcium aluminate cement ("Lumnite").

In the summer of 2001, documentation and assessment activities were carried out at Tyuonyi in order to provide a planning tool to determine treatment priorities for stabilization efforts. The completed assessment forms (*Condition Assessment Forms, Tyuonyi Pueblo, LA 00082*), in three ring binders, are on file in Vanishing Treasures office. In preparation for stabilization efforts, Mary Slater began testing mortar formulations. The goal was to find a sturdy, yet compatible, material to treat the deteriorating stone walls at Tyuonyi. A soil based mortar was deemed appropriate because it harmonized with the original masonry technology and previous successful, yet less durable, stabilization efforts. Thus, the mortar would need to be visually compatible and physically durable. In addition, the soil would have to be obtained outside the Park in accordance with NPS policy and from a source that could be relied on for consistency and availability. Slater describes the process of determining an appropriate mortar in the *2001-2002 Architectural Conservation Report*:

Five soil samples were collected from various commercial suppliers in the nearby Espanola Valley. The bulk samples were examined and photographed, then sieved with a 2mm mesh. Part of the samples were mixed with water to form test coupons, and part of the samples were shaken in glass jars with water to perform rudimentary sedimentation tests. The sedimentation provided rough estimates of particle size distribution between sand, silt, and clay fractions of the samples. The desired soil characteristics included sufficient clay fraction for strength and binding properties. Three soil samples were eliminated from consideration due to excessive clay reactivity (shrinking of the coupon and progressive absorption of water in the sedimentation) or the presence of undesirable organic material. The two remaining samples, "Garcia Dirt" and "Garcia Clay," came from the same supplier and had relatively non-reactive clay fractions (interestingly, "Garcia Clay" is a sandy red soil with a smaller apparent clay fraction than the tan "Garcia Dirt"). These two samples were mixed in varying ratios to produce coupons and sedimentation tests until a mixture of suitable working qualities and color was produced. The soil mixture was then combined with washed masonry sand to increase the strength of the material and to ensure its compatibility with an acrylic modifier for added durability. The acrylic modifier, El Rey 200[®], is a concrete and stucco additive similar to an acrylic copolymer used successfully in stabilization mortars in archaeological sites in several National Parks in the Southwest. **The final formulation consisted of a 1:1 ratio of soil mixture (3:1 "Garcia Dirt": "Garcia Clay") to sand, mixed with 25% (v/v) El Rey 200[®] in water.**

Slater constructed test walls in September of 2003 using four different mortar formulations (see attached schematic and refer to *2003 and 2004 Tyuonyi Stabilization Report*, Appendix A).

Based on the test coupons, the proper weathering of the stabilization test walls, lessons of the field work from 2001-2006, and the Project Agreement between Bandelier National Monument and the Intermountain Regional Office-Santa Fe, Historic Preservation Projects, stabilization work in 2007 continued to use the same materials and basic methodology developed over the past six years.

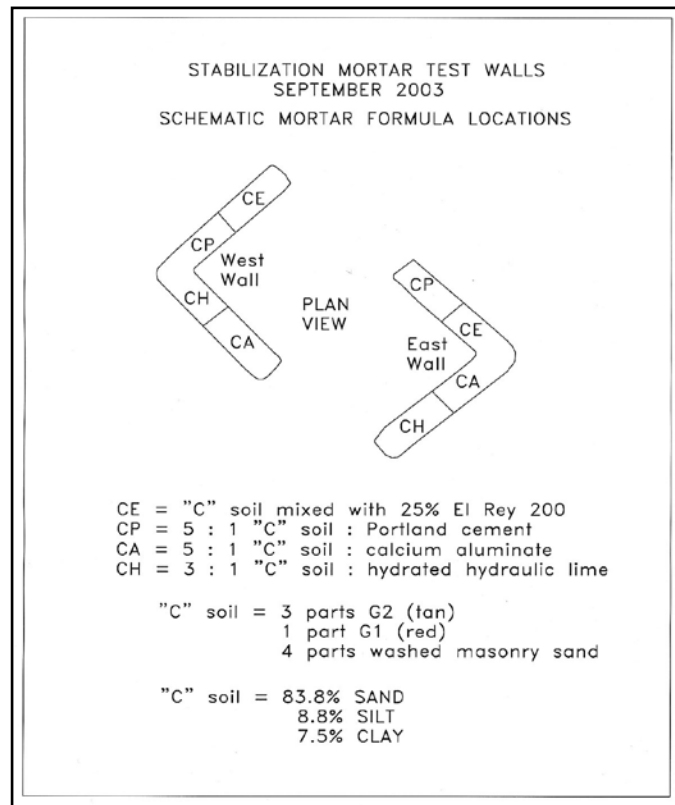


Figure 2: Wall Stabilization Schematic

Section D: Tyuonyi Stabilization Field Report, 2007 Season

1. Goals for 2007 Season

Since 2001, and as noted in the Project Agreement, the primary objective of the project is to reinforce, or stabilize, the stone walls by replacing deteriorated and/or poorly applied mortar. In addition, stabilization efforts were to focus on the walls rated as “high priority” (a list of the walls is in the *2001 Conditions Assessment*). The basic mortar ingredients and stabilization methods in 2007 were developed by Mary Slater and summarized:

The primary objective of the stabilization of Tyuonyi Pueblo is to reinforce the masonry walls by replacing deteriorated and/or poorly applied mortar. Most of the mortar in Tyuonyi is soil cement dating from past stabilization campaigns (See Appendix H, Timeline of Previous Stabilization). Mortar was removed by hand using a hammer and chisels. Stable mortar was raked back to allow for repointing with the modified earthen mortar. Where mortar was totally deteriorated or detached from the stone, the stone was taken off the wall, the mortar removed, and the stone reset in the earthen mortar. Frequently, walls were so unstable that they were partially or completely dismantled and reassembled. In all cases, mortar joints and/or stones were brushed clean of dirt and wetted to facilitate adhesion of the mortar and prevent premature drying of the masonry. Small stones were often used to fill voids and provide support for narrow stone courses and irregularly-shaped stones.

New mortar was finished to resemble an eroded surface by recessing it between $\frac{1}{8}$ ” and $\frac{1}{4}$ ” from the stone faces and texturing it with a sponge. Texturing was accomplished by pressing a wet sponge into the mortar perpendicular to the joint, drawing small clay and silt particles into the sponge and exposing the mortar aggregate (sand). In addition to creating the desired visual appearance, texturing also compacts the mortar and obscures tool marks.

This season was unusual in that a Historic Preservation Projects (HPP) crew (see Section F: Personnel) was scheduled to do the majority of the stabilization work at Tyuonyi, whereas, in the past, Bandelier National Monument hired and trained the

seasonal masonry crew. In addition, the HPP crew was scheduled for two months of work rather than four months as in previous years. The HPP crew were experienced masons and knew basic building techniques but had little experience with ruins stabilization; thus, Bandelier hired Marty Davenport (see Personnel Appendix) as a liaison to coordinate the work of the HPP crew and inform them of the previous season's materials, techniques, and documentation procedures. Also, anticipated interaction with the public offered an opportunity to let visitors know that the ruins were being stabilized in a careful and sensitive manner.

2. Production

The HPP crew, which consisted of a lead mason and two masonry workers, arrived on site July 24 (an additional mason helper was added on August 6) and scheduled to work five ten hour days per week for four weeks, and then take a week break from August 18-26. Work would resume for another four weeks, ending on September 21 (an additional week was added and actual work ended on September 26). Factoring in travel days on each end of the break and the extension of the project for an additional week, the HPP crew was expected to be in the field for approximately 30 to 40 days. With the addition of Bandelier's Davenport, the five workers eventually spent 37 days (168 worker days) on site stabilizing the ruins. During this time period, 97 wall faces representing approximately 119 square meters of stone masonry were treated, either through partial or complete re-building, or by cleaning out the old mortar and re-pointing.

- In the scope of this project, "re-building" means removal of all previous mortars by taking stones off the wall course by course, stone by stone, cleaning them, and relaying them (in original order) in amended mortar.
- In the scope of this project, "re-pointing" means the removal of all previous mortars (including cements and deteriorated mud mortar), packing amended mortar into the voids, and finishing the joint to resemble an eroded surface.

Seventy-five wall faces were assessed as "high priority" and 20 were rated as "medium priority." Thirty-two wall faces were completely re-built from the ground level. However, this figure is misleading for many walls were re-built from the lowest

stable course which might not include the lowest or foundation course. Scheduled treatment work progressed in two stages: In August the crew focused on Tiers 28-33 and in September work moved to Tiers 19 and 20, along the visitor trail. In addition to stabilizing the walls, the crew completed a graphic documentation form, re-graded the compartments to maintain drainage away from the walls, and interacted with the public in an informative and positive manner.

Documentation:

Past treatment work, dating back to the 1930s, was poorly documented and left many gaps in our understanding of what materials were used on which walls and complicated an accurate treatment assessment of the walls. Current stabilization efforts, dating from 2001, emphasize concise, precise, and accurate documentation so future crews may understand the treatment process: “who, where, with what kind of materials, and when it occurred.” A printed copy of the 2001 digital photo was inserted in an acetate sleeve and permanent colored markers were used to document the treatment of the wall (see *Appendix D, Graphic Documentation Instructions, 2004 Tyuonyi Stabilization Report* and example below). These visual records are stored in the Vanishing Treasures office in a three ring binder labeled “Tyuonyi Stabilization, 2007, Completed Graphic Documentation Forms.”

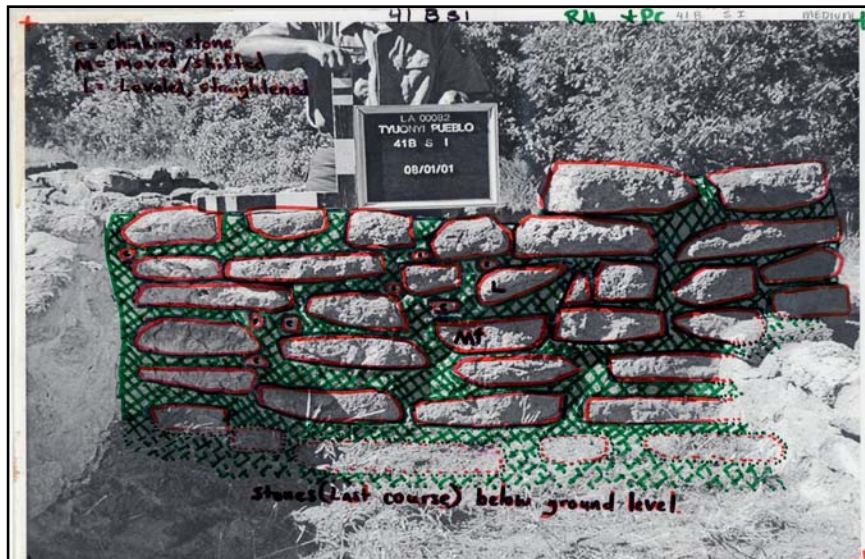


Figure 3: Digital images of the walls taken during the 2001 documentation were printed and inserted into acetate sleeves. Workers used colored permanent markers to indicate where mortar (green) had been replaced and stones (red) were moved and/or re-laid. Other notes were included in the graphic documentation to explain important features.

Some walls in Tier 19 were severely smeared with cement to the extent that individual stones were difficult to identify in the 2001 digital image. Consequently, we learned to clean out as much mortar as possible before disassembling the wall. Then take a current digital photo, and use this image to document the treatment and to help replace the stones in an historical pattern. The 2001 image is stored in the other side of the acetate sleeve for that wall.

Post-care:

The post-care stage began by documenting the treated walls surrounding a compartment (see Fig. 3). Then, the crew cleaned out all rubble and debris (such as spilled mortar and trash), compacted the earth at the base of the wall, re-graded the floor to maintain a positive drainage away from the walls, and swept the floor to remove footprints (which may tempt a visitor to enter the room). Any artifacts found during treatment were documented and replaced. Finally, an inspection by the lead mason (Walt Morris) or the Bandelier liaison (Marty Davenport) finalized the completion.

Interaction with Visitors:

Although not specified in the Project Agreement, interaction with the public proved beneficial and one of the most gratifying aspects of the project for crew members. Visitors were curious about the scope of the work, how their tax dollars were being spent, and general questions about the pueblo and Bandelier National Monument. A greeting sign at the entrance to the pueblo helped visitors generally understand the stabilization project and prompted more questions.

WHAT'S HAPPENING HERE?

Specially trained masons have been stabilizing and repairing the fragile walls of Tyuonyi Pueblo since the 1930s. The “before” picture, below left, shows the cement mortar that was used to stabilize the walls through the 1990s. We now know that the hard cement mortar damages the soft volcanic stone. Beginning in 2001, masons began removing the old mortar and replacing it with a more compatible earthen mixture. The “after” picture, below right, shows the same wall after treatment. The project will continue until all of the walls in Tyuonyi Pueblo have been repaired.

Before



After



Figure 4: Content of Visitor Information Sign

The stabilization crew consisted of masons, not interpreters, yet members of the crew attempted to answer questions aided by the following short review:

“Talking Points-Tyuonyi Pueblo”

- Tyuonyi’s circular shape sets it apart from most Northern Rio Grande pueblos of the time (most are rectangular).
- Tyuonyi was occupied approximately 1325-1600.
- An estimated 100 people lived in Tyuonyi at one given time.
- Edgar Lee Hewett of the School of American Archaeology excavated Tyuonyi from 1908-1912. He exposed 240 ground floor rooms.
- Based on the amount of rubble removed from the site, Hewett thought that there were at least two stories of rooms in parts of Tyuonyi.
- NPS has stabilized Tyuonyi approximately 7 times since 1937. The primary mortar material was soil amended with cement for durability.
- At times, stabilization work was carried out by unskilled Youth Conservation Corps workers who did not always use the best working methods.

- In 2001, the Vanishing Treasures Program documented and assessed Tyuonyi, which had not been stabilized since 1994.
- In 2002, stabilization work commenced under VT. While past stabilization efforts utilized soil mortar amended with cement, the 2002 stabilization initiated the use of soil mixed with a colorless acrylic amendment (El Rey). The acrylic-amended mortar has a more harmonious appearance than the soil-cements.
- Wall 19B SW was pointed out as an example of inappropriate use of cement smeared on a wall.
- Current efforts to remove the cement and replace it with the acrylic-amended mortar means future maintenance would be limited to raking the softer joints and re-pointing, rather than the costly job we are doing of chiseling out cement and completely re-building a wall.

Working around visitors presented some problems. The visitor path needed to remain clear of obstacles such as rubble buckets, tools, the shade structures, and other safety hazards. An incident where a visitor tripped on the uneven path led the crew to bring in several buckets of road base from the gravel yard in an attempt to smooth out portions of the path. Visitors were able to see the stabilization efforts first hand and the crew was able to point out less than obvious details of the progress. Hopefully, those efforts will lead visitors to a greater appreciation for the resources of the park and the amount of maintenance required in ruins stabilization.

3. Wall Stabilization: Methodology and Materials

For the most part, basic masonry techniques and methodology followed the suggestions of the 2004 field report in *Appendix F: Masonry Stabilization Techniques & Tips*. The stages of stabilization followed an organizational pattern:

Preparation, Materials, Stabilization, and Post-care.

a. Preparation Stages

- **Staging areas and Moving Materials:** The crew used two staging areas, one near the Frey kiosk where we parked the utility trailer, and the other located a few yards south of the pueblo (see map, Fig. 1). The Frey staging area was accessible by truck but materials (water, dry mix, El Rey) were hauled to the second staging area in a wheelbarrow. There, we mixed the mortar and carried it to the job site in buckets. A 50 gallon barrel stored our “working” water, was replenished by carrying water from the Frey area, and by the occasional rain storm. A shade structure covered this area during work hours and was taken down each evening.
- **Work Site Preparation:** The first stage in treatment concentrated on obtaining a clear view of the wall. This involved vegetation removal, raking out the compartment, and checking for artifacts or obstacles*. Vegetation was pulled or cut, placed in a plastic trash bag, and removed from the site. In some cases, root systems grew under the walls contributing to instability. The roots were cut back as far as possible and documented (e.g. See Graphic Documentation Form for 31C NEI). Soil was pulled back from the wall with a rake, a brush, and by spraying water until exposing the lowest stones.

*Note: Large Harvester ant-beds in 31C and 30A created an obstacle on the jobsite. Ant bites are painful and the possibility of bites distracts from production when workers are constantly on vigil. After consultation with Jerry McCrea at the Integrated Pest Management office in Santa Fe, Amdro Ant Block (CAS # 67485-29-4 and EPA# 73342-2) was applied to the mounds according to instructions on the bottle. Within two days the ants disappeared and work concluded in these compartments without incident.

- **Treatment Decisions:** Using the 2001 digital photos (which were used in past documentation) and, when possible, archival photos from Onstatt's work in the late 1940s, the worker studied the wall prior to beginning treatment. These photos provided the main blueprint for accurately re-building the wall. However, some photos lacked definition, blended in with the background, and/or didn't show the wall's corners. In addition, on several walls in Tier 19 the cement was smeared to the extent that one could not make out the correct order of the stones by looking at the photo. After dismantling one wall (19C NW I) and trying to replace the stones, the crew learned an important lesson. It is better to carefully knock the cement loose with a mash hammer and clean out enough of the joints so that the stones and basic skeleton of the wall is visible. Then, photograph the wall before taking it down or deciding on a treatment plan. See photos below:



19B NW I, smeared with cement (2001 photo)



19 B NW I, after cleaning out joints and exposing the stones

Further inspection of the wall included detecting loose stones, judging the firmness of the lowest course of stones, and talking among the crew about the treatment strategy: how much to re-build and re-point.

- **Shade Structures:** The shade structures were provided by HPP as a necessary part of doing good work. The shade kept the crew protected during the hottest hours of the day and helped make the stones and mortar more workable. Sun heated stones evaporated water too quickly and caused the mortar to dry prematurely causing potential cracking and insufficient adhesion. Although the structures were moved during the day to follow the sun, they were also secured with weights or buckets of rubble in case of heavy winds during the thunderstorm season.



Figure 5: Typical shade structure

b. Materials and Tools

- The materials and mix ratios for the mortar established over the previous seasons were maintained, with the following exception as explained in the *2005 Long House Stabilization Report*:

In prior years, dry mortar ingredients were mixed by hand from piles several years old. By 2005 the “Garcia” tan pile was depleted. About 20 cubic yards of pre-mixed soil (“C” soil) were ordered and delivered, but the color turned out too red and the mix too sandy (some of this red soil mortar was initially used for pointing in rooms 50-63). A season’s supply of 6 cu. yds had already been delivered to the lower staging area, so there was a considerable delay in the work schedule in May, while the mix formula was adjusted, and more tan soil was ordered. The previous formula was: 3 parts tan soil, 1 part red soil, and 4 parts washed masonry sand. **The new formula is: 2 parts tan soil, 1 part “Garcia 2005 pre-mix” (the “too red” component), 1 part washed masonry sand.** Particle size tests were done, to compare the adjusted mix with the original 2002 mix, and they are nearly identical (Appendix A, Soil Test Images, M. Slater, 2005).

Before the scheduled start of the project, it was determined that there was plenty of sand and “Garcia 2005 pre-mix” available at the gravel yard so only Garcia tan soil was needed. Consequently, 4 yards of the tan mix was ordered and Garcia Landscaping delivered the material to the gravel yard on July 26. Using the HPP mortar mixer, the dry formula (1 part sand, 1 part “Garcia 2005 pre-mix,” and 2 parts Garcia tan) was mixed at the gravel yard and a small trailer was used to transport the dry mix to the staging area near the Frey kiosk. The trailer was also used to transport rubble to the gravel yard. Visually judging the amount of materials left at the gravel yard at the end of the project, approximately 2 yards of Garcia tan, 1 yard of sand, and 1 yard of “Garcia 2005 pre-mix,” were used in the 2007 project. Approximately 1 yard of “Garcia pre-mix,” 1 yard of sand, 2+ yards of Garcia tan, and less than 1 yard of Garcia red soil remains at the gravel yard on Highway 4. Approximately 2 yards of cement rubble were removed from the walls in 2007 and stored at the gravel yard.



Figure 6: Loading up the trailer at the gravel yard



Figure 7: Hauling rubble

- From the Frey staging area, the dry mix was carried in a wheelbarrow to a second staging area at the job site and stored in a covered plastic tub. A 25% solution of El Rey 200 acrylic in water (1 part El Rey and 3 parts water by volume) and the dry formula were mixed on site in a wheelbarrow, carried to the walls in a plastic bucket, and used to stabilize the walls. The crew used slightly less than 46 gallons of El Rey which required 138 gallons of water to create a proper mix of amendment. Estimates are approximate but the following ratios may be helpful, based on 4 yards of dry mix used: 11.5 gallons of El Rey per yard and 46 gallons of water/El Rey mix per yard.

- The HPP crew had their own tools including mason trowels, pointing trowels, hammers, chisels, brushes, water sprayers, cleaning rags, etc. The photos, acetate sleeves, marking pens, and clipboards were kept in a closed tub at the secondary staging area when not in use. The tub was brought in each night.
- Two water coolers were kept on the jobsite, one with ice-water and the other with Gator Aide. Insect repellent, sunscreen, and a basic 1st Aide kit were available in a plastic storage tub at the second staging area. Davenport carried a radio and kept it near the work site in case of emergency or communication.
- Materials and Suppliers

Garcia Landscape Materials: Soil
County Road 0046
Los Luceros, NM
505.852.2569

Cook's Espanola Transit Mix: Sand
Highway 285
Espanola, NM
505.753.2176

El Rey Stucco Company, Inc.: El Rey 200 acrylic additive
4100 Broadway S.E.
Albuquerque, NM 87105
505.873-1180

c. Masonry Stabilization Methods

- Causes of destabilization:

Several culprits lead to de-stabilization of the masonry walls in the Tyuonyi ruins, but the inappropriate use of hard cement mortar and the smearing of cement over the wall face have probably caused the most damage. When the mortar is harder than the stone, moisture gets trapped behind the dense mortar, damages the stone, and contributes to an unstable wall. In addition, smearing Portland based cement on a wall (such as in Tier 19) disguises the authentic appearance of a stone wall in a ruins setting and negates the value of the mortar which is the sacrificial element of the wall. Thus, one of the main goals in stabilization efforts at Tyuonyi is to remove the inappropriate concrete based mortar and replace it with amended mortar, either through cleaning out the joints and re-pointing, or by re-building the wall.

- Clean the joints first:

Stabilization methods mostly followed the recommended procedures outlined in the *2004 Tyuonyi Stabilization Report, Appendix F: "Techniques and Tip."* One important lesson from the 2007 project emerged. It is recommended that, especially, on walls smeared with cement, the old mortar be removed and a photo taken BEFORE totally disassembling the wall (as described earlier in this report). It is easier and more accurate to rebuild a wall from a photo, than trying to rebuild a wall based on documentation sheet sketches and rows of carefully placed stones. In addition, by first carefully cleaning out the old mortar, the mason is better able to determine the overall stability of the wall and proceed with a stabilization plan (whether to totally rebuild, partially rebuild, or re-point).

- Treatment options considered:

Every wall did not necessarily need to be completely re-built. Re-laying the stones does not necessarily make the wall more stable. Walls remain standing in a ruins (versus a building where the walls must support more than their own

mass) because stones rest on top of each other in a vertical plane and gravity helps keep them in place. The mortar bonds the masonry units into a monolithic mass, in effect, helping to keep the stones from sloughing off. The cement mortars stabilized the walls in this fashion but caused serious damage during freeze/thaw cycles and wall movement when the softer stone was affected more than the hard cement. Mortar also prevents water penetration into the wall, yet it must be porous enough to allow the wall to breathe and drain. Rather than preventing moisture, the Portland cement based mortars of the past trapped moisture and caused basal erosion to the extent that the base of many stones deteriorated into a rounded “canoe-like” bottom. The crew joked that re-building a wall was like “stacking footballs.” As a result, after thoroughly cleaning out the joints, if the wall appeared stable (i.e. the stones were stacked and resting securely in a vertical axis) re-pointing, or partial stabilization, was pursued as a treatment objective.

- Re-pointing:

Cleaning out the old inappropriate mortar, including the powdery deteriorated mortars from the 1930s efforts, helped workers visualize that the wall was built with stones. Even partial cleaning of joints allowed a better look at the wall and afforded the next step in treatment. Except for the smeared mortars in Tiers 19 & 20, very little of the alumnite and Portland based mortars adhered to the stone. Rather, it was the way the mortar was tucked into the joints and then dried that created problems. Some of the mortar on the surface could be simply pulled off or “worried out” of the joint. But, recessed mortar had to be gently chiseled out in sections. Once the hard mortar was out, water sprayers could be used to wash out the powdery infill, clean the stone, and re-point the void. The joints were fully packed with amended mortar using pointing tools.

- Re-building:

Generally, walls were rebuilt from the lowest course of stable stones. These stones may, or may not, be part of the “ancient foundation” which is often a

rubble filled trench. The 2004 stabilization efforts emphasized complete rebuilding of the wall from the foundation, as described in the *2004 Tyuonyi Stabilization Report*. However, in many instances, the most stable course might be two or three levels above what might be construed as an “ancient foundation.” If the wall was resting on stable stones at or near grade, and they provided a large enough footprint to disperse the weight from above, the wall was completely rebuilt from that point. Of the 97 treated wall faces, 38 were 100% completely rebuilt from the ground (foundation) up and 23 were 75% (or more) rebuilt from the lowest stable course. The remaining 36 faces were partially re-built and/or re-pointed. One challenge in re-building a wall is to replace the stones in the correct sequence and place based on the photos (current and archival) and an orderly laying out of the stones as the wall is disassembled. Laying a “dry course” helped the mason re-build a wall by courses rather than a single stone at a time. Before setting, the stones must be thoroughly cleaned and moistened with water to ensure that the water in the mortar is not drawn into the surrounding masonry, leading to cracking or poor adhesion. Because the stones are artifacts, none were shaped to make building easier. Chinking stones, or shims, helped fill voids and stabilize the stones.

- Repairing cracked stones:

Cracked stones may present stabilization problems, however they are part of the historic fabric and should be kept in place if not compromising the overall stability of the wall. A combination of concentrated El Rey 200, crushed tuff, and the amended mortar mix in a watery mixture was used in attempts to cement, or glue, broken stones. Instead of buttering the faces with mortar as in past attempts, the stones were pressed together along the fracture zone and the slurry was dripped into the void and allowed to dry. Wall 30CNE contains two broken stones repaired in this manner and should be periodically checked (see Graphic Documentation Forms for location of the stones).

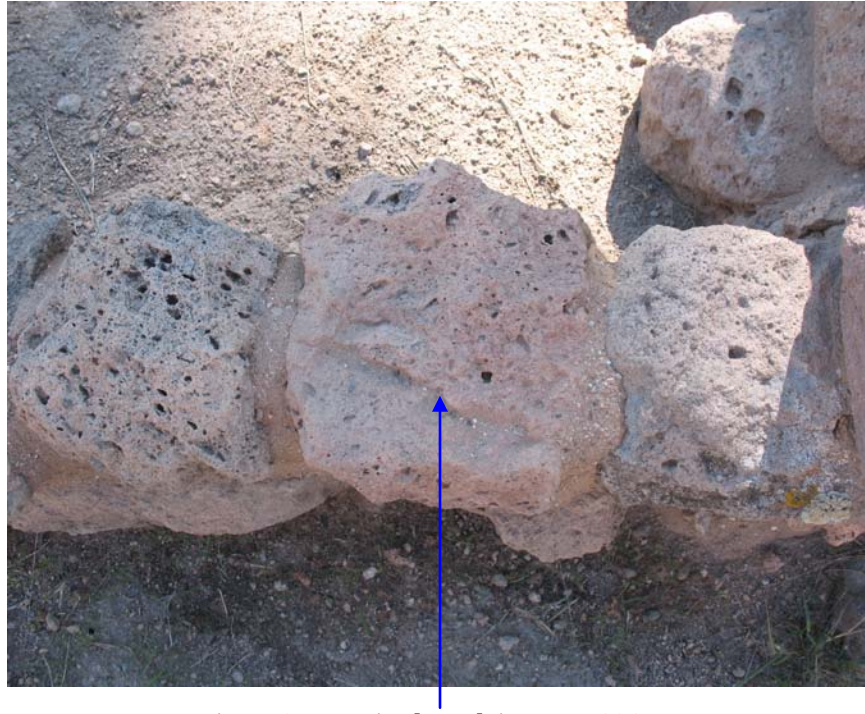


Figure 8: Repaired crack in stone, 30CNE

d. Post-Care

- **Finish:** After sufficient drying time (generally overnight) the joints were sponged to remove tool marks and to reveal the mortar aggregate. This gave the joint a weathered appearance; an appropriate look for a ruins. One potential mistake is to make the walls in a ruins look too “constructed.” A plumb and level wall with evenly spaced courses is appropriate technique for modern buildings. However, it should be kept in mind that visitors should be able to recognize Tyuonyi Pueblo as a 600+ year old ruins and evidence of a past civilization, rather than partial stone walls brought up to a modern masonry code. It is a challenge to keep deteriorating forces at bay, while maintaining a deteriorated appearance.
- After a days work, the newly placed stones were covered with plastic. In the rainy season this protected the recently placed mortar from washing out during a thunderstorm. The plastic also helped the mortar retain moisture, encouraged steady drying, and lessened the potential for mortar cracks or poor adherence.

- Restoring the compartment floor: After completing a wall, mortar residue is cleaned up, found artifacts (mainly pottery sherds) are replaced, the wall is backfilled and tamped down, and the floor is re-graded to encourage water to drain away from the wall. Sweeping the compartment floor with a broom finishes the job and discourages visitors from entering the compartment because they saw footprints and thought it was o.k. to enter.
- Restoring the trails: The final phase included raking and restoring the work paths leading to the job site. Branches, stones, dirt, and dry grass were pulled onto the trail to discourage visitors from following the paths.

4. San Clara Youth Corps:

On July 31, eighteen members of the Santa Clara Pueblo Youth Corps led by Ben Chavarria, visited Bandelier and participated in a masonry training session. This was preliminary to the start of their stabilization efforts at Puyé Pueblo which is the ancestral home of the Santa Clara Pueblo people. AM and PM groups of nine teamed up with the masonry crew and learned the basics of mixing mortar, cleaning out joints, re-pointing, and laying stones. Subsequently, Vanishing Treasures loaned some masonry tools for the stabilization efforts at Puyé. On August 16, we were invited to visit Puyé and see the work completed by the Youth Corps. We considered this a great honor, a chance to strengthen ties with Santa Clara Pueblo, and an opportunity to see a treasure that has been closed to the public for several years.

Section E: Personnel

- **Marty Davenport** returns to Bandelier for a second year after working on the Talus House project in 2006. He has an MA in Public History from New Mexico State University where he focused on historic adobe construction and traditional lime plasters. Further experience with adobe includes work with Cornerstones Community Partnerships and the Historic Santa Fe Foundation. He was a member of the Adobe Code Task Force which wrote the New Mexico Code for Historic Adobe Buildings (2006).
- **Walt Morris** is a master mason with over thirty years experience, is a member of the Bricklayers Union, and four years with NPS Historic Preservation Projects (HPP). He has extensive experience working with brick, stone, block, tile, adobe, concrete, and stucco. His work with historic preservation projects in the private sector included “Craftsman of the Year” for restoration of the Moss Mansion in Billings, Montana (1986). He trained with HPP at Frederick, Maryland, Antietam Battlefield, and other locations. NPS projects include brickwork at Ft. Jefferson; adobe at Scotty’s Castle; stonework at Chickasaw NRA and Mesa Verde; lime mortar at Harpers Ferry; and limestone at the White House, Washington, DC. He has also completed masonry work for the BLM at the Gold Stamp Mill in Topaz, California and the USFS at Grey Towers historic site.
- **Patrick Kinlicheene** worked for the NPS from 1990-2000 doing historic masonry and wood work. He completed six months of HPP training at Williamsport, Maryland and attended Preservation Workshops at Flagstaff, Arizona in 1992. His time with the NPS included work at Death Valley, Fort Jefferson, Fort Smith, The Presidio, and Chickasaw NRA. He also completed work for the BLM at Dripping Springs, New Mexico. He rejoined HPP in July 2007.
- **Matthew Tsosie** has been with HPP since 2005. He has done masonry work at Lassen Volcano, adobe and stone work at Death Valley and stone road trim at Mesa Verde. In addition, he attended safety training at Zion NP.
- **Daniel Roybal** joined HPP in August 2007 after doing emergency stabilization work at Pecos.

Section F: Partial Inventory

Soils	Amount (Approximate)	Location
Masonry sand	1+ yard	Gravel yard
2005 pre-mix	1 yard	Gravel yard
Garcia tan	2 yards	Gravel yard
Garcia red	1 yard-or less	Gravel yard

Amendment	Amount	Location
5 gal buckets, El Rey 200	2	Paint locker
1 gal jugs, El Rey 200	4	Paint locker

Tools	Amount	Location
5 gal plastic buckets	17	Boneyard
Mortar buckets	3	Tuff shed (ts)
Mason hammers	6	ts
Claw hammers	2	ts
mash hammers	2	ts
½ “ cold chisels	4	Ts
1” cold chisels	4	Ts
hatchet	1	Ts
Dash brush	5	Ts
Whisk broom	5	Ts
Large brick trowels	6	Ts
Small brick trowels	8	Ts
Square trowels	4	Ts
Pointing tools	21	Ts
Knee pads (pr)	8	Ts
sponges	3	Ts
shovels	4	Ts
rakes	2	Ts
Homelite string trimmer	1	ts

Section G: Tyuonyi Pueblo Walls Stabilized - 2007

Wall Face Description	Priority	Wall Face m ²	% of Wall Treated	% of Treated Wall Rebuilt	% of Treated Wall Re-pointed	Worker *see key at end
19ANEE	H	3.85	100	30	70	PK
19ANEI	M	1.99	100	25	75	PK
19ANWE	M	1.10	100	25	75	PK
19ANWI	H	1.99	100	25	75	PK
19ASEI	L	2.95	100	25	75	MT/DR
19ASWE	H	0.45	100	100	-	PK
19ASWI	M	1.86	100	25	75	PK
19BNEE	M	2.18	100	60	30	MT/DR
19BNEI	H	1.97	100	75	25	MT/DR
19BNWI	H	2.71	100	25	75	MT/DR
19BSEI	M	3.05	100	80	20	MD
19CSEI	H	2.41	100	100	-	WM
19CSWI	M	1.49	100	25	75	MD
19DNEE	M	1.63	100	75	25	MT/DR
19DNEI	H	1.11	100	80	20	MT/DR
19DNWI	H	2.34	100	100	-	WM
19DSEI	H	1.51	100	100	-	WM
19DSWI	M	1.85	100	25	75	WM
19ENEE	H	0.71	100	30	70	MT/DR WM
19ENEI	H	0.67	100	30	70	MT/DR
19ENWI	H	2.23	100	90	10	WM
19ESEI	H	0.95	100	100	-	MT/DR
19ESWI	H	2.34	100	90	10	WM

Wall Face Description	Priority	Wall Face m²	% of Wall Treated	% of Treated Wall Rebuilt	% of Treated Wall Re-pointed	Worker *see key at end
19FNEE	H	0.41	100	100	-	MT/DR
19FNEI	H	0.61	100	50	50	MT/DR
19FNWI	H	2.17	100	70	30	MT/DR
19FSEE	H	0.62	100	50	50	MT
19FSEI	H	0.60	50	50	-	MT
19FSEI	H	0.60	100	100	-	MT
19FSWI	H	1.37	100	25	75	MT/DR
20ANEI	H	1.37	100	20	80	PK
20ANWE	M	0.80	100	100	-	PK
20ANWI	H	1.28	100	100	-	PK
20CNEI	L	1.30	100	25	75	MD
20DNEI	H	2.16	100	25	75	WM
20FNEI	H	1.51	100	25	75	MT/DR
27ANEE	H	0.80	100	100	-	MD
27ANEI	M	0.88	100	80	20	MD
27ANWI	H	1.07	100	100	-	MD
27DSWI	M	1.84	100	20	80	MT
27ENEI	H	1.35	100	20	80	MT
27FNWE	H	0.53	100	75	25	PK
27FNWI	H	0.09	100	100	-	PK
27GNEI	H	1.12	30	25	75	PK
27GNWE	H	0.61	100	50	50	PK
28ANEE	H	0.72	100	100	-	MD
28ANEI	H	0.35	100	100	-	MD
28ANWI	H	0.37	100	100	-	MD
28ASEI	M	0.26	100	80	20	MD
28ASWI	H	0.64	100	100	-	MD
28BNEI	H	0.65	100	100	-	MD

Wall Face Description	Priority	Wall Face m ²	% of Wall Treated	% of Treated Wall Rebuilt	% of Treated Wall Re-pointed	Worker *see key at end
28BNWI	H	1.28	100	75	25	MT
28BSEI	H	1.08	100	100	-	MD
28CNWI	H	1.34	100	80	20	PK
28CSWI	H	1.57	100	90	10	WM
28DNEI	H	2.59	100	80	20	WM
28DNWI	M	0.32	80	70	30	PK
28DSWI	M	1.69	100	100	-	WM
28ENEI	H	1.83	100	100	-	WM/DR
29ANEE	H	0.48	100	80	20	MD
29ANEI	H	0.49	100	80	20	MD
29ANWI	H	0.52	100	100	-	MD
29ASEI	M	0.47	100	100	-	MD
29ASWI	H	1.10	100	90	10	PK
29BNEI	H	1.28	100	90	10	MT
29BNWI	H	0.73	100	80	20	MT
29BSEI	H	1.31	100	50	50	MT
29CNEI	H	1.46	100	100	-	PK
29CNWI	H	1.82	100	50	50	PK
29CSEI	M	0.70	100	75	25	PK
29DSEI	H	1.20	100	80	20	PK
30ANEE	H	0.49	100	100	-	MD
30ANEI	H	0.53	100	100	-	MD
30ANWI	M	0.47	100	100	-	MD
30ASEI	H	0.48	100	100	-	MD
30BSEI	H	0.53	100	100	-	MT
30BSWI	H	1.26	100	100	-	WM
30CNEI	H	2.04	100	60	40	WM
30CNWI	H	1.20	100	100	-	MT

Wall Face Description	Priority	Wall Face m ²	% of Wall Treated	% of Treated Wall Rebuilt	% of Treated Wall Re-pointed	Worker *see key at end
30CSEI	H	2.42	100	40	60	PK
30CSWI	H	1.21	100	50	50	PK
30DNEI	H	1.66	100	40	60	PK
30DNWI	H	1.03	100	100	-	MT
31ASEI	H	0.56	100	100	-	MD
31BSWI	M	0.90	100	100	-	WM
31CNEI	H	1.30	100	100	-	WM
31CNWI	H	1.31	100	40	60	WM
31CSEI	M	1.37	100	100	-	MT
31DSEI	H	1.33	100	100	-	MT
32BNWI	H	1.54	100	40	60	PK
32BSEI	H	1.16	100	40	60	WM
33ASEE	H	0.56	100	100	-	MD
33ASEI	H	0.65	100	100	-	MD
33CSEI	H	1.15	100	0	100	MD

Totals number of wall faces treated in 2007: 97

High Priority: 75 Completely Rebuilt: 32

Medium Priority: 20 Completely Rebuilt: 6

Low Priority: 2

Wall Face Treated: 118.93 m²

*Worker Key: DR (Daniel Roybal), MD (Marty Davenport), MT (Matt Tsosie),
PK (Pat Kinlicheene), WM (Walt Morris)

Section H: References and Further Reading

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