TECHNICAL SERVICE CENTER
DENVER, COLORADO

UPPER GILA RIVER FLUVIAL GEOMORPHOLOGY STUDY

GEOMORPHIC ANALYSIS ARIZONA

US Department of the Interior
Bureau of Reclamation

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U.S. Department of the Interior
Mission Statement

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.

Mission of the Bureau of Reclamation

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

ARIZONA WATER PROTECTION FUND

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GRAHAM COUNTY, ARIZONA

COST SHARE AGREEMENT 00-GI 32-0054

Graham County and Reclamation are Cost Share Partners in the Upper Gila River Fluvial Geomorphology Study. The views or findings of Reclamation presented in this deliverable do not necessarily represent those of Graham County.

UPPER GILA RIVER FLUVIAL GEOMORPHOLOGY STUDY

GEOMORPHIC ANALYSIS
ARIZONA

PREPARED BY
FLUVIAL HYDRAULICS & GEOMORPHOLOGY TEAM

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The Fluvial Hydraulics & Geomorphology Team from the Technical Service Center is leading the Upper Gila Fluvial Geomorphology Study. The team consists of geomorphologists, engineers, and biologists. The members have expertise in water resources management, fluvial geomorphology, paleohydrology, hydraulics, sedimentation, photogrammetry, mapping, fisheries biology, wildlife biology, and riparian vegetation management.

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EXECUTIVE SUMMARY

The Geomorphic Analysis synthesizes geomorphic information about the Gila River and compares results of the analysis to other tasks performed for the Upper Gila River Fluvial Geomorphology Study. The goal of the geomorphic analysis is to provide an understanding of the fluvial geomorphology and to explain recent geomorphic change on the Gila River in Safford and Duncan Valleys. Methods used for the Geomorphic Analysis include geomorphic mapping, soil descriptions and laboratory analysis. Soil maps developed by Poulson and Youngs (1938) and Poulson and Stromberg (1950) for Safford Valley and Duncan Valley, respectively, provided critical information for developing the Geomorphic Map. In addition to soil surveys, 26 soil/stratigraphic descriptions of bank exposures provide detailed information about areas that are currently being eroded. Laboratory analysis includes both radiocarbon analysis and macrobotanical analysis. Radiocarbon analysis provides quantitative estimates for the age of alluvium, while macrobotanical analysis identifies the charcoal prior to radiocarbon analysis.

In Safford and Duncan Valleys, geomorphic change along the Gila River in recent decades appears to be controlled by changes in internal factors such as levees and diversion dams rather than changes in external factors such as runoff and sediment influx. This conclusion is based on several products developed for the Upper Gila River Fluvial Geomorphology Study as well as this analysis. Geomorphic mapping in these valleys indicates that the Gila River has migrated within the Pima Soil boundary for the last several hundred years and within the Geomorphic Limit for at least the last 1,000 years. Areas of lateral instability are indicated by the erosion of stable soils mapped as part of the Geomorphic Limit or Pima Soil Boundary or erosion of soils that have been stable historically (1935-2000). Several reaches were discovered that had significant erosion of property that warranted a detailed discussion of the areas of property loss and factors that contributed to its erosion. These reaches include: Railroad Wash, the cutoff meander upstream of Duncan Bridge, Duncan Bridge, Whitefield Wash, Kaywood Wash, San Jose Diversion, San Jose Wash, Graham Diversion, Smithville Diversion, Watson and Butler Washes, Curtis Diversion, Fort Thomas Diversion, Fort Thomas Bridge, and Geronimo. Together, these reaches constitute 40% of the entire study reach.

The Catalog of Historical Changes and the Geomorphic Map reveal the close correlation between levee construction and subsequent failure and geomorphic change during large floods along the Gila River in Arizona. As the Geomorphic Map was compiled, several factors causing instability emerged as common to multiple reaches. These factors include: (1) levee failure; (2) downstream propagation of erosion; (3) channel straightening; and (4) diversion dam orientation. Vegetation and alluvial fan development may also act in conjunction with these factors in some cases. The Catalog of Historical Changes, among other studies, shows that the majority of erosion occurs during high flow events. The local factors mentioned above appear to cause minimal geomorphic change during low to moderate flows but are the catalysts of substantial geomorphic change during the large floods of recent decades.

TABLE OF CONTENTS

GEOMORPHIC ANALYSIS ARIZONA

INTRODUCTION

The Geomorphic Analysis synthesizes geomorphic information about the Gila River and compares results of the analysis to other tasks performed for the Upper Gila River Fluvial Geomorphology Study. The geographic area for this analysis extends from the San Carlos Indian Reservation boundary to the Arizona-New Mexico state line (Figure 1). This includes approximately 38 miles (60 km) in Safford Valley and 25 miles (40 km) in Duncan Valley as measured along the axis of the river corridor. The Gila River in this reach flows through two narrow canyons, the longest of which is the Gila Box between Safford and Duncan Valleys. The second and distinctly shorter reach is near Apache Peak in Duncan Valley between Apache Grove and York, Arizona.

Previous studies document historical change changes (e.g. Burkham, 1972; Hooke, 1996) along the Gila River in downstream reaches of the study area. A comprehensive study named the Gila River Phreatophyte Project was conducted by the U.S. Geological Survey in the 1970's (Culler and others, 1970). Numerous geologic studies documenting Pleistocene age and older geologic features and processes have also been conducted (e.g., Houser et al. 1985; Davidson, 1961; Fair, 1961; Heindl, 1958; Knechtel, 1938). The Background Information document of this project provides detailed summaries of these studies as well as summaries of other pertinent hydrologic, biologic, and engineering references related to the Gila River. The Catalog of Historical Changes (Klawon, 2001) also provides a summary of previous work conducted on historical channel change in the study reach.

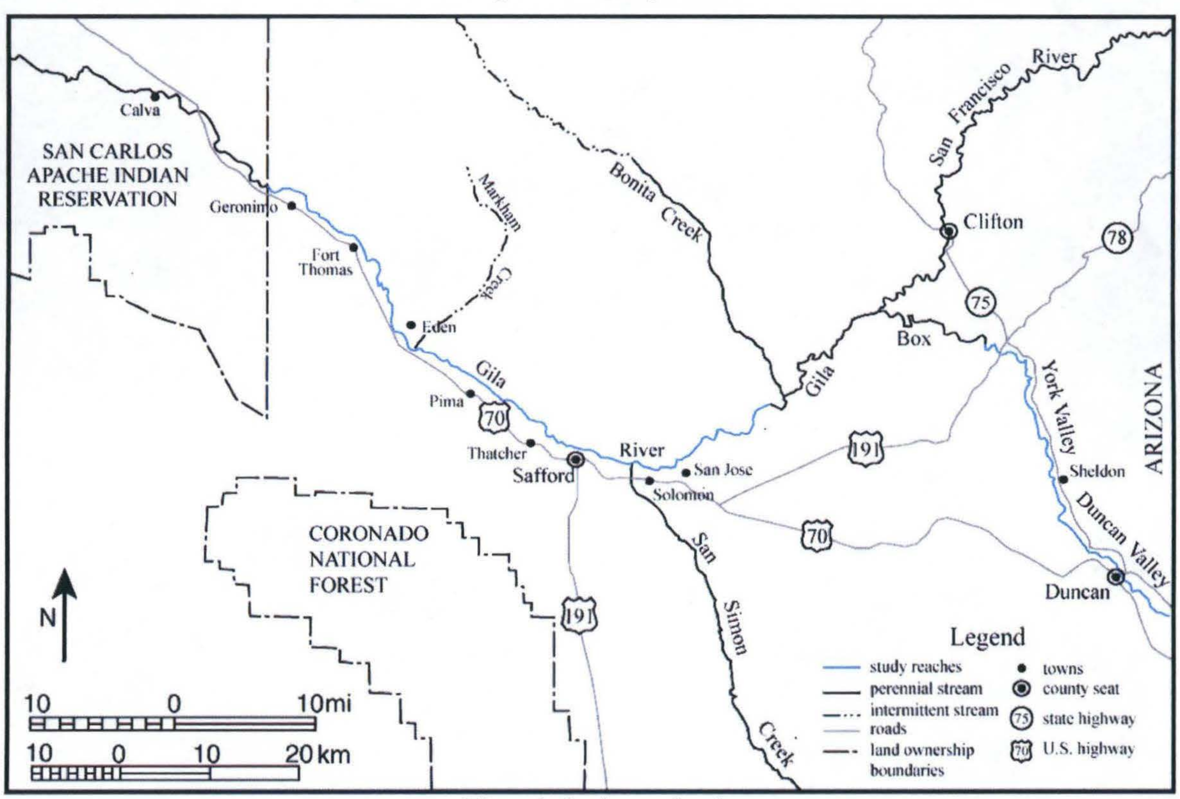


Figure 1. Study area location.

BACKGROUND

Several reports developed prior to the Geomorphic Analysis provide supporting information for this study. The Catalog of Historical Changes documents changes in the Gila River planform from 1935 to 2000. Flood Frequency, Flow Duration, and Trends looks for trends in historical streamflow and rainfall data. The Geomorphic Map documents major historical geomorphic change along the river primarily related to the construction of levees. The Stable Channel Analysis forms a quantitative basis for understanding Gila River sediment transport and channel stability. When combined, these studies cover historical changes in river planform, historical trends in hydrology, the causes of major historical geomorphic change along the river, and insight into channel stability and sediment transport.

PURPOSE

The goal of the geomorphic analysis is to provide an understanding of the fluvial geomorphology and to explain recent geomorphic change on the Gila River in Safford and Duncan Valleys. To accomplish this goal, the Geomorphic Analysis will combine data and analyses conducted during the course of the project. Due to the length of the study reach and complexity of historical alteration of the Gila River, the study is broad in scope seeking to understand the major processes that control the observed fluvial geomorphology.

In recent decades, landowners have experienced a substantial amount of property erosion that has occurred during large floods. Concern arose regarding whether the river was inherently unstable or if conditions in the upper watershed were causing the geomorphic change in Safford and Duncan Valleys. There are multiple hypotheses that can potentially explain the recent geomorphic changes. The following discussion will explore these hypotheses using the analyses produced for this project, and either invalidate or support each idea.

CAUSATION HYPOTHESES

The causation hypotheses for the Gila River fluvial geomorphology in Safford and Duncan Valleys can be grouped into two categories. The first category is based on the influence of factors external to the Gila River in those valleys that may be the cause of recent geomorphic change. The most important of these external factors are changes in the characteristics of runoff or sediment flux from the upper Gila River drainage basin. The second type is based on the influence of factors internal to the Safford and Duncan Valleys. This type of hypothesis would explain the recent geomorphic change in these valleys based on local factors, such as modification of the river through mechanical means.

The basic causation hypotheses for the fluvial geomorphology of the Gila River in the Safford and Duncan Valleys can be stated as:

1. There is no perceptible geomorphic change in these valleys.
2. A change in the upper Gila River drainage basin characteristics has resulted in increased runoff or a change in runoff characteristics. This change in runoff characteristics has resulted in geomorphic change in these valleys.
3. A change in the upper Gila River drainage basin characteristics has resulted in a change in sediment flux. This change in sediment flux has resulted in geomorphic change in these valleys.
4. Some combination of hypothesis two and three.
5. A change in local characteristics of the river has resulted in geomorphic change. This type of local modification would consist of levee construction and subsequent failure, flow redirection

by levees, reduced sediment transport resulting from levee construction, and encroachment by phreatophyte vegetation in the Gila River channel.

Tasks conducted as part of this project and part of a similar project on the Gila River in New Mexico can be used to test the above hypotheses. These tasks include the Background Information, the Qualitative Assessment of Upper Box, New Mexico, the Catalog of Historical Changes, Flood Frequency, Flow Duration, and Trends, the Geomorphic Map, and the Stable Channel Analysis.

The hypothesis that there is no perceptible geomorphic change along the Gila River in the Safford and Duncan Valleys is easily invalidated. The Background Information, the Catalog of Historical Changes, and the Geomorphic Map all chronicle substantial geomorphic change in the Gila River in these Valleys.

Although the Flood Frequency, Flow Duration, and Trends documents some positive trend in precipitation and runoff over the past 70 years, it does not document a trend over the past 40 years, the period during which the majority of property erosion has occurred. Qualitatively this is explained by a pattern observed in other studies such as Webb and Betancourt (1992). This pattern generally displays episodes of frequent large floods followed by episodes of few large floods. These episodes can be irregular and may differ by geographic area and may last several decades to more than 50 years. It appears that the Gila River has experienced two of these episodes with a period of few large floods from the 1930's through the early 1970's bracketed by eras of more frequent large floods, one at the turn of the 20th century and one from the late 1970's through at least the early 1990's. The results of this analysis appear to invalidate the hypothesis that detectable trends runoff resulted in geomorphic change. Instead, over the past several decades, once in an episode of floods, there is apparently no detectable trend in runoff.

The Qualitative Assessment of Upper Box Geomorphology – New Mexico, conducted for a similar study in New Mexico (Levish, 2002), demonstrates that the Gila River in the Upper Box has been stable for at least the last several hundred to perhaps the last several thousand years. This finding is based on the common occurrence of stable geomorphic surfaces with mature vegetation that is not buried by young sediments. This data indicates that there has not been a significant change in sediment flux from the upper Gila River drainage basin over this time interval and invalidates hypothesis three that a change in sediment flux from the upper basin is the cause of geomorphic change in the Safford and Duncan Valleys. This finding is further borne out in Arizona, where with the exception of localized reaches, developing soils in Safford and Duncan Valleys are not buried by deposits of younger sediments.

The fourth hypothesis that geomorphic change is the result of some combination of a change in runoff and a change in sediment flux is also invalidated by the information gathered for this analysis. As there is no apparent trend in runoff over the past four decades and no apparent change in sediment flux over hundreds or thousands of years, there is no evidence to support a combination of the two causing geomorphic change.

The hypothesis that local changes in characteristics of the Gila River channel are responsible for the observed geomorphic change in Safford and Duncan Valleys is supported by the available data. Since changes in runoff and sediment flux from the upper Gila River basin can be discounted as causes of geomorphic change, local factors must be responsible for changes in each of the valleys. These factors include levee and diversion dam construction, bank protection, vegetation encroachment, and tributary alluvial fan development. The effects from these factors on the fluvial geomorphology will be explained in detail in the Discussion.

METHODOLOGY

Methods that are important for developing geomorphic data for the Geomorphic Analysis include geomorphic mapping, soil descriptions and laboratory analysis. Methods used in geomorphic mapping are discussed in detail in the Geomorphic Map Report (Task 8). Soil maps developed by Poulson and Youngs (1938) and Poulson and Stromberg (1950) for Safford Valley and Duncan Valley, respectively, provided critical information for developing the Geomorphic Map. The soils for Safford Valley are mapped at a 1:63,360 scale, while the soils of Duncan Valley are mapped at a 1:15,840 scale. Although more recent soil surveys were available (DeWall, 1981; Gelderman, 1970), they did not accurately reflect fluvial geomorphic processes and therefore were not used. In addition to soil surveys, 26 soil/stratigraphic descriptions of bank exposures provide detailed information about areas that are currently being eroded (Appendix A). Soil and sedimentologic characteristics of bank exposures were described following USDA guidelines and standard sedimentary terminology (Tucker, 1981; Soil Survey Staff, 1993; Birkeland, 1999). The degree of soil development provides important information about the relative age of soils developed on alluvial surfaces in the study area. Characteristics such as carbonate and clay accumulations and soil structure develop with time and can be used as indicators of soil age (Birkeland, 1999; Machette, 1985).

Laboratory analysis includes both radiocarbon analysis and macrobotanical analysis. Appendices B and C provide detailed results of these analyses. Radiocarbon analysis provides quantitative estimates for the age of alluvium. Radiocarbon analysis relies on the decay rate of radiocarbon that was incorporated into the tissue of a once living organism (Trumbore, 2000). The most common materials found in fluvial sediments that are collected for radiocarbon analysis are charcoal and mollusk shell. There are numerous problems associated with ages derived using this methodology. The first kind of problem is related to the incorporation of young or old carbon into the sample material following death of the organism. Rootlets or burrowing that penetrate the sampling area can introduce new carbon into the material and result in an erroneously young age. New carbon may be also introduced to shell material by the recrystallization of aragonite to calcite thereby creating an exchange of modern carbon. Old carbon, or the "hard water effect", may occur where organisms take up carbon from water rich in carbonate derived from limestone or other inert sources. When dated, these shells may give an erroneously old age that could be off by several thousand years (Bradley, 1985). Another kind of problem is associated with the interpretation of the analysis. Given that the sample is not contaminated by old or young carbon, a sample may give an erroneously old age if a significant amount of time has elapsed prior to its deposition in the sampled profile. For example, charcoal from a forest fire in the upper watershed could have been transported and stored several times before being deposited in the sampled profile. Numerous studies and discussions in the literature address these types of issues.

Despite these problems, there are measures that when taken can reduce problems associated with radiocarbon analysis. Samples for this study were floated and identified by species (macrobotanical analysis) so that any rootlets, seeds, or other young material that might contaminate the sample could be discarded. Based on the materials that were identified, materials that could potentially have grown near the site were preferred rather than materials that could have been transported long distances from the upper watershed. Vegetation in the upland areas includes pinyon pine, juniper, manzanita, shrub live oak, and desert hackberry, among others. Vegetation near the Gila River includes creosotebush, tamarisk, cacti, grasses, mesquite, juniper, yucca, and cottonwood, among others (DeWall, 1981; Gelderman, 1970). The latter list would be the preferred vegetation to date. Other plants such as corn at sites with archaeological materials should also be locally derived. The hard water effect was not accounted for in this study. However, dates from shell appear to be consistent with dates from charcoal and are in stratigraphic order.

OVERVIEW OF GEOMORPHOLOGY

The Gila River in Safford Valley and Duncan Valley flows through soils developed on young, intermediate and old alluvial surfaces named the Gila alluvium, Pima alluvium, and alluvium associated with the Geomorphic Limit of flood evidence. Distinctions between the alluvial surfaces, or alluvium, are characterized by soil development and radiocarbon analysis. Gila alluvium exhibits weak soil development and commonly has a sandy texture with obvious sedimentary structures. Radiocarbon dates indicate that these soils range in age from historic to several hundred years old. Pima alluvium has soils that are moderately developed and have greater percentages of silt and clay when compared to the Gila alluvium. Radiocarbon dates for this alluvium could not be obtained in sufficient quantity to provide a quantitative age for the Pima alluvium. This problem occurred because the samples that were acquired were too small for analysis following macrobotanical identification and pretreatment procedures for radiocarbon analysis. Additional bulk sampling and scouring of exposures for charcoal or shell would be necessary to quantify the age of this alluvium. However, soil development suggests that the Pima alluvium is an intermediate age between the young and old soils and therefore is estimated to range from several hundred to 1,000 years. Alluvium associated with the Geomorphic Limit of flood evidence consists of older alluvium as well as younger gravelly alluvial fans that are difficult to erode. Soils of older alluvium have greater soil development, reflected in thicker B horizons, than the Gila or Pima alluvium and have greater percentages of clay in their soil profiles. Soils in tributary alluvial fans are typically composed of sand and gravel and are semi-consolidated with carbonate as a cementing agent where they are observed in vertical exposures. Radiocarbon dates of the older alluvium indicate that soils are greater than 1,000 years old. Few radiocarbon dates were obtained on tributary alluvial fans primarily because it is difficult to find charcoal in gravelly deposits. In general, the alluvial surfaces can also be characterized by the elevation above the modern Gila River and lateral position in the landscape, although moderate variability exists in these factors. For instance, the Gila alluvium is generally the lowest in elevation and closest proximity to the Gila River, while alluvium associated with the Geomorphic Limit is generally the highest in elevation and furthest away from the Gila River. The Pima alluvium is an intermediate surface between the Gila alluvium and Geomorphic Limit alluvium. Soils developed on the Gila, Pima and Geomorphic Limit alluvium are described in detail below with comparison to soils described in published soil surveys for Duncan Valley and Safford Valley (Poulson and Stromberg, 1950; Poulson and Youngs, 1938).

GEOMORPHIC MAP EXPLANATION

The purpose of the geomorphic map is to assess river stability rather than map the extent of individual alluvial units or bedrock units. With this in mind, the geomorphic map shows two boundaries for lateral movement of the Gila River. The Pima Soil Boundary consists of alluvium with soils of the Pima Soil Series. The Geomorphic Limit of flood evidence documents the limit of flood evidence using tonal signatures on aerial photography and receding flood waters observed in post-flood aerial photography to observe areas that floods have inundated surfaces historically as well as observations of soils that are strongly developed and have not been significantly modified by recent floods. In this way, the Geomorphic limit can be defined both by evidence of floods and well as evidence of stable soils that have not been deeply inundated by recent floods. Although not explicitly mapped on the Geomorphic Map, the Gila alluvium with soils of the Gila Soil Series can be inferred to exist between the modern Gila River and the Pima Soil Boundary. If the Pima Soil Boundary is not present at a given location, then the Gila alluvium extends from the Gila River to the Geomorphic Limit (Figure 2).

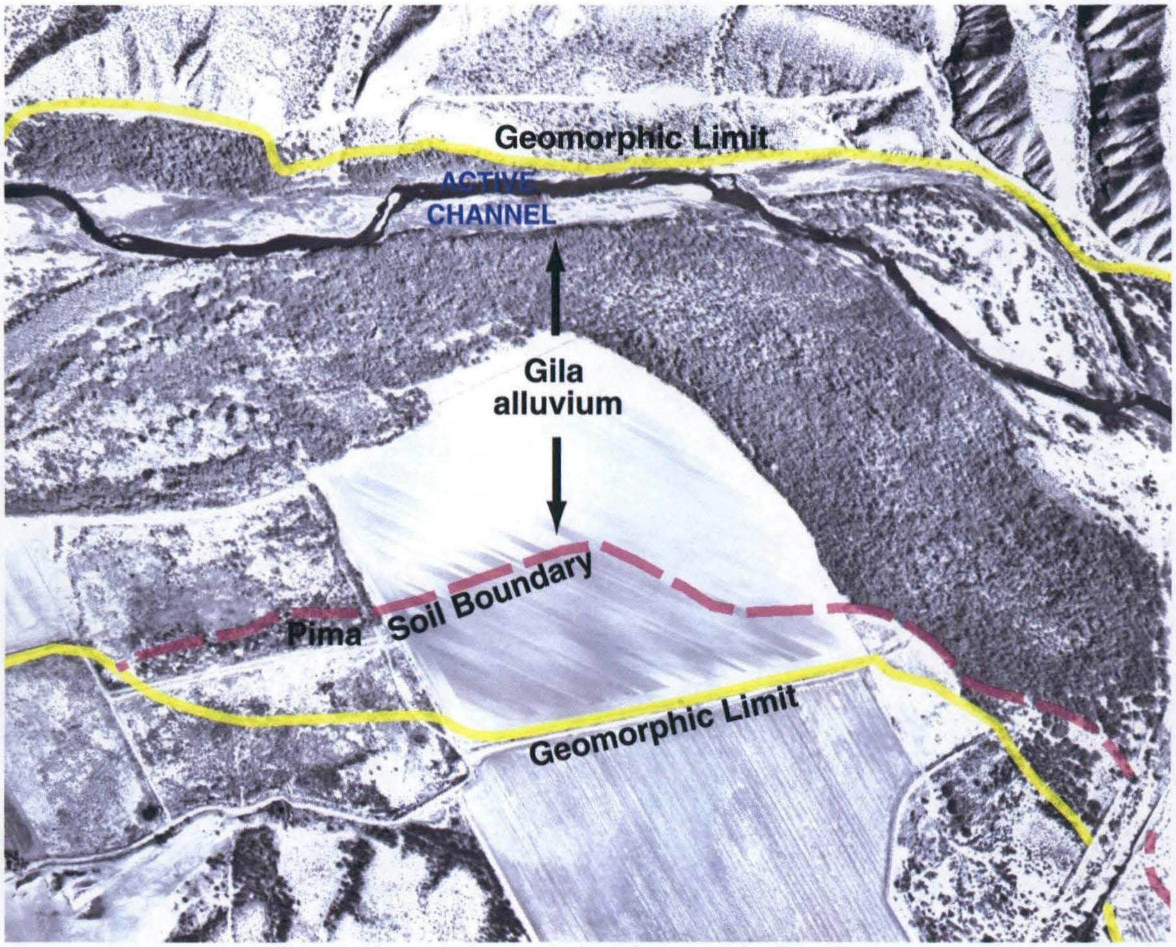


Figure 2. Example showing the lateral extent of the Gila alluvium.

DEFINITION OF MAP UNITS

The map units shown on the Geomorphic Map are described below. These descriptions can also be found in the Geomorphic Map Report, however, additional information for each unit is added here as part of the analysis.

The Gila alluvium is not included as a unit on the Geomorphic Map because it was not an important unit for assessing river stability. In the process of mapping, however, numerous bank exposures of the Gila alluvium were described and are summarized here to provide the evidence that the Gila alluvium is indeed composed of young sediments and part of the channel migration zone of the past several hundred years. The Gila alluvium is composed of weakly developed soils with a C horizon commonly at the surface (Figure 3). Buried soils exist in many cases; some of these soils appear to be truncated with no A horizon while others consist of an A and C horizon with no B horizon development (Figure 4). The texture of the Gila alluvium is typically either a silt loam or sandy loam. The soils generally are formed on point bars, or on floodplain nearest to the river. The Gila Soil Series as described in Poulson and Stromberg (1950) is formed on level to 2% slopes and is generally adjacent to the low flow channel and subject to frequent overflow. The surface is frequently channelized, or channelized scars are readily apparent on the surface. The authors describe a clay loam and fine sandy loam. Both soil profiles are stratified and pale brown to light brownish-gray. Gravelly strata may also exist in the sandy loam. Radiocarbon dates obtained from charcoal samples range in age from 0 to 500 years old.

PIMA SOIL BOUNDARY

This boundary defines the extent of the Pima Soil as shown on soil surveys and as identified in soil descriptions of bank exposures and observations of corresponding stream terraces. The Pima Soil Boundary is an important boundary because it provides a limit to lateral channel migration for the past several hundred years and is an indicator of channel instability where significant areas of this soil have been eroded. Surfaces with the Pima Soil are generally elevated above the active channel by 5 to 10 ft and appear to be formed on alluvium that is several hundred years old. The Pima Soil Series generally runs parallel to the river and is a deep, dark-colored soil formed on level to 2% slopes. Although there is no salt concentration in any particular layer, the soil is generally rich in salts. Stratified materials are present in the subsoil, which is lighter in color below a depth of 2-3 ft (Poulson, 1950). A typical soil consists of 15 inches of brownish gray granular silty clay loam underlain by brownish gray silty clay loam with fine blocky structure to a depth of 24 inches. From 24 to 40 inches, the profile consists of stratified or laminated layers of pale brown to weak brown friable silty clay loam, loam, and clay loam with occasional sandy and silty seams. From 40 to 70 inches, the soil consists of friable stratified pale brown material ranging from fine sandy loam to silty clay loam. Coarser material is present below 70 inches (Poulson and Youngs, 1938). Soil/stratigraphic descriptions compare well with the general soil description provided by Poulson and Youngs (1938). Pima soils at sites described in this project have brown A horizons with sub-angular blocky structure and textures ranging from silt loam to clay loam. Two B horizons are typical, either with a B horizon over a Bk horizon or with 2 Bk horizons. The Bk horizons have stage I carbonate development in fine-grained material. The C horizon typically has a texture of sandy loam except when there are interbeds of clay and silt. For example, site GRS12 exhibits a 25 cm thick A horizon, two B horizons to a depth of 88 cm and several C horizons described to the base of a 2.0 m exposure (Figure 5). *Atriplex* (common name saltbush) obtained from a charcoal-rich contact at 56 cm yielded a date of 1160 ± 40. This is one of only two dates obtained for soils in the Pima Soil Series that define the Pima Soil Boundary. The second date yielded an age of 160 ± 30 from a deeper depth at site GRS13 (Figure 6). The lack of other quantitative information from the Pima Soil precludes definitive estimates for the age of this boundary. However, based on bracketing information from younger and older soils, the Pima alluvium is estimated to be several hundred to 1,000 years old. Surfaces with Pima soils may be accessed by the river during flood flows and may be substantially modified in some cases. These soils are currently being eroded along the river in some locations where the active channel is adjacent to the Pima Soil.

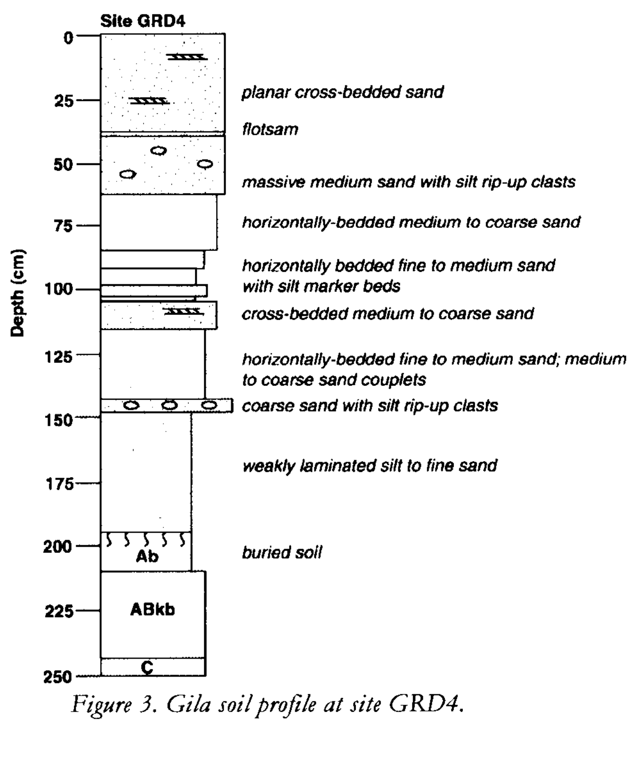


Figure 3. Gila soil profile at site GRD4.

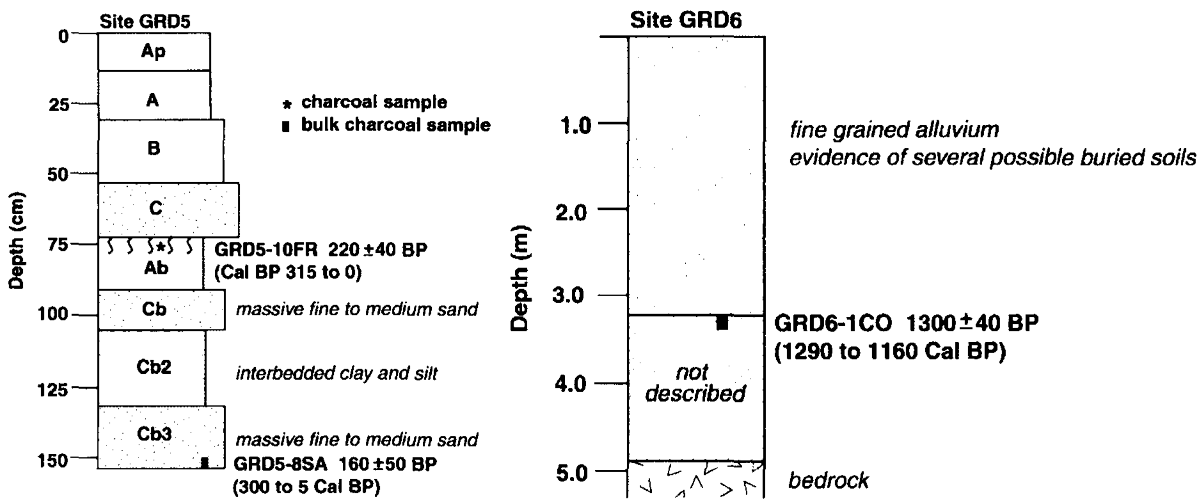


Figure 4. Gila soil profiles at sites GRD5 and GRD6

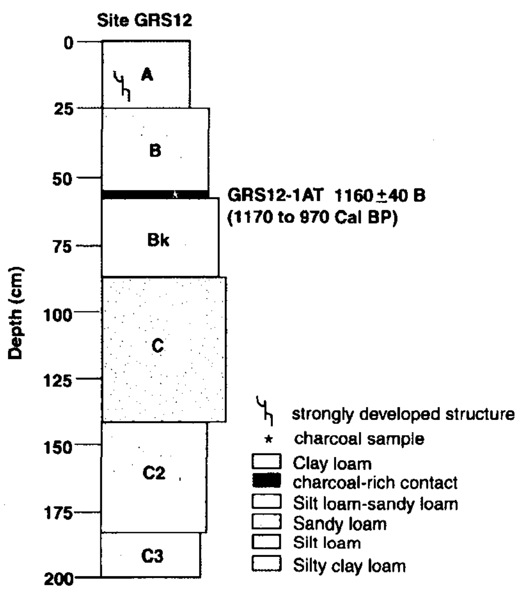


Figure 5. Pima soil profile at site GRS12.

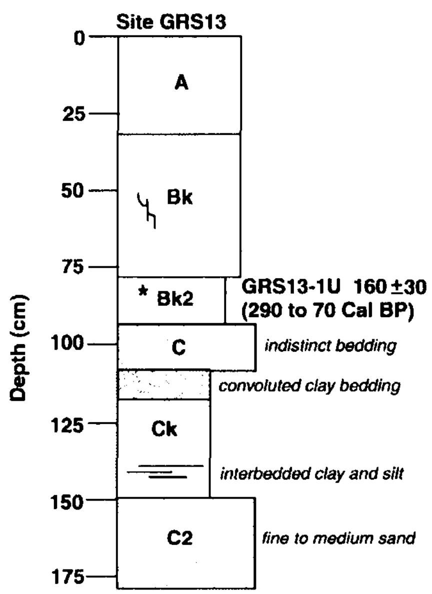


Figure 6. Pima soil profile at site GRS13.

GEOMORPHIC LIMIT OF FLOOD EVIDENCE

The geomorphic limit of flood evidence defines the boundary for surface modification by floods of the Gila River and provides a limit to lateral channel migration for at least the past 1,000 years. Within the geomorphic limit, surfaces are channelized or have tonal signatures on aerial photography that suggest flooding in agricultural fields. Soils developed on surfaces within the geomorphic limit are poorly developed and labeled as the Gila Soil (see Poulson and Stromberg, 1950; Poulson and Youngs, 1938) or are moderately developed soils in the Pima Soil Series.

Beyond the geomorphic limit, soils may be eroded along bank exposures, but are eroded much slower than other banks due to their consolidated nature. Geomorphic units beyond surfaces with flood evidence include bedrock, colluvium, high stream terraces, alluvial fans derived from a single tributary, and alluvial fan complexes on gently sloping piedmonts. These units provide a limit to lateral movement along the Gila River based both on their age and erodibility. Although several soil series are included in this unit, the alluvial soils generally contain higher percentages of gravel and are more sloping than soils of the Pima Series. The soils also typically have carbonate accumulations in a particular horizon in the form of coatings on gravels in gravelly sediments or nodules and filaments in fine-grained sediments. In many cases, these soils have a greater amount of clay when compared to the Pima soil (Poulson and Youngs, 1938). They are also further removed from the active channel where the Pima soil is present and occupy positions of higher elevation than the Pima soil.

Several bank exposures and soil pits near the active channel were described that illustrate these characteristics. Site GRD12, located near Railroad Wash in Duncan Valley, exhibits a 25 cm thick plow pan over a 11cm thick A horizon (Figure 7). Three Bk horizons are developed to a depth of 135 cm and have silty clay loam to clay textures and strongly developed angular blocky structure. Carbonate development ranges from stage I to stage II- while clay films are prominent to distinct on ped faces. Archaeological features including grinding stones and fire-cracked rock are present in these horizons; no other artifacts were noted. Charcoal collected from these horizons is most likely associated with these artifacts. The charcoal was disseminated throughout the horizons, lacking distinct lenses. Charred *Zea mays* (corn cob) and *Atriplex* (saltbush) charcoal were obtained from the Bk2 and Bk3 horizons and have very similar radiocarbon ages of 2570 ± 40 and 2530 ± 40. The C horizon at the base of the profile has a fine sandy loam texture with coarse sub-angular blocky structure and is described to a depth of 160 cm. An additional *Atriplex* charcoal sample collected from the profile at a 145 cm depth in the C horizon has a radiocarbon age of 3270 ± 40 BP.

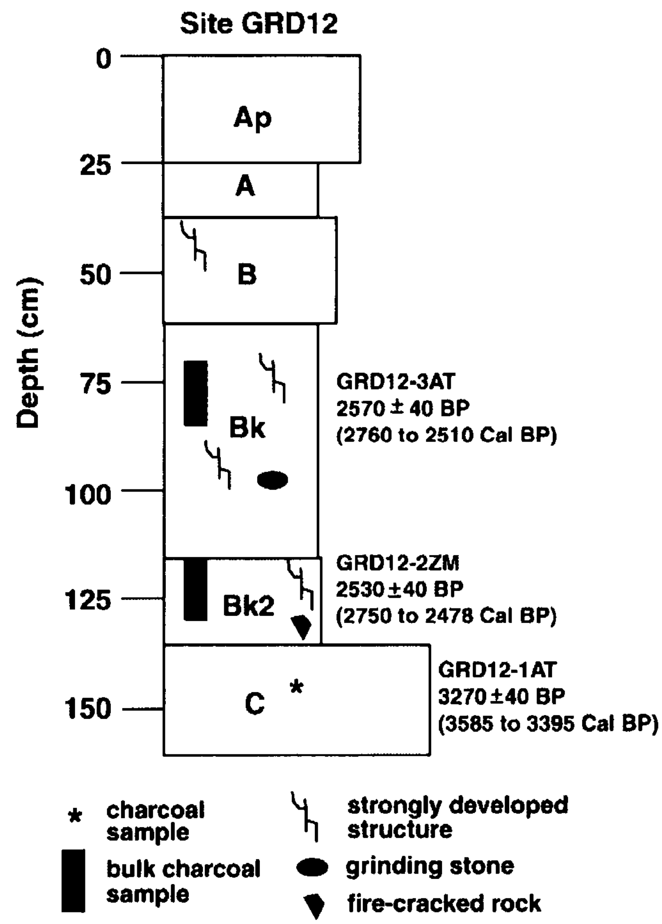


Figure 7. Bank exposure along the Geomorphic Limit, site GRD12.

Site GRD3 is located approximately ¾ mile west of the County Fairgrounds along the Gila River. The surface soil is buried by approximately 15 cm of laminated fine sand and silt, either from floods on nearby tributaries or from the Gila River (Figure 8). Within the C horizon of this buried soil are several hearths at various depths and charcoal-rich sand. Rounded stones are also observed within this horizon and appear to be grinding stones. Radiocarbon ages obtained from this horizon average 2028 ± 40 BP from three samples identified from a bulk sample at a depth of 115 cm and 2 samples identified from a bulk sample at a depth of 125 cm. Below a depth of 195 cm, 5-10 cm thick beds of silt, clay and fine sand overlie two buried soils with moderate to strongly developed sub-angular blocky structure, silt loam texture and stage I carbonate. Charcoal samples from the two buried soils have radiocarbon ages of 3010 ± 40 BP and 4110 ± 40 BP, respectively.

Site GRD10 is located upstream of Apache Creek and is composed of fine grained and gravelly alluvium that may be associated with Apache Creek or Kaywood Wash. The surface soil extends to a depth of 137 cm and consists of moderately to strongly developed structure with sandy loam texture and approximately 10% gravel in the B horizons (Figure 9). The C horizon consists of loosely consolidated rounded gravels with stage I carbonate. An additional soil is buried below the surface soil. No A horizon is preserved. This soil is moderately developed with sub-angular blocky structure, sandy loam to loamy sand texture and stage I carbonate. Charcoal material sampled at depths of 95 and 185 cm and have radiocarbon ages of 230 ± 40 BP and 210 ± 30 BP, respectively. Unfortunately, both of these dates may calibrate to a modern age and are therefore disregarded. These dates point out one of the problems encountered in radiocarbon dating, where the introduction and contamination of young material into an older profile can be a significant source of uncertainty and consternation in estimating its age.

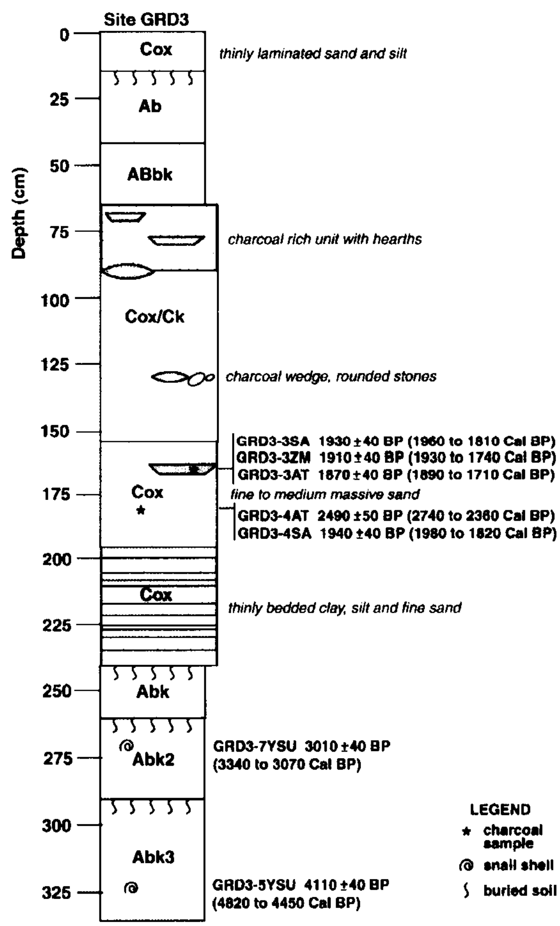


Figure 8. Bank exposure along the Geomorphic Limit, site GRD 3.

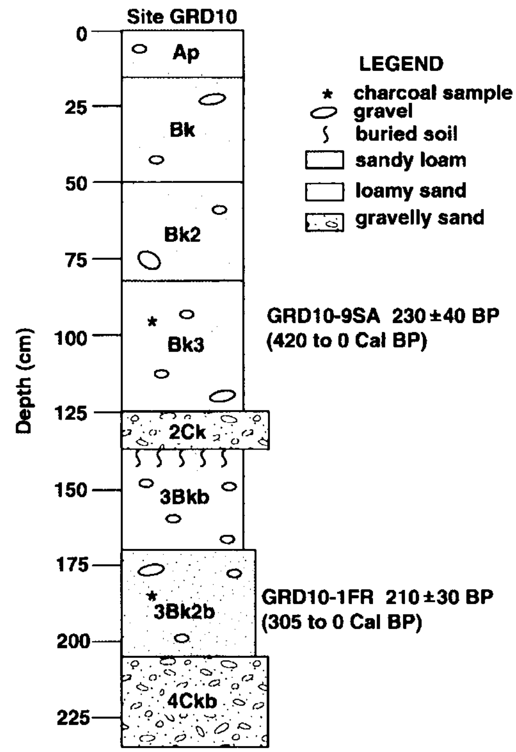


Figure 9. Bank exposure along the Geomorphic Limit, site GRD 10.

Site GRS1 is located near the downstream end of the study area on the property of Doug Hinton west of Geronimo. The soil profile consists of a 10 cm A horizon, and 5 B horizons to a depth of 210 cm (Figure 10). The soil is rich in clay, ranging from silty clay to clay texture and has weak to moderate sub-angular blocky structure. Carbonate accumulations are visible in the lowermost B horizon with stage I morphology. Snail shell samples have radiocarbon ages of 700±40 and 1050±40 at 60 cm within the B2 horizon.

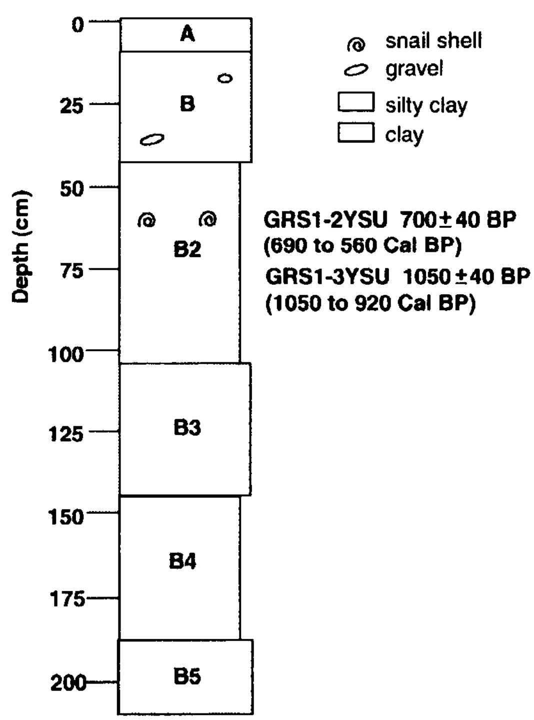


Figure 10. Bank exposure along the Geomorphic Limit, site GRS 1.

LEVEES

Levees from 1953 to 1992 were mapped that appeared to be important factors in property loss during large floods. Although many levees have been built that are not portrayed on the Geomorphic Map, they were not mapped because they did not appear to be catalysts for channel change on the Gila River. Table 1 lists the aerial photographs that were used in mapping levees. Note that the levees are assigned the year of aerial photography, although they may have been present for several years prior to photography. For instance, the 1981 levees were built sometime between the 1978 and 1981 aerial photography.

Table 1. Source data for mapped levees.

DATE	SOURCE	SCALE	FILM TYPE
1953	Army Map Service	1:54,000	Black & White
1967	USDA	1:20,000	Black & White
1978	BLM	1:24,000	Color
1981	USGS	1:32,800 to 1:34,000	Color Infrared
1992	USGS	1:40,000	Black & White

PROPERTY LOSS

Property loss is defined as land lost during large floods apparently as a direct result of levee construction along the Gila River. Property loss includes only land that was not previously channel bottom during the historical period. Farmed areas that were previously part of the channel bottom during the 1930's and 1950's, were leveled for agriculture during the 1960's and 1970's, and subsequently eroded following large floods in recent decades are not included in this map unit. Although we recognize that there was an economic loss when this property was eroded, the purpose in this study is to determine areas of instability in the river channel. Since this property was previously occupied by the Gila River during the historical period (1935-2000), we would not consider the channel to be unstable if it reoccupied these areas during large floods. These areas were found to exist only in Safford Valley. Some examples of areas like this include (Figures 11 and 12).

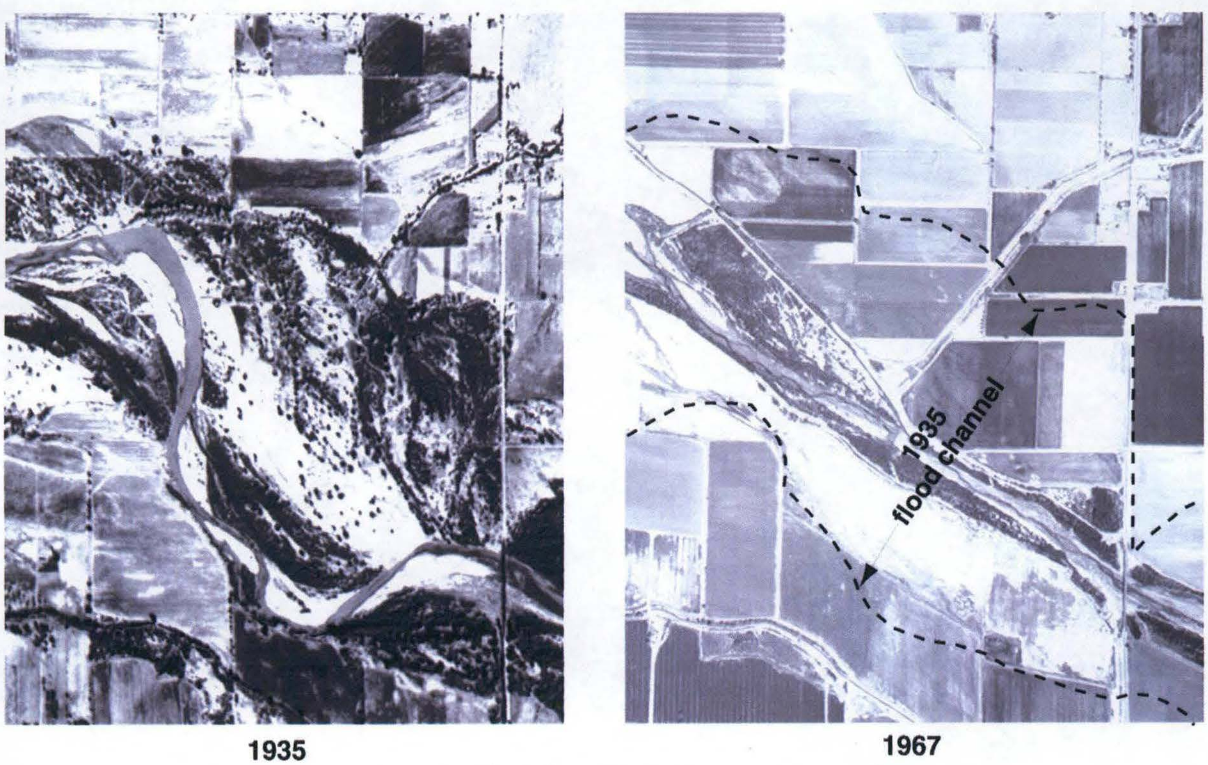


Figure 11. Example of flood channel leveled for agriculture near Solomon.

Areas of property loss as defined above were determined using historic aerial photography and soil surveys to identify areas in the active channel that were previously occupied by older alluvium during the 1930's and 1950's. Older alluvium includes Pima alluvium or alluvium mapped as part of the geomorphic limit. In some cases, recent (less than 100 years old) alluvium with channelized surfaces is also included where it was dramatically eroded due to levees and floods.

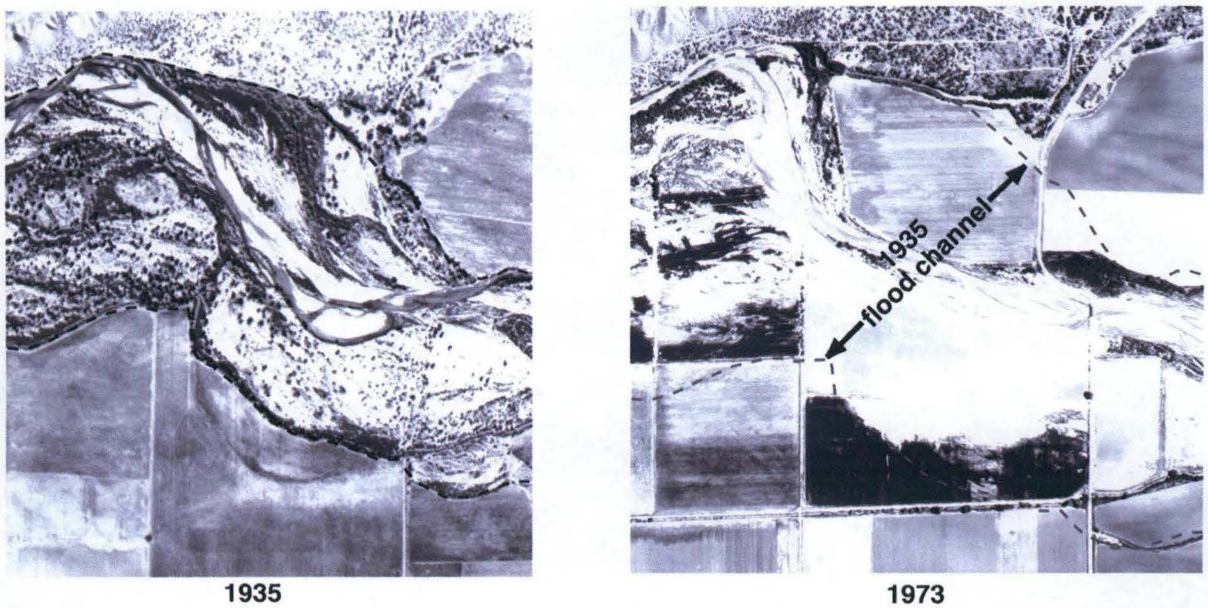


Figure 12. Example of flood channel leveled for agriculture near Solomon.

REACH-BASED ANALYSIS

Several reaches were discovered that had significant erosion of property that warranted a detailed discussion of the areas of property loss and factors that contributed to its erosion. Reaches are discussed from upstream to downstream in order to address in a logical manner the effect of upstream structures and channel changes on downstream channel morphology. Each analysis is accompanied by its portion of the geomorphic map. The yellow lines on each figure represent the geomorphic limit of flood evidence while the purple lines represent the Pima Soil Boundary. Areas shaded blue represent property loss. Additional colors represent levees of various construction years, the most prevalent being 1981 (red), 1992 (green) and 1967 (pink). Flow is from right to left in the geomorphic map figures.

RAILROAD WASH

The Railroad Wash reach extends from the left bank near Railroad Wash to the end of the property loss parallel to Lunt Road (Map 30 Geomorphic Map; Figure 13). This reach has experienced erosion of older alluvium along the left bank and young alluvium along the right bank that had been floodplain historically rather than a part of the channel. It appears that levees constructed along the right bank prevented flow from accessing a point part on the right bank that had been historically flooded during large discharges. The construction of these levees following the 1978 flood forced erosion of the stable consolidated bank. This bank as well as the Railroad Wash alluvial fan just downstream forced floodwaters to breach the left bank levee near the southern end of Lunt Road.

Figure 13. Railroad Wash geomorphic map.

CUTOFF MEANDER

The cutoff meander reach is just downstream from the previous reach and consists of a new channel that was formed during the 1993 and 1995 floods, cutting off a previous meander of the Gila River and effectively reducing the sinuosity of this reach (Map 29 Geomorphic Map; Figure 14).Although it was common for this part of the floodplain to be inundated during large floods such as the 1978 flood, the main channel had remained in a very similar position throughout the historical period. The continuation of the new channel geometry from the Railroad Wash reach caused erosion of the left bank and breach of the levee constructed along the right bank both on the upstream and downstream ends of the new channel. Remnants of the 1981 levee can be observed in the 2000 aerial photography.

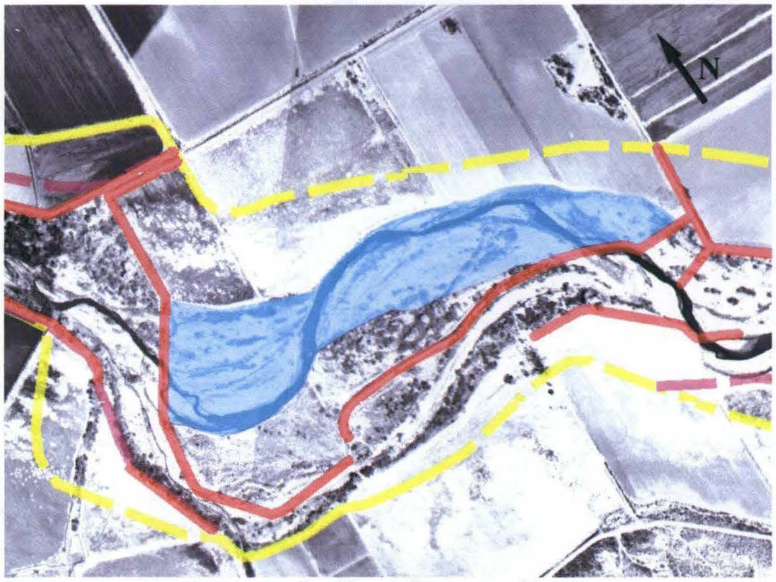


Figure 14. Cutoff meander geomorphic map.

DUNCAN BRIDGE

The Duncan Bridge reach is a short reach located upstream of Duncan Bridge (Map 28 Geomorphic Map; Figure 15). The erosion along the left bank appears to be a result of the extensive levees constructed along the right bank and the propensity of rivers to erode outside bends. Aggradation in the leveed reach has caused repeated breaching of the levee downstream of Duncan Bridge and significant sedimentation over Pima alluvium on the west side of the river.

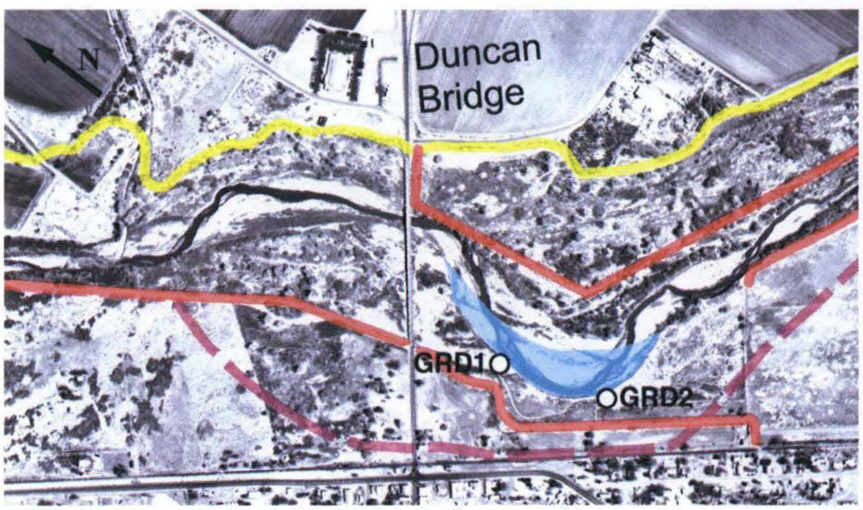


Figure 15. Duncan Bridge geomorphic map.

WHITEFIELD WASH

Located just downstream of Duncan Bridge near Whitefield Wash is a reach which experienced dramatic channel change following the floods of 1993 and 1995 (Geomorphic Map 27; Figure 16). The construction of levees with greater height and extent following the 1978 flood caused erosion of left bank and right bank property as flood flows breached the higher levee, creating a shift in the meander pattern and corresponding erosion of opposing banks as the meander moved downstream.

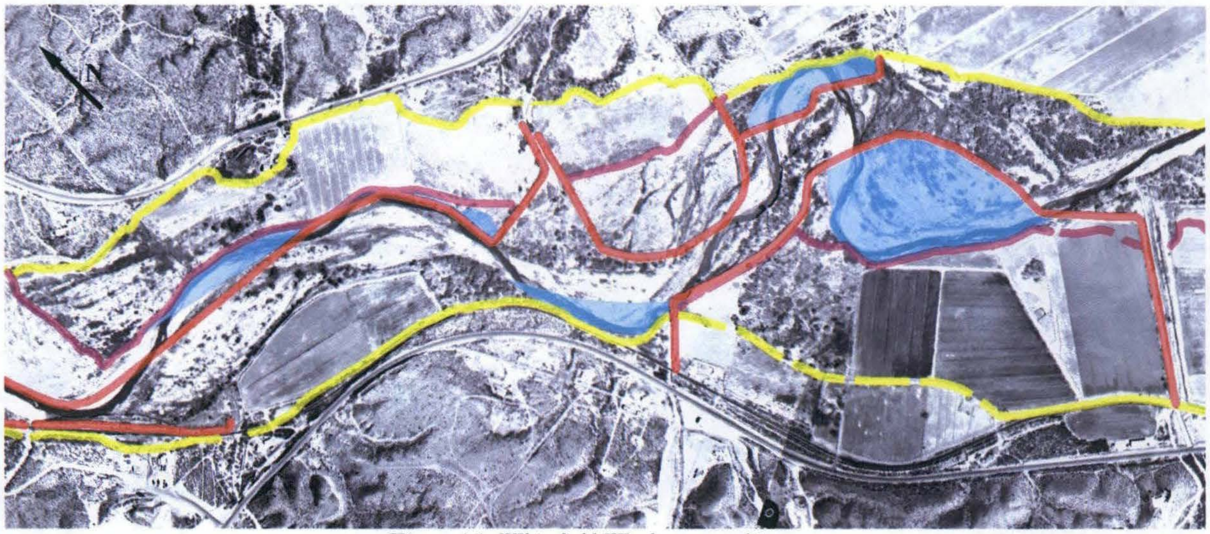


Figure 16. Whitefield Wash geomorphic map.

KAYWOOD WASH

The Kaywood Wash reach is located between Kaywood Wash and Apache Creek. Property loss is located on the right bank, where tributary alluvial fan materials are exposed in vertical banks (see Figure 9; Geomorphic Map 23; Figure 17). Prior to levee construction on the right bank, the river was able to access the right overbank; without this area, the river was directed toward the left bank and into the right bank levee downstream. Vegetation on the left bank may have played a part in directing the river toward the right bank.

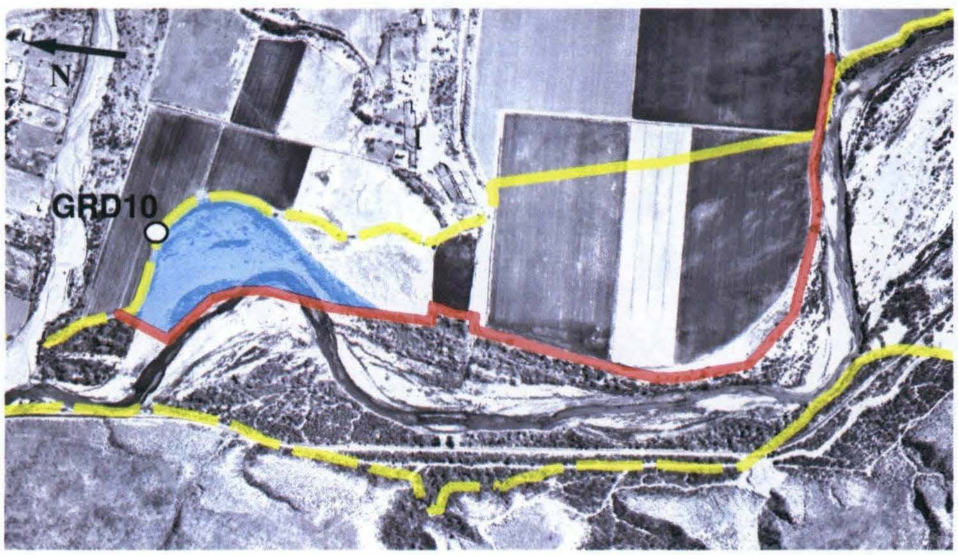


Figure 17. Kaywood Wash geomorphic map.

SAN JOSE DIVERSION

Property loss associated with San Jose Diversion extends for two miles downstream of the structure and is mainly a result of the dam orientation, which directs flow toward the right bank (Geomorphic Map 17-18; Figure 18). During floods in recent decades the river has increased in sinuosity, eroding both right and left banks as the meander propagated downstream.

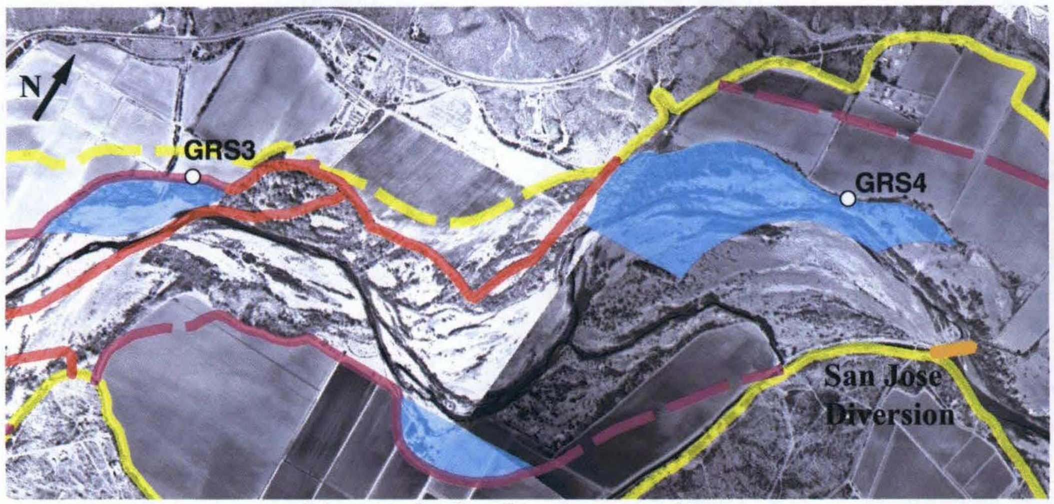


Figure 18. San Jose Diversion geomorphic map.

SAN JOSE WASH

This reach is located near San Jose Wash, where numerous levees were constructed following the 1978 flood (Geomorphic Map 15-16; Figure 19). Some of these levees were constructed along farmland while others were constructed in the channel; regardless, these levees in combination forced subsequent floods to erode opposing banks. Upstream of San Jose Wash, levees on the right bank caused erosion of left bank property while downstream of San Jose Wash, a levee on the left bank forced floods to erode the right bank. These levees were also appear to have been eroded during the floods as well, although it is difficult to reconstruct the sequence of events.

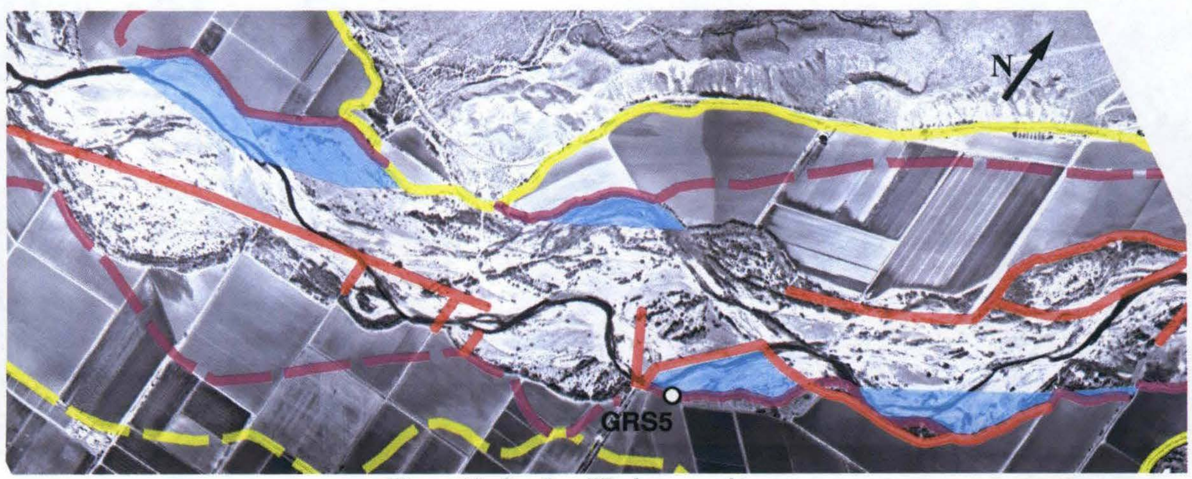


Figure 19. San Jose Wash geomorphic map.

GRAHAM DIVERSION

Levees constructed upstream of Graham Diversion to direct flow over the diversion dam. During large floods, water overtopped this levee, which directed it toward the left bank, causing the erosion of farmland near the ditch between Safford and Hollywood (Geomorphic Map 14; Figure 20). A levee constructed along this property was not successful in preventing the erosion. Although the channel morphology in this area appears unnatural, it has been present since 1935, which is the oldest aerial photography available (Figure 21).

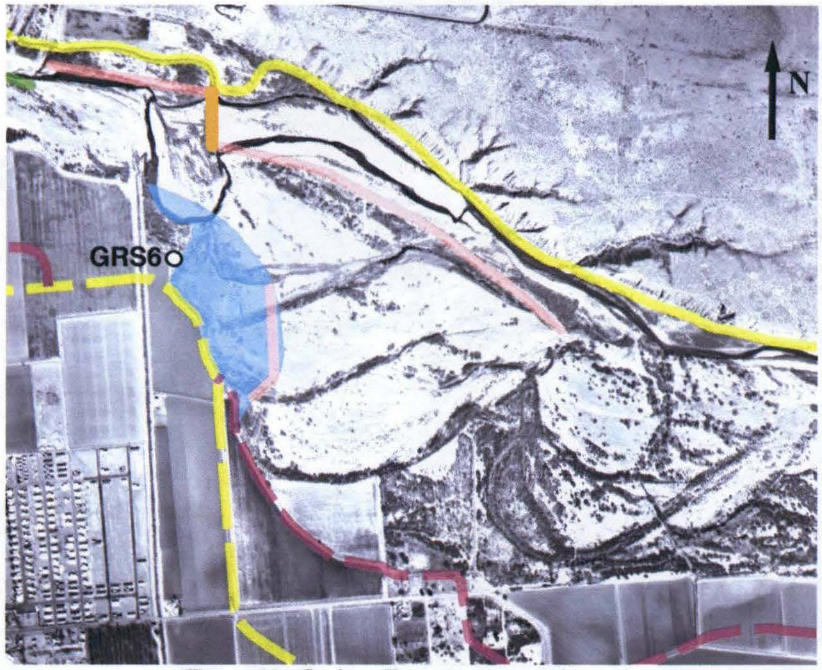


Figure 20. Graham Diversion geomorphic map.

Figure 21. 1935 aerial photograph of Graham Diversion.

SMITHVILLE DIVERSION-TALLEY WASH

The Smithville Diversion reach is located upstream of Smithville Diversion and downstream of Smithville Diversion to Talley Wash (Geomorphic Map 12; Figure 22). Geomorphic changes that are documented are not described necessarily in the order of occurrence. This reach consists of a confined reach downstream of Safford Bridge with levees on the north side and bank protection on the south side of the river. Downstream, a straightened reach where the river is dredged and lined with unconsolidated 'levees'

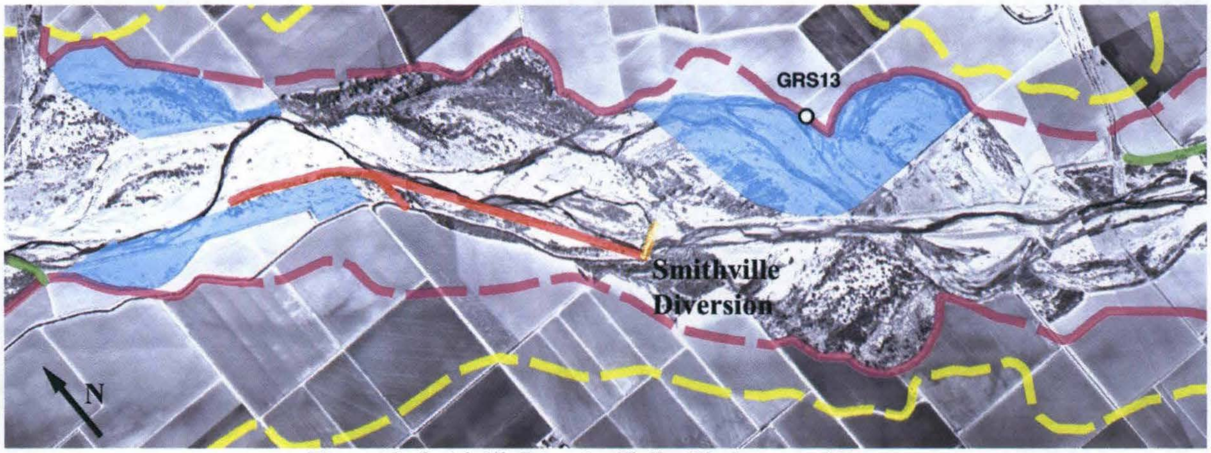


Figure 22. Smithville Diversion-Talley Wash geomorphic map.

is intended to direct flow over the diversion. Flood flow during the 1980's and 1990's was redirected toward the banks, eroding the banks and a field of Pima Soil on the north side of the river. Flow over Smithville Diversion directed floods toward the right bank downstream due to the orientation of the diversion and levee on the left bank. This eroded Pima Soil near Talley Wash. Alluvium downstream of the left bank levee is also eroded. The levee was eventually breached, eroding the floodplain behind the levee.

WATSON AND BUTLER WASHES

The Watson and Butler reach extends from Watson and Butler washes to the first southwest corner of Safford-Bryce Road near the Gila River (Geomorphic Map 10-11; Figure 23). A levee constructed following the 1978 flood between Watson and Butler washes on the right bank, caused erosion of the left bank immediately downstream and propagation of a new meander train. This disturbance continued downstream for approximately two miles. Levees mapped at the downstream end of this reach may have had minor impacts on bank erosion.

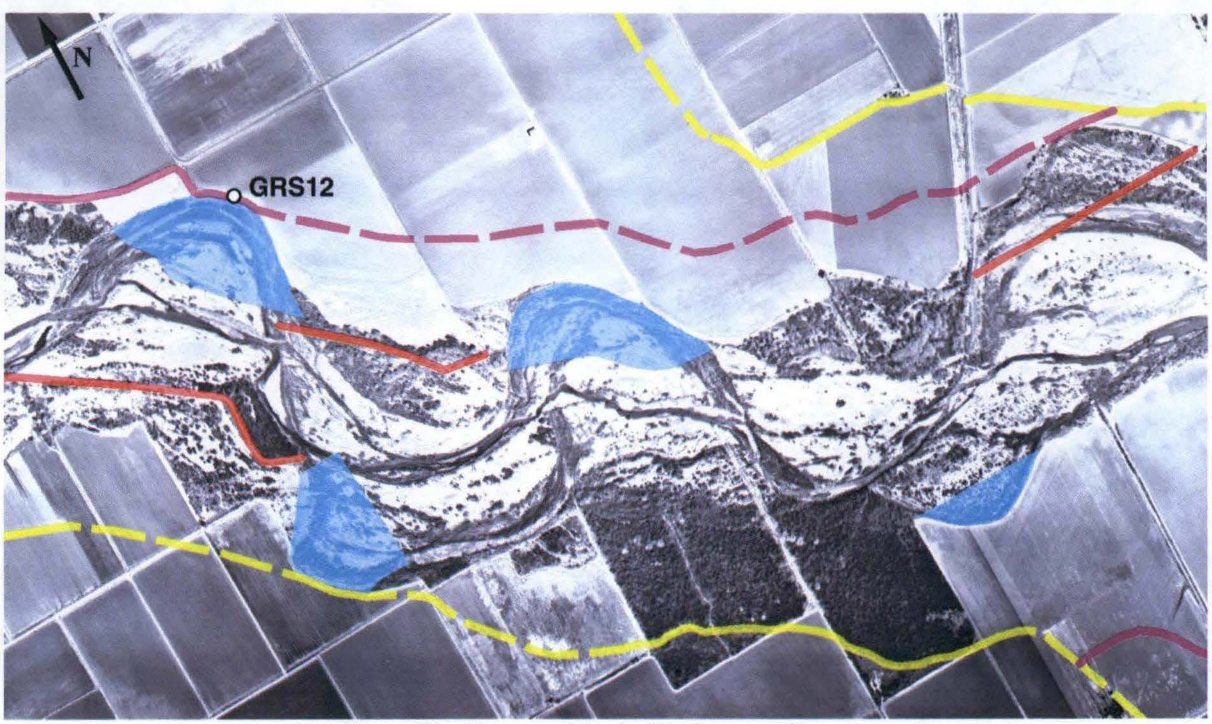


Figure 23. Watson and Butler Wash geomorphic map.

CURTIS DIVERSION

Erosion from Curtis Diversion to Markham Wash appears to be related to channel straightening during the 1970's (Geomorphic Map 8-9; Figure 24). Following the initial channel straightening in the 1970's a new meander pattern was established as the river abandoned the artificial channel. This pattern developed through time as subsequent floods created new channel morphology. Thick vegetation in this reach was important in establishing the new channel morphology. Near the downstream end of the reach, flow repeatedly overtopped the embankments of the channel and flowed perpendicular to the overall flow direction, creating large loop-shaped erosion scars.

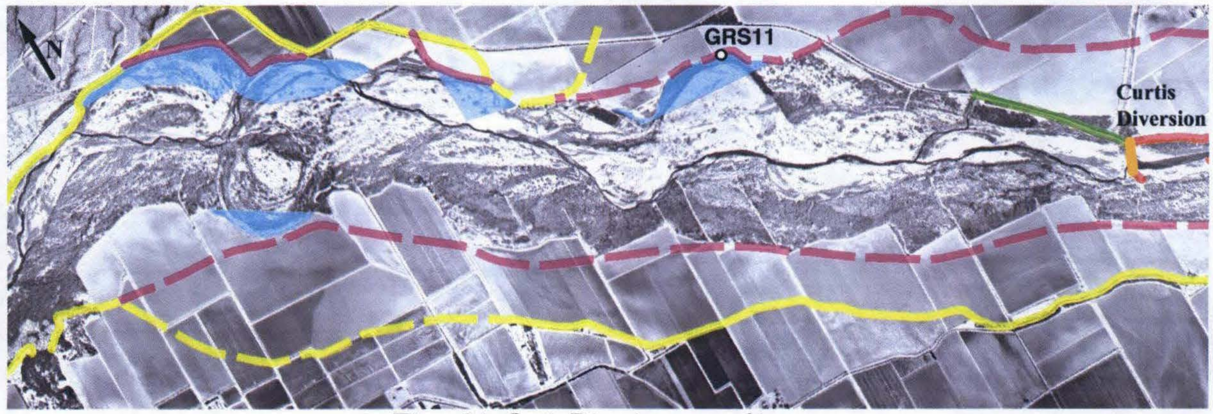


Figure 24. Curtis Diversion geomorphic map.

FORT THOMAS DIVERSION

At Fort Thomas Diversion, erosion of the right bank is most likely associated with breach of a levee constructed after the 1978 flood (Geomorphic Map 7-8; Figure 25). The bank today is heavily rip rapped; mapping and site investigation indicates that Pima alluvium previously occupied the eroded area.

Figure 25. Fort Thomas Diversion geomorphic map.

EDEN BRIDGE

North of Eden Bridge, the Geomorphic Limit is adjacent to the active channel on the left bank. A levee built in 1967 effectively isolated a narrow band of Gila alluvium that was accessed during floods (Geomorphic Map 5-6; Figure 26). During floods in the 1970's, 80's and 90's, the left bank was eroded downstream of the levee. Downstream propagation of erosion caused the left bank to be eroded again downstream and breach of a 1981 levee on the right bank. Although the levee breach did not erode old alluvium, the active channel is presently adjacent to the Geomorphic Limit on the right bank.

Figure 26. Eden Bridge geomorphic map.

FORT THOMAS BRIDGE

The Fort Thomas reach extends from Fort Thomas Bridge to Goodwin Wash (Geomorphic Map 2-3; Figure 27). In contrast to most reaches where the 1983 and levees constructed prior to this flood were factors in channel change, property loss in this reach is associated with floods in the 1990's. Although the 1983 flood caused extensive damage to agricultural fields by breaching the right bank levee upstream of Fort Thomas Bridge, it did not cause extensive channel change (Figure 28). Construction of a new levee in a similar location upstream of Fort Thomas Bridge prevented a breach during subsequent floods.

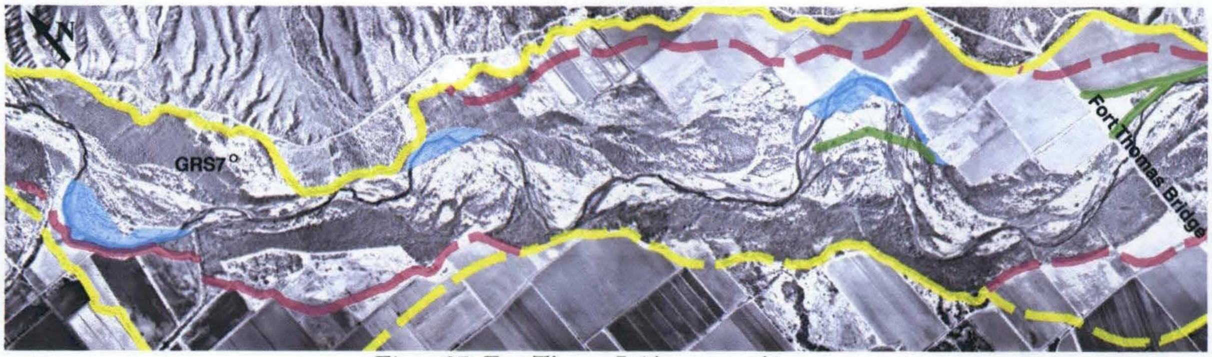


Figure 27. Fort Thomas Bridge geomorphic map.

Figure 28. Receding floodwaters, Fort Thomas Bridge, October 7, 1983.

Instead, floods breached the right bank levee downstream, eroding property and creating new channel bottom. The location of the breach was most likely caused by thick vegetation as well as alluvial fan material from Fine wash on the left bank. Additional property loss continues downstream and is mainly controlled by thick vegetation and the location of alluvial fans such as Day Mine Wash.

GERONIMO

The Geronimo reach is located near Geronimo and extends downstream to the San Carlos Indian Reservation boundary (Geomorphic Map 1; Figure 29). In this reach, levees on the right bank appear to be most problematic; erosion of these levees during the 1980's and 1990's accentuated the outside bend at this location and directed the river toward the left bank where banks older than 700-1000 years were eroded (see site GRS1). The effect on channel morphology has been a historical increase in sinuosity and a channel with 90 degree bends unlike that of 1935 (Figure 30). Although it may seem at first that much more property has been lost than is portrayed, from the 1935 photos it is apparent that much of the property that was farmed on the south side of the river in the 1960's and 1970's was part of the Gila River channel in 1935. In addition, farmland on the north side of the river also has clear evidence for channelization in 1935 and is mapped as young alluvium in the Gila Soil Series.

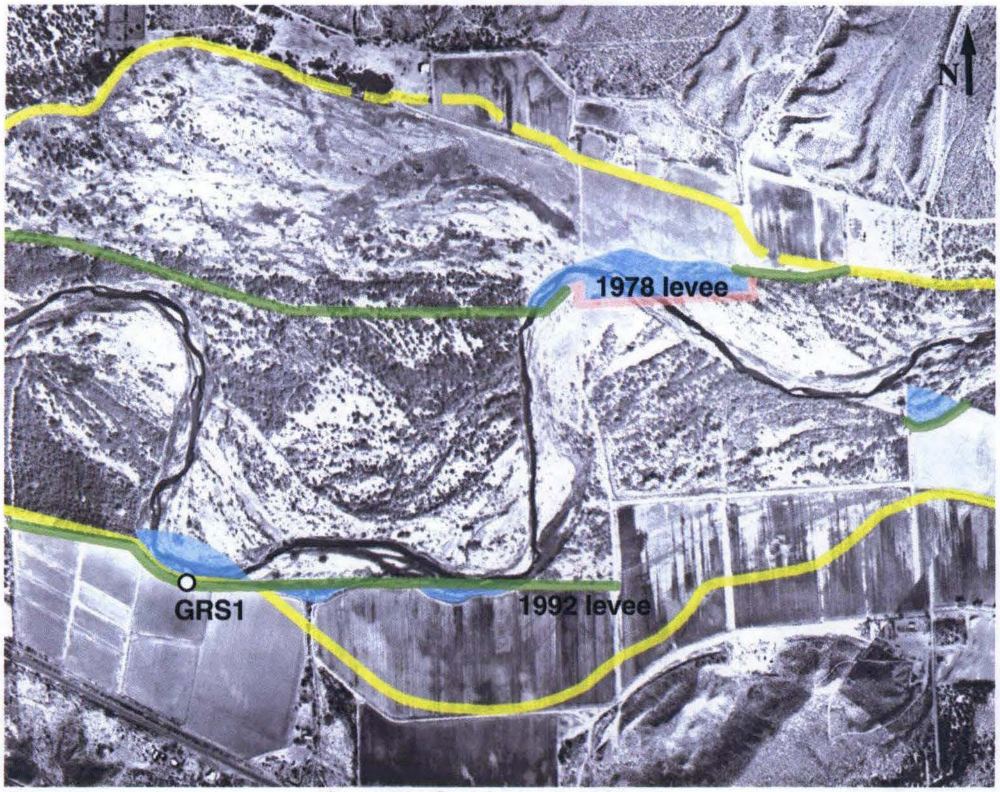
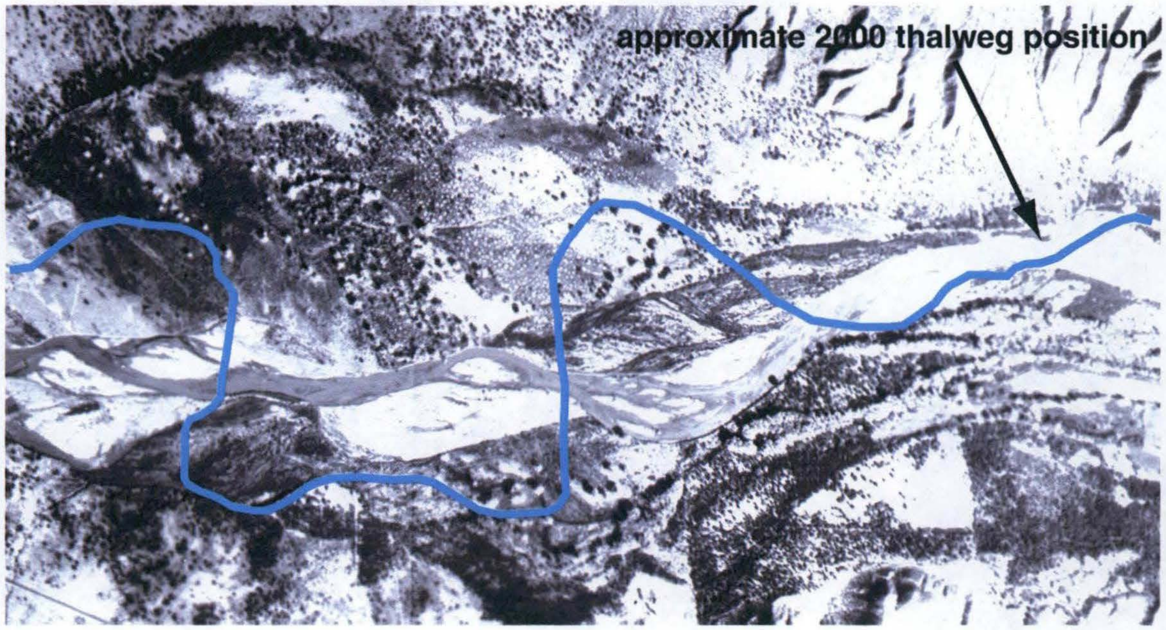


Figure 29. Geronimo geomorphic map.



1935

2000

Figure 30. Comparison between 1935 and 2000 channel near Geronimo, AZ.

DISCUSSION

The geomorphic map provides evidence for lateral stability and instability along the Gila River. Surfaces with well-developed soils have not been deeply inundated for long periods of time and have also not been eroded providing control for lateral movement over the time frame of soil development. The Pima Soil Boundary and Geomorphic Limit provide evidence of stable soils and therefore boundaries for lateral stability. The Geomorphic Limit of Flood Evidence is against bedrock and piedmont alluvium in some places, while in other areas the alluvium appears to be related to the Gila River. This alluvium found in exposed banks has not been deeply inundated for at least 1,000 years. Alluvium in tributary fans may be younger than 1,000 years; however, it provides a limit to lateral migration because it is more difficult to erode. Surfaces with the Pima Soil have been developing for at least several hundred years. Although floods from the Gila River may occasionally inundate these surfaces, they do not appear to be active floodplain based on stratigraphy of bank exposures in which the developing soil is not buried by young sediments. A major exception to this statement occurs in the vicinity of Duncan Bridge where aggradation within the levees has resulted in breaching of the left bank levee downstream of Duncan Bridge and substantial sedimentation over the Pima Soil. In comparing Safford Valley and Duncan Valley, the Geomorphic Limit is much closer to the active channel in Duncan Valley when compared to the Geomorphic Limit in Safford Valley. This seems logical since the size of the river is much smaller in Duncan Valley, whereas the San Francisco River greatly increases the size of peak discharges and therefore the width of the Gila River flood channel in Safford Valley. The Pima Soil is only preserved in wider reaches of Duncan Valley, where floods do not occupy the entire width within the Geomorphic Limit. In Safford Valley, the Pima Soil is more prevalent, paralleling the Gila River for the majority of its length in the study reach.

Tributary alluvial fans appear to play an important role in channel position and recent geomorphic change. In some cases, deposition of alluvial material in the active channel redirects the channel toward the opposite bank (i.e., Railroad Wash). In other cases, the position of old fans exerts a long-term control on channel position, where channel geometry is clearly related to the alluvial fan. Examples of this scenario occur in Duncan Valley near Apache Peak and Kaywood Wash. In Safford Valley, Day Mine Wash and Markham Wash are two fans that exert important controls on channel geometries. Other authors have attributed similar importance to the capacity of alluvial fans to influence channel geometries on the Gila River (i.e., Burkham, 1972; Levish, in prep.).

Recent vegetation encroachment in the floodplain from Pima to the San Carlos Indian Reservation also appears to be an important control on active channel morphology and in geomorphic change during floods. By acting as a barrier to flow, thick vegetation may cause erosion of banks with less vegetation during floods. By allowing a smaller volume of water to flow through the main channel, thick vegetation may increase the likelihood of levee breaches or avulsions from the main channel (see Figure 28; Hooke, 1996; Burkham, 1976).

COMPARISON TO CATALOG OF HISTORICAL CHANGES

The geomorphic analysis compares well with the Catalog of Historical Changes (Task 7A) in identifying reaches of channel change. The majority of reaches are the same; however, the Geomorphic Analysis identified additional areas in both valleys (Figure 31; Table 2). The differences can be partly attributed to differences in the methodologies used for each analysis. The Catalog of Historical Changes identifies areas where historically there has been the greatest variation in channel width regardless of the age of the alluvium that is being eroded. Areas of flood channel that are leveled for agriculture during the historical period are not included in the Geomorphic Analysis while in the Catalog they are retained because it documents historical changes. The Geomorphic Analysis provides a long-term perspective and documents river stability based on erosion of surfaces that have been stable for at least the historical period and in many cases much longer. For example, near Solomon Bridge, 1935 flood channel on the right bank was leveled for agriculture by 1973 (Figure 32). Case Study 4A downstream of Solomon Bridge documents substantial historical channel change due to land leveling for agriculture (Figure 33). The same area in the Geomorphic Analysis is not identified because the area was occupied by historical channels.

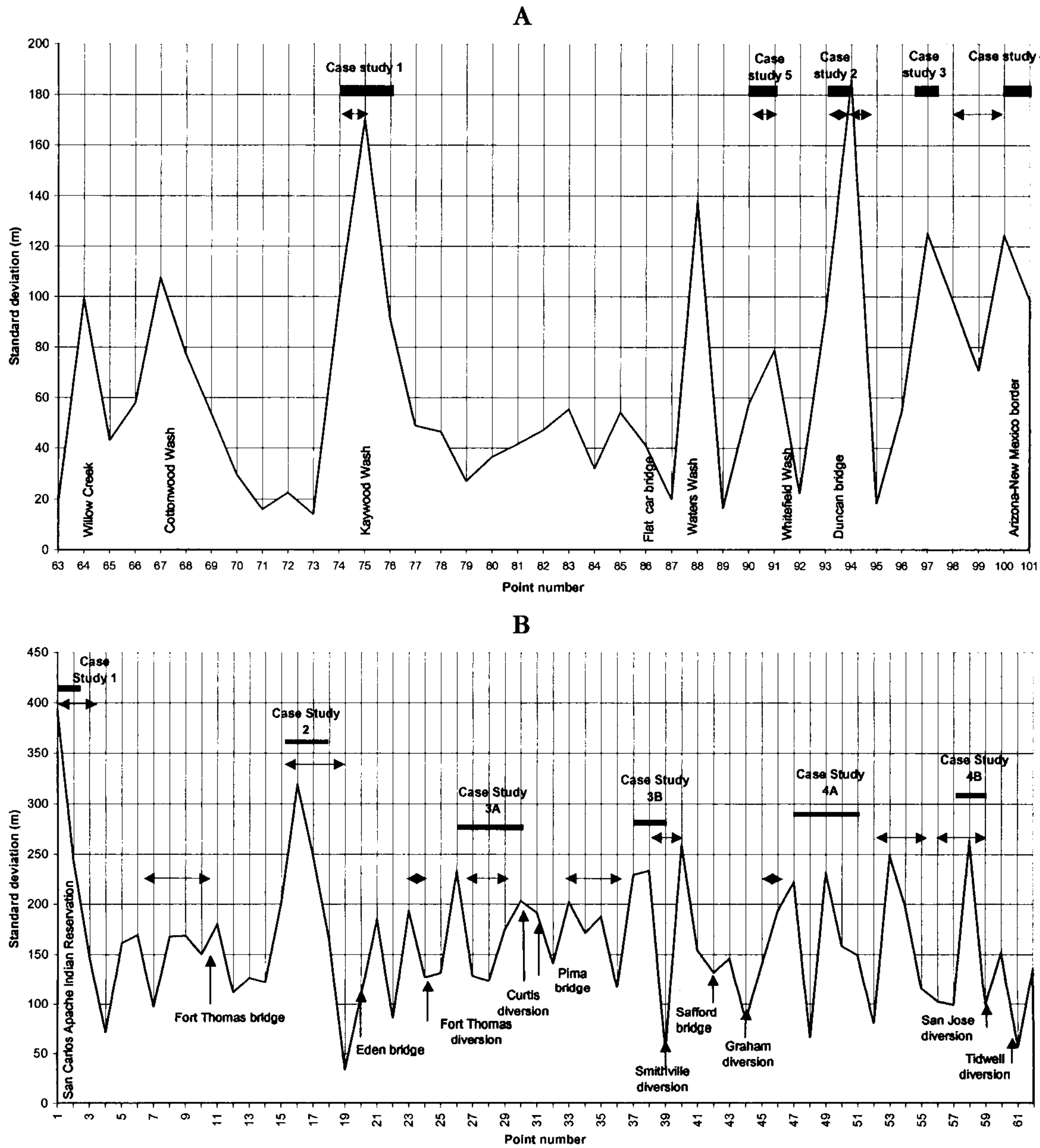


Figure 31. Reach comparison between this analysis and the Catalog of Historical Changes.

Table 2. Reach comparison, this analysis versus the Catalog of Historical Changes (Klawon, 2001).

Reach Name (Geomorphic Analysis)	Corresponding Case Study Reach (Catalog of Historical Changes)
Railroad Wash	3 (Duncan Valley)
Cutoff meander	none
Duncan Bridge	2 (Duncan Valley)
Whitefield Wash	5 (Duncan Valley)
Kaywood Wash	1 (Duncan Valley)
San Jose Diversion	4B (Safford Valley)
San Jose Wash	none
Graham Diversion	none
Smithville Diversion/Talley Wash	none/3B (Safford Valley)
Watson and Butler Washes	none
Curtis Diversion	3A (Safford Valley)
Fort Thomas Diversion	none
Eden Bridge	2 (Safford Valley)
Fort Thomas Bridge	Reach of Intermediate Variability (Safford Valley)
Geronimo	1 (Safford Valley)

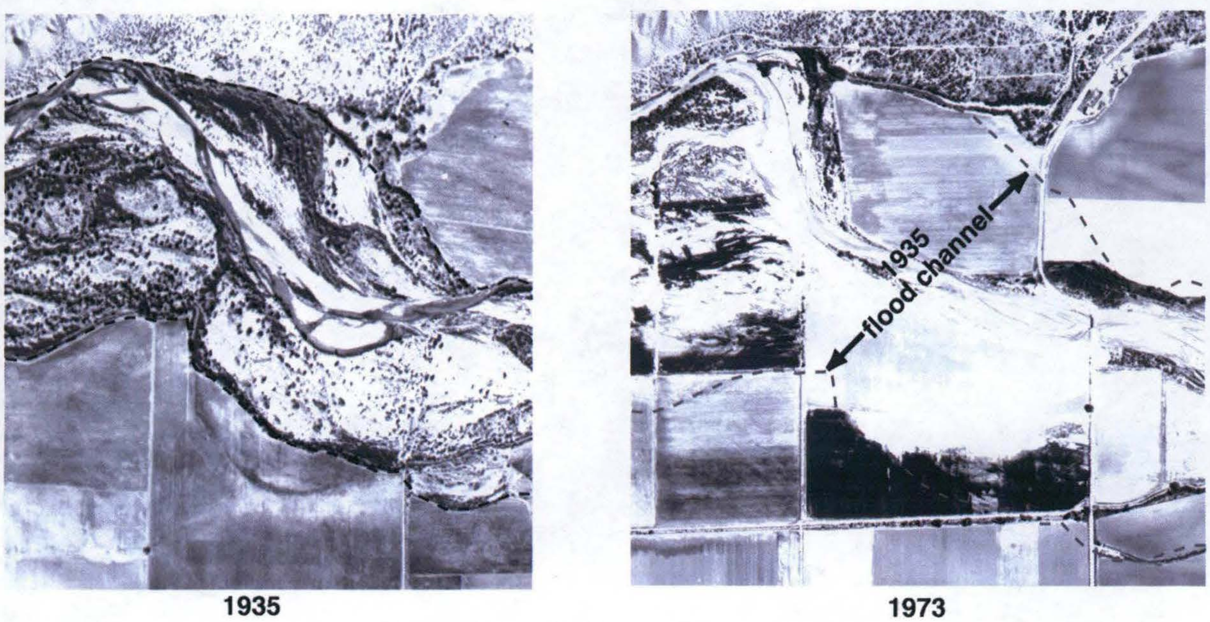


Figure 32. Land leveling near Solomon Bridge.

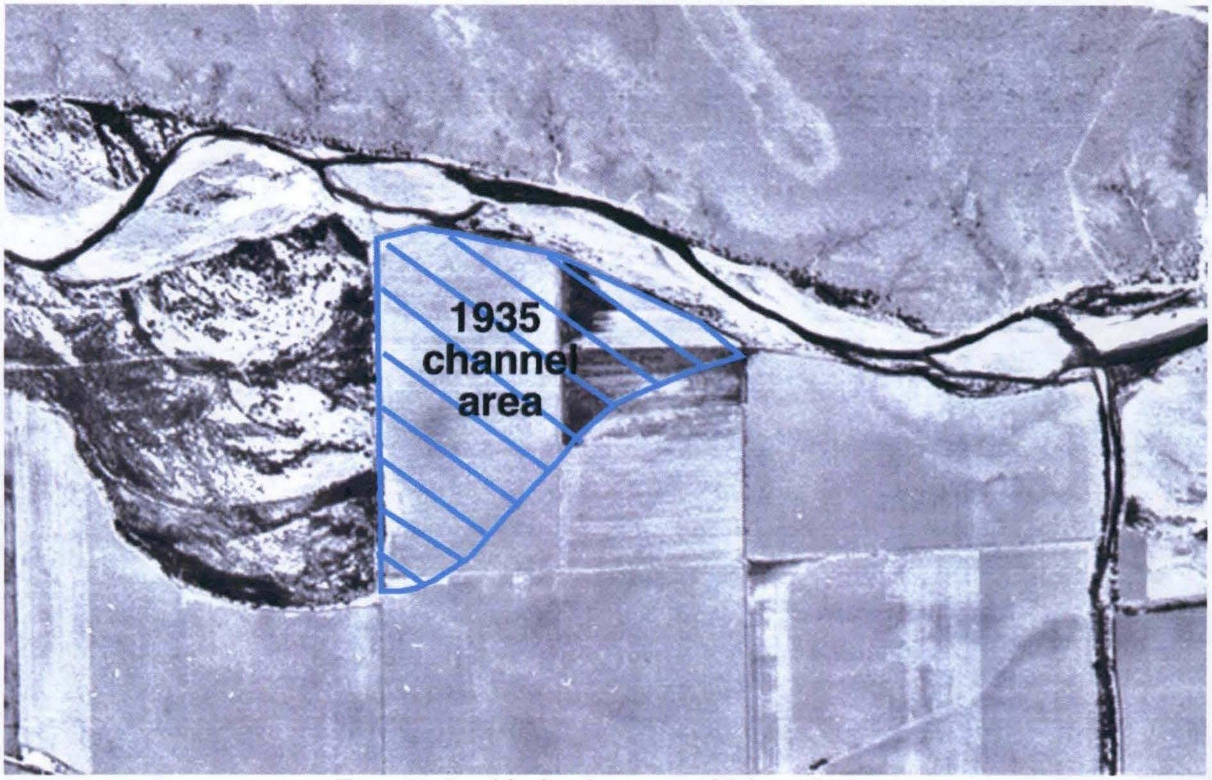


Figure 33. Land leveling downstream of Solomon Bridge.

Other reaches identified in the Geomorphic Analysis that are not identified in the Catalog of Historical Changes do not rank high enough in historical variation in width to be identified as areas of substantial change. A few areas such as between Safford Bridge and Smithville Diversion were not identified because they were simply not selected as case studies. There is also a potential for the methods used in the Catalog to completely miss a short reach of geomorphic change. This is illustrated in the case of the cutoff meander upstream of Duncan Bridge (between points 95 and 96). This reach fell in between width measurements and therefore was not identified.

COMPARISON TO STABLE CHANNEL ANALYSIS

The Geomorphic Analysis also appears to support findings of the Stable Channel Analysis. In the Geomorphic Analysis, reaches along the entire length of Safford Valley have experienced instability, although some with greater amounts of property loss than others. Lower reaches 1 and 2, located downstream of Ashurst, are identified as unstable in the Stable Channel Analysis. Although several unstable reaches are identified here, the instability that the Stable Channel Analysis identifies is one of channel migration in young alluvium. In reaches 3 and 4, the Stable Channel Analysis indicates that while the reaches are relatively stable in the current channel configuration, substantial lateral movement has occurred. This lateral movement is also confirmed by the Geomorphic Analysis in reaches from San Jose Diversion to Curtis Diversion. The Upper Reach, located from Sheldon to Franklin in Duncan Valley, indicates degradation in the Stable Channel Analysis. This result is supported by young alluvium that may be two meters above the active channel. Near Duncan, areas of incision appear to be located on the outer bends of the channel and are relatively localized. Between Waters Wash and Sheldon, young alluvium is incised but is still experiencing deposition on its surfaces during floods. It is possible that these fluctuations are caused by natural constrictions such as alluvial fans and bedrock, and by the process of vertical accretion.

COMMON PATTERNS OF LATERAL INSTABILITY

The Catalog of Historical Changes and the Geomorphic Map reveal the close correlation between levee construction and subsequent failure and geomorphic change along the Gila River in Arizona. As the Geomorphic Map was compiled, several factors causing instability emerged as common to multiple reaches (Table 3). These factors include: (1) levee failure; (2) downstream propagation of erosion; (3) channel straightening; (4) diversion dam orientation. Levee failure causes catastrophic property loss because failure results in water flowing nearly perpendicular to the former flood channel. The reduction of flood plain storage and the decrease in flood channel sinuosity results in higher flood velocities. Since the levees artificially raise the stage of the floodwater, the water flowing from a levee breach generally has tremendous energy compared to normal overbank flows. Once behind the levee, the water must find a return path to the main channel. This return path also acts as an effective flow redirection and can propagate erosion and levee failure downstream. Examples of this pattern are the cutoff meander upstream of Duncan Bridge and Whitefield Wash downstream of Duncan Bridge. These reaches were confined by high levees following the 1978 flood. Once the levees were breached, considerable erosion ensued behind the levees. Much of the floodplain that had previously been inundated during large floods became river channel and was lost to future agriculture. Erosion continued until flow reentered the river downstream. Remnants of levees and the previous main channel can be viewed in the 2000 aerial photography.

Table 3. Agents of geomorphic change in Safford and Duncan Valleys.

Reach Name	Alluvium of eroded banks	Pattern
Railroad Wash	Gila GL	Levee breach
Cutoff meander	Gila	Levee breach
Duncan Bridge	Gila	Channel straightening
Whitefield Wash	Pima GL	Levee failure
Kaywood Wash	GL	Levee failure
San Jose Diversion	Gila Pima	Diversion dam orientation/DS Propagation
San Jose Wash	Gila Pima	Pinball effect
Graham Diversion	Gila Pima	Diversion dam orientation and levee failure
Smithville Diversion/Talley Wash	Gila Pima	Channel straightening DS Propagation
Watson and Butler Washes	Gila Pima GL	DS Propagation
Curtis Diversion	Gila Pima	Channel straightening
Fort Thomas Diversion	Gila Pima	Levee failure
Fort Thomas Bridge	Gila Pima	DS Propagation
Geronimo	Gila GL	DS Propagation

In downstream propagation of erosion, an initial perturbation such as a levee or diversion dam redirects flow toward the opposite bank causing erosion; the process continues downstream so that alternating banks are eroded. In Safford Valley, this wave of propagation generally appears to dissipate within two miles of the initial perturbation. Examples of this pattern include San Jose Diversion and Watson and Butler Washes. While the initial perturbations were different, the effects appear very similar. Both reaches show erosion of alternating banks due to structures which redirected flow into opposing banks.

A similar process occurs when channels are straightened. This channel modification also decreases flood channel sinuosity, decreases sediment transport resulting in aggradation within the levees and redirects flow when floodwaters reach a stage high enough to breach levees. In the case of Smithville Diversion and Curtis Diversion, it appears that relatively unconsolidated levees were constructed from the dredged sediments of the straightened reach. Once the river breached these levees, it was directed toward the banks and began to scour large loop-shaped patterns into the surrounding flood plain (Figure 34). This processed recurred as the channel was straightened repeatedly and large floods breached the levees.

Diversion dam orientation may also cause erosion of opposing banks. This is an isolated case of factor (2), where erosion of the opposing bank does not initiate a propagation of erosion downstream. As water flows over the diversion, it is directed perpendicular to the diversion's orientation. If that direction points toward the opposite bank, then erosion most likely will occur during large floods. A chronology of photos shows progressive erosion of the opposite bank downstream of San Jose Diversion dam inferred to occur during large floods between the years of the aerial photographs (Figure 35). This erosion eventually forced erosion to propagate downstream into older alluvium.

Figure 34. Effects of channel straightening near Curtis Diversion.

VERTICAL CHANGES

A detailed analysis was not performed to assess vertical changes in Safford and Duncan Valleys. Qualitative observations, however, of soils and elevations above the active channel can be used to provide some insight on these types of fluctuations. In general, observations suggest that the Gila River is not currently undergoing widespread aggradation or degradation in Safford and Duncan Valleys. This is based on the absence of young sediments overlying older soils associated with the Pima Soil Boundary and Geomorphic Limit. A few areas of localized vertical changes should be noted. In the vicinity of Duncan Bridge, qualitative observations indicate that there has been aggradation in this reach. Young sediment overlies an older soil in the Gila alluvium on the left bank upstream of Duncan Bridge (Figure 36). This package of sediment appears to thin upstream and thus would be interpreted as a wedge of sediment associated with Duncan Bridge. Downstream of Duncan Bridge, sediment deposition associated with levee breaches on the left bank over the Pima alluvium would also suggest aggradation. Recent channel changes, however, have caused some of the banks of Gila alluvium to be 2 meters or more above the active channel. These high banks are located on outer bends and appear to be localized areas of incision since other areas of Gila alluvium in the vicinity are less than one meter above the active channel. Between Waters Wash and Sheldon, young alluvium is incised but still is experiencing deposition on its surfaces during floods. It is possible that these fluctuations are caused by natural constrictions such as alluvial fans and bedrock, and by the process of vertical accretion. A few areas on the left bank near Safford appear to be aggraded. These areas of aggradation are most likely caused by local bank protection and levees. Although many observations were made in Safford and Duncan Valleys during field work, there may be other short reaches that were not field checked that have similar characteristics.

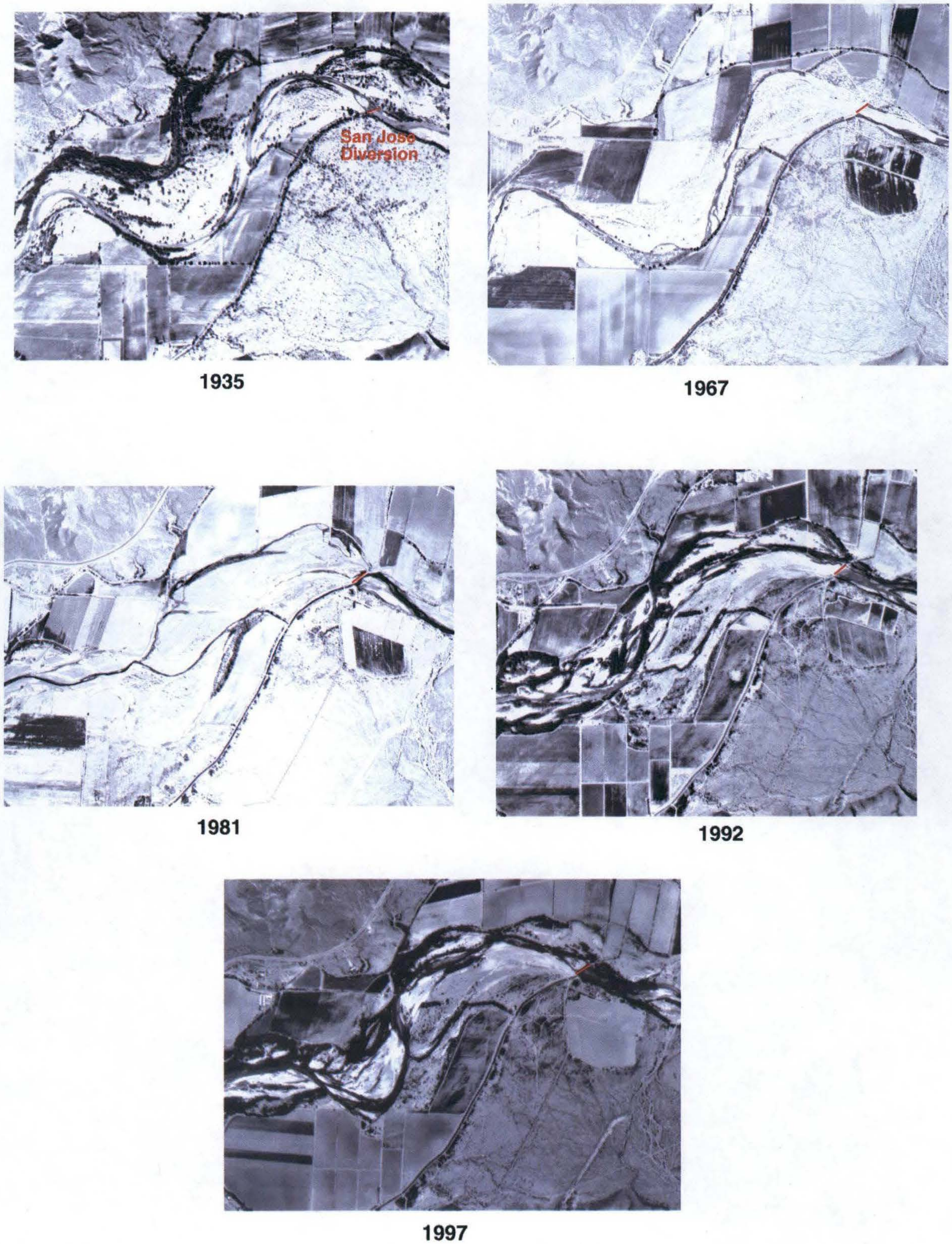


Figure 35. San Jose historical channel changes.

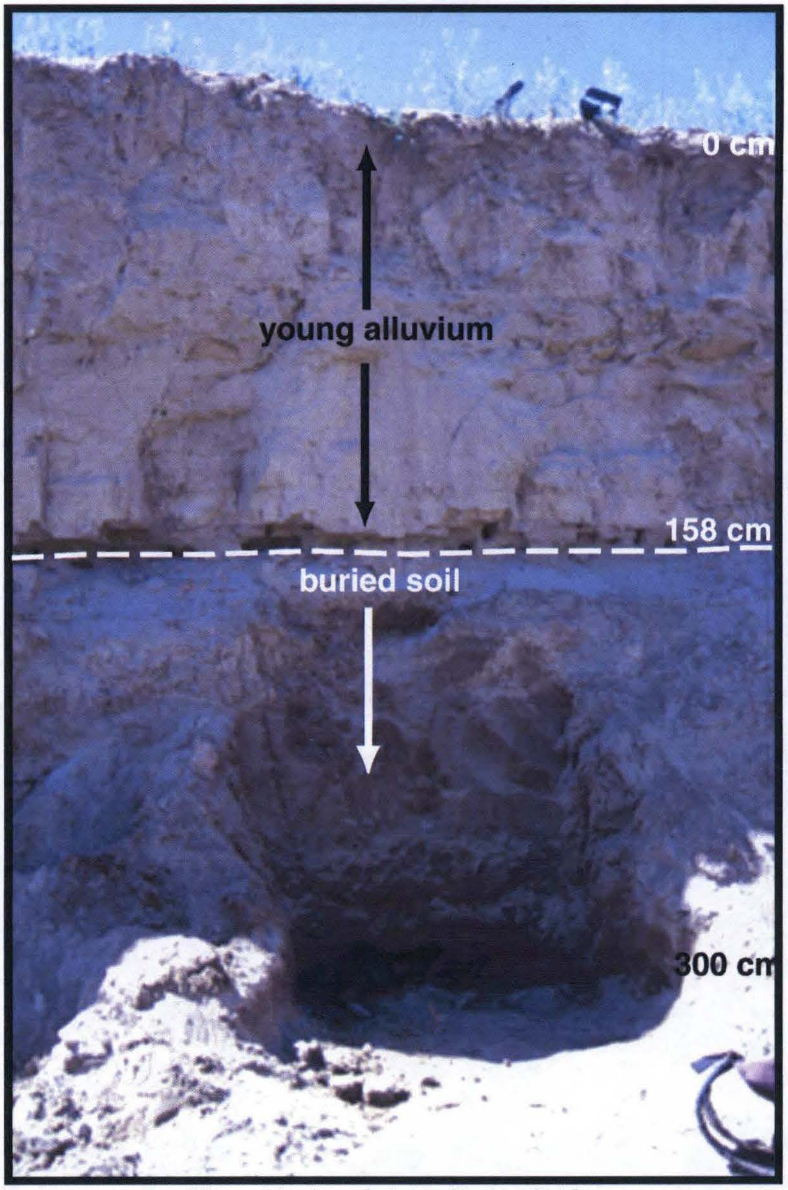


Figure 36. Aggradation at Duncan Bridge.

CONCLUSIONS

In Safford and Duncan Valleys, geomorphic change along the Gila River in recent decades appears to be controlled by changes in internal factors such as levees and diversion dams rather than changes in external factors such as runoff and sediment influx. This conclusion is based on several products developed for the Upper Gila River Fluvial Geomorphology Study as well as this analysis. Using soil/stratigraphic information and lab analyses, geomorphic mapping in these valleys indicates that the Gila River has migrated within the Pima Soil boundary for the last several hundred years and within the Geomorphic Limit for at least the last 1,000 years. Areas of lateral instability are indicated by property loss in which stable soils mapped as part of the Geomorphic Limit or Pima Soil Boundary or soils that have been stable historically (1935-2000) are eroded. Fourteen specific reaches with lateral instability are described ranging from 0.5 to 3.5 miles in length and from about 2 to 154 acres of property loss. Together, these reaches constitute approximately 40% of the entire study reach and a total of roughly 880 acres of property loss. For each valley, the unstable reaches constitute 50% of the entire reach in Safford Valley and 24% of the entire reach in Duncan Valley. Local factors that cause lateral instability include: (1) levee failure; (2) downstream propagation of erosion; (3) channel straightening; and (4) diversion dam orientation. Vegetation and alluvial fan development may also act as controls on channel position in these reaches. The Catalog of Historical Changes, among other studies, shows that the majority of erosion occurs during high flow events such as the flood of October 2-3, 1983. The local factors mentioned above appear to cause minimal geomorphic change during low to moderate flows but are the catalysts of substantial geomorphic change during the large floods of recent decades.

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APPENDIX A

SOIL DESCRIPTIONS

Table A1. List of sites by category of alluvium

Gila Alluvium		Pima Alluvium		Geomorphic Limit	
Site Number	Site Name	Site Number	Site Name	Site Number	Site Name
GRD1	Duncan Bridge I	GRS2	Solomon Bridge	GRD3	Fairgrounds
GRD2	Duncan Bridge II	GRS3	Head Canyon	GRD7	Ash Peak Canyon
GRD4	Waters Wash	GRS5	San Jose Wash	GRD8	Ash Peak Canyon
GRD5	Burma Road Bridge	GRS10	Fort Thomas Diversion	GRD10	Apache Creek
GRD6	Apache Peak Canyon	GRS11	Curtis Diversion	GRD12	Railroad Wash
GRD9	Two Cottonwoods	GRS12	Safford-Bryce Road	GRS1	Hinton bank
GRD11	York Valley	GRS13	Smithville Diversion	GRS8	Eden Bridge North
GRS4	San Jose Diversion			GRS9	Eden Bridge
GRS6	Hollywood Canal				
GRS7	Day Mine Wash				

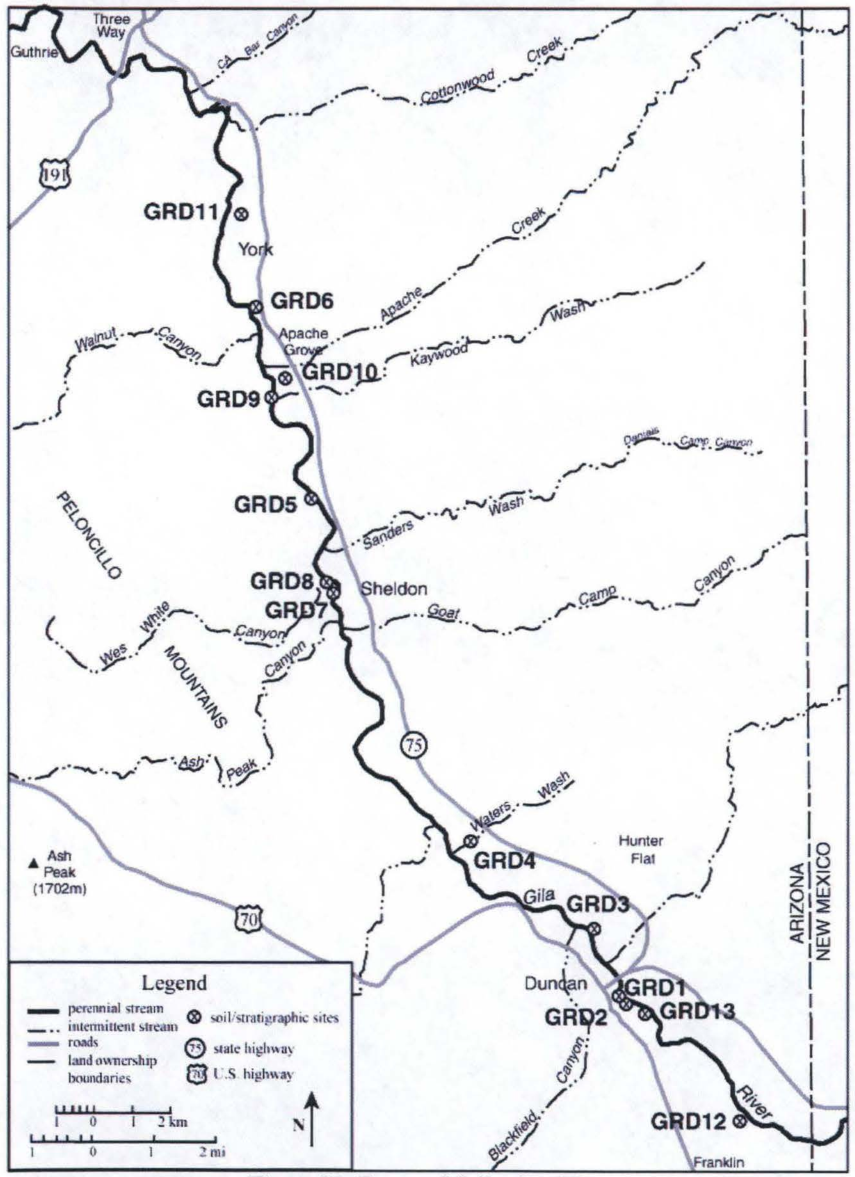


Figure 37. Duncan Valley Site Map.

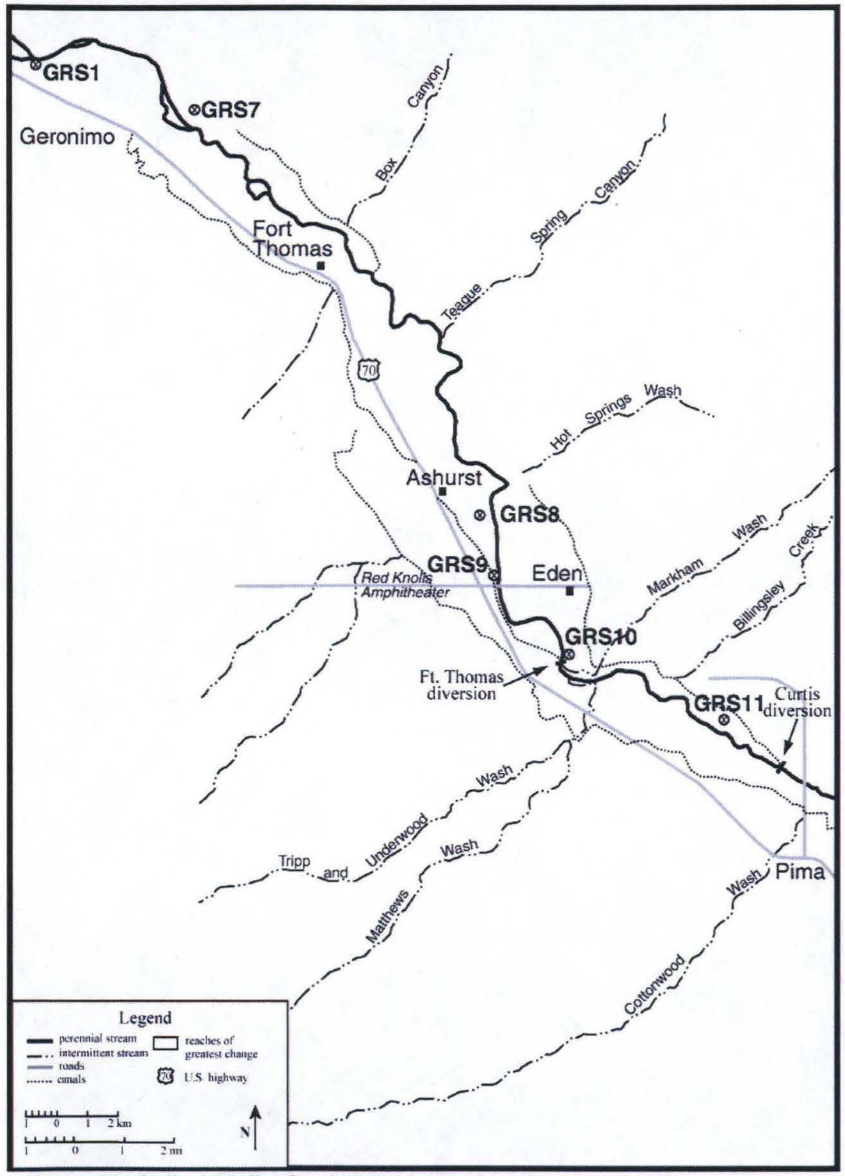


Figure 38. Safford Valley Site Map: Pima to San Carlos Indian Reservation.

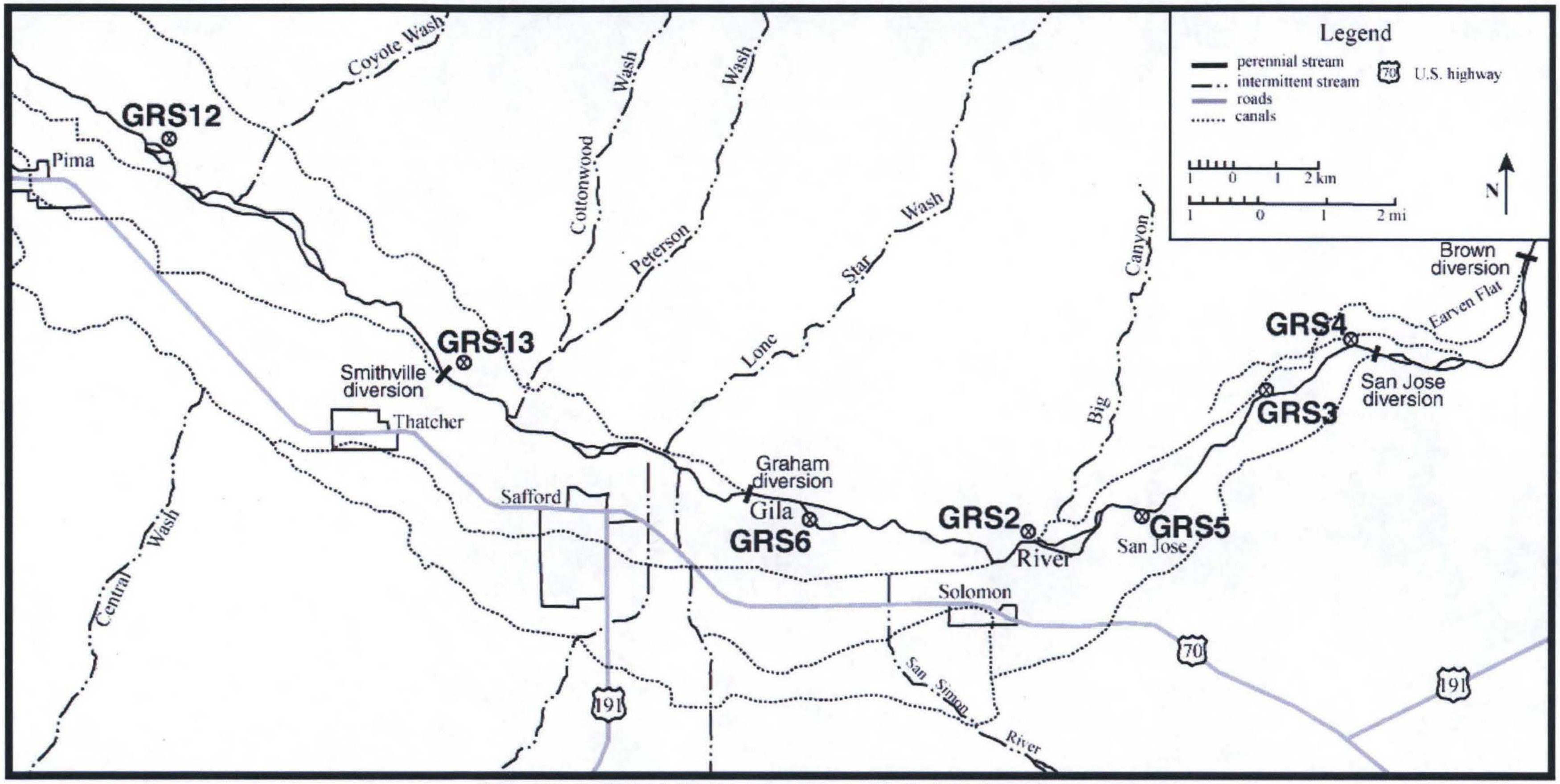
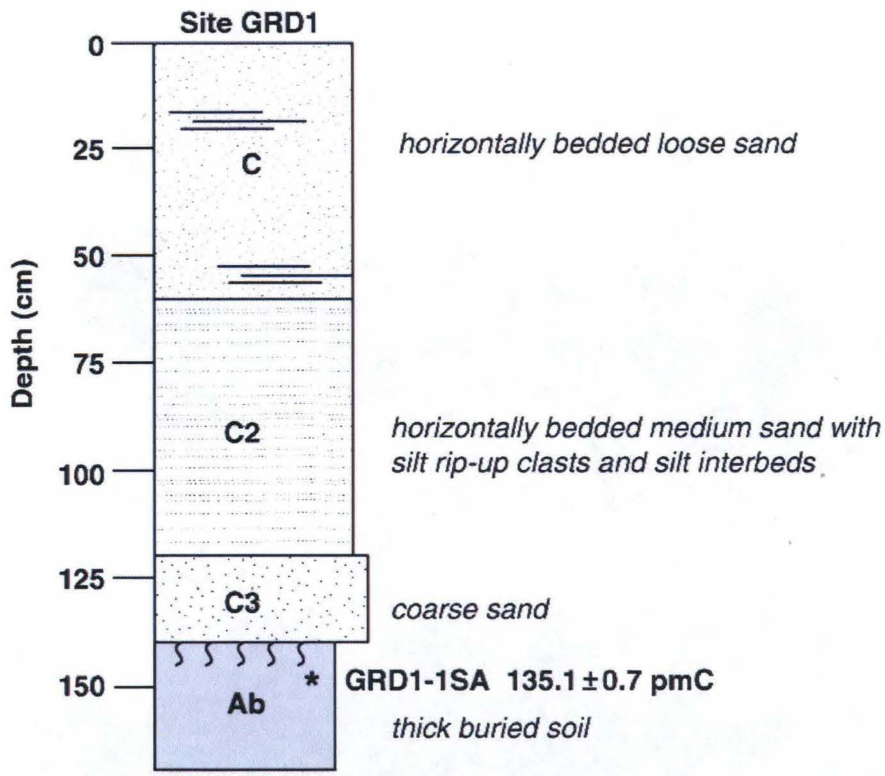


Figure 39. Safford Valley Site Map: Head of Safford Valley to Pima.

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRD1 **Described by** Jeanne Klawon, Dan Levish **Date** 2/07/2001 **Slope** Vertical **Aspect** East
Map Unit Gila alluvium **Parent Material** fine-grained alluvium
Location N32°43'04", W109°05'59"; left bank inside levee upstream of Duncan Bridge
Quadrangle Duncan 7.5' USGS **Township/Range** T8S R32E **Section** 20 SW1/4 **Elevation** 3650 ft
This profile was developed during the reconnaissance phase of the study. A detailed soil profile was not described; however, a general description was made and follows:



FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRD2 **Described by** Jeanne Klawon, Ralph Klinger **Date** 3/28/2001 **Slope** Vertical **Aspect** East
Map Unit Gila alluvium **Parent Material** fine-grained alluvium
Location N32°43'04", W109°05'59"; left bank inside levee upstream of Duncan Bridge
Quadrangle Duncan 7.5' USGS **Township/Range** T8S R32E **Section** 20 SW1/4 **Elevation** 3650 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
A	0-10 (10)	cw	2f-mpl	mSL	none	so	po	sh	0	none (none)	10YR4/3M 10YR6/3D
Cb	10-158 (148)	as	m-sg	mS	none	so	po	lo-so	0-75	none (es)	10YR4/3M 10YR6/2D
Ab	158-183 (25)	cs	3mgr	SiL	none	ss	ps	sh	0	I- (es)	10YR4/3M 10YR6/3D
ABkb2	183-260 (77)	cs	2csbk	SiL	none	ss	ps	h	0	none (es)	10YR4/3M 10YR5/3D
Cb2	260-270 (10)	--	m	fLS	none	so	po	so	0	none (es)	10YR4/3M 10YR6/3D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRD3 **Described by** Jeanne Klawon, Dan Levish **Date** 3/04/2001 **Slope** Vertical **Aspect** Southwest
Map Unit Geomorphic Limit alluvium **Parent Material** fine-grained alluvium
Location right bank exposure, approximately ¾ miles west from fairgrounds in Duncan, AZ
Quadrangle Duncan 7.5' USGS **Township/Range** T8S R32E **Section** 18 NE1/4NE1/4 **Elevation** 3540 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
Cox	0-15 (15)	laminated fine sand and silt									
Ab	15-42 (27)	cw	2f-msbk	fSL-SiL	none	ss	ps	sh	0	none	10YR4/2M 10YR5/3D
ABk	42-65 (23)	cw	2m-csbk	fSL-SiL	none	ss	ps	sh	0	I	10YR4/2M 10YR6/2D
Cox/Ck	65-240 (175)	massive fine to medium sand underlain by thinly bedded (5-10 cm) silts, clays and fine sand.									
Abk	240-260 (20)	cw	2m-csbk	SiL	none	ss	ps-p	h	0	I+	10YR4/2M 10YR6/2D
Abk2	260-290 (30)	as	3f-msbk	SiL	none	ss	ps-p	h	0	I+	7.5YR4/3M 7.5YR6/3D
Cox	290-295 (5)	fine sand									
Abk3	295-335+ (40)	--	2csbk	SiL	none	ss	ps	h	0	I-	7.5YR4/3M 7.5YR5/3D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

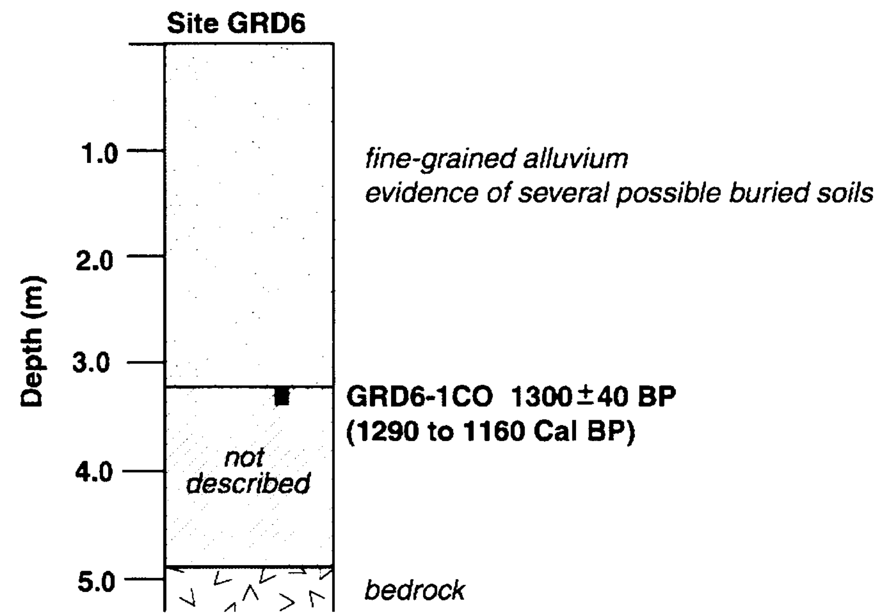
Profile No. GRD4 **Described by** Jeanne Klawon, Ralph Klinger **Date** 3/29/2001 **Slope** Vertical **Aspect** Southeast
Map Unit Gila alluvium **Parent Material** fine-grained alluvium

Location N32°45'09", W109°08'39"; approximately 215 feet from the mouth of Waters Wash
Quadrangle Sheldon 7.5' USGS **Township/Range** T8S R31E **Section** 11 NW1/4SW1/4 **Elevation** 3600 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
C	0-195 (195)	interbedded silt and sand with sedimentary structures									
Ab	195-210 (15)	gi	2mabk	fSiL	none	ss	ps	sh	0	none (es)	7.5YR4/3M 7.5YR6/3D
ABkb	210-243 (33)	aw	1msbk	fSL	none	ss	ps	so	0	I (es)	7.5YR4/3M 7.5YR6/3D
Cb	243-250+ (7)	--	sg-m	fLS	none	so	po	lo-so	0	none (e)	7.5YR4/3M 7.5YR6/3D

FIELD DESCRIPTIONS OF SOIL PROPERTIES
Profile No. GRD6 **Described by** Jeanne Klawon, Dan Levish **Date** 2/07/2001 **Slope** Vertical **Aspect** West
Map Unit Slackwater deposit (Gila alluvium) **Parent Material** fine-grained alluvium
Location N", W"; right bank, Apache Peak Canyon between Apache Grove and York
Quadrangle York 7.5' USGS **Township/Range** T6S R31E **Section** 29SW1/4NW1/4 **Elevation** 3500 ft

This profile was developed during the reconnaissance phase of the study. A detailed soil profile was not described; however, a general description was made and follows:



FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRD7 **Described by** Jeanne Klawon, Ralph Klinger **Date** 3/27/2001 **Slope** Vertical **Aspect** East
Map Unit Geomorphic Limit alluvium **Parent Material** fine-grained alluvium
Location N32°48'50", W109°10'42"; downstream of Ash Peak Canyon
Quadrangle Sheldon 7.5' USGS **Township/Range** T7S R31E **Section** 21 NW1/4NE1/4 **Elevation** 3560 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
A	0-3 (3)	as	2mpl	fSL	none	so	po	so	0	none (es)	10YR3/3M 10YR5/4M
AB	3-14 (11)	cw	1m-csbk	fSL	none	so	po	sh	<10	none (es)	10YR3/3M 10YR5/3D
Bk	14-47 (33)	cw	2cabk-1vcpr	vfSL	none	so	ps	sh	0	I (es)	7.5YR3/3M 7.5YR5/3D
Ck	47-75 (28)	aw	sg-1f-msbk	mSL	none	so	po	lo-so	0	none (none)	10YR3/3-7.5YR3/4M 10YR6/3-7.5YR5/4D
Ab	75-90 (15)	cw	2m-csbk	vfSiL	none	ss	ps	sh	0	none (e-es)	10YR3/3M 10YR5/3D
Cb	90-101 (11)	cw	1f-msbk	fSL	none	so	po	sh	0	none (es)	10YR3/3M 10YR6/3D
Cb2	101-109 (8)	cw	sg	cLS	none	so	po	lo	0	none (none)	10YR3/3M 10YR5/3D
Ab2	109-122 (13)	cw-as	1csbk	fSL	none	so	po-ps	sh	0	I- (e)	10YR3/2M 10YR5/2D
Ab3	122-145 (23)	ce	1csbk	fSL	none	so	po	so	0	I- (e)	10YR3/2M 10YR5/2D
Cb3	145+	--	sg	mS	none	so	po	lo-so	<10	none (e)	10YR4/3M 10YR5/3D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRD8 **Described by** Jeanne Klawon, Ralph Klinger **Date** 3/27/2001 **Slope** Vertical **Aspect** Northeast
Map Unit Geomorphic Limit alluvium **Parent Material** fine-grained alluvium
Location N32°48'55", W109°10'51"; downstream from Ash Peak Canyon
Quadrangle Sheldon 7.5' USGS **Township/Range** T7S R31E **Section** 16 SW1/4SW1/4 **Elevation** 3560 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
A	0-4 (4)	as	m-cpl	fSL	none	ss	po	so	0	none (es)	7.5YR3/3M 7.5YR5/3D
AB	4-16 (12)	aw	1msbk	fSL	none	ss	po	sh	0	none (e)	7.5YR3/3M 7.5YR5/4D
Bk	16-80 (64)	cw	2csbk-vcabk	fSL	none	ss	ps	h	0	I- (e)	7.5YR3/2M 7.5YR5/4D
Ck	80-120 (40)	--	1m-csbk	mSL	none	so	po	so	0	I- (es)	7.5YR3/2M 10YR6/3D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRD9 **Described by** Jeanne Klawon, Ralph Klinger **Date** 3/28/2001 **Slope** Vertical **Aspect** East
Map Unit Gila alluvium **Parent Material** fine-grained alluvium
Location N32°51'28", W109°11'42"; left bank across from Kaywood Wash
Quadrangle Sheldon 7.5' USGS **Township/Range** T7S R31E **Section** 5 NW1/4NE1/4 **Elevation** 3520 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
Cox[2]	0-15 (15)	cw	m-1msbk	mLS	none	so	po	so	0	none (e)	10YR4/3M 10YR5.5/3D
Ab	15-18 (3)	cw	2cgr	fSL	none	so	po	sh	0	none (es)	10YR3/3M 10YR5/3D
Cox	18-32 (14)	as	m	mLS	none	so	po	so	0	none (e)	10YR4/3M 10YR5/3D
Ab	32-40 (8)	cw	2cgr-1msbk	f-mSL	none	ss	po	sh	0	none (e)	10YR3/3M 10YR5/3D
C	40-123 (93)	as	m	fLS	none	so	po	so	0	I- (e)	10YR3/3M 10YR5/3D
C2	123-136 (13)	as	1f-msbk	fSL	none	ss	ps	so	0	none (es)	10YR4/2.5M 10YR6/3D
C3	136-144 (8)	aw	1f-msbk	fSL	none	ss	po	sh	0	none (es)	10YR4/3M 10YR5.5/3D
Ab2	144-206 (62)	as	1-2m-csbk	SiL	none	vs	?	sh	0	I- (e)	10YR3/3M 10YR5/3D
Cb	206-216 (10)	cw	m	mLS	none	so	?	lo	0	none (e)	10YR4/3M 10YR5/3D
Cb2	216+	--	rounded gravels and sand								

[2] 1 cm organic mat on surface
This profile is a composite of two locations along the bank exposure; the break in the description occurs at 40 cm.

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRD10 **Described by** Jeanne Klawon, Ralph Klinger **Date** 3/28/2001 **Slope** Vertical **Aspect** West
Map Unit Geomorphic Limit alluvium **Parent Material** fine-grained alluvium and gravelly alluvium
Location N32°51'51", W109°11'53"; right bank upstream from Apache Creek
Quadrangle Chiloquin 7.5' USGS **Township/Range** T35S R7E **Section** 11 SE1/4NW1/4 **Elevation** 4200 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
Ap	0-15 (15)	cs	2msbk	fSL	nome	so	po	h	<10	none (es)	10YR3.5/3M 10YR5/3D
Bk	15-50 (35)	cs	3msbk	fSL	none	so	po	vh	10	I- (es)	10YR3/3M 10YR5/3D
Bk2	50-82 (32)	cw	2msbk	mSL	none	so	po	h	10	I (es)	10YR3/3M 10YR5/3D
Bk3	82-125 (43)	cw	1msbk	fSL	none	so	po	sh	10	I (es)	10YR3/3M 10YR5/3D
2Ck	125-137 (12)	aw	sg	vcS	none	so	po	lo	75	I (es)	10YR3/3M 10YR5/3D
3Bkb	137-170 (33)	cw	1msbk	fSL	none	ss	ps	sh	10	I (es)	10YR3/3M 10YR5/3D
3Bk2b	170-205 (35)	ci	?	mLS	none	so	po	sh	10	I- (es)	10YR3/3M 10YR5/3D
4Ck	205-235 (30)	--	rounded gravel								

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRD11 **Described by** Jeanne Klawon, Ralph Klinger **Date** 3/28/2001 **Slope** Vertical **Aspect** West

Map Unit Gila alluvium **Parent Material** fine-grained alluvium and gravelly alluvium

Location N32°53'59", W109°12'17"

Quadrangle York 7.5' USGS **Township/Range** T6S R31E **Section** 11 SE1/4NW1/4 **Elevation** 3510 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
A	0-15 (15)	as	1mpl-sbk	mLS	none	so	po	so	0	none (es)	10YR3/3M 10YR5/3D
B	15-37 (22)	aw	1m-csbk	mLS	none	so	po	sh	<10	none (es)	10YR3/3M 10YR5/3D
C	37-112 (75)	cw	m	S	none	so	po	so	0	none (e-es)	10YR4/3M 10YR5/3-2D
C2	112-125 (13)	aw	m	fS	none	so	po	so	0	none (es)	10YR4.5/3M 10YR5/3D
C3	125-160 (35)	--	sg	mS	none	so	po	lo	0	none (e)	10YR4.5/3M 10YR5/3D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRD12 **Described by** Jeanne Klawon, Ralph Klinger **Date** 3/29/2001 **Slope** Vertical **Aspect** Southeast
Map Unit Geomorphic Limit alluvium **Parent Material** fine-grained alluvium
Location N32°41'24", W109°03'56"; left bank across from the end of Lunt Road
Quadrangle Duncan 7.5' USGS **Township/Range** T8S R32E **Section** 33 SE1/4NE1/4 **Elevation** 3660 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
Ap	0-25 (25)	cw	2fgr, 2mpl	L	none	ss	ps	sh	10-25	none (es)	10YR3/3M 10YR5/3D
A	25-36 (11)	aw	2m-cgr	CL	2ppf	s	p	sh	10-25	I (ev)	10YR3/3M 10YR5/2.5D
B	36-62 (26)	gs	3cabk	C	2ppf	vs	vp	vh	0	I (ev)	10YR4/3M 10YR5/2D
Bk	62-115 (53)	cs	3m-cabk	SiCL	2ppf	s	p	vh	0	II- (ev)	10YR3/3M 10YR6/3D
Bk2	115-135 (20)	cw	3f-mabk	C	2dpf	vs	p	h	0	I+ (ev)	7.5YR4/3M 10YR6/2.5D
C	135-160 (25)	--	1csbk	fSL	none	ss	ps	sh	0	none (e)	7.5YR3/2M 10YR6/3D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRS1 **Described by** Jeanne Klawon, Ralph Klinger **Date** 8/28/2003 **Slope** Vertical **Aspect** North
Map Unit Geomorphic Limit alluvium **Parent Material** fine-grained alluvium
Location N33°05'17.3" , W 110°03'00"; left bank of Doug Hinton Property near Geronimo, Arizona
Quadrangle Geronimo 7.5' USGS **Township/Range** T4S R22E **Section** 13 NW1/4NW1/4 **Elevation** 2660 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
A	0-10 (10)	as	2fgr	SiC	none	vs	p-vp	h	0	none (es)	10YR4/4M 10YR5/3D
B	10-43 (33)	cs	2msbk	SiC-C	none	vs	vp	vh-eh	<10	none (ev)	10YR4/4M 10YR6/3D
B2	43-105 (62)	cs	1csbk	C	none	vs	vp	h-vh	0	none (e)	7.5YR 4/3M 7.5YR5/3D
B3	105-145 (40)	cs	2csbk	SiC	none	vs	vp	vh	0	none (e)	10YR4/3M 7.5 YR5/3D
B4	145-188 (43)	cs	2csbk	C	none	vs	p-vp	vh	0	none (e)	7.5YR4/3M 7.5YR5.5/3D
B5	188-210+ (32)	--	1csbk	SiC	none	vs	vp	h	0	I (e-es)	7.5YR4/3M 7.5YR5/3.5D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRS2 **Described by** Jeanne Klawon, Ralph Klinger **Date** 8/27/2003 **Slope** Vertical **Aspect** South
Map Unit Pima alluvium **Parent Material** fine-grained alluvium
Location right bank, north side upstream from Solomon Bridge
Quadrangle San Jose 7.5' USGS **Township/Range** T7S R27E **Section** 18 NW1/4SE1/4 **Elevation** 2960 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
Ap	0-40 (40)	as	--	--	--	--	--	--	--	--	--
Ab	40-68 (28)	as	2msbk	SiCL	none	ss-s	ps-p	h	0	I- (e)	10YR3/3M 10YR5/3D
Ck	68-125 (57)	--	1msbk	mLS	none	so	po	lo-so	0	I- (es)	10YR3/3M 10YR5/3D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRS3 **Described by** Jeanne Klawon, Ralph Klinger **Date** 8/27/2003 **Slope** Vertical **Aspect** South
Map Unit Pima alluvium **Parent Material** fine-grained alluvium and gravelly alluvium
Location N32°51'17", W109°34'11.7"; Head Canyon fan, north side of Gila River
Quadrangle Chiloquin 7.5' USGS **Township/Range** T35S R7E **Section** 11 SE1/4NW1/4 **Elevation** 4200 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
C	0-56 (56)	aw	--	--	--	--	--	--	--	--	--
Bb	56-81 (25)	cw	2msbk	SiL	none	s	ps-p	h	<10	I- (es-ev)	10YR3/4M 10YR5/4D
Bkb	81-120 (39)	--	2-3csbk	SiL	none	ss	ps	h	<10	I (es)	10YR3/4M 10YR5/4D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRS4 **Described by** Jeanne Klawon, Ralph Klinger **Date** 8/27/2003 **Slope** Vertical **Aspect** South
Map Unit San Jose Diversion **Parent Material** fine-grained alluvium
Location N32°51'50.5", W109°32'57.1"; access road west of Sanchez property
Quadrangle Chiloquin 7.5' USGS **Township/Range** T35S R7E **Section** 11 SE1/4NW1/4 **Elevation** 4200 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
Ap	0-37 (37)	as	--	--	--	--			--	--	--
C	37-63 (26)	as	m	SL	none	so	po	lo-so	<10	none	--
Bb	63-113 (50)	as	2vcsbk	SiL	none	ss	ps	h	<10	none (e)	10YR3/4M 10YR5/3D
Bkb	113-123+ (10)	--	2-3csbk	fSL-L	none	ss	ps	h	0	I (e)	10YR3.5/3M 10YR5/3.5D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRS5 **Described by** Jeanne Klawon, Ralph Klinger **Date** 8/27/2003 **Slope** Vertical **Aspect** North
Map Unit Pima alluvium **Parent Material** fine-grained alluvium
Location N32°49'44.7", W109°35'42.5"; left bank, east side of San Jose Wash
Quadrangle San Jose 7.5' USGS **Township/Range** T7S R27E **Section** 9 SW1/4SW1/4 **Elevation** 2990 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
A	0-28 (28)	as	1mcsbk	SiCL	none	s	p	h	<10	none (e)	7.5 YR4/3M 7.5YR5/3D
Bk1	28-125 (97)	as	3vcabk-pr	SiC	1fpf	vs	p-vp	vh-eh	0	I- (e)	7.5YR3.5/3M 7.5YR5/3D
Bk2	125-190+ (65)	--	2vcsbk	CL	none	s	p	h	0	I- (es)	10YR3/4M 10YR5/4D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRS6 **Described by** Jeanne Klawon, Ralph Klinger **Date** 8/27/2003 **Slope** Vertical **Aspect** Southeast
Map Unit Gila alluvium **Parent Material** fine-grained alluvium
Location N32°50'22.3", W109°41'26.5"; access along canal from Hollywood Road
Quadrangle Safford 7.5' USGS **Township/Range** T7S R26E **Section** 11 SW1/4SW1/4 **Elevation** 2930 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
A	0-22 (22)	aw	2cgr	SiL	none	s	ps	h	0	none (e)	10YR3/4M 10YR5/4D
C	22-55 (33)	as	m	SiCL	none	s	p	h	0	none (es)	10YR3/4M 10YR5/4D
Bkb	55-83 (28)	ai	1f-msbk	SiCL	none	s	p	sh-h	0	I (es)	10YR3/4M 10YR5/3.5D
2C	83-115 (32)	as	m	SL	none	so	po	lo-so	0	none (none)	10YR3/4M 10YR5/4D
3Ck	115-130+ (15)	--	1m-csbk	SiL	none	ss	ps	sh	0	I (--)	10YR3/4M 10YR5/3.5D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRS7 **Described by** Jeanne Klawon, Ralph Klinger **Date** 8/28/2003 **Slope** 0-3° **Aspect** South
Map Unit Gila alluvium **Parent Material** fine-grained alluvium
Location N33°04'28.1", W110°00'12.7"; fallow field west of Day Mine alluvial fan
Quadrangle Geronimo 7.5' USGS **Township/Range** T4S R23E **Section** 20 NE1/4NE1/4 **Elevation** 2650 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
C	0-12 (12)	aw	sg	SL	none	so	po	lo	0	none (e)	10YR3/3M 10YR5/3D
Ab	12-18 (6)	as	1mgr	vf-fSL	none	so-ss	ps	so	0	none (e)	10YR3/3M 10YR5.5/3D
Cb	18-34 (16)	as	m	vf-fSL	none	ss	ps	so	0	none (e-es)	10YR3/3M 10YR5.5/3D
Ab2	34-42 (8)	as	2fgr	SiL	none	ss	po	sh	<10	none (es)	10YR4/3M 10YR5.5/3D
Bb	42-70+ (28)	--	1f-msbk	SL	none	so	po	sh	0	none (e)	10YR3/3M 10YR5/4D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRS8 **Described by** Jeanne Klawon, Ralph Klinger **Date** 8/28/2003 **Slope** Vertical **Aspect** East
Map Unit Geomorphic Limit alluvium **Parent Material** fine-grained alluvium
Location N32°58'36.8", W109°55'07.3"; left bank exposure downstream from Eden Bridge
Quadrangle Eden 7.5' USGS **Township/Range** T5S R24E **Section** 19 SE1/4SE1/4 **Elevation** 2730 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
A	0-10 (10)	aw	2fsbk-2cgr	CL	none	s	p	h	0	none (es)	10YR4/3M 10YR5.5/3D
B	10-56 (46)	as	2csbk	C	none	s-vs	vp	h-vh	0	none (es)	10YR3/3M 10YR4.5/2D
Bk	56-82 (26)	as	3csbk	C	2dpf,po	s-vs	p-vp	vh	0	I (es)	10YR3.5/3M 10YR5/3D
C	82-100 (16)	--	m	SiL-SiCL	none	s	ps-p	sh-h	0	none (ev)	10YR5/4M 10YR6/3D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRS9 **Described by** Jeanne Klawon, Ralph Klinger **Date** 8/28/2003 **Slope** 0-3° **Aspect** East
Map Unit Geomorphic Limit alluvium **Parent Material** fine-grained alluvium
Location N32°57'52.1", W109°54'57.3"; west side of river north of Eden Bridge (bee boxes)
Quadrangle Eden 7.5' USGS **Township/Range** T5S R24E **Section** 30 SE1/4SE1/4 **Elevation** 2740 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
A	0-15 (15)	aw	2mgr-pl	SiCL	none	s	ps-p	sh	0	none (es-ev)	10YR4/3M 10YR5/4D
Bk	15-40 (25)	aw	1-2msbk	SiCL	2dpf,po	s	ps-p	so-sh	0	I+ (es)	10YR4/3M 10YR5/4D*
Bk2	40-50+ (10)	--	2msbk	SiC	2dpf,po	s-vs	p	so-sh	0	I+ (es)	10YR4/4M 10YR4/4D[3]

[3] Soils were slightly moist for dry coloring

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRS10 **Described by** Jeanne Klawon, Ralph Klinger **Date** 8/28/2003 **Slope** Vertical **Aspect** West
Map Unit Pima alluvium **Parent Material** fine-grained alluvium
Location N32°56'40", W109°53'35"; right bank downstream of Fort Thomas Diversion
Quadrangle Eden 7.5' USGS **Township/Range** T6S R24E **Section** 4 NE1/4NW1/4 **Elevation** 2740 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
A	0-13 (13)	aw	2fsbk	CL	none	s	p	sh-h	0	none (e)	10YR4/3M 10YR5/3D
Bk	13-38 (25)	cw	2f-msbk	SiCL	none	s	p	h	0	I- (e)	10YR3/3M 10YR4.5/2D
Bk2	38-58 (20)	aw	1m-csbk	SL	2dpf	so	ps	sh	0	I (e)	10YR3/3M 10YR5/3D
2C	58-130 (72)	--	sg	SL	none	so	po	lo-so	0	none (e-es)	10YR3/3M 10YR5/3D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRS11 **Described by** Jeanne Klawon, Ralph Klinger **Date** 8/28/2003 **Slope** Vertical **Aspect** South
Map Unit Pima alluvium **Parent Material** fine-grained alluvium
Location N32°55'51.4", W109°50'56.5"; right bank along Curtis Canal
Quadrangle Pima 7.5' USGS **Township/Range** T6S R24E **Section** 12 NW1/4NW1/4 **Elevation** 2780 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
A	0-20 (20)	aw	2fsbk	SiL	none	ss-s	ps	h	0	none (e)	10YR4/3.5M 7.5-10YR5/3D
B	20-65 (45)	cs	2msbk	SiCL	none	s	p	h	0	none (es)	10YR4/3M 10YR5/3.5D
Bk	65-155 (90)	aw	2msbk	CL	1fpf, 2dpo	s	p	h	0	I (es)	7.5YR4/3M 10YR5.5/3D
Ck	155-180 (35)	as	m	SL	none	so	ps	sh	0	I (e-es)	10YR4/3M 10YR5/3D
Btb	180-210 (30)	--	3vcsbk	C	2ppf,po	vs	vp	vh	0	none (es)	7.5YR4/4M 7.5YR5/4D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRS12 **Described by** Jeanne Klawon, Ralph Klinger **Date** 8/28/2003 **Slope** Vertical **Aspect** South
Map Unit Pima alluvium **Parent Material** fine-grained alluvium
Location N32°54'08.7", W109°48'00"; corner of Safford-Bryce Road
Quadrangle Pima 7.5' USGS **Township/Range** T6S R25E **Section** 21 NW1/4NW1/4 **Elevation** 2820 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
A	0-25 (25)	as	2-3f-msbk	CL	none	s	p	sh-h	0	none (e)	7.5YR4/3M 7.5YR5/3D
B	24-54 (29)	as	1csbk	SiL	none	ss	ps	sh	0	none (es)	7.5-10YR4/3M 7.5-10YR5/3D
Bk	54-88 (34)	gs	1csbk	SL-SiL	none	so	ps	sh	0	I (es)	10YR3/3M 10YR6/3D
C	88-142 (54)	cs	m-sg	SL	none	so	ps	so	0	none (e)	10YR4/3M 10YR5.5/3D
C2	142-183 (41)	cs	m	SiL	none	ss	ps	sh	0	none (es)	10YR3/3M 10YR5/3D
C3	183-200 (17)	--	1f-msbk	SiCL	none	s	p	sh	0	I (es)	10YR4/3M 10YR6/3D

FIELD DESCRIPTIONS OF SOIL PROPERTIES

Profile No. GRS13 **Described by** Jeanne Klawon, Ralph Klinger **Date** 8/28/2003 **Slope** Vertical **Aspect** Northwest
Map Unit Pima alluvium **Parent Material** fine-grained alluvium
Location N32°51'34.4", W109°44'02.9"; right bank upstream of Smithville Diverson
Quadrangle Safford 7.5' USGS **Township/Range** T6S R25E **Section** 36 SE1/4SW1/4 **Elevation** 2870 ft

Horizon	Depth (Thickness) cm	Boundaries	Structure	Texture	Clay Films	Consistence			Gravel %	CaCO3 Morphology (effervescence)	Color (moist/dry)
						Stickiness	Plasticity	Dry			
A	0-32 (32)	as	2f-msbk	SiL	none	ss	ps	sh	0	none (es)	10YR4/3M 10YR5/4D
Bk	32-78 (46)	as	1-2m-csbk-abk	SiL	none	ss	ps	sh	0	I (e-es)	10YR4/3M 10YR5/3D
Bk2	78-94 (16)	as	2csbk	SiCL	v1fpf	s	ps-p	vh	0	I (es)	10YR4/3M 10YR5/4D
C	94-108 (14)	as	m	fSL	none	so	po	so-sh	0	I- (e-)	10YR4/3M 10YR6/3.5D
Ck	108-150 (42)	as	m	SiC	none	s-vs	p	sh	0	I (e)	10YR4/3M 10YR5/3D
C2	150-180 (30)	--	sg	SL	none	so	po	lo	0	I- (e-)	10YR4/4M 10YR5/4D

APPENDIX B

RADIOCARBON ANALYSIS

Table 4. Upper Gila River Geomorphic Analysis - Radiocarbon Ages.

Sample No. (Lab No.)	Depth (cm)	Type of Material	Sample Weight (g)	Age (^{14}C yrs. B.P.[4])	Calibrated Age (cal yrs. B.P.[5])
GRD1-1SA Beta-154511	146	Salicaceae Populus charcoal	0.250	135.1 ± 0.7 pmC[6]	
GRD2-2PR Beta-154512	285-300	Prosopis charcoal	0.018	260 ± 40	430-360 330-280 180-150 10-0
GRD2-2SA Beta-154513	285-300	Salicaceae charcoal	0.026	340 ± 40	500-300
GRD3-3ZM Beta-154514	115[7]	Zea Mays cupules (charred)	0.292	1910 ± 40	1930-1740
GRD3-3AT Beta-154515	115[7]	Atriplex charcoal	0.098	1870 ± 40	1890-1710
GRD3-3SA Beta-154516	115[7]	Salicaceae charcoal	0.018	1930 ± 40	1960-1810
GRD3-4AT Beta-154517	125[7]	Atriplex charcoal	0.033	2490 ± 50	2740-2360
GRD3-4SA Beta-154518	125[7]	Salicaceae charcoal	0.157	1940 ± 40	1980-1820
GRD3-5YSU Beta-154519	322	Succinea spp. snail shell	--	4110 ± 40	4820-4520 4470-4450
GRD3-7YSU Beta-154520	270	Succinea spp. snail shell	--	3010 ± 40	3340-3070
GRD5-8SA Beta-182011	152-155	Salicaceae charcoal	0.018	160 ± 50	300-5
GRD5-10FR Beta-182012	75	Fraxinus charcoal	0.018	220 ± 40	315-265 140-25 25-0
GRD6-1CO Beta-154521	320-340	Conifer charcoal (rounded)	0.008	1300 ± 40	1290-1160
GRD7-9AT Beta-182014	75-90	Atriplex charcoal	0.009	80 ± 30	265-215 140-25 25-0
GRD9-6PI Beta-182015	114	Pinus charcoal	2.507	580 ± 50	655-520
GRD9-8PR Beta-182016	195-205	Prosopis charcoal	0.006	410 ± 40	525-430 375-325

[4] Conventional radiocarbon age in years before present with present being 1950 A.D.

[5] Calibrated radiocarbon age in years before present derived from computer calibration program Oxcal v. 3.5 (see Bronk, 1995).

[6] Percent of modern carbon

[7] Sample was collected along the exposure from a location other than the soil profile description. The original sampling depth is recorded here; however, the corresponding depth in the site's soil profile may be different.

Sample No. (Lab No.)	Depth (cm)	Type of Material	Sample Weight (g)	Age (^{14}C yrs. B.P.[4])	Calibrated Age (cal yrs. B.P.[5])
GRD10-1FR Beta-182017	185	Fraxinus charcoal	0.315	210 ± 30	305-270 210-145 20-0
GRD10-9SA Beta-182018	95	Salicaceae charcoal	0.047	230 ± 40	420-405 315-270 210-145 20-0
GRD12-1AT Beta-182019	145	Atriplex charcoal	0.006	3270 ± 40	3585-3395
GRD12-2ZM Beta-182020	115-130	Zea mays cob (charred)	0.112	2530 ± 40	2750-2475
GRD12-3AT Beta-182021	70-90	Atriplex charcoal	0.130	2570 ± 40	2760-2710 2585-2510
GRD13-1AS Beta-154522	?	Asteraceae charcoal	0.015	121.1 ± 0.6pMC[6]	
GRS1-2YSU Beta-154523	60	Succinea spp. snail shell	--	700 ± 40	690-640 590-560
GRS1-3YSU Beta-154524	60	Succinea spp. snail shell	--	1050 ± 40	1050-920
GRS12-1AT	56	Atriplex charcoal	0.743	1160 ± 40	1170-970
GRS13-1U	83	unidentified hardwood charcoal	0.002	160 ± 30	290-240 230-70

APPENDIX C

MACROBOTANICAL ANALYSES AND MOLLUSK IDENTIFICATIONS

CONTENTS

EXAMINATION OF BULK SOIL AND DETRITAL CHARCOAL FROM THE DUNCAN VALLEY, UPPER GILA RIVER, ARIZONA

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Denver, Colorado

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INTRODUCTION

A total of 42 bulk soil or detrital charcoal samples from study sites along the Upper Gila River in the Duncan Valley in southeastern Arizona were examined to recover organic fragments suitable for radiocarbon analysis. Botanic components and detrital charcoal were identified, and potentially radiocarbon datable material was separated.

METHODS

The bulk samples were floated using a modification of the procedures outlined by Matthews (1979). Each sample was added to approximately 3 gallons of water. The sample was stirred until a strong vortex formed, which was allowed to slow before pouring the light fraction through a 150 micron mesh sieve. Additional water was added and the process repeated until all visible macrofloral material was removed from the sample (a minimum of 5 times). The material which remained in the bottom (heavy fraction) was poured through a 0.5 mm mesh screen. The floated portions were allowed to dry.

The light fractions were weighed, then passed through a series of graduated screens (US Standard Sieves with 4 mm, 2 mm, 1 mm, 0.5 mm and 0.25 mm openings to separate charcoal debris and to initially sort the remains. The contents of each screen were then examined. Charcoal pieces larger than 1 mm in diameter were broken to expose a fresh cross-section and examined under a binocular microscope at a magnification of 70x. The remaining light fraction in the 4 mm, 2 mm, 1 mm, 0.5 mm, and 0.25 mm sieves was scanned under a binocular stereo microscope at a magnification of 10x, with some identifications requiring magnifications of up to 70x. The material which passed through the 0.25 mm screen was not examined. The coarse or heavy fractions also were screened and examined for the presence of botanic remains. Remains from both the light and heavy fractions were recorded as charred and/or uncharred, whole and/or fragments. Individual detrital charcoal/wood samples also were broken to expose a fresh cross-section and examined under a binocular microscope at a magnification of 70x.

Macrofloral remains, including charcoal, were identified using manuals (Core *et al.* 1976; Martin and Barkley 1973; Panshin and Zeeuw 1980; Petrides and Petrides 1992) and by comparison with modern and archaeological references. The term "seed" is used to represent seeds, achenes, caryopses, and other disseminules. Because charcoal and possibly other botanic remains were to be sent for radiocarbon dating, clean laboratory conditions were used during flotation and identification to avoid contamination. All instruments were washed between samples, and samples were protected from contact with modern charcoal.

DISCUSSION

Sites GRD1 through GRD12 are located in the Duncan-York Valley in southeastern Arizona near the Arizona-New Mexico border. Charcoal sample GRD1-1 was collected from a depth of 26 cm in an area of burned soil (Table 1). This sample contained two fragments of conifer charcoal too small to identify to genus weighing 0.010 g and several fragments of probable *Populus* charcoal weighing 0.250 g (Table 2, Table 3). Both of these charcoal types were present in sufficient quantities for AMS radiocarbon analysis. The minimum requirement of charcoal for AMS radiocarbon analysis reported by Beta Analytic, Inc. is 5 mg or 0.005 g.

Most of the charcoal in bulk sample GRD2-1 from a depth of 305-320 cm exhibited some degree of smoothed, rounded edges, suggesting transport in either sediment or water. Charcoal types present include one piece of *Cercocarpus* with rounded edges weighing 0.002 g, three pieces of conifer weighing less than 0.001 g, several fragments of conifer with rounded edges weighing 0.020 g, a piece of *Pinus* with rounded edges weighing 0.001 g, three pieces of vitrified *Prosopis* charcoal weighing 0.001 g, a piece of *Quercus* weighing less than 0.001 g, five fragments of *Quercus* with rounded edges weighing 0.005 g, two pieces of Salicaceae with rounded edges weighing 0.003 g, two pieces of unidentifiable vitrified charcoal weighing 0.007 g, and unidentified charcoal and wood. One piece of charred, vitrified tissue weighing 0.002 g also was present in the sample. Vitrified material has a shiny, glassy appearance due to fusion by heat. This tissue fragment might represent charcoal or other plant tissue too vitrified for identification. The presence of uncharred seeds, a few uncharred rootlets, and an uncharred bone fragment represent introduction of modern material into this area. The sample also contained a snail shell fragment and a moderate amount of calcium carbonate chunks, rock/gravel, and sand.

Bulk sample GRD2-2 from a depth of 285-300 cm also contained charcoal that exhibited some degree of smoothed and rounded edges. Pieces of *Juniperus* charcoal weighing 0.031 g, *Pinus* charcoal weighing 0.025 g, and Salicaceae charcoal weighing 0.026 g were very smooth and rounded. Other charcoal types present include a piece of *Acer* weighing 0.003 g, *Cercocarpus* with rounded edges weighing 0.030 g, conifer with rounded edges weighing 0.021 g, vitrified conifer charcoal with rounded edges weighing 0.008 g, a piece of *Platanus* weighing 0.002 g, vitrified *Prosopis* charcoal weighing 0.018 g, and *Quercus* with rounded edges weighing 0.024 g, as well as unidentified charcoal and wood. The sample also yielded uncharred seeds and rootlets from modern plants, several uncharred bone fragments, a few calcium carbonate chunks, a moderate amount of rock/gravel and sand, and several snail shells.

Bulk sample GRD2-8 was taken from a charcoal rich bed at a depth of 128 cm. This sample contained several charred unidentified seed fragments and five charred *Salsola* seed fragments, as well as several charred herbaceous dicot stem fragments weighing 0.006 g. The herbaceous dicot stem fragments represent a plant stem containing only primary xylem and phloem. *Salsola* (Russian thistle) is reported to have been introduced into the United States in 1873 or 1874 in a shipment of flax seed (Martin 1972:43). Charred Russian thistle seeds have been recovered from prehistoric archaeological samples in Wyoming, Colorado, Nebraska, and Utah, however, and might suggest that a Russian thistle existed in the United States before the historic introduction (Cummings and Puseman 1992; Puseman 1993; Roper 1996). The charcoal record consisted of small, unidentified hardwood twig fragments weighing 0.008 g that can be submitted for AMS radiocarbon analysis. The sample also contained an uncharred piece of unidentified hardwood root wood, uncharred seeds and rootlets from modern plants, several insect chitin fragments, and a small amount of sand.

Bulk sample GRD2-9 was recovered from a charcoal rich lens at a depth of 110 cm. One piece of *Platanus* charcoal weighing 0.005 g is the best candidate for AMS radiocarbon analysis. Other charcoal types present include a piece of *Juniperus* with rounded edges weighing 0.010 g, *Pinus* with rounded edges weighing 0.24 g, a piece of *Prosopis* with rounded edges weighing 0.001 g, a piece of *Quercus* with rounded edges weighing 0.007 g, a piece of Salicaceae with slightly rounded edges weighing 0.001 g, and unidentified charcoal and wood.

This sample contained numerous uncharred seeds and a few rootlets from modern plants, as well as several insect chitin fragments and a small amount of sand.

Charcoal types present in bulk sample GRD2-10 from the Ab1 Horizon at a depth of 160-180 cm include pieces of Asteraceae twig weighing 0.003 g, conifer weighing less than 0.001 g, a piece of conifer charcoal with rounded edges weighing less than 0.001 g, a piece of *Pinus* weighing less than 0.001 g, *Platanus* weighing 0.002 g, Salicaceae weighing 0.003 g, a Salicaceae twig fragment weighing 0.008 g, pieces of Salicaceae charcoal with slightly rounded edges weighing 0.012 g, and unidentified charcoal weighing 0.004 g. Several types of uncharred seeds and a moderate amount of uncharred rootlets reflect introduction of material from modern plants into this area. The sample also contained several insect chitin fragments, a small amount of rock/gravel and sand, five snail shell fragments, and a moderate amount of sclerotia.

Sclerotia are commonly called "carbon balls". They are small, black, solid or hollow spheres that can be smooth or lightly sculpted. These forms range from 0.5 to 4 mm in size. Sclerotia are associated with mycorrhizae fungi, such as *Cenococcum graniforme*, that have a mutualistic relationship with tree roots. Sclerotia are the resting structures of the fungus, identified by Dr. Kristiina Vogt, Professor of Ecology in the School of Forestry and Environmental Studies at Yale University. Many trees are noted to depend heavily on mycorrhizae and may not be successful without them. "The mycelial strands of these fungi grow into the roots and take some of the sugary compounds produced by the tree during photosynthesis. However, mycorrhizal fungi benefit the tree because they take in minerals from the soil, which are then used by the tree" (Kricher and Morrison 1988:285). Sclerotia appear to be ubiquitous and are found with coniferous and deciduous trees including *Abies* (fir), *Juniperus communis* (common juniper), *Larix* (larch), *Picea* (spruce), *Pinus* (pine), *Pseudotsuga* (Douglas-fir), *Acer pseudoplatanus* (sycamore maple), *Alnus* (alder), *Betula* (birch), *Carpinus caroliniana* (American hornbeam), *Carya* (hickory), *Castanea dentata* (American chestnut), *Corylus* (hazelnut), *Crataegus monogyna* (hawthorn), *Fagus* (beech), *Populus* (poplar, cottonwood, aspen), *Quercus* (oak), *Rhamnus fragula* (alder bush), *Salix* (willow), *Sorbus* (chokecherry), and *Tilia* (linden) (McWeeney 1989:229-130; Trappe 1962).

Pieces of *Prosopis* charcoal weighing 0.004 g are the best candidate for AMS radiocarbon analysis in sample GRD2-11from the Ab2 Horizon at a depth of 190-220 cm. Other charcoal types present include conifer weighing less than 0.001 g, conifer charcoal with rounded edges weighing 0.002 g, a piece of vitrified conifer charcoal weighing 0.001 g, *Juniperus* with rounded edges weighing 0.002 g, partially charred *Juniperus* with rounded edges weighing less than 0.001 g, small fragments of *Pinus* weighing 0.001 g, a piece of *Pseudotsuga* weighing less than 0.001 g, a piece of Salicaceae weighing less than 0.001 g, unidentified charcoal, and conifer wood. One charred *Xanthium* fruit (bur) fragment weighing less than 0.001 g and one charred bone fragment also were present. Introduction of modern material is represented by several types of uncharred seeds, a moderate amount of uncharred rootlets, and several insect chitin fragments. Four snail shells and a small amount of rock/gravel and sand complete the record.

Charcoal sample GRD3-2 consists of charcoal and sediment from the base of a fresh flood deposit at a depth of 95 cm. Several pieces of Salicaceae charcoal weighing 0.066 g were present and can be submitted for AMS radiocarbon analysis. The sample also contained a moderate amount of uncharred rootlets from modern plants, one uncharred bone fragment, and a small amount of rock/gravel and sand.

Bulk sample GRD3-3 was collected from soil at the base of a hearth at a depth of 115 cm. This sample contained charred *Zea mays* cupule fragments weighing 0.292 g and kernel fragments weighing 0.039 g, indicating that maize was processed in this hearth. These maize fragments can be submitted for AMS radiocarbon analysis to determine when the hearth was utilized. Recovery of *Atriplex* charcoal weighing 0.098 g, *Juniperus* charcoal weighing 0.031 g, *Quercus* charcoal weighing 0.030 g, and Salicaceae charcoal weighing 0.018 g indicate that saltbush, juniper, oak, and willow/cottonwood was burned as fuel. Pieces of charcoal with a diffuse porous arrangement of vessels weighing 0.063 also represent a hardwood that was burned. The presence of one calcined bone fragment suggests that meat was processed and/or bones discarded in the hearth.

Charcoal sample GRD3-4 from a depth of 125 cm contained pieces of *Atriplex* charcoal weighing 0.033 g, *Prosopis* charcoal weighing 0.152 g, and Salicaceae charcoal weighing 0.157 g. All three charcoal types were present in sufficient quantities for AMS radiocarbon analysis.

Bulk sample GRD3-6 from a depth of 285-305 cm contained very few remains. The five pieces of charcoal present in the sample that measured 0.5 mm in size or larger were too small for identification and too small for AMS radiocarbon analysis, weighing less than 0.001 g. The sample contained one insect chitin fragment, one snail shell fragment, a moderate amount of uncharred rootlets from modern plants, and a small amount of sand.

All of the charcoal in bulk sample GRD4-1 from a depth of 240-260 cm exhibited smoothed and rounded edges. Charcoal types present in this sample include a piece of *Cercocarpus* weighing 0.001 g, conifer weighing 0.002 g, a piece of *Pinus* weighing 0.002 g, *Quercus* weighing 0.004 g, and unidentified charcoal weighing 0.003 g. One charred *Chenopodium* seed weighing less than 0.001 g, a piece of charred, vitrified tissue weighing 0.001 g, an uncharred *Datura* seed, and a few rootlets and sclerotia also were present. Non-floral remains include a few snail shell fragments and a small amount of rock/gravel and sand.

Recovery of a charred *Zea mays* cupule fragment in bulk sample GRD4-2 indicates the presence of burned cultural remains in this sample. Maize might have been processed and/or corn cobs burned as fuel. This cupule fragment weighed less than 0.001 g and is too small for AMS radiocarbon analysis. The sample also contained charred monocot stem fragments weighing less than 0.001 g and charred bark fragments weighing 0.002 g. Uncharred seeds and rootlets represent modern plants. Pieces of conifer charcoal with rounded edges weighing 0.004 g and *Quercus* charcoal weighing 0.006 g suggest that conifer and oak wood were burned as fuel. The *Quercus* charcoal was present in sufficient quantities for AMS radiocarbon analysis. Unidentified charcoal weighing 0.002 g, unidentified wood weighing 0.002 g, and unidentifiable pieces of vitrified charcoal with rounded edges weighing 0.009 g also were present. A few snail shells and a small amount of rock/gravel and sand complete the record.

Charcoal sample GRD4-3 was taken from a depth of 215-220 cm. This sample contained a piece of *Fraxinus* charcoal weighing 0.001 g, pieces of charcoal too small for identification weighing less than 0.001 g, and a partially charred piece of *Juniperus* wood weighing 0.005 g.

Bulk sample GRD5-1 from a depth of 80-100 cm yielded three pieces of *Atriplex* charcoal weighing less than 0.001 g, a piece of Salicaceae charcoal with rounded edges weighing 0.002 g, and charcoal fragments too small for identification weighing 0.008 g. One uncharred *Datura* seed and a moderate amount of uncharred rootlets represent modern plants. The sample also contained an animal tooth fragment, several snail shell fragments, and a small amount of rock/gravel and sand.

Charcoal sample GRD5-2 was recovered from the base of an Ab Horizon at a depth of 50 cm. This sample contained pieces of Asteraceae charcoal weighing 0.009 g and charred monocot stem fragments weighing 0.011 g that can be submitted for AMS radiocarbon analysis. A piece of *Atriplex* charcoal weighing 0.004 g and unidentified charcoal weighing 0.004 g also were recovered. One uncharred *Trianthema portulacastrum* seed represents modern plants. Non-floral remains include sand and a snail shell.

Charcoal sample GRD5-8 from a depth of 152-155 cm contained pieces of Salicaceae charcoal weighing 0.018 g than can be submitted for AMS radiocarbon analysis. The sample also yielded small fragments of unidentified charcoal weighing 0.001 g, a few uncharred rootlets from modern plants, and a small amount of sand.

Four pieces of *Fraxinus* charcoal weighing 0.018 g were present in charcoal sample GRD5-10 from the top of an Ab horizon. This charcoal can be submitted for AMS radiocarbon analysis. Pieces of unidentified charcoal weighing 0.005 g and a few uncharred rootlets from modern plants also were present.

Bulk sample GRD6-1 from a depth of 320-340 cm contained a variety of remains. Charcoal in this sample includes Asteraceae weighing 0.005 g, conifer weighing 0.002 g, conifer with rounded edges weighing 0.008 g, a piece of *Quercus* with rounded edges weighing less than 0.001 g, Salicaceae weighing 0.004 g, and unidentified charcoal weighing 0.008 g. Four charred bark fragments weighing 0.002 g, a charred *Atriplex* fruit and fruit fragment weighing 0.002 g, and a charred unidentified seed weighing less than 0.001 g also were present. Recovery of numerous insect chitin fragments and a moderate amount of rodent fecal pellets suggests subsurface disturbance from insect and rodent activity. Insect and rodent activity in this area probably accounts for the large amount of uncharred seeds and other remains from modern plants, including uncharred wood, present in this sample.

Sample GRD7-1 consists of charcoal and sediment from a depth of 30 cm. This sample contained small fragments of Asteraceae charcoal weighing 0.002 g, as well as charcoal too small for identification weighing 0.002 g. An uncharred *Amaranthus* seed, two uncharred *Trianthema portulacastrum* seeds, and a few uncharred rootlets from modern plants also were present.

Bulk sample GRD7-8 was recovered from a burn horizon at a depth of 110 cm. A piece of *Atriplex* charcoal weighing less than 0.001 g, a piece of *Juniperus* charcoal weighing less than 0.001 g, and Salicaceae charcoal weighing 0.002 g were present in this sample, as well as charred *Atriplex* fruits and seeds, charred monocot stem fragments weighing less than 0.001 g, two charred *Portulaca* seed fragments, a charred Poaceae caryopsis, and three charred unidentified seed embryos. A few charred termite fecal pellets also were present, suggesting that some of the burned wood contained termites. The sample contained numerous uncharred rootlets from modern plants, a few insect chitin fragments, an insect larva, snail shell fragments, and a small amount of sand.

Bulk sample GRD7-9 represents the Ab Horizon at a depth of 75-90 cm. This sample contained pieces of *Atriplex* charcoal weighing 0.009 g that can be submitted for AMS radiocarbon analysis. A piece of *Quercus* charcoal with rounded edges weighing 0.003 g, unidentified charcoal weighing 0.006 g, a charred Apiaceae seed, and three charred *Atriplex* fruit fragments also were present. Recovery of numerous insect chitin fragments suggests some subsurface disturbance from insect activity. Five snail shell fragments and a small amount of sand complete the record.

Very small fragments of charcoal were present in bulk sample GRD7-10 from the Ab2 Horizon at a depth pf 110-120 cm. Charcoal includes a piece of *Atriplex* weighing less than 0.001 g, conifer weighing 0.001 g, conifer with slightly rounded edges weighing less than 0.001 g, *Pinus* with rounded edges weighing 0.001 g, unidentified hardwood weighing less than 0.001 g, unidentifiable vitrified charcoal weighing less than 0.010 g, and unidentified charcoal weighing 0.010 g. Two charred *Atriplex* seed fragments, a charred *Chenopodium* seed fragment, charred *Pinus* bark scale fragments weighing 0.001 g, and a charred Poaceae seed fragment also were present. One uncharred *Sphaeralcea* seed and numerous uncharred rootlets represent modern plants. Non-floral remains include numerous insect chitin fragments, snail shells, and a small amount of sand.

Bulk sample GRD7-11 from the Ab3 Horizon at a depth of 125-145 cm contained several charcoal types, including *Atriplex*, conifer weighing 0.002 g, conifer with rounded edges weighing less than 0.001 g, *Pseudotsuga* weighing less than 0.001 g, *Prosopis* weighing 0.002 g, *Quercus*_ with rounded edges weighing less than 0.001 g, Salicaceae weighing less than 0.001 g, unidentified hardwood weighing 0.003 g, and unidentified charcoal weighing 0.016 g. A charred Poaceae floret fragment, an uncharred *Chenopodium* seed and seed fragment, and numerous uncharred rootlets also were present, as well as four insect chitin fragments, a few snail shells, and a small amount of sand.

Pieces of *Prosopis* charcoal weighing 0.006 g in bulk sample GRD8-5 from the Ck Horizon at a depth of 80-120 cm can be submitted for AMS radiocarbon analysis. The sample also yielded a piece of *Atriplex* charcoal weighing 0.001 g, a piece of *Juniperus* charcoal with rounded edges weighing less than 0.001 g, *Pinus* charcoal weighing less than 0.001 g, a piece of unidentified hardwood charcoal weighing less than 0.001 g, unidentified charcoal weighing 0.008 g, and vitrified tissue fragments weighing 0.010 g. A few uncharred seeds represent modern plants. Non-floral remains include a possible piece of coal, several insect chitin fragments, a few snail shells and worm casts, and a small amount of sand.

Bulk sample GRD8-6 from the base of a Bk Horizon at a depth of 55-65 cm contained very small fragments of conifer charcoal weighing less than 0.001 g and unidentified hardwood charcoal weighing less than 0.001 g. A few uncharred rootlets and a small amount of sand were the only other remains to be recovered.

Bulk sample GRD9-6 was collected from a charcoal bed at a depth of 114 cm. This sample contained pieces of *Pinus* charcoal weighing 2.507 g than can be submitted for radiocarbon analysis. Partially charred *Pinus* wood weighing 1.438 g also was present, as well as uncharred seeds and rootlets from modern plants, a few sclerotia, and a few insect chitin fragments.

Bulk sample GRD9-7 also was taken from a charcoal bed at a depth of 125 cm. Four charred *Prosopis* twig fragments with slightly rounded edges weighing 0.080 g can be submitted for AMS radiocarbon analysis. The sample also contained a piece of probable *Cercidium* charcoal weighing 0.001 g, unidentified charcoal weighing 0.012 g, and several uncharred seeds and rootlets from modern plants.

Bulk sample GRD9-8 from an Ab Horizon at a depth of 195-205 cm contained pieces of *Prosopis* charcoal weighing 0.006 g that can be submitted for AMS radiocarbon analysis. Other charcoal types present in this sample include conifer with rounded edges weighing 0.02 g, a piece of *Juniperus* with rounded edges weighing less than 0.001 g, *Pinus* with rounded edges weighing 0.004 g, and unidentified charcoal weighing 0.009 g. Pieces of charred, vitrified tissue fragments weighing 0.021 g might represent charcoal or other plant tissue too vitrified for identification. A variety of uncharred seeds and uncharred roots and rootlets represent modern plants in the area. Non-floral remains include three insect chitin fragments and a moderate amount of rock/gravel and sand.

Charcoal sample GRD10-1 was collected from the 3Bk2b Horizon at a depth of 185 cm. This sample consisted of *Fraxinus* charcoal weighing 0.315 g that can be submitted for AMS radiocarbon analysis.

Pieces of *Cercocarpus* charcoal weighing 0.008 g and *Juniperus* charcoal weighing 0.015 g were present in bulk sample GRD10-8 from the Bk3 Horizon at a depth of 85-120 cm. These charcoal types can be submitted for AMS radiocarbon analysis. Additional charcoal from this sample includes a piece of Asteraceae weighing less than 0.001 g, conifer with rounded edges weighing 0.004 g, *Juniperus* with rounded edges weighing 0.003 g, a piece of *Fraxinus* weighing 0.001 g, *Fraxinus* with slightly rounded edges weighing 0.003 g, *Quercus* weighing 0.002 g, unidentifiable vitrified charcoal weighing less than 0.001 g, and unidentified charcoal weighing 0.008 g. The sample also contained uncharred seeds and numerous rootlets from modern plants, several insect chitin fragments, seven snail shell fragments, and a moderate amount of rock/gravel and sand.

Charcoal sample GRD10-9 was taken from a depth of 95 cm and contained Salicaceae charcoal weighing 0.047 g, which is a sufficient weight for AMS radiocarbon analysis.

Bulk sample GRD10-10 from the 3Bk2b Horizon at a depth of 75-200 cm contained pieces of *Prosopis* charcoal weighing 0.005 g and *Quercus* charcoal weighing 0.006 g that can be submitted for AMS radiocarbon analysis. This sample also contained conifer charcoal weighing less than 0.001 g, a piece of slightly vitrified conifer charcoal weighing less than 0.001 g, *Juniperus* charcoal with slightly rounded edges weighing less than 0.001 g, unidentified charcoal weighing 0.003 g, a moderate amount of uncharred rootlets, several insect chitin fragments, two insect larvae, and a moderate amount of rock/gravel and sand.

Charcoal sample GRD11-1 from a depth of 102 cm consists of *Atriplex* charcoal weighing 0.019 g. This charcoal is a sufficient weight for AMS radiocarbon analysis.

Sample GRD11-2 consists of sediment with charcoal from a depth of 112-125 cm. This sample contained pieces of *Atriplex* charcoal weighing 0.006 g, *Juniperus* charcoal weighing 0.021 g, and *Pseudotsuga* charcoal weighing 0.005 g that can be submitted for AMS radiocarbon analysis. Other charred remains present in this sample include conifer charcoal weighing 0.002 g, *Fraxinus* charcoal weighing 0.002 g, *Quercus* charcoal weighing 0.001 g, unidentified charcoal weighing 0.007 g, a charred monocot stem fragment weighing less than 0.001 g, and a piece of vitrified tissue weighing 0.001 g. One uncharred *Solanum* seed and a few uncharred rootlets represent modern plants. Non-floral remains include four uncharred bone fragments, four insect chitin fragments, a snail shell fragment, and a small amount of sand.

A variety of charred remains were present in bulk sample GRD11-6 from the C3 Horizon at a depth of 130-155 cm. Pieces of *Juniperus* charcoal weighing 0.005 g are of a sufficient weight for AMS radiocarbon analysis. Other charcoal types include probable *Cercidium* weighing 0.001 g, *Cercocarpus* with rounded edges weighing 0.004 g, conifer weighing 0.003 g, conifer with rounded edges weighing 0.003 g, vitrified conifer weighing 0.001 g, *Juniperus* with rounded edges weighing less than 0.001 g, *Pinus* weighing 0.002 g, *Fraxinus* weighing less than 0.001 g, *Quercus* with slightly rounded edges weighing 0.002 g, and unidentified charcoal weighing 0.031 g. Recovery of a few charred termite fecal pellets and a charred insect fecal pellet suggests that some of the burned wood contained termites and other insects. In addition, charred *Pinus* bark scale fragments weighing 0.004 g, charred monocot stem fragments weighing 0.003 g, and charred *Chenopodium* seeds were present, as well as uncharred seeds, bark, and rootlets from modern plants. The presence of several insect chitin fragments and a few worm casts suggests some subsurface disturbance from insect and earthworm activity. Snail shells, rock/gravel, and sand complete the record.

Sample GRD12-1 consists of sediment with charcoal from a depth of 145 cm. This sample contained pieces of *Atriplex* charcoal weighing 0.006 g that can be submitted for AMS radiocarbon analysis, as well as a piece of Salicaceae charcoal weighing 0.004 g and unidentified charcoal weighing 0.018 g. A few uncharred rootlets, an insect chitin fragment, and a small amount of sand also were present.

A charred *Zea mays* cob fragment weighing 0.112 g and a charred *Zea mays* cupule weighing 0.005 g were present in sample GRD12-2 from the Bk2 Horizon at a depth of 115-130 cm. These charred maize remains indicate the presence of cultural material and can be submitted for AMS radiocarbon analysis. Pieces of *Atriplex* charcoal weighing 0.087 g and Salicaceae charcoal weighing 0.509 g suggest that saltbush and willow/cottonwood were burned as fuel and also can be sent for AMS radiocarbon analysis. In addition, the sample yielded unidentified charcoal weighing 0.040 g, a few uncharred rootlets from modern plants, and a small amount of sand.

Sample GRD12-3 from the Bk Horizon at a depth of 70-90 cm contained pieces of *Atriplex* charcoal weighing 0.130 g, *Prosopis* charcoal weighing 0.004 g, and *Salix* charcoal weighing 0.269 g that can be submitted for AMS radiocarbon analysis. Three charred bone fragments might indicate that this sample contains cultural material. Three uncharred bone fragments, a few uncharred rootlets from modern plants, six snail shell fragments, and a small amount of sand complete the record.

A charred bone fragment in sample GRD12-4 from the B Horizon at a depth of 40-55 cm again might indicate that the sample contains cultural material. Pieces of *Atriplex* charcoal weighing 0.102 g and *Prosopis* charcoal weighing 0.008 g are of sufficient weights for AMS radiocarbon analysis. The sample also yielded Salicaceae charcoal weighing 0.003 g, unidentified charcoal weighing 0.007 g, uncharred *Solanum* seeds and rootlets from modern plants, an uncharred bone fragment, three snail shell fragments, and a small amount of sand.

Sample A was collected from upstream of Duncan Bridge. This sample consists of one piece of Asteraceae charcoal weighing 0.015 g that can be submitted for AMS radiocarbon analysis.

Bulk sample GRS1-1 was taken from a depth of 130 cm. This sample contained charred monocot stem fragments weighing 0.002 g, as well as a few uncharred rootlets, three snail shell fragments, and a small amount of sand.

SUMMARY AND CONCLUSIONS

Examination of detrital charcoal and bulk soil samples from along the Gila River in southeastern Arizona resulted in recovery of charcoal and other charred botanic remains that can be submitted for AMS radiocarbon analysis. A variety of charcoal types were present in these samples, representing several trees and shrubs growing along the Gila River and in the Gila River drainage basin. Samples GRD3-3, GRD4-2, and GRD12-2 contained charred maize cupule, kernel, and/or cob fragments, indicating the presence of cultural material in these samples. Charred bone fragments in samples GRD12-3 and GRD12-4 also might represent cultural remains.

TABLE 1
PROVENIENCE DATA FOR SAMPLES FROM THE DUNCAN VALLEY, GILA RIVER, ARIZONA

Sample No.	Depth (cm)	Description	Date Collected	Analysis
GRD1-1	26	Detrital charcoal from area of burned soil		Charcoal ID
GRD2-1	305-320	Bulk soil		Float/Charcoal ID
GRD2-2	285-300	Bulk soil		Float/Charcoal ID
GRD2-8	128	Bulk soil from charcoal rich bed	3/29/01	Float/Charcoal ID
GRD2-9	110	Bulk soil from charcoal rich lens	3/29/01	Float/Charcoal ID
GRD2-10	160-180	Bulk soil from Ab1 Horizon	3/29/01	Float/Charcoal ID
GRD2-11	190-220	Bulk soil from Ab2 Horizon	2/29/01	Float/Charcoal ID
GRD3-2	95	Charcoal and sediment from base of fresh flood deposit	2/07/01	Charcoal ID
GRD3-3	115	Bulk soil from base of hearth		Float/Charcoal ID
GRD3-4	125	Detrital charcoal		Charcoal ID
GRD3-6	285-305	Bulk soil		Float/Charcoal ID
GRD4-1	240-260	Bulk soil		Float/Charcoal ID
GRD4-2	195-215	Bulk soil		Float/Charcoal ID
GRD4-3	215-220	Charcoal	3/29/01	Charcoal ID
GRD5-1	80-100	Bulk soil		Float/Charcoal ID
GRD5-2	50	Charcoal from base of Ab Horizon	3/27/01	Charcoal ID
GRD5-8	152-155	Charcoal	3/27/01	Charcoal ID
GRD5-10		Charcoal from top of Ab Horizon	3/27/01	Charcoal ID
GRD6-1	320-340	Bulk soil		Float/Charcoal ID
GRD7-1	30	Charcoal and sediment	3/27/01	Charcoal ID
GRD7-8	110	Bulk soil from burn horizon	3/27/01	

GRD7-9	75-90	Bulk soil from Ab Horizon	3/27/01	Float/Charcoal ID
GRD7-10	110-120	Bulk soil from Ab2 Horizon	3/27/01	Float/Charcoal ID
GRD7-11	125-145	Bulk soil from Ab3 Horizon	3/27/01	Float/Charcoal ID
GRD8-5	80-120	Bulk soil from Ck Horizon	3/27/01	Float/Charcoal ID
GRD8-6	55-65	Bulk soil from base of Bk Horizon	3/27/01	Float/Charcoal ID
GRD9-6	114	Bulk soil from charcoal bed	3/28/01	Float/Charcoal ID
GRD9-7	125	Bulk soil from charcoal bed	3/28/01	Float/Charcoal ID
GRD9-8	195-205	Bulk soil from Ab Horizon	3/28/01	Float/Charcoal ID
GRD10-1	185	Charcoal from 3Bk2b Horizon	3/28/01	Charcoal ID
GRD10-8	85-120	Bulk soil from Bk3 Horizon	3/28/01	Float/Charcoal ID
GRD10-9	95	Charcoal	3/28/01	Charcoal ID
GRD10-10	175-200	Bulk soil from 3Bk2b Horizon	3/28/01	Float/Charcoal ID
GRD11-1	102	Detrital charcoal	3/28/01	Charcoal ID
GRD11-2	112-125	Sediment with charcoal	3/28/01	Float/Charcoal ID
GRD11-6	130-155	Bulk soil from C3 Horizon	3/28/01	Float/Charcoal ID
GRD12-1	145	Sediment with charcoal	3/29/01	Float/Charcoal ID
GRD12-2	115-130	Charcoal and soil from Bk2 Horizon	3/29/01	Float/Charcoal ID
GRD12-3	70-90	Charcoal and soil from Bk Horizon	3/29/01	Charcoal ID
GRD12-4	40-55	Charcoal and soil from B Horizon	3/29/01	Float/Charcoal ID
A		Charcoal from upstream of Duncan [illegible]		Charcoal ID
GRS 1-1	130	Bulk soil		Float/Charcoal ID

TABLE 1 (Continued)
TABLE 2
MACROFLORAL REMAINS FROM THE DUNCAN VALLEY, GILA RIVER, ARIZONA

Sample No.	Identification	Part	Charred W	Charred F	Uncharred W	Uncharred F	Weights/ Comments
GRD1-1	CHARCOAL/WOOD:						
26 cm	Total charcoal ≥ 2 mm						
	Conifer	Charcoal		2			0.010 g
	Salicaceae, cf. *Populus*	Charcoal		14			0.250 g
GRD2-1	Liters Floated						4.80 L
305-320 cm	Light Fraction Weight						2.83 g
	FLORAL REMAINS:						
	Vitrified tissue			1			0.002 g
	Datura	Seed				2	
	Euphorbia	Seed			1		
	Mollugo	Seed			1	1	
	Solanum	Seed				2	
	Trianthema portulacastrum	Seed			1		
	Rootlets					X	Few
	CHARCOAL/WOOD:						
	Total charcoal ≥ 1 mm						0.084 g
	Cercocarpus - rounded	Charcoal		1			0.002 g
	Conifer	Charcoal		3			< 0.001 g
	Conifer - rounded	Charcoal		12			0.020 g
	Pinus - rounded	Charcoal		1			0.001 g
	Prosopis - vitrified	Charcoal		3			0.001 g
	Quercus	Charcoal		1			< 0.001 g
	Quercus - rounded	Charcoal		5			0.005 g
	Salicaceae - rounded	Charcoal		2			0.003 g

TABLE 1 (Continued)

	Unidentifiable - rounded and vitrified	Charcoal		2			0.007 g
	Unidentified - rounded	Charcoal		X			0.028 g
	Unidentified	Wood				3	0.006 g
	NON-FLORAL REMAINS:						
	Bone					1	
	Calcium carbonate chunks					X	Moderate
	Rock/Gravel					X	Moderate
	Sand					X	Moderate
	Snail shell					1	< 0.001 g
GRD2-2	Liters Floated						5.80 L
285-300 cm	Light Fraction Weight						10.10 g
	FLORAL REMAINS:						
	Asteraceae	Seed				1	
	Datura	Seed				5	
	Echinocereus	Seed			2	1	
	Mollugo	Seed			82	23	
	Sphaeralcea	Seed			3		
	Trianthema portulacastrum	Seed			4	1	
	Rootlets					X	Few
	CHARCOAL/WOOD:						
	Total charcoal ≥ 1 mm						
	Acer	Charcoal		1			0.003 g
	Cercocarpus - rounded	Charcoal		10			0.030 g
	Conifer - rounded	Charcoal		8			0.021 g
	Conifer - rounded & vitrified	Charcoal		2			0.008 g
	Juniperus - rounded	Charcoal		8			0.031 g
	Pinus - rounded	Charcoal		7			0.025 g
	Platanus	Charcoal		1			0.002 g
	Prosopis - vitrified	Charcoal		5			0.018 g

TABLE 2 (Continued)

	Quercus - rounded	Charcoal		6			0.024 g
	Salicaceae - rounded	Charcoal		2			0.026 g
	Unidentified	Charcoal					0.861 g
	Unidentified	Wood					0.027 g
	NON-FLORAL REMAINS:						
	Bone					14	
	Calcium carbonate chunks					X	Few
	Rock/Gravel					X	Moderate
	Sand					X	Moderate
	Snail shell					18	0.007 g

GRD2-8	Liters Floated						0.300 L
128 cm	Light Fraction Weight						9.832 g
	FLORAL REMAINS:						
	Salsola	Seed		5			
	Unidentified	Seed		11			
	Herbaceous dicot	Stem		13			0.006 g
	Atriplex	Fruit			1		
	Helianthus	Seed			4	50	
	Polygonum	Seed				1	
	Rootlets					X	Few
	CHARCOAL/WOOD:						
	Unidentified hardwood twig	Charcoal		19			0.008 g
	Unidentified $\geq$ 1 mm	Charcoal and Stem		X			0.008 g
	Unidentified hardwood root	Wood				1	0.714 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				28	
	Sand					X	Scant

TABLE 2 (Continued)

GRD2-9	Liters Floated						0.250 L
110 cm	Light Fraction Weight						15.070 g
	FLORAL REMAINS:						
	Amaranthus	Seed			1	1	
	Ambrosia	Seed				1	
	Argemone	Seed			1		
	Asteraceae	Seed			1		
	Helianthus	Seed			9	17	
	Atriplex	Seed			16*		
	Chenopodium	Seed			50*	5	
	Datura	Seed				5	
	Lamiaceae	Seed			1		
	Mentzelia	Seed			2		
	Mollugo verticillata	Seed			1		
	Opuntia	Seed embryo			3	2	
	Physalis	Seed			1		
	Poaceae - Panicoid	Floret			1		
	Portulaca	Seed			10	3	
	Polygonum	Seed			1		
	Quercus	Acorn cap			1	3	
	Rumex	Seed			1		
	Solanum	Seed			1		
	Solanum rostratum	Seed			1		
	Trianthema portulacastrum	Seed			2		
	Unidentified	Seed			2		
	Rootlets					X	Few

GRD2-9	CHARCOAL/WOOD:						
110 cm	Total charcoal $\geq$ 2 mm						
	Juniperus - rounded	Charcoal		1			0.010 g

TABLE 2 (Continued)

	Pinus - rounded	Charcoal		3			0.240 g
	Platanus	Charcoal		1			0.005 g
	Prosopis - rounded	Charcoal		1			0.001 g
	Quercus - rounded	Charcoal		1			0.007 g
	Salicaceae - rounded	Charcoal		1			0.001 g
	Unidentified	Charcoal		X			0.017 g
	Unidentified	Wood				X	3.238 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				40	
	Sand					X	Scant
GRD2-10	Liters Floated						3.50 l
160-180 cm	Light Fraction Weight						1.40 g
	FLORAL REMAINS:						
	Amaranthus	Seed			115*	100*	
	Chenopodium	Seed			28*	32*	
	Euphorbia	Seed			4*		
	Lamiaceae	Seed			10*	1	
	Larrea	Seed			2		
	Mollugo verticillata	Seed			34*		
	Opuntia	Seed				1	
	Portulaca	Seed			8*	4*	
	Sambucus	Seed			15	64*	
	Sphaeralcea	Seed			1		
	Solanum	Seed			94	40*	
	Solanum rostratum	Seed			41	2	
	Trianthema portulacastrum	Seed			1		
	Rootlets					X	Moderate
	Sclerotia				X		Moderate

TABLE 2 (Continued)

GRD2-10	CHARCOAL/WOOD:						
160-180 cm	Total charcoal ≥ 1 mm						
	Asteraceae twig	Charcoa l		3			0.003 g
	Conifer	Charcoa l		3			<0.001 g
	Conifer - rounded	Charcoa l		1			<0.001 g
	Pinus	Charcoa l		1			<0.001 g
	Platanus	Charcoa l		2			0.002 g
	Salicaceae	Charcoa l		2			0.003 g
	Salicaceae twig	Charcoa l		1			0.008 g
	Salicaceae - rounded	Charcoa l		3			0.012 g
	Unidentified	Charcoa l		X			0.004 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				48*	
	Rock/Gravel					X	Scant
	Sand					X	Scant
	Snail shell					5	
GRD2-11	Liters Floated						3.30 L
190-220 cm	Light Fraction Weight						1.18 g
	FLORAL REMAINS:						
	Xanthium	Fruit (Bur)		1			<0.001 g
	Amaranthus	Seed			2	34	
	Chenopodium	Seed			7	24	
	Datura	Seed				4	
	Euphorbia	Seed			1		
	Mollugo verticillata	Seed			1		
	Lamiaceae	Seed			5		
	Polygonum	Seed			1		

TABLE 2 (Continued)

	Sambucus ≥ 0.5 mm	Seed			17	193	
	Sambucus < 0.25 mm	Seed				X	Numerous
	Solanum	Seed			59	18	
	Solanum rostratum	Seed			9	12	
	Trianthema portulacastrum	Seed				3	
	Rootlets					X	Moderate
GRD2-11	CHARCOAL/WOOD:						
190-220 cm	Conifer	Charcoal		2			<0.001 g
	Conifer - rounded	Charcoal		6			0.002 g
	Conifer - vitrified	Charcoal		1			0.001 g
	Juniperus - rounded	Charcoal		5			0.002 g
	Juniperus - rounded	Charcoal		2pc			<0.001 g
	Pinus	Charcoal		8			0.001 g
	Pseudotsuga	Charcoal		1			<0.001 g
	Prosopis	Charcoal		11			0.004 g
	Salicaceae	Charcoal		1			<0.001 g
	Unidentified ≥ 0.5 mm	Charcoal		X			0.011 g
	Conifer	Wood				3	0.001 g
	NON-FLORAL REMAINS:						
	Bone			1			
	Insect	Chitin				69	
	Rock/Gravel					X	Scant
	Sand					X	Scant
	Snail shell				4		
GRD3-2	Liters Floated						0.040 L
95 cm	Light Fraction Weight						2.070 g
	FLORAL REMAINS:						
	Rootlets					X	Moderate

TABLE 2 (Continued)

	CHARCOAL/WOOD:						
	Salicaceae	Charcoal		52			0.066 g
	NON-FLORAL REMAINS:						
	Bone					1	
	Rock/Gravel					X	Scant
	Sand					X	Scant
GRD3-3	Liters Floated						0.15 L
115 cm	Light Fraction Weight						2.79 g
	FLORAL REMAINS:						
	Zea mays ≥ 1 mm	Cupule	9	99			0.292 g
	Zea mays ≥ 1 mm	Kernel		37			0.039 g
	Rootlets					X	Few
GRD3-3	CHARCOAL/WOOD:						
115 cm	*Atriplex*	Charcoal		11			0.098 g
	Juniperus	Charcoal		2			0.031 g
	Quercus	Charcoal		2			0.030 g
	Salicaceae	Charcoal		4			0.018 g
	Unidentified diffuse porous	Charcoal		6			0.063 g
	Unidentified ≥ 2mm	Charcoal		X			0.066 g
	NON-FLORAL REMAINS:						
	Calcined bone			1			
	Rock/Gravel					X	Scant
	Sand					X	Scant
GRD3-4	CHARCOAL/WOOD:						
125 cm	*Atriplex*	Charcoal		6			0.033 g
	Prosopis	Charcoal		7			0.152 g
	Salicaceae	Charcoal		4			0.157 g
GRD3-6	Liters Floated						4.00 L
285-305	Light Fraction Weight						2.58 g

TABLE 2 (Continued)

cm	FLORAL REMAINS:						
	Rootlets					X	Moderate
	CHARCOAL/WOOD:						
	Total charcoal ≥ 0.5 mm						
	Unidentifiable - small	Charcoal		5			< 0.001 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				1	
	Sand					X	Scant
	Snail shell					1	< 0.001 g
GRD4-1	Liters Floated						5.10 L
240-260	Light Fraction Weight						3.62 g
cm	FLORAL REMAINS:						
	Chenopodium	Seed		1			< 0.001 g
	Vitrified tissue ≥ 1 mm			2			0.001 g
	Datura	Seed				1	
	Rootlets					X	Very few
	Sclerotia				X	X	Few
GRD4-1	CHARCOAL/WOOD:						
240-260	Total charcoal ≥ 1 mm						0.026 g
cm	*Cercocarpus* - rounded	Charcoal		1			0.001 g
	Conifer - rounded	Charcoal		5			0.002 g
	Pinus - rounded	Charcoal		1			0.002 g
	Quercus - rounded	Charcoal		5			0.004 g
	Unidentified - rounded	Charcoal		X			0.003 g
	NON-FLORAL REMAINS:						
	Rock/Gravel					X	Scant
	Sand					X	Scant
	Snail shell					6	
GRD4-2	Liters Floated						5.00 L
195-215	Light Fraction Weight						3.99 g
cm	FLORAL REMAINS:						

TABLE 2 (Continued)

	Bark			5			0.002 g
	Monocot	Stem		2			< 0.001 g
	Zea mays	Cupule		1			< 0.001 g
	Chenopodium	Seed			6	7	
	Mollugo	Seed			5		
	Portulaca	Seed			1		
	Solanaceae	Seed				1	
	Datura	Seed				21	
	Trianthema portulacastrum	Seed				6	
	Rootlets					X	Very few
	CHARCOAL/WOOD:						
	Total charcoal $\geq$ 2 mm						
	Conifer - rounded	Charcoal		5			0.004 g
	Quercus	Charcoal		5			0.005 g
	Unidentifiable - rounded and vitrified	Charcoal		2			0.009 g
	Unidentified	Charcoal		6			0.002 g
	Unidentified	Wood					0.002 g
	NON-FLORAL REMAINS:						
	Rock/Gravel					X	Scant
	Sand					X	Scant
	Snail shell					3	< 0.001 g
GRD4-3	Liters Floated						~0.005 L
215-220 cm	Light Fraction Weight						0.047 g
	CHARCOAL/WOOD:						
	Fraxinus	Charcoal		1			0.001 g
	Unidentified $\geq$ 0.5 mm	Charcoal		X			<0.001 g
	Juniperus - rounded	Wood				1pc	0.005 g
	NON-FLORAL REMAINS:						
	Sand					X	Scant
GRD5-1	Liters Floated						5.20 L
80-100 cm	Light Fraction Weight						25.17 g
	FLORAL REMAINS:						

TABLE 2 (Continued)

	Datura	Seed				1	
	Rootlets					X	Moderate
	CHARCOAL/WOOD:						
	Atriplex	Charcoal		3			< 0.001 g
	Salicaceae - rounded	Charcoal		1			0.002 g
	Unidentified ≥ 0.5 mm	Charcoal		X			0.008 g
	NON-FLORAL REMAINS:						
	Animal tooth					1	
	Rock/Gravel					X	Scant
	Sand					X	Scant
	Snail shell					42	0.006 g
GRD5-2	Liters Floated						~0.015 L
50 cm	Light Fraction Weight						0.605 g
	FLORAL REMAINS:						
	Monocot	Stem		8			0.011 g
	Trianthema portulacastrum	Seed			1		
	CHARCOAL/WOOD:						
	Asteraceae	Charcoal		3			0.009 g
	Atriplex	Charcoal		1			0.004 g
	Unidentified ≥ 1 mm	Charcoal		X			0.004 g
	NON-FLORAL REMAINS:						
	Sand					X	
	Snail shell				1		<0.001 g

GRD5-8	Liters Floated						0.030 L
152-155 cm	Light Fraction Weight						0.115 g
	FLORAL REMAINS:						
	Rootlets					X	Few
	CHARCOAL/WOOD:						
	Salicaceae	Charcoal		28			0.018 g

TABLE 2 (Continued)

	Unidentified ≥ 0.5 mm	Charcoal		X			0.001 g
	NON-FLORAL REMAINS:						
	Sand					X	Scant
GRD5-10	Liters Floated						~0.005 L
	Light Fraction Weight						0.066 g
	FLORAL REMAINS:						
	Rootlets					X	Few
	CHARCOAL/WOOD:						
	Fraxinus	Charcoal		4			0.018 g
	Unidentified ≥ 1 mm	Charcoal		X			0.005 g
GRD6-1	Liters Floated						5.40 L
320-340 cm	Light Fraction Weight						8.26 g
	FLORAL REMAINS:						
	Atriplex	Fruit	1	1			0.002 g
	Unidentified	Seed		1			< 0.001 g
	Bark			4			0.002 g
	Amaranthus	Seed			72*	16*	
	Apiaceae	Seed			2		
	Atriplex	Fruit			1	1	
	Atriplex	Seed			30*	8*	
	Chenopodium	Seed			148*	36*	
	Datura	Seed					
	Descurainia	Seed			1		
	Euphorbia	Seed			13	5	
	Helianthus	Seed			3	6	
	Lamiaceae A	Seed			1		
	Lamiaceae B	Seed				1	
	Lamiaceae, *Hedeoma*-type	Seed			8		
	Mollugo	Seed			3	6	
	Opuntia	Seed				2	
GRD6-1	FLORAL REMAINS (continued):						
320-340 cm	*Physalis*	Seed			1		
	Poaceae, Panicoid	Floret			1		
	Poaceae	Caryopsis			1		

TABLE 2 (Continued)

	Polygonum	Seed			3		
	Portulaca	Seed			26		
	Solanum	Seed			7		
	Solanum rostratum	Seed			6	2	
	Trianthema portulacastrum	Seed			60	6	
	Rootlets					X	Numerous
	CHARCOAL/WOOD:						
	Total charcoal ≥ 1 mm						0.023 g
	Asteraceae	Charcoal		3			0.005 g
	Conifer	Charcoal		3			0.002 g
	Conifer - rounded	Charcoal		10			0.008 g
	Quercus - rounded	Charcoal		1			< 0.001 g
	Salicaceae	Charcoal		4			0.004 g
	Unidentified	Charcoal		X			0.008 g
	Total wood ≥ 2 mm						2.401 g
	Asteraceae twig	Wood				1	0.017 g
	Fraxinus	Wood				1	0.010 g
	Platanus	Wood				1	0.011 g
	Salicaceae	Wood				2	0.040 g
	Unidentified root	Wood				7	2.277 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				186	
	Rock					X	Scant
	Rodent fecal pellet				X	X	Moderate
	Sand					X	Scant
	Snail shell					17	0.006 g
GRD7-1	Liters Floated						~0.015 L
30 cm	Light Fraction Weight						0.375 g
	FLORAL REMAINS:						
	Amaranthus	Seed			1		
	Trianthema portulacastrum	Seed			2		
	Rootlets					X	Few

TABLE 2 (Continued)

GRD7-1	CHARCOAL/WOOD:						
30 cm	Asteraceae	Charcoal		12			0.002 g
	Unidentifiable ≥ 0.5 mm	Charcoal		X			0.002 g
GRD7-8	Liters Floated						0.700 L
110 cm	Light Fraction Weight						2.280 g
	FLORAL REMAINS:						
	Atriplex	Fruit	3	6			
	Atriplex	Seed	3		7		
	Monocot	Stem		4			<0.001 g
	Poaceae	Caryopsis	1				
	Portulaca	Seed		2			
	Unidentified	Embryo		3			
	Rootlets					X	Numerous
	CHARCOAL/WOOD:						
	Total charcoal ≥ 1 mm						
	Atriplex	Charcoal		1			<0.001 g
	Juniperus - rounded	Charcoal		1			<0.001 g
	Salicaceae	Charcoal		2			0.002 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				8	
	Insect	Larva			1		
	Sand					X	Moderate
	Termite fecal pellets		X				Few
	Snail shell					9	0.003 g
GRD7-9	Liters Floated						1.500 L
75-90 cm	Light Fraction Weight						7.440 g
	FLORAL REMAINS:						
	Apiaceae	Seed	1				
	Atriplex	Fruit		3			0.005 g
	CHARCOAL/WOOD:						

TABLE 2 (Continued)

	Atriplex	Charcoal		4			0.009 g
	Quercus - rounded	Charcoal		1			0.003 g
	Unidentified ≥ 0.5 mm	Charcoal		X			0.006 g
GRD7-9	NON-FLORAL REMAINS:						
75-90 cm	Insect	Chitin				153	
	Sand					X	Scant
	Snail shell					5	<0.001 g
GRD7-10	Liters Floated						2.400 L
110-120 cm	Light Fraction Weight						1.400 g
	FLORAL REMAINS:						
	Atriplex	Seed		2			<0.001 g
	Chenopodium	Seed		1			<0.001 g
	Pinus	Bark scale		4			0.001 g
	Poaceae	Seed		1			<0.001 g
	Sphaeralcea	Seed			1		
	Rootlets					X	Numerous
	CHARCOAL/WOOD:						
	Atriplex	Charcoal		1			<0.001 g
	Conifer	Charcoal		9			0.001 g
	Conifer - slightly rounded	Charcoal		4			<0.001 g
	Pinus - rounded	Charcoal		4			0.001 g
	Unidentified hardwood	Charcoal		2			<0.001 g
	Unidentifiable - vitrified	Charcoal		1			<0.001 g
	Unidentified ≥ 0.5 mm	Charcoal		X			0.010 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				173	
	Sand					X	Scant
	Snail shell				9	25	0.011 g

TABLE 2 (Continued)

GRD7-11	Liters Floated						2.500 L
125-145 cm	Light Fraction Weight						3.310 g
	FLORAL REMAINS:						
	Poaceae	Floret		1			0.002 g
	Chenopodium	Seed			1	1	
	Rootlets					X	Numerous
GRD7-11	CHARCOAL/WOOD:						
125-145 cm	*Atriplex*	Charcoal		2			
	Conifer	Charcoal		23			0.002 g
	Conifer - rounded	Charcoal		15			<0.001 g
	Pseudotsuga	Charcoal		2			<0.001 g
	Prosopis	Charcoal		2			0.002 g
	Quercus - rounded	Charcoal		4			<0.001 g
	Salicaceae	Charcoal		2			<0.001 g
	Unidentified hardwood	Charcoal		9			0.003 g
	Unidentified ≥ 0.5 mm	Charcoal		X			0.016 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				4	
	Sand					X	Scant
	Snail shell				6	3	0.005 g
GRD8-5	Liters Floated						5.200 L
80-120 cm	Light Fraction Weight						
	FLORAL REMAINS:						
	Vitrified tissue			7			0.010 g
	Chenopodium	Seed				1	
	Descurainia				1		
	Portulaca	Seed			4	1	
	Trianthema portulacastrum	Seed			1	2	
	CHARCOAL/WOOD:						

TABLE 2 (Continued)

	Total charcoal ≥ 0.5 mm						0.028 g
	Atriplex	Charcoal		1			0.001 g
	Juniperus - rounded	Charcoal		1			<0.001 g
	Pinus	Charcoal		3			<0.001 g
	Prosopis	Charcoal		6			0.006 g
	Unidentified hardwood - r	Charcoal		1			<0.001 g
	Unidentified ≥ 0.5 mm	Charcoal		X			0.008 g
	NON-FLORAL REMAINS:						
	cf. Coal					1	
	Insect	Chitin				24	
	Sand					X	Scant
	Snail shell					4	0.004 g
	Worm casts					X	Few
GRD8-6	Liters Floated						<0.005 L
55-65 cm	Light Fraction Weight						0.140 g
	FLORAL REMAINS:						
	Rootlets					X	Few
	CHARCOAL/WOOD:						
	Total charcoal ≥ 0.5 mm						<0.001 g
	Conifer	Charcoal		3			<0.001 g
	Unidentified hardwood	Charcoal		2			<0.001 g
	NON-FLORAL REMAINS:						
	Sand					X	Scant
GRD9-6	Liters Floated						0.200 L
114 cm	Light Fraction Weight						6.780 g
	FLORAL REMAINS:						
	Chenopodium	Seed			2	2	
	Mollugo verticillata	Seed			1		

TABLE 2 (Continued)

	Portulaca	Seed				1	
	Solanum rostratum	Seed			1	1	
	Sphaeralcea	Seed			1		
	Trianthema portulacastrum	Seed			1	1	
	Rootlets					X	Few
	Sclerotia				X		Few
	CHARCOAL/WOOD:						
	Pinus	Charcoal		12pc			1.438 g
	Pinus	Charcoal		X			2.507 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				4	
GRD9-7	Liters Floated						0.150 L
125 cm	Light Fraction Weight						1.300 g
	FLORAL REMAINS:						
	Atriplex	Seed			9	4	
	Unidentified B	Seed			14	2	
	Rootlets					X	

GRD9-7	CHARCOAL/WOOD:						
125 cm	cf. *Cercidium*	Charcoal		1			0.001 g
	Prosopis twig - rounded	Charcoal		4			0.080 g
	Unidentified $\geq$ 0.5 mm	Charcoal		X			0.012 g
GRD9-8	Liters Floated						5.900 L
195-205 cm	Light Fraction Weight						2.790 g
	FLORAL REMAINS:						
	Vitrified tissue			11			0.021 g
	Asteraceae	Seed				1	
	Chenopodium	Seed			1		
	Mollugo verticillata	Seed			6	1	
	Portulaca	Seed			2	2	
	Solanum rostratum	Seed				1	

TABLE 2 (Continued)

	Trianthema portulacastrum	Seed				1	
	Roots					X	Few
	Rootlets					X	Numerous
	CHARCOAL/WOOD:						
	Conifer - rounded	Charcoal		14			0.002 g
	Juniperus - rounded	Charcoal		1			<0.001 g
	Pinus - rounded	Charcoal		3			0.004 g
	Prosopis	Charcoal		7			0.006 g
	Unidentified ≥ 0.5 mm	Charcoal		X			0.009 g
	Pinus	Wood				4	<0.001 g
	Unidentified ≥ 0.5 mm	Wood				5	<0.001 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				3	
	Rock/Gravel					X	Moderate
	Sand					X	Moderate
GRD10-1	Liters Floated						~0.010 L
185 cm	Light Fraction Weight						1.373 g
	CHARCOAL/WOOD:						
	Total charcoal ≥ 1 mm						0.315 g
	Fraxinus	Charcoal		28			0.315 g
	NON-FLORAL REMAINS:						
	Sand					X	Present

GRD10-8	Liters Floated						3.000 L
85-120 cm	Light Fraction Weight						12.900 g
	FLORAL REMAINS:						
	Amaranthus	Seed			2	1	
	Chenopodium	Seed			5		
	Datura	Seed				1	
	Trianthema portulacastrum	Seed			6	6	
	Rootlets					X	Numerous

TABLE 2 (Continued)

	CHARCOAL/WOOD:						
	Asteraceae	Charcoal		1			<0.001 g
	Cercocarpus	Charcoal		4			0.008 g
	Conifer - rounded	Charcoal		7			0.004 g
	Juniperus	Charcoal		6			0.015 g
	Juniperus - rounded	Charcoal		6			0.003 g
	Fraxinus	Charcoal		1			0.001 g
	Fraxinus - slightly rounded	Charcoal		2			0.003 g
	Quercus	Charcoal		5			0.002 g
	Unidentifiable - vitrified	Charcoal		2			<0.001 g
	Unidentified ≥ 1 mm	Charcoal		X			0.008 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				60	
	Rock/Gravel					X	Moderate
	Sand					X	Moderate
	Snail shell					7	0.004 g
GRD10-9	Liters Floated						<0.005 L
95 cm	Light Fraction Weight						0.099 g
	CHARCOAL/WOOD:						
	Salicaceae	Charcoal		38			0.047 g
GRD10-10	Liters Floated						4.000 L
175-200 cm	Light Fraction Weight						2.450 g
	FLORAL REMAINS:						
	Rootlets					X	Moderate

GRD10-10	CHARCOAL/WOOD:						
175-200	Conifer	Charcoal		5			<0.001 g

TABLE 2 (Continued)

cm	Conifer - slightly vitrified	Charcoal		1			<0.001 g
	Juniperus - rounded	Charcoal		2			<0.001 g
	Prosopis	Charcoal		5			0.005 g
	Quercus	Charcoal		9			0.006 g
	Unidentified ≥ 1 mm	Charcoal		X			0.003 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				39	
	Insect	Larva			2		
	Rock/Gravel					X	Moderate
	Sand					X	
GRD11-1	Liters Floated						<0.005 L
102 cm	Light Fraction Weight						
	CHARCOAL/WOOD:						
	Atriplex	Charcoal	7				0.019 g
GRD11-2	Liters Floated						0.035 L
112-125	Light Fraction Weight						3.593 g
cm	FLORAL REMAINS:						
	Monocot	Stem		1			<0.001 g
	Vitrified	Tissue		1			0.001 g
	Solanum	Seed			1		
	Rootlets					X	Few
	CHARCOAL/WOOD:						
	Atriplex	Charcoal		2			0.006 g
	Conifer	Charcoal		5			0.002 g
	Juniperus	Charcoal		15			0.021 g
	Pseudotsuga	Charcoal		7			0.005 g
	Fraxinus	Charcoal		3			0.002 g
	Quercus	Charcoal		2			0.001 g

TABLE 2 (Continued)

	Unidentified $\geq$ 1 mm	Charcoal		X			0.007 g
GRD11-2	NON-FLORAL REMAINS:						
112-125 cm	Bone					4	
	Insect	Chitin				4	
	Sand					X	
	Snail shell					1	<0.001 g
GRD11-6	Liters Floated						4.900 L
130-155 cm	Light Fraction Weight						2.480 g
	FLORAL REMAINS:						
	Chenopodium	Seed	4	6			
	Monocot	Stem		3			0.003 g
	Pinus	Bark scale		4			0.004 g
	Erodium	Seed				1	
	Euphorbia	Seed			1		
	Unidentified	Bark				X	0.119 g
	Rootlets					X	Moderate
	CHARCOAL/WOOD:						
	Total charcoal $\geq$ 2 mm						
	cf. *Cercidium*	Charcoal		2			0.001 g
	Cercocarpus - rounded	Charcoal		4			0.004 g
	Conifer	Charcoal		7			0.003 g
	Conifer - rounded	Charcoal		5			0.003 g
	Conifer - vitrified	Charcoal		3			0.001 g
	Juniperus	Charcoal		7			0.005 g
	Juniperus - rounded	Charcoal		2			<0.002 g
	Pinus	Charcoal		3			0.002 g
	Fraxinus	Charcoal		3			<0.001 g
	Quercus - slightly rounded	Charcoal		6			0.002 g

TABLE 2 (Continued)

	Unidentified ≥ 1 mm	Charcoal		X			0.031 g
GRD11-6	NON-FLORAL REMAINS:						
130-155 cm	Insect	Chitin				80	
	Insect fecal pellet		1				
	Rock/Gravel					X	Scant
	Sand					X	Moderate
	Termite fecal pellets		X				Few
	Snail shell ≥ 1 mm				5	4	0.007 g
	Snail shell < 1 mm					X	Few
	Worm casts				X	X	Few
GRD12-1	Liters Floated						0.015 L
145 cm	Light Fraction Weight						1.330 g
	FLORAL REMAINS:						
	Rootlets					X	Few
	CHARCOAL/WOOD:						
	Total charcoal ≥ 0.5 mm						0.032 g
	Atriplex	Charcoal		30			0.006 g
	Salicaceae	Charcoal		1			0.004 g
	Unidentified ≥ 0.5 mm	Charcoal		X			0.018 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				1	
	Sand					X	Scant
GRD12-2	Liters Floated						0.200 L
115-130 cm	Light Fraction Weight						4.060 g
	FLORAL REMAINS:						
	Zea mays	Cob		1			0.112 g
	Zea mays	Cupule	1				0.005 g
	Rootlets					X	Few
	CHARCOAL/WOOD:						
	Total charcoal ≥ 2 mm						0.750 g

TABLE 2 (Continued)

	Atriplex	Charcoal		11			0.087 g
	Salicaceae	Charcoal		18			0.509 g
	Unidentified ≥ 2 mm	Charcoal		X			0.040 g
	NON-FLORAL REMAINS:						
	Sand					X	Scant
GRD12-3	Liters Floated						0.200 L
70-90 cm	Light Fraction Weight						4.660 g
	FLORAL REMAINS:						
	Rootlets					X	Few
	CHARCOAL/WOOD:						
	Total charcoal ≥ 2 mm						0.442 g
	Atriplex	Charcoal		10			0.130 g
	Prosopis	Charcoal		1			0.004 g
	Salix	Charcoal		26			0.268 g
	Unidentified	Charcoal		X			0.022 g
	NON-FLORAL REMAINS:						
	Bone			3		3	
	Sand					X	Scant
	Snail shell					6	0.008 g
GRD12-4	Liters Floated						0.500 L
40-55 cm	Light Fraction Weight						9.340 g
	FLORAL REMAINS:						
	Solanum	Seed			6	2	
	Rootlets					X	Few
	CHARCOAL/WOOD:						
	Total charcoal ≥ 2 mm						
	Atriplex	Charcoal		19			0.102 g
	Prosopis	Charcoal		1			0.008 g

TABLE 2 (Continued)

	Salicaceae	Charcoal		1			0.003 g
	Unidentified ≥ 2 mm	Charcoal		X			0.007 g
	NON-FLORAL REMAINS:						
	Bone			1		1	
	Sand					X	Scant
	Snail shell					3	
A	CHARCOAL/WOOD:						
	Asteraceae	Charcoa		1			0.015 g

GRS 1-1	Liters Floated						0.40 L
130 cm	Light Fraction Weight						0.73 g
	FLORAL REMAINS:						
	Monocot	Stem		12			0.002 g
	Rootlets					X	Few
	NON-FLORAL REMAINS:						
	Rock/Sand					X	Scant
	Sand					X	Scant
	Snail shell					3	< 0.001 g

W = Whole
F = Fragment
X = Presence noted in sample
g = grams
* = Estimated frequency
- r = rounded

TABLE 2 (Continued)
TABLE 3
INDEX OF MACROFLORAL REMAINS RECOVERED FROM
THE DUNCAN VALLEY, GILA RIVER, ARIZONA

Scientific Name	Common Name
FLORAL REMAINS:	
Amaranthus	Pigweed, amaranth
Ambrosia	Ragweed
Apiaceae	Parsley family
Argemone	Prickly poppy
Asteraceae	Sunflower family
Helianthus	Sunflower
Atriplex	Saltbush, Shadscale
Chenopodium	Goosefoot
Descurainia	Tansy mustard, Flixweed
Echinocereus	Hedgehog or strawberry cactus
Erodium	Storksbill
Euphorbia	Spurge
Lamiaceae	Mint family
Hedeoma	Mock-pennyroyal
Larrea	Creosotebush
Mentzelia	Stickleaf
Mollugo verticillata	Carpetweed
Opuntia	Prickly pear cactus
Poaceae	Grass family
Polygonum	Smartweed, Knotweed
Portulaca	Purslane
Quercus	Oak
Rumex	Dock
Salsola	Russian thistle
Sambucus	Elderberry

TABLE 2 (Continued)

Solanaceae	Nightshade family
Datura	Datura, Jimsonweed, Thornapple
Physalis	Tomatillo, Groundcherry
Solanum	Nightshade
Solanum rostratum	Buffalobur
Sphaeralcea	Globemallow
Trianthema portulacastrum	Pigweed, Horse purslane
Xanthium	Cocklebur
Sclerotia	Resting structures of mycorrhizae fungi
CULTIGENS:	
Zea mays	Maize, Corn
CHARCOAL/WOOD:	
Acer	Maple, Box elder
Asteraceae	Sunflower family
Atriplex	Saltbush, Shadscale
Cercidium	Paloverde
Cercocarpus	Mountain mahogany
Conifer	Cone-bearing, gymnospermous trees and shrubs, mostly evergreens, including the pine, spruce, fir, juniper, cedar, yew, and cypress
Juniperus	Juniper
Pinus	Pine
Pseudotsuga	Douglas fir
Fraxinus	Ash
Platanus	Sycamore
Prosopis	Mesquite
Quercus	Oak
Salicaceae	Willow Family
Populus	Aspen, Cottonwood
Salix	Willow

TABLE 3 (Continued)

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EXAMINATION OF DETRITAL CHARCOAL FROM ALONG THE UPPER GILA RIVER, ARIZONA

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INTRODUCTION

Detrital charcoal samples from along the Upper Gila River in Duncan Valley, southeast Arizona, were floated to recover organic fragments suitable for AMS radiocarbon analysis. Botanic components and detrital charcoal were identified, and potentially radiocarbon datable material was separated.

METHODS

All samples were water-screened through a 250 micron mesh sieve and allowed to dry. The dried samples were scanned under a binocular stereo microscope at a magnification of 10x. Charcoal fragments were separated and examined under a binocular microscope at a magnification of 70x. Macrofloral remains, including charcoal, were identified using manuals
DisplayText cannot span more than one line!and by comparison with modern and archaeological references. The term "seed" is used to represent seeds, achenes, caryopses, and other disseminules. Because charcoal and possibly other botanic remains were to be sent for radiocarbon analysis, clean laboratory conditions were used during water-screening and identification to avoid contamination. All instruments were washed between samples, and samples were protected from contact with modern charcoal.

DISCUSSION

A total of 12 samples were analyzed from deposits along the Upper Gila River in Duncan Valley, southeast Arizona. Charcoal sample GRS3-1 was collected from a B horizon at a depth of 81-120 cm (Table 1). This sample contained very small fragments from a charred monocot or herbaceous dicot stem (Table 2, Table 3). These stem fragments did not yield a sufficient weight for AMS radiocarbon analysis. The minimum requirement of charcoal for standard AMS radiocarbon analysis reported by Beta Analytic, Inc. is 5 mg or 0.005 g; however, Beta now offers an AMS-MS dating technique for very small sample sizes. It now may be possible to date charcoal weighing 1 mg or 0.001 g. The charred stem fragments in sample GRS3-1 weighed less than 0.001 g.

Charcoal sample GRS5-1 was taken from a depth of 110 cm. The three fragments of charcoal present in this sample were too small for identification and too small for AMS radiocarbon analysis. Two small charred *Trianthema*-type seed fragments also were present.

Very small charcoal fragments were present in sample GRS6-1 from a depth of 75 cm. One fragment was identifiable as probable *Cercidium*; however, it weighed less than 0.001 g. Several other charcoal fragments too small for identification also weighed less than 0.001 g.

Unidentified hardwood charcoal fragments in sample GRS6-2 from a depth of 55-83 cm weighed 0.002 g, which is a sufficient weight for AMS-MS radiocarbon analysis. One charred bark fragment weighed less than 0.001 g. In addition, this sample contained a few uncharred rootlets, an insect chitin fragment, a small amount of rock/gravel, and a single sclerotia. Sclerotia are commonly called "carbon balls". They are small, black, solid or hollow spheres that can be smooth or lightly sculpted. These forms range from 0.5 to 4 mm in size. Sclerotia are the resting structures of mycorrhizae fungi, such as *Cenococcum graniforme*, that have a mutualistic relationship with tree roots. Many trees are noted to depend heavily on mycorrhizae fungi and might not be successful without them. "The mycelial strands of these fungi grow into the roots and take some of the sugary compounds produced by the tree during photosyntheses. However, mycorrhizal fungi benefit the tree because they take in minerals from the soil, which are then used by the tree" (Kricher and Morrison 1988:285). Sclerotia appear to be ubiquitous and are found with coniferous and deciduous trees including *Abies* (fir), *Juniperus communis* (common juniper), *Larix* (larch), *Picea* (spruce), *Pinus* (pine), *Pseudotsuga* (Douglas-fir), *Acer pseudoplatanus* (sycamore maple), *Alnus* (alder), *Betula* (birch), *Carpinus caroliniana* (American hornbeam), *Carya* (hickory), *Castanea dentata* (American chestnut), *Corylus* (hazelnut), *Crataegus monogyna* (hawthorn), *Fagus* (beech), *Populus* (poplar, cottonwood, aspen), *Quercus* (oak), *Rhamnus fragula* (alder bush), *Salix* (willow), *Sorbus* (chokecherry), and *Tilia* (linden). Sclerotia originally were identified by Dr. Kristiina Vogt, Professor of Ecology in the School of Forestry and Environmental Studies at Yale University (McWeeney 1989:229-130; Trappe 1962).

Sample GRS8-1 was recovered from a depth of 50 cm. This sample contained an uncharred *Solanum* seed, as well as several fragments of uncharred unidentified hardwood wood weighing 0.019 g.

Twelve fragments of charred monocot or herbaceous dicot stem were present in sample GRS11-1 from a depth of 80 cm; however, these stem fragments were very small and weighed less than 0.001 g. Sample GRS11-2 from a depth of 180-210 cm yielded two fragments of charcoal too small for identification and weighing less than 0.001 g. Several very small charred bone fragments weighing 0.003 g also were present in the sample. These bone fragments were very dark brown in color, suggesting that they had been burned at a low heat. High heat tends to burn bone white or gray in color.

Sample GRS12-1 from a depth of 56 cm yielded fragments of *Atriplex* charcoal weighing 0.743 g that can be submitted for AMS radiocarbon analysis. An abundance of unidentified charcoal in this sample most likely also represents *Atriplex*. Several fragments of *Prosopis* charcoal weighing 0.093 were present in sample GRS12-2 from a depth of 100 cm. This charcoal also can be submitted for AMS radiocarbon analysis.

Charcoal present in sufficient quantities for AMS radiocarbon analysis in sample GRS12-3 from a depth of about 55 cm includes *Atriplex* weighing 0.033 g and *Prosopis* weighing 0.004 g. Several larger fragments of *Prosopis* charcoal weighing 5.164 g were present in sample GRS12-4, also from a depth of about 55 cm. A single large piece of charcoal was pulled to submit for AMS radicoarbon analysis.

Sample GRS13-1 was collected from a depth of 83 cm. This sample contained a single piece of conifer charcoal weighing less than 0.001 g, as well as several fragments of unidentified hardwood charcoal weighing 0.002 g that can be submitted for AMS-MS radiocarbon analysis.

SUMMARY AND CONCLUSIONS

Examination of charcoal samples from deposits along the Upper Gila River in southeast Arizona resulted in recovery of charcoal that can be sent for AMS radiocarbon analysis. Samples from GRS12 yielded several fragments of *Atriplex* and *Prosopis* charcoal, suggesting the presence of saltbush and mesquite in this area.

TABLE 1
PROVENIENCE DATA FOR SAMPLES FROM ALONG THE UPPER GILA RIVER

Sample No.	Depth (cm)	Provenience/ Description	Analysis
GRS3-1	81-120	Charcoal; B horizon	Charcoal ID prior to C-14 analysis
GRS5-1	110	Charcoal	Charcoal ID prior to C-14 analysis
GRS6-1	75	Charcoal	Charcoal ID prior to C-14 analysis
GRS6-2	55-83	Charcoal in peds; Bkb horizon	Charcoal ID prior to C-14 analysis
GRS8-1	50	Charcoal	Charcoal ID prior to C-14 analysis
GRS11-1	80	Charcoal	Charcoal ID prior to C-14 analysis
GRS11-2	180-210	Charcoal	Charcoal ID prior to C-14 analysis
GRS12-1	56	Charcoal	Charcoal ID prior to C-14 analysis
GRS12-2	100	Charcoal	Charcoal ID prior to C-14 analysis
GRS12-3	~ 55	Charcoal	Charcoal ID prior to C-14 analysis
GRS12-4	~ 55	Charcoal	Charcoal ID prior to C-14 analysis
GRS13-1	83	Charcoal	Charcoal ID prior to C-14 analysis

TABLE 2
MACROFLORAL REMAINS IN SAMPLES FROM ALONG THE UPPER GILA RIVER

Sample No.	Identification	Part	Charred W	Charred F	Uncharred W	Uncharred F	Weights/ Comments
GRS3-1	Volume Water Screened						ca. 60 mL
81-120 cm	Screened Sample Weight						2.754 g
	FLORAL REMAINS:						
	Monocot/Herbaceous dicot	Stem		5			<0.001 g
	Rootlets					X	Few
	NON-FLORAL REMAINS:						
	Sand					X	
GRS5-1	Volume Water Screened						ca. 25 mL
110 cm	Screened Sample Weight						0.848 g
	FLORAL REMAINS:						
	Trianthema-type	Seed		2			<0.001 g
	CHARCOAL/WOOD:						
	Unidentified - small	Charcoal		3			<0.001 g
GRS6-1	Volume Water Screened						25 mL
75 cm	Screened Sample Weight						0.444 g
	FLORAL REMAINS:						
	Rootlets					X	Few
	CHARCOAL/WOOD:						
	cf. *Cercidium*	Charcoal		1			<0.001 g
	Unidentified - small	Charcoal		19			<0.001 g
	NON-FLORAL REMAINS:						
	Sand					X	
GRS6-2	Volume Water Screened						150 mL

TABLE 3 (Continued)

55-83 cm	Light Fraction Weight						1.545 g
	FLORAL REMAINS:						
	Bark Rootlets Sclerotia			1	 1	 X	<0.001 g Few
	CHARCOAL/WOOD:						
	Unidentified hardwood - small	Charcoal		13			0.002 g
	NON-FLORAL REMAINS:						
	Insect Rock/Gravel Sand	Chitin				1 X X	 Few

GRS8-1	Volume Water Screened						15 mL
50 cm	Screened Sample Weight						1.008 g
	FLORAL REMAINS:						
	Solanum	Seed			1		
	CHARCOAL/WOOD:						
	Unidentified hardwood	Wood				21	0.019 g
	NON-FLORAL REMAINS:						
	Sand					X	
GRS11-1	Volume Water Screened						ca. 10 mL
	Light Fraction Weight						0.168 g
	FLORAL REMAINS:						
	cf. Monocot/Herbaceous dicot	Stem		12			<0.001 g
	NON-FLORAL REMAINS:						
	Sand					X	
GRS11-2	Volume Water Screened						135 mL
180-210 cm	Screened Sample Weight						0.243 g
	FLORAL REMAINS:						
	Rootlets					X	Few

TABLE 2 (Continued)

	CHARCOAL/WOOD:						
	Unidentified - small	Charcoal		2			<0.001 g
	NON-FLORAL REMAINS:						
	Bone			24			0.003 g
	Sand					X	
GRS12-1	Volume Water Screened						300 mL
56 cm	Screened Sample Weight						23.237 g
	FLORAL REMAINS:						
	Rootlets					X	Few
	CHARCOAL/WOOD:						
	Atriplex	Charcoal		50			0.743 g
	Unidentified	Charcoal		X			Abundant
	NON-FLORAL REMAINS:						
	Insect	Chitin				4	
	Sand					X	
GRS12-2	Volume Water Screened						20 mL
100 cm	Screened Sample Weight						1.860 g
	CHARCOAL/WOOD:						
	Prosopis	Charcoal		30			0.093 g
	Unidentified	Charcoal		X			
	NON-FLORAL REMAINS:						
	Sand					X	
GRS12-3	Volume Water Screened						50 mL
~ 55 cm	Screened Sample Weight						2.06 g
	FLORAL REMAINS:						
	Rootlets					X	Few
	CHARCOAL/WOOD:						

TABLE 2 (Continued)

	Atriplex	Charcoal		7			0.033 g
	Prosopis	Charcoal		9			0.004 g
	Unidentified charcoal - small	Charcoal		X			
	NON-FLORAL REMAINS:						
	Sand					X	
GRS12-4	Volume Water Screened						90 mL
~ 55	Screened Sample Weight						13.64 g
cm	CHARCOAL/WOOD:						
	Prosopis	Charcoal		50			5.164 g
	Unidentified	Charcoal		X			Abundant
	Rootlets					X	Few
	NON-FLORAL REMAINS:						
	Rootlets					X	Few
	Insect	Chitin				1	
	Sand					X	
GRS13-1	Volume Water Screened						30 mL
83	Screened Sample Weight						0.205 g
cm	CHARCOAL/WOOD:						
	Conifer	Charcoal		1			<0.001 g
	Unidentified hardwood	Charcoal		16			0.002 g

W = Whole F = Fragment
X = Presence noted in sample g = grams

TABLE 2 (Continued)

TABLE 3
INDEX OF MACROFLORAL REMAINS RECOVERED FROM THE UPPER GILA RIVER

Scientific Name	Common Name
FLORAL REMAINS:	
Solanum	Nightshade
Sclerotia	Resting structures of mycorrhizae fungi
Trianthema-type	Sea purslane
CHARCOAL/WOOD:	
Atriplex	Saltbush, Shadscale
Cercidium	Palo verde
Conifer	Cone-bearing, gymnospermous trees and shrubs, mostly evergreens, including the pine, spruce, fir, juniper, cedar, yew, and cypress
Prosopis	Mesquite

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21 March 2001
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Dear Jeanne:

I examined the four snails from the four localities that you provided for me last evening, and it turns out they are all shells from the same taxa of snail, *Succinea* spp. The land snail *Succinea* spp. cannot be identified below genus level on the basis of the shell. Typically, the species of *Succinea* lives in moist habitats not far from standing waters. However, I have noticed numerous *Succinea* shells in dry habitats far from rivers or other standing water in Wyoming and Colorado, suggesting the genus has a wide habitat range. It probably is not a deep burrower when it needs to aestivate during dry conditions when it typically burrows down to the base of the leaf litter in soils.

I will try to return your shells either later this week or early next week. If you are not in the office, I will return them to Dan Levish. You mentioned that you will be providing more shell material from the Gila River for me to identify. Since this part of the project has taken me only about an hour to complete, I will add this time to the final project. However, I will bill you for my time if I do not receive the next batch of samples within the next month. I'm looking forward to working with you on this project.

Sincerely,

Emmett Evanoff

Taxonomic List of the Mollusks Collected in the Gila River Project

Phylum Mollusca
- Class Gastropoda
- Subclass Pulmonata
  - Order Geophila
    - Family Succineidae
      - Genus *Succinea* Draparnaud, 1801
        - *Succinea* spp.

Locality List:

GRD 3-5, 2/7/01	in lowest exposed soil	*Succinea* spp.
GRD 3-7, 3/4/01	Abk - 270 cm	*Succinea* spp.
Hinton Bank, Gila-Safford; 2/6/01	±60 cm in place?	*Succinea* spp.
Hinton Bank, Gila-Safford; 2/6/01	±60 cm	*Succinea*? spp.