

**SOIL SURVEY OF THREE WATERSHEDS
ON SOUTH MESA, BANDELIER NATIONAL MONUMENT**

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INTRODUCTION

The purpose of this project was to conduct a high-resolution soil inventory of three experimental watersheds on South Mesa, Bandelier National Monument. The 1.1-ha Frijolito watershed has been the subject of runoff and erosion monitoring for several years (Wilcox & Breshears, 1994; Wilcox et al., 1996a; Wilcox et al., 1996b). The larger paired treatment and control watersheds of the more recent Watershed Restoration project provide an opportunity to build on the findings of the Frijolito studies at a larger scale, and to examine the effects of selective tree thinning on understory growth, runoff and erosion.

The first-order soil survey reported in this document was undertaken to provide baseline information on the distribution and character of soils in the two restoration project watersheds, to determine whether the treatment and control watersheds have similar soil properties, and to provide a basis for comparisons between Frijolito watershed and the restoration project watersheds.

STUDY AREA

The watershed restoration project is located on South Mesa, at approximately 35°46' N, 106°16'30''W. The elevation within the two watersheds ranges from about 1900 to 2000 m. The watersheds are situated on a mesa top that has a general slope of 2-3% to the southeast. The watersheds both are elongated and drain from north to south with an overall slope of about 2.5%, although the side slopes of both drainages are often considerably steeper (up to 15-20%, with much higher slopes on incised canyon walls). The main drainages for the two watersheds join to the south and eventually drain into a tributary of Lummis Canyon. Thus the paired watersheds have the same effective base level. They also have the same underlying bedrock (Bandelier tuff), and probably had similar depths of pumice overlying the tuff after the El Cajete eruption (~ 60 ka).

The Frijolito watershed is similar to the larger watersheds in parent material (Bandelier tuff) and elevation. The overall aspect of this watershed is west-southwest, and the slope is 5-10%.

The vegetation of the paired watersheds is predominantly piñon-juniper woodland with some more open grassy patches and isolated small stands of ponderosa pine. Ponderosa pine is present mainly near the two primary drainage channels. The understory is bare to grassy, with blue grama and little bluestem the most common grasses. The understory vegetation cover is typically less than 50%, although some areas are characterized by more complete grass cover. Significant portions of both watersheds consist of exposed tuff bedrock. The Frijolito watershed has similar vegetation, except that there is virtually no ponderosa pine, and the understory vegetation cover is much less.

Both the treatment and control watersheds are characterized by severe gullying in their headward portions, and generally high rates of erosion in most areas, as shown by bare soil, exposed bedrock, soil pedestals, numerous lobes of active sediment transport, and sediment accumulation behind fallen trees. The history of erosion in these watersheds is not clear; erosion has clearly been active within the last 50 years, and the deepest gullies appear to have been present for at least 100-200 years.

METHODS

The soil survey was conducted in two stages. The first consisted of evaluating the range of soil types and determining their properties for field identification. This was accomplished by excavating soil pits in four locations and by using a soil auger to describe a larger number of profiles. The second stage consisted of identifying map units along roughly east-west transects, using GPS to locate positions.

The four pit profiles (DDSP9701-DDSP9704) were described according to methods described in Soil Survey Manual (Staff, 1993). These profiles were sampled in duplicate by horizon. One set of these samples were shipped to the soil analysis laboratory of the Plant and Soil Science Department at Texas Tech University, and a duplicate set were delivered to BNM personnel for archival storage. Particle size distribution was determined by a modified hydrometer method after mechanical dispersal deionized water aided by sodium hexametaphosphate (Bouyoucos, 1951). The sand fraction was retained by wet-sieving and was then separated into size classes (very coarse, coarse, medium, fine and very fine sand) with a vibrating shaker.

Samples were analyzed for pH, organic carbon (O.C.), cation exchange capacity (CEC), and electrical conductivity (E.C.). Soil pH was determined on saturated pastes (Procedure 2, USDA Handbook 60; U.S. Salinity Laboratory Staff, 1954), which were then vacuum extracted to obtain the soil solution for determining E.C (Procedures 2, 3a, and 4b, USDA Handbook 60; U.S. Salinity Laboratory Staff, 1954). For O.C. determinations, samples were digested in chromic acid followed by back-titration with ferrous ammonium sulfate (Nelson and Sommers, 1982). Cation exchange capacity was determined using Procedure 19, USDA Handbook 60 (U.S. Salinity Laboratory Staff, 1954). The locations of all soil pits, auger holes, and other observations were recorded using a Trimble GeoExplorer GPS unit. Each location consisted of at least 120 positions, using real-time differential correction for maximum accuracy. All data were recorded in UTM coordinates for consistency with other BNM spatial data sets. The GPS data were imported into ARC-VIEW, where boundaries for the map units were constructed. Statistics for map unit areas were calculated using ARC-INFO.

WATERSHED COMPARISONS

In comparing the three watersheds in terms of map unit percentages (Table 2), three striking differences are seen. The first is the area of exposed bedrock. When all map units consisting in all or part of rock outcrop (LR, NR, PM, RM, and RS) are added together, both the treatment and control watersheds have an order of magnitude more exposed bedrock (42.9 and 45.8 percent, respectively) than does the Frijolito watershed (4.5 percent). While the Frijolito watershed does have bodies of RM (bare rock), most are only a few m² in size, and were not mappable even at high resolution. The treatment and control watersheds, on the other hand, have numerous broad areas of exposed bedrock.

The second striking difference among the watersheds is the relative proportions of the two similar soils, Hackroy and Nyjack series. The Hackroy soil is not mapped in either the treatment or the control watershed, while it makes up 34% of the area of the Frijolito watershed. The Nyjack series similarly makes up a much greater proportion of the Frijolito (23.4%) than either the treatment (1.9%) or the control (3.9%) watershed.

The third striking difference is that unnamed soil B (Ochreptic Haplustalf) makes up 19 to 26 percent of the treatment and control watersheds, respectively, but is not mapped in the Frijolito watershed. This difference may be related to the different proportions of Hackroy and Nyjack soils among the three watersheds. Soil B consists of a young pumice soil overlying a buried argillic horizon derived from tuff. This argillic horizon is probably a remnant of either Hackroy or Nyjack soils that have been truncated and buried by mobile pumice. The high percentage of Hackroy and Nyjack in the Frijolito watershed may reflect more recent erosion of the pumice-derived upper portion of soil B, leaving only the tuff-derived subsoil. This subsoil is mapped as Hackroy and, to a lesser extent, deeper Nyjack soils.

It should be noted that comparisons of the small Frijolito watershed with the larger restoration project watersheds are problematic. The small watershed can be

expected to have a smaller range of soil types (6 map units in this case), just as a small subset of either large watershed would have only a portion of the variability of the total watershed (11 and 12 map units). To the extent that soil properties influence runoff and erosion, the small watershed may behave very differently from larger watersheds. An understanding of this problem is critical in evaluating studies that attempt to extrapolate characteristics or behavior from the small to the larger scale.

The treatment and control watersheds are much more similar to each other than they are to the Frijolito watershed. All map unit proportions vary by considerably less than an order of magnitude between the two. Therefore on the basis of soil properties alone, the two watersheds may be expected to behave similarly with respect to runoff and erosion.

SOIL-LANDSCAPE GENESIS

The present soil landscape on South Mesa (and most of the Pajarito Plateau) is the result of multiple episodes of both soil formation (relative landscape stability) and erosion (relative landscape instability). It is important to remember, however, that soil formation and erosion can be active simultaneously within a relatively small portion of the landscape. It is clear from the distribution of soils in the South Mesa watersheds and on the Pajarito Plateau in general that there was a relatively long period (prior to deposition of the El Cajete pumice about 60,000 b.p.) during which the overall landscape was stable enough to allow significant soil development. This is evident in the form of a widespread soil that includes a strong, reddish-brown argillic (clay-enriched) subsoil derived from tuff or tuff-derived alluvium/colluvium. The soil generally is consistent with the official NRCS description of the both the Hackroy and the Nyjack series (Nyhan et al., 1978; National Cooperative Soil Survey, 1986).

The pre-El Cajete soil is present in the two watersheds as broadly-distributed patches consisting of a) <0.1- to 1-ha contiguous units of the soil in various stages of

erosion (NJ), and b) 0.1- to 4-ha zones of the soil evenly interspersed with outcrops of tuff bedrock (NR). In addition, remnants of the Hackroy soil are found as a buried subsoil in profiles designated as OH, with shallow, poorly-developed pumice soils at the surface. This soil unit ranges in area from 0.1 ha to 5 ha, and is the most extensive soil with over 25 ha present within the treatment and control watersheds.

The second-most extensive map unit is rock outcrop-mesic (RM), with over 24 ha present. Two additional map units include significant portions of rock outcrop (PM and NR). When combined with the RM unit, these make up a total of 58 ha, or 46% of the combined watersheds. This is indicative of an overall high rate of erosion in the watersheds, whether at the current time or in a previous cycle of erosion. Despite the high percentage of exposed bedrock, the weighted mean soil depth is about 60 cm, reflecting the fact that a number of the map units consist of soils that are 1m or more deep, e.g. Cajete series.

Field studies have been proceeding since 1993 to understand the processes of runoff and erosion in the Frijolito watershed (Wilcox, et al., 1996a; Wilcox, et al., 1996b). Sediment traps and flumes are providing useful data to help quantify the relationships between runoff events and erosion. A number of natural sediment accumulations retained in that watershed by fallen ponderosa pines also provide evidence for rates of erosion and sedimentation over a longer time frame. Most of these trees have fallen since the severe drought of the 1950's, so that the maximum time of sedimentation behind them is known with some certainty. The soils upslope of fallen logs are buried by sediment deposits up to 28 cm thick (average = 18 cm). If accumulation began in 1960, this reflects an average accumulation rate of about 5 mm yr^{-1} , a figure remarkably close to the reported 6.7 mm yr^{-1} average loss in surface elevation based on microtopography measurements (Wilcox, et al., 1996b). The upper 1 to 2 cm of these soils consists of loose, medium-to-coarse sand and gravel, showing no signs of soil development. Below this uppermost layer, the sediment shows very weak A horizon development in the form of slight organic matter

enrichment, little or no structure development and, in one case, dense rooting even though little or no surface vegetation is present within the deposition areas. The roots within the sediment, some of which are up to 5mm in diameter, clearly belong to nearby pinyon and juniper trees, the only significant vegetation present within several meters.

Three of the four profiles above check dams include A horizons buried beneath the recent alluvium. The tops of these buried A horizons correspond closely to the bottom of the pine logs, and mark the approximate ground surface at the time the trees fell.

Comparison of these profiles with their downslope counterparts shows that 5 to 10 cm of topsoil has been eroded from soils immediately downslope of the dams. Moving farther downslope, erosion increases until the reddish Bt horizons are exposed at the surface about 5m below the check dams. In one of the soil pairs (4-4a) the entire A horizon has been stripped from both the upslope and downslope profiles.

Soil pit DDWP9703 records an extended landscape history in the form of at least two buried soils. The uppermost buried soil includes an unusually thick preserved A horizon (2Ab). This horizon is remarkable in its dark color and thickness as well as the fact that it is well preserved. A horizons of this nature are typically found in thick prairie/grassland soils, and are not common in this region. The horizon immediately under the 2Ab horizon (2Bxb) is also unusual in exhibiting properties of a fragipan. Fragipans are poorly understood horizons that are very hard when dry, to the point of cementation, but soften upon wetting. The mechanism for the hardening process is not known, although silica gels have been suggested as a possible cementing agent. In the case of this buried soil, it is not clear whether the fragic properties of the 2Bxb horizon were present when the soil was the active surface soil, or whether some post-burial process caused the properties to develop. Burial by pumice could provide significant amounts of silica and possibly alter the properties of underlying horizons. If this were the case, however, it seems likely that the buried A horizon would be altered similarly. Because the A horizon exhibits no significant alteration, it is probably more likely that the characteristics of the

2Bxb horizon were established before burial, when that soil was the active surface soil. If so, the fragic properties can be interpreted as reflecting environmental conditions at that time.

PROFILE DESCRIPTIONS OF MAP UNITS

CAJETE SERIES

(Iowa State University, 1997)

Established Series

IRD: LWH/CDL/RJA

6/86

The Cajete series consists of deep, well drained soils that formed in pumice on low hills, terraces, and mountain side slopes. Slopes are 0 to 30 percent. The mean annual precipitation is about 18 inches, and the mean annual temperature is about 44 degrees F.

TAXONOMIC CLASS: Ashy-skeletal, frigid Mollic Vitrandepts

TYPICAL PEDON: Cajete gravelly loam, forested. (Colors are for dry soil unless otherwise stated.)

A1--0 to 7 inches; very dark grayish brown (10 YR 3/2) gravelly loam, very dark brown (10 YR 2/2) moist; weak fine granular structure; soft, very friable, slightly sticky and slightly plastic; many fine and medium roots; 20 percent pumice pebbles; neutral; clear smooth boundary. (5 to 9 inches thick)

A2--7 to 15 inches; dark grayish brown (10 YR 4/2) gravelly loam, very dark grayish brown (10 YR 3/2) moist; weak medium subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; many fine and medium roots; 20 percent pumice pebbles; neutral; gradual wavy boundary. (5 to 10 inches thick)

Bw--15 to 33 inches; pale brown (10 YR 6/3) very gravelly sandy loam, yellowish brown (10 YR 5/4) moist; weak fine and medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; many fine and medium roots; 40 percent pumice pebbles; neutral; abrupt wavy boundary. (10 to 21 inches thick)

C1--33 to 45 inches; matrix, light gray (10 YR 7/2) very gravelly sand, pale brown (10 YR 6/3) moist; single grain; loose, nonsticky and nonplastic; many fine and medium roots concentrated near lamellae, one half inch to 1 inch thick; strong brown (7.5 YR 5/6) extremely gravelly sandy loam, yellowish brown (10 YR 5/6) moist; 75 percent pumice pebbles; matrix has 50 percent pumice pebbles; neutral; abrupt wavy boundary. (10 to 15 inches thick)

C2--45 to 49 inches; very pale brown (10 YR 7/3) very gravelly sand, light yellowish brown (10 YR 6/4) moist; single grain; loose, nonsticky and nonplastic; 60 percent pumice pebbles; mildly alkaline abrupt wavy boundary. (2 to 8 inches thick)

C3--49 to 60 inches; matrix; light gray (10 YR 7/2) very gravelly sand, pale brown (10 YR 6/3) and light yellowish brown (10 YR 6/4) moist; single grain; loose, nonsticky and nonplastic; lamellae one fourth to one half inch thick with colors similar to those described in the C1; 50 percent fine pumice pebbles; mildly alkaline.

TYPE LOCATION: Sandoval County, New Mexico; Baca Location No. 1; 100 yards south of dirt tank 10 feet north of ridge crest. State Plane Coordinates N. 1,758,500 feet and E. 404,500 feet.

RANGE IN CHARACTERISTICS:

Soil Moisture: The soil moisture control section is moist in some part throughout the frost-free period.

Soil temperature 43 to 47 degrees F.

Depth to the base of the Bw horizon 20 to 40 inches.

A horizon Value: 3 through 5 dry, 2 or 3 moist. Chroma: 1 through 3. Texture: Extremely gravelly coarse sandy loam or gravelly loam. Rock fragments: 15 to 80 percent pumice pebbles, by volume.

B horizon Hue: 7.5 YR or 10 YR. Value: 6 through 8 dry, 5 through 6 moist. Chroma: 2 through 4. Rock fragments: 35 to 60 percent pumice pebbles, by volume.

C horizon Hue: 7.5 YR or 10 YR. Value 6 through 8 dry, 5 through 6 moist. Chroma: 2 through 4. Texture: Very gravelly sand or very gravelly sandy loam. Rock Fragments: 35 to 60 percent pumice pebbles, by volume. Reaction: Neutral to mildly alkaline.

COMPETING SERIES: This is the Stines series. A similar soil in another family is the Totavi series. The Stines soils have secondary carbonates in the lower part of the soil. The Totavi soils are nonskeletal.

GEOGRAPHIC SETTING: The Cajete soils are on ridge crests of low hills, terraces, and in pockets on mountain side slopes. They formed in pumice. Slopes are 0 to 30 percent. Elevation is 7,000 to 8,500 feet. The mean annual precipitation is 16 to 20 inches. The mean annual temperature is about 42 to 45 degrees F., and the frost-free period is about 60 to 100 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Totavi soils.

DRAINAGE AND PERMEABILITY: Well drained; slow runoff; rapid permeability.

USE AND VEGETATION: These soils are used for timber production, livestock grazing, and wildlife habitat. Natural vegetation is ponderosa pine, white fir, mountain brome, Arizona fescue, and little bluestem.

SERIES PROPOSED: Sandoval County, New Mexico, 1981.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Mollic epipedon; the zone from the surface to a depth of about 15 inches. (A1, A2 horizons)

Cambic horizon; the zone from about 15 to 33 inches. (Bw horizon)

ADDITIONAL DATA: NSSL Pedon S81NM432 confirms the classification of the series.

HACKROY SERIES

(Iowa State University, 1997)

Established Series

RD: LH/RJA

7/86

The Hackroy series consists of very shallow or shallow, well drained slowly permeable soils formed in material weathered from tuff or basalt on mesas. Slopes are 1 to 8 percent. The mean annual precipitation is about 14 inches, and the mean annual temperature is about 49 degrees F.

TAXONOMIC CLASS: Clayey, mixed, mesic Lithic Haplustalfs

TYPICAL PEDON: Hackroy sandy loam--woodland. (Colors are for dry soil unless otherwise stated.)

A--0 to 3 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 4/3) moist; weak fine subangular blocky structure; hard, friable, nonsticky and nonplastic; many fine roots; common fine tubular pores; mildly alkaline; abrupt smooth boundary. (2 to 6 inches thick)

Bt--3 to 13 inches; reddish brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) moist; moderate fine prismatic structure; hard, firm, sticky and plastic; many fine roots; few very fine tubular pores; 3 percent pebbles; continuous clay films on faces of peds; mildly alkaline; abrupt smooth boundary. (6 to 14 inches thick)

2R--13 inches; tuff.

TYPE LOCATION: Los Alamos County, New Mexico; east on Ancho Canyon trail; N. 1,742,900 feet and E. 502,000 feet.

RANGE IN CHARACTERISTICS:

Soil Temperature: 49 to 54 degrees F.

Depth to lithic contact: 8 to 20 inches

Reaction: Neutral to mildly alkaline

A horizon - Hue: 7.5YR or 10YR Value: 4 or 5 dry, 3 or 4 moist Chroma: 2 through 4
Texture: sandy loam or cobbly loam

B horizon - Hue: 7.5YR or 5YR Value: 3 through 5 Texture: clay loam or clay Clay
content: 35 to 50 percent Rock fragments: less than 15 percent

COMPETING SERIES: These are the Dye and Toqui series. Dye soils have 56 to 58 degrees F. soil temperatures. Toqui soils have calcium carbonate accumulations in the argillic horizon or below the argillic horizon.

GEOGRAPHIC SETTING: Hackroy soils are on mesas. Slopes are 1 to 8 percent. The soil formed in material weathered from tuff or basalt. The elevation is about 6,000 to 8,000 feet. The mean annual precipitation is about 13 to 16 inches. The mean annual temperature is about 47 to 52 degrees F., and the frost-free period is 110 to 130 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are Nyjack (T) and Frijoles (T) soils. Both are deeper than 20 inches to bedrock and contain less than 35 percent clay in the control section.

DRAINAGE AND PERMEABILITY: Well drained; medium runoff; slow permeability.

USE AND VEGETATION: These soils are used mostly for grazing by wildlife. Native vegetation is pinyon, oneseed juniper, and blue grama.

DISTRIBUTION AND EXTENT: Northcentral New Mexico. The series is of small extent.

MLRA OFFICE RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Cibola County, New Mexico, 1985.

REMARKS: Sampled for mineralogy and sent to the SCS Laboratory at Riverside during 1974. Sample Number R74-292.

DIAGNOSTIC HORIZONS AND FEATURES RECOGNIZED IN THIS PEDON ARE:

Ochric epipedon: The zone from the surface to a depth of about 3 inches. (A horizon)

Argillic horizon: The zone from about 3 to 13 inches. (Bt horizon)

Lithic contact: The boundary at about 13 inches. (2R horizons)

National Cooperative Soil Survey
U.S.A.

UNNAMED SOIL A: Loamy, mixed, mesic Lithic Ustochrept.

Soil A consists of shallow, well drained, moderately permeable soils formed in alluvial/colluvial and residual material weathered from tuff. These soils are on level to gently sloping mesa tops near watershed divides. Slopes are 1 to 7 percent. The mean annual precipitation is about 14 inches. A typical profile is described as follows:

A -- 0 to 10 cm, dark brown (7.5 YR 3/2 moist) sandy clay loam; weak fine subangular blocky structure; soft; common fine and medium roots; clear wavy boundary.

Bw -- 10 to 15 cm, dark brown (7.5 YR 3/2 moist) sandy clay loam; weak medium subangular blocky structure; common medium roots; abrupt wavy boundary.

R -- 15+ cm, massive tuff.

NYJACK SERIES
(Iowa State University, 1997)

Established Series
RD: LH/JBC/RJA
7/86

The Nyjack series consists of moderately deep, well drained, moderately permeable soils that formed in alluvium and eolian material weathered from tuff. These soils are on mesas. Slopes are 1 to 15 percent. The mean annual precipitation is about 15 inches, and the mean annual temperature is about 49 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, mesic Aridic Haplustalfs

TYPICAL PEDON: Nyjack loam--woodland. (Colors are for dry soil unless otherwise stated.)

A--0 to 3 inches; brown (10 YR 5/3) loam, dark brown (7.5 YR 3/2) moist; weak fine granular structure; soft, very friable, nonsticky and nonplastic; many fine roots; many vesicular pores; slightly acid; abrupt smooth boundary. (2 to 6 inches thick)

Bt1--3 to 13 inches; brown (7.5 YR 5/4) clay loam, brown (7.5 YR 4/4) moist; moderate medium subangular blocky structure; hard, firm, sticky and plastic; many fine and

medium roots; many vesicular pores; few thin clay films on faces of peds; neutral; clear smooth boundary. (8 to 12 inches thick)

Bt2--13 to 24 inches; brown (7.5 YR 4/4) clay loam, dark brown (7.5 YR 3/4) moist; moderate medium blocky structure; hard, firm, sticky and plastic; few fine roots; many fine tubular pores; thin discontinuous clay films on faces of peds; neutral; abrupt smooth boundary. (8 to 14 inches thick)

2C--24 to 39 inches; light brown (7.5 YR 6/4) gravelly sandy loam, brown (7.5 YR 4/4) moist; massive; slightly hard, friable, nonsticky and nonplastic; few fine roots; 25 percent pumice pebbles; neutral; abrupt smooth boundary. (2 to 18 inches thick)

3R--39 inches; tuff bedrock.

TYPE LOCATION: Los Alamos County, New Mexico; one-half mile east of LASL Administration Building, 300 feet west and 1,450 feet north of the center of sec. 21, T. 19 N., R. 6 E.

RANGE IN CHARACTERISTICS:

Soil Moisture: Intermittently moist in some part of the soil moisture control section December through April and July through October. The soil is dry in May and June.

Soil temperature: 49 to 52 degrees F.

Depth to bedrock: 20 to 40 inches.

A horizon - Hue: 7.5 YR or 10 YR. **Value:** 4 or 5 dry, 3 or 4 moist. **Chroma:** 2 through 4. **Reaction:** slightly acid to neutral.

Bt horizon - Hue: 7.5 YR or 5 YR. **Chroma:** 4 through 6. **Reaction:** neutral to mildly alkaline.

C horizon - Hue: 5 YR or 7.5 YR. **Value:** 4 through 6 dry, 4 or 5 moist. **Texture:** gravelly sandy loam or sandy loam. **Rock fragments, by volume:** 5 to 30 percent pumice pebbles. **Reaction:** neutral to mildly alkaline.

COMPETING SERIES: These are the Augustine, Celacy, Dalhart, Deschell, Flugle, Goesling, Hennessy, Maia, Orlie, Pinitos, Ribera and Vibo series. Augustine, Dalhart, Deschell, Flugle, Goesling, Hennessy, Maia, Orlie, Pinitos, and Vibo soils are deeper than 40 inches. Celacy soils have a paralithic contact and are moist in all parts of the SMCS less than 15 percent of the time and lack pumice pebbles. Ribera soils lack pumice pebbles and have Bk horizons.

GEOGRAPHIC SETTING: Nyjack soils are on mesas. Slopes are 1 to 15 percent. The soil formed in alluvium and eolian material weathered from tuff. The elevation is 6,000 to

7,500 feet. The mean annual precipitation is about 13 to 17 inches. The mean annual temperature is 47 to 50 degrees F., and the frost-free period is 110 to 135 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are Hackroy and Frijoles soils. Hackroy soils have lithic contact at 20 inches or less. Frijoles soils are loamy-skeletal over fragmental.

DRAINAGE AND PERMEABILITY: Well drained; slow runoff; moderate permeability.

USE AND VEGETATION: These soils are used mostly for wildlife and production of wood. Present vegetation is pinyon, oneseed juniper, and blue grama.

DISTRIBUTION AND EXTENT: North-central New Mexico. The series is of small extent.

SERIES PROPOSED: Sandoval County Area, Los Alamos County, New Mexico, 1979.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon: The zone from the surface to a depth of about 3 inches. (A horizon)

Argillic horizon: The zone from 3 to about 24 inches. (Bt horizon)

Lithic contact: The boundary at about 39 inches. (2R horizon)

ADDITIONAL DATA: Reference samples were analyzed for mineralogy family at the Riverside Laboratory, Sample No. R74-295.

UNNAMED SOIL B: Ashy-skeletal, mixed, mesic Ochreptic Haplustalf.

Soil B consists of moderately deep, well drained, rapidly permeable soils formed in alluvial/colluvial pumice over alluvial/colluvial material derived from tuff. The soil is found on 5 to 15 percent slopes on mesa tops. Vegetation is mainly piñon pine and juniper, little bluestem and blue grama. The typical profile consists of a weak pumice soil over a buried, partially truncated tuff-derived Alfisol.

A 0-8 cm, dark grayish brown (10 YR 4/2) very gravelly loam, very dark grayish brown (10 YR 3/2) moist; weak medium crumb structure; very soft dry, very friable moist; many fine and medium roots; about 50% pumice gravel; clear smooth boundary.

CB 8-55 cm, dark yellowish brown (10 YR 4/4) extremely gravelly loam, dark yellowish brown (10 YR 4/4) moist; weak medium subangular blocky structure parting to weak medium crumb structure; soft dry, very friable moist; common fine and medium, few coarse roots; about 70% pumice gravel; abrupt wavy boundary.

2Btk/Cr 55-85 cm, brown (7.5 YR 5/4) silty clay loam, brown (7.5 YR 4/4) moist; weak medium subangular blocky structure; hard dry, firm moist; few medium roots; many continuous distinct clay films on ped faces and pore walls; moderate effervescence; common thin discontinuous to thick continuous calcium carbonate coatings on ped faces; gradual wavy boundary.

2R 85+ cm, tuff.

POGNA SERIES: Loamy, mixed, frigid Lithic Ustorthent.
(Nyhan et al., 1978)

The Pogna series consists of shallow well-drained soils that formed in material weathered from tuff on gently to strongly sloping mesa tops. Native vegetation is mainly ponderosa pine, mountain mahogany, and Kentucky bluegrass.

Typically, the soil is a light brownish gray fine sandy loam, or sandy loam, over tuff bedrock at 25 to 50 cm. The available water capacity of this moderately rapid permeable soil is low, and the effective rooting depth is 25 to 50 cm. Runoff is medium, and there is a moderate water erosion hazard. The representative profile of the Pogna fine sandy loam (3 to 12% slope) is described as follows:

A1--0 to 13 cm, light brownish gray (10 YR 6/2) fine sandy loam, very dark grayish brown (10 YR 3/2) moist; weak fine granular structure; slightly hard and very friable moist; many medium roots; many interstitial pores; neutral; clear smooth boundary.

C--13 to 30 cm, light brownish gray (10 YR 6/2) fine sandy loam, grayish brown (10 YR 5/2) moist; weak fine granular structure; slightly hard and very friable moist; many medium and coarse roots; many interstitial pores; slightly acid.

R--30+ cm, tuff bedrock.

POTRILLO SERIES: Fine-loamy, mixed, mesic Aridic Ustochrept
(Nyhan et al., 1978)

The Potrillo series consists of deep, well-drained soils that formed in alluvial and colluvial sediments derived from tuff and pumice. Potrillo soils are found on level to gently sloping canyon floors and on inextensive, flat benches along the Rio Grande Gorge. Native vegetation is blue grama, piñon pine, one-seed juniper, and annual grasses and

forbs. About 10% of this mapping unit in the canyon floors consists of Puye and Totavi soils and some soils that have a more developed subsoil than the Potrillo soils.

When the Potrillo series is found in canyon floors the surface layer is typically a brown loam about 10 cm thick. The subsoil is a brown loam, or a sandy loam, about 30 cm thick. The substratum is light brown sandy loam with 15% gravel-sized pumice fragments and is neutral to mildly alkaline. The available water capacity of this moderately permeable soil is high, and the effective rooting depth is 150 cm or more. Runoff is very slow, and the erosion hazard is low.

A typical pedon of Potrillo loam (0 to 5% slope) is described as follows:

A1--0 to 10 cm, brown (7.5 YR 5/2) loam, dark brown (7.5 YR 3/2) moist; weak fine granular structure; soft and very friable moist; common fine roots; neutral; clear smooth boundary.

B2--10 to 20 cm, brown (7.5 YR 5/4) loam, dark brown (7.5 YR 3/4) moist; weak medium subangular blocky structure; slightly hard and very friable moist; slightly sticky and slightly plastic wet; common very fine roots; neutral; clear smooth boundary.

B3--20 to 41 cm, brown (7.5 YR 5/4) sandy loam, dark brown (7.5 YR 3/4) moist; weak fine subangular blocky structure; slightly hard; very friable moist, slightly sticky and slightly plastic wet; few very fine roots; 5% gravel-sized pumice; mildly alkaline; clear smooth boundary.

C--41 to 152+ cm, light brown (7.5 YR 6/4) sandy loam, brown (7.5 YR 4/4) moist; massive; 15% gravel-sized pumice; mildly alkaline.

UNNAMED SOIL C: Ashy-skeletal, mixed, mesic Aridic Ustochrept

Soil C consists of deep, well-drained, rapidly permeable soils on terraces and gentle side slopes of mesa-top watersheds. It is formed in alluvial and colluvial pumice. Slopes are 1 to 10 percent. Vegetation is mainly open piñon-juniper woodland, with an understory of blue grama and little bluestem. A typical profile is described as follows:

A 0-15 cm, pale brown (10 YR 6/3) sandy loam, dark brown (10 YR 3/3) moist; weak medium crumb structure; soft dry, very friable moist; common fine and medium roots; gradual smooth boundary.

Bw1 15-45 cm, pale brown (10 YR 6/3) sandy loam, dark brown (10 YR 3/3) moist; weak medium subangular blocky structure; slightly hard dry, friable moist; common fine and medium roots; gradual smooth boundary.

Bw2 45-65 cm, light yellowish brown (10 YR 6/4) gravelly sandy loam, brown (10 YR 4/3) moist; weak medium subangular blocky structure; slightly hard dry, friable moist;

common fine, medium, and coarse roots; about 40% pumice gravel; gradual smooth boundary.

CB 65-100 cm, light yellowish brown (10 YR 6/4) gravelly loamy sand, dark yellowish brown (10 YR 3/4) moist; weak medium subangular blocky structure; slightly hard dry, friable moist; few fine and medium roots; about 50% pumice gravel; clear wavy boundary.

2R 100+ cm, tuff.

UNNAMED SOIL D: Ashy-skeletal, mixed, mesic Vitrandic Ustochrept.

Soil D consists of deep, well drained, moderately permeable soil formed in alluvium and colluvium derived from pumice, with additions of eolian material. The soil is found on gently sloping mesa tops, and is deeply eroded. Slope is 10 to 15 percent. Vegetation is piñon pine, juniper, and ponderosa pine with sparse blue grama and little bluestem. A typical profile is described as follows:

A 0-5 cm, brown (10 YR 5/3) gravelly loam, dark brown (10 YR 3/3) moist; weak medium crumb structure; very soft dry, friable moist; common very fine, fine, and medium roots; about 20% pumice gravel; clear smooth boundary.

Bw1 5-15 cm, brown (10 YR 5/3) gravelly sandy loam, dark brown (10 YR 3/3) moist; weak fine subangular blocky structure; soft dry, friable moist; common very fine, fine, and medium roots; about 30% pumice gravel; gradual smooth boundary.

Bw2 15-130 cm, brown (10 YR 5/3) very gravelly loam, dark brown (10 YR 3/3) moist; weak medium subangular blocky structure; slightly hard dry, friable moist; many fine and medium, common coarse roots; about 50% pumice gravel; clear wavy boundary.

2Ab 130-185 cm, dark grayish brown (10 YR 4/2) clay loam, very dark brown (10 YR 2/2) moist; moderate medium subangular blocky structure; slightly hard dry, friable moist; common medium and coarse roots; clear wavy boundary.

2Bxb 185-235 cm, light yellowish brown (10 YR 6/4) silty clay loam, dark yellowish brown (10 YR 4/4) moist; strong coarse prismatic structure parting to strong coarse subangular blocky structure; very hard dry, extremely firm moist; few medium roots; clear wavy boundary.

3Btb 235-280 cm, brown (7.5 YR 5/3) gravelly silty clay loam, dark brown (7.5 YR 3/3) moist; moderate medium subangular blocky structure; slightly hard dry, friable moist; few medium roots; common continuous distinct clay films on ped faces; about 20% gravel; clear wavy boundary.

3CBb 280-345 cm, light brown (7.5 YR 6/3) very gravelly silty clay loam, brown (7.5 YR 4/3) moist; weak medium subangular blocky structure; very hard dry, very firm moist;

few medium roots; common distinct clay films bridging sand and gravel grains; about 50% gravel; clear wavy boundary.

4R 345+ cm, tuff.

FIELD IDENTIFICATION OF SOIL MAP UNITS

Cajete series (CJ).

The Cajete series may be identified by its combination of landscape position, surface expression, and vegetation. This soil is most commonly found immediately below the crest of both the treatment and control watersheds. In this position the map unit often is bounded directly upslope by tuff outcropping tuff bedrock. The surface of the Cajete map unit is covered with light gray to white pumice to a depth of 2 to 5 cm. Vegetation, in contrast to the type location for the Cajete series, consists of widely spaced piñon pine and juniper, with scattered shrubs and sparse grass including blue grama and little bluestem. Where animals have burrowed into the soil, the excavated material consists primarily of white pumice with occasional clay films (from clay lamellae characteristic of the Cajete series C horizons).

Hackroy series (HA).

The Hackroy series is similar in appearance to the Nyjack series in that it has a reddish-brown subsoil that has a relatively high clay content. The Hackroy soil is shallower, generally only about 30 cm from the surface to bedrock. Field identification is on the same basis of the Nyjack series; soils with these characteristics and greater than 50 cm deep should be identified as Nyjack, while those less than 50 cm deep are Hackroy. Differentiation of the two series is complicated by the eroded condition, in many locations within these watersheds, of both soils. Where Nyjack soils are truncated to less

than 50 cm thickness, they become morphologically much like the Hackroy type. The most important difference between the two series is their thicknesses, so that as they become closer in thickness because of erosion, any functional differences should become even less important. Therefore field differentiation of the two series one from another should not be considered of great importance.

Unnamed soil A -- Lithic Ustochrept-rock outcrop complex (**LR**).

Soil A is a shallow soil that is located mainly near the watershed divides. Although very shallow, it exhibits moderate soil development in the form of a Bw horizon with weak structure and slight clay increases. Therefore it does not have the appearance of the more weakly-developed soils, which appear as essentially unaltered sand and gravel.

Nyjack series (**NJ**).

The Nyjack soil is most easily recognized by the presence of the reddish-brown subsoil, which is commonly exposed by erosion. The subsoil is high in clay, and is often cracked when dry and exposed at the surface. Where the subsoil is not exposed, the soil can be identified by the presence of a loamy or sandy loam topsoil with exposed reddish clay or clay loam subsoil in the immediate area (in contrast to Soil B, which has a pumiceous topsoil). The Nyjack-rock outcrop complex (**NR**) has the same characteristics, with up to 40% of rock outcrop (tuff) included within the map unit.

Unnamed soil B -- Ochreptic Haplustalfs (**OH**).

This soil is superficially similar to the Cajete series, in that the surface is covered with pumice. However, the subsoil is quite different in Soil B; a buried soil similar to Hackroy or Nyjack argillic horizons is found under about 20 to 40 cm of pumice soil. Commonly, this map unit is bounded by exposures of this reddish-brown subsoil in small

drainage channels. In addition, the pumice of this map unit tends to be darker in color than the Cajete series, reflecting a higher degree of weathering and reworking near the surface. Soil B is usually located topographically lower than the Cajete soil, and often grades into that map unit.

Pogna fine sandy loam (PG).

The Pogna series is a very weakly developed soil consisting of a weak A horizon over essentially loose sand and gravel (C horizon). The soil is less than 50 cm deep, usually less than 20 cm, and is commonly found in association with rock outcrops. The soil is thus most abundant near the divides of the watersheds, where it is formed of material supplied by mechanical weathering of tuff. It is also found in and near the main drainage channels of both watersheds, where it consists of channel sands and gravels with very weak soil development. It is found occasionally as isolated patches in or near side-slope drainages where material is being transported downslope by storm runoff. The soil is readily identified by its appearance (that of loose sand and gravel), its association with rock outcrops and channels, and often by a general lack of vegetation, especially on side-slope locations. The Pogna-rock outcrop complex (PM) has the same characteristics, with up to 40% of rock outcrop included within the map unit.

Potrillo series (PO).

Potrillo soils are found on lower side-slopes with relatively gentle slopes (15% or less), and on nearly level terraces above the main drainage channels. They are about 1-1.5 m deep, so rocks are seldom exposed within this unit. Trees (piñon pine, juniper, occasional ponderosa pine) are relatively widely dispersed, and grass cover is relatively dense.

Unnamed soil C -- Aridic Ustochrept, pumic-derived (PP).

Soil C is essentially the Potrillo series (PO), except that it is developed in almost exclusively pumiceous parent material. Its landscape position and other characteristics are the same as Potrillo series. The distinguishing characteristic is that PP has a surface mantle of pumice, whereas PO generally has only scattered pumice on the surface.

Rock outcrop, mesic (RM).

This map unit consists of tuff bedrock exposed at the surface. Unless these areas are larger than about 0.1 ha, they are mapped as part of a complex with another soil unit. RM is defined as rock outcrop of sufficient size on slopes of less than 50%, although the slope is usually less than 20%.

Rock outcrop, steep (RS).

This map unit consists of tuff bedrock with a surface slope of greater than 50%. This occurs mainly at the margins of the deeply incised portions of the main drainage channels.

Unnamed soil C -- Vitrandic Ustochrept (VU).

Soil C is a very deep (> 3m) compound soil that is confined to the severely gullied areas near the heads of both watersheds. A dark grayish brown buried A horizon is clearly visible in most of this profile about 1.5 m below the surface. This soil is partially buried in some locations by the equivalent of the Cajete soil, which thins toward the axes of the watersheds. This is the only soil of such depth in the watersheds, so field identification should be simple based on soil depth, location, and the distinctive buried A horizon.

Descriptions of pit soil profiles

Pit ID: DDSP9701

Classification: Vitrandic Ustochrept

Parent material: pumice

Slope: 14%

Aspect: 80° az.

Vegetation: little bluestem, piñon, juniper

Erosion: severe

Description by: DWD, 3-28-97

- A** 0-7 cm, light brownish gray (10YR 6/2) very gravelly loam, very dark brown (10 YR 2/2) moist; weak fine crumb structure; soft dry, very friable moist; common fine and very fine roots; about 50% pumice gravel; clear smooth boundary.
- Bw1** 7-40 cm, light brownish gray (10YR 6/2) extremely gravelly loam, very dark grayish brown (10 YR 3/2) moist; weak medium subangular blocky structure; slightly hard dry, friable moist; many fine and medium roots; about 70% pumice gravel; clear wavy boundary.
- Bw2** 40-85 cm, pale brown (10 YR 6/3) extremely gravelly loam, brown (10 YR 4/3) moist; weak fine crumb structure; slightly hard dry, friable moist; many medium and coarse roots; about 70% pumice gravel; abrupt irregular boundary.
- 2C** 85-180+ cm, white (10 YR 8/1) pumice, white (10 YR 8/1) moist; single grained; abundant 2mm-thick subhorizontal clay lamellae throughout; common fine and medium roots.

Pit ID: DDSP9702

Classification: Aridic Ustochrept

Parent material: alluvium derived mostly from pumice

Slope: 11%

Aspect: 235° az.

Vegetation: blue grama, little bluestem, piñon, juniper, minor ponderosa pine

Erosion: slight to moderate

Description by: DWD, 3-28-97

- A** 0-15 cm, pale brown (10 YR 6/3) sandy loam, dark brown (10 YR 3/3) moist; weak medium crumb structure; soft dry, very friable moist; common fine and medium roots; gradual smooth boundary.
- Bw1** 15-45 cm, pale brown (10 YR 6/3) sandy loam, dark brown (10 YR 3/3) moist; weak medium subangular blocky structure; slightly hard dry, friable moist; common fine and medium roots; gradual smooth boundary.

- Bw2** 45-65 cm, light yellowish brown (10 YR 6/4) gravelly sandy loam, brown (10 YR 4/3) moist; weak medium subangular blocky structure; slightly hard dry, friable moist; common fine, medium, and coarse roots; about 40% pumice gravel; gradual smooth boundary.
- CB** 65-100 cm, light yellowish brown (10 YR 6/4) gravelly loamy sand, dark yellowish brown (10 YR 3/4) moist; weak medium subangular blocky structure; slightly hard dry, friable moist; few fine and medium roots; about 50% pumice gravel; clear wavy boundary.
- 2R** 100+ cm, tuff.

Pit ID: DDSP9703

Classification: Vitrandic Ustochrept

Parent material: alluvium, pumice

Slope: 14%

Aspect: 80° az.

Vegetation: piñon, juniper, minor ponderosa pine

Erosion: severe

Description by: DWD, 4-1-97

- A** 0-5 cm, brown (10 YR 5/3) gravelly loam, dark brown (10 YR 3/3) moist; weak medium crumb structure; very soft dry, friable moist; common very fine, fine, and medium roots; about 20% pumice gravel; clear smooth boundary.
- Bw1** 5-15 cm, brown (10 YR 5/3) gravelly sandy loam, dark brown (10 YR 3/3) moist; weak fine subangular blocky structure; soft dry, friable moist; common very fine, fine, and medium roots; about 30% pumice gravel; gradual smooth boundary.
- Bw2** 15-130 cm, brown (10 YR 5/3) very gravelly loam, dark brown (10 YR 3/3) moist; weak medium subangular blocky structure; slightly hard dry, friable moist; many fine and medium, common coarse roots; about 50% pumice gravel; clear wavy boundary.
- 2Ab** 130-185 cm, dark grayish brown (10 YR 4/2) clay loam, very dark brown (10 YR 2/2) moist; moderate medium subangular blocky structure; slightly hard dry, friable moist; common medium and coarse roots; clear wavy boundary.
- 2Bxb** 185-235 cm, light yellowish brown (10 YR 6/4) silty clay loam, dark yellowish brown (10 YR 4/4) moist; strong coarse prismatic structure parting to strong coarse subangular blocky structure; very hard dry, extremely firm moist; few medium roots; clear wavy boundary.
- 3Btb** 235-280 cm, brown (7.5 YR 5/3) gravelly silty clay loam, dark brown (7.5 YR 3/3) moist; moderate medium subangular blocky structure; slightly hard dry, friable

moist; few medium roots; common continuous distinct clay films on ped faces; about 20% gravel; clear wavy boundary.

3CBb 280-345 cm, light brown (7.5 YR 6/3) very gravelly silty clay loam, brown (7.5 YR 4/3) moist; weak medium subangular blocky structure; very hard dry, very firm moist; few medium roots; common distinct clay films bridging sand and gravel grains; about 50% gravel; clear wavy boundary.

4R 345+ cm, tuff.

Pit ID: DDSP9704

Classification: Ochreptic Haplustalf

Parent material: pumice, tuff

Slope: 8%

Aspect: 100° az.

Vegetation: piñon, juniper, blue grama

Erosion: moderate

Description by: DWD, 4-2-97

A 0-8 cm, dark grayish brown (10 YR 4/2) very gravelly loam, very dark grayish brown (10 YR 3/2) moist; weak medium crumb structure; very soft dry, very friable moist; many fine and medium roots; about 50% pumice gravel; clear smooth boundary.

CB 8-55 cm, dark yellowish brown (10 YR 4/4) extremely gravelly loam, dark yellowish brown (10 YR 4/4) moist; weak medium subangular blocky structure parting to weak medium crumb structure; soft dry, very friable moist; common fine and medium, few coarse roots; about 70% pumice gravel; abrupt wavy boundary.

2Btk/Cr 55-85 cm, brown (7.5 YR 5/4) silty clay loam, brown (7.5 YR 4/4) moist; weak medium subangular blocky structure; hard dry, firm moist; few medium roots; many continuous distinct clay films on ped faces and pore walls; moderate effervescence; common thin discontinuous to thick continuous calcium carbonate coatings on ped faces; gradual wavy boundary.

2R 85+ cm, tuff.

Descriptions from auger holes

Profile ID: DDSO9701

Location: east flank of treatment watershed (385211 x 3959142 uncorrected position)

Classification: Lithic Haplustalf

Parent material: alluvium derived from Bandelier tuff

Slope: 9%

Aspect: 215°

Vegetation: piñon pine, juniper

Erosion: moderate to severe

- A** 0-8 cm, pale brown (10 YR 6/3) gravelly loam, dark brown (10 YR 3/3) moist; moderate medium crumb structure; very soft dry, very friable moist; common fine and very fine roots; 15% gravel (mostly pumice); clear boundary.
- Bt** 8-40 cm, light brown (7.5 YR 6/4) clay loam, strong brown (7.5 YR 4/6) moist; moderate medium subangular blocky structure; slightly hard dry, firm moist; few fine and medium roots; few thin discontinuous clay films on ped faces; clear boundary.
- R** 40+ cm, tuff bedrock.

Profile ID: DDSO9702

Location: east flank of treatment watershed (385226 x 3959018, uncorrected position)

Classification: Lithic Ustorthent

Parent material: alluvium/colluvium derived from Bandelier tuff

Slope: 14%

Aspect: 235°

Vegetation: piñon pine, juniper, blue grama, little bluestem

Erosion: moderate to severe

- A** 0-15 cm, brown (10 YR 4/3 moist) fine sandy loam; single grain; very soft dry, very friable moist; few fine roots; 5% gravel; clear boundary.
- R** 15+ cm, pinkish gray (5 YR 6/2) tuff bedrock.

Profile ID: DDSO9703

Location: east flank of treatment watershed (385211 x 3959029 uncorrected position)

Classification: Aridic Haplustalf

Parent material: alluvium/colluvium derived from Bandelier tuff and El Cajete pumice

Slope: 16%

Aspect: 270°

Vegetation: piñon pine, juniper, little bluestem

Erosion: slight to moderate

- A** 0-10 cm, brown (10 YR 4/3 moist) gravelly loam; weak medium crumb structure; very soft dry, very friable moist; common fine and medium roots; 20% gravel; clear boundary.
- Bt** 10-35 cm, strong brown (7.5 YR 5/6 moist) sandy clay loam; weak medium subangular blocky structure; slightly hard dry, friable moist; few fine and medium roots; few thin discontinuous clay films on ped faces; 5% gravel; gradual boundary.
- Bt/Cr** 35-70 cm, strong brown (7.5 YR 4/6 moist) sandy clay loam; moderate medium subangular blocky structure; very hard dry, very firm moist; few medium roots; common thick continuous clay films on ped faces; 30% rock fragments; gradual boundary.
- R** 70+ cm, white (7.5 YR 8/1 moist) tuff bedrock.

Profile ID: DDSO9704

Location: northern portion of control watershed

Classification: Lithic Haplustalf

Parent material: alluvium/colluvium derived from Bandelier tuff

Slope: 5%

Aspect: 215°

Vegetation: piñon pine, juniper, little bluestem

Erosion: moderate

- A** 0-12 cm, light brownish gray (10 YR 6/2) fine sandy loam, brown (10 YR 4/3) moist; weak fine subangular blocky structure; soft dry, very friable moist; few fine and medium roots; 5% gravel; clear boundary.
- BC** 12-30 cm, brown (7.5 YR 4/3 moist) gravelly sandy clay loam; weak fine subangular blocky structure; slightly hard dry, friable moist; few medium roots; 20% gravel; clear boundary.
- 2Bt/Cr** 30-50 cm, reddish brown (5 YR 4/4 moist) clay loam; moderate medium subangular blocky structure; hard dry, firm moist; few medium roots; common thick discontinuous clay films on ped faces and pores; 10% gravel; abrupt boundary.
- R** 50+ cm, tuff bedrock.

Descriptions of Frijolito watershed profiles

Profile ID: DWD-1 (20m downslope from BAND 2 / FS-27 flag)

Classification: Lithic Ustochrept

Parent material: Bandelier tuff

Slope: 5%

Aspect: S

Vegetation: Pinyon, juniper

Erosion: Moderate

Description by: DWD, 8/24/94

A -- 0 to 10 cm, dark brown (7.5 YR 3/2 moist) sandy clay loam; weak fine subangular blocky structure; soft; common fine and medium roots; clear wavy boundary.

Bw -- 10 to 15 cm, dark brown (7.5 YR 3/2 moist) sandy clay loam; weak medium subangular blocky structure; common medium roots; abrupt wavy boundary.

R -- 15+ cm, massive tuff.

Profile ID: DWD-2 (10 m east of BAND 2 / FS-27 flag)

Classification: Lithic Haplustalf

Parent material: Bandelier tuff

Slope: 3-5%

Aspect: S

Vegetation: Pinyon, juniper, blue grama

Erosion: Slight to moderate

Description by: DWD, 8/24/94

A -- 0 to 10 cm, dark brown (10 YR 3/3 moist) sandy loam; weak medium subangular blocky structure; soft; common fine and medium roots; clear wavy boundary.

Btk/Cr -- 10 to 45 cm, brown (7.5 YR 4/4 moist) clay loam; weak medium subangular blocky structure; hard; few medium and coarse roots; common thin, discontinuous coatings and threads of calcium carbonate on ped faces; clear wavy boundary.

R -- 45+ cm, light gray (5 YR 7/1) massive tuff, pinkish gray (5 YR 6/2) moist.

Profile ID: DWD-3 (approx. 20m above met station, on west side of watershed)

Classification: Typic Ustorthent

Parent material: Bandelier tuff, El Cajete pumice

Slope: 5-7%

Aspect: S

Vegetation: open pinyon-juniper woodland; sparse little bluestem

Erosion: slight to none

Description by: DWD, 8/24/94

A -- 0 to 8 cm, dark brown (7.5 YR 3/2 moist) gravelly loam; single grained; loose; common fine and medium roots; 15% pumiceous gravel; gradual wavy boundary.

BC -- 8 to 50 cm, dark brown (7.5 YR 3/2 moist) gravelly loam; single-grained to weak fine subangular blocky structure; soft; common medium roots; 15% pumiceous gravel; clear wavy boundary.

2Btb -- 50 to 70 cm, brown (7.5 YR 4/4 moist) sandy clay loam; moderate medium subangular blocky structure; hard; common medium roots; 10 to 15 % tuffaceous gravel; clear wavy boundary.

R -- 70+ cm, light gray (5 YR 7/1) massive tuff, pinkish gray (5 YR 6/2) moist.

Profile ID: DWD-4 (Band 3 / FS-76 flag)

Classification: Typic Ustorthent

Parent material: Bandelier tuff, El Cajete pumice

Slope: 5%

Aspect: S

Vegetation: Pinyon-juniper woodland, mountain mahogany

Erosion: slight to none

Description by: DWD, 8/24/94

O -- 0 to 2 cm

A -- 2 to 15 cm, very dark grayish brown (10 YR 3/2 moist) gravelly loam; single grained; soft dry consistence; many fine and medium roots; 15% pumiceous gravel; clear wavy boundary.

CB -- 15 to 75 cm, dark brown (10 YR 3/3 moist) very gravelly loam; single grained; soft dry consistence; common medium roots; 40% pumiceous gravel; clear wavy boundary.

2Btb -- 75 to 115 cm, brown (7.5 YR 4/4 moist) silty clay loam; weak to moderate medium subangular blocky structure; slightly hard; few medium roots; less than 5% tuffaceous gravel; clear wavy boundary.

2Crb -- 115 to 140 cm, dark yellowish brown (10 YR 3/4 moist) gravelly sandy clay loam; weak medium subangular blocky structure; slightly hard to hard; no roots; 15 to 20 % tuffaceous gravel; clear wavy boundary.

R -- 140+ cm, light gray (5 YR 7/1) massive tuff, pinkish gray (5 YR 6/2) moist.

Profile ID: DWD-5 (BAND 4 / FS 80)

Classification: Typic Haplustalf

Parent material: Bandelier tuff

Slope: 3%

Aspect: S

Vegetation: Pinyon, juniper, blue grama

Erosion: moderate

Described by: DWD, 8/24/94

A -- 0 to 8 cm, very dark grayish brown (10 YR 3/2 moist) loamy sand; weak fine subangular blocky structure; soft; few fine roots; clear wavy boundary.

Bt1 -- 8 to 35 cm, brown (7.5 YR 4/3 moist) sandy clay loam; moderate medium subangular blocky structure; hard; few medium roots; diffuse wavy boundary.

Bt2 -- 35 to 55 cm, brown (7.5 YR 4/4 moist) sandy clay loam; moderate medium subangular blocky structure; very hard; no roots; clear wavy boundary.

R -- 55+ cm, very pale brown (10 YR 7/3) massive tuff, brown (10 YR 5/3) moist.

Profile ID: DWD-6 (2 flags upslope from BAND 4 / FS 80)

Classification: Lithic Haplustalf

Parent material: Bandelier tuff

Slope: 7-10 %

Aspect: S

Vegetation: Pinyon, juniper

Erosion: moderate

Described by: DWD, 8/24/94

A -- 0 to 10 cm, very dark grayish brown (10 YR 3/2 moist) sandy loam; weak fine subangular blocky structure; soft; few fine roots; clear wavy boundary.

Bt -- 10 to 43 cm, brown (10 YR 4/3 moist) sandy clay loam; weak medium subangular blocky structure; hard; few medium roots; clear wavy boundary.

R -- 43+ cm, very pale brown (10 YR 7/3) massive tuff, brown (10 YR 5/3) moist.

Profile ID: DWD-7 (natural sediment trap #4)

Classification: Typic Haplustalf

Parent material: Bandelier tuff, recent alluvium

Slope: 8-10%

Aspect: S

Vegetation: Pinyon-juniper woodland; sparse grasses

Erosion: moderate

Description by: DWD, 7/26/94

C -- 0 to 2 cm, recent alluvium; sand; single grained; loose; 10% tuffaceous gravel; clear smooth boundary.

2A1 -- 2 to 11 cm, dark grayish brown (10 YR 4/2 moist) loamy sand; weak fine subangular blocky structure; soft; common fine roots; 5% tuffaceous gravel; clear smooth boundary.

2A2 -- 11 to 28 cm, dark grayish brown (10 YR 4/2 moist) loamy sand; weak medium subangular blocky structure; soft; many fine and medium roots; 5 to 10% tuffaceous gravel; few pottery fragments at 15 cm depth; clear wavy boundary.

3Bt -- 28 to 40 cm, brown (7.5 YR 4/4 moist) silty clay loam; moderate medium blocky structure; hard; common medium roots; few thin, discontinuous calcium carbonate coatings on ped faces; clear wavy boundary.

3Cr/Btk -- 40 to 50+ cm, brown (7.5 YR 4/4 moist) gravelly sandy clay loam; weak medium subangular blocky structure; hard; common medium roots; few thin, discontinuous calcium carbonate coatings on ped faces; moderate effervescence; 30% tuffaceous gravel.

Profile ID: DWD-8 (natural sediment trap #5)

Classification: Lithic Ustorthent

Parent material: Bandelier tuff, recent alluvium

Slope: 5-7%

Aspect: S

Vegetation: Pinyon-juniper woodland

Erosion: moderate

Description by: DWD, 7/26/94

C -- 0 to 2 cm, recent alluvium; sand; single grained; loose; 5 to 10% tuffaceous gravel; clear smooth boundary.

2A -- 2 to 10 cm, very dark brown (10 YR 2/2 moist) sandy loam; weak fine subangular blocky structure; soft; many fine and few medium roots; common pottery fragments; abrupt wavy boundary.

R -- 10+ cm, light gray (5 YR 7/1) massive tuff, pinkish gray (5 YR 6/2) moist.

Profile ID: DWD-9 (FS-4 flag, near top of watershed)

Classification: Lithic Ustorthent

Parent material: Bandelier tuff

Slope: 5-7%

Aspect: S

Vegetation: Pinyon, juniper, blue grama

Erosion: Slight to moderate

Description by: DWD, 8/24/94

A -- 0 to 10 cm, very dark grayish brown (10 YR 3/2 moist) sandy loam; weak medium subangular blocky structure; soft; few fine and medium roots; clear wavy boundary.

Cr -- 10 to 20 cm, dark brown (7.5 YR 3/2 moist) sandy clay loam; weak medium subangular blocky structure; slightly hard; few medium roots; clear wavy boundary.

R -- 20+ cm, light gray (5 YR 7/1) massive tuff, pinkish gray (5 YR 6/2) moist.

Profile ID: DWD-10 (natural sediment trap #3)

Classification: Typic Haplustalf

Parent material: Bandelier tuff, recent alluvium

Slope: 5%

Aspect: S

Vegetation: none in immediate area; surrounded by pinyon-juniper woodland

Erosion: moderate

Description by: DWD, 7/26/94

C -- 0 to 1 cm, recent alluvium; sand; single grained; loose; clear smooth boundary.

2A1 -- 1 to 10 cm, very dark grayish brown (10 YR 3/2 moist) loamy sand; single grained; loose; common fine and medium roots; 5% gravel consisting of pinkish white (7.5 YR 8/2 dry) pumice; clear smooth boundary.

2A2 -- 10 to 40 cm, dark brown (10 YR 3/3 moist) loamy sand; weak medium subangular blocky structure; friable; many fine and medium roots; 5% pumiceous gravel; clear wavy boundary.

3CrBt -- 40 to 50+ cm, brown (7.5 YR 4/2 moist) gravelly sandy clay loam; moderate medium subangular blocky structure; firm; few fine and medium roots; 20% tuffaceous gravel.

Profile ID: DWD-11 (natural sediment trap #2)

Classification: Lithic Haplustalf

Parent material: Bandelier tuff, recent alluvium

Slope: 9%

Aspect: S

Vegetation: pinyon-juniper woodland

Erosion: moderate

Description by: DWD, 7/26/94

C -- 0 to 2 cm, recent alluvium; sand; single grained; loose; no roots; 10 to 15% tuffaceous gravel; clear smooth boundary.

2A1 -- 2 to 8 cm, dark brown (10 YR 3/3 moist) loamy sand; single grained; loose; common fine and medium roots; 5% tuffaceous gravel; clear wavy boundary.

2A2 -- 8 to 20 cm, very dark brown (10 YR 2/2 moist) sandy loam; moderate medium subangular blocky structure; slightly hard; many fine and medium roots; 5% tuffaceous gravel; clear wavy boundary.

2Bt -- 20 to 30+ cm, brown (7.5 YR 4/3 moist) sandy loam; moderate medium subangular blocky structure; hard; common fine and medium roots; 5% tuffaceous gravel.

Profile ID: DWD-12 (natural sediment trap #1)

Classification: Typic Haplustalf

Parent material: Bandelier tuff, recent alluvium

Slope: 5-7%

Aspect: S

Vegetation: pinyon-juniper woodland, sparse grasses (three-awn, etc.)

Erosion: moderate

Relief: 5m

Description by: DWD, 7/26/94

C -- 0 to 1 cm, recent alluvium; gravelly sand; single grained; loose; no roots; 20% tuffaceous gravel; clear smooth boundary.

2A -- 1 to 5 cm, dark grayish brown (10 YR 4/2 moist) sand; single grained; loose; few fine and medium roots; under 5% tuffaceous gravel; clear wavy boundary.

2C1 -- 5 to 12 cm, brown (10 YR 4/3 moist) coarse to very coarse sand; single grained; loose; few fine and medium roots; 5 to 10 % tuffaceous and pumiceous gravel; thin (5mm) horizontal bands of fine pumice gravel; clear wavy boundary.

2C2 -- 12 to 19 cm, very dark grayish brown (10 YR 3/2 moist) medium sand; single grained; loose; common fine roots; under 5% tuffaceous and pumiceous gravel; thin (5mm) horizontal bands of fine pumice gravel; clear wavy boundary.

3Ab -- 19 to 24 cm, very dark grayish brown (10 YR 3/2 moist) loamy sand; weak medium subangular blocky structure; slightly hard; common fine and medium roots; under 5% tuffaceous gravel; gradual wavy boundary.

3Btb -- 24 to 40+ cm, brown (7.5 YR 4/3 moist) clay loam; moderate medium subangular blocky structure; hard; common medium and coarse roots; 10 to 15% tuffaceous gravel.

Profile ID: DWD-13 (Band 6 / FS4 flag)

Classification: Typic Ustorthent

Parent material: Bandelier tuff, El Cajete pumice

Slope: 5%

Aspect: S

Vegetation: none (scattered pinyon, juniper; no understory vegetation--surface covered with "popcorn" pumice)

Erosion: slight to none

Description by: DWD, 8/24/94

AC1 -- 0 to 20 cm, dark brown (10 YR 3/3 moist) gravelly loam; single grained; loose dry consistence; many fine roots; pumiceous gravel; diffuse wavy boundary.

AC2 -- 20 to 35 cm, dark brown (7.5 YR 3/2 moist) gravelly sandy loam; single grained; loose dry consistence; common medium roots; pumiceous gravel; clear wavy boundary.

CB -- 35 to 50 cm, brown (7.5 YR 4/3 moist) gravelly sandy loam; single grained; loose dry consistence; few medium roots; pumiceous gravel; clear wavy boundary.

2BCb -- 50 to 170 cm, brown (7.5 YR 4/4 moist) sandy clay loam; weak medium subangular blocky structure; soft dry consistence; no roots; common medium, subangular tuff fragments; clear wavy boundary.

R -- 170+ cm, light gray (5 YR 7/1) massive tuff, pinkish gray (5 YR 6/2) moist.

Profile ID: DWD-14 (below BAND 7 / FS 2)

Classification: Typic Ustorthent

Parent material: Bandelier tuff, El Cajete pumice

Slope: 7-9%

Aspect: S

Vegetation: mostly pinyon, some juniper, sparse grasses and cactus

Erosion: slight

Description by: DWD, 8/24/94

C -- 0 to 2 cm, white pumice

A -- 2 to 20 cm, very dark brown (10 YR 2/2 moist) gravelly loam; weak medium subangular blocky structure; soft; many medium, few coarse roots; pumiceous gravel; diffuse wavy boundary.

CB -- 20 to 75 cm, brown (10 YR 4/3 moist) gravelly loam; weak medium subangular blocky structure; slightly hard; few medium roots; pumiceous gravel; clear wavy boundary.

2Crb -- 75 to 145 cm, dark yellowish brown (10 YR 4/4 moist) sandy clay loam; weak medium subangular blocky structure; slightly hard; no roots; abrupt wavy boundary.

R -- 145+ cm, light gray (5 YR 7/1) massive tuff, pinkish gray (5 YR 6/2) moist.

Profile ID: natural sediment trap #1a

Classification: Typic Haplustalf

Parent material: Bandelier tuff, recent alluvium

Slope: 5-7%

Aspect: S

Vegetation: pinyon-juniper woodland, sparse grasses (three-awn, etc.)

Erosion: moderate

Relief: 5m

C -- 0 to 2 cm, light brownish gray (10 YR 6/2) sand, very dark grayish brown (10 YR 3/2) moist; single grained; loose consistence; no roots; clear smooth boundary.

2A -- 2 to 10 cm, light brownish gray (10 YR 6/2) sandy loam, very dark grayish brown (10 YR 3/2) moist; weak medium subangular blocky structure; firm consistence; many fine roots; clear wavy boundary.

2Bt1 -- 10 to 20 cm, brown (7.5 YR 5/3) sandy clay loam, dark brown (7.5 YR 3/3) moist; moderate medium subangular blocky structure; hard consistence; common fine and medium roots; clear wavy boundary.

2Bt2 -- 20 to 70 cm, brown (7.5 YR 5/4) sandy clay loam (higher clay content than 2Bt1), brown (7.5 YR 4/3) moist; moderate medium subangular blocky structure; hard consistence; common medium and coarse roots; gradual boundary.

R -- 70+ cm, light gray (5 YR 7/1) tuff, pinkish gray (5 YR 6/2) moist; massive but soft; no roots.

Profile ID: natural sediment trap #2a

Classification: Lithic Haplustalf

Parent material: Bandelier tuff, recent alluvium

Slope: 9%

Aspect: S

Vegetation: pinyon-juniper woodland

Erosion: moderate

C -- 0 to 1 cm, light brownish gray (10 YR 6/2) loamy sand, grayish brown (10 YR 5/2) moist; single grained; loose consistence; many fine roots; clear smooth boundary.

A -- 1 to 8 cm, grayish brown (10 YR 5/2) loamy sand, dark grayish brown (10 YR 4/2) moist; weak medium subangular blocky structure; soft consistence; many fine and medium roots; clear wavy boundary.

Bt -- 8 to 27 cm, brown (7.5 YR 5/4) sandy clay loam, dark brown (7.5 YR 3/4) moist; moderate medium subangular blocky structure; hard consistence; common medium roots; thin discontinuous carbonate coatings on ped surfaces; clear undulose boundary.

Bt/Cr -- 27 to 35 cm, light brown (7.5 YR 6/4) sandy loam, brown (7.5 YR 4/4) moist; weak medium subangular blocky structure; firm consistence; few medium roots; clear undulose boundary.

R -- 35+ cm, light gray (5 YR 7/1) tuff, pinkish gray (5 YR 6/2) moist; massive but soft; no roots.

Profile ID: natural sediment trap #3a

Classification: Typic Haplustalf

Parent material: Bandelier tuff, recent alluvium

Slope: 5%

Aspect: S

Vegetation: none in immediate area; surrounded by pinyon-juniper woodland

Erosion: moderate

A -- 0 to 20 cm, brown (10 YR 5/3) loamy sand, dark brown (10 YR 3/3) moist; weak fine subangular blocky structure; soft consistence; many fine and medium roots; clear smooth boundary.

Bt/Cr -- 20 to 45 cm, brown (7.5 YR 5/4) sandy clay loam, dark brown (7.5 YR 3/3) moist; moderate medium subangular blocky structure; hard consistence; many medium and common coarse roots; clear wavy boundary.

Cr -- 45 to 53 cm, pink (7.5 YR 7/4) sandy clay loam, brown (7.5 YR 5/4) moist; weak medium subangular blocky structure; very hard consistence; no roots; clear wavy boundary.

R -- 53+ cm, light gray (5 YR 7/1) tuff, pinkish gray (5 YR 6/2) moist; massive; no roots.

Profile ID: natural sediment trap #4a

Lithic Haplustalf

Parent material: Bandelier tuff, recent alluvium

Slope: 8-10%

Aspect: S

Vegetation: Pinyon-juniper woodland; sparse grasses

Erosion: moderate

C -- 0 to 2 cm, recent alluvium; grayish brown (10 YR 5/2) loamy sand, very dark grayish brown (10 YR 3/2) moist; single grained; loose; few fine roots; clear smooth boundary.

2BC -- 2 to 15 cm, grayish brown (10 YR 5/2) loamy sand, very dark grayish brown (10 YR 3/2) moist; weak medium subangular blocky structure; firm consistence; common fine and medium roots; clear undulose boundary.

2Cr/Bt -- 15 to 28 cm, brown (7.5 YR 5/4) clay, dark brown (7.5 YR 3/4) moist, as thick continuous coatings on tops and sides of slightly weathered tuff fragments; very hard consistence; common medium and coarse roots; 60-70% coarse fragments; clear undulose boundary.

R -- 28+ cm, light gray (5 YR 7/1) tuff, pinkish gray (5 YR 6/2) moist; massive; no roots.

Profile ID: BAND 7 / FS-2 flag

Classification: Lithic Ustorthent

Parent material: Bandelier tuff

Slope: 5-7%

Aspect: S

Vegetation: Pinyon, juniper, blue grama

Erosion: Slight to moderate

Description by: DWD, 8/24/94

A -- 0 to 15 cm, very dark grayish brown (10 YR 3/2 moist) loamy sand; single grained; loose; many fine, few medium and coarse roots; abrupt wavy boundary.

R -- 15+ cm, light gray (5 YR 7/1) massive tuff, pinkish gray (5 YR 6/2) moist.

Profile ID: ST-1; sediment trap

Classification: Lithic Haplustalf

Parent material: Bandelier tuff, recent alluvium

Slope: 5-7 % Aspect: S

Vegetation: Pinyon, juniper

Erosion: Moderate

Description by: DWD, 7/15/94

A -- 0 to 8 cm, brown (7.5 YR 4/2 moist) sandy loam; weak medium subangular blocky structure; slightly hard; common fine and medium roots; diffuse wavy boundary.

BC -- 8 to 20 cm, brown (7.5 YR 4/3 moist) sandy clay loam; weak medium subangular blocky structure; slightly hard; common medium roots; abrupt wavy boundary.

2C -- 20 to 27 cm, brown (7.5 YR 4/3 moist) very gravelly sandy loam; single grained; loose; few medium and coarse roots; 80% tuffaceous gravel and cobbles consisting of tuff clasts up to 10 cm in diameter; abrupt wavy boundary.

3Cr/Btb -- 27 to 46 cm, brown (7.5 YR 4/4 moist) gravelly sandy clay loam; weak medium subangular blocky structure; hard; common medium, few coarse roots; 20% tuffaceous gravel; abrupt wavy boundary.

R -- 46+ cm light gray (7.5 YR 7/1) massive tuff, gray (7.5 YR 6/1) moist.

Profile ID: ST-2; sediment trap

Classification: Lithic Haplustalf

Parent material: Bandelier tuff, recent alluvium

Slope: 5-7 %

Aspect: S

Vegetation: Pinyon, juniper

Erosion: Moderate

Description by: DWD, 7/12/94

A -- 0 to 8 cm, very dark grayish brown (10 YR 3/2 moist) sandy loam; weak medium subangular blocky structure; slightly hard; few fine and medium roots; clear wavy boundary.

2CrBt -- 8 to 25 cm, reddish brown (5 YR 4/3 moist) gravelly sandy clay; weak fine subangular blocky structure; hard; thin discontinuous clay films on ped faces; common medium and coarse roots; 20% tuffaceous gravel; abrupt wavy boundary.

R -- 25+ cm, light gray (5 YR 7/1) massive tuff, pinkish gray (5 YR 6/2) moist.

Profile ID: ST-3; sediment trap

Classification: Typic Ustorthent

Parent material: Bandelier tuff, recent alluvium

Slope: 7-10 %

Aspect: S

Vegetation: Pinyon, juniper

Erosion: Moderate

Description by: DWD, 7/12/94

A -- 0 to 16 cm, very dark grayish brown (10 YR 3/2 moist) loamy sand; weak medium subangular blocky structure; soft; many fine, common medium roots; diffuse wavy boundary.

C -- 16 to 26 cm, very dark grayish brown (10 YR 3/2 moist) gravelly loamy sand; single grained; loose; many fine, few medium roots; 15% tuffaceous gravel; clear wavy boundary.

2Cb -- 26 to 31 cm, very dark grayish brown (10 YR 3/2 moist) very gravelly loam; single grained; loose; few medium roots; 80% tuffaceous gravel; abrupt wavy boundary.

3Ab -- 31 to 43 cm, very dark grayish brown (10 YR 3/2 moist) loamy sand; weak medium subangular blocky structure; soft; common fine, few medium roots; clear wavy boundary.

3Cr/Btb -- 43 to 63 cm, brown (7.5 YR 4/3 moist) gravelly clay loam; weak medium subangular blocky structure; slightly hard; common medium and coarse roots; 25% tuffaceous gravel; abrupt wavy boundary.

R -- 63+ cm, light gray (5 YR 7/1) massive tuff, pinkish gray (5 YR 6/2) moist.

Profile ID: ST-4; KDR sediment trap

Classification: Lithic Haplustalf

Parent material: Bandelier tuff

Slope: 5-7%

Aspect: S-SE

Vegetation: Pinyon, juniper

Erosion: Moderate

Description by: DWD, 7/12/94

A -- 0 to 14 cm, dark brown (7.5 YR 3/2 moist) sandy loam; weak medium subangular blocky structure; slightly hard; many fine and medium roots; abrupt wavy boundary.

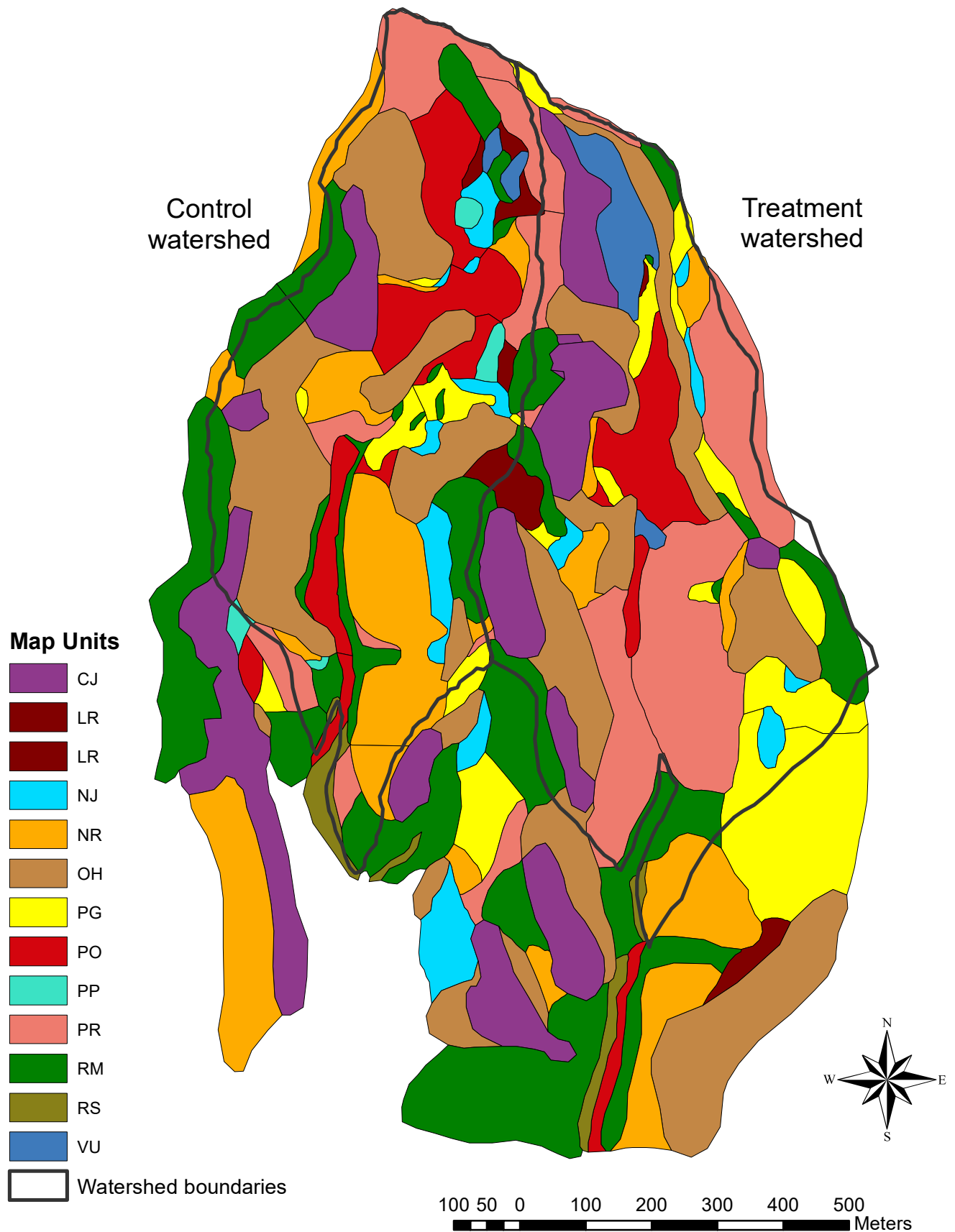
2CrBt -- 14 to 30 cm, reddish brown (5 YR 4/3 moist) sandy clay loam; moderate medium subangular blocky structure; hard; few medium and coarse roots; weak effervescence; common rounded cobbles of tuff, up to 8 cm in diameter; clear undulose boundary.

R -- 30+ cm, light gray (5 YR 7/1) massive tuff, pinkish gray (5 YR 6/2) moist.

SOIL LEGEND

Symbol	Map Unit	Classification
CJ	Cajete series	Vitrandid Ustochrept
HA	Hackroy series	Aridic Haplustalf
LR	Unnamed soil A-rock outcrop complex	Lithic Ustochrept
NJ	Nyjack series	Aridic Haplustalf
NR	Nyjack-rock outcrop complex	Aridic Haplustalf
OH	Unnamed soil B	Ochreptic Haplustalf
PG	Pogna fine sandy loam	Lithic Ustorthent
PM	Pogna-rock outcrop complex	Lithic Ustorthent
PO	Potrillo series	Aridic Ustochrept
PP	Potrillo series, pumice-derived	Aridic Ustochrept
RM	Rock outcrop, mesic	--
RS	Rock outcrop, steep	--
VU	Unnamed soil C	Vitrandid Ustochrept

Watershed Restoration Project Soil Map



Frijolito Watershed Map Units

— 2009 Drainages

□ Frijolito Watershed boundary

MAP_UNIT

CJ

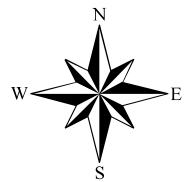
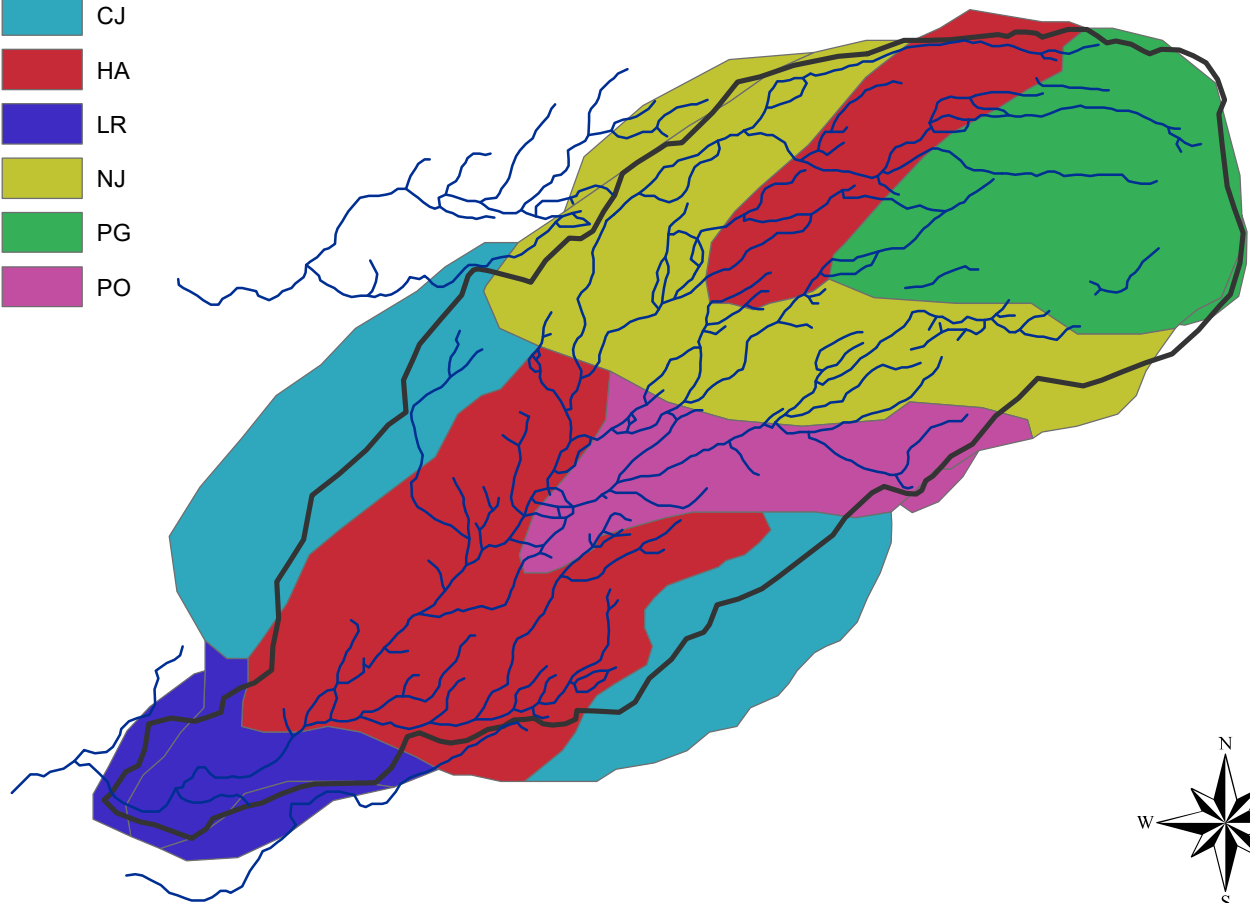
HA

LR

NJ

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50 25 0 50 Meters

Table 1. Spatial and map unit data for all pit, auger and observation points in control, treatment, and Frijolito watersheds.

Northing	Easting	Elevation	Map Unit	Location
3959487.16	384876.85	1975.6	LR	CHNL
3958315.14	384877.26	1952.2	CJ	CTWSB
3959422.54	384963.62	1979.6	LR	CTWSB
3958115.55	384762.42	1936.2	NR	CTWSB
3958799.23	384879.58	1973.4	NR	CTWSB
3958188.92	384808.94	1945.0	OH	CTWSB
3958258.66	384869.10	1947.1	OH	CTWSB
3959109.36	384927.87	1978.6	PG	CTWSB
3958367.89	384870.76	1960.8	PM	CTWSB
3958776.10	384888.83	1961.5	PM	CTWSB
3958430.92	384915.02	1955.4	PM	CTWSB
3958492.36	384924.39	1966.5	PM	CTWSB
3959116.67	384940.37	1969.3	PM	CTWSB
3959410.46	384976.16	1991.5	PM	CTWSB
3958850.68	384839.76	1968.6	RM	CTWSB
3958855.74	384852.87	1971.0	RM	CTWSB
3958927.74	384866.63	1973.6	RM	CTWSB
3958976.36	384866.77	1975.0	RM	CTWSB
3958880.33	384873.85	1962.2	RM	CTWSB
3958956.02	384876.14	1971.0	RM	CTWSB
3958768.28	384894.53	1975.4	RM	CTWSB
3958419.34	384918.38	1954.0	RM	CTWSB
3959116.88	384931.41	1978.2	RM	CTWSB
3958685.13	384931.42	1968.7	RM	CTWSB
3959179.24	384963.57	1963.7	RM	CTWSB
3959183.98	384969.02	1977.2	RM	CTWSB
3958796.33	384429.12	1967.0	CJ	CW
3958785.66	384453.65	1963.2	CJ	CW
3958753.95	384454.50	1960.6	CJ	CW
3958644.07	384469.72	1951.4	CJ	CW
3958777.55	384477.92	1957.4	CJ	CW
3958877.27	384490.88	1964.8	CJ	CW
3958752.54	384492.60	1955.1	CJ	CW
3958596.87	384503.92	1952.7	CJ	CW
3959135.41	384512.95	1976.7	CJ	CW
3959129.30	384518.80	1977.1	CJ	CW
3958662.01	384520.47	1952.1	CJ	CW
3959133.74	384525.42	1973.5	CJ	CW
3958525.43	384528.24	1960.3	CJ	CW

Table 1, continued. Spatial and map unit data for all pit, auger and observation points in control, treatment, and Frijolito watersheds.

Northing	Easting	Elevation	Map Unit	Location
3959131.04	384532.91	1968.7	CJ	CW
3958139.36	384549.98	1939.9	CJ	CW
3958225.16	384581.70	1947.0	CJ	CW
3959424.02	384682.93	1979.8	CJ	CW
3959340.68	384705.90	1976.4	CJ	CW
3958565.34	384767.13	1934.4	CJ	CW
3958829.38	384626.28	1945.9	LR	CW
3959202.03	384842.06	1961.8	LR	CW
3959033.32	384883.88	1981.4	LR	CW
3959429.63	384905.75	1975.1	LR	CW
3959020.16	384907.12	1975.4	LR	CW
3959530.74	384911.91	1979.7	LR	CW
3959516.23	384924.51	1982.0	LR	CW
3959099.55	384797.53	1954.6	NJ	CW
3958918.33	384799.43	1960.0	NJ	CW
3958757.85	384802.53	1954.2	NJ	CW
3959075.31	384806.24	1959.9	NJ	CW
3958818.29	384813.01	1962.1	NJ	CW
3959311.95	384814.98	1952.8	NJ	CW
3958919.28	384815.63	1970.3	NJ	CW
3958385.06	384823.87	1946.5	NJ	CW
3959458.82	384863.80	1973.0	NJ	CW
3959345.12	384864.37	1964.7	NJ	CW
3959380.92	384866.93	1971.1	NJ	CW
3959472.38	384877.34	1973.2	NJ	CW
3959378.59	384879.33	1970.9	NJ	CW
3958670.40	384883.80	1959.0	NJ	CW
3959442.70	384885.07	1976.5	NJ	CW
3959429.73	384891.09	1974.7	NJ	CW
3959121.59	384905.12	1969.9	NJ	CW
3958550.77	384495.44	1947.7	NR	CW
3959153.81	384504.11	1981.1	NR	CW
3958533.87	384507.60	1948.2	NR	CW
3958769.00	384583.00	1952.4	NR	CW
3959107.96	384619.54	1961.6	NR	CW
3959136.13	384637.26	1964.4	NR	CW
3959125.05	384658.93	1965.0	NR	CW
3958934.38	384695.53	1947.1	NR	CW
3959137.87	384696.53	1958.9	NR	CW
3958667.09	384699.27	1945.2	NR	CW
3958817.33	384706.35	1946.0	NR	CW
3959105.16	384715.94	1957.7	NR	CW

Table 1, continued. Spatial and map unit data for all pit, auger and observation points in control, treatment, and Frijolito watersheds.

Northing	Easting	Elevation	Map Unit	Location
3958667.71	384739.74	1951.2	NR	CW
3959316.73	384741.15	1963.3	NR	CW
3958782.27	384745.13	1953.8	NR	CW
3958924.17	384751.19	1960.8	NR	CW
3958759.05	384762.82	1953.5	NR	CW
3958819.71	384763.17	1957.1	NR	CW
3958670.52	384768.71	1961.8	NR	CW
3958918.78	384772.96	1961.0	NR	CW
3959305.24	384786.63	1959.1	NR	CW
3958786.82	384817.75	1956.7	NR	CW
3958436.47	384854.31	1943.6	NR	CW
3959169.64	384526.41	1972.4	OH	CW
3958652.27	384544.82	1949.6	OH	CW
3958858.02	384545.17	1949.8	OH	CW
3959157.60	384555.57	1967.3	OH	CW
3959129.38	384558.74	1966.0	OH	CW
3959150.41	384584.40	1962.8	OH	CW
3958839.33	384588.06	1949.3	OH	CW
3959122.27	384589.93	1963.4	OH	CW
3958765.35	384629.42	1951.3	OH	CW
3959474.19	384664.99	1986.3	OH	CW
3959480.90	384707.01	1977.4	OH	CW
3959141.84	384707.32	1961.1	OH	CW
3959129.45	384717.06	1959.4	OH	CW
3959421.44	384718.04	1975.9	OH	CW
3959036.35	384754.97	1955.4	OH	CW
3959418.02	384759.51	1967.7	OH	CW
3959475.69	384761.65	1972.3	OH	CW
3959016.53	384770.67	1964.3	OH	CW
3958391.41	384790.41	1944.1	OH	CW
3958994.68	384801.97	1965.6	OH	CW
3959084.99	384817.85	1960.3	OH	CW
3959095.47	384824.99	1965.5	OH	CW
3958790.91	384837.73	1963.4	OH	CW
3958766.59	384839.00	1957.2	OH	CW
3959230.67	384845.58	1964.4	OH	CW
3959099.61	384845.91	1967.5	OH	CW
3959239.45	384854.66	1960.2	OH	CW
3959080.54	384854.89	1963.5	OH	CW
3959117.39	384864.99	1966.3	OH	CW
3958669.66	384865.90	1955.9	OH	CW
3959121.51	384877.26	1969.5	OH	CW

Table 1, continued. Spatial and map unit data for all pit, auger and observation points in control, treatment, and Frijolito watersheds.

Northing	Easting	Elevation	Map Unit	Location
3959083.36	384882.29	1969.0	OH	CW
3959109.33	384897.10	1964.5	OH	CW
3959092.13	384898.72	1966.9	OH	CW
3959074.20	384904.69	1974.8	OH	CW
3959105.30	384915.76	1969.5	OH	CW
3959094.04	384925.22	1980.5	OH	CW
3959138.48	384604.19	1962.3	PG	CW
3959126.20	384605.89	1961.1	PG	CW
3959051.49	384726.76	1952.0	PG	CW
3959098.29	384752.81	1950.9	PG	CW
3959119.13	384760.58	1954.4	PG	CW
3959117.09	384773.99	1957.7	PG	CW
3959079.45	384781.65	1958.4	PG	CW
3959100.56	384785.58	1957.0	PG	CW
3959129.70	384793.28	1959.3	PG	CW
3959313.44	384800.35	1953.3	PG	CW
3959112.34	384802.36	1957.5	PG	CW
3959159.31	384804.33	1958.4	PG	CW
3958681.80	384832.68	1961.6	PG	CW
3959112.51	384846.36	1964.5	PG	CW
3958433.11	384881.05	1951.0	PG	CW
3959131.93	384892.05	1971.5	PG	CW
3958752.75	384552.97	1955.3	PM	CW
3958667.77	384590.07	1961.0	PM	CW
3958735.69	384599.14	1953.8	PM	CW
3959085.93	384649.36	1962.6	PM	CW
3958574.59	384670.30	1947.5	PM	CW
3959114.45	384690.64	1958.9	PM	CW
3958771.44	384707.02	1946.7	PM	CW
3959099.44	384735.64	1953.5	PM	CW
3958398.47	384760.48	1951.3	PM	CW
3958751.82	384524.07	1953.9	PO	CW
3958604.59	384633.54	1926.4	PO	CW
3958825.60	384645.64	1942.7	PO	CW
3958924.94	384651.20	1944.1	PO	CW
3958917.53	384652.78	1939.9	PO	CW
3958813.34	384656.27	1939.3	PO	CW
3958659.65	384663.82	1939.9	PO	CW
3958764.88	384670.72	1941.1	PO	CW
3958712.80	384674.10	1934.8	PO	CW
3958725.28	384674.57	1939.3	PO	CW
3959047.83	384735.25	1953.4	PO	CW

Table 1, continued. Spatial and map unit data for all pit, auger and observation points in control, treatment, and Frijolito watersheds.

Northing	Easting	Elevation	Map Unit	Location
3959306.01	384769.45	1963.6	PO	CW
3959186.60	384795.84	1959.5	PO	CW
3959514.53	384799.86	1973.1	PO	CW
3959548.91	384800.85	1970.7	PO	CW
3959547.43	384801.64	1974.9	PO	CW
3959571.90	384802.93	1971.7	PO	CW
3959408.42	384816.53	1968.2	PO	CW
3959471.35	384817.71	1970.4	PO	CW
3959534.62	384828.64	1970.8	PO	CW
3959325.31	384834.74	1965.7	PO	CW
3959190.36	384838.60	1972.1	PO	CW
3959217.37	384848.47	1951.5	PO	CW
3959193.88	384865.50	1967.3	PO	CW
3959237.89	384876.01	1971.3	PO	CW
3959344.19	384878.25	1969.2	PO	CW
3959337.69	384895.78	1984.2	PO	CW
3958774.44	384511.94	1954.4	PP	CW
3958732.66	384631.21	1951.1	PP	CW
3959414.02	384852.90	1970.5	PP	CW
3959432.46	384856.70	1975.4	PP	CW
3959188.11	384876.75	1977.6	PP	CW
3959223.31	384898.23	1960.3	PP	CW
3959182.34	384511.37	1978.4	RM	CW
3958597.61	384560.47	1949.8	RM	CW
3958164.14	384566.42	1959.9	RM	CW
3958656.97	384576.10	1928.1	RM	CW
3958598.03	384589.68	1951.2	RM	CW
3958841.85	384602.24	1944.8	RM	CW
3958661.83	384628.11	1946.0	RM	CW
3958727.12	384659.69	1936.2	RM	CW
3958927.30	384660.50	1944.0	RM	CW
3958815.84	384665.09	1939.6	RM	CW
3959079.73	384674.36	1961.2	RM	CW
3958660.74	384682.41	1945.5	RM	CW
3958766.47	384685.56	1944.8	RM	CW
3958729.77	384686.36	1938.5	RM	CW
3959067.62	384698.71	1953.8	RM	CW
3958740.27	384722.54	1939.9	RM	CW
3958407.89	384737.25	1937.6	RM	CW
3958747.09	384745.10	1951.1	RM	CW
3959119.10	384753.31	1955.0	RM	CW
3959106.83	384780.34	1954.2	RM	CW

Table 1, continued. Spatial and map unit data for all pit, auger and observation points in control, treatment, and Frijolito watersheds.

Northing	Easting	Elevation	Map Unit	Location
3958450.45	384787.23	1937.0	RM	CW
3959175.62	384802.17	1952.7	RM	CW
3959182.26	384808.19	1953.8	RM	CW
3958982.17	384809.66	1967.5	RM	CW
3959135.76	384813.59	1958.9	RM	CW
3959120.93	384814.39	1954.0	RM	CW
3958552.60	384824.74	1940.7	RM	CW
3959620.79	384833.06	1968.9	RM	CW
3958921.84	384835.89	1969.3	RM	CW
3959642.92	384851.36	1983.5	RM	CW
3959608.76	384865.76	1976.9	RM	CW
3959568.82	384867.82	1977.7	RM	CW
3959616.38	384872.29	1981.8	RM	CW
3959569.76	384888.52	1980.0	RM	CW
3959557.78	384896.23	1974.6	RM	CW
3959491.72	384897.07	1972.4	RM	CW
3958675.00	384907.08	1958.4	RM	CW
3959506.66	384911.05	1978.1	RM	CW
3959446.83	384911.30	1979.0	RM	CW
3958584.26	384644.52	1943.9	RS	CW
3958660.09	384649.52	1939.8	RS	CW
3958457.31	384774.56	1925.9	RS	CW
3959515.18	384882.51	1982.5	VF	CW
3959495.05	384887.55	1975.7	VF	CW
3959538.75	384899.03	1998.2	VF	CW
3958570.38	384438.15	1954.7	CJ	CWB
3959163.38	384480.28	1982.6	NR	CWB
3959183.80	384491.04	1980.6	NR	CWB
3958135.43	384501.08	1950.3	NR	CWB
3958493.71	384508.92	1968.8	NR	CWB
3958225.52	384520.42	1948.4	NR	CWB
3958401.40	384535.39	1962.8	NR	CWB
3958342.20	384538.85	1962.4	NR	CWB
3959476.66	384628.97	1996.3	NR	CWB
3958794.22	384406.58	1971.1	RM	CWB
3958748.92	384430.40	1967.1	RM	CWB
3958598.13	384444.31	1956.9	RM	CWB
3958642.51	384446.66	1967.1	RM	CWB
3959434.52	384644.63	1985.6	RM	CWB
3959364.14	384664.63	1983.6	RM	CWB
3959562.67	384825.96	1972.5	PO	DDSO9722
3959562.92	384826.75	1976.5	PO	DDSO9722

Table 1, continued. Spatial and map unit data for all pit, auger and observation points in control, treatment, and Frijolito watersheds.

Northing	Easting	Elevation	Map Unit	Location
3959430.78	384869.70	1976.2	PP	DDSO9723
3959450.84	384872.11	1973.6	NJ	DDSO9724
3959436.57	385063.69	1978.0	CJ	DDSP9701
3959146.86	385141.69	1976.7	PO	DDSP9702
3959415.07	385104.63	1955.8	VF	DDSP9703
3959332.17	384741.99	1968.3	OH	DDSP9704
3959856.75	384476.00	--	LR	FRIJ
3959853.75	384502.50	--	NJ	FRIJ
3959939.00	384519.50	--	NJ	FRIJ
3959952.00	384540.00	--	NJ	FRIJ
3959958.00	384542.50	--	NJ	FRIJ
3959938.00	384547.25	--	NJ	FRIJ
3959961.50	384582.25	--	NJ	FRIJ
3959886.50	384457.25	--	OH	FRIJ
3959908.00	384481.25	--	OH	FRIJ
3959873.75	384530.50	--	OH	FRIJ
3959918.25	384533.25	--	OH	FRIJ
3959875.50	384553.00	--	OH	FRIJ
3959960.25	384583.75	--	PG	FRIJ
3959969.25	384608.50	--	PG	FRIJ
3958239.10	384866.43	1949.5	CJ	TW
3958880.30	384878.99	1967.1	CJ	TW
3958264.32	384884.88	1949.8	CJ	TW
3958961.18	384901.49	1973.6	CJ	TW
3958185.02	384903.79	1944.0	CJ	TW
3958778.06	384905.55	1958.8	CJ	TW
3958892.60	384915.04	1972.1	CJ	TW
3958418.57	384965.96	1952.3	CJ	TW
3959108.76	384972.66	1980.0	CJ	TW
3959557.46	384980.23	1989.0	CJ	TW
3958144.01	384983.03	1932.9	CJ	TW
3958266.44	384998.79	1943.4	CJ	TW
3959188.94	385001.63	1978.8	CJ	TW
3959620.70	385003.62	1984.8	CJ	TW
3959017.01	385010.69	1954.0	CJ	TW
3959330.70	385013.26	1975.3	CJ	TW
3959496.73	385022.37	1979.3	CJ	TW
3959411.78	385032.51	1971.6	CJ	TW
3959104.35	385034.07	1964.0	CJ	TW
3959328.65	385034.29	1983.2	CJ	TW
3959182.53	385048.85	1964.7	CJ	TW
3959336.32	385051.23	1961.3	CJ	TW

Table 1, continued. Spatial and map unit data for all pit, auger and observation points in control, treatment, and Frijolito watersheds.

Northing	Easting	Elevation	Map Unit	Location
3958267.34	385057.11	1937.2	CJ	TW
3959309.75	385063.09	1967.3	CJ	TW
3959181.36	385081.76	1956.9	CJ	TW
3958924.74	385296.54	1959.6	CJ	TW
3959050.97	384902.34	1965.8	LR	TW
3959206.86	384914.76	1962.8	LR	TW
3958993.72	384933.24	1973.4	LR	TW
3959027.84	384937.95	1975.3	LR	TW
3959018.15	384955.83	1973.9	LR	TW
3958990.88	385058.12	1959.7	LR	TW
3959325.52	385126.82	1957.7	LR	TW
3958286.09	385266.25	1925.2	LR	TW
3958310.35	385310.11	1935.4	LR	TW
3958262.81	384861.54	1951.3	NJ	TW
3958928.34	385022.84	1953.6	NJ	TW
3959333.86	385182.31	1967.5	NJ	TW
3958633.30	385314.06	1936.6	NJ	TW
3958704.59	385344.84	1940.5	NJ	TW
3958298.63	385426.90	1946.7	NJ	TW
3959371.48	384914.58	1973.6	NR	TW
3959349.62	384934.52	1935.9	NR	TW
3958269.18	384966.21	1942.9	NR	TW
3958867.61	385013.28	1963.6	NR	TW
3959106.38	385046.44	1961.5	NR	TW
3959014.62	385048.41	1957.7	NR	TW
3958943.51	385056.23	1932.1	NR	TW
3958850.05	385071.96	1980.0	NR	TW
3959405.61	385125.99	1968.1	NR	TW
3958388.03	385140.02	1951.4	NR	TW
3958850.92	385246.18	1948.6	NR	TW
3958315.47	385275.60	1932.6	NR	TW
3958271.28	384946.12	1943.9	OH	TW
3958493.03	384953.37	1962.9	OH	TW
3958884.48	384977.67	1958.7	OH	TW
3958767.77	385018.50	1944.8	OH	TW
3958470.24	385032.92	1935.9	OH	TW
3958395.12	385034.09	1940.5	OH	TW
3958946.81	385036.18	1943.9	OH	TW
3959545.59	385036.72	1980.7	OH	TW
3958955.34	385068.35	1945.9	OH	TW
3958851.39	385068.65	1969.8	OH	TW
3958266.15	385072.29	1938.7	OH	TW

Table 1, continued. Spatial and map unit data for all pit, auger and observation points in control, treatment, and Frijolito watersheds.

Northing	Easting	Elevation	Map Unit	Location
3959097.28	385084.59	1968.6	OH	TW
3958857.48	385091.06	1953.5	OH	TW
3958923.92	385095.83	1932.2	OH	TW
3959507.04	385100.04	1975.3	OH	TW
3959400.17	385145.42	1969.2	OH	TW
3959330.52	385151.49	1964.2	OH	TW
3959101.56	385194.79	1954.2	OH	TW
3959014.45	385210.34	1968.6	OH	TW
3958738.10	385270.84	1944.7	OH	TW
3958868.05	385292.26	1958.4	OH	TW
3958273.56	385313.34	1934.0	OH	TW
3958304.47	385338.83	1938.1	OH	TW
3958728.15	385359.87	1945.0	OH	TW
3958256.85	385374.60	1940.7	OH	TW
3958297.11	385405.38	1930.2	OH	TW
3959628.27	384952.76	1986.7	PG	TW
3958931.92	384974.15	1947.1	PG	TW
3959175.44	385114.38	1951.4	PG	TW
3959350.76	385127.25	1962.1	PG	TW
3959235.90	385130.68	1953.1	PG	TW
3958844.33	385210.48	1973.1	PG	TW
3959004.75	385250.80	1962.5	PG	TW
3958736.33	385318.29	1942.5	PG	TW
3958679.22	385335.21	1945.7	PG	TW
3958866.18	385357.33	1966.7	PG	TW
3959496.03	384985.44	1986.1	PM	TW
3959595.86	384991.72	1987.1	PM	TW
3959333.92	384991.87	1981.7	PM	TW
3958489.77	385040.61	1937.5	PM	TW
3958761.84	385067.38	1943.6	PM	TW
3958850.42	385125.19	1945.7	PM	TW
3958759.53	385125.83	1927.4	PM	TW
3958933.88	385173.63	1956.2	PM	TW
3958838.10	385180.67	1967.0	PM	TW
3958742.23	385208.60	1946.0	PM	TW
3959109.64	385255.45	1971.5	PM	TW
3958916.55	385257.71	1953.5	PM	TW
3959057.83	385052.01	1942.3	PO	TW
3959076.60	385055.66	1959.4	PO	TW
3959037.54	385075.70	1959.2	PO	TW
3959070.75	385083.06	1954.3	PO	TW
3959039.81	385101.21	1953.6	PO	TW

Table 1, continued. Spatial and map unit data for all pit, auger and observation points in control, treatment, and Frijolito watersheds.

Northing	Easting	Elevation	Map Unit	Location
3959065.78	385104.73	1956.6	PO	TW
3958760.69	385106.81	1942.4	PO	TW
3958853.46	385111.89	1951.3	PO	TW
3958276.98	385114.13	1927.6	PO	TW
3958920.31	385122.14	1941.8	PO	TW
3959050.59	385123.06	1955.8	PO	TW
3959088.87	385126.55	1958.8	PO	TW
3959170.44	385127.11	1950.2	PO	TW
3959140.81	385129.75	1958.6	PO	TW
3959000.30	385131.27	1957.2	PO	TW
3959107.64	385151.81	1980.1	PO	TW
3959166.72	385152.51	1949.5	PO	TW
3959135.60	385164.05	1957.0	PO	TW
3959151.36	385169.38	1957.2	PO	TW
3959009.56	385178.58	1955.9	PO	TW
3958061.27	384768.40	1930.0	RM	TW
3958046.19	384819.04	1934.5	RM	TW
3958047.50	384894.01	1932.1	RM	TW
3959398.08	384913.33	1962.0	RM	TW
3959199.10	384938.98	1989.7	RM	TW
3959023.62	384952.97	1960.1	RM	TW
3958137.13	384968.60	1936.6	RM	TW
3958941.32	384987.31	1954.4	RM	TW
3959174.15	384988.97	1967.5	RM	TW
3958174.33	384998.86	1932.3	RM	TW
3958030.09	385009.71	1928.5	RM	TW
3959022.40	385060.05	1954.8	RM	TW
3958024.65	385068.87	1921.3	RM	TW
3958989.28	385080.38	1947.8	RM	TW
3958400.82	385087.92	1928.8	RM	TW
3958286.57	385125.21	1931.9	RM	TW
3959349.22	385133.68	1962.1	RM	TW
3958291.57	385232.41	1931.7	RM	TW
3958851.42	385237.68	1972.9	RM	TW
3958940.70	385291.13	1960.4	RM	TW
3958031.86	385035.05	1922.7	RS	TW
3958278.42	385092.94	1930.3	RS	TW
3958387.49	385117.30	1935.9	RS	TW
3959498.58	385035.69	1976.0	VF	TW
3959528.19	385061.80	1978.8	VF	TW
3959407.59	385062.11	1971.6	VF	TW
3959504.91	385080.09	1975.1	VF	TW

Table 1, continued. Spatial and map unit data for all pit, auger and observation points in control, treatment, and Frijolito watersheds.

Northing	Easting	Elevation	Map Unit	Location
3959327.81	385082.39	1958.6	VF	TW
3959341.89	385096.32	1957.4	VF	TW
3959285.14	385105.78	1937.1	VF	TW
3959330.81	385114.82	1959.3	VF	TW
3959381.66	385116.65	1961.6	VF	TW
3959351.76	385117.91	1956.1	VF	TW
3958927.34	385135.13	1955.3	VF	TW
3959363.31	385138.40	1954.9	VF	TW
3959341.53	385141.47	1960.6	VF	TW
3958236.44	385425.51	1936.4	NJ	TWB
3958267.43	385497.31	1903.9	NJ	TWB
3959336.40	385214.19	1971.0	NR	TWB
3959408.69	385190.89	1979.0	PG	TWB
3959013.64	385302.31	1968.9	PM	TWB
3958939.95	385342.69	1962.3	PM	TWB
3959522.30	385140.47	1980.6	RM	TWB
3958879.85	385393.73	1962.9	RM	TWB

CW = control watershed

TW = treatment watershed

CTWSB = control/treatment watershed boundary

CWB = control watershed boundary

TWB = treatment watershed boundary

DDSP---- = soil pit

DDSO---- = described auger profile

FRIJ = Frijolito watershed

Table 2. Areas of map units in treatment, control, and Frijolito watersheds.

Map unit	Total map unit area (ha)			Percent of total area		
	Restoration watershed		Frijolito	Restoration watershed		Frijolito
	Treatment	Control		Treatment	Control	
CJ	5.8	2.1	0.1	14.0	5.5	9.0
HA	--	--	0.4	--	--	34.2
LR	0.5	0.9	0.1	1.3	2.2	4.5
NJ	0.8	1.5	0.3	1.9	3.9	23.4
NR	2.2	6.7	--	5.4	17.2	--
OH	7.9	10.1	--	19.2	25.9	--
PG	4.6	1.2	0.2	11.1	3.2	18.9
PM	11.0	4.0	0	26.6	10.2	--
PO	2.7	5.2	0.1	6.6	13.5	9.9
PP	--	0.5	--	--	1.3	--
RM	3.9	6.1	--	9.4	15.6	--
RS	0.1	0.2	--	0.2	0.6	--
VU	1.8	0.3	--	4.3	0.8	--

Table 3. Particle size distribution by horizon for pit soil profiles.

Location	Horizon	Depth (cm)	SAND	SILT (%)	CLAY	TEXTURE
DDSP9701	A	0-7	49.3	31.4	15.1	SL
	Bw1	7-40	51.5	24.7	15.2	SL
	Bw2	40-85	47.0	32.8	19.3	L
	2C	85-140	39.2	4.8	6.8	S
DDSP9702	A	0-15	60.0	23.6	11.9	SL
	Bw1	15-45	55.8	23.0	15.0	SL
	Bw2	45-85	59.7	24.6	15.0	SL
	CB	85-100	70.7	21.8	8.9	SL
DDSP9703	A	0-5	33.4	47.7	17.4	L
	Bw1	5-15	42.7	47.5	12.1	L
	Bw2	15-130	40.8	44.7	13.1	L
	2Ab	130-185	44.9	42.5	18.3	L
	2Bxb	185-235	25.7	55.4	22.4	SiL
	3Btb	235-280	18.6	48.3	32.2	SiCL
	3CB	280-345	24.9	41.0	32.3	CL
DDSP9704	A	0-8	75.9	21.9	4.8	SL
	CB	8-55	58.6	25.8	13.1	SL
	2Bt/Cr	55-85	44.7	30.9	26.6	L

SL = sandy loam

L = loam

S = sand

SiL = silt loam

SiCL = silty clay loam

CL = clay loam

Table 4. Sand fractionation data by horizon from pit soil profiles.

Location	Horizon	Depth (cm)	VCS	CS	MS	FS	VFS
			(%)				
DDSP9701	A	0-7	20.2	22.8	11.8	13.8	30.9
	Bw1	7-40	17.5	26.0	14.1	15.2	27.2
	Bw2	40-85	14.8	26.8	13.8	14.7	29.2
	2C	85-140	45.8	35.7	11.3	3.6	3.4
DDSP9702	A	0-15	18.5	25.9	13.9	14.0	27.3
	Bw1	15-45	19.5	25.1	14.6	14.9	25.6
	Bw2	45-85	18.4	23.8	14.0	15.8	27.9
	CB	85-100	28.9	29.3	12.7	10.1	19.0
DDSP9703	A	0-5	9.6	21.1	11.1	14.2	43.7
	Bw1	5-15	21.5	23.3	9.7	10.1	35.6
	Bw2	15-130	17.7	21.3	10.2	13.2	37.5
	2Ab	130-185	16.4	24.9	11.9	12.4	34.2
	2Bxb	185-235	2.6	4.3	3.3	9.9	80.3
	3Btb	235-280	1.4	4.0	2.9	6.8	84.7
	3CB	280-345	12.2	17.6	9.6	12.2	48.6
DDSP9704	A	0-8	50.0	26.8	7.6	5.7	9.7
	CB	8-55	17.0	28.1	15.4	15.1	24.1
	2Bt/Cr	55-85	23.0	14.7	6.8	11.3	43.9

VCS = very coarse sand (2.0-1.0 mm)

CS = coarse sand (1.0-0.5 mm)

MS = medium sand (0.5-0.25 mm)

FS = fine sand (0.25-.010 mm)

VFS = very fine sand (0.10-0.05 mm)

Table 5. Chemical data by horizon from pit soil profiles.

Location	Horizon	Depth (cm)	pH	E.C. (dS m ⁻¹)	O.C. (%)	CEC (cmol kg ⁻¹)
DDSP9701	A	0-7	6.8	0.53	0.58	18.5
	Bw1	7-40	6.6	-	0.38	18.1
	Bw2	40-85	6.9	0.33	0.47	19.9
	2C	85-140	8.0	-	0.09	14.2
DDSP9702	A	0-15	6.7	0.30	0.54	11.5
	Bw1	15-45	7.2	-	0.20	15.3
	Bw2	45-85	7.2	0.30	0.16	12.3
	CB	85-100	7.4	-	0.15	-
DDSP9703	A	0-5	7.3	1.43	1.00	25.4
	Bw1	5-15	8.1	0.80	0.47	26.0
	Bw2	15-130	7.9	4.25	0.24	20.0
	2Ab	130-185	8.7	0.75	0.33	20.8
	2Bxb	185-235	8.4	1.30	0.17	17.5
	3Btb	235-280	8.5	0.60	0.23	23.9
	3CB	280-345	8.2	1.90	0.14	-
DDSP9704	A	0-8	6.2	0.50	0.86	20.4
	CB	8-55	7.1	0.40	0.46	18.8
	2Bt/Cr	55-85	7.8	-	0.05	19.4

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[223] From: USGS Jemez Mts Field Station at NP-BAND 9/2/97 9:31AM (2371 bytes: 10240 ln)

To: Brian Jacobs at NP-BAND, Richard Gatewood at NP-BAND, Elizabeth Mozzillo at NP-BAND, Mike Elliott at NP-BAND
Subject: Dates etc. from Reneau

----- Forwarded -----
From: sreneau@lanl.gov (Steven Reneau) at NBS-Internet-Gateway 8/25/97 5:49PM (2077 bytes: 10240 ln)

To: Craig Allen at NP-BAND
Subject: working e-mail? (repeated message)

----- Message Contents -----

Text item 1: Text Item

Craig:

FYI, just got back 3 14-C dates (boot-legged, compliments of Seismic Hazards) from the "Frijolito Mesa" badlands. Must be something wrong with them--they look too good, consistent with other Plateau dates and suggesting nice clean story.

3.5 m deep, near base of section, 24,300 BP. 1.9 m deep, within nice dark buried A horizon, 10,340 BP. 1.05 m deep, above buried soil, within stratified sediments similar to stuff dated ~7000-8000 BP at other sites, 8590 BP.

Dates and stratigraphy suggest erosion of that "mesa-top drainage" to bedrock prior to last (late Wisconsin) glaciation, slow accumulation of sediment through "full glacial" climate, relative stability during "late glacial" and/or Pleistocene-Holocene transition allowing nice soil to develop, and rapid sediment deposition beginning in early Holocene (beginning of intense monsoons? beginning of P-J? major erosion cycle initiated?).

Also FYI, visited archeologists in Capulin last week. Coincidentally, they working a site (LA 71104) in S. trib to Capulin upstream from Base where Sue Cannon and I got 2 14-C dates from fan sediments in summer 1996. Arch site notable for many terraces on fan surface, inferred to be early Classic (1400 AD $\pm$). Upstream of site, last major fan-building event (inferred to be fire-related) we dated was 540 $\pm$ 100 BP, calibrating to 1410 AD $\pm$ a bunch, suggesting they built terraces on fairly fresh surface. This trip collected series of charcoal samples from section below terraces, which could give interesting story if \$\$ can be scammed.

Hope all going well. May hassle you this week about dendro: false rings in Pondo? hopelessness of cottonwood?

Please pass e-mail on to Brian and other interested parties.

Later.

Steve

July 15, 1997

To: Tammy K. Gallegos
Contracting Officer
Bandelier National Monument
HCR 1, Box 1, Suite 15
Los Alamos, NM 87544-9701

cc: Brian Jacobs, COTR

Re: South Mesa Soil Survey Final Report
Purchase Order 1443PX712097008

Dear Ms. Gallegos:

Enclosed are the report and supporting materials (field data sheets, lab analysis data sheets, floppy disk containing electronic copy of report) required for completion of the above contract.

Please note that the maps were electronically produced using GPS data. This data and all associated files are in the possession of Kay Beeley and Richard Gatewood. The hard copy map included in the report does not show elevation data due to processing limitations. However, all soil data is georeferenced to topography and all other known features of all three watersheds. Thus any combination of information desired is available through the use of Bandelier's existing GIS system.

Please contact me if you have any questions or if further information is required. Thank you.

Sincerely,



David W. Davenport
2531-A 46th Street
Los Alamos, NM 87544
505-662-9739

Enclosures

July 15, 1997

To: Tammy K. Gallegos
Contracting Officer
Bandelier National Monument
HCR 1, Box 1, Suite 15
Los Alamos, NM 87544-9701

cc: Brian Jacobs, COTR

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Please contact me if you have any questions or if further information is required. Thank you.

Sincerely,



David W. Davenport
2531-A 46th Street
Los Alamos, NM 87544
505-662-9739

Enclosures

STATEMENT OF WORK

TASK

The purpose of this contract is to conduct a high resolution soil inventory of three experimental watersheds on South Mesa. Soil units will be mapped and characterized as part of ongoing collaborative research efforts at these sites. This contract work will accomplish the following:

- 1) Map soil units at "1st Order" resolution, where individual map units will range between 0.1 ha and 1.0 ha in size. Where distinguishable, smaller units may be mapped.
- 2) Each different soil type will be characterized by detailed analysis of a representative soil pit. In each pit, individual soil horizons will be described using standard NRCS taxonomic methods (based upon USDA "Soil Taxonomy"). Pits will extend at least 60 inches in depth, or until bedrock is reached. A minimum of four soil pits are needed. Cultural resource sites (already identified in these watersheds) will be strictly avoided. Soil pit locations will be determined and mapped through use of GPS technology and comparisons to other mapped features and aerial photographs.
- 3) Laboratory analyses will be performed on each of the individual soil horizons described from the pits. Analyses at a minimum will include: organic matter content; soil particle size distribution; cation exchange capacity; and pH. Archival samples of the individual horizons will be bagged, labelled, and transferred to Bandelier National Monument to enable additional laboratory work in the future, if needed.
- 4) The distribution of the identified soil units will be mapped across the sampled watersheds. Methods used will include auger-samples of soils along transects and mapping patterns onto overlays of aerial photographs. Auger-samples will avoid cultural resources. All auger-sample locations will be determined and mapped through use of GPS technology and comparisons to other mapped features and aerial photographs.
- 5) Prepare progress and final reports.

DELIVERABLES

The contractor will deliver three copies of the final report specified in the task statement by July 15, 1997. This final report will include:

- 1) detailed maps of the three watersheds, showing the soil units at a resolution of 0.1 to 1.0 hectare, geo-referenced atop topography;
- 2) detailed maps of the three watersheds, showing all soil pit and auger-sample locations geo-referenced to topography and permanent research sampling points;
- 3) a table with the UTM coordinates of all soil pit and auger-sample locations;
- 4) copies of field notes, including overlays of aerial photographs used in the mapping process;
- 5) descriptions of each soil pit;

- 6) laboratory analysis data for each sampled soil horizon;
- 7) a summary description of each described soil unit (to include estimates of infiltration capacity, degree of soil profile truncation due to erosion, visual soil surface characteristics);
- 8) a table listing the soil unit(s) found at each auger-sample location;
- 9) methodology used; and
- 10) a summary discussion, to include: comparisons among the three watersheds, correlations with soils observed elsewhere in the Bandelier area on the Pajarito Plateau; general impressions of erosion effects; and a visual "key" (checklist) to allow resource managers to correctly classify the different soil types in the field.

In addition, bagged and labelled archival soil samples from each sampled soil horizon will be deposited at Bandelier for future reference.

At the discretion of the contractor, a preliminary report may also be developed and delivered of work in progress once at least four soil pits have been described, to allow reimbursement of up-front expenses incurred before completion of the project. This preliminary report will include a brief text summary of all soil characterization activities conducted up to that time, including hardcopy maps of surveyed areas.

ACCEPTANCE CRITERIA

The final report must summarize the methods used in this work, highlighting any issues or problems which might affect interpretations of the reported data. The final report will include hardcopy and computer file (MS-WORD or WP 5.1) copies of the text, and only a hardcopy of the maps and field notes.

COST

Total = \$15,000. This includes all costs for fieldwork, laboratory analyses of soil horizon samples (about \$1600), necessary supplies and materials, data analysis, and report preparation.

GOVERNMENT RESPONSIBILITIES

1. Provide access to the study sites.
2. Provide needed environmental clearances (natural and cultural resources) for the specified work.
3. Provide access to needed aerial photographs, GIS data, and base maps.
4. Send notification of acceptance or nonacceptance of summary report to vendor within 10 working days of receipt of report, or else the report will be deemed acceptable and payment due.

PAYMENT SCHEDULE

One-half of the total project cost (\$7500) can be paid upon receipt of an acceptable preliminary report of work in progress once a minimum of four soil pits are described, to allow reimbursement of up-front expenses incurred before completion of the project. This report will include a brief text summary of all soil characterization activities conducted up to that time, including hardcopy maps of surveyed areas.

The balance (\$7500) will be paid upon receipt of the final summary report in both hardcopy (three copies) and electronic file forms, the associated field notes and laboratory sample data sheets, and the archival soil samples.

Sole Source Contractor Justification:

Dr. David W. Davenport, a local soil scientist, was selected as the vendor for the following reasons:

- both general and local soil science expertise;
- extension of ongoing collaborative work;
- ability to meet our immediate time frame;
- cost-effective high quality results ensured.

The expertise and experience required for characterization of our local soils at the Order 1 Level is rare and requires a considerable time investment. Dr. Davenport already has both the general knowledge of NRCS standard procedures for soil mapping and characterization as well as the locally particular expertise in assessing soil conditions required for this project. Dr. Davenport described soils on nearby Los Alamos National Laboratory for his Ph.D. dissertation research project (Title: Micromorphology, mineralogy, and genesis of soils and fracture fills on the Pajarito Plateau, New Mexico), and has been continuously conducting soil science research at Los Alamos and Bandelier since 1992. Dr. Davenport has been collaborating with Bandelier, and the co-located USGS Jemez Mts. Field Station, for the past three years in ongoing studies of soil erosion, with several publications already produced (e.g., Davenport et al. - in press; Wilcox et al. 1996; and Davenport et al. 1995). Indeed, this project is basically an extension of initial soil research work he has already conducted on the Frijolito watershed (where he has already collected soils data from 22 locations), one of the 3 areas specified for full inventory in this project. Finally, Dr. Davenport is experienced in recognizing (and thereby avoiding sampling impacts to) local archeological sites, which is an important criteria for workers in Bandelier.

Several logistical considerations are also important. Bandelier needs this soils information immediately in order to allow optimal implementation of other ongoing research activities in the revegetation treatment plot, including stratifying the watershed by soil type to most effectively sample soil nutrients, soil moisture, and soil erosion. It is very important that this soils research occur as soon as possible, before the ongoing restoration treatments alter the pre-existing soil conditions. If the soils research work occurs now the soils field work can be greatly facilitated by the in-the-field presence of the revegetation project staff. Dr. Davenport is available to begin immediately on this project. Bandelier staff have had extensive meetings with the USDA Natural Resource Conservation Service (the only other identified potential contractor) over the past year in efforts to solicit development of needed soils information; the NRCS is not be able to meet our needs for at least 2 years from now, and they are not set up to conduct the highly intensive (Order 1) surveys we require for these experimental watersheds. Indeed, there is currently a generalized shortage of soil scientists at this time. Dr. Davenport lives locally, so housing and travel expenses are not an issue. Utilizing Dr. Davenport for this project will ensure that important, high quality, soils information will be provided to the park in a timely and cost-effective fashion.

References Cited:

Davenport, D.W., D.D. Breshears, B.P. Wilcox, and C.D. Allen. In press. Viewpoint: Sustainability of piñon-juniper ecosystems: a unifying perspective of soil erosion thresholds. *Journal of Range Management*.

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Wilcox, B.P., J. Pitlick, C.D. Allen, and D.W. Davenport. 1996. Runoff and erosion from a rapidly eroding piñon-juniper hillslope. pp. 61-77 In: M.G. Anderson and S.M. Brooks (eds.). *Advances in Hillslope Processes, Volume 1*. John Wiley and Sons Ltd.

Rationale/Justification for Price:

It can be demonstrated that the total contract price of \$15,000 is a good value. Lab analyses will cost \$1700, leaving \$13,300 for salary, benefits, supplies and materials, travel, etc. This job is estimated to take 3 person-months to complete, for someone with Dr. Davenport's existing level of knowledge and expertise regarding local soils. If Dr. Davenport were contracted through Los Alamos National Laboratory the personnel cost alone for 3 person-months would be \$21,000 (at his current status as a post-doctoral research associate); to get a LANL staff member's time for 3 months would cost about \$60,000. The contracted work is at the level of a research soil scientist (at least a GS-12 level), indicating that personnel costs alone (including benefits) to use a government employee would be about \$15,000, at a minimum. Of course, these estimates do not include additional non-personnel costs (e.g., travel, per diem, supplies and materials, laboratory analysis), nor the personnel costs associated with the extra front-end time required to develop an adequate level of local soils knowledge (one to several person-months). Thus it is not surprising that NRCS estimates for even coarser-resolution soil surveys of Bandelier generated cost/acre values similar to the \$75/acre we estimate here, despite the huge economies of scale potentially available to the NRCS effort.

Given that Dr. Davenport has the expertise to start work immediately and would not have any overhead or travel costs, he can afford to conduct this project for the relatively limited funding we have available.

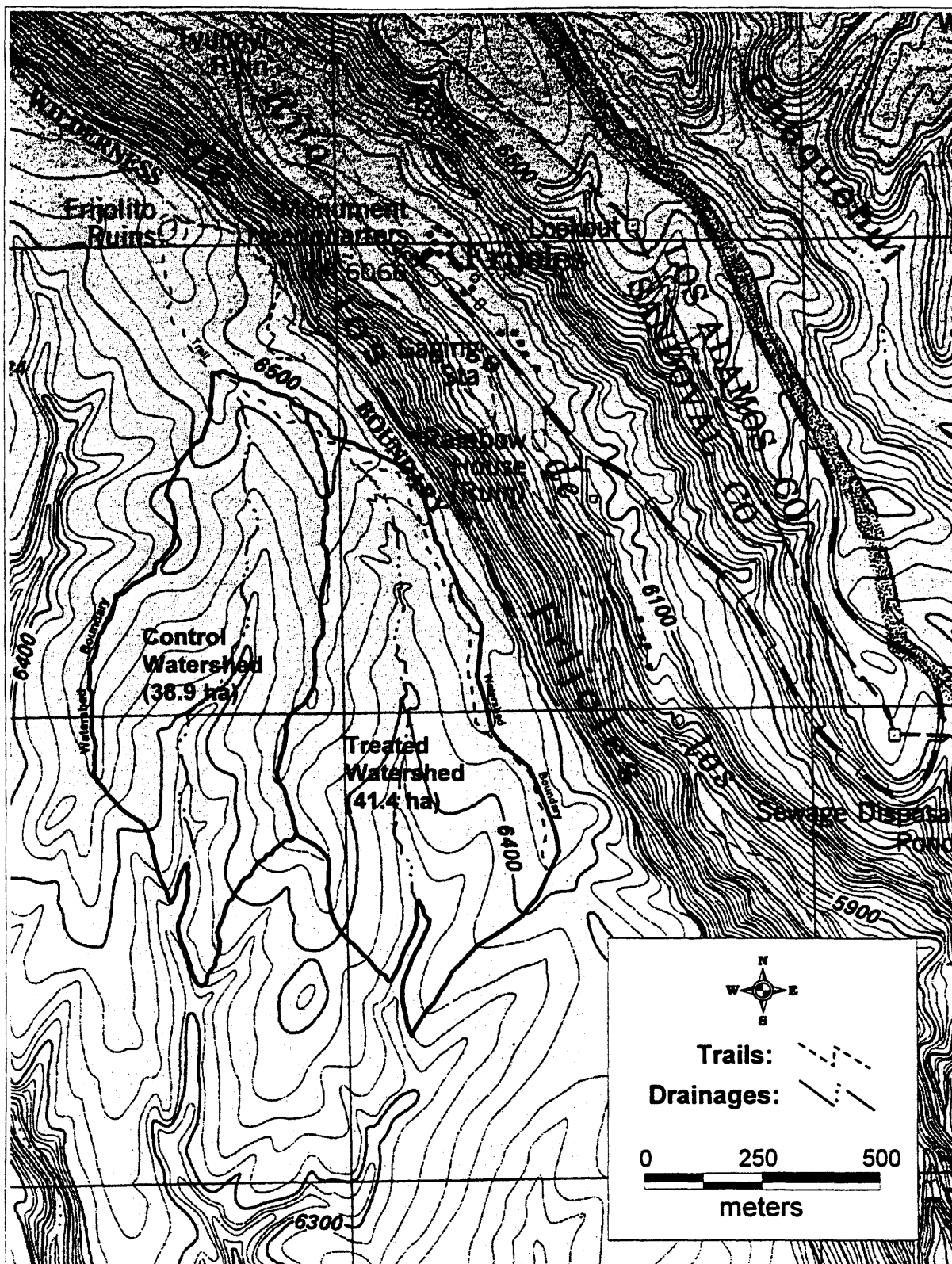


Figure 1. Proposed watersheds for the restoration demonstration project at Bandelier National Monument.

DRAFT

Soils Information needed for the Paired Watershed Restoration Project.

In order to allocate limited restoration resources effectively managers need tools that will help them identify critical areas for restoration. The soil resource is probably the easiest to assess and probably the most limiting to the success of restoration efforts. Soil provides primarily two important needs to overall ecosystem productivity: nutrients and water storage. The latter being the most important to Piñon-Juniper woodlands. Several physical and chemical factors inherent in soils influence these two critical factors. The following is the information that can be obtained within the context of a soil survey .

Soil factors limiting water availability.

The most limiting factor to plant growth and development in Piñon-Juniper Woodlands is plant available water. Although this is overall influence by climate, there are two primary soil characteristics that influence the soil's ability to capture and hold moisture; the amount of water infiltration and the amount of water the soil can store.

Factors Influencing Water Infiltration:

The amount of water that can cross the soil-atmosphere interface per precipitation event contributes to the amount of water that may ultimately be available to plants. These factors are:

- particle size distribution (affects rate of infiltration in addition to storage capacity)
- organic matter content (affects infiltration rates and water storage)
- surface roughness (affects the rate of water runoff)
- slope (affects the rate of runoff)
- development of vesicular crusts impedes infiltration

Thus the amount of water that infiltrates the soil surface is a function of rate of infiltration and rate of runoff.

Water Storage Capacity:

The presence of a horizon or layer that limits water movement down through the soil profile is a major factor contributing to overall soil water storage capacity . The following horizons are typically found in soils that influence this characteristic:

- petrocalcic or petrogypsic horizon
- a clay rich or argillic horizon
- lithic or paralithic contact.
- hardpans or duripans

The closer these layers occur to the soil surface the smaller the soil volume available for water storage.

Particle size distribution or soil texture and Organic Matter content also influences water storage capacity. Coarse textures lower water holding capacity than fine textured soils. The soil moisture storage capacity is also proportional to organic matter content.

Soil factors influencing nutrient availability

After water the most limiting resource to plant growth is nutrient availability with nitrogen primarily being the most limiting macro-nutrient. Several chemical and physical factors influence nutrient availability. These include the following:

- pH
- Organic Matter content

Soil pH is affected by various compounds found in the soil. Calcareous soils which by definition are high in calcium carbonate and are typically associated with Piñon-Juniper woodlands of the semiarid southwest have pHs greater than 7.0. Thus nutrients are prone to be bound to soil colloids rendering them unavailable for plant uptake. The exception is the trace element molybdenum which becomes more mobile at higher pHs.

Organic Matter in addition to influencing water properties discussed above is also correlated to soil nutrient status.

Information that should be gained from the Soil Survey.

Below is a list of data that should be obtained through the soil survey process. This data will give us insight on how the items discussed above interact with the proposed treatments. Other information will also be obtained that may provide some information about the past history of the site and what kinds of conditions may have been present to develop particular soil features.

Delineation and width of soil horizons
Epipedons and subsurface diagnostic horizons
Soil particle size distribution by horizon
soil structure and color by horizon
presence of nodules or concretions
Depth to any water limiting horizons
Estimate of water holding capacity per horizon per mapping unit per mapping unit
Soil surface characteristics specifically the presence of pumice, gravel or desert pavement
Organic Matter Content
The presence of calcium carbonate or gypsum
pH by horizon
slope

parent material
presence of salts and sodium
indications of gleying

Included in the survey for each mapping unit a measure of variation such as confidence intervals should be made for each characteristic for which there is data to estimate such. An example would be variations in horizon width and particle size distributions.

Possible mapping strategies.

Systematic Grid Sampling

One approach is to sample systematically across each watershed with a 100 to 150 foot sampling grid and from that determine the characteristics of each mapping unit. This would provide a very large number of samples per unit area and probably provide more information than is necessary to estimate variation for each mapping unit. Soil boundaries would then be delineated from these observations.

Sampling along Mapping Unit Transects

A second approach would be to delineate mapping unit boundaries from large scale aerial ortho-photos. These boundaries would be drawn to delineate landscape positions such as ridge tops, slopes, draws and watershed bottoms. Ten observations could then be made along transects across each mapping unit delineation to validate the location of the boundaries. From the ten observations an estimate of variation can be made and confidence intervals calculated. On extensive mapping unit delineations a greater number of observations may be required to fully measure variability. This will provide a means to validate the location of mapping units for a more accurate placement of soil boundaries.