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Hohokam Irrigation and Agriculture on the Western Margin of Pueblo Grande: Archaeology for the PHX Sky Train Project

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DESERT ARCHAEOLOGY, INC.

About this Publication

The archaeological investigations documented in this report were conducted by Desert Archaeology, Inc. Desert Archaeology is an Arizona small business offering cultural resources research and consulting services through offices in Tucson and Phoenix. The company has been in the forefront of cultural resources management since 1982, serving a diverse set of clients, from government agencies to private firms. Desert Archaeology has successfully completed more than 2,000 projects in the Greater Southwest, ranging from small surveys to large excavations, such as the PHX Sky Train® project.

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The PHX Sky Train Project

The PHX Sky Train® project was sponsored by the City of Phoenix in advance of construction of the 44th Street Station for Phoenix Sky Harbor International Airport's then-new automated train system. The 17-acre station area is situated on the western margin of the Pueblo Grande ballcourt and platform mound community and lies just upstream of the headwaters of prehistoric Canal System 2. Project excavations revealed a surprising diversity of irrigation and agricultural features, the study of which provided new insights about Hohokam irrigation and agricultural practices near the head of the largest prehistoric irrigation network in the Salt River Valley. T. Kathleen Henderson directed the entire project, with Elizabeth Bagwell and Connie Darby serving consecutively as Field Director for the two sessions of fieldwork conducted for the PHX Sky Train project.

About the Editor

Dr. T. Kathleen Henderson, Senior Research Archaeologist for Desert Archaeology, Inc., has considerable experience in the archaeology of the Phoenix Basin. Across the span of more than 35 years, she has overseen large-scale excavations and research at multiple Hohokam village, agricultural, and irrigation sites, including La Ciudad, Dutch Canal Ruin, Pueblo Patricio, Tres Pueblos, La Cuenca del Sedimento, and Crismon Ruin in the lower Salt River Valley and the Grewe and Gillespie Dam sites in the middle Gila River Valley. Her research interests include Hohokam social organization, community development, aboriginal canal technology, and chronometric applications.

For information about other contributors, see the inside back cover.

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Pueblo Grande Museum
City of Phoenix Parks and
Recreation Department

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ABSTRACT

The results of phased data recovery efforts for the City of Phoenix Aviation Department in advance of construction of the PHX Sky Train are presented in this report. Investigations were conducted within the Sky Train's 44th Street Station area, located immediately west of 44th Street and south of the Grand Canal in Phoenix, Arizona. Twelve medium to large prehistoric canals were encountered during the project, which was an anticipated discovery given the project's location northwest of the Park of Four Waters at Pueblo Grande Museum and Cultural Park and in the trajectory of main canals that fed prehistoric Canal System 2. Unexpected was the discovery of prehistoric irrigated field systems comprised of ditches and field areas. This project provided the first plan exposure of such systems in the Salt River Valley.

Also encountered during the project were several canal-side water catchment features and Hohokam habitation structures. The structures included pithouses, probably used a seasonal farmhouses, and a surface adobe structure, with associated pits, which was occupied more permanently as a farmstead. The ages of the archaeological remains ranged from the later Colonial period through the early Classic period, roughly A.D. 850-1350.

The numbers and types of features documented by the project illustrate that people were using the canals and local terrain in a variety of ways, despite the intrusion of several large System 2 trunk canals through the area. Within the project area, land use, subsistence practices, and irrigation were inextricably intertwined. The results of the project reveal the Hohokam's intimate knowledge of their landscape and how to manipulate it to best advantage. The findings highlight why the study of the irrigated spaces between prehistoric settlements is crucial to fully understand how the Hohokam managed to thrive for so many centuries in their desert environment.

COMPLIANCE SUMMARY

Date: 1 May 2013

Report Title: *Hohokam Irrigation and Agriculture on the Western Margin of Pueblo Grande: Archaeology for the PHX Sky Train Project, Phoenix, Arizona,* edited by T. Kathleen Henderson. Anthropological Paper No. 41. Archaeology Southwest, Tucson, Arizona.

Client: City of Phoenix

Client Project Name: PHX Sky Train (a.k.a. Automated Train Project)

Compliance Agency: Federal Aviation Administration (FAA), Arizona State Museum

Compliance Level: Federal, State

Applicable Laws/Regulations: National Historic Preservation Act of 1966, as amended; Arizona Antiquities Act (A.R.S. 841-841 et seq.)

Applicable Permits: Arizona Antiquities Act Project Specific Permit No. 2008-135ps

Tribal Consultation: This project was conducted under the general City of Phoenix Burial Agreement for burial discoveries on City of Phoenix lands, Pueblo Grande Museum Project No. 2007-46. No human burials or associated mortuary objects were discovered by this project.

Project Description: Archaeological data recovery to mitigate adverse effects of Stage 1 Sky Train construction on significant cultural resources within the area of the planned PHX Sky Train 44th Street Station.

Fieldwork Dates and Crew Person-days (non-supervisory): Two field sessions spanning the periods 16 December 2008 to 5 February 2009, and 17 August to 23 October 2009; 218 person-days were expended in the combined effort.

Final Disposition of Project Artifacts, Field Notes, Data, and Records: All artifacts, field notes, data, and records are curated at Pueblo Grande Museum, PGM Project No. 2007-46. Report copies also curated at Arizona State Museum, ASM Accession No. 2008-711.

Location:

Land Ownership: City of Phoenix
County and State: Maricopa County, Arizona
Legal Description: NW ¼ Section 7, Township 1 North, Range 4 East of the USGS 7.5-minute topographic quadrangle, Tempe, Arizona (AZ U:9:[NW]).

Area of Potential Effects (APE): The APE consists of the 84 acres in which construction of Stage 1 of the PHX Sky Train, formerly Automated Train Project, will occur. This stage of the project includes: construction of the 44th Street Station; the stretch of the Sky Train that extends between the 44th Street Station, the East Economy Parking Lot, and Terminal 4; and a maintenance and storage facility at the eastern end of the airport north of Sky Harbor Boulevard (see Figure 1.1). The Final Environmental Impact Statement prepared for the Airport Development Program, of which PHX Sky Train construction is a part, determined that archaeological resources would be potentially affected only in the 44th Street Station area of the APE.

Number of Surveyed Acres: N/A

Number of Sites: 4

List of Register-Eligible Properties: AZ U:9:1 (ASM), AZ U:9:2 (ASM), AZ U:9:28 (ASM)

List of Register-Ineligible Properties: AZ T:12:258 (ASM)

Summary of Results: Desert Archaeology, Inc., recorded 99 archaeological features in the 44th Street Station project area. Of these, 80 features were prehistoric, and included canals, ditches, fields, pithouses, and extramural pits, among others. Based on their relationship with prehistoric canal alignments previously identified east of the project, the canals were assigned to one of two site numbers associated with prehistoric Canal System 2, either AZ U:9:2 (ASM) (three canals) or AZ U:9:28 (ASM) (nine canals). The U:9:2 canals included a segment of the North Canal located in Park of Four Waters. Ditches, fields, water catchments, and associated features (*n* = 39) were also assigned to U:9:2:8 based on their location and irrigation-related nature. Prehistoric habitation and associated extramural features (*n* = 29) were considered part of the Pueblo Grande settlement, AZ U:9:1 (ASM). The habitation features primarily reflected seasonal agricultural activity on the margin of Pueblo Grande, although one habitation locus was apparently occupied more permanently in the form of a farmstead. The ages of the prehistoric features spanned the later Colonial (A.D. 850-950), Sedentary (A.D. 950-1150), and early Classic (A.D. 1150-1300) periods of the Hohokam sequence. Research topics explored during the project included prehistoric irrigation, land use, and subsistence practices.

Nineteen features were late historic/early modern in origin; these were assigned to the historic North neighborhood, AZ T:12:258 (ASM). As it was agreed in consultation with the City Archaeologist that further study of these late historic/early modern features would not yield important information about the Historic era, this PHX Sky Train data recovery study focused exclusively on the prehistoric features.

The discovery of prehistoric canals in the project was anticipated given the location of the project northwest of Park of Four Waters, south of Pueblo Grande Museum, and in the trajectory of main canals that fed Canal System 2. In contrast, the discovery of prehistoric irrigated field systems comprised of ditches and field areas was entirely unexpected. This project provided the first plan exposure of such systems in the Salt River Valley. The discovery of a few other rarer features, such as water catchments/reservoirs and a canal-side basin that seems to have served multiple purposes, further illustrated that people were using the watercourses and local terrain in a variety of ways, despite the intrusion of several large Canal System 2 canals through the area. Within the project area, land use, subsistence practices, and irrigation were inextricably intertwined; the results of the project reveal the Hohokam's intimate knowledge of their landscape and how to manipulate it to best advantage. The findings highlight why study of the irrigated spaces between prehistoric settlements is crucial to fully understanding how the Hohokam managed to thrive for so many centuries in their desert environment.

Recommendations: Desert Archaeology has completed its data recovery effort for the PHX Sky Train Project. The fieldwork and archaeological studies were conducted in accordance with the approved treatment plan prepared for the project. The archaeology project has yielded an abundance of new and important information about prehistoric activity in this small area of the Salt River Valley. As all requirements for the recovery of data within the archaeologically sensitive 44th Street Station area were satisfied upon completion of the fieldwork, it was recommended that Sky Train construction could proceed within the Stage 1 PHX Sky Train APE. This recommendation was originally provided following conclusion of the data recovery fieldwork in a Preliminary Report, dated 9 November 2009, to Dr. Todd Bostwick, City Archaeologist, City of Phoenix Parks and Recreation Department, to allow construction of the PHX Sky Train 44th Street Station to proceed.

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ACKNOWLEDGMENTS

The archaeological investigations described in this report were sponsored by the City of Phoenix Aviation Department, and coordinated by the City of Phoenix Archaeologist, Todd Bostwick, succeeded by Laurene Montero. Jay Dewitt and Kyle Kotchou were Aviation's contract administrators. We are grateful to these individuals for their interest and patience in seeing this project to completion.

Elizabeth Bagwell directed the first phase of fieldwork in the winter of 2009, assisted by Connie Darby. The first phase field crew included Leslie Aragon, Chris Virden-Lange, and Chris Whiting. Darby later directed the second phase of fieldwork in the late summer and fall of 2009. Her field crew included Leslie Aragon, Franco Boggle, Dan Dybowski, Ed Dosh, Ralph Koziarsky, Chris Virden-Lange, Hoski Schaafsma, Ryan Stone, Sandra Wadsworth, and Josh Watts. Mike Brack and Tyler Theriot conducted field mapping and computer cartography for both phases. Our backhoe operators included Masson Riddle and Cliff Nino of E5 Construction, LLC.

Specialists aiding in the field efforts included Gary Huckleberry, project geomorphologist; Glenn Berger, geochronologist and luminescence dating specialist; Manuel Palacios-Fest, micropaleontologist specializing in the study of ostracode and other microfossil remains; and Hoski Schaafsma, paleoecologist and specialist in the study of prehistoric fields. In addition, French geoarchaeologist Louise Purdue joined the first phase of fieldwork for two weeks, during which time she assisted in drawing and annotating canal profiles. She also collected micromorphological and charcoal samples from several canals to be analyzed and used for her dissertation research. Michael Droz of Archaeological Consulting Services, Ltd. collected archaeomagnetic samples from pithouse hearths during the second fieldwork phase.

Debt is owed to the analysts and consultants who contributed to this report. In-house analysts included Jenny Adams, Leslie Aragon, Mike Diehl, Chris Lange, Mary Owens, and Stacy Ryan. Outside consultants and specialists included previously mentioned Gary Huckleberry, Glenn Berger, and Manuel Palacios-Fest, along with Susie Smith, Jan Gish, Steve Bozarth, and Stacey Lengyel.

The support staff of Desert Archaeology also made contributions to this project. Essential tasks were performed by Lisa Eppley (laboratory management), Sara Lely (data entry), Ted Oliver (database management), and Jean Kramer (accounting). The report production team included publications director, Emilee Mead, and Donna Doolittle. Susan Hall and Tyler Theriot prepared the report graphics. Bill Doelle, president of Desert Archaeology, and Trish Castalia, projects manager, provided general oversight and support throughout the project.

Finally, we dedicate this report to the memory of Dr. Glenn Berger, affiliated with Desert Research Institute, who pioneered the technique of luminescence dating of Hohokam canals in a previous Sky Harbor Airport study. This project was among the last he conducted in the Phoenix area, prior to his untimely death in 2011. Several of us on staff can attest to his interest and energy in advancing the dating technique on this project as well as others in the American Southwest. His research contributions will be missed by all who continue to do research in central Arizona.

PROJECT AND RESEARCH BACKGROUND

T. Kathleen Henderson
Desert Archaeology, Inc.

The results of phased data recovery efforts for the City of Phoenix (City) Aviation Department in advance of construction of the PHX Sky Train are presented in this report. Investigations were conducted within the Sky Train's 44th Street Station area, located immediately west of 44th Street (formerly State Route [SR] 153) and south of the Grand Canal in Phoenix, Arizona (Figure 1.1). Twelve prehistoric canals were encountered during the project, which was an anticipated discovery given the location of the project northwest of the Park of Four Waters at Pueblo Grande Museum and Cultural Park and in the trajectory of main canals that fed prehistoric Canal System 2 (Figure 1.2). Unexpected was the discovery of prehistoric irrigated field systems comprised of ditches and field areas. This project provided the first exposure of such systems in the Salt River Valley. The project also encountered several canal-side water catchment features and Hohokam habitation structures. The structures included pithouses, probably used as seasonal farmhouses, and a surface adobe structure, with associated pits, that may have seen use over a longer term than the pithouses. The ages of the archaeological remains spanned the later Colonial (A.D. 750-950), Sedentary (A.D. 950-1150), and Classic (A.D. 1150-1450 [?]) periods of the Hohokam chronology (Table 1.1).

The PHX Sky Train is being constructed at Phoenix Sky Harbor International Airport to provide frequent, convenient, and reliable service for airport passengers, visitors, and employees. This automated train system is one of several improvements proposed as part of the Airport Development Program (ADP), which aims to serve projected increases in airline passenger activity. The Federal Aviation Administration (FAA) completed a Final Environmental Impact Statement (FEIS) for the ADP in February 2006. An archival study conducted by URS Corporation (Rogge and Erickson 2005) for the FEIS identified the possibility of archaeological remains in the area of the planned 44th Street Station.

Pursuant to a resulting Memorandum of Agreement (MOA) for treatment of cultural resources affected by the ADP, the City Aviation Department contracted with Desert Archaeology, Inc., to develop, and later implement, a treatment plan (Henderson and Bagwell 2007) to investigate the archaeologically sensitive area that would be affected by the first stage of PHX Sky Train construction. This first stage, formerly the Stage 1 Automated Train Project (ATP), includes: (1) construction of the 44th Street Station and associated facilities; (2) the stretch of the Sky Train that extends between the 44th Street Station, the East Economy Parking Lot, and Terminal 4; and, (3) a maintenance and storage facility at the eastern end of the airport north of Sky Harbor Boulevard. The area in which this construction takes place constitutes the Area of Potential Effect (APE) for the Stage 1 ATP, as depicted in Figure 1.1. The FEIS and consequent archaeological treatment plan determined that archaeological resources would be potentially affected only in the 44th Street Station area of the APE.

Data recovery fieldwork was conducted in two field sessions spanning the periods 16 December 2008–5 February 2009, and 17 August–23 October 2009. Dr. Kathleen Henderson, Principal Investigator, directed the project with daily supervision of the first field session exercised by Dr. Beth Bagwell and the second field session by Ms. Connie Darby. In all, 218 crew person-days were expended in the combined effort. The fieldwork was conducted in accordance with the treatment plan and field session specific work plans prepared for the PHX Sky Train project (Henderson 2008, 2009b; Henderson and Bagwell 2007). The work was performed under the authority of Arizona Antiquities Act Project Specific Permit No. 2008-135ps (ASM Accession No. 2008-711).

In total, 99 archaeological features were recorded during the fieldwork. Of these, 80 features were prehistoric features, and included canals, ditches, fields, pithouses, extramural pits, and an adobe structure (Table 1.2). The canals were assigned to one of two site numbers associated with prehistoric Canal System 2, AZ U:9:2 (ASM) or AZ U:9:28 (ASM), based on their relationship with canal alignments previously identified east of the project (Masse 1976; Woodbury 1960) (Figure 1.3). Ditches, fields, and associated features were also assigned to U:9:28, based on their location and irrigation-related nature.

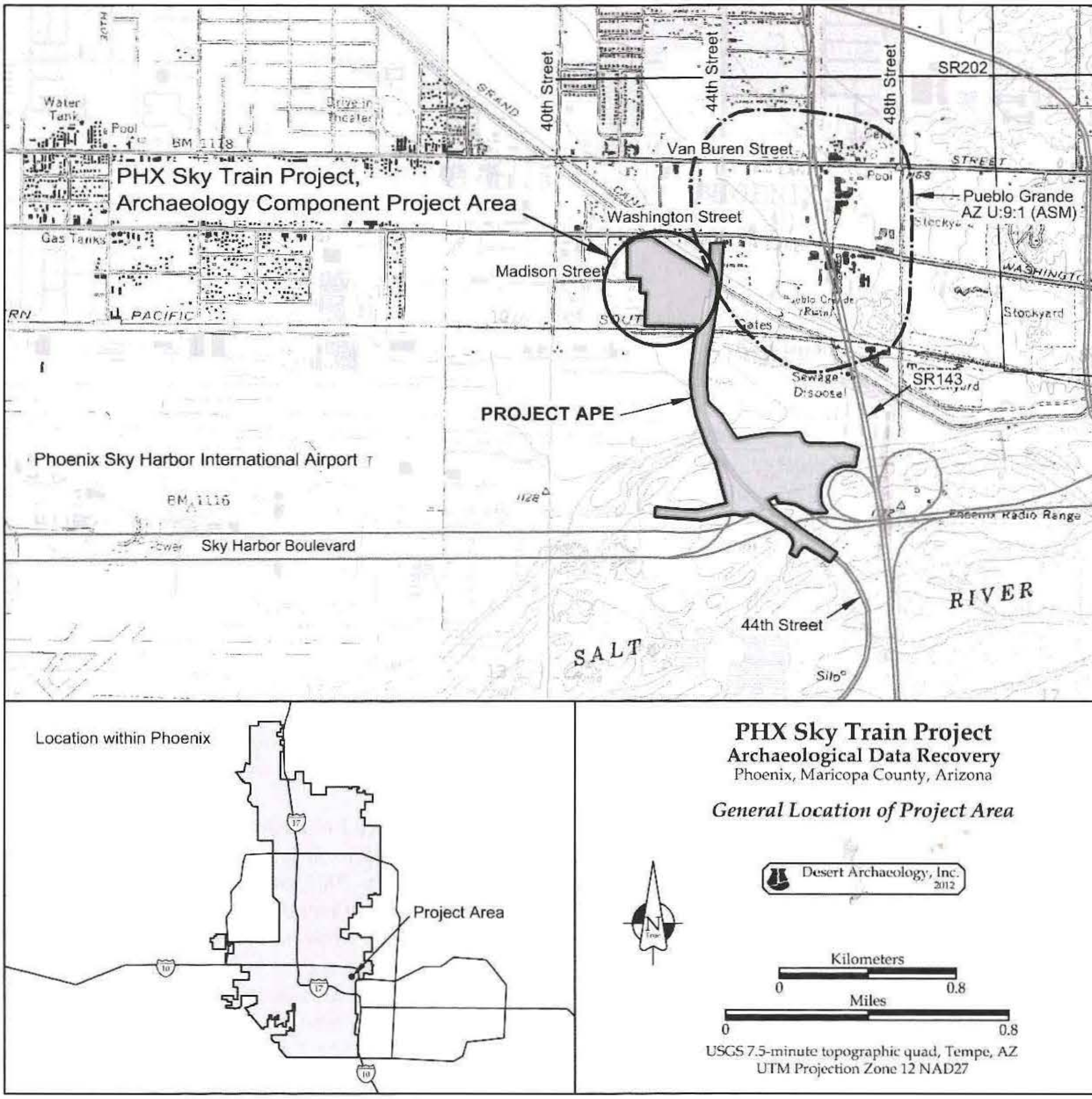

Figure 1.1. Location of the PHX Sky Train, Archaeology Component, project area.

Prehistoric habitation and associated extramural features were considered part of the Pueblo Grande settlement, AZ U:9:1 (ASM). Nineteen features were late historic/early modern in origin; these were assigned to the historic North/32nd Street neighborhood, AZ T:12:258 (ASM). Because none of the late historic/early modern features were archaeologically or historically significant, studies here focus exclusively on the prehistoric features.

This report is composed of 17 chapters. This first chapter includes background information, descriptive details about the project area and its natural and archaeological setting, previous archaeological research as it relates to this project, and the research design that guided the project's archaeological studies. Fieldwork and field results are the subject of Chapter 2, which describes the staging of fieldwork and excavation methods, and presents summary descriptions of the excavated features. Canals, fields, and other irrigation features are the focus of Chapters 3-8. Studies presented in these chapters include detailed descriptions and geoarchaeological analysis of the larger investigated canals (Chapter 3), descriptions and soil analyses of water catchments and irrigated fields (Chapters 4-5), paleoecological analysis of canal and catchment sediments (Chapter 6), and palynological and biosilicate analyses of field and catchment contexts (Chapters 7-8). Attention shifts in Chapters 9-16 to Hohokam habitation activity within the 44th Street Station area. Detailed

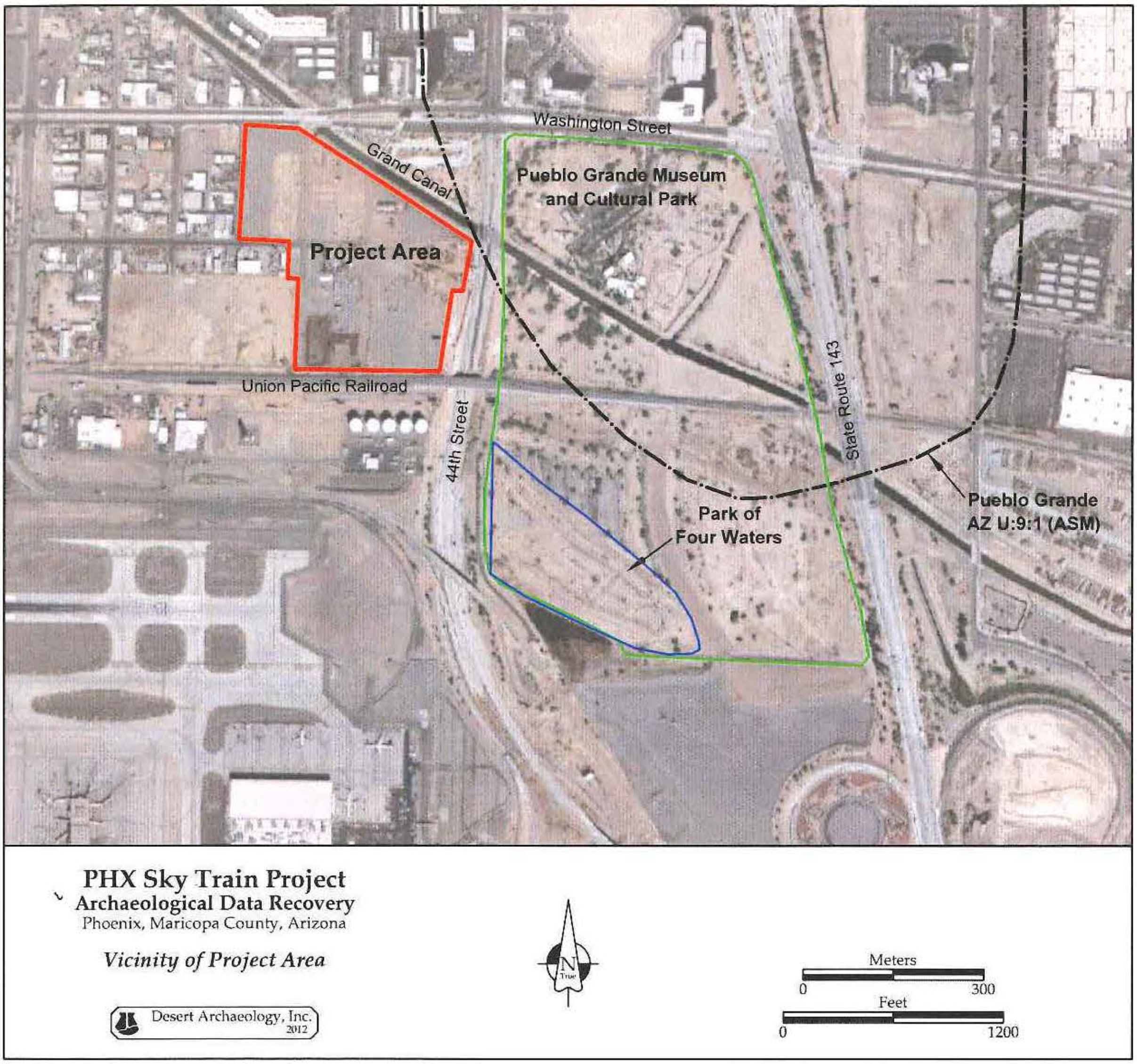

Figure 1.2. Aerial view of the PHX Sky Train archaeology project area and vicinity.

descriptions of investigated habitation features and their segregation into temporally specific activity areas are presented in Chapter 9, while analyses of artifacts and biological remains are presented in Chapters 10-16. Finally, project findings are reviewed in Chapter 17 and considered in the context of research questions posed at the outset of the project. Supporting data and studies are provided in Appendices A-E.

PROJECT LOCATION AND SETTING

The PHX Sky Train 44th Street Station is located in eastern Phoenix, northeast of the Sky Harbor runways, in the NW ¼ of Section 7, Township 1 North, Range 4 East (Gila and Salt River Base and Meridian), Maricopa County, Arizona (see Figure 1.1). The station area comprises 24 acres bounded by Washington Street and the Grand Canal to the north, 44th Street (previously SR 153) to the east, the Union Pacific Railroad to the south, and 41st Place and 42nd Street to the west (see Figures 1.2-1.3).

To the east, just across the 44th Street roadway, lies the Pueblo Grande Museum and Cultural Park, which preserves a portion of the archaeological site of Pueblo Grande. Covering an area of more than 240 acres, Pueblo Grande was one of the largest and perhaps most politically prominent Hohokam villages in the Phoenix area. In addition to the large platform mound preserved within the park, the site once contained scores of adobe-walled compounds, pithouse habitation areas, cemeteries, ballcourts, and an adobe tower, or "Great House."

Table 1.1. Periods, phases, and chronology for the lower Salt River valley.

Periods	Phases	Date Ranges
Historic		A.D. 1860-1950
Abandonment?/	Unnamed gap	A.D. 1650?-1860
Protohistoric	Bachi (?)	A.D. 1450-1650?
Hohokam Classic	Polvorón	A.D. 1350?-1450?
	Civano	A.D. 1300-1450?
	Soho	A.D. 1150-1300
Hohokam Sedentary	Sacaton, late	A.D. 1050/1075-1150
	Sacaton, middle	A.D. 1000-1050/1075
	Sacaton, early	A.D. 950-1000
Hohokam Colonial	Santa Cruz	A.D. 850-950
	Gila Butte	A.D. 750-850
Hohokam Pioneer (late)	Snaketown	A.D. 700-750
	Estrella/Sweetwater	A.D. 650-700
Hohokam Pioneer (early)	Vahki	A.D. 500-650
	Red Mountain	A.D. 1-500
Archaic	Cienega?	800 B.C.-A.D. 1
	San Pedro	1200-800 B.C.
	Chiricahua	3000-1200 B.C.

Table 1.2. Feature types identified by site, PHX Sky Train project.

	ASM Sites				
Feature Type	AZ U:9:1	AZ U:9:2	AZ U:9:28	AZ T:12:258	All Sites
Canal	–	3	9	–	12
Ditch	–	–	26	–	26
Field	–	–	7	–	7
Water catchment	–	–	3	–	3
Pond	–	–	1	2	3
Modified natural channel	–	–	1	–	1
Pithouse	10	–	–	–	10
Possible pithouse	2	–	–	–	2
Adobe structure	1	–	–	–	1
Pit	14	–	1	9	24
Artifact concentration	2	–	–	–	2
Privy/Outhouse	–	–	–	3	3
Cesspool	–	–	–	2	2
Septic tank	–	–	–	2	2
Floor/Foundation	–	–	–	1	1
Total features	29	3	48	19	99

South of the preserved ruins in the area called Park of Four Waters are the extant remains of several enormous prehistoric canals. These canals represent the headwaters of prehistoric Canal System 2. Diverging from the Salt River a short distance to the southeast, System 2 main canals swept around the southern edge of the Pueblo Grande settlement and then turned northwestward, some crossing the 44th Street Station area, to eventually spread across a large portion of metropolitan Phoenix (Figure 1.4).

On the natural landscape, the project APE is located in the lower Salt River Valley within the north-central portion of the Phoenix Basin (Péwé 1978), a part of the larger Basin and Range physiographic province. The specific locale is on the northern side of the Salt River, extending across the interface of the Pleistocene (Mesa) and Holocene (Lehi) river terraces to what was once the active river channel. The broad expanse and low gradient of these river terraces in the Salt River Valley provided excellent ter-

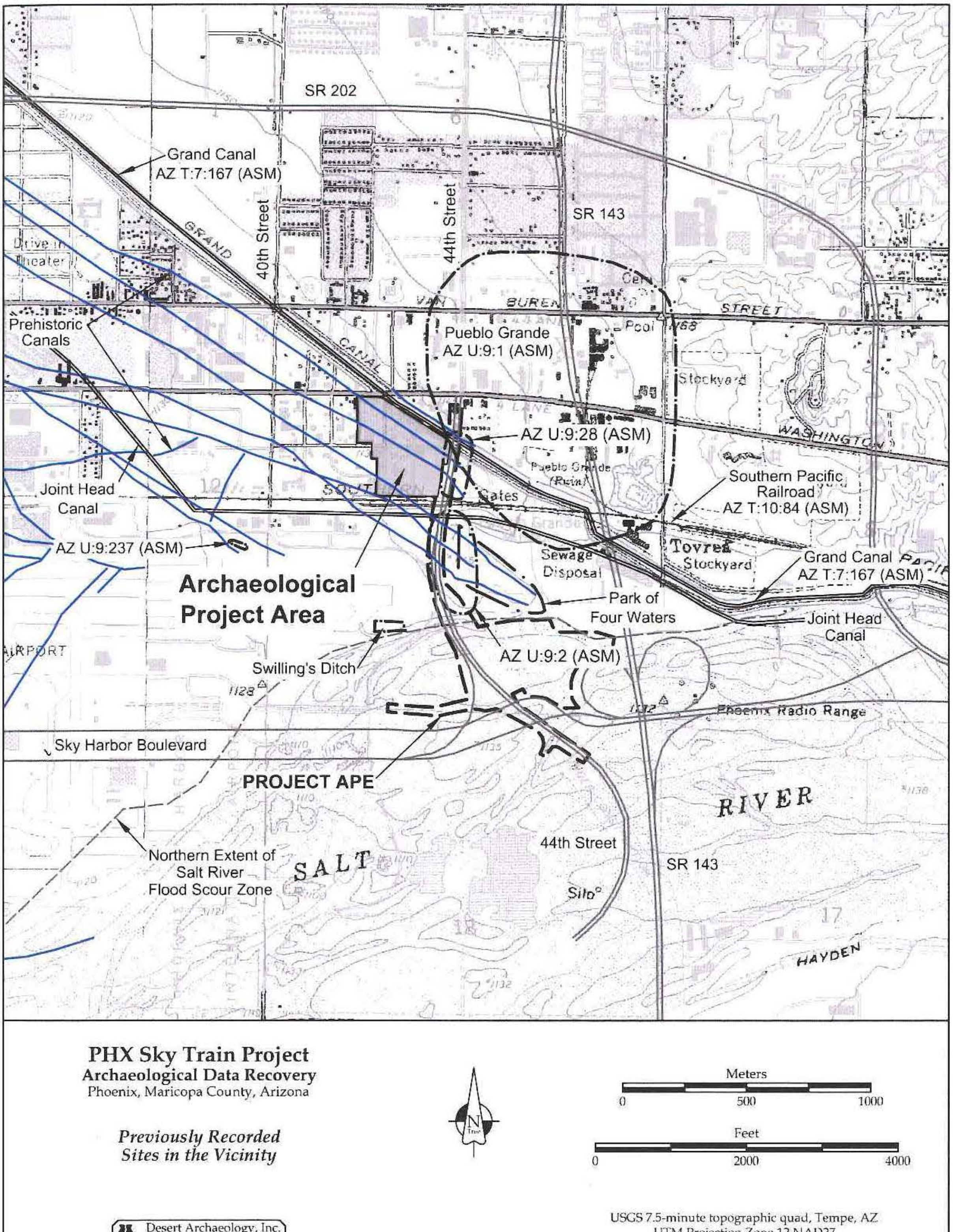

Figure 1.3. Map showing previously identified archaeological sites and historic properties within 0.5 mile of the Area of Potential Effect. The boundaries for sites AZ U:9:2 (ASM) and AZ U:9:28 (ASM) are based on Hohokam Expressway Project work (Bradley 1999; Masse 1976) and as presented in Rogge and Erickson (2005).

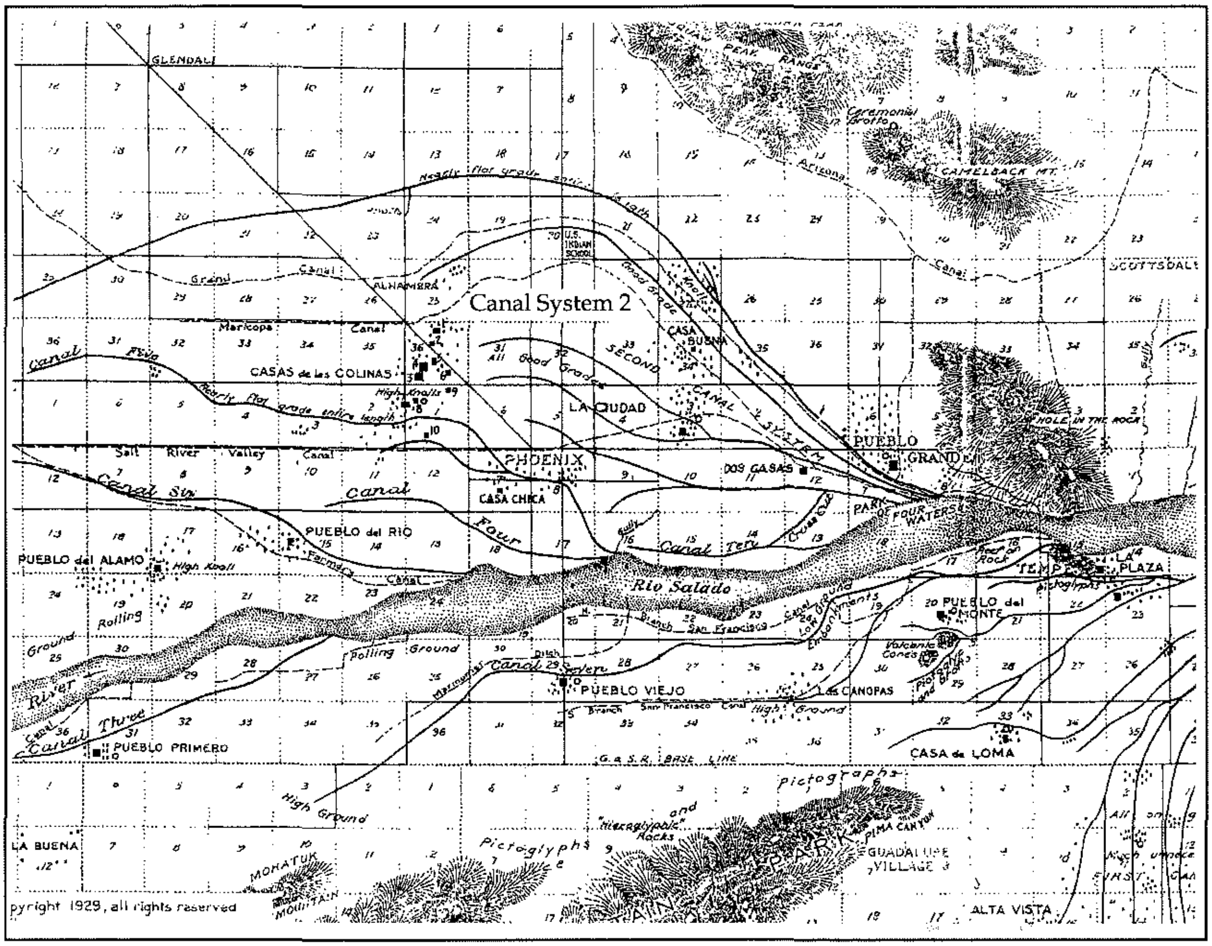

Figure 1.4. Canal System 2 as depicted on Turney's 1929 map of prehistoric irrigation systems in the Salt River Valley.

rain for the construction and use of prehistoric and historic canals. Prehistoric Pueblo Grande and the historic town of Phoenix are examples of the many settlements in the valley associated with canal systems that diverted water from the river to surrounding farmable land.

The lower Salt River Valley has been utilized by people living and farming along the river for more than 2,000 years. The Hohokam occupied the area for much of this time, from the first centuries A.D., to sometime around the fifteenth or sixteenth centuries (see Table 1.1). This culture is best known for several traits, including fully sedentary villages, multigenerational habitation sites, limited-activity sites, extensive canal systems, public architecture, and a rich and diverse artifact assemblage that included red-on-buff and red-on-brown pottery.

During the Hohokam occupation, the river margins and lower terraces were replete with small, seasonal, agrarian sites. Terraces beyond the reach of floodwaters contained villages, many of them large, sprawling, and structurally complicated, with ballcourts (earlier), platform mounds (later), and central plazas surrounded by residential areas, cemeteries, and trash mounds. Woven among these settlements were canals of the often elaborate irrigation systems that might be considered the framework upon which the Hohokam culture was built. One of the largest of these prehistoric waterworks is Canal System 2, or "Second Canal System," as named by Turney (1929) (see Figure 1.4).

PREVIOUS ARCHAEOLOGICAL RESEARCH

Rogge and Erickson (2005) and Henderson and Bagwell (2007) provide standard records reviews of the subject property. Attention is focused here on those previous archaeological studies that framed the research to be conducted within the PHX Sky Train 44th Street Station area. This discussion has been largely extracted from the project treatment plan (Henderson and Bagwell 2007).

Hohokam Canal Studies

O. A. Turney, a hydrologist and Phoenix City Engineer between 1915 and 1924, compiled the first comprehensive study of prehistoric irrigation canals in the Salt River Valley (Turney 1929). He brought what had been documented by settlers, historians, surveyors, and other canal enthusiasts together with his own extensive knowledge to define, describe, and map 15 distinct prehistoric canal systems within the valley.

Turney (1929) hypothesized that of the irrigation systems he defined, Canal Systems 1 and 2 were the earliest, utilizing, as they did, the most favorable locations for capturing water. Canal System 1 irrigated land south of the Salt River across a large expanse of present-day Tempe, while Canal System 2 irrigated a vast area across Phoenix north of the river. Regarding System 2, Turney (1929:45) observed that its headwaters were positioned "at the best point to take advantage of a considerable underflow forced to the surface by the Reef of Rock," which spanned the river between Papago and Tempe Buttes. Throughout his study, Turney (1929) marveled at the sophisticated engineering the Hohokam brought to the construction of their canals. He observed that "the work of the ancient engineers could not be improved upon," and "in no case has it been found feasible to divert water at any point which they [the ancient Hohokam] had not utilized" (Turney 1929:51). He also intrinsically recognized that it was these irrigation systems that allowed the Hohokam to flourish in the valley.

Since Turney (1929), canals associated with System 2 have been the focus of three pioneering studies of prehistoric irrigation technology (Howard and Huckleberry 1991; Masse 1976; Woodbury 1960). As discussed below, two of these bear directly on the project locale, while the third is more synthetic in nature and provides findings that demonstrate the importance of additional study of earlier studied Hohokam canals.

In 1959, Woodbury (1960) excavated several Hohokam canals, including two large canals in the Park of Four Waters (referred by Woodbury [1960] as the North and South Canals). His excavations involved the use of long, deep trenches oriented perpendicular to the canal course to provide cross sections capable of accurately displaying the size and configuration of the channels. In addition to canal size and morphology, Woodbury (1960) utilized stratigraphic data, pollen analysis, and diagnostic ceramics to inform on dates of construction and abandonment, stages of use, and maintenance of the canals. His analyses suggested that both canals dated to the Classic period and contained sediments that reflected regular cleaning but no dramatic flooding events. Overall, this project demonstrated the skilled engineering behind Hohokam canal construction, as well as the central role of irrigation in Hohokam society (see also Woodbury 1961). Woodbury's (1960) project set methodological standards for examining canals and posed important questions about the role of Hohokam irrigation that are being explored to the present day.

Arizona State Museum's (ASM) data recovery excavations in the early 1970s for the "Hohokam Expressway" (SR 153; later renamed the Sky Harbor Expressway), led by Masse (1976), built and expanded upon Woodbury's (1960, 1961) work. Two sites proximate to the project APE, U:9:2, located south of the Union Pacific Railroad, and U:9:28, located north of the railroad (see Figure 1.3), were investigated by Masse (1976). Eleven Hohokam canals and a portion of the historic Joint Head Canal at U:9:2 and eight Hohokam canals at U:9:28 were recorded and profiled, with small segments of 14 of these canals being excavated; two of the canals within U:9:2 were extensions of Woodbury's (1960) North and South Canals (Figure 1.5). In addition to canals, the ASM project also documented two Hohokam activity areas (possibly fields), a prehistoric hearth, a flood deposit laden with Hohokam artifacts, four historic trash pits, and a historic privy.

Masse's (1976) research goals were to confirm Woodbury's (1960) findings and to explore some previously unconsidered data sets. These included: (1) using large horizontal exposures to identify temporal relationships among canals; (2) obtaining canal gradients and using them to inform on canal morphology and operation; (3) using pollen and freshwater shell analysis of canal sediments to more completely understand local environment, crops, and seasonality of canal use; and, (4) using particle-size analysis of sediments from separate stratigraphic layers to examine the rate of water flow and its variability within each canal (the latter analysis was reported in Masse 1988). Although archaeomagnetic and radiocarbon dating were available at the time, neither technique was used to date the canals or associated features. Instead, Masse (1976) relied on associated diagnostic ceramics and stratigraphic relationships among canals to deduce their age; the use of all canals was assigned to the Sedentary and/or Classic periods.

In addition to the introduction or further development of a variety of specialized canal analyses, the Hohokam Expressway project also yielded unexpected results. First, far more canals were found than anticipated based on surface evidence. This was particularly true for the area around U:9:28, where Masse (1976) expected to find pithouses or other forms of residential activity, based on its location immediately west of Pueblo Grande. Instead, the area was replete with canals, indicating the primacy of this piece of the landscape for water-management purposes. Second, although Woodbury (1960) observed only one channel in the North and South Canals, Masse's (1976) examination revealed distinct upper and lower channels in both. The presence of these channels demonstrated that a single cut

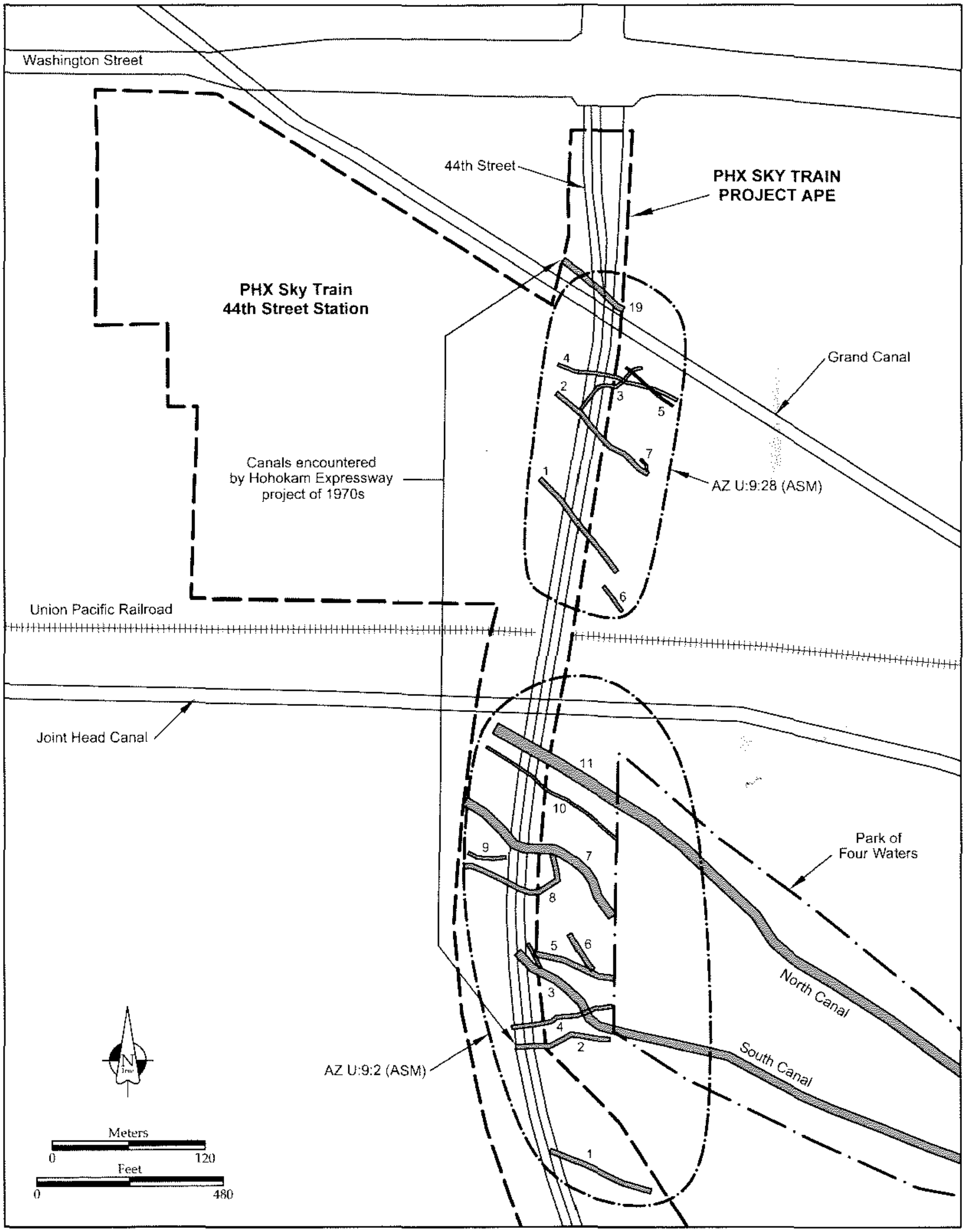

Figure 1.5. Map showing prehistoric canals encountered during the 1970s Hohokam Expressway (SR 153) project.

through a canal would not necessarily reveal its full history; it was evident that cultural activities, such as construction, cleaning, and remodeling or reconstruction, could combine to create discontinuities in the sediment profile of a canal along its course. Finally, Masse (1976) noted the diversity in size and morphology of the Hohokam canals within the Expressway project area, as well as compared to those few canals that had been studied elsewhere in southern Arizona. He recognized that this variability was tied, in part, to the varying functions of canals, prompting him to advocate a standard terminology in reference to Hohokam canals. His definitions of main, distribution, and lateral canals have been widely applied to the present day.

Variability not only in canals, but also associated water-related features, was reinforced by the return of ASM during the winter of 1977-1978 to investigate a portion of SR 153 that was unavailable at the time of Masse's (1976) work. This project sampled the highway right-of-way north of the Grand Canal (B. Bradley 1999). A single prehistoric canal was encountered about 17 m north of and paralleling the Grand Canal. Unanticipated features found associated with this canal included shallow basins in its floor that contained sets of human footprints and the larger portion of a Casa Grande Red-on-buff jar. Above these, on the uphill slope of the canal bank, was a shallow, U-shaped groove or swath that graded from the probable prehistoric ground surface to the upper edge of the active canal channel. B. Bradley (1999) interpreted the swath as a walk-in, a path intentionally constructed to ease access into the canal. The presence of human footprints confirmed that prehistoric peoples were entering the canal, and their association with the shallow basins suggested these might have been dipping pools for potable water.

The inventory of water-related features in this vicinity was expanded in a recent Metro Light Rail-related project abutting the west side of SR 153/44th Street, north of the Grand Canal (Schilz et al. 2007). In addition to investigating segments of B. Bradley's (1999) canal, this project also documented a reservoir that was filled from the canal, a device probably used to control water flow within the canal, and a possible agricultural field. Application of ostracode analysis, a technique unavailable at the time of Masse's (1976) and B. Bradley's (1999) studies, further revealed that the canal might have been used not only to direct water to fields, but also to store water for other uses. This is consistent with B. Bradley's (1999) evidence suggesting use of the canal as an open well.

The last in the trio of pioneering works is Howard and Huckleberry's (1991) study of Canal System 2, the first detailed evaluation of an entire Hohokam canal system. The study included four essential elements. First was the creation of a map of all canals and habitation sites within Canal System 2, as well as the larger Salt River Valley, combining information from Turney (1929), Midvale (1966, 1968), Nicholas (1981), aerial photographs, and past archaeological projects. The map, titled "Central Phoenix Basin Archaeology," is among the first that present-day archaeologists and cultural resource managers consult to determine what types of archaeological resources might be present in a valley project.

The second element was a synthetic analysis that examined the geomorphology and sedimentological characteristics of System 2 canals (Huckleberry 1991). The analysis used morphological (hydraulic) and sediment data that had been collected during a variety of projects from 176 cross sections within 67 System 2 canals to inform on their operation, carrying capacity, regularity of flow, and maintenance needs.

The third element was development of a regression model to reconstruct the operation of a prehistoric canal from head to terminus using data from single cross-sectional points (Howard 1991a). The model was based on hydraulic data from historic Salt River canals, including the historic Appropriators (Grand) Canal. The regression model allowed Howard (1991a) to estimate total canal length and volume for 36 System 2 canals, which provided a basis for estimating the amount of labor used to build and maintain the system, as well as the number of irrigated acres.

These analyses were combined in a final diachronic reconstruction of the growth, operation, and capacity of Canal System 2 (Howard 1991b), lending insight to its functional parameters, labor investments, and administrative requirements across time. Based on his results, Howard (1991b) suggested that the growth, engineering, and capacity of Canal System 2 (initiated during the Pioneer period [A.D. 1-750]) was relatively steady during the Colonial, Sedentary, and Classic periods, with highest production in the Colonial period. In contrast to the arguments of earlier scholars (see, for example, Masse 1976), Howard (1991b:5.33) suggested that large canals built with sophisticated engineering requirements and managed by a sophisticated system of administration were in place early in the Colonial period.

In sum, this seminal work established models and methods for the study of prehistoric canals that have formed the basis for many subsequent canal studies. Notably, several of the canals used for Howard's (1991a) System 2 reconstruction would or might pass through the current APE. Reevaluations of these canals as part of the current project have the potential to enhance or change the interpretations of Canal System 2 capacity and operation.

The collective work of Woodbury (1960), Masse (1976, 1988), and Howard and Huckleberry (1991) has helped set the standard for the few, smaller, canal-related excavations that have taken place near Pueblo Grande since 1980, as well as Hohokam canal studies in general. In the first of these smaller studies, Soil Systems, Inc. (SSI), identified one historic canal and three prehistoric canals east of Park of Four Waters during the Pueblo Grande project (Birnie 1994; Birnie et al. 1992).

The prehistoric canals were all relatively small, suggesting that they likely functioned as laterals. None were aligned with the canals known from the Park of Four Waters (Woodbury 1960) or Hohokam Expressway (Masse 1976) excavations, so the relationship among these canals is unknown.

In 2001, URS Corporation tested the site of Sky Harbor Fire Station No. 29 for the City Aviation Department (Rogge et al. 2002); two Hohokam canals and an adjacent field area were encountered during the project. Radiocarbon, pollen, ostracode, canal morphology, and grain-size analyses of sediments suggested the two canal segments were contemporary main canals. One of these canals may have been used, while the other was being cleaned to increase system capacity or to accommodate seasonal overloads. Most recently, Archaeological Consulting Services (ACS) revisited the canal originally investigated by B. Bradley (1999) within the SR 153 corridor. The results of this project have been described in more detail above.

Pueblo Grande

All previous work within the SR 153/44th Street corridor, as well as in areas sampled to its north and west, suggested that archaeological remains associated with the large Hohokam village site of Pueblo Grande were unlikely to be present within the PHX Sky Train project area. Nevertheless, it would be remiss to not discuss this site, given its critical connection to the irrigation features that were expected to be found.

The site of Pueblo Grande, particularly its very visible platform mound, has attracted the attention of archaeologists for more than 130 years. Among the prominent early visitors were Adolph Bandelier who, in 1883, drew the first archaeological map of the site, and Frank Hamilton Cushing, who described the Great House in 1887. In the 1920s, Turney (1929) mapped the site, noting that it extended at least 1 mi^2 north of the platform mound. He also identified the four large prehistoric canals just south of Pueblo Grande as the Park of Four Waters.

These early visits are especially important because many of the features described were subsequently destroyed by agricultural activities and urbanization. The best-known summary of archaeological work at Pueblo Grande was published by Hayden (1957), as part of a comparison with the University Indian Ruin, AZ BB:9:33 (ASM), in Tucson. Major projects by the U.S. Public Works Administration, Works Progress Administration, and Civilian Conservation Corps (CCC) between 1934 and 1940, took place within the park, but no final report was written. Despite this professional interest and the completion of multiple projects, a synthesis of work at Pueblo Grande was not completed until the early 1990s (Bostwick and Downum 1994; Downum 1998; Downum and Bostwick 1993). Together, they found that projects completed prior to 1990 had identified 121 pithouses and other structures, 150 cremations, 77 inhumations, several hornos, and numerous pits within the 102 acres of the Pueblo Grande Cultural Park. Most of these features were excavated between 1936 and 1940, by CCC crews, supervised by Hayden.

Although these early projects provided an initial characterization of Pueblo Grande, it was not until the 1988-1990 Pueblo Grande Project, conducted by SSI, that a more thorough understanding of the site and its composition was obtained. This later work was sponsored by the Arizona Department of Transportation (ADOT) to mitigate construction impact of the (new) Hohokam Expressway, SR 143. Excavations took place along a 1-km stretch just east of the City park. SSI identified 14 residential loci or "habitation areas" in the project area. These loci contained an average of 23 architectural features and 107 pits, and many were continuously occupied for as long as 300 years. In all, 348 architectural features, 17 cemeteries with 620 inhumations and 189 cremations, and 1,377 pits were found. The remains dated primarily to the Classic period (Mitchell 1994). Other recent work at Pueblo Grande by SSI includes a large data recovery project located on the north side of Washington Street, immediately north of Pueblo Grande Museum and Archaeological Park. This work, conducted for a commercial development, documented more than 300 architectural features and recovered 870 human burials (Breternitz et al. 2006).

Pueblo Grande was established in the Pioneer period, in approximately A.D. 400-500, and was continuously occupied until its abandonment at the end of the Classic period, circa A.D. 1450. The site is located immediately above the headwaters of Canal System 2, and due to its location, would have controlled a vital resource (water) shared with other villages along the canal system. As summarized in Bostwick and Downum (1994), current evidence indicates the Pioneer period site consisted of a small cluster of houses, possibly comprising a farmstead. The farmstead was likely supported by Pioneer period canals, although none have been identified yet in the immediate vicinity. The site expanded in the Colonial period to include several clusters of pithouses, clearly defined cremation cemeteries, a trash mound, and a ballcourt. The Sedentary period saw continued growth; 50+ pithouses, a ballcourt, and a small platform mound were built during this time.

The site reached it largest extent during the Classic period, with at least 14 habitation areas, 12 adobe-walled compounds, an immense platform mound, and a three-story adobe Great House.

Pueblo Grande was one of the largest Classic period villages in the Salt River Valley. Like other contemporary villages with platform mounds, Pueblo Grande may have organized the construction and maintenance of the canals. The site may also have played a dominant role among all the large sites in Canal System 2, because it would have been able to control their access to irrigation and drinking water.

Pueblo Grande was abandoned at the end of the Classic period during what appears to have been a collapse of Hohokam society and much of the irrigation system. This collapse may have been tied to a failure to rebuild irrigation systems after catastrophic floods (Bostwick 1994; Nials et al. 1989).

RESEARCH DESIGN

Review of previous archaeological studies in the project vicinity indicated archaeological resources within the 44th Street Station area would consist primarily of Hohokam canals that were part of Canal System 2. Thus, the primary research topic selected to guide the PHX Sky Train studies was, "History and Development of Prehistoric Irrigation in the Salt River Valley," a variation on the statewide historic context developed by Dart (1989). Although previous studies along SR 153/44th Street for the then-Hohokam Expressway (B. Bradley 1999; Masse 1976) suggested that residential features associated with Pueblo Grande would not be present, archaeological projects to the north and west (Aguila 2007; Greenwald et al., eds. 1994; Henderson 2003; Landis 1988) had encountered features, such as fieldhouses, farmsteads, processing pits, and so forth, that reflect a variety of agricultural and other nondomestic activities within the prehistorically irrigated lands. A secondary research topic, "Prehistoric Land Use and Subsistence Practices in the Salt River Valley," was thus proposed to guide the study of non-irrigation features, if encountered. The two research topics are discussed in greater detail below.

Prehistoric Irrigation in the Salt River Valley

In his context study, Dart (1989) observes that the practice of irrigation agriculture has dramatic effects on human populations. For example, by allowing greater agricultural productivity, irrigation affects the size, growth, and density of prehistoric populations. The distribution of residential settlements is dependent, in part, on how irrigation systems can be located across the landscape. The labor requirements of building and maintaining canals, as well as the need for water management, influences the organizational complexity of the people dependent upon them. This particular relationship between irrigation and the structure of human societies has been recognized by many Hohokam archaeologists (Cable 1991; Doyel 1980; Gregory 1991; Haury 1976; Howard 1993, 2006; Hunt et al. 2005; Masse 1991; Nicholas 1981; Nicholas and Neitzel 1984; Upham and Rice 1980; Wilcox 1991; Woodbury 1961).

However, there is not a universal agreement about the effect of irrigation on Hohokam society. Some have argued that the managerial requirements of the Salt River canal systems underlay the development of complex social organizational forms in the Sedentary and Classic periods (Doyel 1980; Gregory 1991; Howard 2006; Nicholas 1981; Nicholas and Neitzel 1984; Upham and Rice 1980). Howard (1993) partly agrees with these arguments, although he suggests the processes of sociopolitical complexity may have started earlier and that competition for water, rather than management, was the primary instigator of increased organizational complexity. Woodbury (1961) and Haury (1976) provide contrasting views, suggesting Hohokam irrigation systems could have been easily built and maintained through cooperative efforts, and that Hohokam society was egalitarian and unchanging in nature, although elaborated through time. Hunt et al. (2005) present a more middle-of-the road perspective, recognizing that the size of many Hohokam irrigation systems demands an internal management system, but that this management may have been vested in a communally accepted charter of authority.

Resolution of the relationship between Hohokam irrigation agriculture and sociopolitical organization ultimately lies in understanding the dynamics of the irrigation networks. At the most general level, aboriginal canal systems along the Salt River had to accommodate the unpredictable flow characteristics of arid region rivers. For example, Ackerly (1989a; also, Ackerly et al. 1987) has suggested there was considerable instability in the Salt River channel, which would have caused periods of canal abandonment. Similarly, Nials et al. (1989) have argued that flooding along the Salt River would have regularly caused significant damage or destruction of canal headgates, resulting in the loss of one or more growing seasons. Given the low relief of the floodplain throughout most of the Salt River Valley, long segments of major canals and associated laterals would almost certainly have required major reconstruction following flood episodes, with many channels being permanently abandoned in favor of new canal alignments. This would have been particularly true of the upstream segments of the canals nearest the intake structures.

The issue of continuity in canal use is also critical in estimating the magnitude of irrigation systems over time. Numerous scholars have attempted to estimate the amount of land irrigated by the Hohokam (Howard 1991a; Midvale 1968; Nicholas 1981; Turney 1929), but most of these studies are based on assumptions of long-term canal use and stability, and have ignored the effects of seasonal variation in flow rates of the Salt River. The studies of both Ackerly (1989a; also, Ackerly et al. 1987) and Nials et al. (1989) indicate that seasonal variation would have had a significant effect on the amount of water available for irrigation.

The question is, how did Hohokam farmers contend with the vagaries of Salt River discharge and its effects? Study of the canals in the PHX Sky Train project area can contribute important information toward resolving this question. For example, details of the construction, engineering, and operation of the canals can be garnered. Improvements and additions to the canals, as well as rebuilding episodes, may be assessed from archaeological excavations. Dating of the canals can contribute to an understanding of canal longevity and the time period the features were in use. If the ages of canals differ significantly, correlations with streamflow reconstructions (Graybill et al. 2006) may help explain the series of canal constructions.

The relationship between flooding episodes and rebuilding/replacement activities may also be examined. Evidence of the magnitude of canal rejuvenation following flood episodes, along with assessments of seasonal variations in the use of the canals, are critical sources of information. Collectively, these data augment current understanding about the operation of irrigation systems. In turn, knowledge of how these systems functioned contributes to an understanding of the implications of their use and management for cultural evolution. There is some evidence to suggest that both prehistoric and aboriginal historic canals were overbuilt (Southworth 1919; see also Crown 1987a); that is, they were built to accommodate a much greater amount of water than they routinely carried. This overbuilding may represent one of the few direct technological responses to the highly variable flow of the river available to these prehistoric irrigators, and it is an aspect of their irrigation technology that deserves attention.

Previous work along SR 153/44th Street and at the Park of Four Waters (B. Bradley 1999; Masse 1976, 1988; Woodbury 1960) provides baseline information about the canals anticipated to be present in the current APE. Descriptions of their morphology and assessments of their hydraulic efficiency and possible age have been provided. These data, in combination with PHX Sky Train results, can be used to refine the use histories of individual canals, and allow construction of developmental histories.

In sum, research is directed toward an understanding of the details of canal construction, operation, and longevity. Specific questions to be addressed include the following. What flow regimes are associated with the canals? What is the water capacity of the canals? Is there evidence of flood events? Were repairs of the canals undertaken? What types and numbers of repairs were attempted? Is there an increase in the technological capacity of canals over time? Were canals overbuilt relative to the amounts of water they routinely carried? When were the canals built, and when were they abandoned? What is the length of their use-lives? Were canals constructed sequentially? If so, what time interval separates the canals?

Prehistoric Land Use and Subsistence Practices

Previous archaeological investigations on the northern floodplain and terraces of the lower Salt River outside of permanent settlements suggest a land use system composed of small, agriculturally focused sites. First appearing on the floodplain in the Pioneer period, these sites are characterized by dispersed fieldhouse and farmstead loci positioned along canals and near agricultural fields.

Recent research indicates the size and composition of these farm sites exhibited marked changes through time. For example, cumulative data from Dutch Canal Ruin, AZ T:12:62 (ASM) (Greenwald et al., eds. 1994; Henderson 2003), and Pueblo Salado, AZ T:12:47 (ASM) (Greenwald et al. 1995, 1996), suggest that from the late Pioneer period through the early Sedentary period, settlement in the area consisted primarily of seasonally occupied fieldhouses. The absence of these structures during the subsequent late Sedentary and early Classic period suggests a shift in use away from temporary, short-term occupations of the floodplain. Settlement practices changed again in the late Classic period, when small, permanent farmsteads were established along the routes of the canals.

The hiatus in seasonal occupation of the floodplain between roughly A.D. 1050 and A.D. 1300 was previously thought to reflect a decline in agricultural use of the landscape, if not outright abandonment (Greenwald et al., eds. 1994; Henderson 1995a). Greenwald et al., eds. (1994:342) asserted the Hohokam had abandoned floodplain irrigation because they recognized the landscape as a "high-risk zone" due to its susceptibility to flooding. Henderson and Clark (2004) recently challenged this interpretation, suggesting that the disappearance of fieldhouses, which were determined to represent the farms of village-based households, reflected a system-wide change in the organization of agricultural production as a result of (or entailing) modifications in land tenure.

There are additional contrasting views about land use and subsistence practices in the Salt River Valley. Some have argued that demographic growth and agricultural intensification went hand-in-hand (Cable and Doyel 1987; Cable and Mitchell 1988), and suggest that the dependence on irrigation agriculture increased over time as canal systems were expanded in response to growing populations. A different model of land use was proposed by Henderson (1995a), who suggested that Hohokam subsistence practices in this area of the Salt River Valley may have been highly variable. Rather than viewing canal expansion and agricultural intensification as a gradual, continuous process, she suggested that there may have been periods of time when other subsistence strategies, such as floodwater farming and wild resource procurement, may have been emphasized more, over irrigation agriculture.

The present project provides the opportunity to gather data to examine these various models. Research questions related to land use practices are focused on the identification of feature function, and the patterns formed by these features, both spatially and temporally. Specific research questions include the following. What is the function of identified features and sites? What are their ages? Were sites/features used seasonally? What kinds of economic resources were exploited in the area? Were subsistence activities in the project area focused exclusively on agricultural pursuits, or did residents also utilize wild resources? If so, are there temporal trends in the types of, and degree to which, wild food products were exploited? Do particular activities show differential distributions across time? Did the use of this land change over time? Are there changes in the intensity of use over space and time? Who used this land? What was their relationship to the nearby site of Pueblo Grande? Do these social relationships change through time?

FIELD METHODS, PROJECT PHASES, AND RESULTS

Connie A. Darby and T. Kathleen Henderson
Desert Archaeology, Inc.

Desert Archaeology, Inc., conducted archaeological fieldwork for the PHX Sky Train project in two phases between late December 2008 and the end of October 2009. This work took place in the area of the planned 44th Street Station, an irregular 24-acre parcel that extends southward from the Grand Canal to the Union Pacific Railroad, and westward from 44th Street to 41st Place (north station area) and 42nd Street (south station area). Prior to fieldwork, this area was further subdivided into 117 individual properties, or parcels, whose acquisition by the City of Phoenix (City) determined the sequencing of fieldwork. For project tracking purposes, the 44th Street Station project area was subdivided by city block, numbered for convenience as Blocks 1-7 (Figure 2.1).

The archaeological work was scheduled to accommodate the City Aviation Department's phased construction plan for the Sky Train 44th Street Station. Fieldwork was implemented when large contiguous sections of the 44th Street Station area had been, or were soon expected to be, acquired and cleared by the City. Land clearing entailed the demolition of all aboveground structures and removal or abandonment of underground utilities, dry wells, septic tanks, and storage tanks. Because Sky Train construction activity would avoid or only minimally affect adjacent streets, archaeological fieldwork occurred solely within cleared parcels. Fieldwork was staggered during the second phase according to parcel demolition schedules. In some cases, parcels slated for archaeological work were not available for investigation until fieldwork was quite advanced. A few parcels were never investigated.

Fieldwork was designed to include both testing (Phase 1 data recovery, in federal compliance language) and intensive data recovery (Phase 2 data recovery). To facilitate construction within the 44th Street Station area, these stages were implemented consecutively during each project fieldwork phase, with conditions of the transition between the stages established through field consultation by Desert Archaeology and the City Archaeologist. This practice was approved by the Federal Aviation Administration (FAA) and the State Historic Preservation Office (SHPO).

FIELD METHODS

Standard archaeological methods, described here, were used during the investigation of the project parcels. The methods section is followed by a discussion of each project phase, which provides further insight about the staging of fieldwork.

Testing Methods

The purpose of testing was to identify archaeological features within the PHX Sky Train project area, including their numbers, location, and layout. This was accomplished by excavating backhoe trenches placed at systematic intervals across areas available for investigation. The original work plan, presented in the project treatment plan (Henderson and Bagwell 2007), proposed placing trenches at 50-m intervals, oriented in a southwest-northeast direction, to intersect expected southeast-northwest trending canals (see Figure 1.3). This approach was generally followed during the first phase of fieldwork, but was modified during the second phase to utilize more north-south and east-west oriented trenches, which proved more effective for capturing canals that might pass through an area.

The test trenches were 2 ft wide and dug to depths no greater than 5 ft to conform to Occupational Safety and Health Administration (OSHA) standards. When a depth greater than 5 ft was required to investigate archaeological features, such as, for example, canals, trenches were stepped to comply with OSHA regulations. All trench walls were scraped with hand tools and examined for archaeological features. Each feature was marked, numbered, and assigned to one of four previously recorded sites depending on its location, type, and/or temporal affiliation. Canals were assigned to one of two sites associated with Canal System 2, AZ U:9:2 (ASM) or AZ U:9:28 (ASM), based on their relation to specific canal alignments previously identified east of the current project area (see Figure 1.3). Prehistoric non-canal features were considered part of the Pueblo Grande settlement, AZ U:9:1 (ASM), and

Figure 2.1. PHX Sky Train project area overview map.

late historic/early modern features were assigned to the historic North/32nd Street neighborhood, AZ T:12:258 (ASM).

All identified features were documented on standardized forms that included information about the type of feature identified, the nature of fill sediments, whether or not artifacts were present, and an assessment of postoccupational disturbances. Photographs were taken, and scaled drawings were made of prehistoric features; sketch maps were drawn for late historic/early modern features. Trench and feature locations were plotted.

While the primary goal of testing dictated the placement of initial test trenches, wherever indications of possible prehistoric habitation or other activities, such as agriculture, were identified, additional trenches were excavated to further investigate and delineate the activity areas. These secondary trenches often signaled the transition from testing to data recovery, helping to define areas for horizontal stripping and excavation.

Data Recovery Methods

Data recovery efforts included: (1) excavation of additional trenches to trace canal alignments and to further sample areas containing other feature types; (2) feature profiling and sampling; (3) horizontal stripping; and, (4) excavations. Overburden above select canals was scraped mechanically to expose the alignments in plan view. Segments of some channels were excavated using a combination of hand and mechanical techniques to remove the canal sediment and expose the interior feature(s). Samples such as flotation, pollen, and charcoal were collected from appropriate contexts.

Canals, ditches (field laterals), water catchments, and other irrigation features were documented primarily by detailed cross-sectional profiles. These scaled drawings included descriptions of individual strata and sediments both inside and outside the irrigation features. A stratigraphically ordered series of sediment samples was collected from at least one exposure of each canal and selected catchment and field features for later specialized studies, for example, soil texture, density, and chemistry, and pollen, ostracode, and biosilicate content. A different set of sediment samples was collected for luminescence dating. Several samples from charcoal-bearing canal sediments were removed for possible radiocarbon dating. The excavation of any canal or irrigation-related feature was documented on standard Desert Archaeology forms, photographed, and mapped.

Related to irrigation features, but unanticipated by the work plan, was the presence of prehistoric irrigated fields. Where exposure of preserved field surfaces was possible, the field surfaces and their accompanying lateral ditches were intensively sampled via backhoe, hand-trenches, and plan view exposures, with consequent detailed profiling, plan mapping, and sediment sample collections.

Data recovery efforts for non-canal features included the excavation of prehistoric pithouses, an adobe structure, and extramural pits. No human burials were encountered during the project. Structures were initially sampled using a 1-m by 2-m control unit, except when preserved remains were too small to accommodate the standard control; the remainder was then excavated in larger units to reveal the house plan. Units were generally excavated in natural levels to 5 cm above the structure floor. The final 5 cm of fill was excavated separately from upper fill levels. After the excavation was complete, the floor and any floor-contact artifacts were mapped, photographed, and collected. All identified pits were relatively small, so these were excavated as a single unit in one or two natural or arbitrary levels.

Fill from these excavations was screened through ¼-inch mesh, and all artifacts were collected. Flotation, pollen, and radiocarbon samples were collected from appropriate contexts in excavated units. Two archaeomagnetic dating samples were collected from pithouse hearths. All excavations were recorded on standard Desert Archaeology forms; plan views and profiles were drawn at the completion of excavations, and digital photographs were taken.

All trenches, stripping areas, and feature locations were mapped using dual L1/L2 frequency sub-centimeter GPS receivers with real-time kinematic correction. Horizontal and vertical positioning was based on an average OPUS solution derived from multiple long-duration redundant static observations. Coordinate values are relative to NAD83(CORS92:2002) and NAVD88(Geoid03), and were tied to off-site ground control points.

PROJECT PHASES

Fieldwork was accomplished in two phases, defined by the City, including testing and data recovery. The purpose of the phased excavations was to mesh with the PHX Sky Train project construction schedule, allowing the City Aviation Department to proceed with construction activity in archaeologically cleared parcels. The work accomplished during each phase is summarized below. These discussions are supplemented by Figures 2.2-2.7.

Phase 1

The Phase 1 study area consisted of the first set of acquired parcels that had been cleared of existing structures and utilities within the 44th Street Station area. Forty-two parcels, with a combined area of 6.3 acres, comprised the Phase 1 area, or approximately

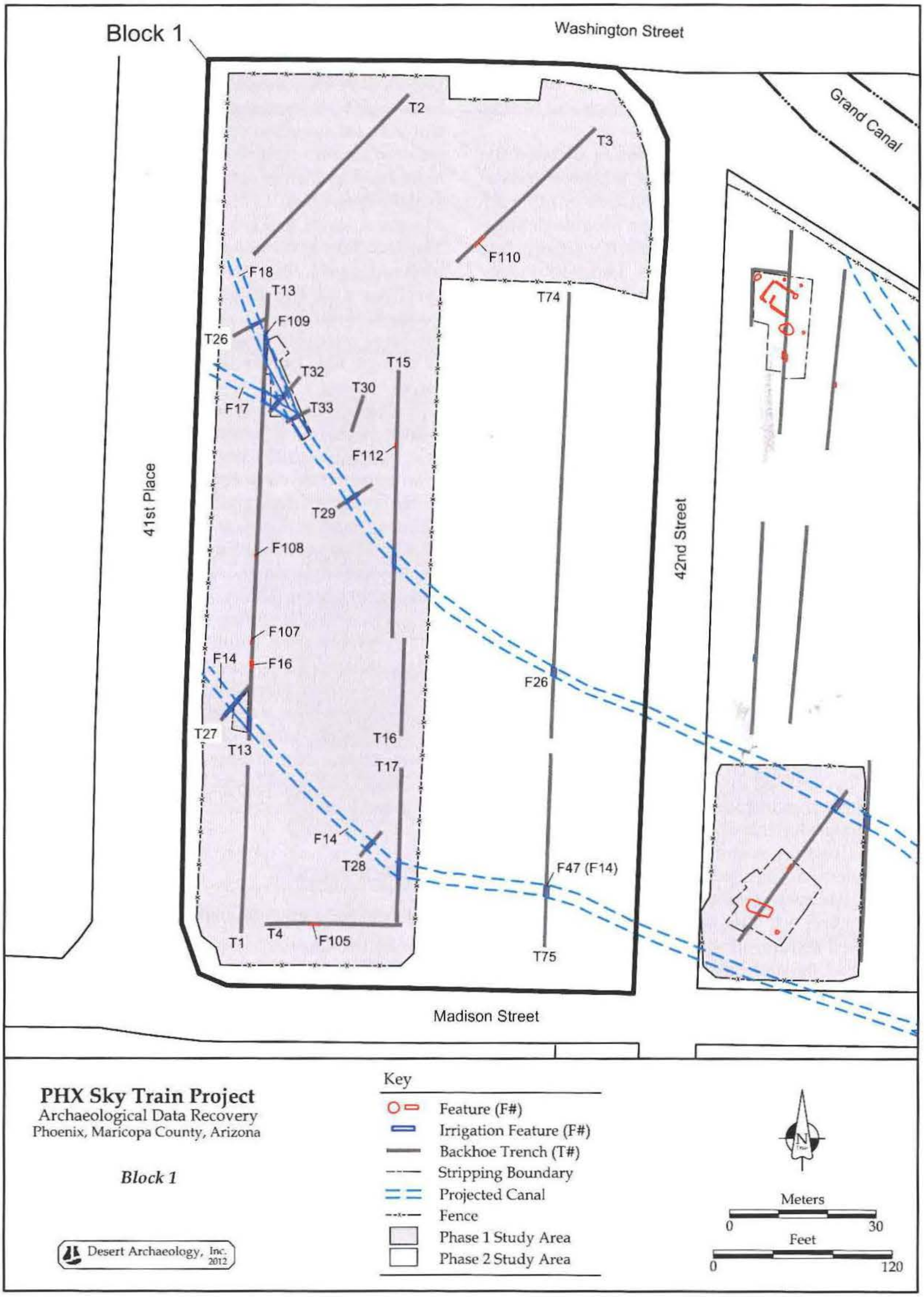

Figure 2.2. Map of Block 1, PHX Sky Train project, showing trenches, stripped areas, and feature locations.

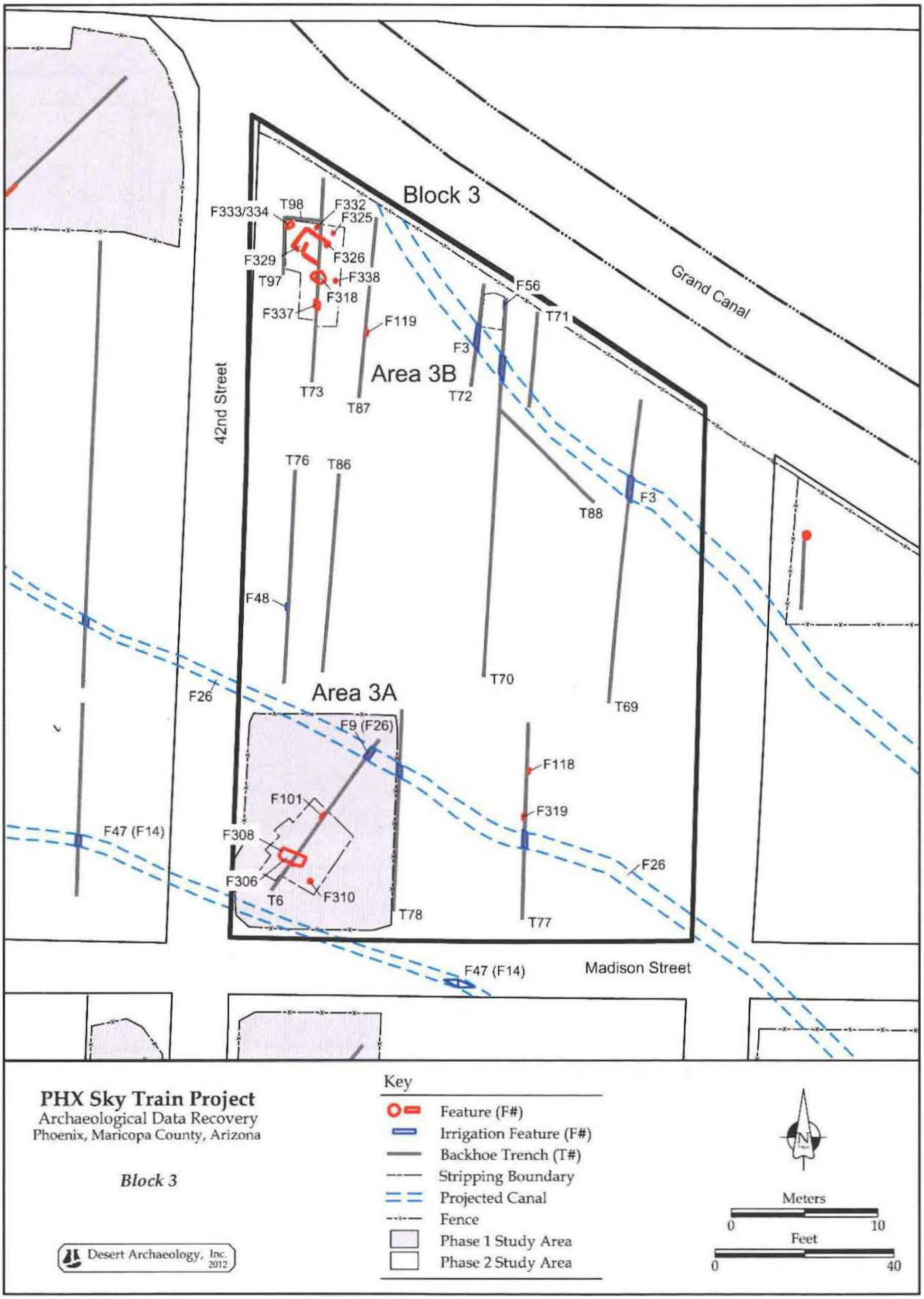

Figure 2.3. Map of Block 3, PHX Sky Train project, showing trenches, stripped areas, and feature locations.

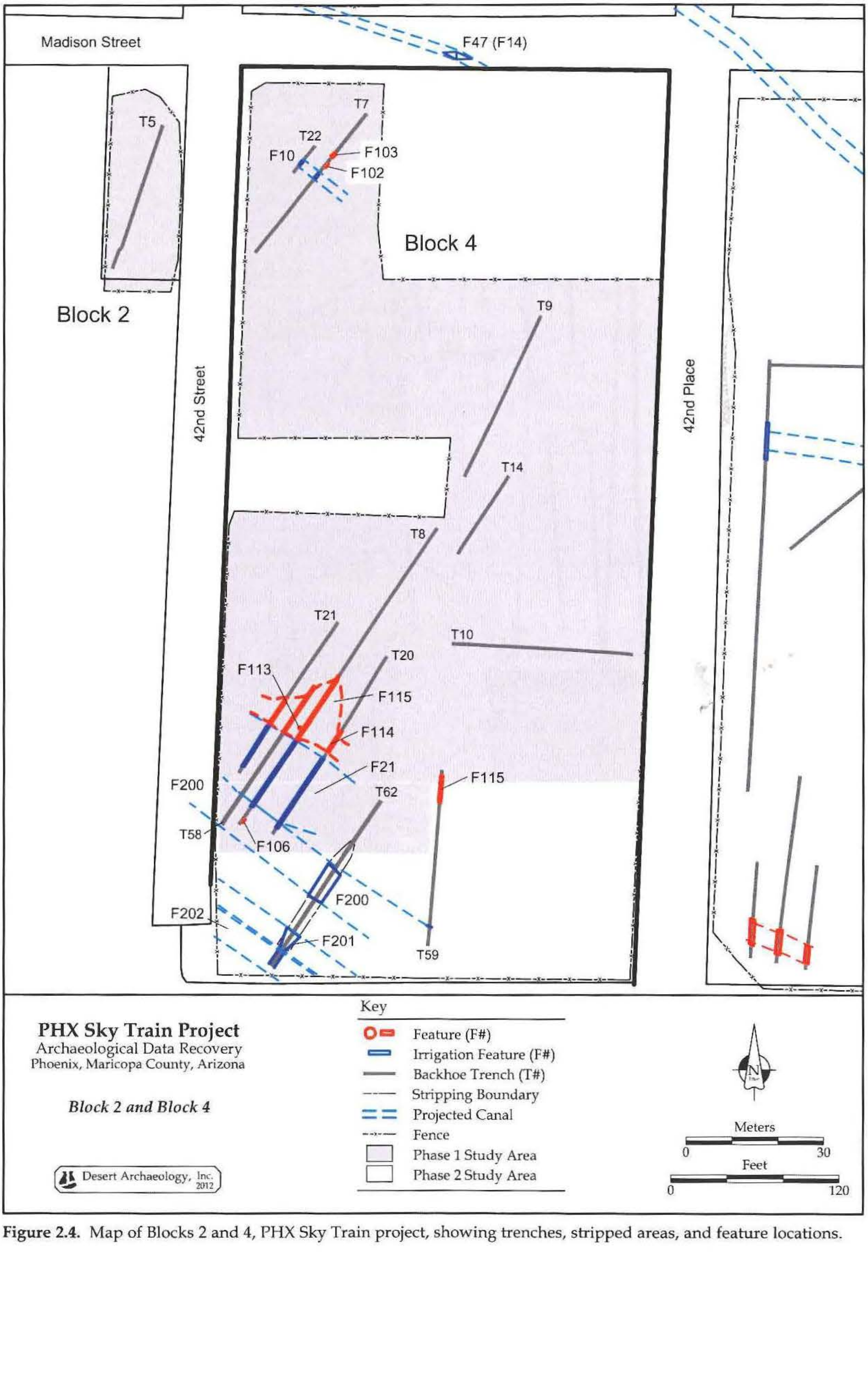

Figure 2.4. Map of Blocks 2 and 4, PHX Sky Train project, showing trenches, stripped areas, and feature locations.

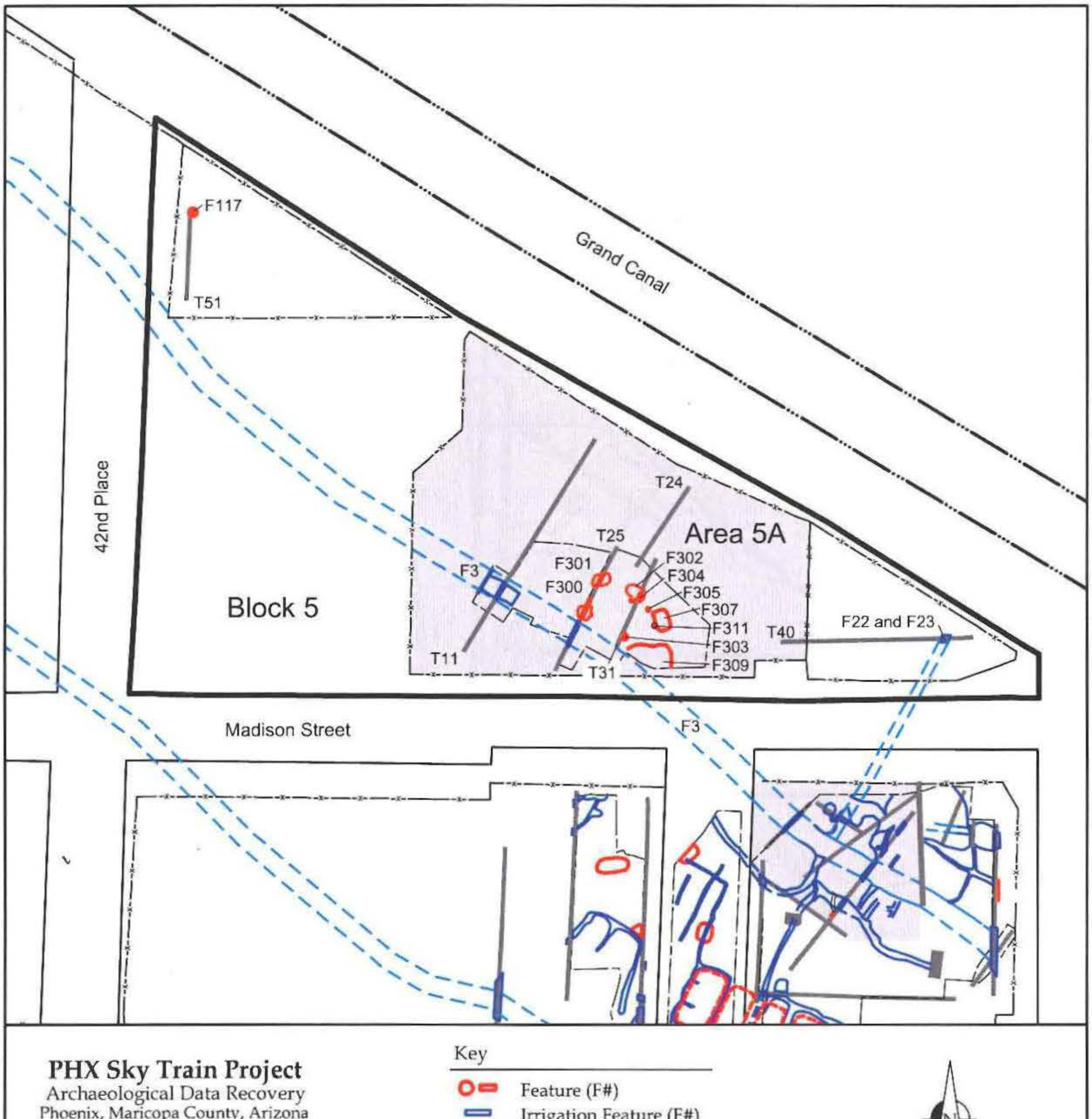

Figure 2.5. Map of Block 5, PHX Sky Train project, showing trenches, stripped areas, and feature locations.

36 percent of the area to be potentially examined (Table 2.1). Phase 1 fieldwork occurred in portions of Blocks 1-5 and 7 (see Figure 2.1). The work was conducted between 16 December 2008 and 5 February 2009, with backfilling of excavations concluding on 13 February 2009. In all, 96 crew person-days were expended in the effort.

The Phase 1 effort included both a testing phase and an intensive data recovery stage. Placement of trenches during the testing stage followed the original work plan (Henderson and Bagwell 2007), with slight adjustments to spacing and trench orientation to allow coverage within the areas available for investigation (see Figure 2.1), except in Block 1. Because

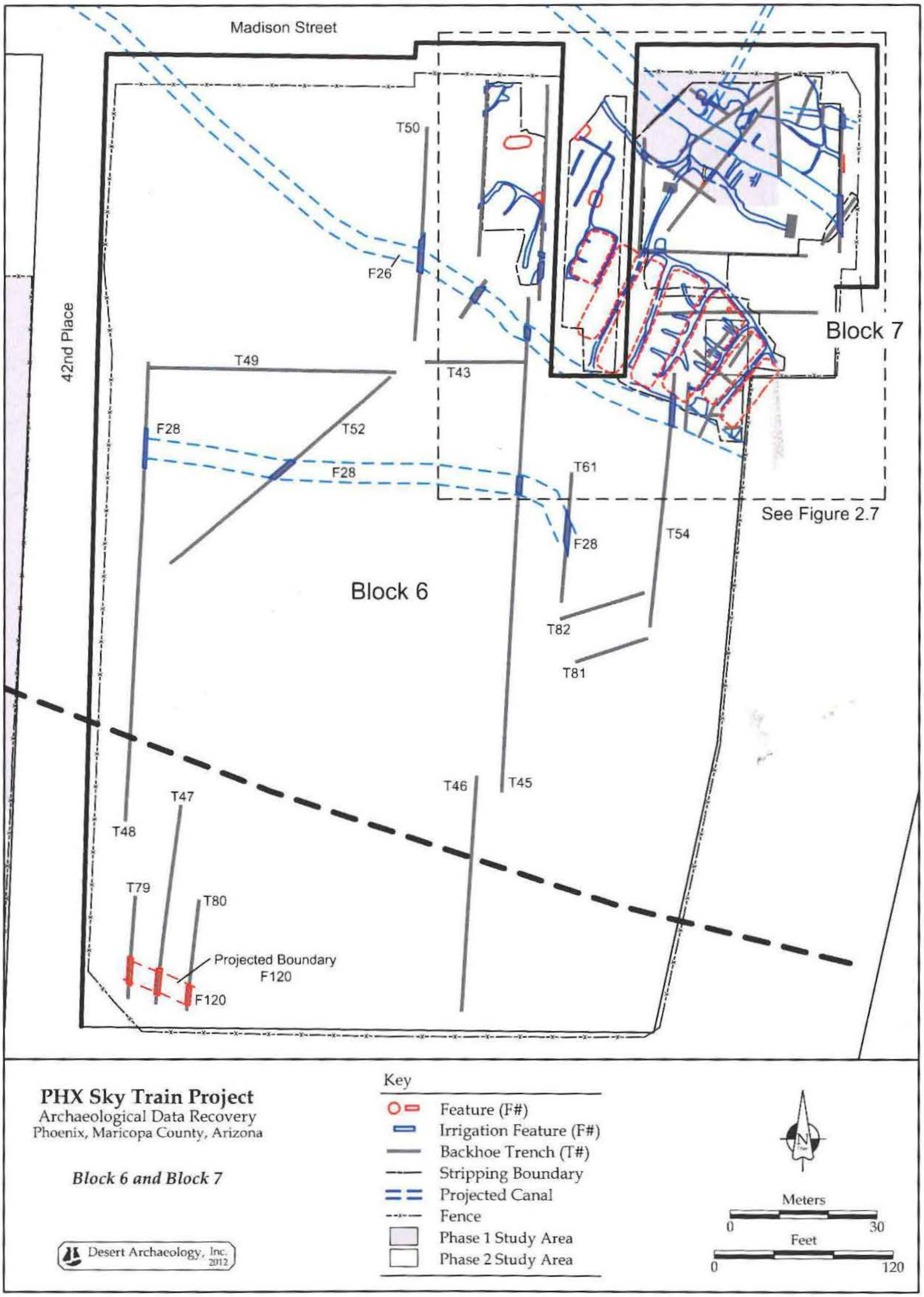

Figure 2.6. Map of Blocks 6 and 7, PHX Sky Train project, showing trenches and feature locations, except as noted.

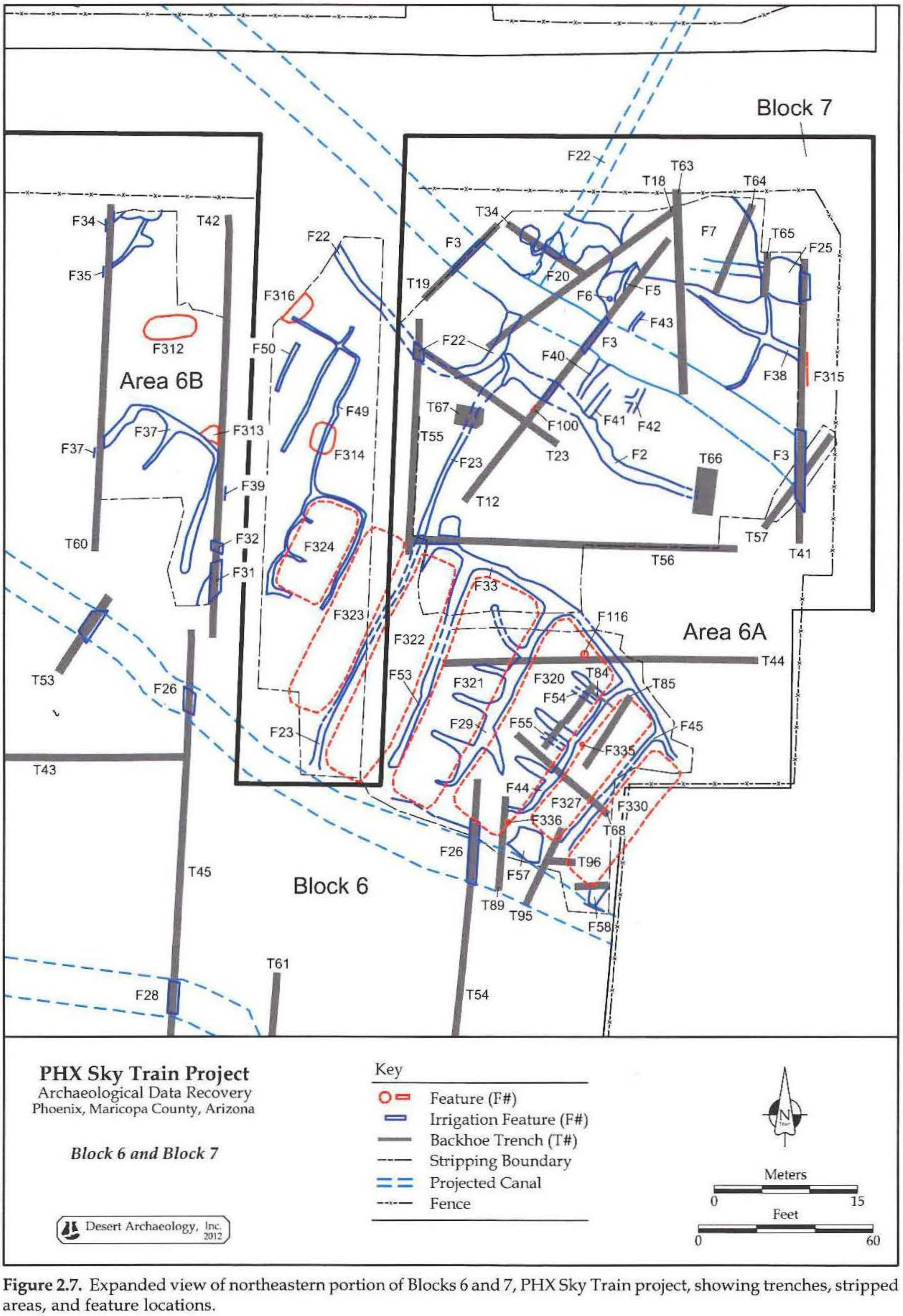

Figure 2.7. Expanded view of northeastern portion of Blocks 6 and 7, PHX Sky Train project, showing trenches, stripped areas, and feature locations.

Table 2.1. Acreage summary for PHX Sky Train Phases 1 and 2.

Block	Block Boundaries	Phase 1 Study Area (acres)	Phase 2 Study Area (acres)	Total Acres
1	Washington Street to Madison Street, 41st Place to 42nd Street	2.45	1.46	3.91
2	Southwest corner of Madison Street and 42nd Street	0.15	–	0.15
3	Grand Canal to Madison Street, 42nd Street to 42nd Place	0.28	2.19	2.47
4	Madison Street to Union Pacific Railroad, 42nd Street to 42nd Place	2.39	1.69	4.08
5	Grand Canal to Madison Street, 42nd Place to State Route 153	0.73	1.03	1.76
6	Madison Street to Union Pacific Railroad, 42nd Place to State Route 153	–	4.58	4.58
7	Inset into northwestern corner of Block 6 between 43rd Street and State Route 153	0.30	0.15	0.45
Total acres		6.30	11.10	17.40
Percent of total		36	64	100

the entire width of Block 1 was not available for investigation, it was determined to be more efficient to test for anticipated canals by excavating a north-south oriented trench near the western edge of the block. This trench served not only to identify any canals crossing the block, but also delineated where encountered canals left the project area. This allowed a better projection of their course beyond the Sky Train project area.

Once canals were encountered in this western north-south trench, similarly oriented trenches were excavated along the eastern edge of the available block. The southwest-northeast orientation was retained in the two northernmost parcels of Block 1, because angled 50-m-wide spaced trenches were appropriate to the breadth of the combined parcels and the expectation that any buried canals would course northwest.

A north-south oriented trench was considered for the small Block 2 parcel at the southwestern corner of Madison and 42nd Street, but a canal running across its northeastern corner would be missed by this trench. Therefore, an angled trench was used to test this parcel. Additionally, two east-west oriented trenches were positioned along the southern end of Block 1 and the southern end of the then-available eastern portion of Block 4 (see Figure 2.1). These trenches were placed to intercept canal alignments oriented in a more north-south direction, a possibility suggested by examination of the Central Phoenix Basin Archaeology Map (Howard and Huckleberry 1991).

Phase 1 fieldwork moved rapidly to data recovery with the excavation of additional trenches in Blocks 1, 4, 5, and 7. In addition to detailed profiling and sample collections of canals, data recovery efforts focused on four areas: (1) the canal Feature 17/Feature 18 junction in Block 1 (see Figure 2.2); (2) the area surrounding pithouse Feature 306 in Block 3 (see Figure 2.3); (3) the area containing several pithouses and canal Feature 3 in Block 5 (see Figure 2.5); and, (4) the available portion of Block 7, where it appeared that natural channel sediments had ponded against the large canal, Feature 3 (see Figures 2.6-2.7).

A very large canal, Feature 200, which was barely intercepted in two trenches at the southwestern corner of then-available Block 4 was not investigated at this time (see Figure 2.4). Historic aerial photographs indicated Feature 200 was the same as the "North Canal," originally investigated by Woodbury (1960; see also Masse 1976) in Park of Four Waters south of Pueblo Grande. Because there was insufficient space to expose this canal in its entirety, it was agreed, in consultation with the City Archaeologist, that study of Feature 200 would be deferred until Phase 2 investigations.

By the conclusion of Phase 1 fieldwork, 34 backhoe trenches totaling 955 m had been excavated, and areas totaling roughly 1,008 m^2 were horizontally stripped. The combined trench sampling fraction of the available area was 2.7 percent, which met the goal of a 2-3 percent sampling fraction established in the Phase 1 work plan (Henderson 2008). In total, 43 archaeological features were identified in trench walls or through mechanical stripping, including 10 prehistoric canals with 7 irrigation-related features, 12 prehistoric non-canal features, and 14 late historic/early modern features (Table 2.2). A preliminary (end of fieldwork) report prepared for the City following the Phase 1 fieldwork recommended that PHX Sky Train construction could advance in all Phase 1 parcels except those at the southern end of Block 4 (Bagwell and Henderson 2009).

Table 2.2. Archaeological features and data recovery effort, PHX Sky Train project. (Features identified during Phase 1 are italicized; all others were identified during Phase 2.)

Site Number/ Feature Number	Feature Type	Location	Data Recovery Effort/Comment
AZ U:9:28 (ASM)			
1	*Voided*	*Block 7, Trench 12*	*Reassigned as Feature 100, AZ T:12:258 (ASM)*
2	*Ditch*	*Block 7, Trench 12, 66*	*Detailed profile, portion of plan view defined*
3	*Canal*	*Block 3, Trenches 69, 70, 71, 72; Block 7, Trenches 12, 19, 41, 57, 63*	*Detailed profiles, alignment traced, portion of plan view defined, sediments sampled*
4	*Voided*	*Block 7, Trench 12*	*Natural channel*
5	*Ditch*	*Block 7, Trench 12*	*Detailed profile, portion of plan view defined*
6	*Pit*	*Block 7, Trench 12*	*Profiled, plan view defined*
7	*Water catchment*	*Block 7, Trench 12, 18, 63, 64, 65*	*Detailed profiles, portion of plan view defined, sediments sampled*
8	*Voided*	*Block 7, Trench 12*	*Recognized during stripping as part of Feature 7*
9	*Canal (same as Feature 26)*	*Block 3, Trench 6*	*Detailed profile*
10	*Canal*	*Block 4, Trenches 7, 22*	*Detailed profile*
11	*Voided*	*Block 4, Trench 8*	*Reassigned as Feature 200, AZ U:9:2 (ASM)*
12	*Voided*	*Block 4, Trench 21*	*Profiled; reexamined during Phase 2 and recognized as part of Feature 115, AZ T:12:258 (ASM)*
13	*Voided*	*Block 4, Trench 21*	*Profiled; during Phase 2 recognized as lens of organic/oxide precipitates at base of Feature 115, AZ T:12:258 (ASM)*
14	*Canal*	*Block 1, Trenches 13, 17, 27, 28*	*Detailed profiles, alignment traced, portion of plan view defined, sediments sampled*
15	*Voided*	*Block 1, Trench 13*	*Determined to be part of canal Feature 14*
16	*Ditch*	*Block 1, Trench 13*	*Detailed profile*
17	*Canal (branch and same alignment as Feature 26)*	*Block 1, Trenches 13, 15, 29, 32, 33*	*Detailed profiles, alignment traced, portion of plan view defined, sediments sampled*
18	*Canal (branch and same alignment as Feature 26)*	*Block 1, Trenches 13, 15, 26, 29, 32, 33*	*Detailed profiles, alignment traced, portion of plan view defined, sediments sampled*
19	*Voided*	*Block 7, Trench 19*	*Same as canal Feature 3*
20	*Water catchment*	*Block 7, Trenches 12, 18*	*Detailed profile, portion of plan view defined*
21	*Ponded sediments*	*Block 4, Trenches 8, 20, 21*	*Profiled*
22	*Canal*	*Block 5, Trench 40; Block 7, Trench 55*	*Detailed profile, alignment traced, portion of plan view defined, sediments sampled*
23	*Canal*	*Block 5, Trench 40; Block 7, Trenches 56, 67*	*Detailed profile, alignment traced, portion of plan view defined, sediments sampled*
24	*Voided*	*Block 7, Trench 23*	*Same as canal Feature 22*
25	Canal	Block 7, Trenches 41, 65	Detailed profile, alignment traced, portion of plan view defined, sediments sampled; canal cut by Feature 7
26	Canal (same as Features 9 and 17/18)	Block 1, Trench 74; Block 3, Trenches 77, 78; Block 6, Trenches 45, 50, 53, 54, 89, 95	Detailed profile, alignment traced, portion of plan view defined, sediments sampled
27	Voided	Block 6, Trench 47	Same as Feature 120, AZ T:12:258 (ASM)
28	Modified natural channel	Block 6, Trenches 45, 48, 52, 61	Highly variable in size and visibility; profiled, alignment traced, artifacts collected
29	Ditch	Block 6, Trench 44	Secondary field lateral; detailed profile, alignment traced, portion of plan view defined, sediments sampled
30	Voided	Block 6, Trench 44	Recognized during stripping as an arm of Feature 29, reassigned as Feature 29.02

Table 2.2. Continued.

Site Number/ Feature Number	Feature Type	Location	Data Recovery Effort/Comment
31	Ditch	Block 6, Trench 42	Probable field lateral; profiled, portion of plan view defined
32	Ditch	Block 6, Trench 42	Probable field sublateral; profiled, portion of plan view defined
33	Ditch	Block 6, Trench 44, 56	Primary field lateral; detailed profile, plan view defined, portion excavated, sediments sampled
34	Ditch	Block 6, Trench 60	Probable field sublateral; profiled, portion of plan view defined
35	Ditch	Block 6, Trench 60	Probable field sublateral; profiled, portion of plan view defined
36	Voided	Block 6, Trench 60	Same as ditch Feature 37
37	Ditch	Block 6, Trenches 42, 60	Series of field sublaterals; profiled, portion of plan view defined
38	Ditch	Block 7, Trench 41	Profiled, portion of plan view defined, sample excavation
39	Ditch	Block 6, Trench 42	Probable field sublateral; profiled
40	Ditch	Block 7, south of Feature 3	Trace remnant of probable field sublateral; portion of plan view defined
41	Ditch	Block 7, south of Feature 3	Trace remnant of probable field sublateral; portion of plan view defined
42	Ditch	Block 7, south of Feature 3	Trace remnant of probable field sublateral; portion of plan view defined
43	Ditch	Block 7, north of Feature 3	Trace remnant of probable field sublateral; portion of plan view defined
44	Ditch	Block 6, south of Feature 33; Trenches 68, 83, 84, 89, 90	Detailed profiles, alignment traced, portion of plan view defined, sediments sampled
45	Ditch	Block 6, south of Feature 33; Trench 68	Detailed profile, alignment traced, portion of plan view defined, sediments sampled
46	Voided	Block 6, Trench 3	Reassigned as pit Feature 337, AZ U:9:1 (ASM)
47	Canal (same as Feature 14)	Block 1, Trench 75; Qwest utility trench in Madison Street	Detailed profile, alignment traced
48	Ditch	Block 3, Trench 76	Isolate; profiled
49	Ditch	Block 6, under 43rd Street	Trace remnants of a series of field sublaterals; portion of plan view defined
50	Ditch	Block 6, under 43rd Street	Trace remnant of probable field sublateral; portion of plan view defined
51	Voided	Block 6, under 43rd Street	Same as ditch Feature 54
52	Voided	Block 6, under 43rd Street	Same as ditch Feature 55
53	Ditch	Block 6, east of Feature 23	Alignment traced, portion of plan view defined, sediments sampled
54	Ditch	Block 6, above Feature 44.01	Trace remnant of probable field sublateral; detailed profile, sediments sampled
55	Ditch	Block 6, above Feature 44.02	Trace remnant of probable field sublateral; detailed profile, sediments sampled
56	Ditch	Block 3, Trench 70	Fragment of isolate; detailed profile, sample excavation
57	Water catchment	Block 6, north side of Feature 26 between trenches 89 and 95	Enigmatic interaction between canal Feature 26 and the field system to the north; plan view defined, detailed profiles, sample excavation, sediments sampled

Table 2.2. Continued.

Site Number/ Feature Number	Feature Type	Location	Data Recovery Effort/Comment
58	Ditch	Block 6, east of Feature 45	Probable field sublateral; alignment traced, portion of plan view defined, sediments sampled
320[a]	Field	Block 6, west side of Feature 44	Detailed profile, portion of plan view defined, sediments sampled
321[a]	Field	Block 6, west side of Feature 29	Plan view defined, sediments sampled
322[a]	Field	Block 6, west side of Feature 53	Impacted by modern disturbances; plan view defined
323[a]	Field	Block 6, west side of Feature 23	Impacted by modern disturbances; plan view defined
324[a]	Field	Block 6, east side of Feature 49	Impacted by modern disturbances; plan view defined
327[a]	Field	Block 6, west side of Feature 45	Impacted by modern disturbances; plan view defined
330[a]	Field	Block 6, west side of Feature 58	Impacted by modern disturbances; portion of plan view defined
AZ U:9:2 (ASM)			
200	*Canal*	*Block 4, Trenches 8, 58, 59, 62*	*Woodbury's North Canal; detailed profile, alignment traced, sediments sampled*
201	Canal	Block 4, Trench 62	Detailed profile, sediments sampled
202	Canal	Block 4, Trench 62	Small portion of northern bank identified, possibly Hagenstad Canal; detailed profile
AZ U:9:1 (ASM)			
300	*Pithouse*	*Block 5, Area 5A, Trench 25*	*Sample excavation with plan shape defined, one 1-m by 2-m control unit to floor*
301	*Pithouse*	*Block 5, Area 5A, Trench 25*	*Sample excavation with plan shape defined, one 1-m by 2-m control unit to floor*
302	*Pithouse*	*Block 5, Area 5A, Trench 31*	*Sample excavation with plan shape defined, one 1-m by 2-m control unit to floor*
303	*Pit*	*Block 5, Area 5A, Trench 31*	*Sampled (east half excavated)*
304	*Pit*	*Block 5, Area 5A, Trench 31*	*Sampled (east half excavated)*
305	*Pit*	*Block 5, Area 5A, stripped area*	*Complete excavation*
306	*Pithouse*	*Block 3, Area 3A, Trench 6*	*Sample excavation with plan shape defined, one 1-m by 2-m control unit to floor*
307	*Pithouse*	*Block 5, Area 5A, stripped area*	*Sample excavation with plan shape defined, one 1-m by 2-m control unit to floor*
308	*Pit*	*Block 3, Area 3A, stripped area*	*Complete excavation*
309	*Trash concentration*	*Block 5, Area 5A, stripped area*	*Sampled using 1-m by 2-m control unit*
310	*Pit with trivets*	*Block 3, Area 3A, stripped area*	*Complete excavation*
311	*Pit*	*Block 5, Area 5A, stripped area*	*Complete excavation*
312	Pithouse	Block 6, Area 6B, north of Feature 37	Sample excavation with plan shape defined, one 1-m by 2-m control unit to floor
313	Pithouse	Block 6, Area 6B, Trench 42	Sample excavation with plan shape defined
314	Pithouse	Block 6, Area 6B, under 43rd Street	Sample excavation with plan shape defined, one 1-m by 2-m control unit to floor
315	Possible pithouse	Block 7, Area 6B, Trench 41	Poorly preserved; detailed profile, artifacts collected from profile
316	Pithouse	Block 6, Area 6B, under 43rd Street	Sample excavation with portion of plan shape defined, one 1-m by 2-m control unit to floor
317	Voided	Block 3, Trench 70	Reassigned upon excavation as Feature 56, AZ U:9:28 (ASM)

Table 2.2. Continued.

Site Number/ Feature Number	Feature Type	Location	Data Recovery Effort/Comment
318	Pithouse	Block 3, Area 3B, Trench 73	Sample excavation with plan shape defined, one 1-m by 2-m control unit to floor
319	Possible pithouse	Block 3, Trench 77	Poorly preserved; detailed profile
325	Pit	Block 3, Area 3B, stripped area	Complete excavation
326	Pit	Block 3, Area 3B, stripped area	Complete excavation
328	Voided	Block 6, east of Trench 89	Natural sediments
329	Adobe structure	Block 3, Area 3B, stripped area	Sample excavation with plan shape defined, one 1-m by 2-m control unit to floor
331	Voided	Block 6, Trench 89	Natural sediments
332	Pit	Block 3, Area 3B, stripped area	Intrudes on Feature 329; sampled (south half excavated)
333	Pit	Block 3, Area 3B, stripped area	Complete excavation
334	Pit	Block 3, Area 3B, stripped area	Complete excavation
335	Pit	Block 6, west of Trench 85	Sample excavation
336	Pit	Block 6, Trench 89	Sample excavation
337	Pit	Block 3, Area 3B, stripped area	Detailed profile, portion of plan view defined, artifacts collected
338	Artifact concentration	Block 3, Area 3B, stripped area	RV 2009-1 with small number of additional sherds identified during stripping; artifacts collected
AZ T:12:258 (ASM)			
100	*Pit*	*Block 7, Trench 12*	*Not sampled*
101	*Pit*	*Block 3, Trench 6*	*Not sampled*
102	*Privy*	*Block 4, Trench 7*	*Not sampled*
103	*Cesspool*	*Block 4, Trench 7*	*Not sampled*
104	*Voided*	*Block 1, Trench 4*	*Modern disturbance*
105	*Septic tank*	*Block 1, Trench 4*	*Not sampled*
106	*Pit*	*Block 4, Trench 8*	*Not sampled*
107	*Privy*	*Block 1, Trench 13*	*Not sampled*
108	*Privy*	*Block 1, Trench 13*	*Not sampled*
109	*Pit*	*Block 1, Trench 13*	*Not sampled*
110	*Surface/floor*	*Block 1, Trench 3*	*Not sampled*
111	*Voided*	*Block 7, Trench 23*	*Modern disturbance*
112	*Pit*	*Block 1, Trench 15*	*Not sampled*
113	*Pit*	*Block 4, Trench 8*	*Not sampled*
114	*Septic tank*	*Block 4, Trench 20*	*Not sampled*
115	Pond (cattle wallow)	Block 4, Trenches 58, 59	Not sampled; originally identified as Feature 12, AZ U:9:28 (ASM)
116	Trash-filled pit	Block 6, Trench 44	Not sampled
117	Cesspool	Block 5, Trench 51	Not sampled
118	Trash-filled pit	Block 3, Trench 77	Not sampled
119	Trash-filled pit	Block 3, Trench 87	Not sampled
120	Pond	Block 6, Trench 47, 79, 80	Similar to Feature 115; not sampled

[a]Originally assigned to AZ U:9:1 (ASM), but later reassigned to AZ U:9:28 (ASM), because the field area is clearly a component of the larger irrigated field system.

Phase 2

The Phase 2 study area was comprised of 75 parcels, with a combined area of 11.1 acres, or approximately 58 percent of the PHX Sky Train 44th Street Station area (see Table 2.1). The Phase 2 effort occurred in portions of all blocks, except Block 2, where archaeological work was completed during Phase 1 investigations (see Figures 2.1 and 2.4). Phase 2 fieldwork began on 17 August 2009, and was completed on 23 October 2009, with final backfilling of excavations concluded on 26 October 2009. In all, 122 field crew person-days were expended in the effort.

Because the City had not acquired or cleared all Phase 2 parcels when fieldwork began, testing and intensive data recovery efforts overlapped throughout the duration of Phase 2. Most of the parcels in Blocks 1 and 3 were not available for testing until mid- to late September 2009. A few parcels were never available for archaeological fieldwork, due to either the presence of environmentally hazardous soils that required remediation (see Block 5 and west-central Block 4 parcel in Figure 2.1) or the intransigence of a single property owner that affected demolition clearing of adjacent parcels (see northeastern Block 4 and northwestern Block 6 in Figure 2.1).

After testing of initially available parcels began, early data recovery efforts focused on parcels located in the city-defined "Priority 1 Area," bounded roughly by 42nd Place, the rights-of-way for the Grand Canal and 44th Street, and a line running east-west near the southern end of 43rd Street. Priority 1 was so designated due to the need for archaeology to be completed in this area by mid- to late September, so installation of relocated Qwest communication lines could begin by 28 September 2009. After consultation with the City Archaeologist, intensive data recovery was initiated primarily in the form of broad horizontal exposures in the eastern portion of the Priority 1 Area, where an abundance of small canals and even smaller shallow ditches had been encountered in trench cuts. The first of these horizontal exposures, located at the southeastern end of the Priority 1 Area, revealed an unexpected find, the first prehistoric irrigated field system to be exposed, in plan, in the Salt River Valley (Figure 2.8). The system included a distribution canal, Feature 23, primary field lateral, Feature 33, secondary field lateral, Feature 29, and tertiary lateral fingers (see Figure 2.7). The areas between lateral fingers define field cells.

Given this unique find, subsequent efforts focused on exposing as much of these systems as possible within the Priority 1 Area. This work included removal of the pavement of 43rd Street to allow horizontal exposures of the subsurface context below the road. As shown in Figures 2.6 and 2.7, field laterals (ditches) were defined across the focus area, although not all of these were as well preserved as the initially identified field areas. Three pithouses were encountered in the stripping effort, with a fourth recognized late in the Priority 1 Area effort. A deep, benched cut was also excavated to expose

Figure 2.8. Remains of an irrigated field exposed during Priority 1 Area excavations, PHX Sky Train project; view to the southeast from a boom lift.

the entire face of Feature 3 (Figure 2.9), a large main canal that extended northwest across the project area (see Figure 2.1).

Although effort was concentrated in the Priority 1 Area, a deep, benched cut was also excavated across earlier identified canal Feature 200 (Woodbury's North Canal) in the newly available parcels in the southwestern portion of Block 4 (see Figure 2.4). Two additional canals were exposed in this cut, Feature 201 and 202, which are inferred to correlate with site U:9:2 canals 10 and 7, respectively, of the 1970s Hohokam Expressway project (Masse 1976) to the east (see Figure 1.5).

Figure 2.9. Main canal Feature 3 in Trench 57, view to the southeast.

Overall, approximately 460 m of trench were excavated in the Priority 1 Area, and areas totaling roughly 1,676 m² in size were stripped. This effort resulted in the identification of 22 prehistoric features, including 6 distribution canals, 10 field laterals, 1 water catchment feature, 4 pithouses, and 1 possible pithouse. The Priority 1 Area fieldwork was completed on 25 September 2009. An interim preliminary report recommending that construction could proceed in this area was submitted to the City on 28 September 2009 (Henderson 2009a).

Once the Priority 1 Area was cleared, data recovery efforts began in the remaining available Phase 2 parcels. Those efforts included detailed documentation of the large canals encountered in the southwestern corner of Block 4 and additional detailed study of the prehistoric field system south of the Priority 1 Area, that is, south of Block 7. Importantly, the modern disturbed zone was more shallow south of Block 7, which resulted in preserved field surfaces. These fields, as well as accompanying lateral channels, were intensively sampled via backhoe- and hand-dug trenches and plan view exposures with consequent detailed profiling, plan mapping, and sediment sample collections of the field features.

A noteworthy additional find in the field system area was Feature 57, a roughly 2-m-square "pond" adjacent to canal Feature 26 at the southern end of the field system (see Figure 2.7). Given its odd configuration and juxtaposition to both canal and field, an intensive effort ensued in the final days of Phase 2 to define, document, and sample the feature.

Finally, horizontal stripping and excavations were conducted in the area of a prehistoric adobe structure identified in the northwestern corner of Block 3. The configuration of adobe walls suggested a multiroom unit, with one interior room confirmed via exposure of a hearth. A small pithouse was found nearby, along with several extramural features, all of which were thoroughly investigated.

Overall, 59 backhoe trenches totaling 1,695 m were excavated, and areas totaling roughly 2,782 m² were horizontally stripped during Phase 2. In total, 59 archaeological features were identified in trench profiles or through mechanical stripping, including 4 prehistoric canals with 25 irrigation-related features, 7 fields, 17 prehistoric non-canal features, and 6 late historic/early modern features. A preliminary (end of fieldwork) report recommending that PHX Sky Train construction could advance in all Phase 2 parcels was submitted to the City Archaeologist and Aviation Department on 9 November 2009 (Darby and Henderson 2009).

FIELD RESULTS

In all, 93 backhoe trenches totaling 2,650 linear m and areas covering roughly 3,793 m² were horizontally stripped during the two phases of archaeological fieldwork for the PHX Sky Train project. Most areas of the city blocks comprising the Sky Train project area were sampled in some fashion, except a block of parcels at the northeastern end of Block 4 and the northwestern end of Block 6 (see Figure 2.1). The eventual inaccessibility of these parcels was unfortunate, because it is in this area that two canals identified farther west, Features 10 and 14, must have diverged from a main distribution canal, Feature 26, that extends from the east. However, given the breadth of information recovered during the project, the fact that the relationship of these canals was not established does not diminish this project's considerable results.

A total of 99 archaeological features was documented during the project, with most related to the three prehistoric sites that intersected the project area (see Table 1.2). As anticipated at the beginning of the project, irrigation-related features dominated the feature types, although the variety and number of types within this group was unexpected. Prehistoric habitation features were also found, as were a smattering of late historic/early modern features. An overview of the features follows, with more detailed descriptions provided in subsequent chapters of this volume.

Canals

Twelve prehistoric canals were identified in the project area. These include Features 3, 10, 14, 17, 18, 22, 23, 25, and 26 assigned to U:9:28, and Features 200, 201, and 202 assigned to U:9:2. Several of these canals extend alignments identified during previous archaeological projects east of the current project area (Masse 1976; Woodbury 1960).

Feature 3 was a large canal, 4.4 m wide and 2.1 m deep, that coursed southeast to northwest through Blocks 3, 5, and 7. It is the northernmost of canals found in the project area (see Figures 2.1, 2.3, and 2.5). The canal is the same alignment identified as Canal 2[1] at U:9:28 during the Hohokam Expressway project (Masse 1976) (Figure 2.10). Feature 3 was initially exposed and sampled via a deep trench in Block 5 during Phase 1. Phase 2 investigations were able to trace the alignment across the project area, and an additional deep trench was excavated and sampled at the eastern edge of Block 7. Feature 3 appears to be one of the latest canals in the project area, as it cuts through several other irrigation features in Block 7.

Feature 10 was a small canal, 1.2 m wide and 40 cm deep, identified during Phase 1 in the northwestern corner of Block 4 (see Figure 2.4). The canal trended northwest toward Block 1. The canal was initially thought to be the same alignment as Feature 14. However, Phase 2 investigations demonstrated this was not the case. Because the parcels east of Feature 10 were never available for sampling, the relationship of this canal with other canals located to the north is unknown. However, based on its size and orientation, Feature 10 was probably a small distribution canal, similar to Features 22 and 23 in Blocks 6-7.

Feature 14 was a medium-sized canal, 2.2 m wide and 80 cm deep, originally identified in the western half of Block 1 (see Figure 2.2). The canal was subject to detailed profiling and sampling as part of Phase 1 data recovery. Phase 2 efforts were limited to documenting new exposures in trenches, labeled during this phase as Feature 47. In addition to a trench in the eastern half of Block 1, Feature 14 was also identified in a utility trench excavated by Qwest to relocate communication lines on the southern side of Madison Street (see Figure 2.3). The canal could not be tracked eastward from this point due to the presence of thick concrete slabs that were not removed until after archaeological work had concluded. However, Feature 14 presumably shared a relationship with Feature 26, as no other canal alignments were identified in the numerous trenches excavated south of Feature 26 in Block 6 (see Figure 2.1).

Features 17 and 18 were originally identified as two separate medium-sized canals, 1.8 m wide and 70 cm deep and 1.8 m wide and 90 cm deep, respectively, in Trench 13, Block 1 (see Figure 2.2). Excavation of additional trenches and horizontal stripping revealed that the two canals diverged from a shared alignment, designated Feature 26 during Phase 2. Feature 17 was determined to be the younger alignment, reflecting reconstruction and rerouting of the original Feature 18/26 canal.

Features 22 and 23 were small canals, 1.5 m wide and 60 cm deep and 1.0 m wide and 60 cm deep, respectively, that initially shared the same alignment before diverging along separate courses. Feature 23 could be seen as the stratigraphically earlier channel in Trench 40, Block 5. The shared alignment entered the project area at the easternmost portion of Block 5 and ran northeast to southwest into Block 7 (see Figures 2.6 and 2.7). Near the middle of Block 7, Feature 22 turned abruptly to the west and then northwest, while Feature 23 continued toward the southwest, eventually running to, or possibly into, canal Feature 26. Features 22 and 23 feed an array of smaller organized ditches that irrigated a series of presumed agricultural fields. The primary water source for the two canals is unknown. Features 22 and 23 are likely among the earlier canals in the project area, predated minimally by the later construction of Feature 3, which cut through the shared Feature 22-23 alignment. Sediments from catchment Features 7 and 20 also extended over the two earlier canals.

Feature 25 was a medium-sized canal, 3.1 m wide and 80 cm deep, that entered the project area in the northeastern corner of Block 7, almost immediately widened into a pool, then narrowed again and continued a short distance westward until intruded upon by water catchment Feature 7 (see Figure 2.7). Fea-

[1]In later publications, Masse (1981, 1988) renumbered this canal as Canal 14; the number was not site specific.

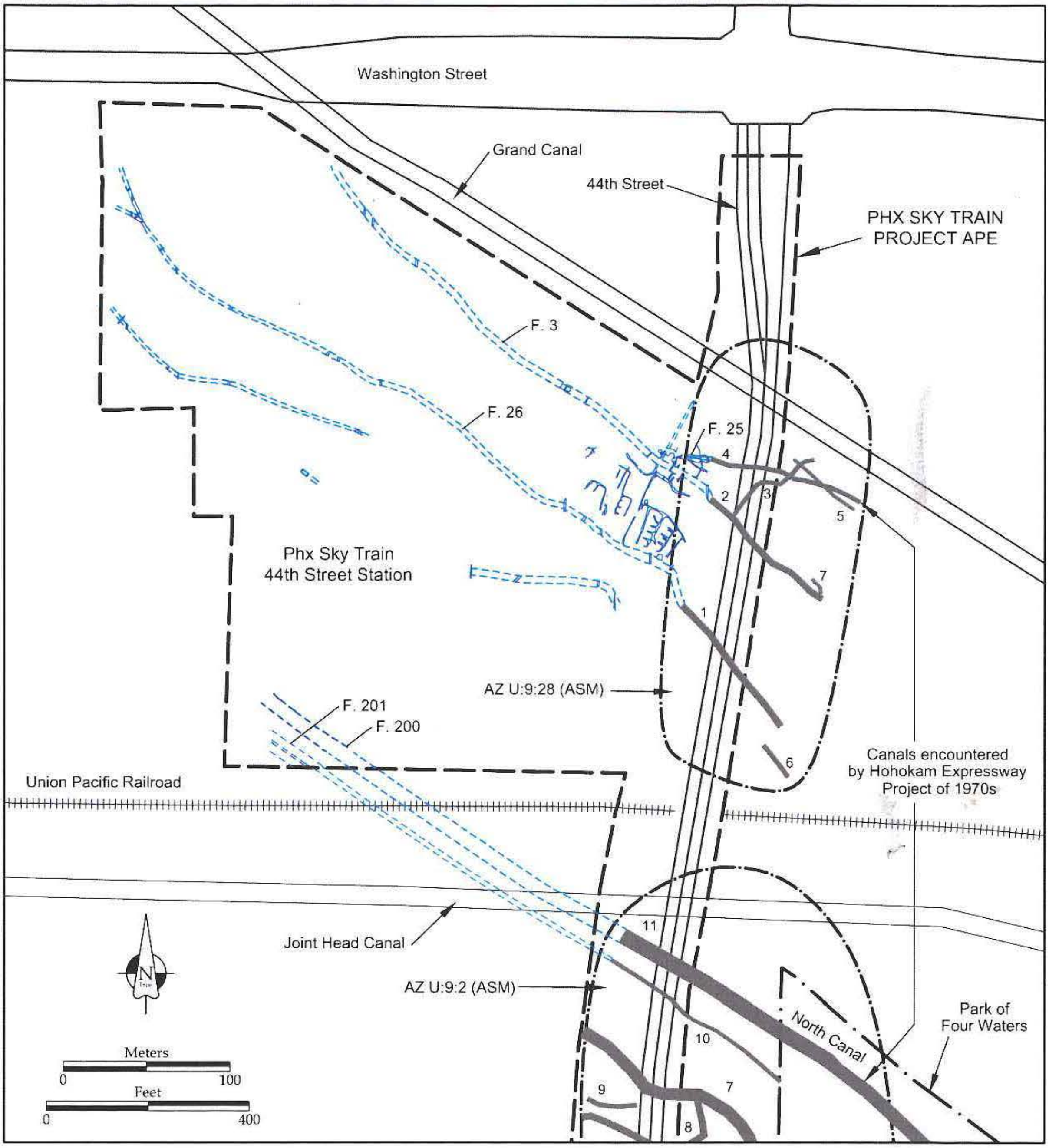

Figure 2.10. Map showing the relationship of current project canals and alignments identified during the 1970 Hohokam Expressway project.

ture 25 was not identified elsewhere in the project area. Feature 3 may have reused a portion of the Feature 25 alignment, obscuring or removing the earlier canal with its larger scale. Alternately, Feature 25 may have been used to feed the water catchment area defined by Feature 7 and other proximate features. Feature 25 is evidently the same as Canal 4 of U:9:28, Hohokam Expressway project (see Figure 2.10).

Feature 26 was a medium-sized canal, 3.0 m wide and 90 cm deep, that traversed the entire project area south of canal Feature 3. Correlating with Hohokam Expressway project Canal 1 of U:9:28 (see Figure 2.10), Feature 26 entered the project area south of the irrigated field systems in Block 6 (see Figure 2.6), then ran northwest through Blocks 3 and 1. Near the western edge of Block 1, earlier (Feature 18) and later channels (Feature 17) of Feature 26 branch apart (see Figure 2.2). The alignment diminishes in size across the span of the project area, with its width reduced to 2.1 m and its depth to 60 cm in Block 1. That its size diminishes across the span of the project area suggests Feature 26 may also have fed canal Feature

14 during the same time interval. Contemporary use of the southernmost field systems and Feature 26 is also suspected, given that the field system laterals terminate along the northern side of the canal.

Feature 200 was a very large canal identified during Phase 1 at the southern ends of Trenches 8 and 20 in Block 4 (see Figure 2.4). As mentioned, Feature 200 is an additional alignment of the North Canal originally investigated by Woodbury (1960) south of Pueblo Grande. Previous excavations determined this canal measured 9.5 m in width and extended to a depth of 3.0 m below the modern ground surface (Masse 1976). The current exposure was 7.2 m wide, but still extended to 3.0 m below the modern ground surface. Only the northernmost edge of this canal was exposed during Phase 1 excavations, due to the unavailability of parcels to the south, a situation remedied during Phase 2.

Regular 5-ft-deep trenches were excavated to pinpoint the orientation of the canal alignment prior to excavating a long, deep trench that intersected the canal at a perpendicular angle. This exposure revealed Feature 200 as a deep, broad canal containing relatively uniform, fine sandy deposits. Although active use sediments were distinguished in the lower one-third of the channel, the upper two-thirds had been filled by a single, massive flood episode. The canal was not cleaned out after this filling, indicating the flood event terminated use of the canal.

Excavation was designed to expose Feature 200 well beyond the limits of the canal to investigate the nature of sediments on either side of the canal. During this effort, two additional large canals, Features 201 and 202, were exposed south of Feature 200.

Feature 201 was a large clay-filled canal, 4.3 m wide and 1.4 m deep, located roughly 8 m south of Feature 200 (see Figure 2.4). Reference to Hohokam Expressway project findings suggests Feature 201 is the same as previously recorded Canal 10 at U:9:2 (see Figure 2.10). Because Feature 201 was identified in only one trench close to the southern project boundary, its trajectory can only be assumed to be similar to that of the other large canals in the vicinity, southeast to northwest. Phase 2 recovery efforts included detailed profiling and sampling.

Like Feature 200 during Phase 1, only the upper edge of the northern bank of Feature 202 was exposed south of Feature 201; most of Feature 202 extends south and outside the project area. The northern bank of Feature 202 merged with berm and clean-out deposits on the southern side of Feature 201, suggesting Feature 202 predates Feature 201. Again, reference to the Hohokam Expressway project findings suggests Feature 202 is the same as the earlier project's Canal 7 at U:9:2 (see Figure 2.10), also named the Hagenstad Canal (Masse 1976).

Like Feature 200-Woodbury's North Canal, the Hagenstadt Canal was very large, up to 10 m wide and 3 m deep. Masse (1976) distinguished at least three major construction episodes in its cross section. Hohokam Expressway project evidence indicated construction and use during the pre-Classic. Because Feature 202 was intercepted at the extreme southwestern edge of the project area, and based on its reported large size, additional trenching to pursue the canal was impractical given logistical limitations. The only place large enough to allow the deep-stepped trench that would be necessary to provide an exposure of this canal would have been inside paved 42nd Street or the parcel to the west. A profile was drawn of the exposed portion of Feature 202.

Ditches

Twenty-six irrigation features in the project area were identified as ditches. These include individual ditches, a series of organized ditches, and isolated ditch fragments. All were assigned to U:9:28, and all could be recognized as field laterals or sublaterals, based on their size and associations.

Block 7 and the northeastern corner of Block 6 contained most of the identified ditches, many of which were parts of organized field irrigation systems (see Figure 2.7). Canal Features 22 and 23 were, or appeared to be, the primary laterals that fed the fields defined by the ditch sublaterals. Feature 22 likely fed branching ditches Feature 49 and Feature 50 (see Figure 2.7). These features, which were located under 43rd Street, had been significantly truncated by road construction. Feature 23 fed field lateral Feature 33, which, in turn, supplied water to Features 53, 29, 44, 45, and 58 (west to east) before exiting the project area (see Figure 2.7). Many of these ditches exhibited subextensions that formed a comb-like pattern, presumably to better irrigate the intervening field space.

Additional ditch fragments were identified northwest of this well-defined field system, but because the 43rd Street curbs and other obstacles could not be removed, the course of most of these features could not be pursued, nor could their connection be established with a recognizable system (although some fragments appear to fit the general pattern; for example, Feature 37 and the southern portion of Feature 49 in Figure 2.7). Isolated ditch fragments presumably reflect additional field systems. For example, Features 40, 41, and 42 were roughly parallel ditch fragments of nearly identical character in Block 7; unfortunately, their fragmentary condition made it impossible to determine their relationships with nearby features. Ditches were profiled and/or traced in plan, when possible; ditches composing the well-defined field systems were intensively profiled and sampled.

Fields

Seven fields could be distinguished in the patterned distribution of sets of sublateral ditches. These include the spaces roughly bounded by ditch Features 49, 53, 29, 44, 45, and 58 (from west to east; see Figure 2.7). Other fragmentary ditches indicate additional fields were in this vicinity; unfortunately, the fragments were insufficiently preserved to allow definition of the associated field area.

The upper limits of preserved field surfaces in Blocks 6 and 7 were very close (centimeters if not millimeters) to the zone of modern disturbance. In most places, modern land leveling had removed the actual field surface. Recognizing this problem, mechanical stripping of modern overburden was stopped as close to, but still above, this delicate interface, when possible, in the area of ditch Feature 44. Hand-trenches were then used—through careful examination of exposed walls—to define and allow fragments of preserved field surfaces to be located and sampled. Detailed profiles were drawn at all points where the field surfaces could be recognized; locations of collected samples were included on these profiles. More general soils-sediments were sampled from areas where the actual field surface could not be identified.

Water Catchments

Three features were encountered that contained thick bedded sediments indicating the capture and retention of water over some period of time. For lack of a better term at the conclusion of fieldwork, the features were identified simply as catchments. They include Features 7, 20, and 57 at U:9:28.

Originally identified during Phase 1, Features 7 and 20 consisted of thick, 1.1-m-deep, alternating beds of clay, silt, and sand that dominated the then-available portion of Block 7 north of canal Feature 3. The features were deduced to be deposits of natural channel sediments that had ponded against the artificial barrier created by construction of Feature 3. The profile in Trench 18 further showed that Feature 7 represented earlier episodes of ponding, while Feature 20 was a distinct later episode. Additional portions of Feature 7 were exposed in plan and profile during Phase 2. Trench 63 excavated during Phase 2 revealed not only that water was once directed into Feature 7 via canal Feature 25, but also that cleaning episodes had occurred, in addition to modification of the catchment area banks. While petrographic analyses (Chapter 4, this volume) confirmed that Feature 7 was filled at least in part through natural processes, it was evident that prehistoric inhabitants were also manipulating its capacity to receive and hold water.

Feature 57 was uncovered during stripping to expose irrigated fields in Block 6 south of Block 7. The feature extended north from the edge of canal Feature 26 to near the end of ditch Feature 44 in Block 6 (see Figure 2.7). Subsequent excavation revealed Feature 57 was a channel-like construction, roughly rectangular in plan and fan-shaped in cross section, that led into Feature 26. Thin, alternating beds of silt and clay completely filled the feature. Some of these sediments could have derived from the canal, although others seemed to be related to the adjacent field area. Given its unusual shape and attributes, multiple cross sections were drawn to illustrate the morphology of Feature 57, and its sediments were heavily sampled.

Modified Natural Channel

One modified natural channel, Feature 28, was identified during Phase 2 in Block 6. The linear feature was tentatively identified in four trenches south of canal Feature 26 (see Figure 2.6). While very generally similar in overall shape and relative location, with each cross section containing a single characteristic stratum (basal coarse sand and gravel containing a notable quantity of small ceramic sherds), the encountered profiles were also widely dissimilar in relative depth and size. Given the dissimilarities, the project geomorphologist suggested Feature 28 was merely a natural wash or a series of depressions that contained artifact-rich sheetwash from occupation areas to the northeast. Alternately, the feature may have been a modified natural channel (for water capture?), with some areas more modified than others. The relatively concentrated number of sherds associated with each profile further suggested some trash disposal occurred in or near the feature. Feature 28 was profiled, and sherds large enough to be identified were collected from the feature.

Ponded Sediments

Feature 21 was assigned to layers of clay-rich sediments (Figure 2.11) that extended 20 m or more northward from the northern edge of canal Feature 200 in Block 4 (see Figure 2.4). The sediments are the result of wash from natural channels that ponded against the artificial barrier created by construction of Feature 200. Given the capacity of these soils to

Figure 2.11. Photograph showing layered clayey sediments on the upslope side of canal Feature 200 in Trench 62, view to the southeast.

retain moisture, they may have been used opportunistically by the Hohokam as informal agricultural fields. Detailed profiles of Feature 21 were drawn, and charcoal samples were collected.

Habitation Features

Twenty-nine habitation features, defined broadly here to include architectural structures and associated extramural features, were identified during the project. All were given the Pueblo Grande site designation. One adobe structure, 10 pithouses, 2 possible pithouses, 14 pits, and 2 trash or artifact concentrations comprised the group (see Tables 1.2 and 2.2). These features are summarized below by "Area," a term very roughly synonymous with archaeological locus in that the features tend to be spatially and temporally discrete.

Feature 306 was a roughly rectangular pithouse located in Area 3A, the southwestern corner of Block 3 (see Figure 2.3). The northwestern corner of the house was intruded by a small pit, Feature 308. Horizontal stripping around the pithouse exposed a shallow basin, Feature 310, containing three modeled clay trivets. No charcoal or ash was associated with the trivets, suggesting these had been cached. Diagnostic ceramics from the pithouse and pit were all Late Gila Butte or Santa Cruz red-on-buff, suggesting late Gila Butte/early Santa Cruz phase use of the area (see Table 1.1).

Area 3B included an adobe structure, Feature 329, a poorly preserved pithouse, Feature 318, an artifact concentration, Feature 338, and a variety of pits (see Figure 2.3). Also related to this area is a ditch, Feature 56 of U:9:28, which was filled with prehistoric trash, possibly refuse deposited by Area 3B occupants. The adobe structure contained one main room, floor and hearth relatively intact, with additional wall fragments extending from the room defining possible extramural spaces. Most notable among the extramural features were three cobble-bottomed pits, Features 326, 333, and 334. Each was a small- to moderately sized pit with a large flattish cobble at its bottom. Cobble-bottomed pits have been noted previously in the Pueblo Grande vicinity (Mitchell 1994). Evidence was also found to suggest Feature 326 may have been reused as a post. Although buff ware was rare, an abundance of red ware, in conjunction with the adobe architecture, indicate a Classic period age, possibly earlier Classic (Soho phase), given an absence of Salado polychrome ceramics.

Four pithouses (Features 300, 301, 302, and 307), four prehistoric pits (Features 303, 304, 305, and 311), and one trash concentration (Feature 309) were identified north of canal Feature 3 in Block 5, Area 5A (see Figure 2.5). The pithouses had relatively well-prepared caliche floors but no discernible walls. The entryways for all the structures were difficult to define, but they appeared to face toward a common extramural area, with a trash concentration to the southeast. Recovered diagnostic ceramics were dominated by Late Sacaton or Casa Grande red-on-buff types, suggesting occupation of Area 5A at the cusp of the Classic period, in the late Sacaton or early Soho phase.

The remaining excavated pithouses, Features 312, 313, 314, and 316, were located among the agricultural field systems west of Block 7 in the area designated 6B (see Figure 2.7). Feature 312 was a larger, moderately preserved pithouse, while the others were small and fair to poorly preserved. Preservation of features in this area was compromised by modern constructions, especially 43rd Street. Each small house also had a prehistoric irrigation ditch intruding into it, indicating the houses had been abandoned prior to development of the local field system(s). Pithouse architecture in this area was generally insubstantial, implying all were used as seasonal fieldhouses.

The two possible pithouses, Features 315 and 319, were identified from trench wall profiles only. Each was so poorly preserved as to make identification tentative. The surface of Feature 315, located along the eastern edge of Block 7 (see Figure 2.7), was defined by several semicontiguous fragments of caliche, possibly floor. Given its deeply buried position at the extreme eastern edge of the project area and its poor preservation, it was deemed both impractical and unproductive to pursue this particular feature. Feature 319, located in the southeastern corner of Block 3 very near Feature 26 (see Figure 2.3), was a small fragment of a charcoal-flecked compacted surface. While identified as a possible pithouse, it may, instead, reflect a stable surface near, or related to, the canal.

Historic Features

Nineteen features were identified as late historic/ early modern. All were assigned to T:12:258. The late historic/early modern feature types included 9 trash-filled pits, 3 privy pits, 2 brick-lined cesspools, 2 concrete-lined septic tanks, 2 areas of ponding, and 1 concrete slab/floor surface. The ponds, Features 115 and 120, both occur proximate to the northern side of Feature 200, the berms of which were still at least partially present through the 1930s. The two features probably formed through processes much like prehistoric Feature 21, that is, a product of sheetwash pooling upslope from the extant canal.

Features 115 and 120 could be recognized as historic features from the proximity of the sediments to the present-day ground surface, occasional bits of rusted metal, and the presence of cow bones in Feature 115. The ponds, whether created naturally or artificially, were likely related to watering cattle penned near the railway or at the stockyards.

CHAPTER 3

GEOARCHAEOLOGICAL ANALYSIS OF PREHISTORIC CANALS NEAR PARK OF FOUR WATERS, PHX SKY TRAIN PROJECT

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The Hohokam and their predecessors constructed sophisticated irrigation canal systems in central and southern Arizona that supported an agricultural way of life for more than 3,000 years. Canals were diverting water from the lower Salt River by at least A.D. 100, and eventually, they became a key technological component to subsistence and population growth over the next approximately 1,200 years (Gregory 1991; Henderson 1989; Howard 1994; Hunt et al. 2005). Archaeologists have mapped more than 500 km of main, distribution, and field lateral canals in the Phoenix metropolitan area alone (Howard and Huckleberry 1991; Turney 1929). Most of this evidence for pre-Columbian water control is no longer visible at the surface and is, instead, partially or wholly preserved beneath roads, houses, and modern agricultural fields. Only a few prehistoric canals are still visible at the surface, including two large main canal segments approximately 250 m in length located immediately east of Sky Harbor Airport and south of the platform mound at Pueblo Grande Museum and Cultural Park (Figure 3.1). Except the few instances where canals are preserved at the surface, these ancient water works are defined primarily as layers of sediment below the surface. Within these layers of sediment are clues about how the Hohokam developed a highly successful adaptive strategy that persisted for centuries despite numerous sociocultural and climatic changes. Why the Hohokam eventually abandoned these canal systems is still not understood.

Hohokam canals in the lower Salt River Valley form a complex network of superposed and intersecting human-constructed channels, many representing repeated cycles of construction, abandonment, and re-use. The density of canal channels is greatest where arable land was easily accessed by gravity-fed streamflow and where local geology favored relative floodplain stability. One of the larger clusters of Hohokam canals in the valley is what Turney (1929) referred to as Canal System 2 (see Figure 1.4). This network of canals was constructed at different times over the course of several centuries, with main canals originating on the Salt River downstream from its constriction between Tempe Butte and the Papago Buttes.

Several of the main canals within Canal System 2 had their headworks near Pueblo Grande, AZ U:9:7 (ASM), in an area Turney called Park of Four Waters (see Figure 3.1). The earliest archaeological excavations of Canal System 2 canals were conducted at Park of Four Waters, where, in the 1950s, Woodbury (1960) placed a trench across the two preserved canal segments located south of the mound at Pueblo Grande, documenting their shape and stratigraphy. In the 1970s, Masse (1976, 1981) worked west of the two preserved canal segments within the right-of-way of the "Hohokam Expressway," later renamed the Sky Harbor Expressway (State Route [SR] 153) and known today as 44th Street. Despite historic disturbances that truncated the prehistoric canals, Masse (1976) identified and described the middle to lower parts of 18 discrete canal segments, including downstream segments of the two preserved canals described by Woodbury (1960). A nineteenth canal was later identified and described within the Hohokam Expressway right-of-way immediately north of the historic Grand Canal (Bradley 1978); this canal represents the uppermost (highest elevation) canal within Canal System 2.

Several archaeological projects conducted in the 1980s and 1990s, most associated with road construction in the city of Phoenix, provided additional opportunities to excavate canal alignments located farther downstream within Canal System 2. Approximately 30 years after the Hohokam Expressway excavations, the PHX Sky Train project provides a new opportunity to study Canal System 2 main canals located close to Park of Four Waters (see Figure 3.1). Sky Train excavations by Desert Archaeology, Inc., in 2008 and 2009, within several blocks of land located north of Sky Harbor Airport resulted in the identification of seven medium to large prehistoric canals aligned approximately southeast-northwest. This includes a downstream segment of

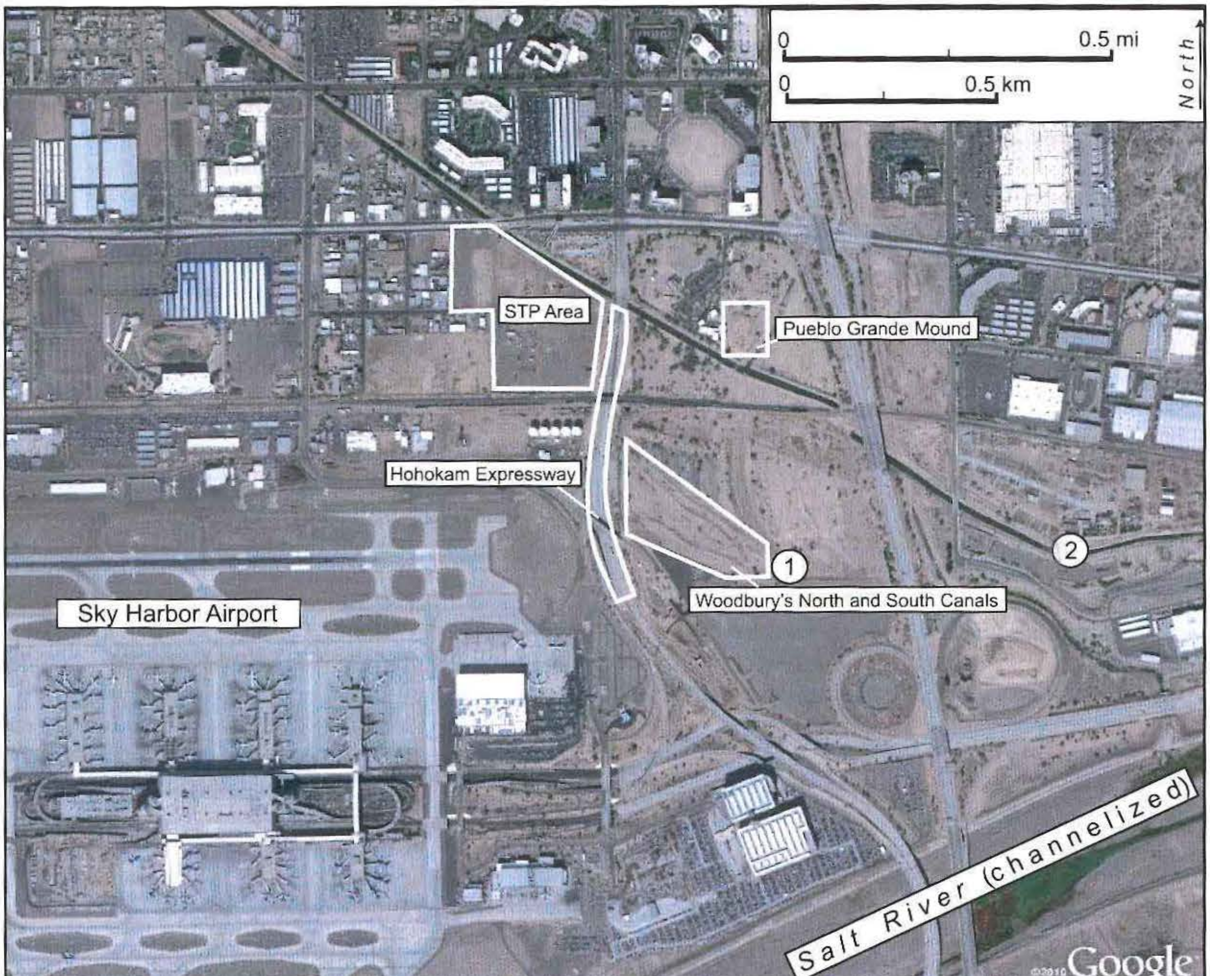


Figure 3.1. Google® image of Park of Four Waters area at the edge of SkyHarbor Airport, with previous canal study areas, the PHX Sky Train project area, and Pueblo Grande platform mound. (Locations 1 and 2 denote hypothesized headworks for System 2 canals discussed in report.)

Woodbury's (1960) "North Canal" and other canals excavated by Masse (1976) in the Hohokam Expressway project. Several smaller canals were also identified within the PHX Sky Train project area, including small distribution and field lateral canals (Chapters 2, 5, and 6, this volume). The discovery of prehistoric field laterals is significant, because they are difficult to identify during excavation but provide important insight into water delivery and agricultural production.

Because canals are fluvial features sharing many characteristics of natural stream channels, it is useful to analyze their stratigraphic and sedimentological properties and to subsequently place them within a larger geomorphological context. Such an approach provides insight into canal construction, use history, flow capacity, and vulnerability to uncontrolled flooding (Huckleberry 1991, 1999a, 1999b; Nials and Gregory 1989). This approach also provides important stratigraphic context to chronometric information collected from canals. Consequently, a geoarchaeological analysis was conducted that emphasizes the geomorphology, stratigraphy, sedimentology, and chronometry of the larger Sky Train project canals and their relationship to Canal System 2.

The results of this analysis are used to correlate the three largest Sky Train canals to downstream canal segments within Canal System 2 (Ackerly et al. 1987; Howard, ed. 1988; Howard and Huckleberry 1991; Huckleberry 1988, 1989, 1990, 2005), which, in turn, permits an analysis of downstream changes in channel size (see Howard 1991a, 1994). This geoarchaeological investigation also considers sedimentological evidence of destructive flooding during the Classic period (A.D. 1150-1450) in the largest canal within Canal System 2. Stratigraphic and sedimentological data provide insight into what a destructive flood deposit within a large Hohokam main canal looks like and how it changes downstream within the canal alignment. The identification and dating of uncontrolled flooding in Hohokam canals is an essential part of testing hypotheses that link destructive flooding to agricultural instability and demographic decline (Graybill et al. 2006; Gregory 1991; Nials et al. 1989).

The results of the geoarchaeological analysis of the larger PHX Sky Train project canals are presented here. The first section includes a description of the physical setting of the Sky Train project area, with an emphasis on lower piedmont and riverine floodplain geomorphology. This is followed by a presentation of the field and laboratory methods and the stratigraphic, sedimentological, and chronometric results. Stratigraphically defined canal dimensions are then used to estimate former water velocity, discharge, and irrigation capacity of the larger canals. The size, stratigraphy, and relative position of the large Sky Train canals are used for correlation with previously excavated canal segments within Canal System 2. This is followed by an expanded discussion of flood stratigraphy in the largest Sky Train canal and how it might help future efforts to identify flood-damaged canals.

The geoarchaeological analysis of the Sky Train canals supports the conventional wisdom that Park of Four Waters was a desired location for diverting flow from the lower Salt River for several centuries and directing that water toward numerous irrigation communities located on the higher piedmont. The scale of irrigation within Canal System 2 declined after circa A.D. 1300, with the area abandoned sometime after A.D. 1450. Canal irrigation did not return until approximately 400 years later, with the arrival of Euro-American settlers in the 1860s, and the founding of Phoenix.

PHYSICAL SETTING

Canal-irrigated agriculture is strongly influenced by environmental variables, such as landforms, climate, vegetation, soils, and hydrology. This section places the PHX Sky Train project canals within their natural physical setting, something that can be difficult to perceive within the modern urban landscape.

Geomorphology

Phoenix lies within the Basin and Range physiographic province, a broad region of western North America containing normal fault bounded mountains and deeply filled basins (Dohrenwend 1987). Much of this topography was formed by crustal extension that ceased approximately eight million years ago in south-central Arizona. Since then, the predominant geological processes have been mountain erosion and basin filling. Several small mountain ranges extend above the deep basin fill in the Phoenix area, including Tempe Butte, the Papago Buttes, and Camelback Mountain located east and north of the Sky Train project area. Prolonged erosion of these hills and mountains is evidenced by the Papago Pediment, a gently sloping, truncated granitic surface extending from the Papago Buttes, located on the northern side of the lower Salt River upstream from the Sky Train project area (Wellendorf et al. 1986). The Papago Pediment grades into coalesced alluvial fans to the west, and is cut by the Salt River to the south at Park of Four Waters.

The Salt River is the primary source of surface water for central Arizona, and it has a catchment area of 33,670 km^2, with an annual streamflow of circa 11.9×10^8 m^3, or 965,000 acre-feet. Prior to dams, diversions, and channelization, the lower Salt River was a wide, braided river, with a wide floodplain containing multiple shifting channels (Graf 1983). Floods regularly deposited large volumes of sand and gravel, causing the primary flow channel to shift laterally, creating a complex belt of interconnected channels more than 1.6 km wide (Graybill and Nials 1989). An exception is where the braided channel belt narrows as it passes between Tempe Butte and the Papago Buttes, approximately 4 km upstream from Park of Four Waters. Relative channel stability and more dependable surface flow related to shallow bedrock made the reach next to the Papago Pediment well suited for canal diversion. Today, much of the lower Salt River has been artificially channelized within the Phoenix metropolitan area, allowing urban expansion into the former braided channel belt. In the PHX Sky Train area, the Salt River has been channelized and displaced southward to facilitate expansion of Sky Harbor Airport (see Figure 3.1).

Areas regularly inundated by the lower Salt River prior to dam construction and channelization corresponds to what is locally known as the Lehi Terrace (Péwé 1978) (Table 3.1). This is one of four Quaternary river terraces mapped in the Phoenix metropolitan area. The older Salt River terraces (Blue Point, Mesa, and Sawik) converge into a single Pleistocene surface in the vicinity of Tempe and Papago Buttes. This surface is recognized on the western side of the Tempe and Papago Buttes beyond the Papago Pediment and north of the Salt River and is correlated to the Mesa Terrace (Wellendorf et al. 1986). The boundary between the Lehi and Mesa terraces in central Phoenix is topographically subtle and not readily seen today. However, historic irrigation maps reveal a break in topography closely following East Van Buren Street (close to the southern boundary of Sections 1-4 in Township 1 North, Range 3 East) (Figure 3.2), that marks the boundary between the two terraces. Historically, the largest Salt

Table 3.1. Riverine and piedmont landforms in the vicinity of the PHX Sky Train project area (adapted from Pearthree and Huckleberry 1994; Péwé 1978; Wellendorf et al. 1986). Soil development terms based on USDA nomenclature (Soil Survey Staff 1993) and Birkeland (1999).

Landform	Age	General Soil Development	Notes
River Terrace			
Lehi	Holocene (10 ka-present)	A/C, Bw, Bk; Stage I $CaCO_3$ development	Continuous along the modern Salt River channel; mapped as Qyr by Pearthree and Huckleberry (1994)
Mesa	Middle Pleistocene (750-250 ka)	Bkm, Bkqm; Stage IV+ $CaCO_3$ development	Converges with Blue Point and Sawik terraces at Tempe; poorly expressed downstream from Tempe Butte but reemerges as a distinct terrace from circa 59th Avenue to the Agua Fria River; locally buried by alluvial fan deposits north of Sky Train area
Geological Surface			
Alluvial fan	Holocene (10 ka-present)	A/C, Bw, Bk; Stage I $CaCO_3$ development	Derived from Camelback Mountain and Papago Buttes; arkosic mineralogy; merges with Lehi Terrace within Sky Train area
Alluvial fan	Middle-Late Pleistocene (750-10 ka)	Bk, Btk; Stage I+ to III $CaCO_3$ development	Derived from Camelback Mountain and Papago Buttes; arkosic mineralogy; common to middle and upper piedmont north of project area; mapped as Qmlf by Pearthree and Huckleberry (1994)
Pediment	Pleistocene (1.6 Ma-10 ka)	Bkm, Bkqm; Stage IV+ $CaCO_3$ development	Formed into Precambrian granite south and west of Papago Buttes; occurs northeast of Sky Train area

River floods extended across the Lehi Terrace up to this boundary, with the last floods to reach this far north occurring in 1891 and 1905 (Bales et al. 1986). The boundary separating the Lehi and Mesa terraces represents the approximate extent of the maximum probable flood along this reach of the Salt River over the past several thousand years (Graybill and Nials 1989; Pearthree and Huckleberry 1994).

The Mesa Terrace in central Phoenix is largely buried by alluvial fan deposits derived from the Papago Buttes and Camelback Mountain. Because this area has long been urbanized, the age and distribution of different alluvial fan surfaces are not well known. Physical evidence used to distinguish different landforms, such as stream patterns, depth of stream channel dissection, and soil formation, are not visible or easily accessible in this area. Previous soil surveys (Adams 1974) indicate a predominance of mostly older Pleistocene soils, and the area is interpreted as containing alluvial fans that are mostly Middle to Late Pleistocene in age (Pearthree and Huckleberry 1994) (see Table 3.1). The general slope of the piedmont crossed by Canal System 2 is to the southwest, with numerous ephemeral stream channels that regularly flood in response to heavy rains in the summers. This flooding caused problems for historic farms in the area (Zarbin 1980), and flood control structures were eventually constructed to protect canals on the piedmont. During the Hohokam sequence, alluvial fan flooding would have been a recurrent event adding to the maintenance requirements of Canal System 2.

The largest Hohokam site in the vicinity of the PHX Sky Train project area is Pueblo Grande, which is strategically located at the convergence of the pediment, the alluvial fan, and the Salt River floodplain (Figures 3.3-3.4). Within the Sky Train project area, Holocene alluvial fans grade into the Lehi Terrace, as evidenced by geologically young soils and alluvial deposits. Alluvial fan deposits tend to be red (7.5-10 YR hue), gravelly, and arkosic; that is, they are composed primarily of quartz and potassium feldspar minerals (Table 3.2). Gravelly alluvial fan channel deposits tend to be lenticular and extend laterally for several meters before terminating. In contrast, Salt River deposits are finer textured and have more tabular architectur; that is, they have subhorizontal upper and lower boundaries that can be traced for tens to hundreds of meters. The boundary separating alluvial fan and lower Salt River (Lehi) deposits trends southeast to northwest across the southern end of Block 6 and the central part of Block 4 within the project area (Figure 3.5). While Salt River overbank flood deposits overlie alluvial fan deposits at the southern end of Block 6, elsewhere, the stratigraphic relationship is more grad-

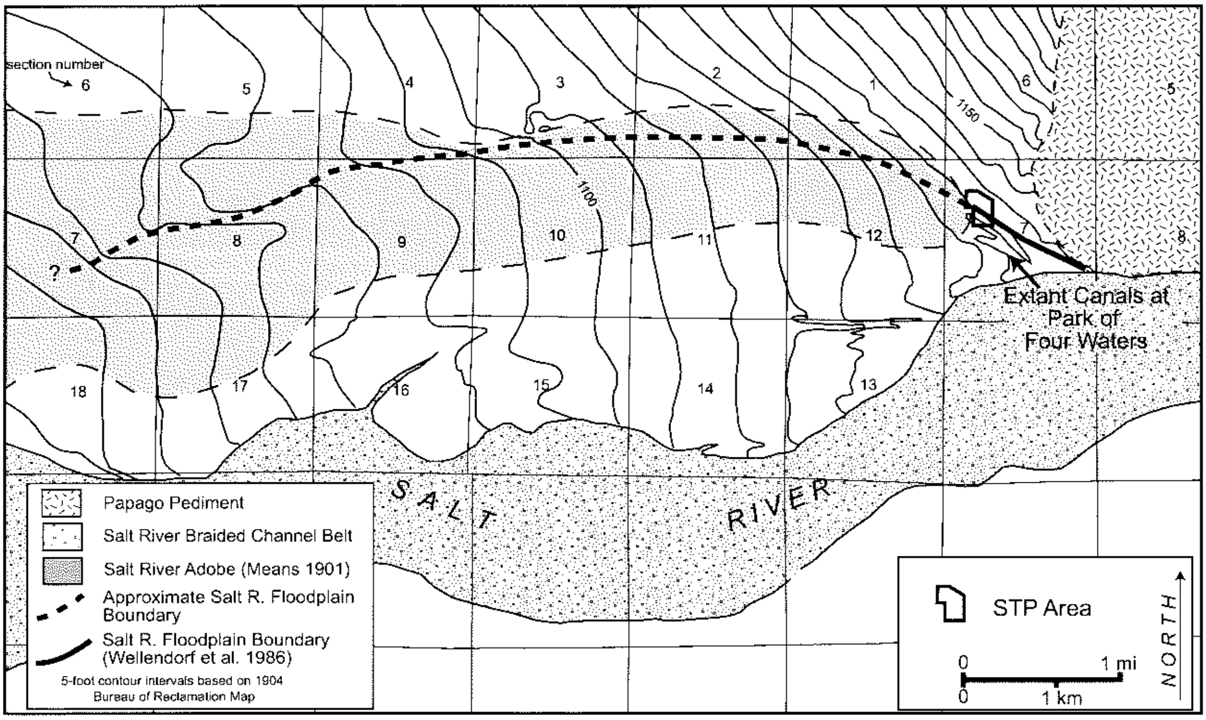


Figure 3.2. Historic topographic map of the east-central Phoenix area, showing approximate northern boundary of the Salt River geological floodplain in relation to previous geoarchaeological studies and the current project area.

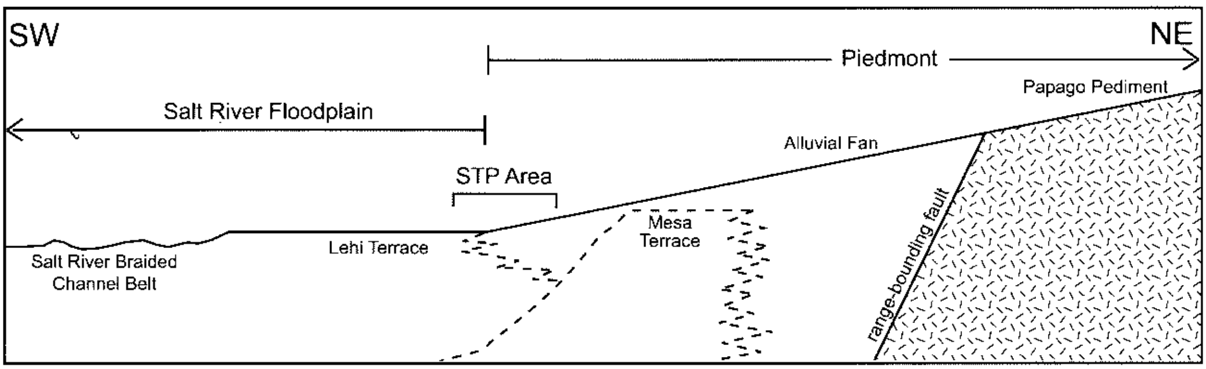


Figure 3.3. Schematic geological cross section of the PHX Sky Train project area.

ual, with alternating (interfingering) alluvial fan and river deposits.

Piedmont-floodplain transitions are well known for containing a diversity of biotic resources (Fish et al. 1992; Kwiatkowski 2003). At Pueblo Grande, natural vegetation on the piedmont consisted of plants associated with the Lower Colorado River division of the Sonoran Desert (Turner and Brown 1994), including creosote (*Larrea tridentate*), saguaro (*Carnegiea*), and paloverde (*Cercidium*). In contrast, the Lehi Terrace supported riparian vegetation (Minckley and Brown 1994), and included mesquite (*Prosopsis*), cottonwood (*Populus fremontii*), and willow (*Salix goodingii*). In between was a transition zone, likely dominated by desert saltbush (*Atriplex polycarpa*). The distribution of different plants within the riparian zone was spatially dynamic, as floods and channel shifts destroyed plant communities and created new disturbed surfaces for the colonization of pioneer species (Stromberg et al. 1991), resulting in a complex mosaic of trees, forbs, and grasses. Spatial variability in plant communities on the Lehi Terrace would have been further enhanced by clearing for canal construction and field preparation near the headworks of Canal System 2.

Soils

Both alluvial fan and river floodplain soils within the Sky Train area are relatively young, dating to the late Holocene (< 5,000 years old), and classify as

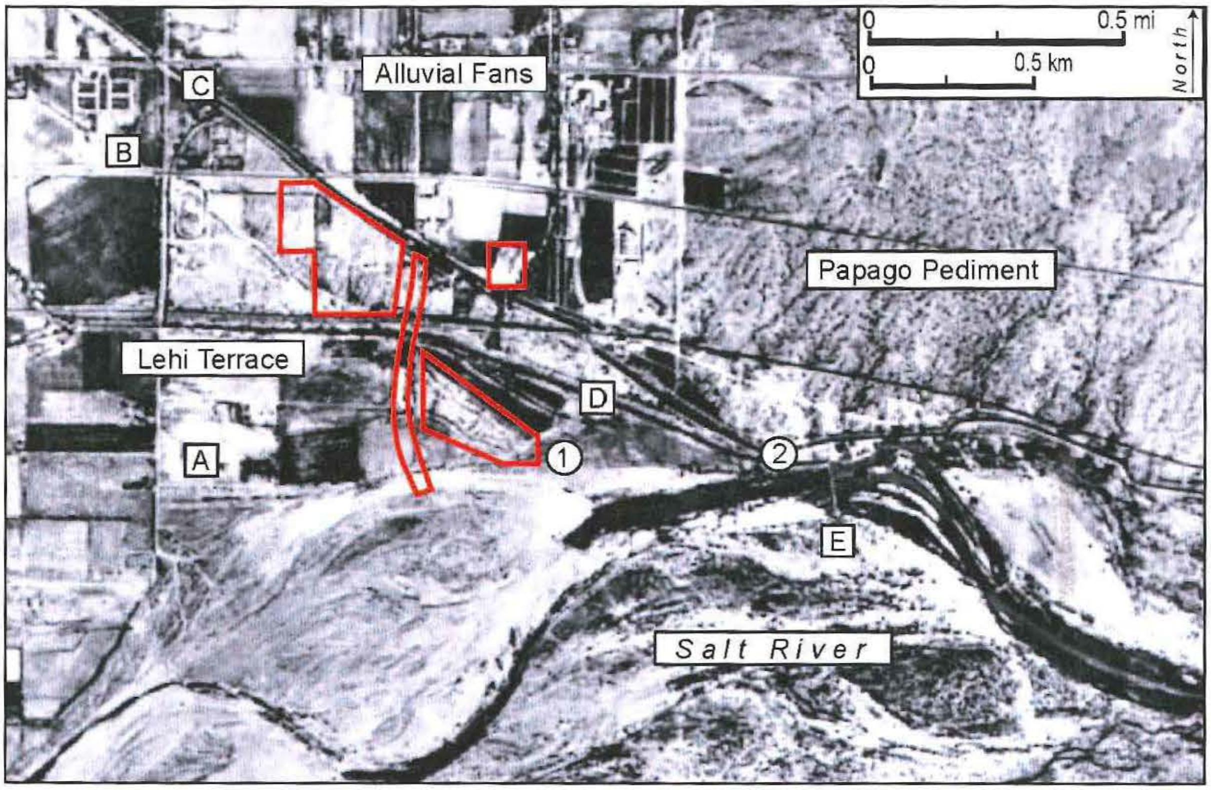


Figure 3.4. Historic (1937) aerial photograph of Park of Four Waters area showing major geomorphic features and irrigation features: (A) historic Swilling Ditch; (B) Woodbury's North Canal; (C) historic Grand Canal; (D) historic Joint Head Canal; (E) historic Joint Head Dam (note water in Salt River channel upstream from dam). Outlined areas and points (1) and (2) correspond to Figure 3.1. Note northward extent of Salt River channel prior to channelization and construction of Sky Harbor Airport. (Historic aerial photography courtesy of the Maricopa County Flood Control District [http://www.fcd.maricopa.gov/GIS/maps.aspx]).

Table 3.2. Sedimentological differences between alluvial fan and Lehi Terrace deposits in the Sky Train project area.

Alluvial Fan Deposits	Lehi Terrace Deposits
7.5-10 YR hue	10 YR hue
Sandy loam, loamy fine sand	Sandy loam; silt loam, silty clay loam
Common, fine, angular, gravels	Rounded gravels and cobbles at depth
Arkosic mineralogy	Mixed mineralogy
Lenticular, cut-and-fill architecture	Predominant tabular architecture

Torrifluvents and Haplocambids (Soil Survey Staff 1999). Such soils tend to have simple A/C horizonation, or possibly A/Bw/C and A/Bk/C horizonation, with the B horizon containing slight evidence of pedogenesis in the form of weak structural development or Stage I $CaCO_3$ morphology (see Table 3.1). These soils are generally well suited for agriculture, although repeated cultivation would have required some form of supplemental nitrogen to maintain fertility. Pleistocene soils are more extensive higher on the piedmont, with younger Holocene alluvial soils (Torrifluvents) concentrated along active drainages.

Centuries of repeated canal irrigation and consequent deposition of fine-textured sediment along canal alignments and in adjacent fields affected the chemical and physical properties of the natural soils. This was noted more than 100 years ago by government soil scientists, who noticed the presence of heavy, dark clay soils along some of the larger Hohokam canals (Means 1901). Originally referred to as "Adobe clay" (see Figure 3.2), these dark, fine-textured soils were later mapped as Cashion clay by Adams (1974). These organic, clayey soils often occur as linear bands parallel to Canal System 2 canals on the Lehi Terrace and parts of the lower piedmont (Dart 1986). Lateral changes in soil texture within these soils have also been spatially related to prehistoric canals (Anderson, Huckleberry, and Nials 1994; Huckleberry 1992). These anthropogenic soils tend to be thickest on the Lehi Terrace west of the Sky Train area, where canal irrigation was practiced for more than 1,000 years by the Hohokam (Nials and Henderson 2004).

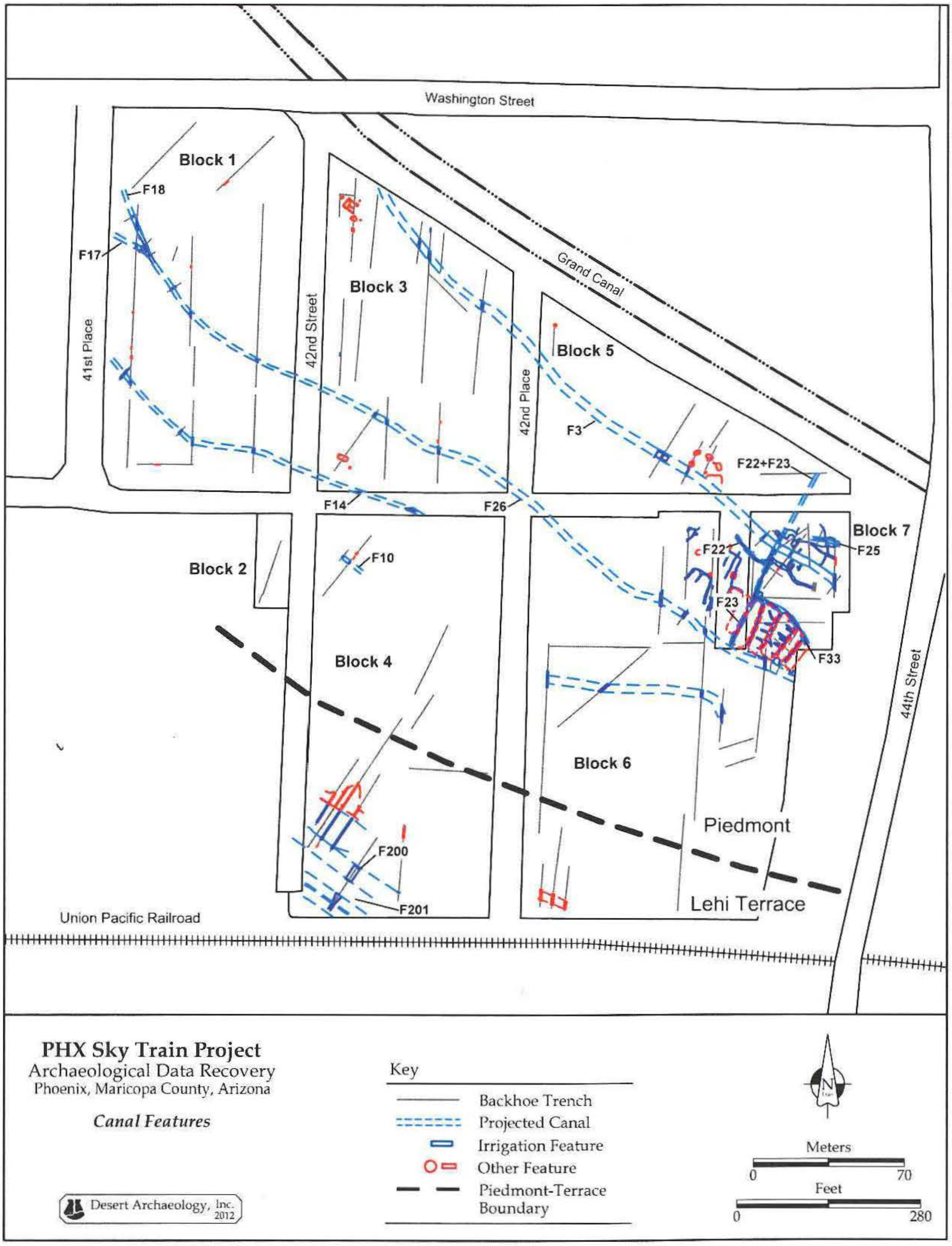


Figure 3.5. Map of the PHX Sky Train project area and approximate location of the piedmont-Lehi Terrace boundary.

Although irrigation deposition of silt and clay onto natural sandy soil may improve fertility and water retention (Hesse and Baade 2009; Schaafsma and Briggs 2007), the accumulation of fines may eventually result in problems of waterlogging and reduced tilth, especially on the Lehi Terrace where fine-textured soils and shallow water tables naturally occur. Nevertheless, it is unlikely that soil degradation was an important factor in the eventual abandonment of Canal System 2. Waterlogging, salinization, and soil compaction were likely managed by shifting field locations (allowing soils to periodically remain fallow) and canal alignments within Canal System 2.

Hydroclimatology

Hydroclimatology refers to the climatic characteristics of a region that strongly influence the seasonality, frequency, and magnitude of streamflow. The operation of Canal System 2 depended on not only the technological aspects of the canal network, such as alignment, gradient, channel shape, placement of headgates, and so forth, but also on the time-variant aspects of Salt River streamflow. The Greater Southwest is characterized by general aridity, controlled in large part by a persistent ridge of subtropical high pressure that keeps air relatively dry and warm throughout much of the year. Elevations below 1,000 m, including the lower Salt River Valley, are particularly arid and hot. In contrast, the Central Highlands of Arizona, located north and east of Phoenix, are cooler and receive more precipitation (Figure 3.6), thereby providing important runoff to the lower desert valleys in southern and western Arizona.

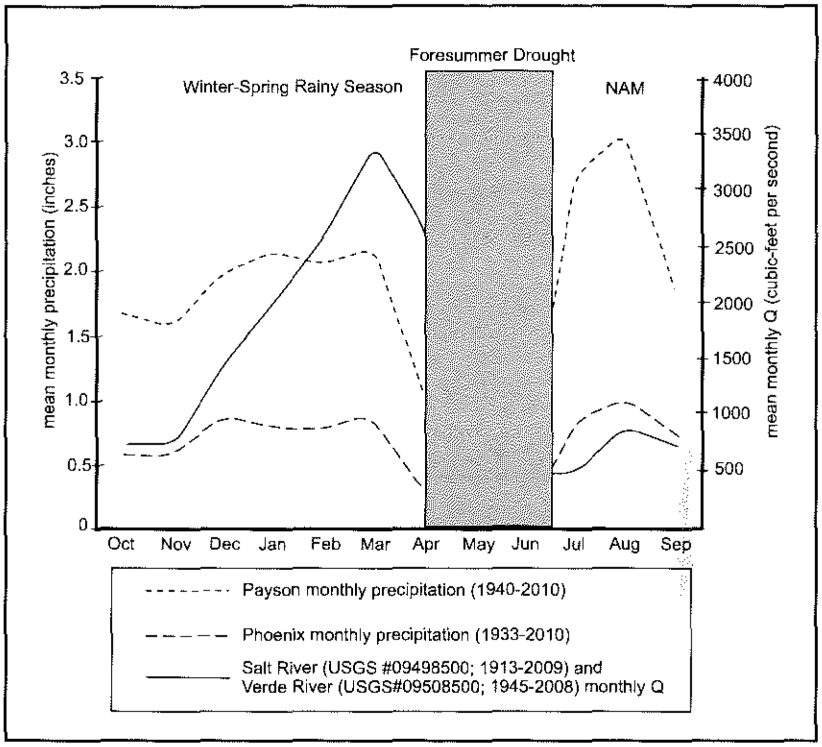


Figure 3.6. Mean monthly precipitation for Payson and Phoenix (WRCC 2011), in relation to seasonal moisture regimes and mean monthly discharge (Q) for the combined Salt and Verde rivers (http://waterdata.usgs.gov/az/nwis/sw/).

More than 100 years of weather records from Phoenix (Western Regional Climate Center 2011) indicate annual average minimum and maximum temperatures of approximately 15.2°C and 30°C, respectively. Maximum daily temperatures between 1 May and 1 October frequently exceed 38°C, resulting in high water requirements for domesticated crops. However, warm temperatures allow for a relatively long frost-free season compared to higher elevations, and it is generally thought that the Hohokam were able to double crop in the Phoenix Basin, provided an adequate supply of water (Bohrer 1970).

Mean annual precipitation in Phoenix is about 20 cm, with most rainfall occurring in two distinct seasons (see Figure 3.2). The winter-early spring rainy season (November-March) is associated with Pacific storms that periodically track across southern California and Arizona (Woodhouse 1997). These storms tend to produce gentle but geographically extensive precipitation, and more importantly, generate snowpack in the high country. Whereas winter rain and snow in the upper Salt River basin account for less than half of the annual precipitation, it produces roughly 73 percent of the streamflow that reaches the Phoenix Basin (Graybill and Nials 1989:11).

Annual variability in winter precipitation is strongly affected by hemispheric scale changes in Pacific Ocean temperatures and atmospheric pressure such as the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). The warm phase of ENSO, or El Niño, and a positive phase of the PDO, are associated with above average winter-early spring precipitation in Arizona (Andrade and Sellers 1988; Redmond and Koch 1991) and also enhance the flood regime of large rivers with upland catchments like the Salt and Verde rivers (Ely 1997; Redmond et al. 2002; Webb and Betancourt 1992). Although winter precipitation displays high annual variability related to ENSO and PDO, lower Salt River peak discharge always occurs in late winter and early spring (see Figure 3.6).

The summer rainy season (July-mid-September) is associated with the North American Monsoon

(Adams and Comrie 1997). Heating of the continental interior in northwestern Mexico and the southwestern United States creates a surface low pressure that draws in maritime air from the south. As westerly winds diminish in strength, convection of moist air, augmented by orographic lifting, results in thunderstorm activity and localized heavy rainfall. Although summer rainfall is an important source of streamflow on relatively small drainages, the contribution of the North American Monsoon to Salt River streamflow is less important than that from winter-early spring precipitation (see Figure 3.6). This is largely due to the fact that summer rainfall occurs at a time of maximum evapotranspiration, resulting in a reduced precipitation to runoff ratio. Also, the limited size of convective storm cells typically associated with the monsoon results in localized rainfall, thereby affecting only small portions of large watersheds at any one time. The magnitude of individual floods generated by isolated thunderstorms is likely to dissipate downstream due to floodplain reservoir effects and water loss due to infiltration. Whereas summer rains are key to dry farming (rainfall-fed) in the uplands and runoff irrigation farming at diverse elevations (Benson 2011), they play less a role in supporting canal irrigation agriculture on large rivers like the lower Salt River. Summer flash floods do, however, create problems for canals crossing ephemeral stream channels, such as the canals in Canal System 2.

Another important component of local climate is the period of minimum precipitation and warm temperatures in the late spring and early summer known informally as the foresummer drought (Sheppard et al. 1999) (see Figure 3.6). Lower Salt River streamflow peaks in March, and progressively declines until reaching its lowest levels in June and early July. In late July, streamflow increases slightly in response to summer rain, but remains far below the level of the March peak. The foresummer drought is a critical time for irrigating crops, as streamflow decreases while temperatures and evapotranspiration rates rapidly increase. This is the time when water availability is crucial for seed germination and early plant development in maize (Benson 2011). During years of relatively low winter precipitation, the foresummer drought was likely a time of competition for water by different Hohokam canal systems tapping into the Salt River, leading to potential conflict among irrigation communities (Rice 1998). As noted, the headworks for Canal System 2 are strategically located immediately downstream from the Papago Pediment and constriction formed by Tempe and Papago Buttes, where there is enhanced channel stability and base flow (Masse 1988; Nials and Gregory 1989). This would have placed Pueblo Grande in a strategic location for controlling water within Canal System 2 during the foresummer drought.

Although diminished streamflow during the foresummer drought was a seasonal challenge to successful crop production for some canal alignments, flooding threatened all lower Salt River canals during the rainy seasons. The largest floods on the lower Salt River occur in winter, and usually represent multiple incursions of storms associated with Pacific cold fronts, build-up of heavy snowpack in the Central Highlands, and rapid melting, the latter often caused by rainfall on preexisting snow. The six largest historic floods on the lower Salt River (1891, 1905, 1916, 1920, 1978, and 1980) all occurred during wet winters when the area experienced multiple cold fronts and build-up of snowpack in the upper watershed. Other large floods in central and southern Arizona have occurred during late summer and early fall when east Pacific tropical cyclones are periodically steered over the Southwest (Smith 1986). While these floods do not involve rapidly melting snowpack, they can generate very large discharges for lower elevation rivers, such as the San Pedro and Santa Cruz in southern Arizona (Webb and Betancourt 1992).

Large winter floods on the lower Salt River had the potential to not only destroy diversion structures and canal headgates composed of rock and brush, but to also rapidly fill the main canal alignment with sediment. Early historic canals in the Phoenix area were prone to repeated washouts in winter (Ackerly et al. 1987; Davis 1897:52; Zarbin 1980), often filling long segments of the main canal with sand and silt (Huckleberry 2011b). Further, the largest recorded lower Salt River floods resulted in rapid shifting of the primary flow channel (Graf 1983) away from canal intakes, leaving some alignments without a water source.

Masse (1988) identified evidence of uncontrolled lower Salt River flooding in two prehistoric canals located within the Hohokam Expressway project area, including irregular erosional unconformities and sandy deposits with chunks of silty clay (rip-up clasts), suggesting turbulent, high-energy streamflow (also see Bales et al. 1986). Nevertheless, most canals investigated in the lower Salt River Valley do not contain obvious evidence of Salt River flooding (Huckleberry 1999a), leading to the question of whether or not this reflects a rarity of uncontrolled flooding, or rather, an inability to identify flood deposits in canals (see below).

Archival records of flood-damaged historic canals and the few stratigraphic examples of destructive flood evidence in prehistoric canals have generated interest in relating the regional paleoflood and archaeological records (Ingram 2008; Nials et al. 1989; Van West and Altschul 1997). Because flood frequency and magnitude can change in response to only slight changes in climate (Knox 2000), flood regime and floodplain conditions have likely varied significantly through time in south-central Arizona. These changes almost certainly created problems and opportunities for pre-Columbian irrigation agriculturalists. Past changes in flood regime at decadal to century timescales within the Southwest are suggested by both tree-ring (Graybill et al. 2006) and geological evidence (Ely 1997; Harden et al. 2010), although the climatic reconstructions produced by these lines of evidence often do not correlate.

Relevant to Canal System 2 are tree-ring reconstructions of annual streamflow for the Salt River compiled by Graybill and colleagues (Graybill 1989; Graybill et al. 2006). Although dendrohydrological reconstructions do not directly identify discrete floods, certain years when large floods are more likely to have occurred can be recognized, and multiyear patterns in streamflow variability can be identified, with increased frequency of floods and droughts leading to greater geomorphic instability (Balling and Wells 1990; Nials et al. 1989).

Graybill et al. (2006) distinguish five distinct periods of lower Salt River streamflow from A.D. 572-1988, based on frequency and magnitude of reconstructed annual discharge (Table 3.3), three of which overlap with the operation of Canal System 2. The first interval, A.D. 572-900, was a time of high discharge variability, with relatively high potential for rapid lower Salt River channel shifting. This was followed by the period A.D. 900-1361, a time of relatively low discharge variability, with fewer large floods and inferred greater geomorphic stability. It should be noted that this interval of time includes the Sedentary-Classic period transition, circa A.D. 1050-1150, when there was significant reorganization of canal systems along the lower Salt River and other major drainages in south-central Arizona (Waters and Ravesloot 2001). The third interval, A.D. 1361-1746, begins with a series of large annual flows, although it is generally characterized by only moderate discharge variability. The beginning of this interval correlates with significant population decline along the lower Salt River, a demographic trend that continued for some 100 years, culminating in the general abandonment of the area. Although floods alone seem unlikely to have caused the collapse of Hohokam intensive agriculture, some argue that increased streamflow variability, following a period of overall steady floodplain conditions, in conjunction with other environmental and cultural events, played an important role in the significant Hohokam decline of the late Classic period (Abbott 2003; Graybill et al. 1989; Gregory 1991; Howard 1994; Masse 1991).

Can the role of flooding be verified as a catalyst to Hohokam societal decline? Most of the geological evidence that has been used to infer paleoflood history in south-central Arizona is derived from the upper watershed of the Gila River where there are more natural exposures of stratigraphy and where streams and rivers tend to have confined floodplains conducive for reconstructing the size of past floods (Kochel and Baker 1988). A synthesis of late Holocene alluvial chronologies from upland paleoflood slackwater sites in the Southwest suggests that large flood frequency increased after 400 B.C., with particular peaks in flood intensity around A.D. 900-1100 and after A.D. 1400 (Ely 1997). However, a more recent synthesis of Holocene alluvial chronologies from both upland paleoflood slackwater sites and lower elevation alluvial reaches of rivers suggests that, although the period from 1300 B.C. to A.D. 1 experienced fewer large floods than from A.D. 1 to the present, dramatic variability in flood regime was not apparent during the past 2,000 years (Harden et al. 2010).

Because sediment storage in floodplains varies in time and space, it is not surprising that alluvial chronologies (and inferences of flooding) may differ not only between different rivers but also between upper and lower reaches of the same river (Harvey and Pederson 2011). The challenge is to separate climatic information from a complex physical system that is also influenced by other non-climatic (intrinsic) geomorphological controls. For example, in reconstructing the paleoflood history of the lower Salt River, more alluvial stratigraphic control from the Phoenix Basin where much Hohokam canal irrigation took place would be useful. Unfortunately, there is a paucity of stratigraphic exposures in the lower Salt River floodplain, and in only a few areas has the Lehi Terrace been systematically excavated for purposes of dating alluvial stratigraphy (see Birnie 1994; Onken et al. 2004).

Along the middle Gila River where more systematic stratigraphic excavations within the floodplain have been conducted, there is evidence of increased flooding at approximately A.D. 1000-1100, which has been correlated to canal system consolidation and settlement shifts at the end of the Sedentary period (A.D. 900-1150) (Huckleberry 1995; Waters and Ravesloot 2001). Interestingly, there is no geological evidence for increased flooding along the middle Gila River during the late Classic, when several large canal systems were abandoned (Woodson 2010a). To what degree the alluvial stratigraphic record of the middle Gila River correlates to the lower Salt River is unknown as these two rivers have different hydroclimatological characteristics (Graybill et al. 2006; Ingram and Craig 2010).

Table 3.3. Intervals of contrasting streamflow and inferred floodplain conditions for the Salt River, based on dendrohydrological reconstructions (adapted from Graybill et al. 2006:Table 5.4).

Interval	Age	Description
V	A.D. 1921-1988	Low discharge variability; combined with increased regulated flow and channelization for flood control; trend toward relative geomorphic stability
IV	A.D. 1746-1921	High discharge variability; frequent extreme high annual flows; several periods of prolonged low flow; high geomorphic instability in channel braid belt
III	A.D. 1361-1746	Moderate discharge variability; infrequent high annual flows, although interval begins with largest annual flow in 480 years following a period of overall stability; occasional geomorphic instability in channel braid belt
II	A.D. 900-1361	Low discharge variability; no extreme high annual flows; numerous extended periods of low flow; relatively stable channel conditions
I	A.D. 572-900	High discharge variability; numerous extreme and high annual flows; inferred high geomorphic instability in channel braid belt

Inconsistencies and limitations in existing dendrohydrological and geological records mandate that more local physical evidence of past flooding is needed before paleoflood history can be linked to Hohokam canal system instability and changes in settlement and population. The PHX Sky Train investigations provide new information related to uncontrolled flooding and the operation of Canal System 2 canals during Hohokam time.

METHODS

PHX Sky Train project canals and related features were exposed through backhoe trenching (see Figure 3.5). Canal stratigraphy was profiled and described in the field, and selected canals were sampled for particle-size, pollen, and ostracode analysis, as well as stratigraphic dating using ^{14}C and optically stimulated luminescence (OSL). Sediment samples from Features 14, 17, 18, 22, 23, 26, and 33 were submitted to Mottz Laboratory in Tempe for textural determination (percent sand, silt, and clay) using the hydrometer method (Bouyoucos 1962). Sediment samples from Features 3, 200, and 201 were submitted to the Geoarchaeology Laboratory at the University of Arizona for more detailed granulometry. Granulometric analysis involved coarsely grinding the sediments with a mortar and pestle and passing them through a 16-mm, 4-mm, and 2-mm screen on a sonic sifter. The < 2-mm fraction was further ground to remove clay aggregates and was processed with a 1.0-mm and 0.5-mm screen on the sonic sifter. The weight of all material in the screens was recorded.

A subsample of approximately 10 gm was obtained from the < 0.5-mm fraction for pipette analysis (Janitzky 1986). This sample was pretreated with dilute hydrochloric acid (HCl) to remove calcium carbonate ($CaCO_3$) and a hydrogen peroxide (H_2O_2) bath to remove organic matter. The samples were wet screened at 63 microns and the < 0.5-mm and > 63.0-micron fractions were then dried and weighed. Percentages of silt and clay were determined by pipette extraction with a silt/clay aliquot at approximately 62.5 microns and the clay aliquot at 3.9 microns. Silt and clay fractions were dried and weighed. Basic grain size statistics, including mean, standard deviation, and skewness, were calculated from the granulometric data using graphical methods (Boggs 2001).

CANAL FEATURES

Five medium to large prehistoric canals, Features 3, 14, 26, 200, and 201, transect the Sky Train project area in approximately southeast-northwest alignments (see Figure 3.5), following the general axis of main canals within Canal System 2. One of the canals, Feature 26, branches into two smaller canals, Features 17 and 18, at the western boundary of the project area. The edge of a sixth canal, Feature 202, was encountered at the southern boundary of the project area but could not be fully exposed; this feature likely correlates to Masse's (1976) Canal 7 (Hagenstad canal) at AZ U:9:2 (ASM). The stratigraphic and sedimentological properties of the Sky Train canals are presented below in order of occurrence from south to north. Stratigraphic descriptions are provided on each cross-sectional profile; results of particle-size analyses are presented in Appendix A (this volume).

It should be noted that all the project canals occur near the modern surface and have been historically truncated. Canal channel dimensions presented below are based on stratigraphy exposed in trenches placed at right angles to the axis of the channels.

Channel width is measured at the preserved top of the channel, either at the base of the surface disturbed zone or at the uppermost point where channel edges can be stratigraphically distinguished. Channel depth is measured from the base of the channel to the level at which top width is measured.

Canal chronometry presented here includes estimates of canal age based on previous excavations and analysis of ceramics by Masse (1976) in the Hohokam Expressway project and newly obtained ^{14}C and OSL ages during the Sky Train project. Radiocarbon ages (Table 3.4) are provided courtesy of Louise Purdue from the Université de Nice-Sophia Antipolis, France. All ^{14}C ages were calibrated with CALIB 6.0, using the Intcal09 dataset (Reimer et al. 2009). Conventional ^{14}C ages are presented at 1-sigma precision and rounded to 5-year intervals; calibrated ages are presented at 2-sigma precision and also rounded to 5-year intervals. Optically stimulated luminescence ages (Table 3.5) are provided by Glenn Berger, formerly of the Desert Research Institute in Reno, and presented at 1-sigma precision; see Appendix B (this volume) for details regarding OSL sampling and laboratory methods.

Feature 201

Feature 201 passes through the far southwestern corner of Block 4 and was exposed in Trench 62 (see Figure 2.4). The canal segment consists of a large parabolic channel excavated into the Lehi Terrace, with a truncated cross-sectional area of 3.8 m^2 (Table 3.6). Despite the large cross-sectional area of the canal and the potential to support relatively rapid streamflow, channel deposits are remarkably fine textured and consist primarily of silt and clay, with only a couple thin lenses of fine sand (Figure 3.7). Thin silt lenses within the middle and lower channel (Strata 2-7) conform with the parabolic shape of the channel and represent through-flowing water within the alignment; unstratified sediments adjacent to the northern wall of the channel are interpreted as clean-out deposits. In the upper channel fill, thin silt and clay lenses (Strata 9, 12, and 13) are more subhorizontal and reflect deposition after most of the channel had filled, probably as postabandonment slopewash. A well-developed zone of iron and manganese oxyhydroxides occurs along the base of the channel. No ^{14}C or OSL information is available for Feature 201.

The size, location, and stratigraphy of Feature 201 suggest this canal correlates to Canal 10, U:9:2, of the Hohokam Expressway project (see Figure 2.9), which Masse (1976) briefly described as containing a channel fill dominated by clay with some silt laminations. However, he also noted that Canal 10 was a "...moderately large V-shaped canal..." with 2.5 m by 2.5 m channel dimensions[1] (Masse 1976:23), a shape that does not correlate well with Feature 201 at Trench 62. However, channel shape can change rapidly downstream due to either vagaries in the original excavation (perhaps in response to the changing depth of resistant substrates) or subsequent scour, especially in loose sandy soils on the Lehi Terrace (Anderson, Huckleberry, and Nials 1994; Lombard 1988). Based on a few ceramics recovered from the channel fill, Masse (1976) suggested this canal dated to the Sedentary period.

Feature 200

Based on historic aerial photography, it was anticipated that Woodbury's (1960) North Canal would pass through the southern part of the PHX Sky Train project area. Indeed, it was identified in the far southwestern corner of Block 4, approximately 10 m upslope (northeast) of Feature 201 (see Figure 2.4). Feature 200 crosses the Lehi Terrace, and it contains a very large truncated parabolic channel that was fully exposed in Trench 62. The truncated canal measures 7.4 m wide and 2.5 m deep, resulting in a cross-sectional area of 12.3 m^2 (see Table 3.6). The lower one-third of the channel contains stratified fine sands and sandy silt (Strata 1-6 in the eastern wall; Strata 1-7 in the western wall), with localized preserved cross bedding and large silt rip-up clasts (Figures 3.8-3.9). Stratified silts and sands are typical for large main canals located close to their headworks and likely represent active use of the alignment. The lower deposits contrast with the upper two-thirds of the channel, which contains a relatively uniform stratigraphy composed of loamy fine to medium sand (Stratum 7 in the eastern wall; Stratum 8 in the western wall). Discontinuous silt laminae are preserved in the lower part of this fill and diminish upward in the profile. This massive deposit is suggestive of a single depositional event, with the silt laminae representing water velocity pulsations within confined unidirectional flow (Visher 1972). Because this deposit extends laterally beyond the upper edges of the channel (the north bank in the eastern wall of Trench 62 in Figure 3.8), it is interpreted as the result of uncontrolled Salt River flooding that rapidly filled the canal (see below).

The large channel and massive upper deposit correlate well with Canal 11, U:9:2, of the Hohokam Expressway project (see Figure 2.9), which Masse (1976) directly traced to Woodbury's (1960) North Canal at Park of Four Waters (Figure 3.10). The ca-

[1]An illustrated profile of Canal 10 was not presented in Masse (1976).

Table 3.4. Radiocarbon ages for selected PHX Sky Train project canals (courtesy of Louise Purdue).

Context	Laboratory Code	Conventional Radiocarbon Age (BP)	1-Sigma Calibration (Cal A.D.)	2-Sigma Calibration (Cal A.D.)	1-Sigma Calibration (simplified/rounded)	2-Sigma Calibration (simplified/rounded)
Ponded sediments upslope of canal Feature 200, Trench 8, Strat 5	Lyon-6296	905±30	1045-1095, 1120-1141, 1147-1172	1039-1208	Cal A.D. 1045-1170	Cal A.D. 1040-1210
Ponded sediments upslope of canal Feature 200, Trench 8, Strat 11	Lyon-6297	975±30	1020-1046, 1090-1121, 1139-1155	1014-1155	Cal A.D. 1020-1155	Cal A.D. 1015-1155
Canal Feature 3, Trench 18, Strat 4	Lyon-6298	935±30	1039-1053, 1079-1153	1025-1163	Cal A.D. 1040-1155	Cal A.D. 1025-1165
Canal Feature 3, Trench 11, Strat 8	Lyon-6299	755±30	1229-1231, 1242-1246, 1251-1281	1221-1284	Cal A.D. 1230-1280	Cal A.D. 1220-1285
Canal Feature 3, Trench 11, Strats 20-22	Lyon-6301	760±30	1228-1232, 1241-1247, 1251-1279	1220-1283	Cal A.D. 1230-1280	Cal A.D. 1220-1285
Canal Feature 10, Trench 22, Strat 1	Lyon-6381	990±30	999-1002, 1013-1045, 1095-1120, 1141-1147	989-1053, 1079-1153	Cal A.D. 1000-1150	Cal A.D. 990-1155
Canal Feature 17, Trench 13, Strat 8	Lyon-6300	735±30	1261-1285	1224-1293	Cal A.D. 1260-1285	Cal A.D. 1225-1295
Catchment Feature 7, Trench 18, Strat 39	Lyon-6302	830±30	1186-1200, 1206-1254	1161-1264	Cal A.D. 1185-1255	Cal A.D. 1160-1265

Note: CALIB Radiocarbon Calibration Program 6.0, calibration data set: INTCAL09.

Table 3.5. Optically stimulated luminescence ages for selected project canals (Appendix B, this volume).

Site	OSL Sample	Feature	Trench	Stratum	Sample Age (before 2010)	Sample Mean Years A.D.	1 Standard Deviation Range Years A.D.	Begin 1 Standard Deviation Range Years A.D.	End 1 Standard Deviation Range Years A.D.
U:9:2	FNX09-1	200	62	8a[a]	1160±130 yr	850	720-980	720	980
U:9:2	FNX09-2	200	62	8a[a]	729±60 yr	1281	1221-1341	1221	1341
U:9:28	FNX09-3	26	50	4-6[b]	996±70 yr	1014	944-1084	944	1084
U:9:28	FNX09-4	22	55	3[c]	921±71 yr	1089	1018-1160	1018	1160
U:9:28	FNX09-5	23	56	3	860 +75, -80 yr	1150	1075-1230	1075	1230
U:9:28	FNX09-6	29	44	4[d]	993±67 yr	1017	950-1084	950	1084
U:9:28	FNX09-7	26	54	3-4[e]	945±62 yr	1065	1003-1127	1003	1127
U:9:28	FNX09-8	25	41	4	1072 +48, -76 yr	938	862-986	862	986

[a]Feature 200, Trench 62, west wall profile.
[b]Correlates with Strata 4-6, Feature 26, Trench 53.
[c]Correlates with Stratum 9, Feature 22, Trench 40.
[d]Silt halo.
[e]Correlates with Strata 3-4, Feature 26, Trench 53.

nal maintains its broad parabolic shape at all three localities. However, Masse (1976:23-25) notes at least two channels, with an earlier channel partially preserved as interbedded sand, silt, and clay on the south side of the feature. Such deposits were not recognized in Trench 62. Another difference is that Woodbury (1960) noted a thin clay lining on the lower edge of the channel he interpreted as a hand-applied layer designed to reduce seepage. Evidence of such a clay lining was not identified within the Hohokam Expressway corridor (Masse 1981) or in the PHX Sky Train project area. Intentional lining of Hohokam canals with sediment to reduce seepage is not commonly recognized, and natural mechanisms, such as seepage of muddy water into underlying soil, can produce such features.

Woodbury (1960) hypothesized that the North Canal operated during the Classic period, and findings from the current project support that age estimate. Within the PHX Sky Train project area, fine-textured "pond" deposits stratigraphically cut by Feature 200 in Trench 8 yielded ages of 905±30 ^{14}C yr BP (A.D. 1040-1210), and 975±30 ^{14}C yr BP (A.D. 1015-1155) (see Table 3.4). An OSL sample from the lower channel fill in the western wall of Trench 62 dated 1160±130 yr b.p.[2] (A.D. 720-980), while a second OSL sample from higher in the channel within the lower part of the thick homogenous flood deposit dated 729±60 yr b.p. (A.D. 1221-1341) (see Table 3.5). The upper OSL sample more likely reflects the true age of the canal, based on ceramics (Masse 1976), as well as the Classic period settlements located along the alignment of this canal (Howard 1990; Howard, ed. 1988). Sediments in the lower channel fill are not likely to be 200 years older than the overlying flood deposit. The height of its preserved berms at Park of Four Waters (see Figure 3.10) indicates this canal required regular dredging that likely would have removed older sediment within the channel. Therefore, the lower OSL sample is estimated as too old.

[1]Before present (b.p.), in this analysis is the year 2010.

Feature 14

Feature 14 is a medium-sized canal traced circa 170 m across the western part of the PHX Sky Train project area between Madison Street and 41st Place (see Figure 3.5). It was not identified farther east in Block 6, suggesting it probably branches off Feature 26 in an area not available for excavation. Feature 14 has a slightly sinuous alignment that may reflect its position on the distal toe of the piedmont as it crossed alluvial fan channels. The truncated channel has a cross-sectional area of approximately 0.7 m^2, and is filled with relatively fine-textured alluvium (Figure 3.11). Except a basal layer of arkosic gravel derived from surrounding alluvial fan soils, the channel fill consists of thin, alternating beds of mostly silt and clay. Six sediment samples from the channel fill average 39.7 percent clay vs. 18.0 percent sand. Low sand content suggests controlled, relatively slow water velocities, perhaps related to a headgate at this canal's diversion point on Feature 26.

Chronometric information is not directly available for Feature 14, but artifactual, ^{14}C, and OSL ages are available for Feature 26 and one of its branching channels, Feature 17. These are presented below.

Table 3.6. Hydraulic reconstructions and estimated irrigable area for PHX Sky Train canals.

Feature	Trench	Flow Depth	Width (m)	Depth (m)	Width/ Depth	Wetted Perimeter (m)	Area (m^2)	Hydraulic Radius (m)	Velocity[a] (m/s)	Discharge (m^3/s)	Irrigable Area[b] (ha)
3	57	Full	4.2	1.8	2.3	6.3	5.0	0.8	0.7	3.56	4,382
3	57	Half	2.2	0.9	2.4	3.2	1.3	0.4	0.5	0.60	737
14	27	Full	1.6	0.7	2.3	2.4	0.7	0.3	0.4	0.28	343
14	27	Half	0.9	0.4	2.3	1.4	0.2	0.2	0.3	0.06	75
17	32	Full	1.6	0.6	2.7	2.2	0.6	0.3	0.4	0.23	282
17	32	Half	0.9	0.3	3.0	1.2	0.2	0.2	0.2	0.04	52
18	26 and 32	Full	1.8	0.7	2.6	2.5	0.8	0.3	0.4	0.33	405
18	26 and 32	Half	1.1	0.4	3.1	1.4	0.3	0.2	0.3	0.07	83
22	40	Full	1.1	0.4	2.8	1.5	0.3	0.2	0.8	0.24	294
22	40	Half	0.7	0.2	3.5	0.9	0.1	0.1	0.6	0.05	63
23	56	Full	1.3	0.3	4.3	1.5	0.3	0.2	0.8	0.20	241
23	56	Half	0.9	0.2	6.0	1.0	0.1	0.1	0.5	0.04	55
26	53	Full	4.2	0.9	4.7	4.7	2.5	0.5	0.5	1.36	1,667
26	53	Half	2.5	0.4	6.3	2.7	0.7	0.2	0.3	0.22	265
200	62	Full	7.4	2.5	3.0	9.7	12.3	1.3	1.0	11.86	14,585
200	62	Half	4.4	1.3	3.4	5.4	3.8	0.7	0.6	2.46	3,028
201	62	Full	3.8	1.5	2.5	5.4	3.8	0.7	0.6	2.46	3,027
201	62	Half	2.5	0.8	3.1	3.2	1.3	0.4	0.5	0.61	750

[a]Slope for main canals (0.0006); slope for Features 22 and 23 is 0.0052; Manning's n for all canals is 0.030.
[b]Based on historic ratio of 1,230 ha irrigated area per 1 m^3/s (86 ac per 1 ft^3/s) presented in Ackerly (1991).

Features 17, 18, and 26

Feature 26 is a medium-sized canal, with a wide, parabolic channel traced about 390 m from the eastern edge of Block 7 to where it splits into Features 17 and 18 at the western edge of Block 1 near 41st Place (see Figure 3.5). The canal alignment is slightly sinuous, and is located on the distal edge of the piedmont. Channel cross-sectional area is 2.5 m^2 at Block 6 (see Table 3.6), upstream from where it potentially branched into Feature 14 and from where it splits into Features 17 and 18. Channel fill is characterized by a thin basal coarse sand, overlain by dark brown silty clay, indicative of low-energy flow conditions (Figure 3.12). Six sediment samples from the channel fill average 21.0 percent sand and 36.7 percent clay, confirming relatively low energy, controlled streamflow. Both sides of the channel contain an assemblage of mixed (poorly sorted) sand, silt, and fine arkosic gravel (strata 4, 7, 8, and 9), representing earlier clean-out deposits. Ostracodes from the channel fill suggest relatively slow and constant streamflow (see Chapter 6).

In the western half of Block 1, Feature 26 contains a smaller parabolic channel with two distinct channel fills. As revealed through mechanical stripping and trenching (Figure 3.13; see also Figure 2.2), the earlier channel fill is traceable to Feature 18 (Figure 3.14), which continues to the northwest, close to the overall alignment of Feature 26. This earlier channel is dominated by non-bedded silt and clay, with some sand and gravel. Ten sediment samples from the channel fill of Feature 18 average 50.4 percent sand and 21.2 percent clay. The more recent channel is continuous with Feature 17 (Figure 3.15), with fill dominated by gravelly silt and clay. Six sediment samples from the channel fill average 57.3 percent sand and 22.0 percent clay. Thus, both Features 17 and 18 contain considerably more gravel and sand than Feature 26, located farther upstream.

Increases in sand and gravel suggest both an increase in water velocity and abundance of coarse sediment derived from local alluvial fan soils. Feature 18 makes a slight turn to the north-northwest, following a lower gradient and directing water higher onto the piedmont. Cross-sectional areas for Features 17 and 18 are 0.4 m^2 and 0.6 m^2, respectively (see Table 3.6). This represents a substantial decrease in cross-sectional area from Feature 26 in Block 6, further suggesting a branching relationship between Feature 26 and Feature 14 in the vicinity of Blocks 4 and 6.

There is contrasting chronometric information for Feature 26 and its branching channels. The location, channel shape, and stratigraphy of Feature 26 correlate to Masse's (1976) Canal 1, AZ U:9:28 (ASM) (see Figure 2.9), which has a broad parabolic shape and deposits dominated by silt and clay. Classic period sherds in the lower deposits of Canal 1 suggest it was used during the Soho phase (Masse 1976:30), or A.D. 1150-1300. However, two OSL samples from the lower fill of Feature 26 collected in Trenches 50 and 54 yielded slightly older ages of 996±70 yr b.p. (A.D. 944-1084) and 945±62 yr b.p. (A.D. 1003-1127), respectively (see Table 3.5). Additionally, charcoal collected from the upper channel fill of Feature 17 in Trench 13 dated 735±30 ^{14}C yr BP (A.D. 1225-1295) (see Table 3.5). On the other hand, field laterals and related features that contain Sacaton phase (A.D. 950-1150) ceramics located in Block 6 do not extend beyond Feature 26, suggesting these were contemporaneous (Kathy Henderson, personal communication 2011). The bulk of the evidence suggests an initial construction during the middle Sedentary period (circa A.D. 1000-1050), with a possible remodeling and use during the early Classic period (circa A.D. 1150-1300).

Feature 3

Feature 3 is a large main canal segment traced roughly 300 m across Blocks 3, 5, and 7 near the northern edge of the PHX Sky Train project area south of the modern Grand Canal (see Figure 3.5). Feature 3 transects the lower piedmont and has a remarkably fine-textured alluvial channel fill (Figures 3.16-3.17). The lower half of the channel contains alternating thin beds of silt and silty clay (Strata 4-15 in Figure 3.17), while the upper half contains a more uniform, thick deposit of sandy clay loam, Stratum 2, interrupted by a single, thin and subhorizontal layer of silty clay, Stratum 3. Despite their fine texture, the lower deposits conform to the parabolic channel shape and represent active but slow streamflow within the alignment. Subhorizontal bedding of Stratum 3 suggests the upper stratigraphy represents postabandonment deposition.

The location, size, and relatively narrow parabolic shape of Feature 3 correspond to Masse's (1976) Canal 2, U:9:28 (see Figure 2.9), the largest canal encountered during the Hohokam Expressway project north of the railroad tracks. The canal was described as U-shaped with a basal deposit consisting of "...sandy silt which contained occasional particles of grus..." overlain by a thick deposit of "chunky clay" in the middle section and sandy clay in the middle to upper channel (Masse 1976:Figure 42). He estimated the canal dated to the Classic period (Masse 1981:Table 1). This age interpretation is supported by ^{14}C dating of the canal within the PHX Sky Train area where three charcoal samples were collected and analyzed. One sample comes from the lower channel fill exposed in Trench 18 and dated

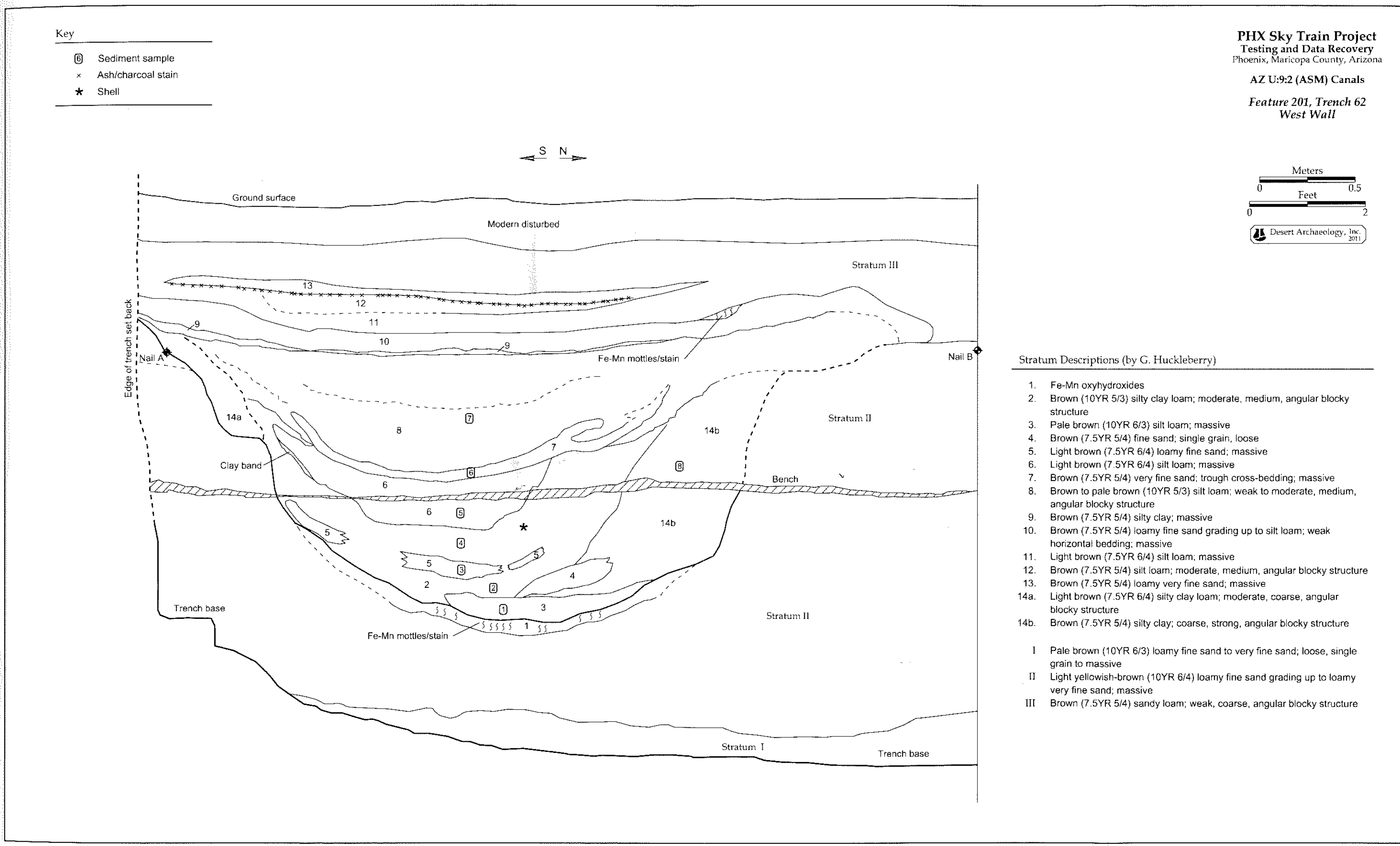
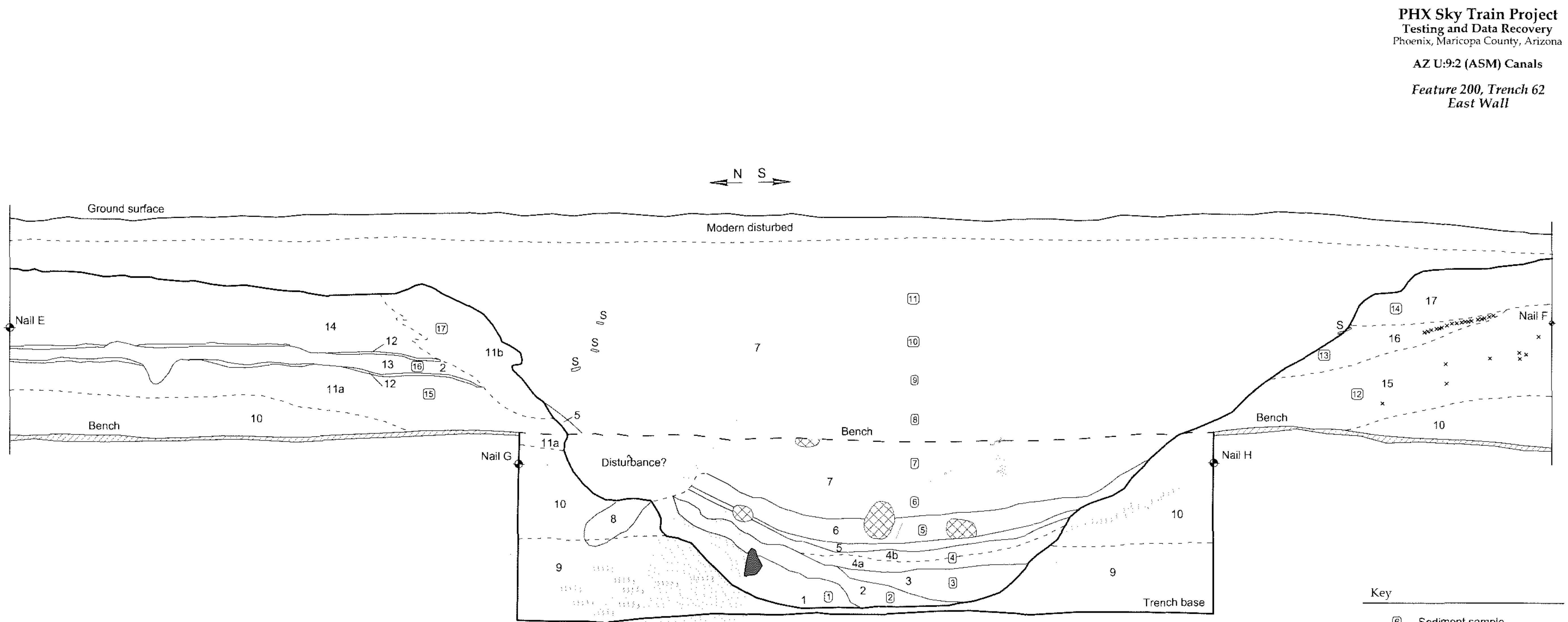


Figure 3.7. Profile of Feature 201 at Trench 62, PHX Sky Train project.



Stratum Descriptions (by G. Huckleberry)

1. Yellowish-brown (10YR 5/4) fine sand; trough cross-bedding and common subangular rip-up clasts of silt; moderate, fine, angular blocky structure
2. Yellowish-brown (10YR 5/4) fine sand; trough cross-bedding;black heavy mineral laminae; loose, single grain
3. Yellowish-brown (10YR 5/4) silt loam; weak, fine, angular blocky structure

4a. Pale brown (10YR 6/3) loamy medium sand with silt laminae; weak, fine to medium, platy to angular blocky structure

4b. Pale brown (10YR 6/3) silt loam with fine sand laminae; weak, fine to medium, platy to angular blocky structure

5. Pale brown (10YR 6/3) silt; massive
6. Yellowish-brown (10YR 5/4) fine sand; trough cross-bedding and common subangular rip-up clasts of silt; sandy matrix is loose, single grain
7. Yellowish-brown (10YR 6/3) loamy fine to medium sand with silt laminae; lower part is more laminated; massive
8. Pale brown (10YR 6/3) loamy coarse sand and silt loam; horizontally bedded at ca. 30° angle; massive to single grain, loose

Stratum Descriptions

9. Light yellowish-brown (10YR 6/4) loamy fine sand; massive
10. Light brown (7.5YR 6/4) silt loam; weak, coarse, angular blocky structure

11a. Brown (10YR 5/3) silty clay loam; moderate, coarse, angular blocky structure

11b. Brown (10YR 5/3) silty clay loam with pockets of loamy sand (mixed); moderate, coarse, angular blocky structure

12. Brown (7.5YR 5/4) silty clay; strong, very fine, angular blocky structure
13. Brown (10YR 5/3) silty clay loam; moderate, medium, angular blocky structure
14. Light brown (7.5YR 6/4) loamy very fine sand grading up to silt loam; lower part massive; upper part weak medium, angular blocky structure
15. Brown (10YR 5/3) silty clay loam; strong, medium to coarse, angular blocky structure; common fine pieces of charcoal
16. Brown (7.5YR 5/4) silty clay and silty clay loam; weak, horizontal bedding; strong, fine to very fine angular blocky structure
17. Brown to light brown (7.5YR 5.5/4) silt loam; weak, medium, angular blocky structure

Figure 3.8. Profile of Feature 200, east wall of Trench 62, PHX Sky Train project.

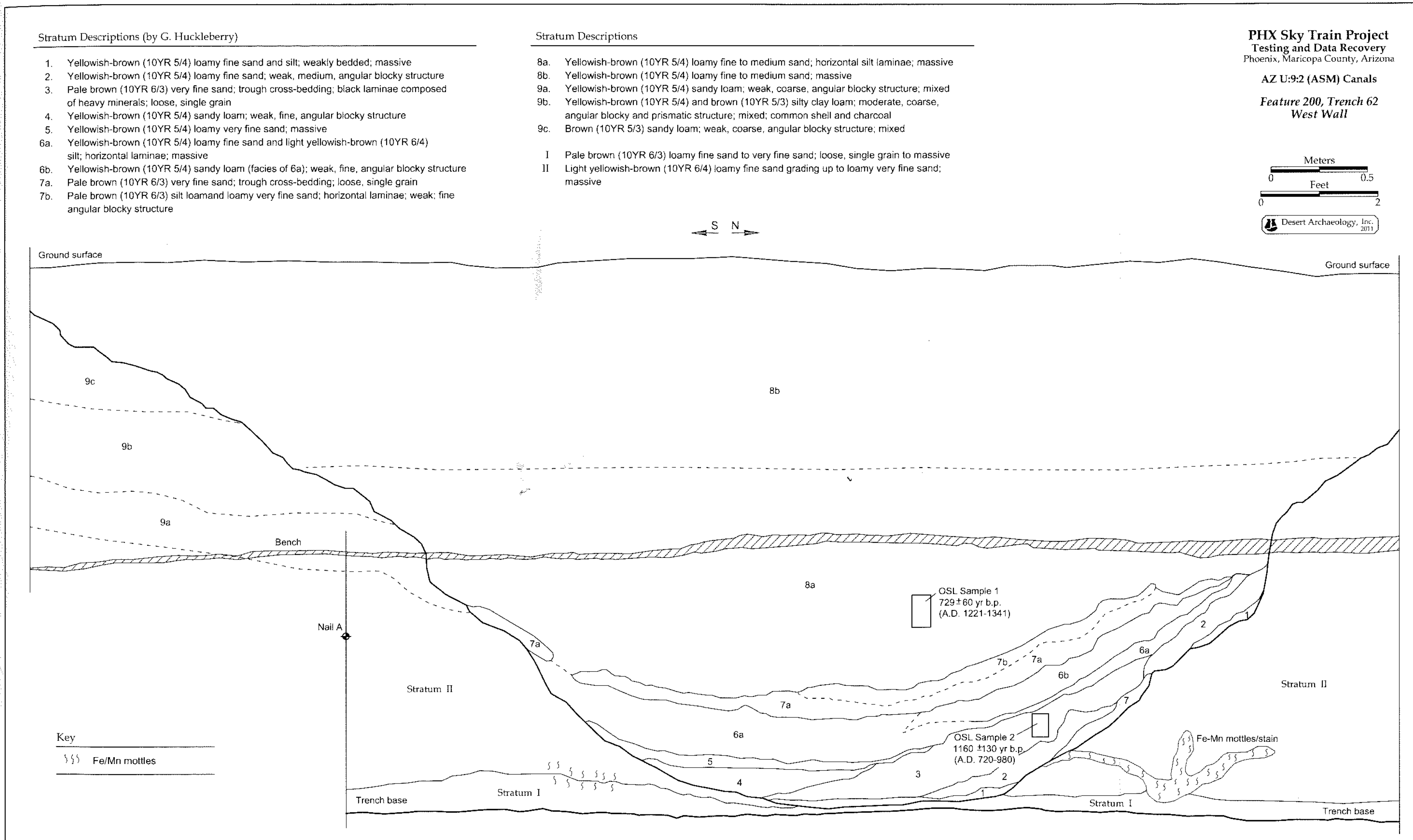


Figure 3.9. Profile of Feature 200, west wall of Trench 62, PHX Sky Train project.

Figure 3.10. Woodbury's (1960) North Canal at Park of Four Waters. (Photo taken October 2007, approximately 450 m southeast [upstream] of PHX Sky Train project exposure at Trench 62; view is to the southeast.)

935±30 ^{14}C yr BP (A.D. 1025-1165) (see Table 3.4). The other two samples come from the same profile in Trench 11 (see Figure 3.16). Charcoal from the lower channel fill dated 755±30 ^{14}C yr BP (A.D. 1220-1285); charcoal from the upper channel fill yielded essentially the same age of 760±30 ^{14}C BP (A.D. 1220-1285).

Of relevance is the fact that charcoal from the upper channel fill in Trench 11 comes from an in situ burn, as evidenced by charcoal, ash, and red oxidized sediment. The charcoal was relatively fine (< 2 mm), suggesting the burning of non-woody vegetation. This sample is unlikely to yield an erroneous age for deposition, due to fluvial reworking of old wood. It is considered to be from an ideal context for ^{14}C dating canal sediments. Therefore, the two ^{14}C samples from Trench 11 probably reflect the true age of this canal during its final episode of use. Averaging the two ^{14}C ages (Long and Rippeteau 1974) yields an age of 760±20 ^{14}C yr BP (A.D. 1225-1280), placing the last operation of the canal at the Soho-Civano phase transition within the Classic period. These ages support stratigraphic relationships where Feature 3 is intrusive into a pond-canal complex, Features 7, 20, and 25, located within Block 7, which dates to the Sedentary period (see below).

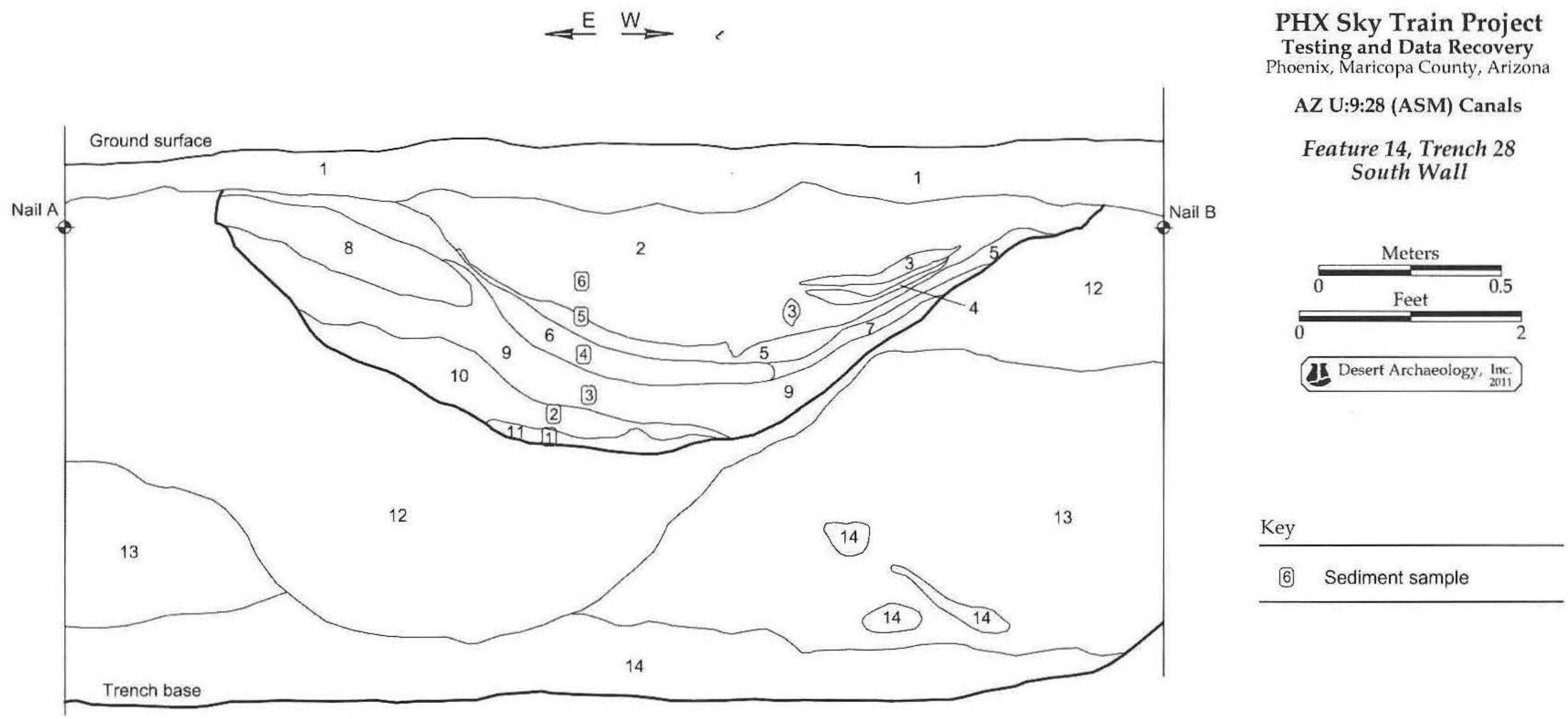
Features 22, 23, and 33

Features 22, 23, and 33 are part of the irrigated field system identified in Block 7 (see Chapter 5). Features 22 and 23 are two small canals aligned south-southwest that were traced from the eastern end of Block 5 into Block 7 (see Figure 3.5). Both canals were stratigraphically cut by, and thus predate, Feature 3. In Block 5, Feature 22 is inset into, and thus postdates, Feature 23 (Figure 3.18). Both canals are aligned directly downslope on the lower piedmont and supply a series of field laterals identified within Blocks 6 and 7, including Feature 33. Feature 22 contains relatively equal mixtures of sand, silt, and clay, resulting in a weakly stratified channel fill with loam textures. In contrast, Feature 23 contains considerably more sand and fine gravel (predominantly granules); four sediment samples from channel fill average 51.5 percent sand and only 15.0 percent clay. The mineralogy in both features is predominantly quartz and feldspar, with common rock (gneiss) fragments (see Chapter 6).

The cross-sectional areas of Feature 22 and 23 are 0.3 m^2 and 0.2 m^2, respectively (see Table 3.6). The alignment and small size of these canals indicate they are small distribution canals derived from an undefined, upslope canal located outside the project area. The general stratigraphy of Feature 23 suggests relatively rapid, episodic, short-lived flow as might be expected for a distribution canal aligned directly downslope and heading toward field areas. This interpretation is inconsistent with evidence presented in Chapter 6, which suggests slower, more persistent flow, potentially allowing for moderate evaporation and increasing downstream salinity. However, the micro-invertebrate assemblage does support a scenario of episodic and short-lived streamflow in Feature 22.

Feature 33 is a small channel that is part of the field lateral system supplied by Features 22 and 23 within Block 7. Feature 33 was cut obliquely in Trench 56 (Figure 3.19), which revealed a sequence of stratified sand, silt, and clay. Mineralogy is predominantly quartz and feldspar, with common rock (gneiss) fragments and few micro-invertebrates (see Chapter 6). Six sediment samples from the channel fill average 35.0 percent sand and 26.7 percent clay. Stratified sands and fine gravel within the channel fill indicate the canal supported multiple pulses of moderate water velocity as it approached the field areas. Preservation of micro-invertebrates within Feature 33 was poor, supporting the episodic nature of this canal's operation.

An OSL sample taken from the lower channel fill of Feature 22 (correlates with Stratum 9 in Figure 3.18) yielded an age of 921±71 yr b.p. (A.D. 1018-1160) (see Table 3.5). This is consistent with stratigraphic relationships that place Feature 22 prior to construction of Feature 3, which was likely constructed in the A.D. 1200s. Another OSL sample was collected from the lower channel fill of Feature 23 (Stratum 3 in Figure 3.19), and dated 860+75, -80 yr b.p. (A.D. 1075-1230). Feature 23 supplied water via



Stratum Descriptions (by Desert Archaeology staff)

1. Brown (10YR 4/3) silty sand mixed with construction debris
2. Dark brown (10YR 3/3) clay; very compact, prismatic structure
3. Grayish-brown (10YR 5/2) silt; very finely bedded, some laminae slightly darker brown
4. Brown (10YR 4/3) silty clay; compact, slightly prismatic structure
5. Yellowish-brown (10YR 5/6) silt; finely bedded, some laminae slighty darker brown
6. Pale brown (10YR 6/3) silty sand, medium, no gravel
7. Brown (10YR 5/3) clay; very compact, prismatic structure

Stratum Descriptions

8. Pale brown (10YR 6/3) silty sand; no gravel
9. Yellowish-brown (10YR 5/4) silt; finely bedded
10. Yellowish-brown (10YR 5/6) silt; finely bedded, charcoal flecked
11. Dark brown (10YR 3/3) silty clay; finely bedded
12. Reddish-brown (5YR 5/4) silt with gravel
13. Yellowish-brown (10YR 5/6) arkosic gravel with caliche nodules
14. Brown (10YR 5/4) silt; finely bedded

Figure 3.11. Profile of Feature 14 at Trench 28, PHX Sky Train project.

Feature 33 to another small field lateral in Block 6 labeled as Feature 29 (see Figure 2.7) that provided a single OSL date of 993±67 yr b.p. (A.D. 950-1084). Taken together, Features 22, 23, and 33 and other downstream field laterals in Block 6 are interpreted as having operated circa A.D. 1000-1150, during the Sedentary period.

Features 7, 20, and 25

The northeastern part of Block 7 upslope (north) from Feature 3 contained a complex series of canal and pond deposits. Feature 25 is a canal that entered the northeastern corner of Block 7 (see Figure 2.7) and terminated in an area of stratified pond sediments interpreted as some form of water storage feature or basin. Pond stratigraphy consisted of stratified gravels, sand, silt, and clay, indicating multiple pulses of flooding. It also contained stratigraphic unconformities, suggesting at least two episodes of dredging; thus, two feature numbers, Features 7 and 20, were assigned to the basin (Chapter 4, this volume). Petrographic analysis of four sediment samples from Feature 7 indicates the deposits are dominated by alkali granite fragments (quartz and feldspar with minor amounts of biotite), derived from flooding on the piedmont rather than the Salt River (Appendix C, this volume). Feature 25, however, appears to be a canal originating on the Salt River. The channel has a cross-sectional area of 0.9 m^2 (see Table 3.6) (Figure 3.20), and correlates to Masse's (1976) Canal 4, U:9:28 (see Figure 2.9), where he described the channel fill as consisting of a basal "chunky clay" overlain by "sandy silt with occasional clay chunks and grus particles." He interpreted this canal to date to the Sedentary period.

Feature 7 contained relatively abundant assemblages of ostracodes and gastropods, indicating it supported ponded water for sustained periods of time (see Chapter 6). Features 7 and 20 appear to have been part of a water storage feature that was supplied primarily by summer flooding on the piedmont. If so, it would have required construction of some type of earthen dam, similar to *charcos* historically constructed by O'odham in the Papaguería (Castetter and Bell 1942). Part of Feature 7 was contemporaneous with Feature 25, indicating that canal water was diverted into the basin at least once, perhaps prior to, or following, the summer rainy season, when runoff is more likely to occur on the piedmont.

Sediments from canal Feature 25 provided an OSL date of 1072+48,-76 yr b.p. (A.D. 862-986); charcoal from upper sediments in basin Feature 7 dated 830±30 ^{14}C yr BP (A.D. 1160-1265). These two disparate ages are difficult to resolve. It is probable that canal and basin were constructed during the Sedentary period, and the basin may have been dredged and reused during the early Classic period.

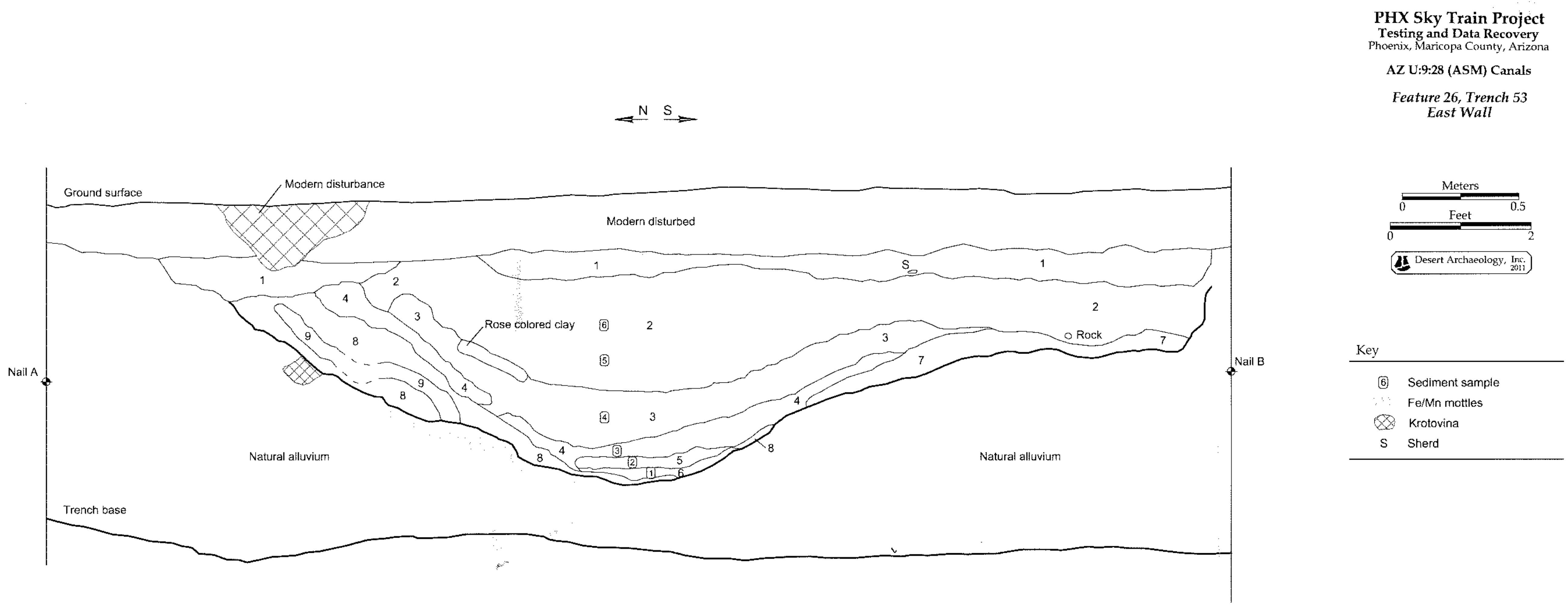
VARIABILITY IN CANAL ALLUVIAL GRAIN SIZE

The PHX Sky Train canals display stratigraphic variability, such as differences in grain size, stratum thickness, color, and so forth, that likely reflects several processes, some cultural and related to regulation of flow within the system, and some natural and related to uncontrolled events like flooding. Certain trends and variability in alluvial grain size within the PHX Sky Train canals stand out and warrant discussion.

Fine-textured Channel Fill of Features 3 and 201

Large main canals located close to their headworks on large rivers like the lower Salt River may be expected to contain sandy deposits indicative of relatively steep gradients, similar to the supplying watercourse, and relatively deep water levels. Many of the large canals encountered by Masse (1976) in the Hohokam Expressway project contained sandy, and in a few cases gravelly, deposits within their channels. This was especially true for the southern canals that Masse (1988) attributed to greater proximity to the headworks of the canals on the Salt River. In contrast, channel fill deposits in Features 3 and 201 in the PHX Sky Train project area contain very little sand and have textures that classify as clay, silty clay loam, and silt loam (see Table A.1). Mean grain sizes for canal use deposits in Features 3 and 201 are small, ranging from 0.006-0.019 mm and 0.007-0.026 mm, respectively (Table 3.7). There is little difference between canal use and postabandonment sediments in Feature 3; the average of mean grain sizes for canal use and postabandonment deposits in Feature 3 are the same, at 0.008 mm (Table 3.8).

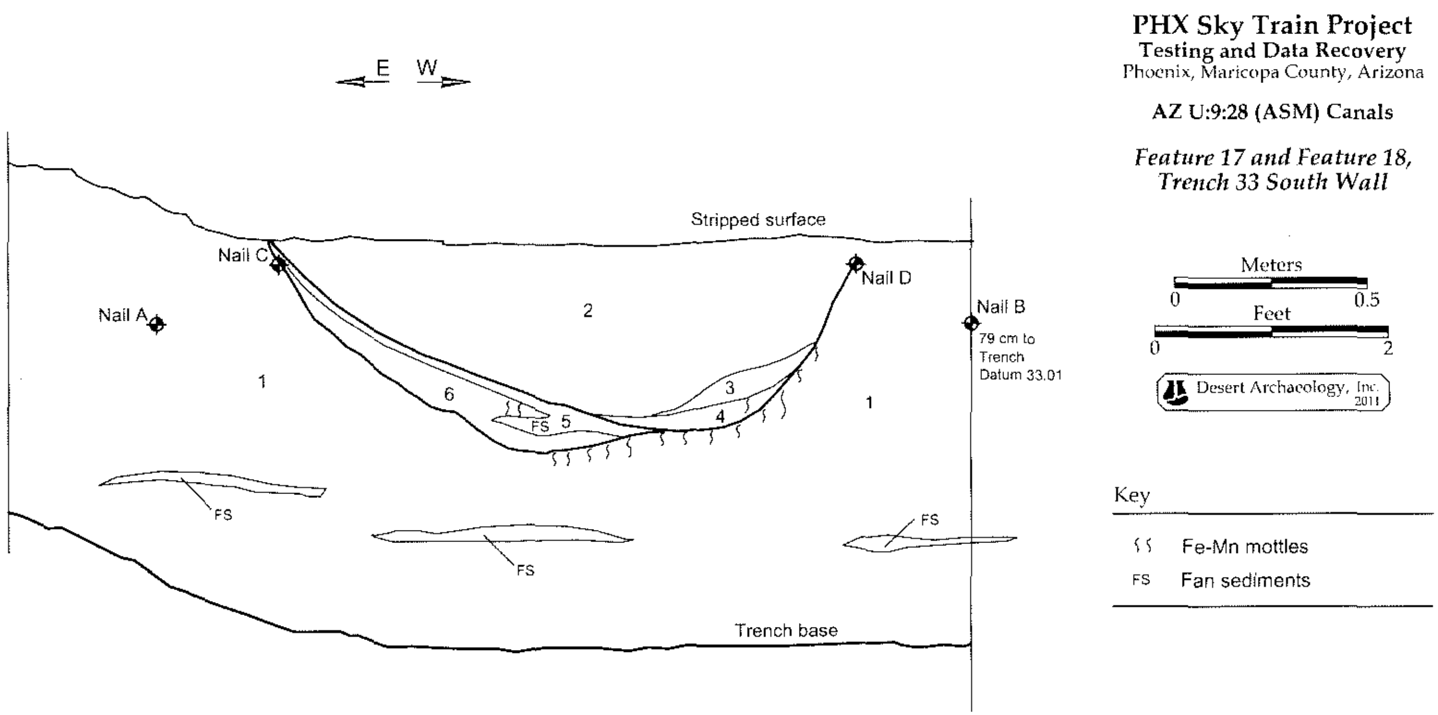
The paucity of coarse-textured alluvium in these two canals suggests that either sand and coarser grain sizes were not available for sediment transport, or that water velocities were insufficient for transporting such grain sizes. Given the availability of coarse sand and gravels in the lower Salt River braided channel belt, the only way for there to have been a paucity of coarse-textured alluvium is if the weirs and headgate structures supplying water to these two alignments prevented the penetration of coarse sand and fine gravel from entering. Unfortunately, prehistoric intake structures are seldom preserved due to floods and erosion. Ethnographic examples of weirs and canal headgates are constructed



Stratum Descriptions (by G. Huckleberry)

1. Brown (10YR 5/3) clay loam; moderate, fine, angular blocky structure
2. Brown (10YR 5/3) silty clay loam; moderate, coarse, angular blocky structure
3. Brown (10YR 5/3) silty clay; strong, fine and coarse, angular blocky structure
4. Brown (10YR 5/3) silty clay loam; moderate, medium, angular blocky structure
5. Light yellowish-brown (10YR 6/4) silt loam; moderate, coarse platy to moderate, medium, angular blocky structure
6. Pale brown (10YR 6/3) silty clay loam; moderate, medium, angular blocky structure
7. Brown (10YR 5/3) silty clay loam (mixed); weak, fine, angular blocky structure
8. Brown (10YR 5/3) silty clay loam; moderate, medium, angular blocky structure
9. Yellowish-brown (10YR 5/4) silt loam; weak, medium, angular blocky structure

Figure 3.12. Profile of Feature 26 at Trench 53, PHX Sky Train project.



Stratum Descriptions (by Desert Archaeology staff)

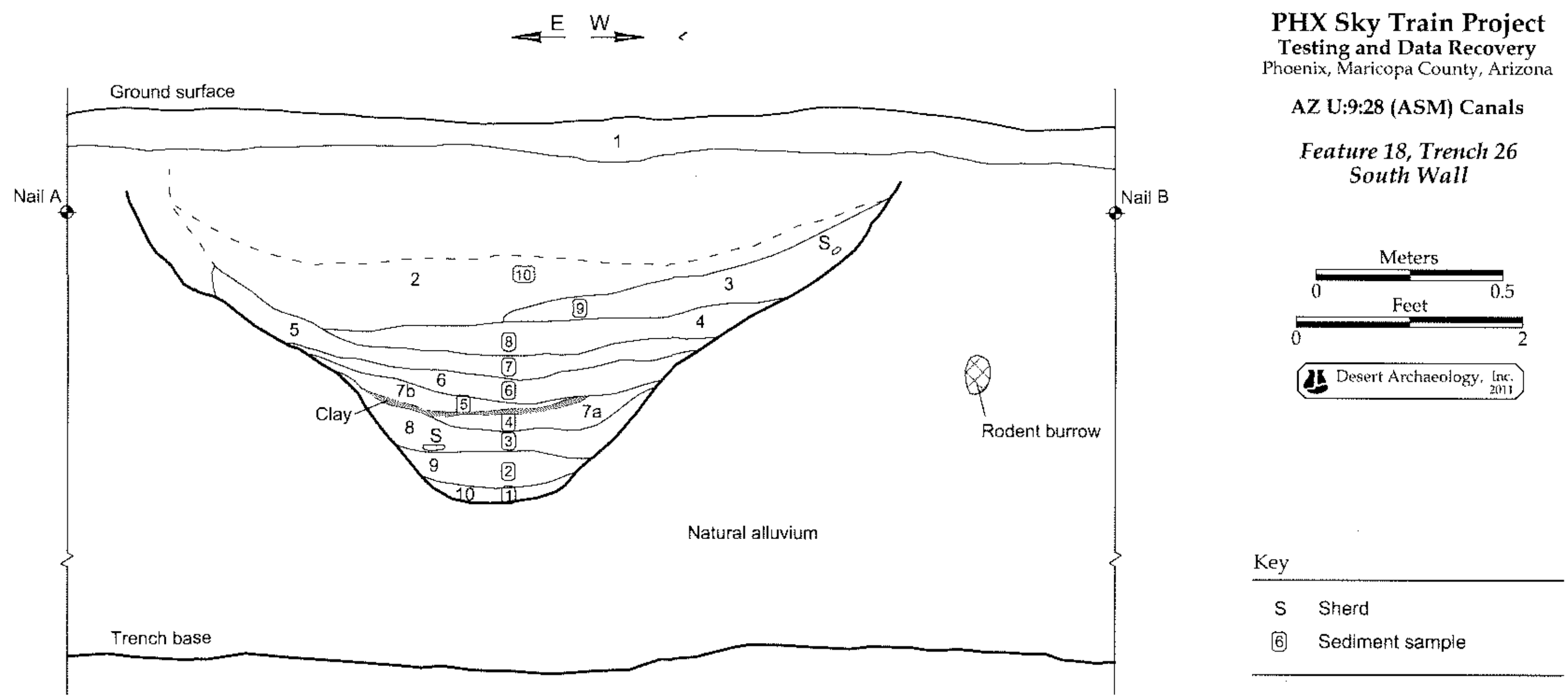
Feature 17

1. Reddish-brown gravels and coarse sand with thin lenses of fine silty sand below the canal
2. Grayish-brown clay; angular blocky structure; occasional charcoal pieces (up to 1 cm diameter), snail shells
3. Lighter grayish-brown clay; bedded; grades into 4
4. Gray to reddish-brown mix of fine gravel, coarse sand, and clay; common Fe-Mn mottles

Feature 18

5. Light brown fine silty sand; bedded; common Fe-Mn mottles
6. Fine gravel grading upward to coarse sand and silty medium sand; bedded

Figure 3.13. Profile of Features 17 and 18 at Trench 33, PHX Sky Train project.



Stratum Descriptions (by L. Purdue)

1. Yellowish-brown (10YR 5/4) sandy silt with gravel and construction debris (modern disturbed zone)
2. Yellowish-brown (10YR 5/4) compact silty clay
3. Brown (10YR 5/3) silt with some clay aggregates, prismatic
4. Pale yellowish-brown (10YR 6/4) silt with some clay aggregates; very loose, massive; bioturbated
5. Dark grayish-brown (10YR 4/2) clay; blocky structure
6. Light yellowish-brown (10YR 6/4) silt with some small gravel (1 mm); loose, massive
7. 7b. Brown (7.5YR 5/4) heterogeneous deposit with small clay aggregates and pockets of sand; slightly prismatic
   7a. Reddish-brown (5YR 5/4) sand with some gravel (1-2 mm); massive
8. Dark brown (10YR 4/6) clay; blocky structure
9. Light yellowish-brown (10YR 6/4) fine silt with pockets of sand and occasional gravels; some laminae evident
10. Very pale brown (10YR 7/4) silt with some small gravel (<1 mm); compact, slightly prismatic, bedded

Figure 3.14. Profile of Feature 18 at Trench 26, PHX Sky Train project.

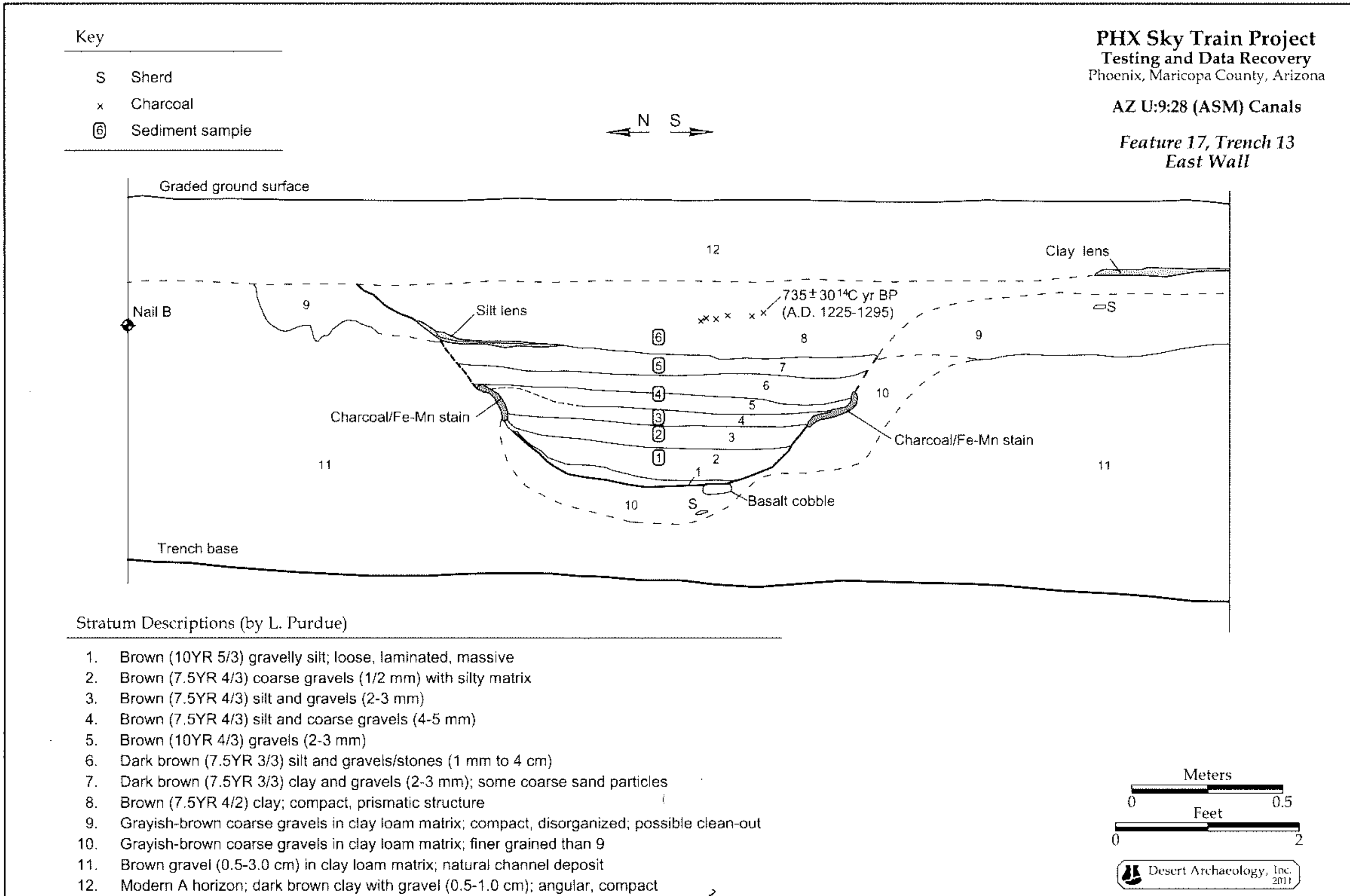
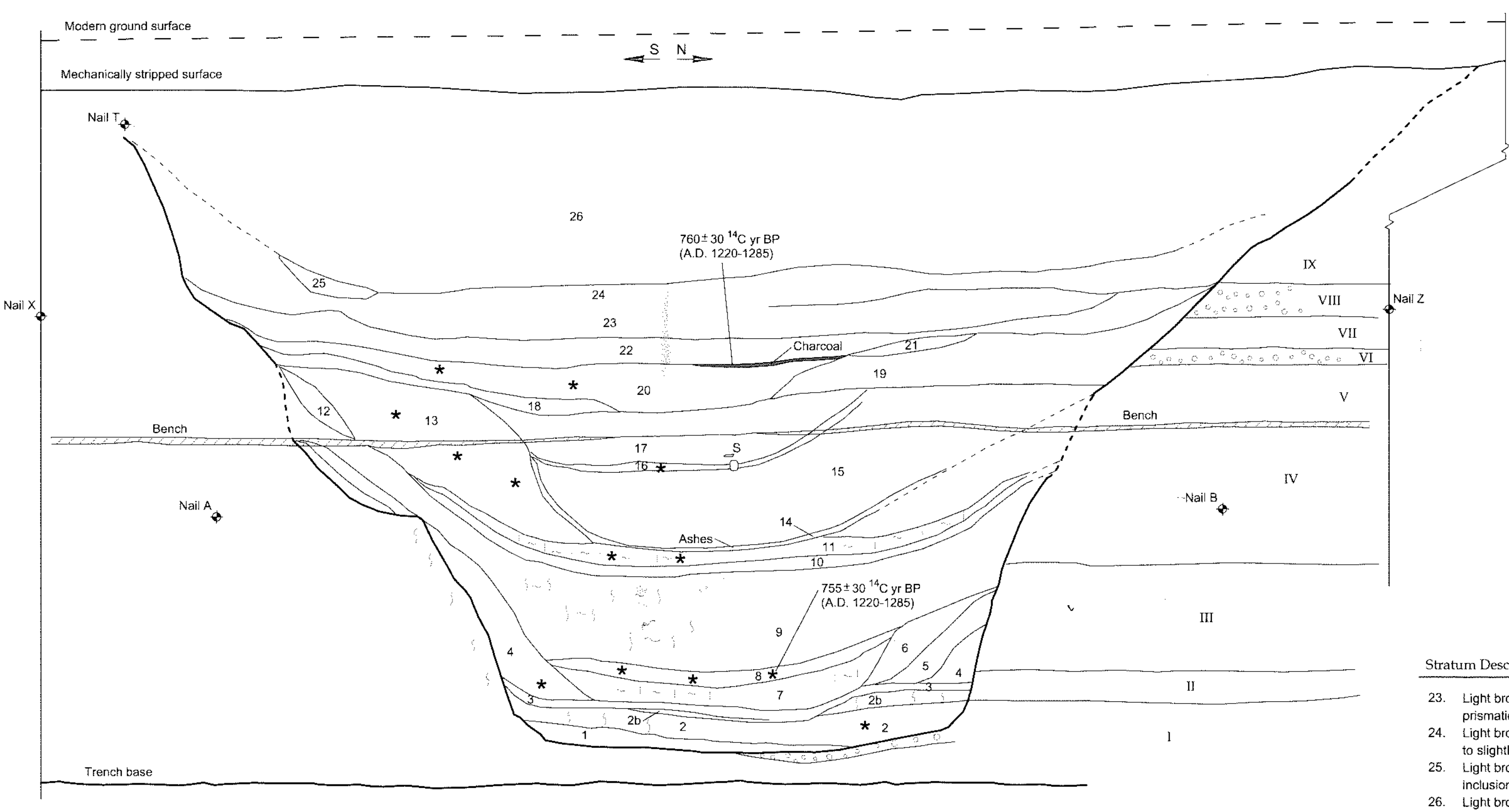
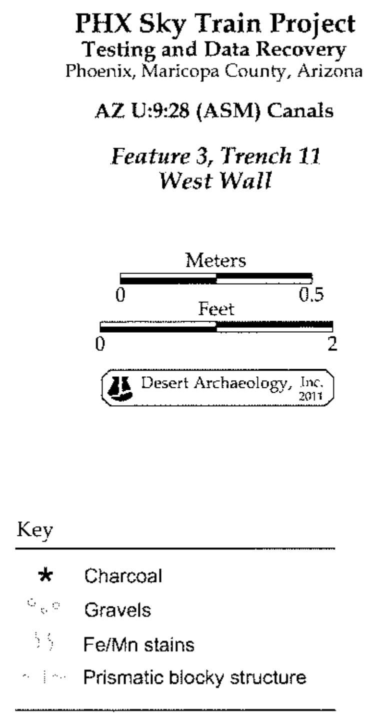


Figure 3.15. Profile of Feature 17 at Trench 13, PHX Sky Train project.





Stratum Descriptions (by L. Purdue)

1. Yellowish-brown (10YR 6/4-5/4) fine sand; loose, slightly laminated, massive
2. Same as 1, but with Iron/Manganese (Fe/Mn) stains
2b. Light brown (10YR 6/4-5-4) sandy silt with occasional gravel (1 mm); massive; Fe/Mn stains
3. Yellowish-brown (10YR 6/4-5/4) sand with some gravel (1-2 mm); loose, laminated; massive; Fe/Mn stains
4. Light brown (10YR 5/3) silt with gravel inclusions (2-4 mm); massive and compacted; Fe/Mn stains
5. Very light brown (10YR 5/3) silt; laminated; Fe/Mn stains at base
6. Light brown (10YR 5/3) silty sand with gravel inclusions (2-3 mm)
7. Reddish-brown (5YR 4/3) clay; blocky/platy structure
8. Light brown clayey silt; massive to slightly prismatic; numerous shells
9. Reddish-brown (5YR 4/3) clay; blocky structure
10. Light brown (10YR 6/4) silty clay; finely prismatic
11. Same as 9, with shells, charcoal flecking

Stratum Descriptions

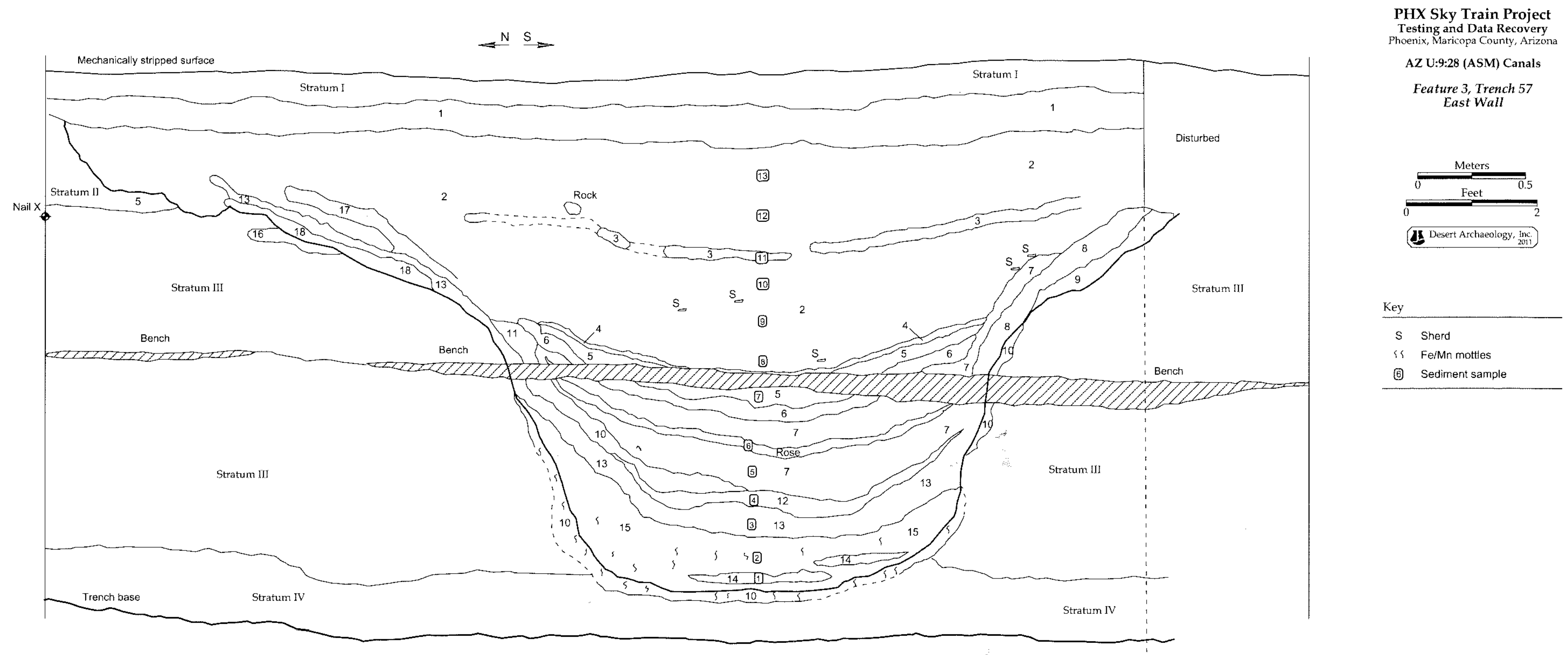
12. Light brown sandy silt with some gravel (2-3 mm) and clay aggregates; loose, heterogeneous deposit
13. Light brown silt with some gravel (1-2 mm) and small clay aggregates; compacted, massive to prismatic; heterogeneous deposit with shell fragments
14. Same as 9 and 11; ashes in situ at base of stratum
15. Brown sandy silt with gravel (1-3 mm); massive; heterogeneous deposit with shells
16. Same as 9, but much finer aggregates (1-3 mm), charcoal flecks
17. Brown sandy silt; loose, massive to slightly prismatic
18. Light brown silty sand with some small gravel (1-2 mm); crumbly
19. Light brown sandy silt; loose, massive to slightly prismatic
20. Light brown (10YR 6/4) sandy silt; more compacted than 19; massive to slighty prismatic
21. Yellowish-brown (10YR 6/4) sand with gravel inclusions (2-3 mm);laminated; decantation facies at top
22. Light brown (orange) silt with gravel inclusions (2-3 mm); slightly prismatic

Stratum Descriptions

23. Light brown (10YR 6/4) sandy silt; compact, slightly prismatic
24. Light brown (10YR 6/4) sandy silt; compact, massive to slightly prismatic
25. Light brown (10YR 6/4) sandy silt with high gravel inclusions (2-4 mm)
26. Light brown (10YR 6/4) sandy silt with some gravel inclusions (2-3 mm); compact, massive

I Yellowish-brown (10YR 6/4-5/4) silt with gravel (up to 1-2 cm); massive
II Yellowish-brown (10YR 6/4-5-4) silt with gravel (1 mm); very loose, massive
III Yellowish-brown (10YR 6/4-5/4) gravelly silt; loose, massive
IV Yellowish-brown (10YR 6/4-5/4) silt with gravel inclusions (all sizes); massive; some clay aggregates
V Same as IX with alternating gravelly layers (1-4 mm)
VI Gravel (< 1 cm) with a silty matrix
VII Same as IX
VIII Gravel (1-3 cm) with a gravelly silty matrix (2 mm)
IX Light brown gravelly silt (gravel 2 mm-1 cm); massive; heterogeneous deposit

Figure 3.16. Profile of Feature 3 at Trench11, PHX Sky Train project.



Stratum Descriptions (by G. Huckleberry; Strata I - IV by Desert Archaeology Staff)

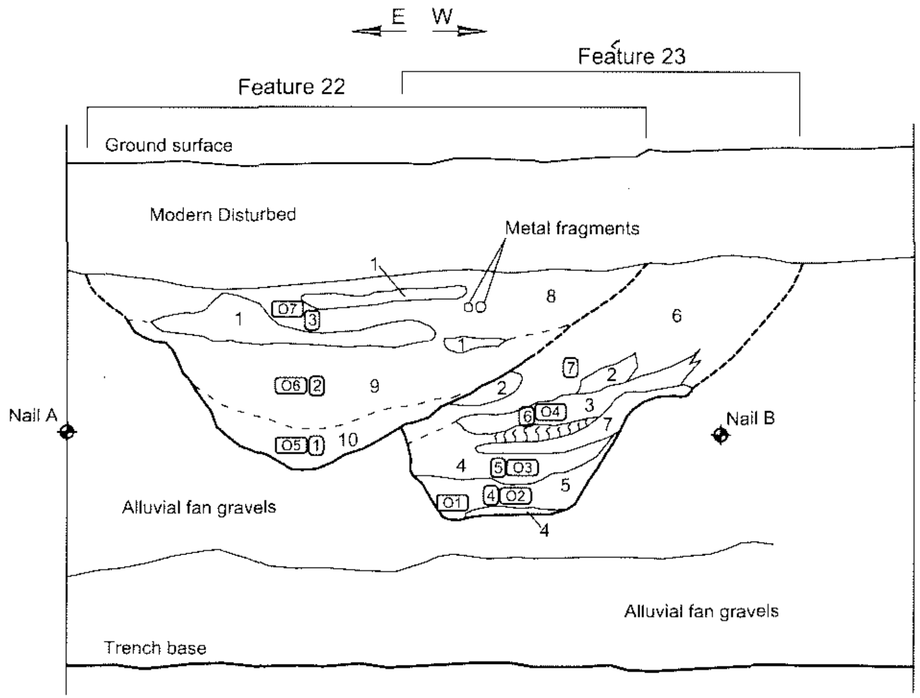
1. Brown (10YR 5/3) sandy clay loam; isolated, rounded, fine gravel (< 1%); moderate, medium, granular structure
2. Brown (10YR 5/3) sandy clay loam; isolated, rounded, fine gravel (< 1%); massive
3. Brown to dark brown (10YR 4/3) silty clay; strong, fine to medium, angular blocky structure
4. Brown to dark brown (10YR 4/3) clay; strong, fine, angular blocky structure
5. Brown (10YR 5/3) silty clay; strong, fine, angular blocky structure
6. Pale brown (10YR 6/3) silty clay; moderate, medium, angular blocky structure
7. Brown (10YR 5/3) silty clay; strong, fine to medium, angular blocky structure
8. Brown (10YR 5/3) silty clay; weak, medium, angular blocky structure
9. Pale brown (10YR 6/3) sandy loam; weak, medium, angular blocky structure
10. Very dark brown (10YR 2/2) and light yellowish-brown (10YR 6/4) Fe/Mn mottles in loamy fine sand; massive
11. Light yellowish-brown (10YR 6/4) silt loam; massive

Stratum Descriptions

12. Light yellowish-brown (10YR 6/4) silt; massive
13. Grayish-brown (10YR 5/2) silty clay; strong, fine, angular blocky structure
14. Brown (10YR 5/3) silty clay; strong, very fine, angular blocky structure
15. Pale brown (10YR 5/3) silt; weak, medium, angular blocky structure
16. Krotovina (Same as 13)
17. Same as 13
18. Pale brown (10YR 6/3) silt loam; weak, medium, angular blocky structure

I Modern disturbance
II Same as III but more angular and bioturbated
III Light yellowish-brown (10YR 6/4) gravelly (1-2 mm) silt; compact, medium, granular
IV Yellowish-brown (10YR 5/4) loose gravel (up to 1-2 cm) and coarse sand;massive; natural channel deposits

Figure 3.17. Profile of Feature 3 at Trench 57, PHX Sky Train project.



PHX Sky Train Project
Testing and Data Recovery
Phoenix, Maricopa County, Arizona

AZ U:9:28 (ASM) Canals

Feature 22 and Feature 23, Trench 40, South Wall

Meters
0 0.5
Feet
0 2

Desert Archaeology, Inc. 2011

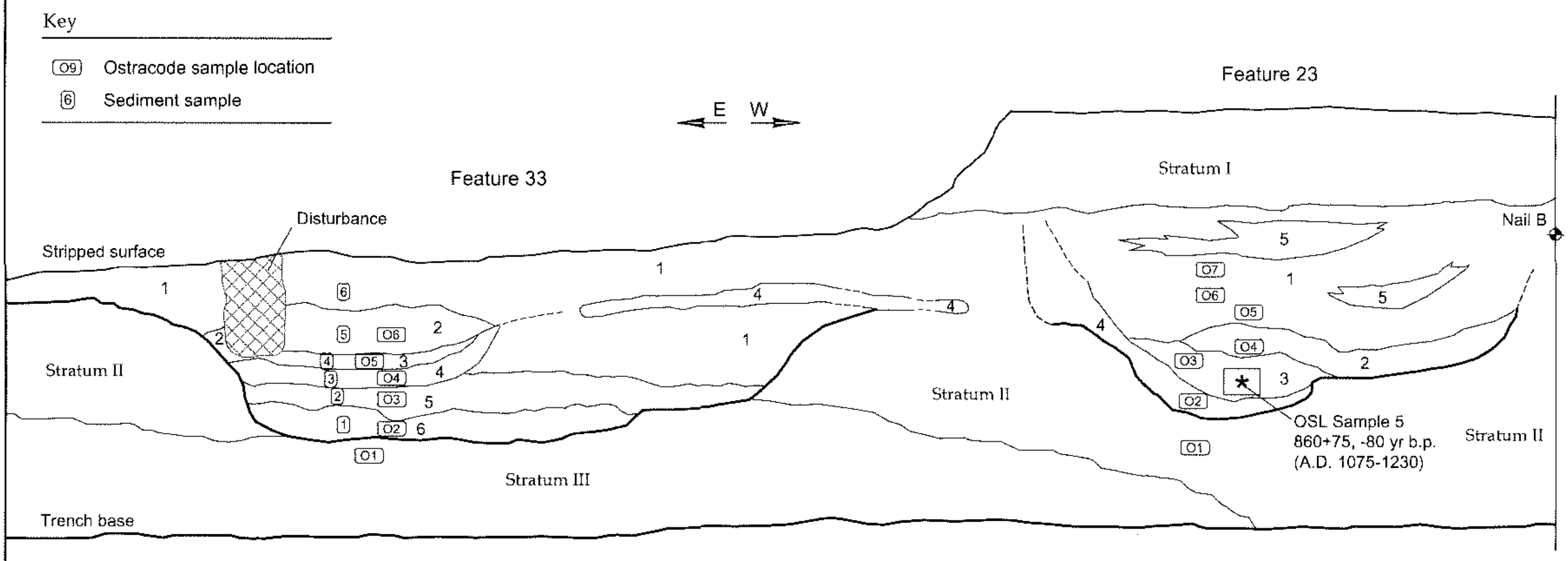
Key

O9	Ostracode sample location
6	Sediment sample
ʃʃ	Fe-Mn stains

Stratum Descriptions (by G. Huckleberry)

1. Brown (7.5YR 5/4) very gravelly coarse sand; ~30% fine, angular, arkosic, fine gravel; single grain; loose
2. Grouped with 6
3. Brown (7.5YR 5/4) sandy loam; massive
4. Brown (7.5YR 5/4) gravelly coarse sand; ~20% fine, angular, arkosic gravel; single grain; loose
5. Reddish-yellow (7.5YR 6/6) very fine sand with lenses of coarse sand; weak trough cross-bedding; massive
6. Brown (7.5YR 5/4) sandy clay loam; weak, medium, angular blocky structure
7. Reddish-yellow (7.5YR 6/6) sandy loam; massive
8. Yellowish-brown (10YR 5/4) sandy loam; ~10% fine, angular, arkosic gravel; massive
9. Yellowish-brown (10YR 5/4) sandy loam; ~2% fine, angular, arkosic gravel; massive; weakly stratified
10. Yellowish-brown (10YR 5/4) sandy clay loam; ~2% fine, angular, arkosic gravel; weak, fine, angular blocky structure

Figure 3.18. Profile of Features 22 and 23 at Trench 40, PHX Sky Train project.



Feature 33 Stratum Descriptions (by G. Huckleberry)

1. Light brown (7.5YR 6/4) sandy loam; ~2% fine, angular, arkosic gravel; massive to weak, medium, angular blocky structure
2. Brown (10YR 5/3) silty clay loam; strong, fine, angular blocky structure
3. Brown to dark brown (10YR 4/3) silty clay; strong, fine, angular blocky structure
4. Brown (7.5YR 5/4) silt loam; moderate, medium, angular blocky structure
5. Brown (7.5YR 5/4) sandy clay loam; moderate, fine, angular blocky structure
6. Brown (7.5YR 5/4) sandy loam; weak, medium, angular blocky structure

I Dark brown clay loam; angular blocky structure, modern disturbed zone

II Light yellowish-brown (10YR 6/4) gravelly (1-2 mm) silt; compact, medium, granular

III Yellowish-brown (10YR 5/4) silty gravel (up to 1-2 cm) with coarse sand intermixed; loose, massive

Feature 23 Stratum Descriptions (by G. Huckleberry)

1. Brown (7.5YR 5/4) gravelly sandy loam with common clasts of silty clay loam; moderate, fine to medium, granular structure with lenses of loose single grain structure
2. Light brown (7.5YR 6/4) sandy loam; moderate, medium, angular blocky structure
3. Dark yellowish-brown (10YR 4/4) clay; strong, fine, angular blocky structure
4. Light yellowish-brown (10YR 6/4) silt loam; massive
5. Subangular fine arkosic gravel

PHX Sky Train Project
Testing and Data Recovery
Phoenix, Maricopa County, Arizona

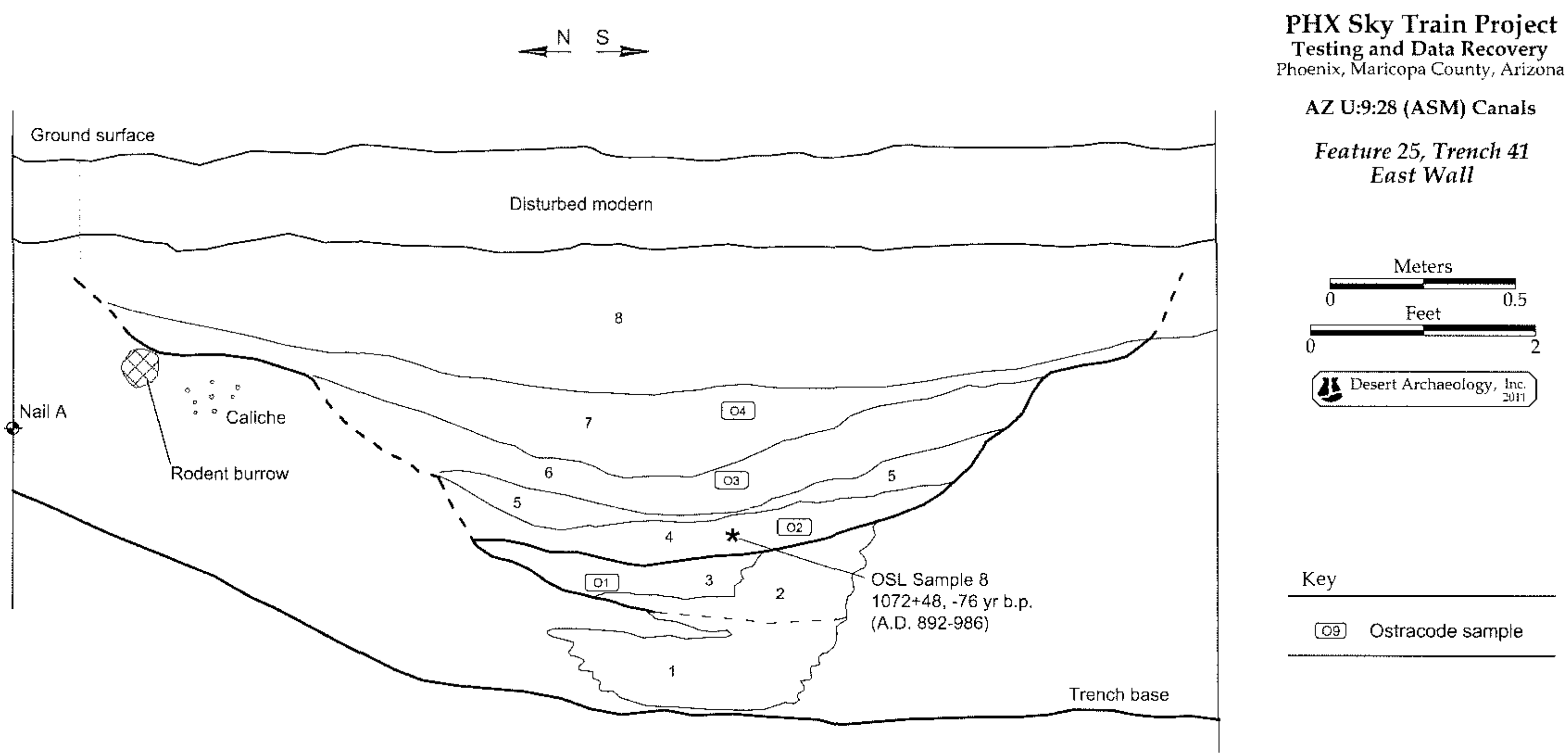
AZ U:9:28 (ASM) Canals

Feature 22 and Feature 23, Trench 56, South Wall

Meters
0 0.5
Feet
0 2

Desert Archaeology, Inc. 2011

Figure 3.19. Profile of Features 23 and 33 at Trench 56, PHX Sky Train project.



Stratum Descriptions (by K. Henderson)

1. Natural wash channel; reddish-brown (5YR 6/4) gravel (< 5 cm); coarse, loose
2. Light brown (7.5YR 6/4) channel gravel (< 1 cm) and sand; coarse, loose
3. Yellowish-brown (10YR 6/4) silt to lightly sandy silt; compact, uniform; grades at northern end to coarse sand to bedded gravel
4. Light brown (7.5YR 6/4) alternating beds of fine sandy silt to silt and gravel; slight Fe/Mn stain at base
5. Yellowish-brown (10YR 6/4) bedded fine silty sand; soft, very finely laminated; beds/laminae follow contour of the canal
6. Light brown (10YR 6/3) sandy silt to silt; compact, blocky angular structure grading to silty clay overlain by thin gravel lens at interface with 5
7. Darker brown (10YR 5/3) clay; hard; blocky, angular structure; no obvious beds
8. Light brown to grayish-brown (7.5YR 6/3) clayey silt to silty loam; very compact, hard, granular structure; slightly porous

Figure 3.20. Profile of Feature 25 at Trench 41, PHX Sky Train project.

Table 3.7. Particle size statistics for canal Features 3, 200, and 201, PHX Sky Train project.

Feature	Sample	Mz[a] (ϕ)	Mz (mm)	σi[b] (ϕ)	Ski[c]	Interpretation
3	1	6.9	0.008	1.7	0.2	Canal use
	2	5.7	0.019	1.8	0.2	Canal use
	3	7.2	0.007	2.4	0.0	Canal use
	4	6.1	0.015	1.8	0.0	Canal use
	5	Insufficient data				Canal use
	6	8.7	0.002	2.3	-0.5	Canal use
	7	7.4	0.006	1.4	0.3	Canal use
	8	6.8	0.009	2.1	0.0	Postabandonment
	9	7.0	0.008	2.6	-0.3	Postabandonment
	10	6.7	0.010	2.6	0.0	Postabandonment
	11	8.0	0.004	3.0	0.2	Postabandonment
	12	7.1	0.007	2.5	0.0	Postabandonment
	13	6.4	0.012	2.5	0.2	Postabandonment
200	1	4.8	0.035	2.2	3.7	Canal use
	2	3.8	0.072	1.4	0.9	Canal use
	3	5.8	0.018	2.4	0.5	Canal use
	4	3.9	0.067	2.6	1.7	Canal use
	5	5.0	0.031	2.3	0.2	Canal use
	6	4.2	0.053	2.7	2.0	Flood
	7	5.0	0.032	2.7	1.4	Flood
	8	3.3	0.099	3.0	3.3	Flood
	9	4.4	0.048	3.0	2.5	Flood
	10	4.0	0.064	2.9	1.5	Flood
	11	4.0	0.063	3.1	2.0	Flood
	12	6.8	0.009	2.1	1.3	Clean-out
	13	7.8	0.004	1.6	0.2	Clean-out
	14	6.4	0.012	1.9	0.6	Clean-out
	15	6.5	0.011	2.2	1.2	Clean-out
	16	6.2	0.014	2.1	0.0	Clean-out
	17	5.6	0.020	2.2	0.2	Clean-out
201	1	6.5	0.011	1.7	0.0	Canal use
	2	6.8	0.009	1.3	-0.1	Canal use
	3	6.9	0.009	1.3	-0.1	Canal use
	4	7.0	0.008	1.7	0.2	Canal use
	5	6.1	0.015	1.8	0.0	Canal use
	6	5.3	0.026	1.9	1.7	Canal use
	7	7.1	0.007	1.8	0.0	Postabandonment
	8	8.3	0.003	2.1	0.0	Clean-out

[a]Mz = graphic mean particle size.
[b]σi = graphic standard deviation.
[c]Ski = graphic skewness (see Boggs 2001).

of rock and vegetation (Doolittle 2000:364; Haury 1976:148-149) that appear to permit the entry of sand, and indeed, the sandy berms of Woodbury's (1960) North and South canals at Park of Four Waters suggests that lower Salt River sand regularly entered these large canals. Indeed, the larger main canals may have only contained weirs for diverting river flow but no headgates to regulate the size of the discharge (Masse 1988). Thus, the predominance of fine-textured deposits in large canals presumably located close to their headworks strongly suggests limited water velocities. This, in turn, implies relatively limited water depths and insufficient flow to transport coarser sediment, at least during their final stages of use.

Another possible explanation for the relatively fine-textured channel fill for Features 3 and 201 is that the headworks for each canal were located some distance upstream, such that most of the sand introduced by the Salt River into the canal alignment fell

Table 3.8. Mean and variation of grain size statistics for canal Features 3, 200, and 201.

Feature	Deposit Type	Mean of Mz (ϕ)	Mean of Mz (mm)	CV of Mz (ϕ)
3	Canal use	7.0	0.008	0.15
3	Postabandonment	7.0	0.008	0.08
200	Canal use	4.7	0.038	0.18
200	Flood	4.1	0.058	0.13
200	Clean-out	6.6	0.010	0.11
201	Canal use	6.5	0.011	0.10

out of suspension before reaching the PHX Sky Train area. This seems unlikely for Feature 201 due to its proximity to the historic Salt River braided channel belt. Feature 3, however, is located at a higher elevation farther from the river on the toe of the piedmont, and it could have extended farther upstream, perhaps beyond Point 2 shown on Figure 3.4. Unfortunately, much of the northern edge of the Salt River floodplain adjacent to the Papago pediment has been scoured, leaving little potential for preservation of such an alignment.

Flood Deposit in Feature 200

Feature 200 was unique in that approximately two-thirds of its channel fill was relatively homogenous, suggesting uniform streamflow. Because this deposit extends laterally beyond the edges of the channel (see Figure 3.8), it was clearly formed by a Salt River flood that inundated the canal alignment. One of the great challenges of identifying evidence for destructive flooding in most of the lower Salt River Hohokam canals is that the upper dimensions are seldom preserved, thereby removing the opportunity to trace flood deposits beyond the canal channel. Why this key stratigraphic relationship is preserved at Trench 62 is unclear given historic land leveling in the PHX Sky Train project area. The upslope (northern) edge of Feature 200 that is overlain by flood sediments does not appear to contain evidence of a berm (see Figure 3.8).

The Trench 62 profile reveals that the lower contact of the flood deposit becomes progressively more shallow to the north, but does not appear to overlie a berm. The same is true for the southern end of Trench 8, which exposed only the northern edge of Feature 200, but that again, did not reveal any evidence of a canal berm but did have flood deposits extending beyond the canal alignment. This is at odds with historic Bureau of Reclamation topographic maps that show berms of Woodbury's (1960) North and South canals extending northwest into the PHX Sky Train project area (see Figure 3.2). The berm heights of these large canals may have decreased downstream as they became more vulnerable to floodwater overtopping the channel, causing the erosion of berm segments, possibly at scales too small to have been recorded by the Bureau of Reclamation in the early 1900s. Unfortunately, Feature 200 only transected a small corner of Block 4 and did not allow for detailed excavations along the canal alignment.

Active canal deposits (lower stratigraphy) in Feature 200 are sandy with silt rip-up clasts, suggesting moderate streamflow with some turbulence. Interestingly, the lower deposits are not dramatically different in texture than the overlying flood deposit. The Feature 200 flood deposit lacks gravel and contains only a limited amount of coarse sand. Mean grain sizes for the flood deposit range from 0.032-0.099 mm, while active (canal-use) deposits range from 0.018-0.072 mm (see Table 3.7). The average grain size for all the flood deposit samples was 0.058 mm, compared to 0.038 mm for the canal-use deposits (see Table 3.8). Similarity in grain size between the lower and upper deposits may have been why Masse (1976:24) was reluctant to declare the upper homogenous fill as evidence for flooding. Feature 200 demonstrates that a single Salt River flood can completely fill and bury a very large earthen canal in its upper reaches with moderately fine-textured, sandy and silty alluvium.

Grain Size Variability in the Smaller Canals

Detailed granulometry was not conducted on the smaller distribution and field lateral canals. However, the sand, silt, and clay fractions within the channel fill of these features can be used to infer flow regime and use-history. For example, assuming equal availability of different grain sizes for transport, the ratio of sand:silt + clay reflects differences in relative water velocity within and among canals. Overall, the PHX Sky Train distribution and field lateral canals display variable water velocity. Features 14 and 26 both have deposits dominated by silt and clay, with sand:silt + clay ratios of < 1.0 (Table A.2) suggesting low-velocity streamflow. In contrast, the middle to lower deposits in Features 17 and 18 have sand:silt + clay ratios > 1.0. Because Features 17 and 18 are downstream segments of the Feature 26 alignment, it suggests a discontinuity within the canal system. The last use of Feature 26 appears to have delivered water down the Feature 14 alignment, whereas Features 17 and 18 represent earlier episodes of use within the Feature 26 system. Alternatively, the uppermost fine-textured deposits in Features 17 may be coeval with the last use of

Feature 26. It is difficult to know for sure without continuous tracing of canal stratigraphy down the alignment.

Regardless of the connectivity of these canals, an earlier use of Feature 26 was characterized by relatively ample streamflow, and the last use was characterized by limited water depths and reduced water velocity, resulting in the deposition of silt and clay-dominant alluvium. This last episode of use appears to have occurred during the Classic period, based on the ^{14}C date of 735±30 ^{14}C yr BP (A.D. 1225-1295) from charcoal in the upper fill of Feature 17 (see Table 3.4).

Features 22 and 23 are different than other PHX Sky Train distribution canals in that they are aligned directly down the piedmont, resulting in a greater hydraulic gradient and larger range of water velocities. This is demonstrated by Feature 23, which contains both high-energy gravelly sandy deposits and low-energy silt and clay deposits. Feature 22, in contrast, contains low-energy deposits with sand:silt + clay ratios of < 1.0. Field lateral Feature 33, which directed water to field cells in Block 6, is also dominated by low-energy silt and clay.

Variability in grain sizes seen in smaller distribution and field lateral canals is ultimately controlled by the amount of water released into their channels at their respective headgate structures. Those small canals that have a general coarse to fine vertical particle size trend likely reflect individual episodes of use and the regulation of flow by upstream headgates. Those with predominantly fine-textured sediments throughout the channel fill may indicate issues of limited water availability. Evidence of flood damage, either from the Salt River or piedmont, is not apparent in these smaller PHX Sky Train channels.

HYDRAULIC RECONSTRUCTIONS

Water velocity and discharge reconstructions for the PHX Sky Train canals were calculated by combining measures of channel width and depth with estimates of channel slope and hydraulic roughness and using standard equations for open-channel flow (Chow 1959; Farrington 1980). Resulting discharge estimates, in turn, were used to calculate the irrigation capacity; that is, the amount of land a canal could have supported for successful production of crops (Haury 1976; Howard 1994; Mabry et al. 2008). Despite this straightforward approach, hydraulic reconstructions in prehistoric canals are subject to error due to subjectivity in estimating hydraulic parameters (Holmlund 2008), chief among them, depth of flow. Earthen canals did not support bankfull flow during normal operation, especially those located on the Lehi Terrace, where sandy soils were prone to scour (Lombard 1988). How much less than bankfull flow the PHX Sky Train canals actually supported is unclear, and would likely have changed through time within and among canal alignments depending on water availability. Despite these unknowns, it remains worthwhile to conduct discharge reconstructions for the project canals, as they provide a reasonable estimate of flow capacity, susceptibility to channel scour, and potential agricultural productivity.

Channel width and depth were combined with estimates of local slope and hydraulic roughness to reconstruct water velocity and discharge for the Sky Train canals using the Manning equation for open channel flow, as follows.

$$V = R^{0.67} \cdot S^{0.5} \cdot n^{-1}$$

where V = velocity (m/s)
R = hydraulic radius (m)
S = slope
n = coefficient of roughness

and the continuity equation:

$$Q = A \cdot V$$

where Q = discharge (m^3/s)
A = cross sectional area (m^2)

Two different slope estimates were in the velocity reconstructions. Canals aligned southeast to northwest were estimated to have a slope of 0.0006, based on the gradient measured for the upper approximately 7 km (4.3 mi) of prehistoric Canal Bueno, Feature 200, as mapped by Howard and Huckleberry (1991) and using topographic map software[3]. This slope value matches the gradient of the nearby historic Grand Canal (Huckleberry 1988:163) (see Figure 3.4). Features 22 and 23 are aligned northeast to southwest on the lower piedmont, and are estimated to have a slope of 0.0052, based on a 1 km transect through the NW ¼ of Section 7, Township 1 North, Range 3 East. The Manning's coefficient of roughness is estimated at *n* = 0.030, based on an assumption of relatively straight to gradually curving channels, sandy loam bank material, and some vegetation growth along the banks (Chow 1959:101-106).

Two different flow depths were used for estimating water velocity and discharge (see Table 3.6). One is a "full" flow depth using the maximum depth of the extant channel preserved in the subsurface. As noted, it is unlikely that regulated flow was bankfull in these canals. However, the resulting velocity

[3]Slope calculated using Terrain Navigator (version 8.51).

and discharge values represent a theoretical maximum, and provide insight into the erosive potential of unregulated streamflow. The other depth used in the hydraulic reconstructions is half the full flow depth. This represents a more reasonable estimate of regulated streamflow in the canals, although Ackerly (1991) notes that average flow depths for historic earthen canals were often as low as one-third full channel depth.

Resulting bankfull water velocities in all the canals except Feature 200 are less than 1.0 m/s, which is close to the upper limit for bank stability in channels excavated into loamy sand soils (Fortier and Scobey 1926). Bankfull water velocity for Feature 200 is 1.0 m/s, and thus, approaches the threshold for channel scour. Therefore, the flood that marks the final flow event in this canal may have eroded the berm on the northern side of the channel as previously posited. Water velocity reconstructions for half-full conditions in the main canals resulted in values of 0.2-0.5 m/s. These velocities are certainly below the threshold for erosive scour, but are likely to have had limited capacity to transport coarse sand, and coarser grain sizes, within the alignment (Hjulstrom 1939). The paucity of coarse sand in the relatively large channels of Features 3 and 201 suggests they may have only supported half-full (or lower) water depths during their final episodes of use.

Discharge estimates assumed here for half-full canals approximate normal flow conditions. The largest canal, Feature 200, has a half-full discharge of 2.5 m^3/s, which is considerably larger than any of the other canals (see Table 3.6); the next two largest canals, Features 3 and 201, have half-full discharge values of only 0.6 m^3/s. The smaller canals with southeast-northwest alignments have half-full discharge values of 0.04 to 0.2 m^3/s, while the two small canals aligned directly downslope on the lower piedmont, Features 22 and 23, have discharge values of 0.04-0.05 m^3/s.

Historic analogs that relate canal discharge and irrigated acreage provide some insight into the irrigation potential of the PHX Sky Train canals. Ackerly's (1991) analysis of discharge and irrigated area, based on early Euro-American earthen canals from Arizona and New Mexico, suggests that about 86 acres could be supported by 1 ft^3/s of canal discharge (or roughly 1,230 ha supported by 1 m^3/s). Using this empirical relationship, the largest PHX Sky Train canal, Feature 200, could have supported 3,028 ha (7,482 ac, or 11.7 mi^2). This does not exceed the potential arable area located downslope from this 15-km-long canal as it crosses the piedmont. However, the canal likely did not actually support this much irrigated area at any one time, and the estimate is considered an upper limit to potential irrigable area. The other two large main canals, Features 3 and 201, have considerably smaller estimated irrigable areas of 737-750 ha (1,821-1,853 ac, or 2.8-2.9 mi^2). The other southeast-northwest aligned PHX Sky Train canals have estimated irrigable areas of 52-265 ha (128-655 ac, or 0.2-1.0 mi^2).

Whereas the canals aligned southeast-northwest may have delivered water to areas located some distance from the PHX Sky Train project area on the Lehi Terrace and piedmont, Features 22 and 23 supported fields identified in Block 6. These two canals have estimated irrigable areas of 55-63 ha (136-156 ac, or ca. 0.2 mi^2). This is considerably larger than the area of the Block 6 agricultural fields identified during excavation. Either these canals supported other field areas not identified in the project area, or the historic analogs overestimate irrigated area.

These hydraulic calculations highlight the uncertainties involved in estimating irrigation capacity from partially preserved relict earthen canal segments. Irrigation requirements in the lower Salt River Valley depend on crop, soil type, local hydrology, and canal design, among other factors (Nials and Gregory 1989). Several of these factors differ between prehistoric and historic canal systems, making it difficult to identify the true agricultural capacity of a canal without preservation of the entire system from primary intake to irrigated field. The identification of prehistoric agricultural fields and their supporting canals in Block 6 and similar features recently encountered at the Las Capas site, AZ AA:12:111 (ASM), near Tucson (Herr 2009a) will hopefully improve current understanding of the relationships between canal channel size, discharge, and irrigable area. Preliminary analysis suggests that historic analogs overestimate irrigable area.

CORRELATIONS IN CANAL SYSTEM 2

Features 3, 200, and 201 are main canals located relatively high within Canal System 2 that continued some distance northwest of the PHX Sky Train project area. Thus, there is a good probability that downstream segments of these canals were encountered during previous archaeological investigations within Canal System 2 (Figure 3.21). Unfortunately, the ability to link distant canal segments is complicated by the fact that there are multiple, closely spaced, parallel alignments, and that canal channel morphology and stratigraphy change downstream. In a previous investigation of Canal System 2, Howard (1990, 1994) established rigorous criteria for linking distant canal segments, including canal contemporaneity, elevation, historic mapping, historic aerial photography, and channel morphology (Howard 1990:47-48). Howard (1990) linked segments within seven main canal alignments in Canal

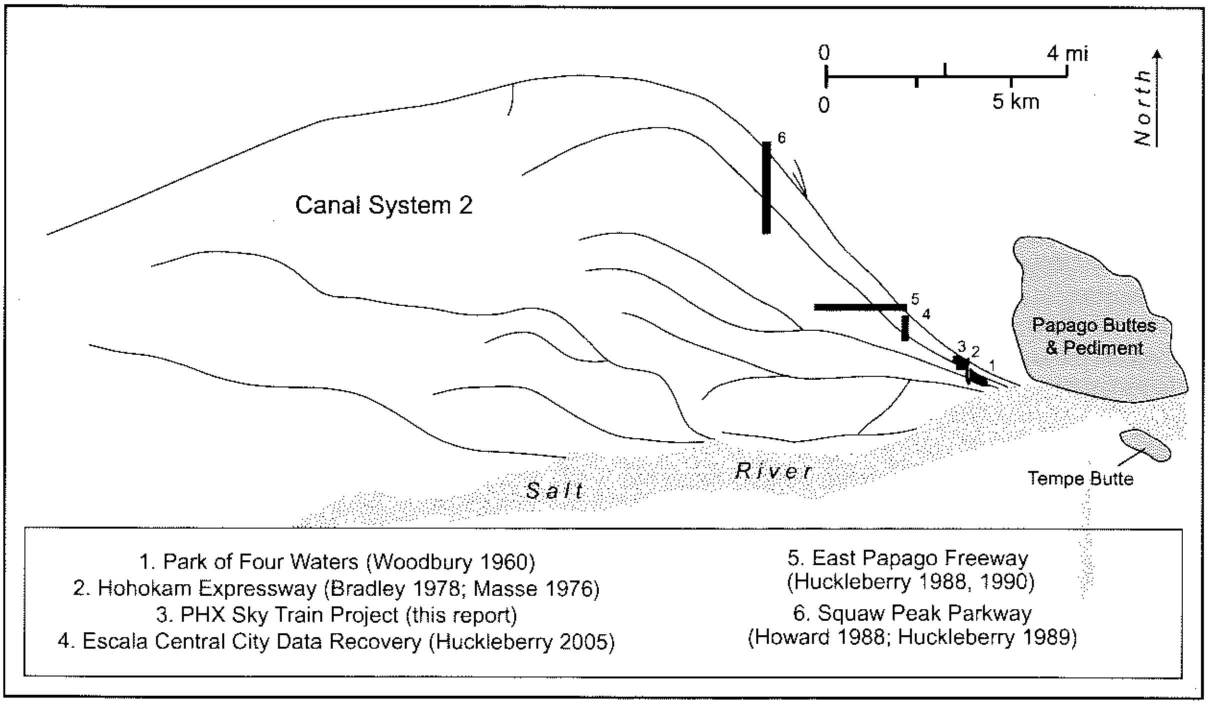


Figure 3.21. Location of selected canal investigations within Canal System 2 containing canals that correlate to the current project area.

System 2 and determined that cross-sectional area rapidly decreases near the headworks and then more gradually farther downstream. This can be modeled with a negative exponential equation, similar to that used to standardize tree-ring chronologies (see R. Bradley 1999:406-412), or a negative logarithmic equation, such as used by Howard (1990, 1994).

Correct correlation of prehistoric canal segments and modeling of the downstream decrease in cross-sectional area within Canal System 2 has the potential to shed light on the allocation of water within the system, which, in turn, relates to the spatial organization of settlements and fields. It also allows a better estimate of the size of a canal system and the labor requirements associated with its construction and maintenance (Howard 1994; Hunt et al. 2005). From a geoarchaeological perspective, correlation of distant canal segments helps one to better describe downstream sedimentological changes within canal alignments, and thus, better model depositional facies within these fluvial systems. The characterization of depositional facies within canals is the first step toward reconstruction of canal use history (Huckleberry 1991; Masse 1988) and helps to identify evidence of destructive flooding (Huckleberry 1999a, 1999b), a process that greatly increased labor requirements and decreased the life span of canal systems (Ackerly et al. 1987; Howard 1994; Ingram and Craig 2010).

Given multiple, parallel, closely spaced alignments within Canal System 2, there is the potential for miscorrelation of canal segments, especially when canal exposures are separated by several kilometers. Greater confidence can be ascribed to correlations of canal segments located in the upper part of Canal System 2 at the higher elevations, such as prehistoric Canal Grande, the highest (farthest upslope) canal on the piedmont (Turney 1929). Howard (1994) linked segments of this canal that were excavated in the northern end of the Hohokam Expressway project north of the modern Grand Canal (Bradley 1978), East Papago Freeway (now SR 220) (Huckleberry 1988, 1990), Squaw Peak Parkway (now SR 51) (Huckleberry 1989), and in a storm drain beneath Central Avenue near Camelback Road (Howard 1990). Several other Canal System 2 main canal alignments occur approximately parallel and downslope (lower on the piedmont) from Canal Grande, some of which pass through the PHX Sky Train project area. How Features 3, 200, and 201 connect with the rest of Canal System 2 and compare with Howard's (1994) linking analysis are presented below. The canals are presented in order of their occurrence from south to north in the PHX Sky Train project area.

Feature 201

Feature 201 is a downstream segment of Masse's (1976) Canal 10, U:9:2. Howard (1990:Figure 7) suggested that Masse's Canal 10 turned west before crossing the Southern Pacific Railroad and eventually linked with canal Feature 247 at the Los Solares locale of La Ciudad, AZ T:12:1 (ASM) (see Ackerly et al. 1987). An alternative correlation presented here is that Feature 201 maintains a more northwesterly alignment and links to Feature 4 at Escala Central City Project area at 36th Street and Van Buren (Huckleberry 2005) and Feature 26 in the East Papago Freeway (Huckleberry 1988) (Figure 3.22; Table 3.9; see also Figure 3.21). This is supported not only by cross-sectional area measurements, but also by a very distinct clay channel fill that is found in the Hohokam Expressway, PHX Sky Train, Escala Central City Project, and East Papago Freeway canal segments. This canal alignment is also positioned immediately downslope from prehistoric Canal Bueno, Feature 200, in both the PHX Sky Train and East Papago Freeway project areas.

Correlation of Feature 201 with other canals previously identified downstream of the East Papago Freeway is less certain. It is proposed here that PHX Sky Train Feature 201 may link with Feature 79 at Casa Buena, AZ T:12:36 (ASM), located within the Squaw Peak Parkway (Howard, ed. 1988:254). Feature 79 contains two channels, indicating an episode of remodeling. Of these, Channel 2 is the most recent and best-preserved channel, although it is relatively sandy and unlikely to represent use coeval with the channel fill in PHX Sky Train Feature 201. In contrast, Channel 1 contains a dark brown, organic, blocky clay that strongly matches channel fill identified in the East Papago Freeway and PHX Sky Train area. The dimensions of Channel 1 are partly hidden by Channel 2, although Howard (ed. 1988) estimates a channel width of about 4.5 m; the depth of Channel 1 is 90 cm.

Feature 79 also appears to be the closest, northwest-aligned canal located downslope from Canal Bueno within the Squaw Peak Parkway corridor. A possible challenge to this correlation, however, is the fact that Hohokam Expressway Canal 10, PHX Sky Train Feature 201, and East Papago Freeway Feature 26 are thought to date to the Sedentary period, whereas the fill of Squaw Peak Parkway Feature 79, Channel 1 contains early Classic period ceramics (Howard, ed. 1988:265). Consequently, the linkage between East Papago Freeway Feature 26 and Squaw Peak Parkway Feature 79, Channel 1 is considered here to be tenuous.

A reasonable location for the former headworks of Feature 201 is the east (upstream) side of the preserved canal segments at Park of Four Waters (Area 1 in Figure 3.1). Using this location as a starting point for the canal, the downstream decrease in cross-sectional area for this alignment is curvilinear, with the relatively wide channel at Escala Central City Project creating a single outlier in the overall pattern of decreasing channel size (Figure 3.23). The longitudinal profile is best modeled with a negative exponential equation, yielding an R^2 value of 0.84.

Feature 200

Howard (1990, 1994) previously linked Woodbury's North Canal and Masse's (1976) Canal 11, U:9:2, with the second highest main canal mapped by Turney (1929) within Canal System 2, otherwise known as Canal Bueno (Midvale 1968). Canal Bueno is thought to have operated during the Classic period, connecting several settlements located on the piedmont and farther west toward lower Cave Creek and the Hohokam site of Las Colinas, AZ T:12:10 (ASM) (Masse 1988). Turney (1929) mapped this canal as a broad arc passing just north of the U.S. Indian Boarding School on Central Avenue and terminating in Section 25, Township 2 North, Range 2 East near Indian School Road and 27th Avenue north of Las Colinas. Because the Canal Bueno alignment is faintly visible on 1937 aerial photography beyond 27th Avenue, more recent mapping by Howard and Huckleberry (1991) extended the canal another 1-2 km to the southwest, for a total length of approximately 15 km. Although Canal Bueno was shorter than Canal Grande, which, at 24 km, is considered to be the longest canal in Canal System 2, the former canal contained a larger cross-sectional area (flow capacity) and was a major water supply to agricultural settlements located on the piedmont during the Classic period.

Feature 200 can be traced on 1937 aerial photography through the PHX Sky Train project area and beyond (see Figure 3.4). Although Howard (1990: Figure 7) originally hypothesized that Woodbury's North Canal veered west downstream from the Hohokam Expressway toward La Ciudad (approximately 16th Street and Van Buren Street), he later linked it to Feature 30 in the East Papago Freeway (Howard 1994:Figure 19, Table 3). In addition to being able to directly trace PHX Sky Train Feature 200 to East Papago Freeway Feature 30 on historic aerial photography, the large cross-sectional area of Feature 30 (8.0 m^2) further supports their correlation. Further, both canal exposures have a distinct stratigraphy marked by a thick and uniform middle to upper channel fill interpreted here to be the result of uncontrolled Salt River flooding. This indicates that Salt River floodwaters extended at least 3.8 km down the Canal Bueno alignment during this disruptive event.

Howard (1990, 1994) noted that the downstream decrease in cross-sectional area of Canal Bueno was probably curvilinear, although stratigraphic control was limited to three localities. Archaeologists were

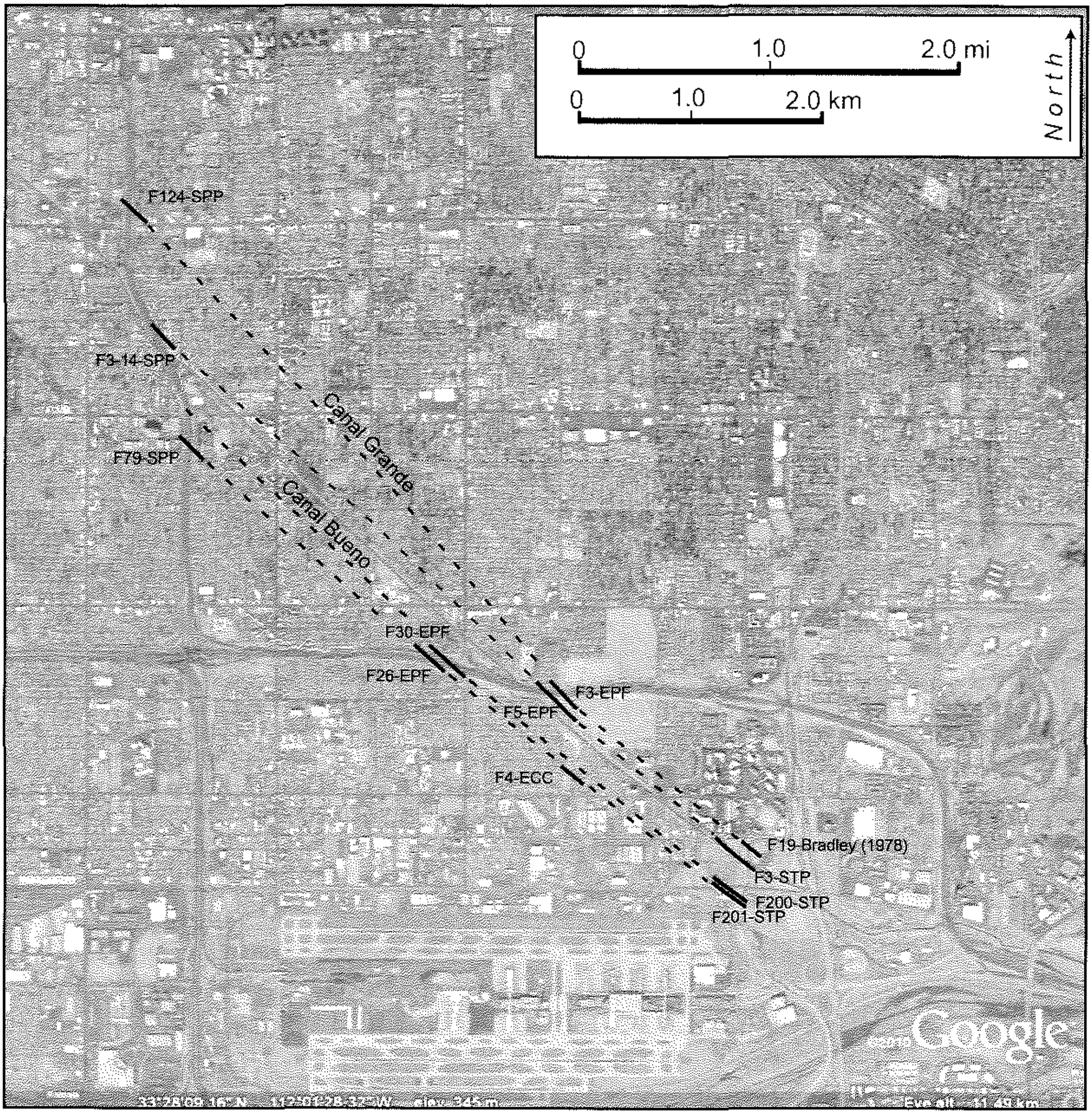


Figure 3.22. Correlation of selected Canal System 2 canal segments between Hohokam Expressway (HE) (Bradley 1978), PHX Sky Train (STP) (this report), East Papago Freeway (EPF) (Huckleberry 1988), and Squaw Peak Parkway (SPP) (Howard, ed. 1988; Huckleberry 1989) project areas.

not able to access Canal Bueno within the Squaw Peak Parkway, because it crossed the project corridor at Thomas Road (Howard, ed. 1988). In the current study, Woodbury's (1960) cross-sectional area for the canal near its headgate is not used due to the potential for overestimating water depth in this preserved segment of the channel (see Figure 3.10). Instead, the Hohokam Expressway, PHX Sky Train, and East Papago Freeway profiles are used to model a curvilinear reduction that is best characterized by a negative logarithmic equation, yielding an R^2 value of 0.65 (see Figure 3.23).

Feature 3

Feature 3 is a downstream segment of Masse's (1976) Canal 2 within the Hohokam Expressway at U:9:28. Howard (1990:57-58, 1994:Table 3) correlated this canal segment downstream to Feature 5 in the East Papago Freeway corridor. The cross-sectional area of Masse's (1976) Canal 2 is small compared with downstream correlated segments, but Howard (1990, 1994) recognized that this was due to a stratigraphic disturbance that removed the upper part of the channel in the Hohokam Expressway. Excavations within

Table 3.9. Downstream changes in cross-sectional area of correlated canal segments within Canal System 2.

Canal Alignment	Location[a]	Feature	Profile(s)	km from headgate	Area (m^2)	Trend
Unnamed						
	HE	Canal 10 (Masse 1976)[b]	Averaged	10.4	4.2	Curvilinear
	STP	201 (this report)	Trench 62	0.8	3.8	
	ECC	4 (Huckleberry 2005)	Trench 30	2.3	4.2	
	EPF	26 (Huckleberry 1988)	Averaged	3.8	3.2	
	SPP	79, Channel 2 (Howard, ed. 1988)	Averaged	6.6	2.7	
Canal Bueno						
	HE	Canal 11 (Masse 1976)[b]	Averaged	0.4	10.9	Curvilinear
	STP	200 (this report)	Trench 62	0.8	12.3	
	EPF	30 (Huckleberry 1988)	Trench 409J	3.8	8.0	
Unnamed						
	STP	3 (this report)	Trench 57	1.3	5.0	Linear
	EPF	5 (Huckleberry 1988)	Averaged	3.2	4.1	
	SPP	3-14 (Huckleberry 1989)	Averaged	8.0	1.9	
Canal Grande						
	HE	19 (Bradley 1978)	Trench 10	1.3	7.8	Curvilinear
	EPF	3 (Huckleberry 1988)	Averaged	3.2	3.7	
	SPP	124 (Huckleberry 1989)	Averaged	8.0	1.6	
	Camelback	Canal (Howard 1990)	Single trench	13.9	1.0	

[a]STP = Sky Train Project; ECC = Estrella City Center; EPF = East Papago Freeway; HE = Hohokam Expressway; SPP = Squaw Peak Parkway.
[b]AZ U:9:2 (ASM).

the PHX Sky Train project area indicate that Howard (1990, 1994) was correct and that the Hohokam Expressway cross-sectional area underestimates the canal's true size at this location; he projected the sides of the preserved channel to the average depth of the plowzone and estimated a cross-sectional area of 6.5 m^2 for Hohokam Expressway Canal 2. Excavations in the PHX Sky Train area suggest a slightly smaller cross-sectional area of 5.0 m^2. Nonetheless, the linking of PHX Sky Train Feature 3 and East Papago Freeway Feature 5 is supported by a similar cross-sectional area and a distinct textural break between the finer-textured lower and coarser upper stratigraphy (Huckleberry 1999a:Figure 5). Both features also have a surprisingly low channel width:depth ratio for a canal of this size.

Continuing downstream within Canal System 2, Howard (1990:59) links East Papago Freeway Feature 5 to Feature 22-16 in the Squaw Peak Parkway, based on interpretation of 1937 historic aerial photography; however, he notes the complexity of multiple alignments in this area. It is proposed here that Feature 5 in the East Papago Freeway may, instead, correlate with Feature 3-14 in the Squaw Peak Parkway (see Figure 3.22), a canal segment identified slightly north of Feature 22-16. Feature 3-14 has a relatively low width:depth ratio and high clay content in its lower channel fill (Huckleberry 1990:Table 6.2), similar to PHX Sky Train Feature 3 and East Papago Freeway Feature 5.

The spacing between Feature 200 and Feature 3 within the PHX Sky Train area suggests that these two canals likely had different headworks, and that the diversion for Feature 3 was probably located farther upstream on the Salt River (Masse 1988). A possible headgate location is the southwestern edge of the Papago Pediment close to where the Grand Canal currently makes a northward turn in its alignment (Location 2 in Figure 3.1). If correct, some. 8.0 km of this main canal can be linked across the piedmont. Interestingly, the downstream decrease in cross-sectional area between the PHX Sky Train, East Papago Freeway, and Squaw Peak Parkway areas is linear rather than curvilinear (see Figure 3.23). Unless this canal deviates from the more typical negative exponential or logarithmic decrease in channel capacity seen in canals located in the upper reach of their systems, this canal almost certainly headed farther east near the floodplain constriction formed by the Tempe and Papago buttes.

Correlation Summary

Correlating prehistoric canal segments separated by several kilometers is not easy, and even the most rigorous set of linking criteria may result in erroneous correlations. Three large prehistoric main canals transecting the PHX Sky Train project area, Features 3, 200, and 201, can be linked to segments identified

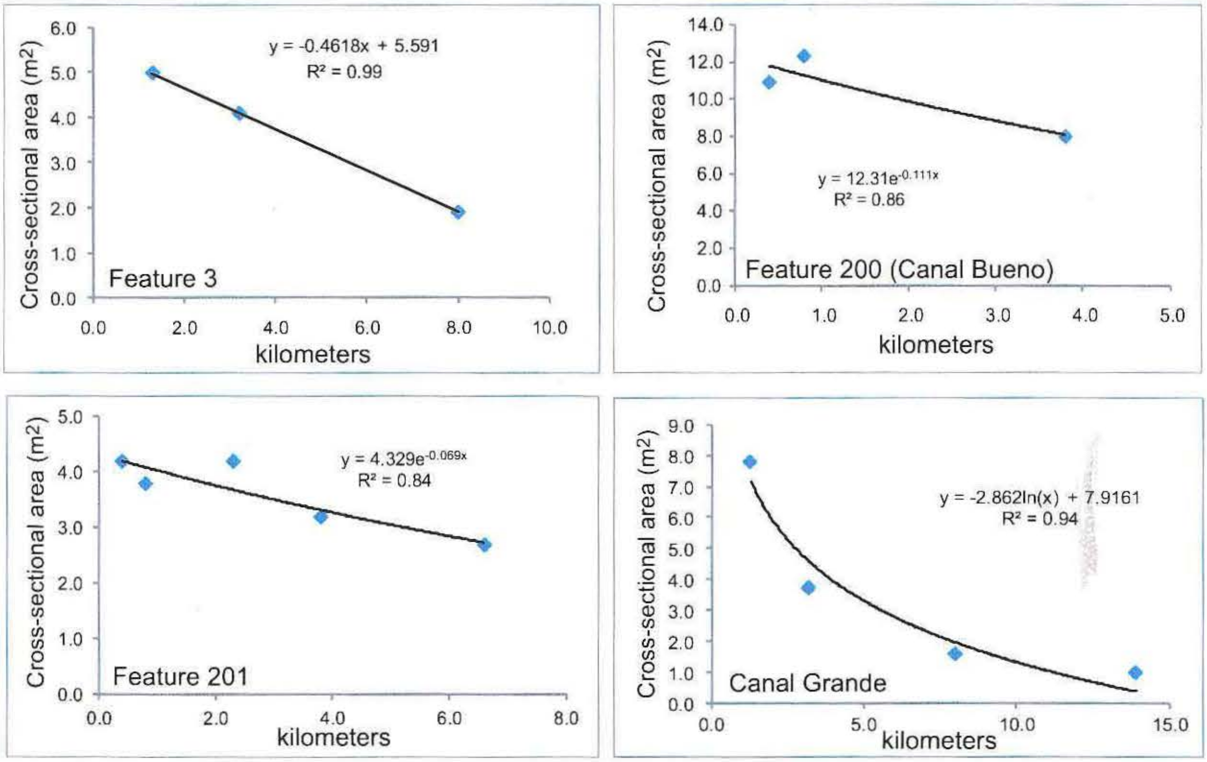


Figure 3.23. Trend lines for cross-sectional area and distance from headworks associated with PHX Sky Train canal Features 201, 200, and 3 (this report), and prehistoric Canal Grande (Bradley 1978; Huckleberry 1988, 1989).

several kilometers downstream within Canal System 2 (see Figure 3.22). Feature 200 (Canal Bueno) was previously linked by Howard (1994) between the Hohokam Expressway and East Papago Freeway. Feature 3 was linked by Howard (1994) between the Hohokam Expressway and the Squaw Peak Parkway, and the correlation presented here differs slightly in that the canal is thought to link with Squaw Peak Parkway Feature 3-14 rather than Feature 22. PHX Sky Train Feature 201 was previously unlinked within Canal System 2. This Sedentary period canal is located downslope from Canal Bueno and linked between Hohokam Expressway Canal 10, East Papago Freeway Feature 26, and Squaw Peak Parkway Feature 79. Overall, greater confidence can be ascribed to correlations between the PHX Sky Train area and the East Papago Freeway than between the East Papago Freeway and the Squaw Peak Parkway.

Although limited to only three to five control points along an individual canal alignment, the upper Canal System 2 main canals appear to have a curvilinear downstream decrease in cross-sectional area that can be modeled using either a negative exponential or logarithmic equation. The uppermost segments of the canals near their intakes are the largest, and they decrease rapidly downstream. This may be a by-product of frequent scour and cleanout near the master headgate due to seasonal flooding on the lower Salt River (see Nials and Gregory 1989:48, for historic examples). Away from the headgates, the reduction in main canal cross-sectional area is more gradual. Downstream decrease in cross-sectional area for Features 200 and 201 are best modeled with a negative exponential equation (see Figure 3.23). In contrast, Feature 3 has a linear decrease in cross-sectional area between the PHX Sky Train area and Squaw Peak Parkway, suggesting the headworks of the canal are located upstream of Park of Four Waters. A more distant intake for Feature 3 may help explain the small grain sizes of the channel fill (see Table 3.7); that is, much of the sand fraction fell out of suspension upstream from the PHX Sky Train project area.

Except the limited number of control points along an individual canal alignment, another limitation to this type of analysis includes estimation of canal dimensions and location of the headworks. Some subjectivity is involved in defining the channel boundaries of truncated prehistoric canals, which, in turn, influences the measured cross-sectional area and longitudinal profile. In several cases, channel dimensions estimated in this investigation differed slightly from those made by Howard (1990, 1994), resulting in different measures of cross-sectional area.

There are also slight differences in where the locations of the original headworks are estimated to have been located. Howard (1990, 1994) considered the historic Appropriator's Canal as an analog for placement of headworks and downstream changes in cross-sectional area. However, diversions into the main canals of Canal System 2 may have been different during the Hohokam sequence, depending on time-variant geomorphic conditions within the braided channel belt of the lower Salt River. Differences in the measurement of channel dimensions and the estimated location of headworks do not invalidate the general curvilinear longitudinal model proposed by Howard (1990, 1994), but they do generate different empirical equations. These equations should be used cautiously to predict the location of headworks or to model the entire longitudinal profile of a canal alignment from only one control point (stratigraphic exposure), especially for main canals located outside Canal System 2 that occur in different geomorphological settings.

Despite potential sources of error in linking analyses, results presented here suggest that downstream decreases in cross-sectional area for Features 3, 200, and 201 are gradual northwest of the PHX Sky Train area, indicating discharge steadily diminished as these Hohokam main canals crossed the piedmont within Canal System 2. Gradual loss of water was due to both intentional diversions into distribution and field lateral canals and progressive seepage, and, to a lesser degree, evaporation. There does not appear to be any major single diversion of water along the upper approximately 8 km of these canals, suggesting they were designed to extend to agricultural areas located in the central and terminal parts of Canal System 2.

DESTRUCTIVE FLOODING

Prehistoric canal irrigation greatly increased agricultural production but required a significant amount of human labor to maintain (Castetter and Bell 1942:160; Haury 1976:8.47; Nials and Gregory 1989; Woodson 2008). The amount of labor invested depended on the size of the system, frequency of use, and local environmental factors. Even under the best of hydrological and technological circumstances, canals fill with sediment during their use, with the rate of sedimentation influenced by the design of the canal (channel shape and gradient), efficacy of the headworks (diversion dam or weir), and the sediment load of the supplying water source. Added to this "fixed cost" of canal operation is the impact of uncontrolled flooding, which can not only erode channel and headgate structures, but that can also rapidly fill the alignment with sediment. At a minimum, flooding can delay the delivery of water to crops located within the irrigation network. However, destructive flooding also has the potential to render the entire system inoperable, leading to crop failure, and, perhaps, the abandonment of the canal alignment.

Most Hohokam canals within Canal System 2 were vulnerable to two types of flooding. Historically, lower Salt River flooding repeatedly damaged roads, bridges, and canals every few years prior to dam construction for flood control (Ackerly et al. 1987; Davis 1897; Masse 1988; Zarbin 1980). The Hohokam also faced the challenges of an unpredictable Salt River, with the largest floods resulting in channel shifting and downcutting, thereby limiting the ability to repair canal intakes and return the system to operation in time for the irrigation season (Ackerly 1991; Nials and Gregory 1989:53-54).

The other source of destructive flooding was from localized but heavy rainfall on the piedmont. Ephemeral streams on the piedmont are subject to flash flooding during the summer, and were transected by Canal System 2 main canals. The canals acted as temporary obstructions to natural runoff, causing water to pond upslope of the canal channel until reaching a point where it would breach the berm and enter the canal alignment. Once within the alignment, floodwaters would flow down the canal until breaching the downslope side of the channel, at which point it would continue to flow down the piedmont, only to be intercepted by another parallel canal. While the largest Salt River floods tended to occur during the winter when the canal system was likely to be idle, summer flash floods on the piedmont coincided with operation of the canals and were, therefore, disruptive to irrigation during the growing season.

Evidence for piedmont flooding within the PHX Sky Train area includes basin Features 7 and 20 located upslope from main canal Feature 3 in Block 7 (see Figure 2.7). Arkosic sediments within the basins confirm flooding from the piedmont rather than from the Salt River (see Appendix C). It is uncertain if Feature 3 was operational during this accumulation of water on the upslope side of its channel. Although piedmont flooding was undoubtedly disruptive to the operation of Canal System 2 canals, the consequences may not have all been deleterious. Piedmont flooding and ponding of water behind active or abandoned canal alignments may have provided a supplemental source of water, possibly utilized for irrigation or domestic use. Moreover, smaller floods on the piedmont may have been intentionally captured or diverted for agriculture or other needs. Larger floods, however, would have been difficult to manage. Given the number of ephemeral drainages crossed by the higher elevation main canals in Canal System 2, piedmont flooding would have been a recurrent threat to canal operation during the summer rainy season.

Despite problems caused by piedmont flooding, the potential damage caused by large riverine floods is much greater, with individual large floods potentially impacting multiple canal alignments and irrigation communities at one time. Dendrohydrological reconstructions of Salt River annual streamflow during the middle to late A.D. 1300s, have been linked to canal instability and abandonment of irrigation communities during the Classic period (Graybill et al. 2006; Gregory 1991; Howard 1994; *contra* Ingram 2008). Whereas wet years with high annual reconstructed streamflow are likely to have experienced large floods (Ackerly 1991; Redmond et al. 2002), annual discharge and the discharge of individual floods are two different things. Years with high reconstructed annual streamflow may not have experienced large floods, whereas years with low reconstructed annual streamflow may have experienced large floods. Consequently, there is a need for independent and more direct evidence for past flooding in the lower Salt River Valley to test some of these hypotheses linking fluvial geomorphology and archaeology.

If Hohokam canals regularly experienced destructive flooding, they should be repositories for paleoflood information. For example, Bales et al. (1986) used flood deposits associated with canals excavated by Masse (1976) in the Hohokam Expressway to help define the northern boundary of the Lehi Terrace and to assess flood hazards. In this case, flood deposits within the canal extended beyond the berms of the channel, thereby making interpretation of a large flood event fairly straightforward.

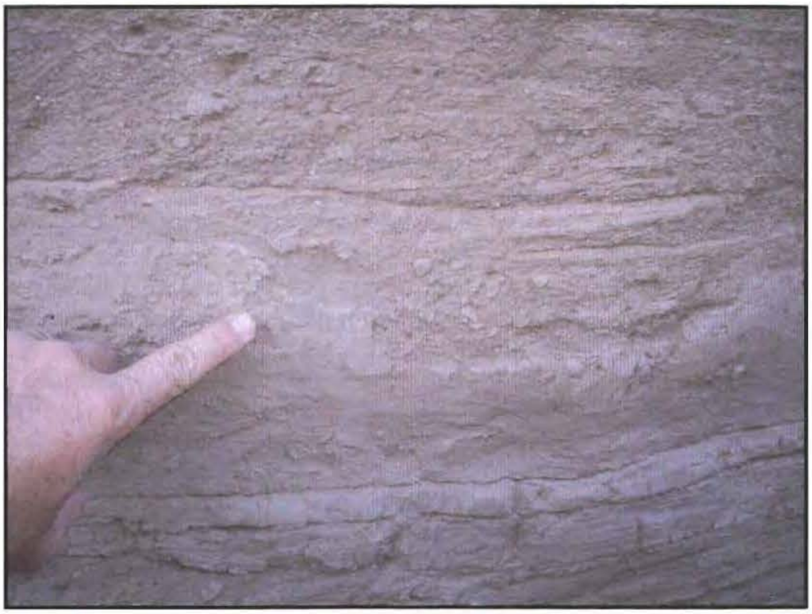
The proximity of the PHX Sky Train canals to the Hohokam Expressway project corridor and the Salt River suggested the potential for similar flood stratigraphy to be identified. Of all the PHX Sky Train canals, however, only one, Feature 200, contains unequivocal evidence for uncontrolled Salt River flooding. As described, Feature 200 has two types of channel fill: (1) a lower fill dominated by well-sorted, stratified sands and silt (Strata 1-6 in the Trench 62 east wall and Strata 1-7 in Trench 62 west wall in Figures 3.8 and 3.9); and, (2) an upper fill consisting of a single deposit that extends laterally beyond the edges of the channel (Stratum 7 in Trench 62 east wall, Stratum 8 in Trench 62 west wall). This upper deposit was clearly formed by uncontrolled Salt River flooding, and it allows an analysis of the sedimentological properties of such a deposit within a main Hohokam canal.

Within the channel of Feature 200, the flood deposit overlies an abrupt, irregular unconformity that intrudes the lower stratigraphy and that was likely formed by the initial flood surge. This is supported by the presence of numerous small (< 2 cm) subangular, silt rip-up clasts, also known as intraclasts (Figure 3.24a), that decrease in frequency upward in the profile. Masse (1976, 1988) identified similar features in a large canal, Canal 7, or Hagenstad Canal, within the Hohokam Expressway that he ascribed to uncontrolled flooding. Discontinuous horizontal laminae are also present in the lower part of the Feature 200 flood deposit and gradually disappear toward the modern surface. The rip-up clasts are an indication of turbidity currents, and the horizontal bedding may relate to deceleration of turbulent flow and velocity pulsations.

Sediment samples collected from a vertical column within the flood deposit (see Figure 3.8) reveal slight changes in mean particle size, with depth ranging from 0.03 mm to 0.10 mm (see Table 3.7), again, probably reflecting surges in water velocity during the flood. Noticeably absent are cross-beds, which are present in the lower fill, and coarse sediment, such as coarse sand and gravel. Gravels are generally uncommon in Hohokam main canals along the lower Salt River except where they cross gravelly alluvial fan channels (see Huckleberry 1990), although they were present in the large Hagenstad Canal within the Hohokam Expressway (Masse 1976, 1988). Coarse sands are more common, and have been associated with uncontrolled flooding in Hohokam canals in the Scottsdale Canal System (Huckleberry 1995) and near the headworks for Canal System 1 in the Mesa area (Jerry Howard, personal communication 2006).

It is surprising given the large cross-sectional area of the channel of Feature 200 and proximity to the Salt River that coarse sands and gravels were not present. However, it appears that even large destructive floods on big rivers like the Salt and Gila may not deposit coarse sediments within the canal alignments. Five relict historic Akimel O'odham canal segments impacted by Gila River floods within the Gila River Indian Community contain primarily fine-textured deposits, with the coarsest alluvium consisting of medium to coarse sand (Huckleberry 1999b). This included Gila River flood deposits that extended over the berm of one of the canals.

Relatively fine-textured flood deposits were also identified in the historic Gila Bend Canal, located directly below Gillespie Dam (Huckleberry 2011b). This canal operated intermittently between 1892 and 1895, and was damaged several times by Gila River flooding. For the Gila Bend Canal, water was diverted from a dam placed within a bedrock reach of the Gila (precursor to the current Gillespie Dam). Nonetheless, archival records indicate the dam and intake to the canal were breached, allowing unregulated flood waters to surge within the canal align-



(a)

(b)

Figure 3.24. Stratigraphic features in Feature 200 at Trench 62. Erosional unconformity separating sandy sediments with silt rip-up clasts in Stratum 7 formed by turbulent flow overlying bedded sand and silt deposits (a). Large silt rip-up clast from Stratum 1, east wall (b; also see Figure 3.8).

ment, depositing sediment. Despite this flooding, coarse sand and gravels are rare to absent in the historic Gila Bend Canal, and flood deposits consist primarily of fine to medium sand containing silt and silty clay rip-up clasts, similar to the flood deposit in Feature 200.

Although large floods on the Salt and Gila rivers have the potential to carry sediment as large as boulders, flood deposits in earthen prehistoric and historic canals tend to lack gravels, and are often composed of fine to medium sand, with or without primary bedforms, such as cross-bedding. However, turbulent flow is suggested by the common presence of silt and clay rip-up clasts generated by erosion of upstream channel and bank material. Riverine flood deposits may extend several kilometers down a main canal alignment. In Feature 200, a single flood deposit extends at least 3 km downstream from the PHX Sky Train area to the East Papago Freeway corridor (Feature 30, Trench 409J, in Huckleberry 1988). Mean sand, silt, and clay content from Strata 2, 3a, and 3b in this downstream segment of the canal is 12 percent, 49 percent, and 39 percent, respectively. By contrast, mean sand, silt, and clay content from the six particle-size samples collected from the flood deposit in PHX Sky Train Feature 200 (Stratum 7 in Trench 62, east wall (see Figure 3.8, Table A.1) is 43 percent, 45 percent, and 13 percent, respectively. As the flood surged down Canal Bueno, a considerable amount of sand fell out of suspension over the first 3 km of the alignment. This suggests the same deposit located farther down the alignment should be increasingly dominated by silt and clay. It would be challenging, at best, for anyone excavating a segment of this canal in the middle to lower part of Canal System 2 to relate this deposit to uncontrolled Salt River flooding.

It should be noted that the lower channel fill in Feature 200 is interpreted as reflecting controlled streamflow within the canal but cannot be distinguished from flood deposits based solely on sedimentology. The lower deposits of Feature 200 contain sandy textures and silt rip-up clasts not unlike the upper flood deposit. One subangular silt clast is more than 10 cm in diameter, and it represents a significant "chunk" of bank material or channel fill that became detached and transported a short distance (see Figure 3.24b). Granulometric analysis indicates the upper and lower deposits have similar mean grain size, sorting, and skewness coefficients (see Table 3.7). For such a large canal located near its main intake, surges in velocity and discharge are expected while the canal is in use, depending on the nature of the weir and the flow of the Salt River. Regular flow depths are also expected to have been substantially below the top of the canal channel and berm to allow for these fluctuations in flow, especially close to the canal intake. Although the initial flow represented by the lower channel fill of Feature 200 may have been turbulent, the lower deposits have repeated vertical changes in grain size and bed thickness common to most prehistoric canals (Huckleberry 1999a; Masse 1988). Regardless, evidence for destructive flooding, even in the upper reaches of main canals, is complicated by issues of equifinality whereby different processes may result in deposits with similar sedimentology.

More work is necessary to analyze the stratigraphy of historic and modern canals with known use-histories to better understand and relate the sedimentology and stratigraphy of prehistoric canals to their formation processes. This includes identifying evidence of destructive flooding. Whereas prehistoric canals can contain evidence of paleofloods, correctly identifying and interpreting that evidence can be challenging. In Canal System 2, uncontrolled piedmont flooding is relatively easy to identify. These floods tend to be flashy and transect coarse, gravelly soils, which penetrate main canals and deposit coarse sand and gravel with a mineralogy that differs from Salt River alluvium. However, identifying evidence for destructive riverine flooding is more difficult, especially if key stratigraphic relationships of channel fill extending beyond the margins of the canal are not preserved. The best opportunities to find such relationships preserved are in the upper parts of canal systems close to their intakes on the supplying river.

SUMMARY

The PHX Sky Train project provided the first detailed excavation and stratigraphic analysis of Hohokam main canals near Park of Four Waters since the Hohokam Expressway excavations of the 1970s (Bradley 1978; Masse 1976, 1981). Geoarchaeological analyses, in conjunction with ^{14}C and OSL dating of the PHX Sky Train canals, provide new insights into the history of these ancient hydraulic works. The PHX Sky Train project area is located at the transition between alluvial fans and Salt River floodplain immediately downstream from the Papago Pediment. This was a major corridor for Hohokam canals where water was diverted onto the piedmont to maximize irrigable area. The three largest PHX Sky Train canals, Features 3, 200, and 201, represent segments of main canals located in the upper (higher elevation) part of Canal System 2. Of these, Feature 200 is the most well known, and is part of 15-km-long prehistoric Canal Bueno, first excavated by Woodbury (1960) at Park of Four Waters, and traceable all the way to Las Colinas. A smaller canal, Feature 26, aligned parallel with the three large canals, was also identified, and it branches into three still smaller distribution canals, Features 14, 17, and 18, suggesting irrigation of more local areas to the west in an area of distinct, irrigation-affected soils (see Figure 3.2). Feature 25 is another small canal that appears to have been associated with a local water storage feature that collected runoff from the piedmont and canal-delivered water from the Salt River. Smaller distribution and field lateral canals were also identified on the lower piedmont and are described in further detail in Chapter 5.

The function of the large PHX Sky Train main canals was to supply irrigation and domestic needs of Sedentary and Classic period (circa A.D. 950-1400) communities located on the piedmont. These canal segments were correlated with downstream canal segments previously excavated within Canal System 2, and they confirm Howard's (1990, 1994) curvilinear model of downstream reduction in canal cross-sectional area, in which channel cross-sectional area decreases rapidly downstream near the headworks and then more gradually farther down the alignment. Based on the correlations presented here, there does not appear to have been any single major diversions of water within the upper 8 km of the three large PHX Sky Train canals, Features 3, 200, and 201, suggesting they were designed to reach farms and settlements located in the middle to terminal portions of Canal System 2.

Of the three large PHX Sky Train canals, Features 3 and 201 were capable of supporting roughly 700-800 ha (1,730-1,980 ac) of irrigated crops, while Feature 200 had an irrigation potential of about 3,000 ha (7,500 ac). Whether these canals actually supplied this much land depends, in part, on the availability of water. Fine alluvial grain sizes (mostly silt and clay) in the channels of Features 3 and 201, and the smaller Feature 26, suggest the last episodes of canal use were characterized by shallow water depths, indicating less than optimal streamflow. Whether this was due to decreasing water availability in the Salt River or some other process warrants further study.

An important characteristic of Feature 200 is that it contains clear evidence of having been filled with Salt River flood sediments and then abandoned. The middle to upper portion of the channel is filled with a thick, relatively uniform fine sand and silt deposit that extends beyond the edges of the canal. An OSL single-grain sample from the lower part of this flood deposit yielded an age of 729±60 yr b.p. (A.D. 1221-1341), placing the event in the middle to late Classic period. This age predates the period of increased streamflow variability inferred from the dendrohydrological record (A.D. 1361-1746, Interval III in Table 3.3), but does confirm that Classic period Hohokam at Pueblo Grande and other communities in Canal System 2 had to deal with the vagaries of Salt River streamflow.

Stratigraphy within the PHX Sky Train main canals presents potential evidence of too little water, for example, Feature 3, and certain evidence of too much water, for example, Feature 200. The flood surge that terminated the use of Canal Bueno, Feature 200, extended at least 3 km down the alignment and filled the channel with sediment. This flood deposit is relatively fine textured but unusually thick, occupying the middle and upper part of the channel and extending outward onto the Lehi Terrace within the PHX Sky Train project area. Without preservation of the upper stratigraphy and the ability to trace it beyond the canal alignment, it would be very difficult to confidently identify this stratigraphy as the product of uncontrolled Salt River flooding, especially in the middle to terminal reaches of the canal alignment, where the deposit becomes progressively finer textured. Fortunately, such key stratigraphic relationships are preserved within the PHX Sky Train project area, and they provide the first clear evidence of a Salt River flood filling several kilometers of a major Hohokam canal with sediment, leading to its abandonment.

Why the Hohokam left the lower Salt River Valley after many centuries of successful farming remains unknown. Bioarchaeological evidence from Pueblo Grande raises questions regarding the nutritional health of Classic period populations within Canal System 2 and to what degree they were able to maintain a diverse and adequate diet (Abbott 2003). Variability in streamflow related to floods and droughts may still be considered a relevant variable with regard to Hohokam food production, although several environmental and sociocultural factors were likely responsible for the demographic decline during the fourteenth and fifteenth centuries. If we are to successfully explain the abandonment of the lower Salt River Valley after centuries of sustained cultivation, it will require archaeological, paleoecological, geological, and ethnographic evidence and perspectives. As a key component of Hohokam subsistence, canals will continue to be an important part of that story.

STUDIES OF TWO WATER FEATURES, PHX SKY TRAIN PROJECT

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Two of the more intriguing features encountered during the PHX Sky Train project were the loosely defined "catchments," Features 7 and 57 at AZ U:9:28 (ASM). Although both features were characterized by thick-bedded sediments, suggesting capture and retention of water over some period of time, other characteristics indicated the two performed vastly different and, in the case of Feature 57, unknown functions. To more fully understand and even determine how these features were used, sediments from Features 7 and 57 were subjected to paleoecological, palynological, chemical, and other analyses, as appropriate (Table 4.1) (see also Chapters 6-8, 13, and Appendix C, this volume). The results of our field and analytical inquiries into the nature and functions of Features 7 and 57 are provided here.

FEATURE 7, AZ U:9:28 (ASM): WATER CATCHMENT AND RESERVOIR

On the northern side of canal Feature 3 in Block 7 (Figure 4.1; see also Figures 2.6 and 2.7) was a large formation of variably deep water-lain sediments, evidently the result of water catchment. Most of this area was defined as Feature 7, although a later catchment episode was distinguished in the same area and designated Feature 20 (Figure 4.2). Over the course of the project, several trenches were excavated in the area of Feature 7. Profiles revealed lengthy areas of highly stratified deposits of clays, silts, sands, and gravels (Figures 4.2-4.4). Although a mix of high- and low-energy deposits were present, the defining characteristic of these deposits was the widespread presence of clay beds (Figure 4.5), suggesting the feature had regularly and repeatedly contained low-energy water flow or standing water.

Stripping away the heavy clay overburden north of Feature 3 helped clarify the size and shape of this feature. Overall, Feature 7 was a large (approximately 180 m by 100 m), elongated, shallow basin with deeper interior pools containing alternating beds of clay, silt, sand, and gravel (see Figure 4.1). The deepest portions of the feature appear to have been intersected by Trenches 12, 18, and 63. However, mechanical stripping of the area revealed thin diversion channels and small depressions around the shallow western periphery of the feature, suggesting that related activity extended beyond the edge of the feature's main basin. In the eastern half of Feature 7, trenches and mechanical stripping revealed a shallower, broader clay deposit, except Trench 64, which encountered only heavy modern disturbance.

Although two pools were suggested from the various trench cuts, these may have, in fact, been connected, resulting in a larger multilobed pool. Strata defining the upper shallower basin, ranging from 35-40 cm thick and thinning at the edges, were primarily undifferentiated sandy silt (Strata 43 and 44 in Trench 12) grading to clayey silt (Strata 4-5 in Trench 18) in the eastern parts of the feature. Interior pools, which contained multiple strata or beds, extended to 1 m in depth. All pool exposures contained the general fill sequence: coarse to medium sands, sandy silt, two thick clay lenses separated by thinly bedded fine sand or clay and silt, and overlying upper basin sandy silt to clayey silt (see Strata 37-43 in Figure 4.3 and Strata 13-5 in Figure 4.4). An earlier filling cycle was also evident in the southern pool exposed in Trench 18 and at the northern end of the basin exposed in Trench 63.

During Phase 1, Feature 7 (also Feature 20) was thought to represent natural channel sediments that had ponded against the artificial barrier created by construction of canal Feature 3. In addition to the fact that both Features 7 and 20 resided partially atop alluvial wash gravels, support for this conjecture was provided by a radiocarbon date, 830±30 ^{14}C yr BP, or cal A.D. 1160-1265 [2-sigma], from an upper stratum in Feature 7 (see Stratum 39, Figure 4.3). The age is consistent with other evidence that points to early Classic period construction of Feature 3. While Feature 7 may have begun as an alluvial channel or depression within a channel, profiles exhibited sufficient evidence for clean-out and modification to suggest this catchment feature was maintained for the use/benefit of the local inhabitants. For example,

Table 4.1. Special samples concordance list, Features 7 and 57, AZ U:9:28 (ASM), PHX Sky Train project.

Feature	Sample ID	FN	Comments[a]	Soil	Pollen	Ostracode	Phytolith
Feature 7 Sample Contexts							
7	O1	153	Strat 31: Coarse sand, 0.05 m above feature base	–	–	X	–
7	O2, P2	154, 164	Strat 33: Very fine sand with siltier areas, 0.15 m above feature base	–	X	X	–
7	O3, P3	155, 165	Strat 35: Clay; 0.25 m above base	–	X	X	–
7	O4, P4	156, 166	Strat 36: Sandy silt, 0.34 m above base	–	X	X	–
7	O5, P5	157, 167	Strat 37: Fine sand, 0.42 m above base	–	X	X	–
7	O6, P6	158, 168	Strat 39: Sandy silt, 0.58 m above base	–	X	X	–
7	O7, P7	159, 169	Strat 40: Clay, 0.63 m above base	–	X	X	–
7	O8	160	Strat 40a: Clay, 0.73 m above base	–	–	X	–
7	O10	162	Strat 43: Sandy silt, 0.84 m above base	–	–	X	–
Feature 57 Sample Contexts							
Samples below are undifferentiated gray-tan silty clay (Stratum 7; Table 4.2) from shallow end (NW) of Feature 57							
57	SL1a (S2)	1164	GS/P #26: Gray-tan silty clay from upper edge of channel near its northern end	–	X	X	X
57	SL1a	1119	BSS 57.03: Gray-tan silty clay from balk; northernmost point of the gray-tan silt deposit; corresponds with SL1a [1164]	X	–	–	–
Sample below is upper gray-tan silty clay (Stratum 7; Table 4.2), deep end of Feature 57							
57	SL5a (D3)	1120	BSS 57.04: Upper gray-tan silt, eastern side of Feature 57/26 junction	X	X	X	X
Samples below are "rainbow" clay (Stratum 5; Table 4.2) from shallow end (NW) of Feature 57							
57	SL1b (S1)	1168	GS/P #29: Rainbow clay, northwestern flat area	–	X	X	X
57	SL1b	1167	GS/P #28: Rainbow clay, southwestern flat area; roughly corresponds with SL1b [1168]	X	–	–	–
Samples below are "rainbow" clay (Stratum 5; Table 4.2) from deeper parts of Feature 57							
57	SL3b (D1)	1125	BSS 57.09: Rainbow clay from bottom of feature, thick "rainbow" clay deposit	X	X	X	X
57	SL3b(4)	1118	BSS 57-02: Dense rainbow clays lining the bottom of much of Feature 57	X	–	–	–
Samples below are lower grayish-brown clay with tan silt (Stratum 4; Table 4.2), deep end of Feature 57							
57	SL3a	1163	GS/P #25: Lower gray-tan strat near bottom of feature	–	X	–	X
57	D2	1123	BSS 57.07: Lower gray-tan strat south of Units 4 and 5; bottom gray-tan soils, no snails present; corresponds with SL3a [FN 1163]	X	–	X	–
57	D2	1122	BSS 57.06: Lower gray-tan stratum at 57/26 junction; snails present	X	–	–	–
Samples below are "special" contexts (for example, rose-colored clay as a constituent of "rainbow" clay; sealed [under mano] context)							
57	SL2b	1159	GS/P #21: Rose-colored clay, northeastern quarter; sample size is small and context mottled with fine sand (Stratum 5; Table 4.2)	–	X	–	–
57	SL4b	1160	GS/P #22: Rose-colored clay, from near bottom of deepest part of channel/basin, under mano (Stratum 5; Table 4.2)	–	X	–	–

Table 4.1. Continued.

Feature	Sample ID	FN	Comments[a]	Soil	Pollen	Ostracode	Phytolith
57	SL4a	1162	GS/P #24: Lower gray-tan silt mottled with dark brown clay, bottom of this fill from directly below mano and two nearby large stones (Stratum 4; Table 4.2)	–	X	–	X
57	SL6a	1124	BSS 57.08: Lower gray-tan soils, larger clumps with possible plant/leaf impressions (Stratum 4; Table 4.2)	–	X	–	X
57	SL6b	1169	GS/P #30: Lower silts, lower "leafy" soil (Stratum 3; Table 4.2)	–	X	–	–
Samples below are rose-colored clay, shallow and deep contexts							
57	SL6(4)	1158	GS/P #20: Rose-colored clay, southwestern quarter (from Stratum 5; Table 4.2)	X	–	–	–
57	SL6	1161	GS/P #23: Rose-colored clay, from very bottom of feature near intersection with F26 (from Stratum 5; Table 4.2)	X	–	–	–
Samples below are canal Feature 26							
26	C3	1143	BSS 26.02: Upper gray-tan silts in canal Feature 26, Trench 95, eastern side of 57/26 junction	–	–	X	–
26	C2	1144	BSS 26.03: Lower gray-tan clayey silt in canal Feature 26, Trench 95, eastern side of 57/26 junction	–	–	X	–
26	C1	1171	GS/P #32: Dark brown clay at bottom of canal at junction with Feature 57	–	–	X	–

[a]GS/P = Grain size and/or pollen sample; BSS = Bulk soil sample.

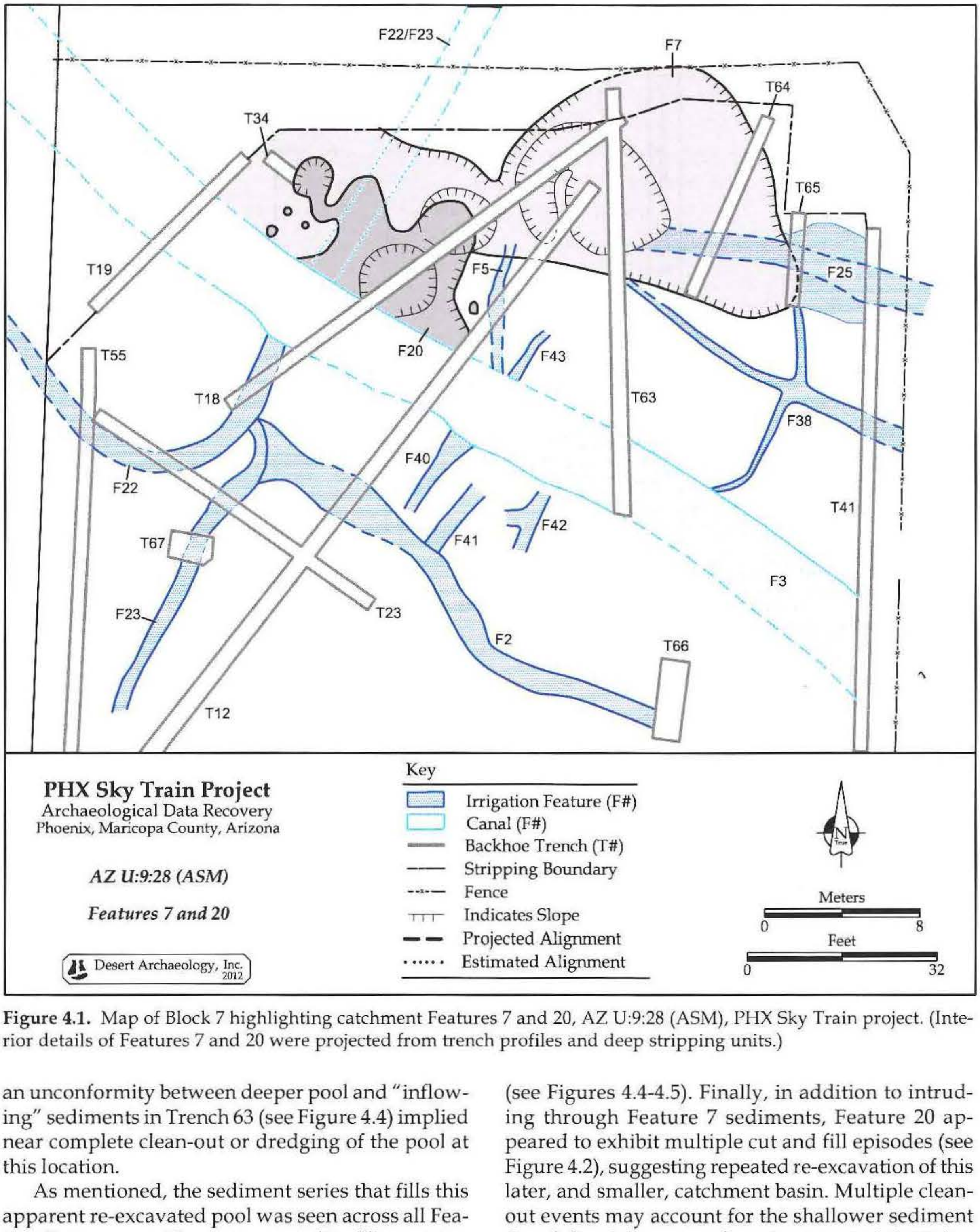
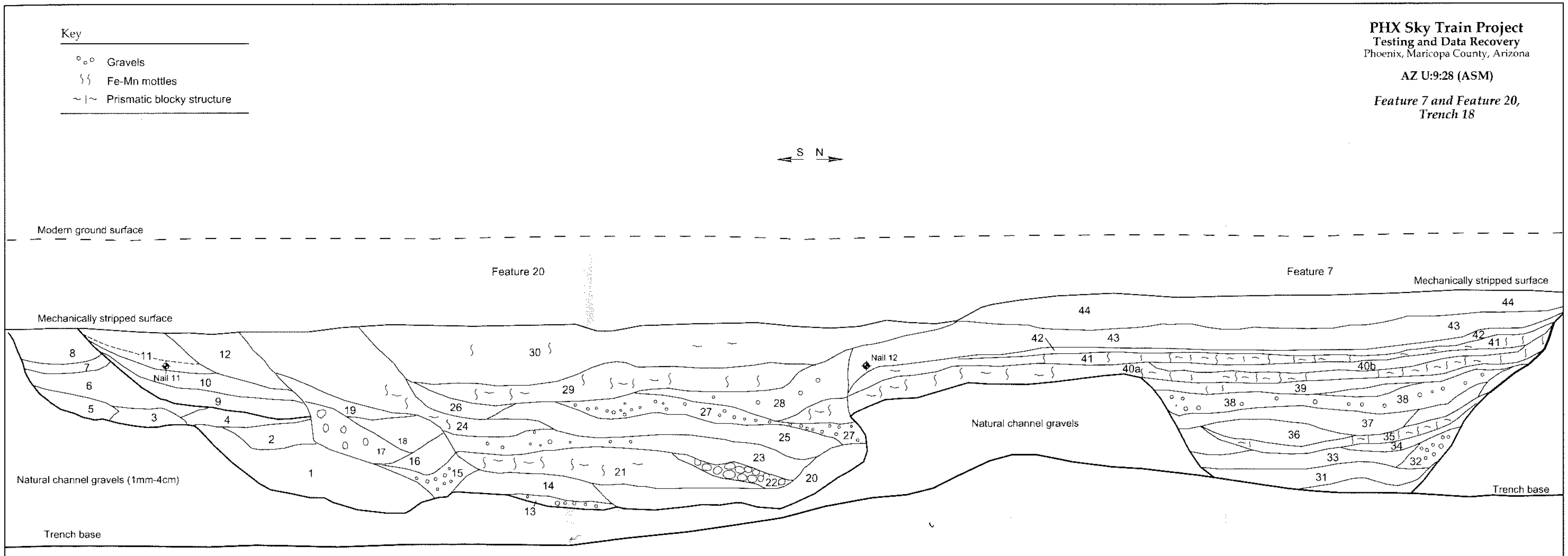


Figure 4.1. Map of Block 7 highlighting catchment Features 7 and 20, AZ U:9:28 (ASM), PHX Sky Train project. (Interior details of Features 7 and 20 were projected from trench profiles and deep stripping units.)

an unconformity between deeper pool and "inflowing" sediments in Trench 63 (see Figure 4.4) implied near complete clean-out or dredging of the pool at this location.

As mentioned, the sediment series that fills this apparent re-excavated pool was seen across all Feature 7 exposures. However, an earlier fill sequence is evident below this common sediment series in the smaller southern pool exposed in Trench 18 (see Strata 31-35, Figure 4.3), implying more than one episode of cleaning and filling. Also suggestive of purposeful modification was the steep, sharply defined southern bank of the deep pool in Trench 63 (see Figures 4.4-4.5). Finally, in addition to intruding through Feature 7 sediments, Feature 20 appeared to exhibit multiple cut and fill episodes (see Figure 4.2), suggesting repeated re-excavation of this later, and smaller, catchment basin. Multiple clean-out events may account for the shallower sediment that defined the upper, broader extent of these features; that is, it is possible, even probable, that these strata represent spoils spread around the catchment features as material was dredged from the inner pools.

Although petrographic analysis of sands from the southern Feature 7 pool exposed in Trench 18 con-



Stratum Descriptions (by L. Purdue)

1. Light brown silt with gravel (2 mm-1 cm); heterogeneous
2. Brown gravel (1 mm-2 cm)
3. Light brown silt with small gravel (1 cm); coarse sand at base
4. Light brown silt and gravels (1 cm)
5. Same as 3; lacks coarse sand at base
6. Brown silt with gravels and clay aggregates
7. Yellowish-brown silt with oxidized clayey aggregates
8. Brown sandy silt with clay aggregates
9. Dark brown clay; crumbly
10. Brown silty clay with occasional gravels
11. Same as 9
12. Gravelly silty clay; shells
13. Brown gravel (1-2 mm)
14. Light brown gravelly silt
15. Brown gravel
16. Light brown sand to coarse sand with silt
17. Brown sand; heterogeneous deposit with sherds, rocks (4-5 cm), clay and silt aggregates
18. Brown gravel (1 mm-1 cm); heterogeneous
19. Light brown to brown silty sand with gravel (1-2 mm)

Stratum Descriptions

20. Light brown very fine sand; laminated
21. Brown clay; blocky structure
22. Brown gravel (1 cm); homogeneous
23. Brown gravel (1-2 mm)
24. Reddish-brown clay; blocky structure
25. Light brown sandy to gravelly silt
26. Brown gravel (4-5 mm); homogeneous
27. Brown small gravel (2-3 mm)
28. Light brown to brown sand, silt, and gravel (1 mm-1 cm); heterogeneous
29. Reddish-brown clay; blocky structure
30. Brown silty clay; prismatic; occasional aggregates
31. Light brown coarse sand in pockets
32. Light brown gravel (1 cm); heterogeneous
33. Very light brown very fine sand with some siltier areas; laminated; shells, occasional gravelly areas
34. Light brown sandy silt
35. Grayish-brown clay; blocky structure; strong oxidation
36. Light brown to brown fine to medium sand with occasional gravel (2-3 mm)
37. Light brown fine sand; finely laminated

Stratum Descriptions

38\. Brown gravel in coarse sand matrix; gravel grades upward from 1 cm at the base to 1-3 mm
39\. Light brown sandy silt; slightly blocky, laminated
40a. Dark brown clay; blocky structure; Fe/Mn mottles
40b. Yellowish-brown very fine sand; platy to blocky structure
41\. Same as 40
42\. Grayish-brown silty clay; platy structure
43\. Brown sandy silt; occasional gravels
44\. Brown gravelly silt (1 mm-1 cm)

Meters 0 0.6
Feet 0 2.4
Desert Archaeology, Inc. 2012

Figure 4.2. Profile of Features 20 and 7, southern end and west wall of Trench 18, AZ U:9:28 (ASM), PHX Sky Train project.

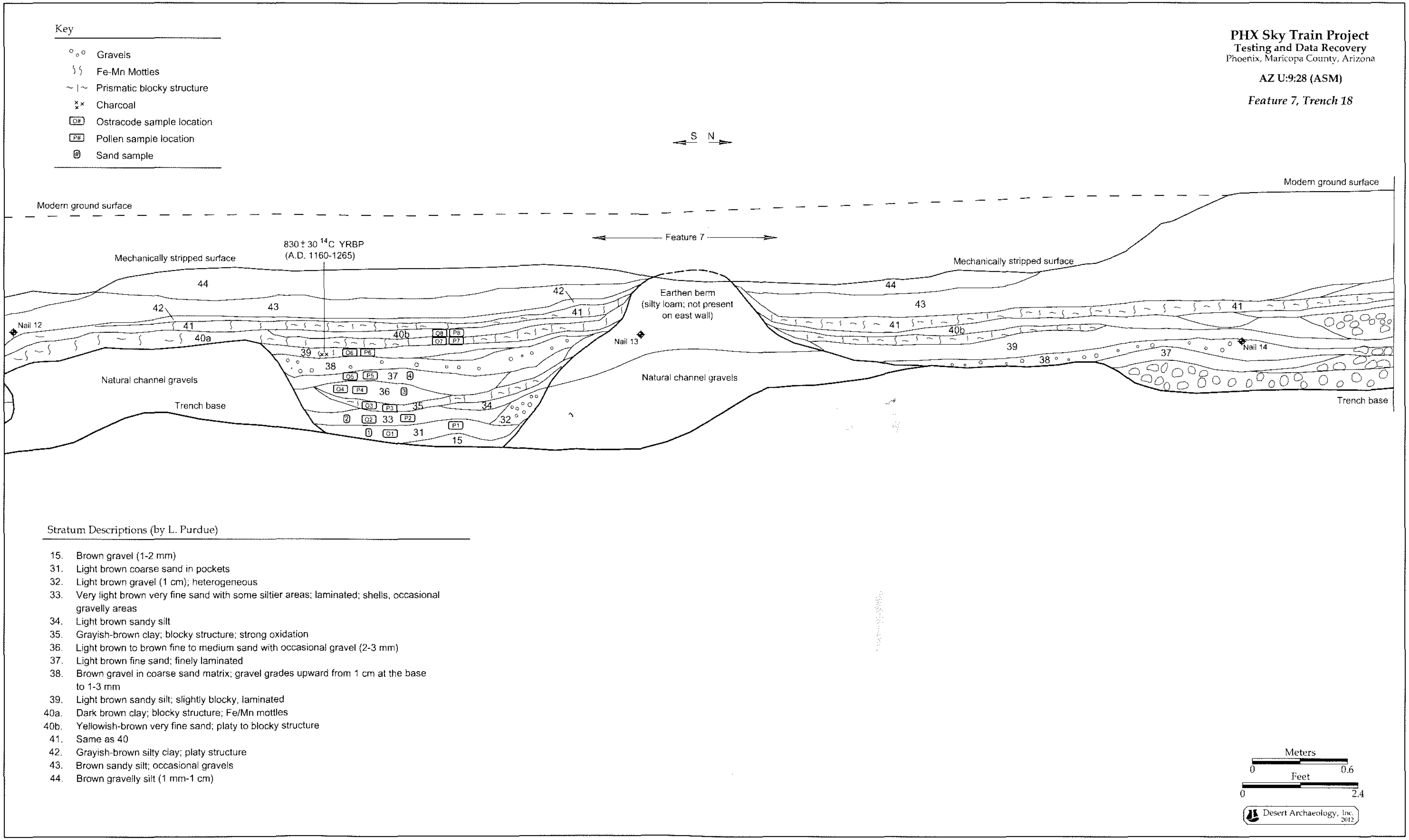
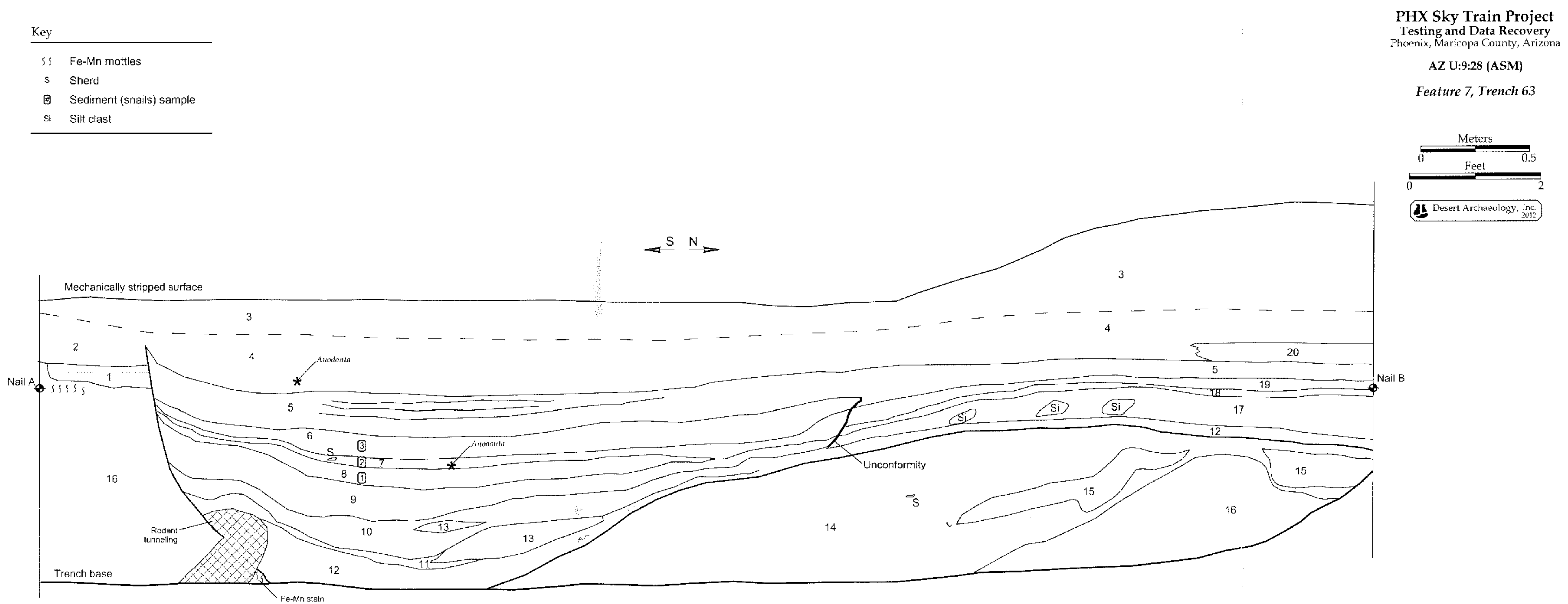


Figure 4.3. Profile of Feature 7, northern end and west wall of Trench 18, AZ U:9:28 (ASM), PHX Sky Train project.



Stratum Descriptions (by K. Henderson and C. Darby)

1. Intermixed lenses of coarse sand and clayey silt
2. Silty clay/clay silt loam; jumbled, disorganized, possibly clean-out
3. Clay silt; slightly bedded; disturbed by modern compaction, rootlets
4. Grayish-brown clay silt loam; similar to 3 but less blocky finer textured and porous; no bedding evident
5. Brown fine sandy silt; central portion of stratum with bedded coarse sands, some grains up to 1 cm
6. Grayish-brown to dark grayish-brown clay; blocky, angular
7. Alternating thin (< 1 cm) bands of clay and silt; some snails; *Anodonta* fragment at base of stratum
8. Same as 6; many snail shells noted at top of unit
9. Loamy clay; bedding evident at north edge of feature; toward the base grayish-brown clay loam grades to light brown silt; charcoal flecking, snails, reddish Fe-Mn staining near base - not precipitates

Stratum Descriptions

10. Brown very fine sandy silt; very finely bedded/laminated (1-2 mm thick)
11. Fine silty sand
12. Silty medium sand grading down to sandy silt; bedded
13. Medium to coarse sand and gravel; minor amounts to 2 cm diameter; angular
14. Bedded coarse sand and gravel with some bands of medium sand; cross-bedded
15. Brown silt loam; dislodged bank? clast? clean-out?
16. Natural (sterile) alluvium; brown silt with gravel inclusions
17. Gravelly sand and gravel with silt clasts
18. Light brown silt
19. Grayish-brown clay; blocky, angular; similar to 6 and 8
20. Bedded sand and gravel

Figure 4.4. Profile of Feature 7, west wall of Trench 63, AZ U:9:28 (ASM), PHX Sky Train project.

Figure 4.5. Catchment Feature 7 exposed in the west wall of Trench 64, AZ U:9:28 (ASM), PHX Sky Train project (view is to the north).

firmed that the lowermost strata were channel sediments or sheetwash draining from the local piedmont (Appendix C, this volume), the discovery during Phase 2 of a canal, Feature 25, entering the eastern end of Feature 7 presented new complexities for understanding the feature. Where first encountered (see Figure 4.1), Feature 25 was distinguishable as a relatively narrow discrete channel that widened into a pool upon entering Feature 7, whereupon it became indistinguishable from the catchment feature. However, through careful examination of trench exposures and deeper stripping, the base of Feature 25 was eventually tracked to the eastern wall of Trench 63 (Figure 4.6).

Western profiles of Feature 7, Trenches 12 and 18, showed no trace of Feature 25, and the canal did not reappear west of the feature. Although any westward extension of Feature 25 may have been erased by construction of later canal Feature 3, the simpler conclusion is that the canal terminated in Feature 7, more specifically, in the southeastern pool of Feature 7, which, as observed, seems to have been thoroughly dredged, resulting in the truncation of the canal and any sediment it might have deposited. Regardless, a conclusion to be drawn is that Feature 7 might have originated as a reservoir, that is, a purposeful construction to store water diverted from a natural source by ditches or canals (after Crown 1987b).

Whether strictly a catchment or a reservoir, evidence of the capacity for water storage by Feature 7 was soundly supported by the results of microinvertebrate (Chapter 6, this volume) and freshwater mollusk (Chapter 13, this volume) analyses. A continuous and relatively diverse assemblage of microinvertebrates (ostracodes and gastropods) was found in samples collected from the southern pool at Trench 18 (see Chapter 6; sample locations shown in Figure 4.3). Ostracodes commonly present in the samples included *Limnocythere staplini, Cyprideis beaconensis, Cypridopsis vidua,* and *Candona patzcuaro. Physa virgata* dominated among micro-gastropods, although its occurrence was primarily restricted to lower deposits. Following initial high velocity flows in the two cycles of filling evident in the southern pool, the habitat was sufficient to allow perpetuation of ostracode populations for some period of time (see Chapter 6). Here, the dominant presence of *Candona patzcuaro* throughout the stratigraphic sequence is particularly informative, as the time required for this species to mature and reproduce (90 days-1 year) indicates Feature 7 contained water for periods longer than 3 months.

Similar evidence of water retention was obtained from three flotation samples collected from the clay-rich strata in Trench 63, specifically for their snail content (see Figure 4.4). Relatively abundant quantities of *Helisoma tenue*, an aquatic snail, are reported from the two lower samples (see Chapter 13). Although only *H. tenue* adults were present in the lower stratum, the middle stratum contained both juveniles and adults, suggesting the environment was optimum for producing multiple generations. Although no source could be found regarding the life cycle of *H. tenue*, a similar species, *H. trivolvis*, matures at an age of 3-4 months (Dillon et al. 2006). The uppermost sampled strata yielded only a small number of *Hawaiia minuscula* and *Succinea* spp. snails, both terrestrial species that prefer wet, muddy areas with vegetation or rootlets to which they can attach themselves. The presence of these snails suggests Feature 7 held water long enough to support vegetation growing along the banks.

Sediment samples from Trench 18 were also analyzed for their pollen content, to inform on hydrological conditions (see Figure 4.3). Unfortunately, the results simply reflected the geomorphological assessment that the sampled location was filled with natural channel sediments (Chapter 7, this volume). The Feature 7 pollen assemblage, which included some algal polyads and cultigens, probably related to the movement and reworking of sediments from upslope

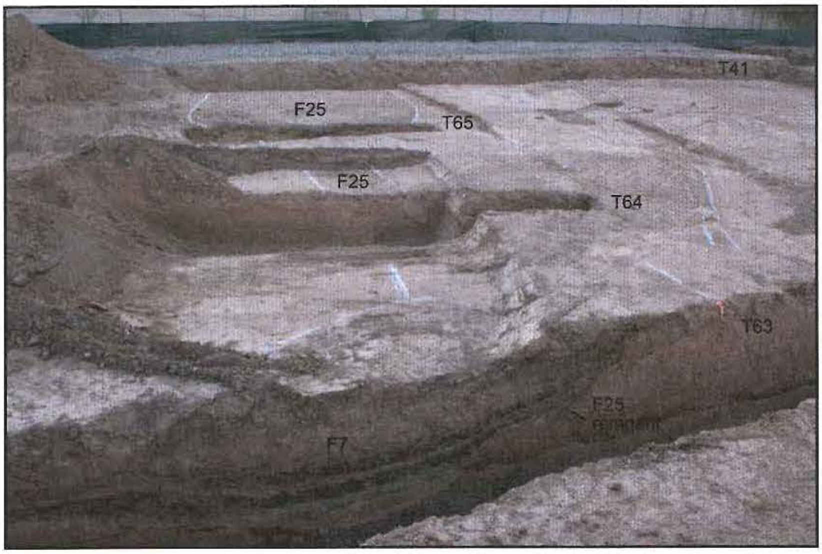


Figure 4.6. Photograph showing deep stripping units used to track canal Feature 25 across Feature 7. View is to the east from the west side of Trench 63, AZ U:9:28 (ASM), PHX Sky Train project. (A remnant of the canal is visible below the basal sediments of Feature 7 in this east trench wall; it was not visible or had been obscured by rodent disturbance on the west wall.)

canals, agricultural fields, and trash middens within Pueblo Grande Ruin, AZ U:9:1 (ASM).

Because Feature 7 was located at the eastern edge of the project area and immediately south of Madison Street, its northern limits were not exposed; therefore, little is known about the natural water source that eventually fed the feature. We cannot be sure what water might have been available to the water catchment from the north and east. In the same way, the shared alignment of canal Features 22 and 23, which ran past and were partially covered by the shallower sediments of Feature 7 on the west, brought water to small fields in this area from an unknown source to the northeast. Based on the coarse sands and gravels seen in these ditches, it is possible that they were also fed by a channel collecting seasonal runoff from the piedmont.

In conclusion, Feature 7 was a water storage feature initially filled by canal Feature 25. Feature 25 was subsequently abandoned, and the basin was cleaned out, probably expanded, and modified to collect seasonal runoff through a natural channel rather than canal water. While Feature 7 was supplied at least in part through natural processes, it was evident that prehistoric inhabitants were also manipulating its capacity to hold water. Obviously, such a reserve would prove useful in augmenting the local water supply, especially when nearby canals were running low. Although Feature 7 functioned primarily as a reservoir, its area may also have been used as an informal agricultural field, especially later in its use-life, when the basin would have been shallower and the water it collected was spread over a larger area.

FEATURE 57, AZ U:9:28 (ASM): CANAL-SIDE BASIN

Feature 57 was an enigmatic canal-side basin tentatively interpreted as having served as a field tail water return point, a boat or raft slip, or a feature for soaking potter's clay, hides, or other products. Feature 57 was associated with canal Feature 26, field lateral Features 44 and 45, and field Features 320 and 327. It dated to the middle to late Sacaton phase, circa A.D. 1000-1150, based on luminescence (OSL) and radiocarbon dates from Feature 26 and associated agricultural field laterals, as well as temporally diagnostic flat-lying sherds recovered from the base of the feature.

Feature 57 was roughly rectangular in plan view, with convex, gradually downsloping sides. Defined on the east, north, and west by a silt berm, the southern side of Feature 57 articulated with canal Feature 26 (Figure 4.7). The silt berms measured roughly 30-45 cm wide by 15 cm high. Feature 57 had a flared shape, wide and deep where it joined with canal Feature 26, curving up along the eastern, northern, and western sides, and becoming relatively flat and shallow in the upper portions near the silt edge berms (Figure 4.8). The feature measured 7.9 m north to south along the alignment of Trench 92, the northern edge measured 3.5 m long, and the southern edge, where it articulated with Feature 26, measured approximately 4.0 m long. Some ambiguity of measurements arises from the unexcavated southwestern portion of the feature at its juncture with canal Feature 26 and the fact that Features 26 and 57 gradually blended together along this edge.

At the base of Feature 57, where the sides came together, a channel-like "groove" was formed. The groove transected from the northeastern corner to the center of the southern side of Feature 57, where it joined Feature 26. At this juncture, a carefully shaped, approximately 2.6-m-long crescent-shaped descent, or drop off, was carved into the substrate at the termination of the groove. Thus, the base of Feature 57 at the juncture remained 10 cm higher than the base of canal Feature 26. A slight groove

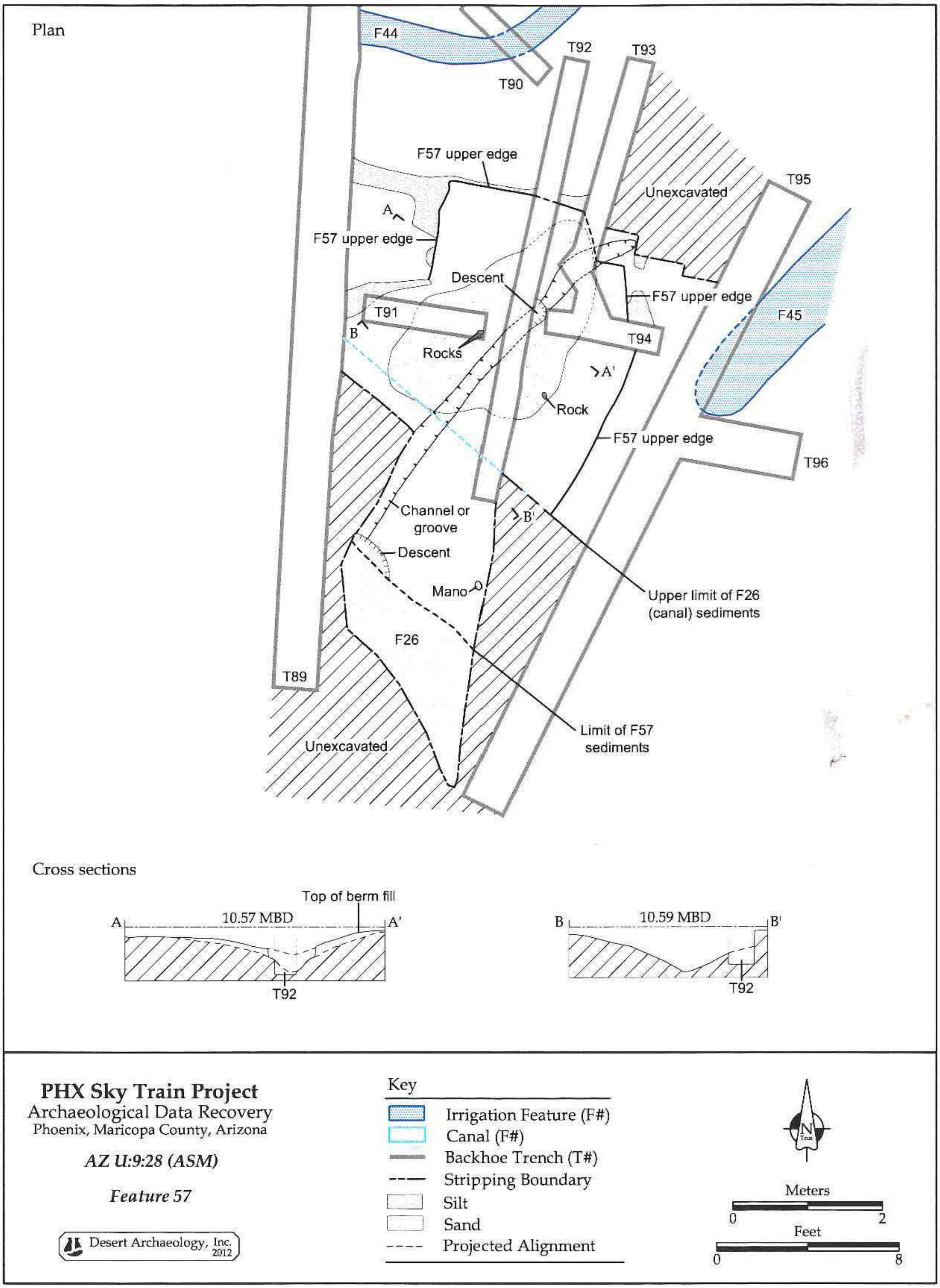


Figure 4.7. Plan view of Feature 57, AZ U:9:28 (ASM), PHX Sky Train project, showing backhoe trenches, hand trenches, and spatially related features.

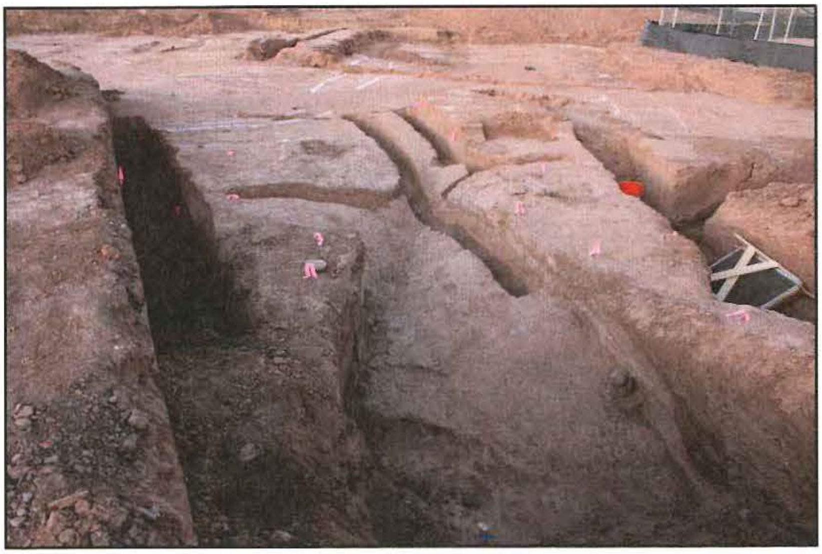


Figure 4.8. View to the north up Feature 57, AZ U:9:28 (ASM), PHX Sky Train project. (Note banks that fan out from centrally positioned channel or "groove." The apparent gouge at the lower left is the lower "descent." The tracks of field ditch Features 44 and 45 are visible at upper left and upper right, respectively; above these are the balks and trench used to sample field Feature 320.)

was formed at the base of the crescent-shaped descent in the base of canal Feature 26. It should be noted that the western portion of the crescent-shaped descent was unexcavated, remaining under a balk left at the western side of the basin-canal junction.

Interestingly, a second descent was recorded in the northern portion of the groove, although it varied in design relative to the first. Here, the crescent shape did not extend beyond the width of the groove, and an 18-cm-deep drop was noted. Below this descent, the groove initially averaged 30 cm deep and 30 cm wide but eventually became wider, merging with the flared sides of the feature (see Figure 4.7). Above and north of this descent, the groove was shallower and wider (averaging 10 cm deep and 40 cm wide) and curved slightly, terminating near the northeastern corner of Feature 57. Throughout Feature 57, the groove created a reasonably uniform central divide, measuring 5.8 m in its passage from northeast to southwest. Both sides of Feature 57 extended an average of 4.1 m on either side of the centerline formed by the groove. No secondary features were identified in Feature 57.

Excavation Strategy

Feature 57 was initially discovered during mechanical stripping of the southern lower end of field Feature 320 in an effort to determine if and how field lateral Features 44 and 45 and field Features 320 and 327 articulated with canal Feature 26 (see Figure 2.7). Mechanical stripping was anticipated to address numerous questions, including: (1) had tail water flowed from field Features 320 and 327 during episodes of irrigation; (2) if tail water had flowed from field Features 320 and 327, might it have been directed into canal Feature 26; and, (3) if the tail water did not return to canal Feature 26, did it pool and settle adjacent to the northern berm of Feature 26.

Mechanical stripping exposed a roughly rectangular area of multicolored clays and silts between Features 26 and 320 (see Figure 2.7). These deposits were later determined to be the upper sediments of Feature 57, initially presumed to be a canal feature. Lateral Features 44 and/or 45 were expected to articulate with Feature 57 as possible routes for tail water drainage from the fields into canal Feature 26. However, after the stripping unit had been cleared, it was evident that Features 44 and 45 did not, in fact, articulate with Feature 57. Instead, Feature 44 turned west just north of Feature 57, and Feature 45 terminated just east of Feature 57 (see Figure 4.7).

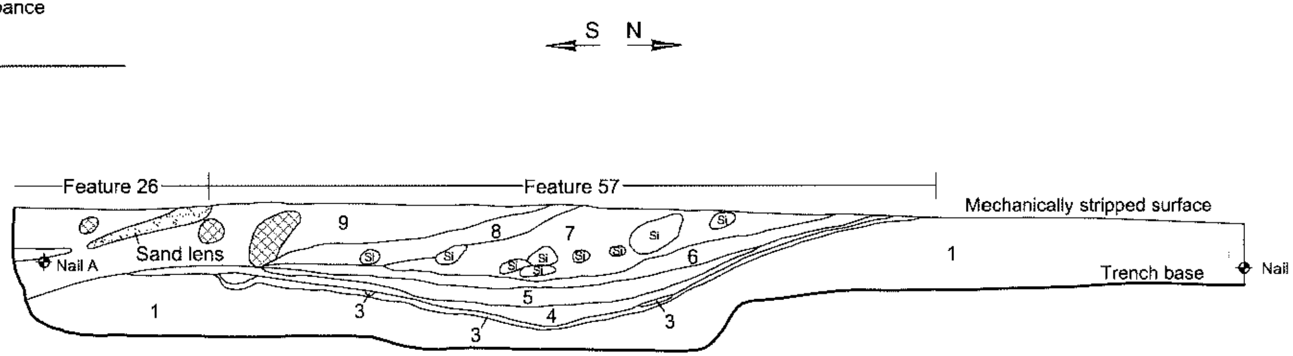
After the extent of Feature 57 was exposed in plan view, several hand trenches were excavated to confirm its identification as a canal, to document its characteristics through cross section, and to obtain sediment samples. Trench 92 was oriented north-south through the center of the feature. The morphology and character of the sediments observed in the profile initially suggested Feature 57 was a prehistoric east-west trending canal (Figure 4.9). To investigate further, Trenches 91 and 94 were excavated at right angles to Trench 92. However, sediments contained in profiles of Trenches 91 and 94 (Figures 4.10 and 4.11), though water-lain, revealed a funnel-shaped pit feature rather than a canal. Thus, Trench 93 was excavated to define the northern edge of the feature. The northern edge of the feature was visible in the trench profile as basin fill strata terminating against a silt berm (Figure 4.12).

Three excavation units were judgmentally placed over Feature 57 to sample and define it: (1) Unit 4 encompassing the western half of Feature 57, as defined by the west side of Trench 92; (2) Unit 5 encompassing the eastern half of Feature 57, except the area of its juncture with canal Feature 26; and, (3) Unit 6 encompassing the excavated junction area (Figure 4.13). While most feature fill was excavated by hand in Units 4 and 5, the fill in Unit 6 was me-

Key

Rodent disturbance

Si Silt clast



Stratum Descriptions (by H. Schaafsma)

1. Tan sandy silt; natural alluvium
2. Light tan silt; "silt halo" (Stratum 2 in Table 4.2)
3. Dark gray silt / grayish-brown clay-silt (Stratum 3 in Table 4.2)
4. Mottled dark brown and rose colored blocky clay (Stratum 5 in Table 4.2)
5. Banded dark brown clay and silty clay (Stratum 6 in Table 4.2)
6. Light gray-tan silt / silty clay (Stratum 7 in Table 4.2)
7. Dark tan coarse-grained sand with silty clay clasts (Stratum 8 in Table 4.2)
8. Reddish-brown coarse-grained sand (Stratum 9 in Table 4.2)
9. Brown silty clay; canal Feature 26 upper sediment

PHX Sky Train Project
Testing and Data Recovery
Phoenix, Maricopa County, Arizona

AZ U:9:28 (ASM)

Feature 57, Hand Trench 92

Meters
0 0.8
Feet
0 3.2

Desert Archaeology, Inc. 2012

Figure 4.9. Profile of Feature 57, AZ U:9:28 (ASM), PHX Sky Train project, western wall of hand Trench 92.

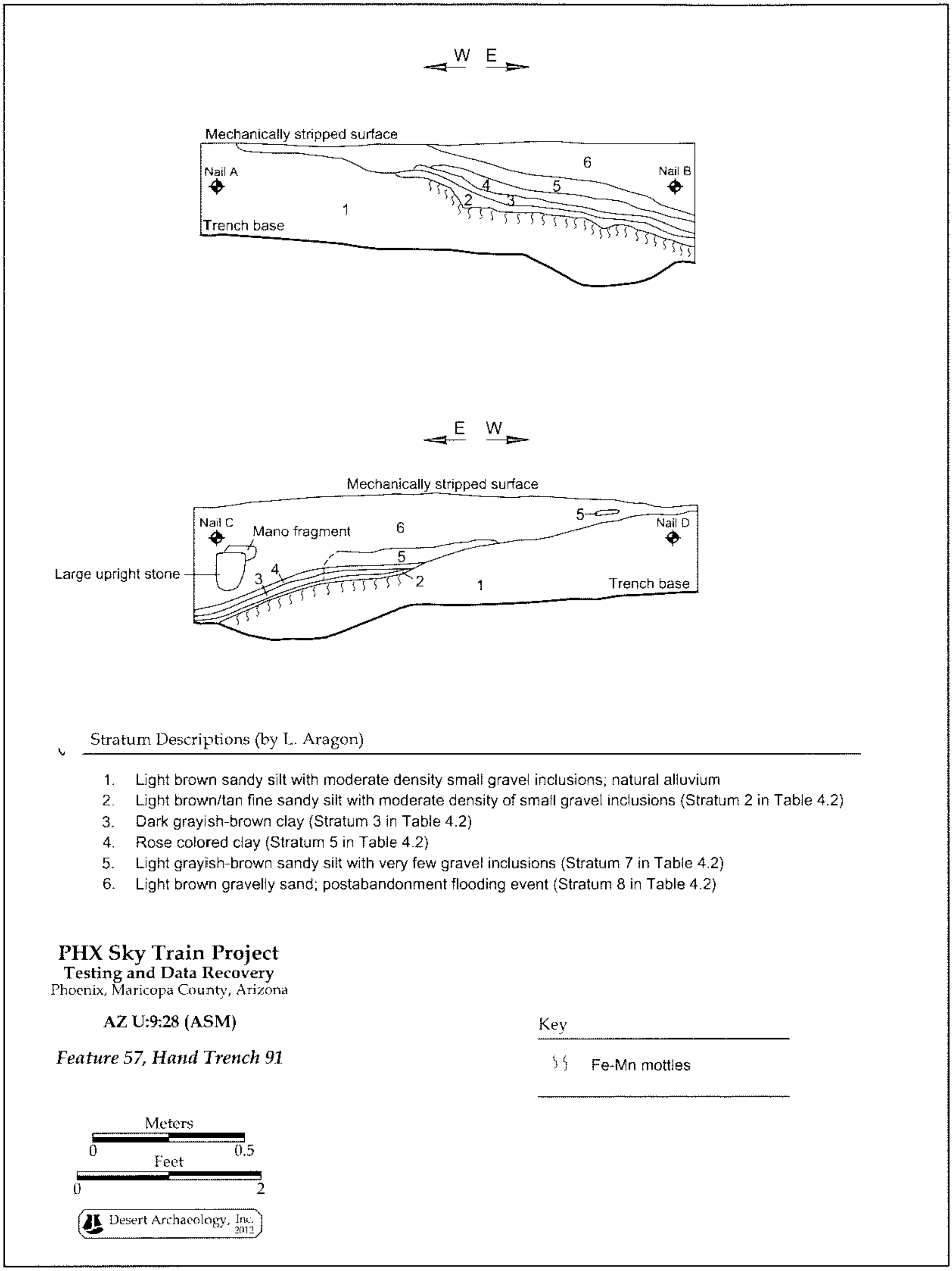


Figure 4.10. Profile of Feature 57, AZ U:9:28 (ASM), PHX Sky Train project, northern and southern walls of hand Trench 91. (This profile near the center of Feature 57 exhibits three elements of the lower field-associated strata, the silt halo, dark grayish-brown clay, and rose-colored clay, overlain by gray-tan fine silt loam and later flood deposit. Note in the south profile that portions of the upper gray-tan silt stratum were removed by floodwaters scouring the feature.)

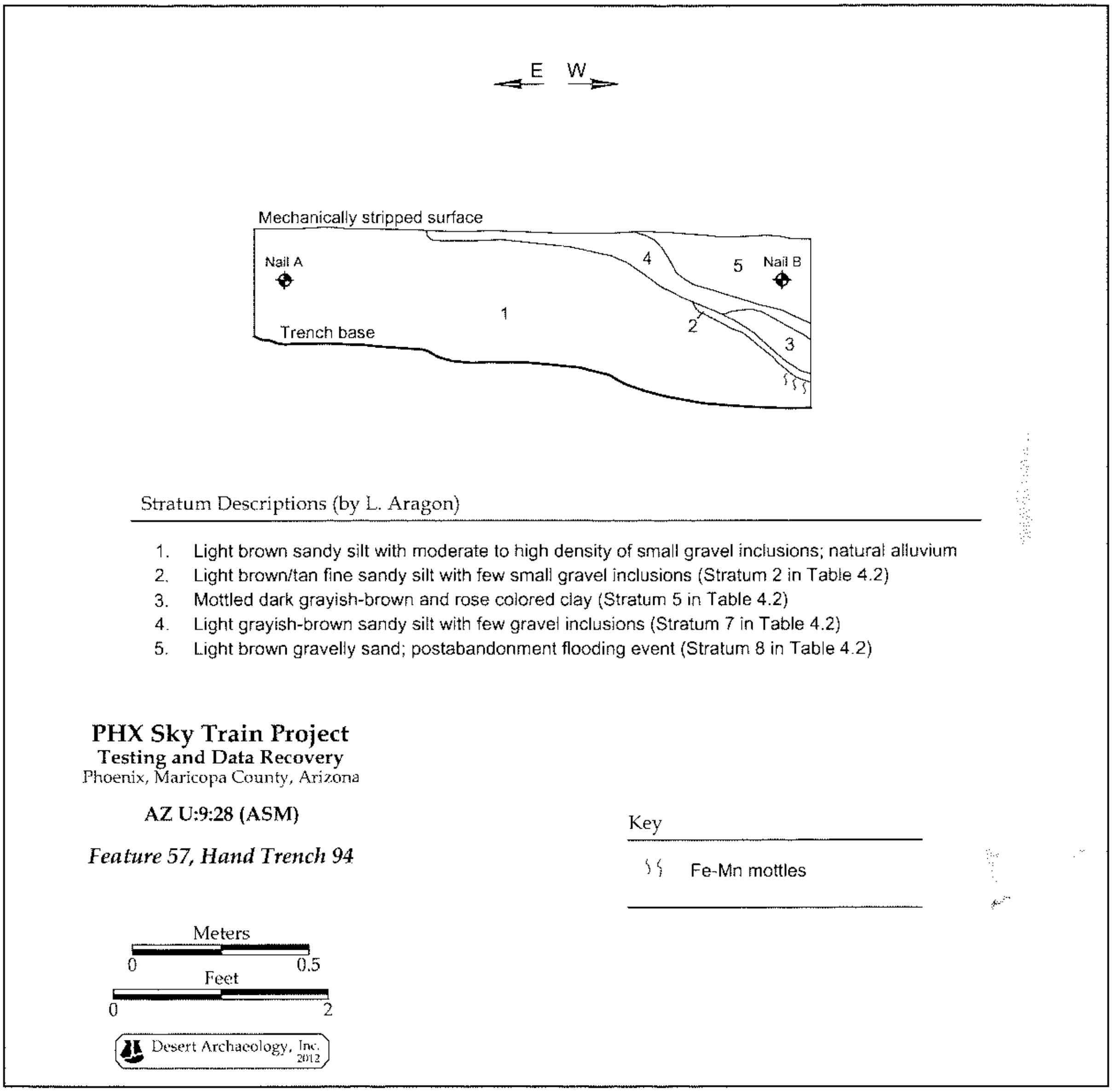


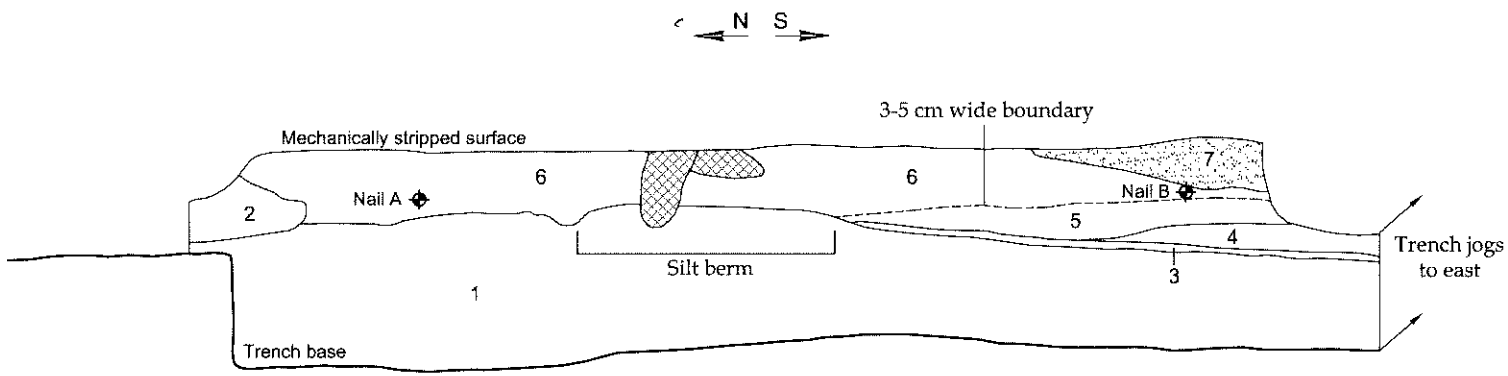
Figure 4.11. Profile of Feature 57, AZ U:9:28 (ASM), PHX Sky Train project, southern wall of hand Trench 94. (This profile exhibits only two of the lower field-associated strata: the silt halo and mottled dark brown and rose-colored clay.)

chanically excavated, with only the lower 10 cm removed by hand. A balk in the northeastern corner of Feature 57 was left unexcavated to obtain a cross section of the upper portion of the feature and the silt berms. Similarly, Unit 4 in the southwestern portion of the feature was largely unexcavated for the purposes of obtaining feature cross sections.

Twenty-four soil samples were collected from Feature 57, as strata were exposed during excavation. Seventeen of these, many of which were partitioned as subsamples, were submitted for analysis, including soil properties ($n = 9$), pollen ($n = 10$), phytolith ($n = 7$), ostracode ($n = 5$), and freshwater mollusks ($n = 1$) (see Table 4.1). Three soil samples collected from canal Feature 26 were also submitted for ostracode analysis to complement the results from Feature 57. The results of these special analyses are provided in Chapters 6-8 and Chapter 13.

Fill

The fill in Feature 57 consisted of 11 distinct strata, although not all were visible in any single profile or exposure (Table 4.2). The lowest stratum, Stratum 1, was a thin (≤ 1 cm) deposit of medium-grained sand found only along the bottom of the groove between the upper and lower descents. This



Stratum Descriptions (by H. Schaafsma)

1. "Sterile" dark tan sandy alluvium (natural alluvium)
2. Medium brown silt with mottling of 1-2 cm diameter grayish-brown silty clay chunks
3. Thin (0.5-0.2 cm) layer representing the original bottom of Feature 57; consists of mostly dark gray clay with thin fingers of fine brown sand, gray silt, reddish silt, and some large sand grains (Stratum 10 in Table 4.2)
4. Grayish-tan silty clay (Stratum 7 in Table 4.2)
5. Medium brown sandy loam with a hint of reddish-brown (mixed Strata 8 and 9 in Table 4.2)
6. Postabandonment fill; medium brown silty loam (Stratum 11 in Table 4.2)
7. Area with higher density of larger grained sand

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AZ U:9:28 (ASM)

Feature 57, Hand Trench 93

Key

Rodent disturbance

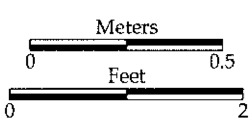

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Figure 4.12. Profile of Feature 57, AZ U:9:28 (ASM), PHX Sky Train project, at hand Trench 93 showing northern silt berm.

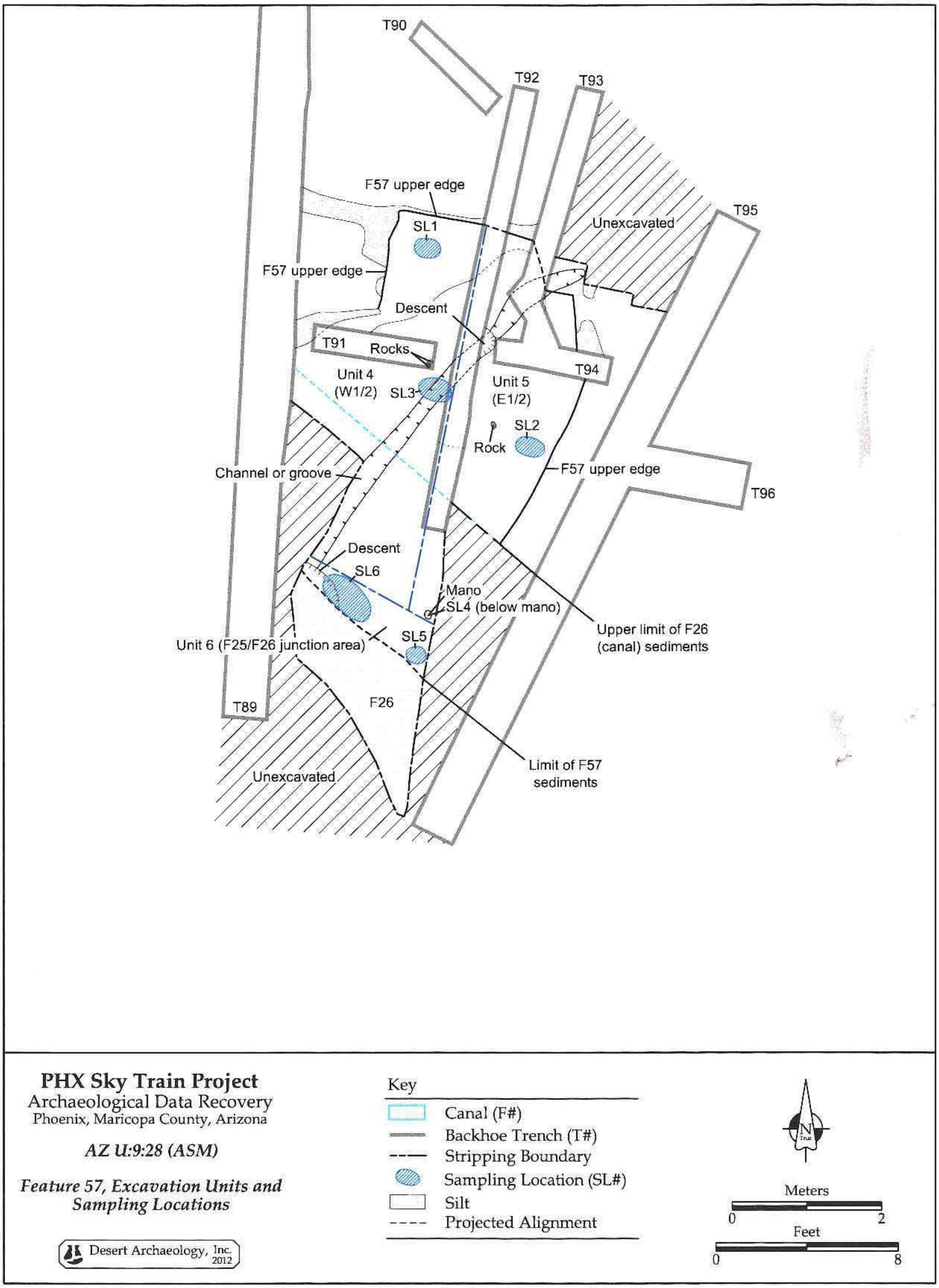

Figure 4.13. Plan view of Feature 57, AZ U:9:28 (ASM), PHX Sky Train project, showing excavation units and sampling locations.

Table 4.2. Definitions of Feature 57 strata, AZ U:9:28 (ASM), PHX Sky Train project.

Stratum	Description
1	Light brown medium-grained sand
2	Light brown to tan fine sandy silt (termed the 'silt halo')
3	Dark grayish-brown heavy clay silt
4	Dark brown clay silt mottled with tan sandy silt
5	Mottled dark brown and rose-colored clay (sometimes termed 'rainbow clays')
6	Dark brown heavy clay
7	Grayish-tan fine silty loam
8	Tan coarse sand and small gravels, tan sands
9	Reddish-brown coarse sand and small gravels
10	Dark grayish-brown clay with thin lamina of fine brown sand, gray silt, reddish silt, and a few large sand grains
11	Medium reddish-brown sandy loam

Notes: Stratum 1 was only found in the base of the groove. Stratum 4 was only found in the southern 1.5 m of the feature, primarily south of Trench 92; the top of this stratum was thinly covered with a coarse-grained sand; these sand particles were more angular than those of Stratum 1. Stratum 7 keyed out as brown (7.5YR 5/4) on the Munsell scale (see Chapter 6). Strata 8 and 9 were postabandonment flood deposits. Stratum 10 was only preserved in the northeastern corner balk, as recorded in Trench 93 profile. This stratum probably represents extremely thin, indistinguishable gradations of Strata 3-6. Stratum 11 was the final postabandonment filling of Feature 57.

medium-grained sand layer was not observed within associated canal Feature 26, field lateral Features 44 and 45, or field Features 320 and 327. Twenty-six ceramic sherds were discovered flat-lying and either embedded in or directly on top of the sand found at the base of the groove.

Above this and covering all but the highest portions of the bottom of Feature 57 was a series of strata that were visually and texturally similar to the sequence of strata in the associated field lateral Features 33, 29, 44, 45, and 53, and in the field furrows in Features 320 and 327. These strata formed a distinctive sequence (see Strata 2-6, Table 4.2), collectively referred to here as the 'lower strata' of Feature 57. Two of these lower strata were visually striking. The lowest of the sequence was a light tan silty clay that outlined the features in this group earning the field name of 'silt halo;' the second was a mottled red and brown clay that was dubbed 'rose-colored' clay by Masse (1976). That name is continued to be used here. At the top of Stratum 4, the base of Stratum 5 was a layer of coarse-grained sand. This was as thick as 1 cm in the southern 1.5-2.0 m of the feature, becoming thinner above the northern drop. It was only noted within the lowest part of the feature, along the groove. The sand was similar to Stratum 1, but the particles were more angular than those of Stratum 1. This sand may have been placed similarly to Stratum 1 (see below), although it appeared to be more of a natural deposit, perhaps a relatively small non-damaging local flood.

These lower sediments were not found in the bottom of canal Feature 26, although they did extend down the sides to the top of the lower descent. It is not surprising that they were not seen in the base of Feature 26, as this canal appears to have been re-excavated at least once to realign with Features 17 and 14 (see Chapter 3). There is also evidence that Feature 26 may have originally been only as deep as the bottom of Feature 57, and later reworking deepened it 10 cm, accounting for the descent seen at the junction of the two features. There was also evidence of at least several canal cleaning episodes present in the sediments at the intersection of Features 57 and 26.

Directly above Strata 2-6 was a stratum of fine silt loam, Stratum 7, that, in the field, appeared grayish-tan (Munsell colors keyed this strata as brown, 7.5YR 5/4). Here, it is referred to as gray-tan silt. The lower half of Stratum 7 was slightly darker and mottled, with inclusions of a dark gray clay silty loam. The upper half was lighter and uniform in color. Stratum 7 ranged between 1 cm and 5 cm thick, and formed a thin deposit in the shallow portions of the feature that thickened rapidly in the deeper portions of Feature 57, to a maximum of 37 cm near the junction with canal Feature 26.

The central and upper fill of Feature 57 contained two texturally similar strata, Strata 8 and 9; each consisted of chunks of the grayish-tan sediments, coarse sand, and small gravels. One of these upper deposits contained tan sands (Stratum 8, present primarily in the northern and western portions of Feature 57), while the other contained reddish sands (Stratum 9, present primarily in the southern portion of Feature 57). These appear to have been deposited by two postabandonment floods originating off the piedmont above the fields to the north.

As discussed, flood deposits from the piedmont were also detected in reservoir Feature 7.

Artifacts and Age

The fill of Feature 57 contained relatively few artifacts throughout. These included five pieces of flake stone debitage (Chapter 11, this volume) and four pieces of ground stone (Chapter 12, this volume). All the ground stone and four of the lithic flakes were recovered from the flood deposits. One lithic flake was found at the base of the groove; the others were found in the fill. All the flaked stone artifacts appear to be incidental to the use of Feature 57. Four fist-sized cobbles and an elongated waterworn pebble were noted. One was in the upper flood sediments, two cobbles and the pebble were recovered from the eastern side of Feature 57, and one was located near the south end of the groove. One of the cobbles found along the eastern side exhibited several flake scars. The cobble near the south end of the groove, one lithic flake, and one pebble were the only non-ceramic objects in contact with the base of the groove.

In all, 116 ceramic sherds were recovered from the fill. Roughly one-third of this assemblage (n = 37) was found in the upper flood deposits, while 64 sherds were collected from the lower sediments. Of these, 26 were discovered at the base of the feature, and all were either embedded within the sand layer at the bottom of the groove, or directly on the top of the sand lens. Two separate sets of sherds, some of which fit together, originated from the same buff ware vessels (counted as one each in the ceramic analysis). Diagnostic ware types from the base included three Middle Sacaton Red-on-buff or Late Sacaton Red-on-buff or Casa Grande Red-on-buff and one Late Sacaton Red-on-buff or Casa Grande Red-on-buff. Seven plain ware, one red ware, and 18 indeterminate red-on-buff ceramics were also collected from the base (Chapter 10, this volume). Their location in the base of the groove and the fact that they were found embedded in the unusual and thin sand layer suggests the ceramics and the sand were part of an offering placed at the bottom of the feature when its construction was completed.

Although no material was found to provide an independent date for Feature 57, OSL dates indicate components of the field lateral system leading to this feature were functioning sometime in the interval between A.D. 1000-1150, or the middle to late Sacaton phase (Chapter 9, this volume). This age is consistent with diagnostic ceramics recovered from Feature 57, especially those recovered from the groove, although these imply an age somewhat later in the defined interval, perhaps A.D. 1070-1150, the time when Late Sacaton Red-on-buff was produced.

Discussion

Throughout its excavation, interpretations for the construction and use of Feature 57 were few, despite numerous discussions with, and field visits by, several Southwestern researchers, including those specializing in Hohokam canals, sedimentology, and geomorphology. Initial postfield research focused on interpretations relating to Feature 57 having functioned as a walk-in for canal access, a tail water collection basin, or as an artificial wetland to cultivate plant food or weaving materials. Any of these uses may have also attracted faunal resources, such as birds, turtles, and frogs. However, for numerous reasons discussed in the following sections, after all lines of evidence were explored, Feature 57 is cautiously interpreted as a boat or raft slip and/or a pool for soaking products, such as potter's clay, plant material such as agave fiber, and hides. In the final analysis, a variety of activities likely occurred in and around Feature 57.

Life History of Sediment Deposition for Feature 57

This section provides a life history of the sediment deposition of Feature 57. As with most fluvial deposits, there was variability in the thickness and presence or absence of each stratum throughout the feature. Thus, individual profiles might show more or fewer strata than another. That said, the lower strata and gray-tan silts, Strata 2-7, were essentially uniform throughout.

Stratum 1, located along the base of the Feature 57 groove (Figure 4.14), may have been intentionally placed. As mentioned, Stratum 1 consisted of medium-grained sand and was not present elsewhere in the feature, nor was it observed in the associated field and canal features. The flat-lying ceramics at the base of the groove were embedded in, or rested directly on top of, this thin layer. Stratum 1 extended only from the base of the northern descent to the top of the southern descent; it was not present above the northern descent, or below the southern descent in canal Feature 26. Streamflow sufficient to have carried this size sand would be expected to also contain fine sands and silts, which should be intermixed with the larger grained sands. However, the Stratum 1 sand was uniform in size. The localized extent of this sand, following only the bottom of the groove, as well as its uniformity, suggests it was placed there intentionally with the ceramics, rather than by natural processes.

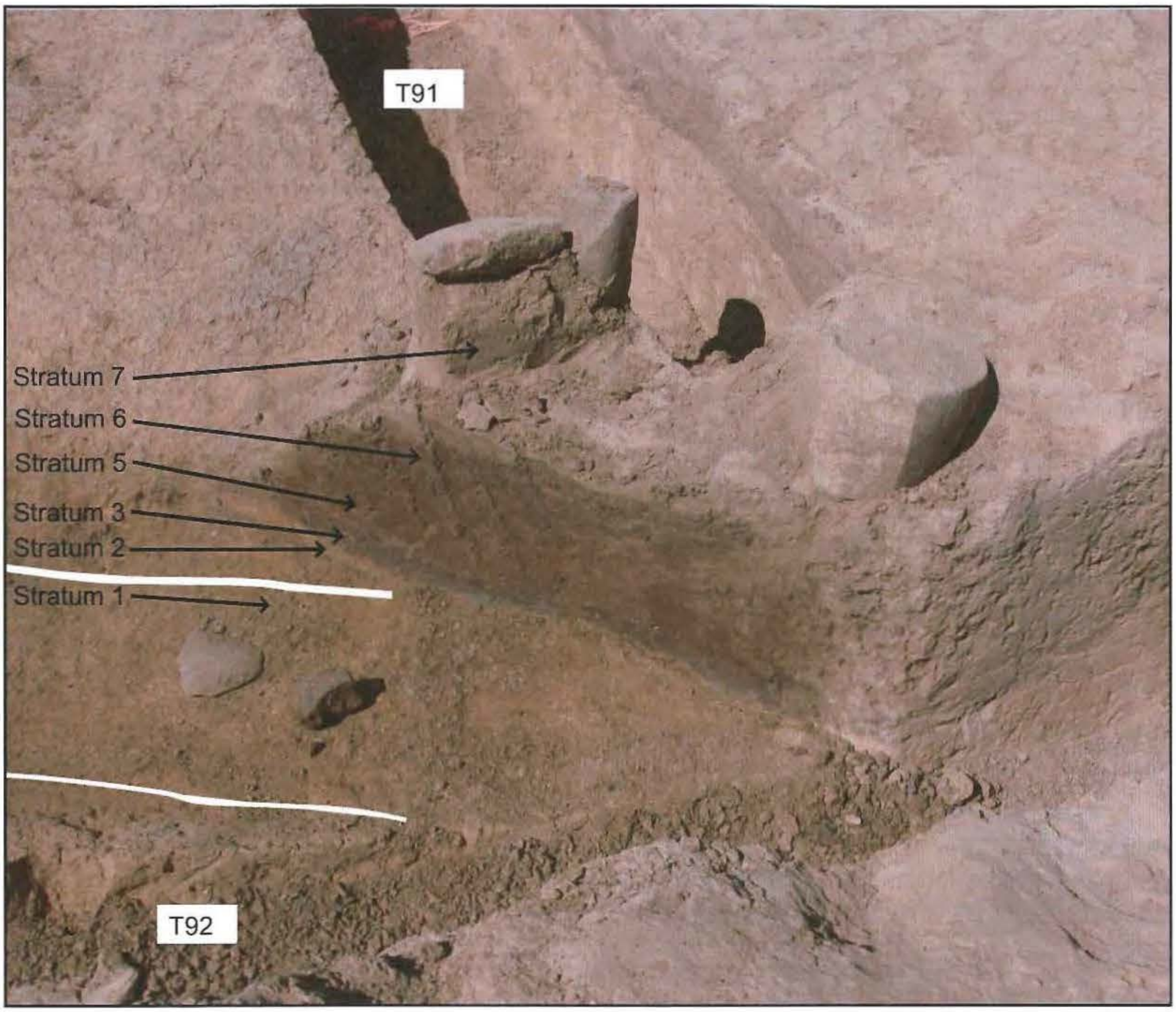

Figure 4.14. Bottom of groove near the center of Feature 57, AZ U:9:28 (ASM), PHX Sky Train project, is shown between light-colored lines; note large-grained sand covering the base. (Strata are defined in Table 4.2; compare also with strata in Trench 91 [Figure 4.10].)

The lowest strata in Feature 57, Strata 2-6, apparently originated from the field system located to the north. The strata sequence was visually similar to strata noted in canal Features 29, 33, 44, and 45, field Feature 320, and Feature 57. This sediment sequence was deepest in the bottom of the feature, overlying the groove, and became thin, 1-2 cm, in the shallow portions of the feature. While the strata from Features 29, 33, 320, and 57 were visually and texturally similar to each other, soil texture analysis revealed that the sediments in Feature 57 had a higher silt fraction relative to comparable strata in the associated field features (Figure 4.15): 50 percent silt in Feature 57, 47 percent in lateral Feature 29, and 38 percent in lateral Feature 33. Explanations for this trend are discussed below. Samples from the gray-tan silts, Stratum 7, contain up to a 74 percent silt fraction, with an average silt content of 72 percent.

It is notable that the sediments of Feature 57 had the highest percentage of silt fraction of all the features sampled during the current project (Table 4.3). All the activities that occurred in Feature 57 presumably resulted in silt being deposited into the feature, and further, these activities likely began as soon as the feature was constructed. Silt generated solely within Feature 57 would contribute silt to the inflowing field sediments, accounting for their visual similarity but higher silt content. Given that the full sequence of sediments from the fields was found also in Feature 57, the initial construction and use of Feature 57 must have been coincident with the initial construction and use of the fields irrigated by canal Feature 33. In sum, although the activities being conducted within Feature 57 added silt to the sediments arriving from the adjacent field system, the higher levels of silt deposition in Feature 57 still implies

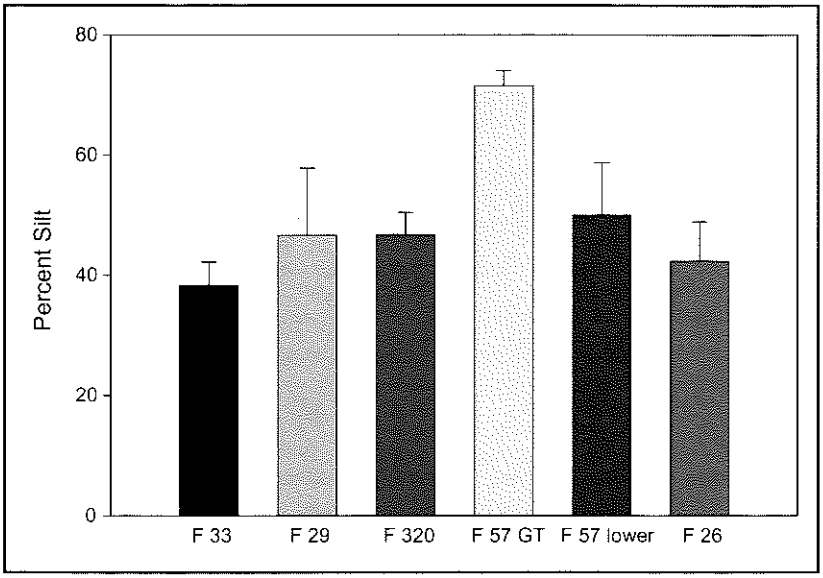

Figure 4.15. Bar graph showing average silt fraction in features associated with Feature 57, AZ U:9:28 (ASM), PHX Sky Train project. (This graph shows only the average silt fraction for sampled associated feature; the lower sediments, F 57 lower, and upper gray-tan silts, F 57 GT, of Feature 57 are displayed separately.)

some specialized, albeit as yet unidentified, activity.

At least some of the activities conducted within Feature 57 seem to be independent from its relationship to the adjacent field systems. As mentioned, based on available data, the lower sediments, Strata 2-6, were delivered to Feature 57 from the adjacent field system, likely via an extension of either field lateral Feature 44 or Feature 45. This connection continued for most of the time the fields were in use. This is evidenced by the fact that the shared sequence of strata among the features represents virtually the entire sediment sequence in the fill of the field furrows and the laterals (Figure 4.16; see also field lateral profiles provided in Chapter 5, this volume).

When the flow of field sediments into Feature 57 stopped, Feature 57 continued to be used. The activity generating the silt continued, resulting in the buildup of the gray-tan silts, Stratum 7. During excavation of the silt stratum, it was noted that the silt appeared as many, extremely thin (< 0.2 mm) lamina, such that the troweled surface looked like fine-grained wood. These well-preserved thin lamina suggest stable conditions within the feature. Further support for the stability of the depositional environment was provided by phytolith concentrations found in both the upper and lower portions of the gray-tan silts (see Chapter 8).

The volume of silt generated appears to have been so great that it periodically, or slowly and continuously, slumped into canal Feature 26. This required intermittent cleaning of canal Feature 26, as substantiated by two discrete deposits of gray-tan silt on the northern bank of canal Feature 26 and a third in field lateral Feature 45. One canal Feature 26 deposit was along the bank, roughly 2 m downstream from Feature 57; the second was upstream about 1 m from their juncture. A small lens of gray-tan silt was also noted in profile of Feature 45 in Trench 96. This was interpreted as gray-tan silt, Stratum 7, cleaned out of canal Feature 26, subsequently deposited on the north side of the berm of Feature 26, and finally washed into Feature 45. Whatever its use, Feature 57 contained large quantities of silt that were not deposited solely as a result of its relationship with the adjacent field systems, nor did the silt enter Feature 57 from Feature 26.

Canal Feature 26 continued to be used after Feature 57 was abandoned. At the end of its use, roughly half of Feature 57 was filled with sediment. This left a notch in the northern bank of canal Feature 26 where the upper half of Feature 57 was now abandoned. This void was filled with a mottled clean-out deposit of dark brown clay and gray-tan silt (Figure 4.17). The north bank of canal Feature 26 was then reshaped so that the general curve of the canal cut through the Feature 57 gray-tan silts, Stratum 7. After the clean-out of Feature 26, the first of two floods that originated off the piedmont to the north flowed through the northern half of Feature 57 and into canal Feature 26, depositing Stratum 8 (Figure 4.18). A second flood later filled the remainder of the Feature 57 with reddish-brown sands, Stratum 9.

The early use of canal Feature 26 was characterized by relatively high streamflow, and the last-use deposited silt and clay soils were due to low or slow flow (Chapter 3, this volume). The last use of Feature 57 appears to have occurred prior to this period in the use of Feature 26, as the heavy brown clays filling Feature 26 are primarily above the gray-tan silts at the articulation of the two features. Thus, it seems safe to say that Feature 57 was abandoned some time before the calibrated A.D. 1225-1295 date from canal Feature 17 (see Table 3.5) associated with the later realignment or reconstruction of canal Feature 26.

Analyses of the soil characteristics, including the content of organic and total carbon, available and total phosphorus, and common cations, including calcium, manganese, sodium and potassium, were

Table 4.3. Feature 57, AZ U:9:28 (ASM), PHX Sky Train project, gray-tan silt and lower sediment textures compared with associated Features 33, 29, 26, and 320, and internally within Feature 47. (Note that the gray-tan silts differ significantly from all other texture profiles in the sand and silt groups, and in all groups within Feature 57. Note also that the lower sediments of Feature 57 are not significantly different from the sediments in field lateral Features 33 and 29, the source for the lower sediment.)

Feature 57 Sediment	t-test	Sand %	Silt %	Clay %
Feature 57-Feature 320				
	T value	-7.352	12.868	1.555
Gray-tan silt	P value	0.000	> 0.001	0.134
	df	22	22	22
	T value	-3.584	1.303	3.685
Lower sediments	P value	0.002	0.206	0.001
	df	23	23	23
Feature 57-Feature 26				
	T value	-2.394	8.421	-2.315
Gray-tan silt	P value	0.044	> 0.001	0.049
	df	8	8	8
	T value	0.561	1.673	-1.722
Lower sediments	P value	0.589	0.129	0.119
	df	9	9	9
Feature 57-Feature 29				
	T value	-6.047	4.300	-1.787
Gray-tan silt	P value	> 0.001	0.003	0.112
	df	8	8	8
	T value	0.872	0.543	-1.051
Lower sediments	P value	0.406	0.600	0.321
	df	9	9	9
Feature 57-Feature 33				
	T value	-3.489	14.963	-0.724
Gray-tan silt	P value	0.008	> 0.001	0.490
	df	8	8	8
	T value	-1.520	2.968	-0.088
Lower sediments	P value	0.163	0.016	0.932
	df	9	9	9
Feature 57 gray-tan silts-Feature 57 lower sediments				
	T value	-4.007	4.718	-1.659
Gray-tan silt to lower sediments	P value	0.005	0.002	0.141
	df	7	7	7

conducted on the soils from Feature 29 (lateral), Feature 320 (field), and Feature 57 (Tables 4.4 and 4.5; results for Feature 320 are reported in Chapter 5). This set of features allowed an opportunity to study the connectivity between Feature 57 and the canal system originating from canal Feature 33. It was hoped that these analyses would help shed light on the use of Feature 57.

The hypothesis that the feature may have functioned as a pool for soaking organic materials suggested that the carbon content of the sediments should be higher in Feature 57 than in other features sharing the same water flow. The results show that field lateral Feature 29 and Feature 57 have similar percentages of organic and total carbon, as well as total phosphorus (a number of samples did not return results for the total carbon, resulting in fewer samples for comparison) (see Table 4.4). Of note is that the lower stratum known as the rose-colored clay had almost three times as much available phosphorus in Feature 57 when compared to lateral Feature 29, although this apparent difference might be a product of the small number of samples. The available phosphorus in Features 320 and 57 was simi-

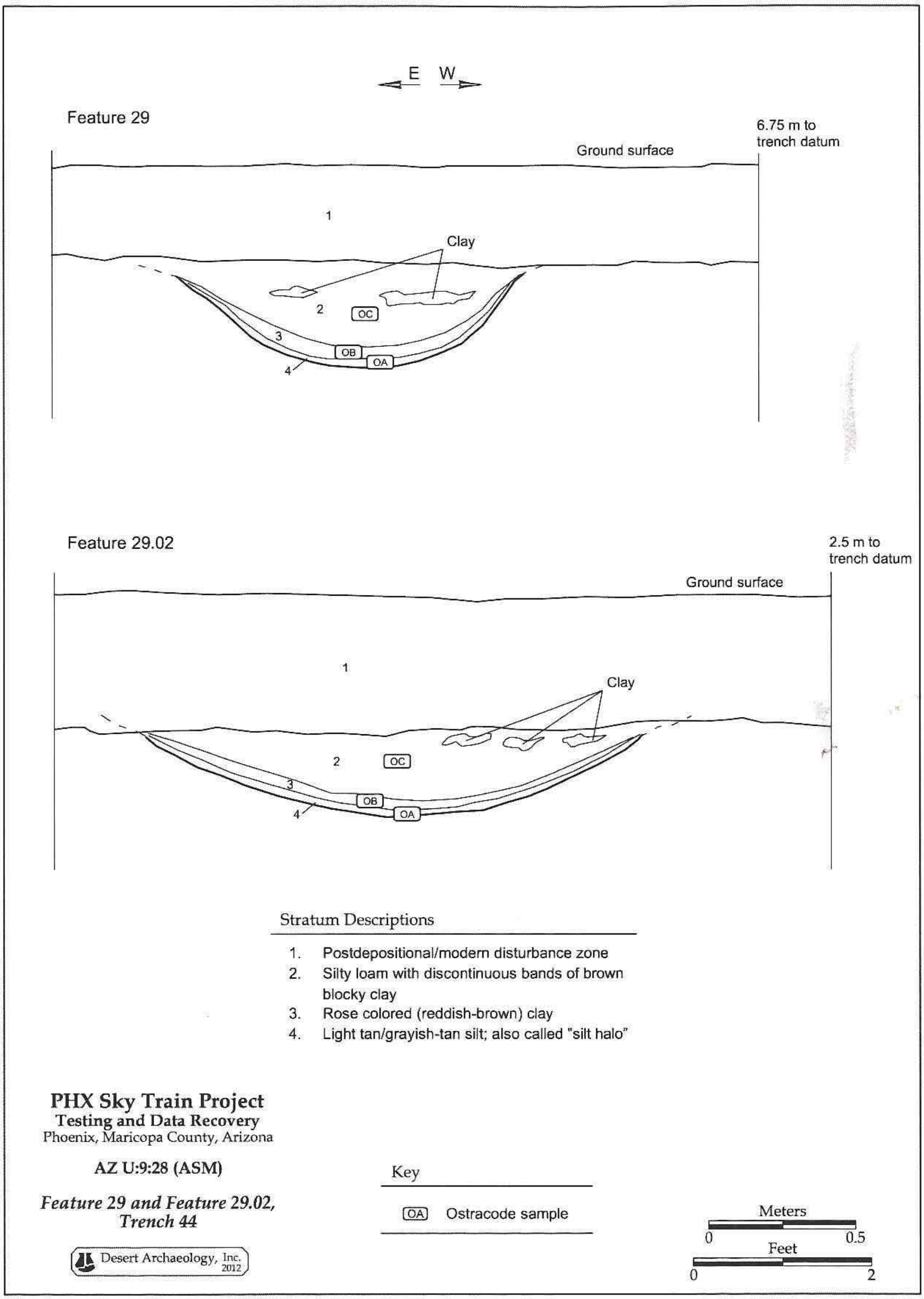

Figure 4.16. Profile of field lateral and sub-lateral, Features 29 and 29.02, AZ U:9:28 (ASM), PHX Sky Train project, showing lower sediment layers that were also seen in Feature 57.

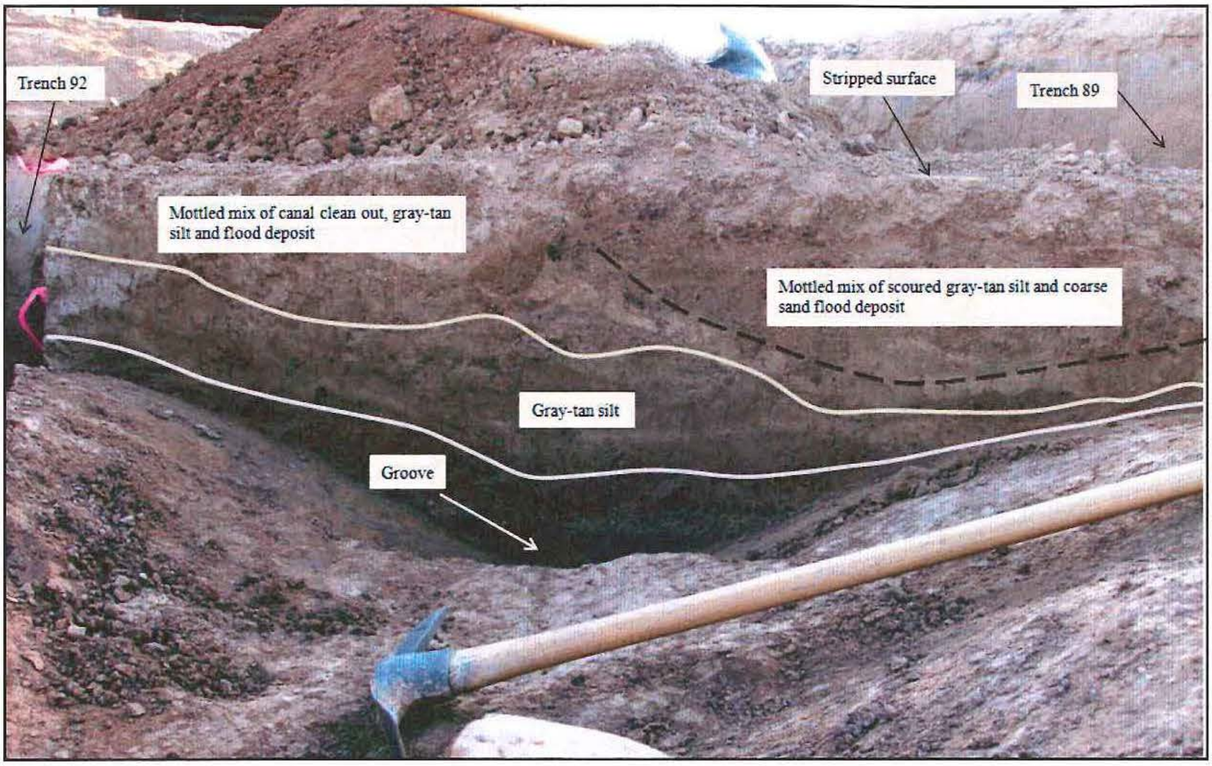

Figure 4.17. Photograph of Feature 57, AZ U:9:28 (ASM), PHX Sky Train project, east-west profile exposed during excavation. (The gray-tan silts have been removed from the foreground, and the top of the lower sediments exposed. The lower sediments have been removed to sterile at the profile, also exposing the base of the groove. The boundary between the lower strata and gray-tan silt was relatively narrow and sharp. The upper boundary of the gray-tan silts was heavily mottled due to flood scour, 1-5 cm. Note the channel from the coarse sand flood deposits on the left.)

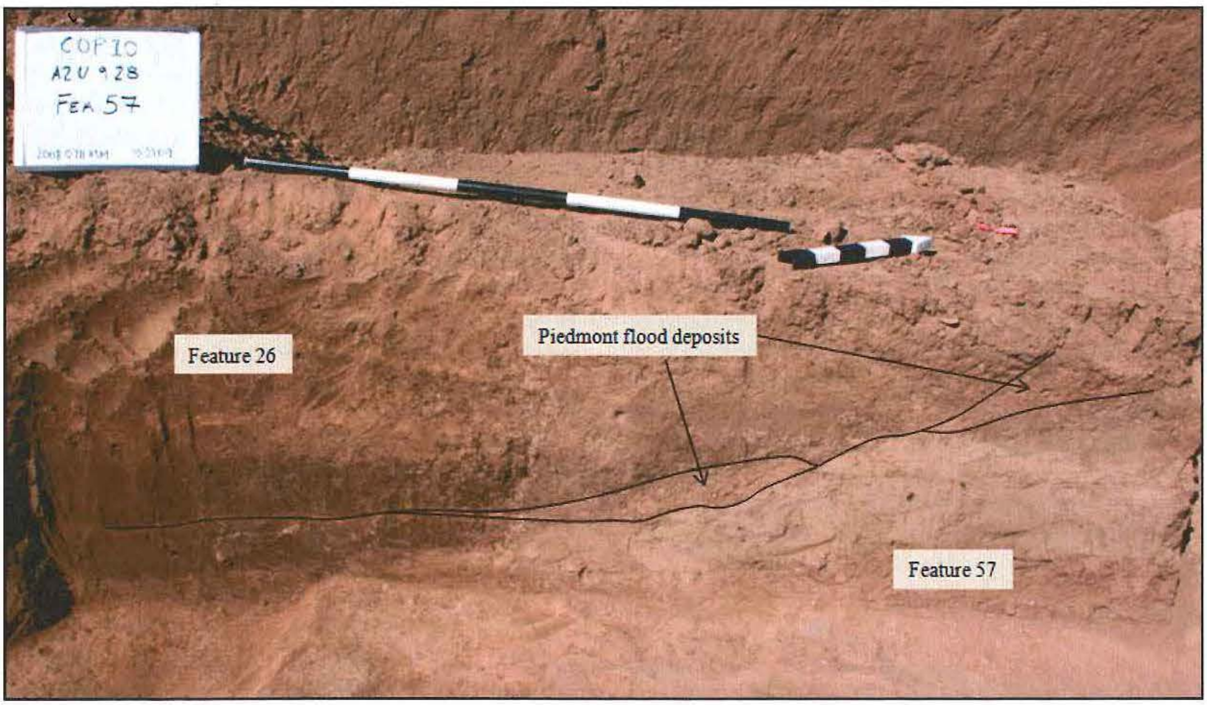

Figure 4.18. Photograph showing flood deposits at the articulation of Features 26 and 57, AZ U:9:28 (ASM), PHX Sky Train project. (The piedmont-derived flood deposits lie between Feature 26 and Feature 57 sediments. Darker brown sediments left of the flood deposits are silty clays in the canal. To the right of the flood deposits are sediments in Feature 57. The "gray-tan silts," Stratum 7, are directly above the Feature 57 label.)

Table 4.4. Feature 57, AZ U:9:28 (ASM), PHX Sky Train project, soil properties: texture, bulk density, organic carbon, and phosphorus.

Feature	Sample ID	Texture[a] Sand (%)	Silt (%)	Clay (%)	Soil Classification	Bulk Density[b] (gm/cm3)	Total Carbon[c] (%)	Organic Carbon[d] (%)	Total Phosphorus[e] (%)	Available Phosphorus[f] (ppm)
29	A	22	56	22	Silt loam	1.37	0.59	1.1	0.93	5.6
29	B	24	32	44	Clay	1.34	ND	1.7	1.10	2.0
29	C	18	48	34	Silty clay loam	1.34	0.79	1.2	1.00	3.5
29.02	A	22	58	20	Silt loam	1.35	2.60	1.0	0.98	3.1
29.02	B	18	34	48	Clay	1.30	1.20	1.7	1.10	2.5
29.02	C	24	52	24	Silt loam	1.37	0.34	1.0	1.00	5.9
57	SL1a	2	72	26	Silt loam	1.19	1.60	1.4	1.20	5.6
57	SL1b	14	64	22	Silt loam	1.33	ND	1.1	1.10	3.6
57	SL5a (D3)	12	72	16	Silt loam	1.25	0.42	1.5	1.20	3.3
57	D2	10	74	16	Silt loam	1.23	1.10	1.2	1.10	3.7
57	D2	8	68	24	Silt loam	1.25	0.64	1.4	1.00	4.0
57	SL3b (D1)	30	40	30	Clay loam	1.30	1.20	1.3	1.00	3.6
57	SL3b(4)	20	48	32	Silt loam	1.26	1.50	1.4	1.10	3.2
57	SL6(4)	26	50	24	Silt loam	1.18	0.80	1.5	1.10	4.5
57	SL6	30	48	22	Loam	1.31	1.00	1.4	1.00	7.0

Note: ND means none detected.
[a]Hydrometer method (Gee and Bauder 1986).
[b]Chapter 3.7:50-51 (Brady 1974).
[c]Analysis by combustion (Carter 1993).
[d]ASTM D2974-00, Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.
[e]WREP 125 (Gavlak et al. 1994).
[f]Olsen bicarbonate method (Jones 1999).

lar, although higher in Feature 320. The lower sediments of Feature 57 and the gray-tan silt contain virtually identical percentages of carbon and phosphorus (see Table 4.4).

The analysis of cations, electrical conductivity, and pH showed some differences among the features (Figure 4.19; see also Table 4.5), but did not shed light on the enigma that is Feature 57. The main result of the cation study was to note that there were more salts in the field soils than other features, not an unexpected result for an irrigated field surface. As noted in the discussion of field Feature 320 (see Chapter 5), not enough salts were present to hinder the agricultural potential of the field. The lower sediments of Feature 57 had slightly elevated levels of calcium and sodium, and the gray-tan silts had somewhat less. No trend was noted that offered any interpretation for the function of Feature 57.

Life History of the Biota of Feature 57

A study of nonmarine (freshwater) mollusk remains was conducted on sediment samples collected from catchment Feature 7 and Feature 57 (see Chapter 13). Sediments containing shells from Feature 57 were collected from near the southern descent in the groove at the junction between canal Feature 26 and Feature 57. Four species of gastropod were collectively identified in Features 7 and 57, although only two species were present in Feature 57, *Physa virgata* and *Hawaiia minuscula*. The gastropod *P. virgata* was the only fully aquatic species identified. One individual of this species was found in Feature 7, while 18 were recovered from Feature 57. The establishment of aquatic *P. virgata* within Feature 57 corroborates evidence indicating the feature remained inundated for extended periods of time, a finding consistent with the results of the ostracode study (see Chapter 6). Specifically, the ostracode data point to Feature 57 having been inundated, but not vegetated. Although *P. virgata* was the only shellfish found in the samples from Feature 57, *Planorbella scalaris* was identified within catchment Feature 7. *P. scalaris* prefers thickly vegetated habitats (see Chapter 6). The fact that both *P. scalaris* and *P. virgata* were present at the site, but that only *P. virgata* was present in Feature 57 further supports the idea that this feature was both inundated and free of vegetation.

Table 4.5. Feature 57, AZ U:9:28 (ASM), PHX Sky Train project, soil chemical properties: pH, electrical conductivity, sodium adsorption ratio, and bases in saturation paste extract.

				Saturated Paste[a]-Cations						
Feature	Sample ID	pH[a]	Electrical Conductivity[b] (dS/m)	Sodium Adsorption Ratio	Sodium (mg/L)	Calcium (mg/L)	Manganese (mg/L)	Potassium (mg/L)	Moisture (%)	Total Dissolved Solids (ppm)
29	A	7.7	2.7	7.1	512.9	260.0	81.1	27.3	1.50	1,700
29	B	7.8	1.9	5.3	282.9	136.0	49.6	19.5	2.20	1,200
29	C	7.6	3.8	7.8	680.8	366.0	124.6	42.9	2.30	2,400
29.02	A	7.9	1.5	4.7	230.0	112.0	39.9	27.3	1.50	960
29.02	B	7.8	1.9	4.6	264.5	156.0	55.7	23.4	2.10	1,200
29.02	C	7.6	2.4	4.3	395.6	410.0	140.4	54.6	1.90	1,600
57	SL1a	7.6	5.6	7.0	885.5	758.0	268.6	113.1	1.80	3,600
57	SL1b	7.6	4.0	5.3	563.5	522.0	197.2	70.2	2.00	2,600
57	SL5a (D3)	7.6	3.1	5.1	437.0	316.0	142.8	46.8	1.70	2,000
57	D2	7.6	3.8	5.2	457.7	326.0	160.9	42.9	1.60	2,400
57	D2	7.6	4.2	5.5	512.9	376.0	170.6	50.7	2.20	2,700
57	SL3b (D1)	7.5	7.2	7.7	1,159.2	1,018.0	430.8	109.2	1.90	4,600
57	SL3b(4)	7.6	5.0	6.1	772.8	784.0	267.4	74.1	1.90	3,200
57	SL6(4)	7.4	4.1	4.6	515.2	568.0	236.0	31.2	3.10	2,600
57	SL6	7.4	3.7	4.6	496.8	526.0	217.8	27.3	2.40	2,400

[a]WREP 125 (Gavlak et al. 1994).

[b]Saturated paste extract, analyzed by probe or conductance bridge.

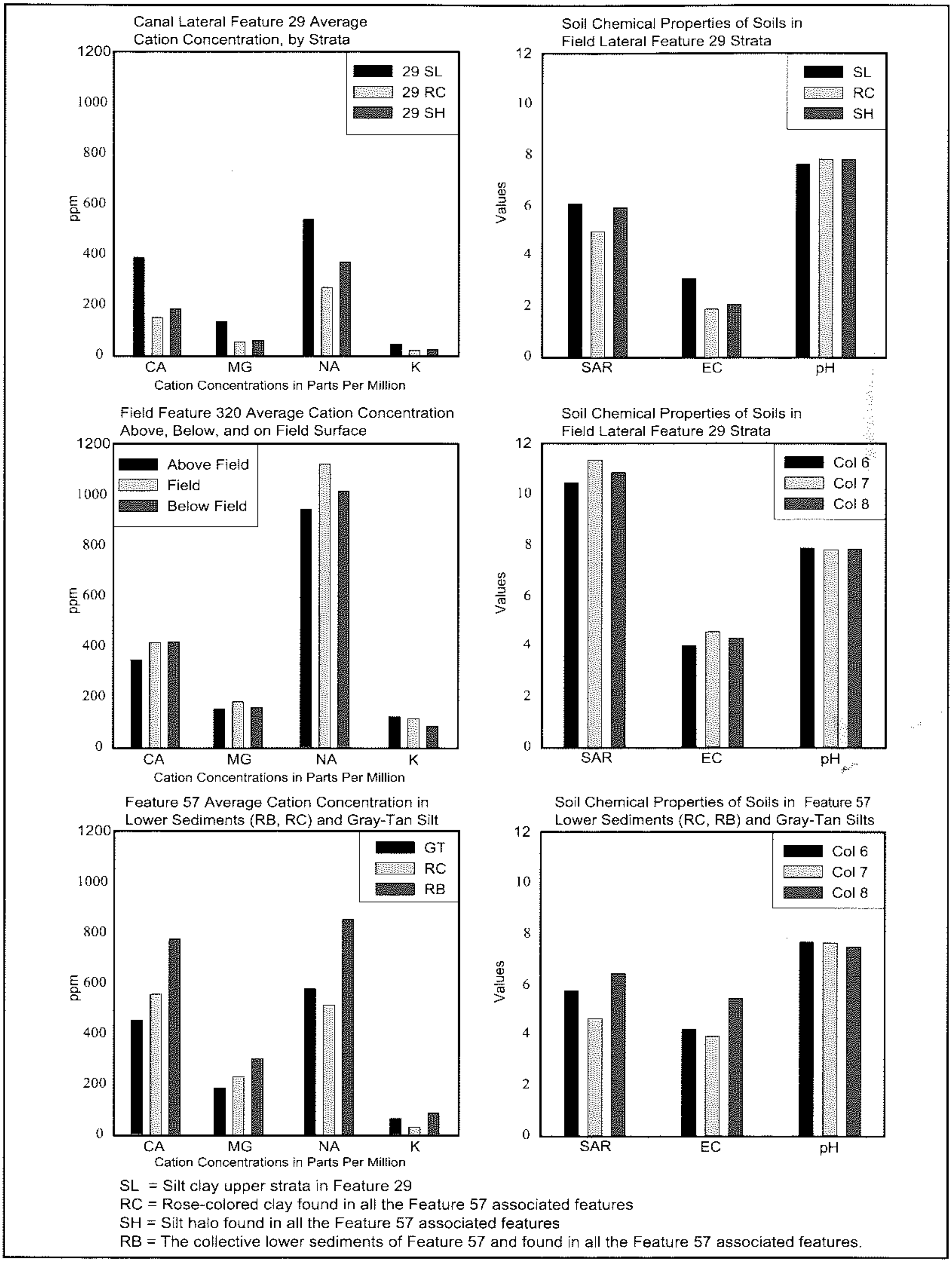

Figure 4.19. Graphs of soil chemical and electrical conductivity properties in sediments from Features 29, 320, and 57, AZ U:9:28 (ASM), PHX Sky Train project. (Graphs on the left show concentrations of calcium, magnesium, sodium, and potassium. Field lateral Feature 29 has the least concentration while field Feature 320 has the greatest concentrations. Overall, numbers show elevated calcium and sodium, but not sufficiently high to be injurious to crops. Feature 57 had elevated calcium and manganese. The sodium adsorption rate and the electrical conductivity values track with the sodium concentration. The pH values were all virtually identical, ranging from a low reading of 7.4 to a high of 7.9.)

A counterargument to the inundation of Feature 57 appears in the presence of the terrestrial gastropod *Hawaiia minuscula* in the sample collected from Feature 57. These were present in much greater number than in catchment Feature 7 (*n* = 10 and *n* = 1, respectively). *H. minuscula* prefers terrestrial, grassy, or moderately arboreal vegetation (see Chapter 13). In archaeological sites in Arizona, *H. minuscula,* is typically found in contexts that include agricultural fields and terraces rather than ponds or other water features. In light of all the other evidence that Feature 57 was inundated throughout much of its use-life, the elevated numbers of *H. minuscula* in the feature, a species characterized by a preference for inhabiting terrestrial vegetation, likely reflects the introduction of the species into Feature 57 via soaking a vegetative product, or they may have been carried in as passengers on reed rafts.

Further evidence for long-term inundation of Feature 57 was documented by the increasing diversity of ostracode species in the upper strata of both Features 57 and 26 (see Chapter 6). As has been established, during operation of the field system, Feature 57 was connected in some way to the field system irrigated by canal Feature 33. Ostracode data also indicate that lateral Features 29, 29.02, and 44 were contemporary. Finally, similar assemblages of ostracodes were cataloged in Features 29, 57, and 26, arguing for connectivity among these features.

As noted, Feature 57 was surprisingly free of any aquatic and mesic plant pollens. Samples from Feature 57 did produce more high elevation tree pollen than other features tested (see Chapter 7), indicating the Salt River was its primary source of water, rather than tail water from the fields or local desert run-off. This is not unexpected given its connection with canal Feature 26. The pollen spectrum from Feature 57 contained pollen from almost every taxon, although curiously, two species that are well represented in most of the rest of the features were nearly absent from Feature 57, cotton and summer poppy (see Figure 7.2). There was an unusually high count of Ambrosia pollen relative to other features, possibly indicative of dense stands of *Ambrosia psilostachya*. This plant is typically found in damp and disturbed soils (see Chapter 7).

This condition fits the interpretation of Feature 57 postabandonment. At that time, Feature 57 would have been filled with canal clean-out from Feature 26 with a slight depression north of the berm, an ideal damp and disturbed location for *Ambrosia psilostachya* to flourish. The pollen analysis also found large quantities of algal polyads, representing a possible algae. The high numbers of these in the sediments of Feature 57 further indicates an inundated, aquatic environment. This was further confirmed by the phytolith study (see Chapter 8); sediments within Feature 57 contained the highest count of sponge spicules of any feature in the study. The high counts of grass phytoliths found in Feature 57 are interpreted as indicating that the gray-tan silts were deposited when the feature was dry and host to grasses (see Chapter 8). An alternate interpretation is that grasses may have been part of the material that was soaked in Feature 57, or of balsas docked in the feature.

Feature 57 as Canal Access Such as a Walk-in

Given its proximity and relationship to canal Feature 26, its water-lain deposits, and its gently sloping sides, the possibility that Feature 57 was constructed for the purposes of canal access must be evaluated. Such a feature type is virtually unknown to Hohokam archaeologists. To this author's knowledge, only one researcher has reported on this feature class. B. Bradley (1999) identified two features as having been constructed to provide canal access. The first, recorded at U:9:28 as a "walk-in" dating to the Soho phase of the early Classic period, was located just north of the modern Grand Canal, heading off the Salt River. This feature was discovered within approximately 150 m of the currently described Feature 57. B. Bradley (1999) also suggests a feature dating to the Pioneer period and recorded at Snaketown, AZ U:13:1 (ASM), as a "groove" by Haury (1976:136), could be interpreted as a walk-in. The Snaketown groove was also located in the northern uphill bank of Canal 1, heading off the Gila River. Haury (1976) does not provide a detailed description, nor does he offer an interpretation for the original use of this feature.

B. Bradley's (1999) narrative of the walk-in does not include dimensions for the feature, although based partially on photographs of the backhoe trench (B. Bradley 1999:50, Figures 13-14), the walk-in feature appears to be approximately 1.0-2.0 m long and about 30 cm wide. Similarly, Haury's (1976:133, Figure 8.22a) map of the groove suggests it measured 1.0 m long and about 30 cm wide. The Feature 57 groove was longer (5.8 m), but also measured roughly 30 cm wide. The two features described by B. Bradley (1999) as walk-ins, as well as Feature 57, all entered canals from the uphill side. The grooves sloped gently and had distal ends higher than the water carrying capacity of the canal, therefore precluding their use as turnouts for water from the canal. The deepest point of Feature 57 reached to within 10 cm of the base of canal Feature 26.

Unfortunately, the backhoe trench excavated by B. Bradley (1999) removed the intersection of the walk-in and the canal so their exact relationship could not be determined. However, it appears that the walk-in did not slope steeply enough to articulate with the bottom of the canal (B. Bradley 1999:50, Figures 13-14). The walk-in B. Bradley (1999) described may have had steps or have increased its slope to reach the bottom of the canal, or simply it may have ended up the side of the canal. Haury (1976:Figure 8.22a) does not mention how far into the Snaketown canal the groove extended, but the shallow nature of canal Feature 1 suggests the groove may have reached close to the base of the canal. Both the walk-in and groove features appear to have been constructed to form passages through the berms and onto the canal. At U:9:28, B. Bradley (1999) interprets the presence of a broken ceramic jar and footprints at the base of the canal as evidence that the feature served as access for people collecting water from dipping pools. Haury (1976) also found dipping pools excavated into the base of Canal Feature 1 near the groove. The excavated portions of canal Feature 26 did not reveal dipping pools near Feature 57.

As noted, one of the initial assumptions upon finding Feature 57 was that it would prove to be a walk-in. It was the same site in close proximity to the walk-in reported by B. Bradley (1999). There were also similarities in the structure of Feature 57 relative to the features described by both B. Bradley (1999) and Haury (1976). However, as excavation proceeded, differences emerged, confounding the interpretation that Feature 57 had served as a walk-in. In short, Feature 57 included several components the other features did not. The silt berms surrounding Feature 57 were unique, and they would not have served to aid in accessing canal Feature 26. Rather, they would have hindered access, as they were designed to form a rectangular area of standing water, roughly 4 m^2, 15 cm deep at the shallowest edges, and deeper in the middle. The sediments indicated that the feature was fully inundated for extended periods of time, as exhibited by strata that were continuous from the northern silt berm to the southern junction with canal Feature 26 (the light tan 'silt halo,' Stratum 2), rose-colored clay (Stratum 5), and gray-tan silt (Stratum 7) were particularly noticeable for their nearly complete coverage of the feature (see Figures 4.9-4.11). Standing water was also indicated by the well-developed manganese oxyhydroxide deposits along the bottom and high up the sides of Feature 57 (see Figure 4.10).

When the canal and therefore Feature 57 were dry, the groove could have been used as an access path. A groove constructed to provide access to the canal would experience some level of foot traffic along the center of the groove and possibly some amount along the sides as well. If this was done while the feature was wet and muddy, the passage of many feet would mix the stratigraphy of the sediment (see B. Bradley 1999:43, Figure 7). B. Bradley (1999:Figure 7) illustrates a prehistoric footprint showing that the person stepped into mud, which oozed up around the foot. The strata of Feature 57 exhibited remarkable continuity throughout the feature with no sign of mixing. If, on the other hand, people only walked into the canal while it was dry, thereby not disturbing the sediment to any great extent, evidence of drying episodes, such as drying cracks and eolian deposits, would be expected (B. Bradley 1999:43; Haury 1976:144; Masse 1976:14). No indications of drying episodes were identified within Feature 57.

A further difference exhibited by Feature 57 relative to B. Bradley's (1999) and Haury's (1976) features was that the sediments within Feature 57 were not consistent with those recorded within its conjoining canal. Feature 57 shared virtually no sediment with canal Feature 26. Feature 57 had three distinct depositional events from three different sources. In contrast, neither feature described by B. Bradley (1999) or Haury (1976) mention fill stratigraphy differing from the canal sediments. In fact, B. Bradley (1999) notes that the sediment in the walk-in feature was similar to the sediment within its conjoining canal.

The evidence suggests Feature 57 was more complex than a simple path into a canal. While the fact that it was apparently inundated with water for much of its use does not preclude its use as a walk-in, the construction of the berm to form a rectangular water surface, the structure of internal sediments, and their distinct lack of any apparent disturbance suggests an alternate interpretation is necessary.

Feature 57 as a Tail Water Catchment Feature

One of the most commonly offered suggestions regarding the use of Feature 57 was that it served as a catchment to collect tail water from field Features 320 and 327 and channel it into canal Feature 26. The similarity of the strata between Feature 57 and the adjacent field systems seems to support this interpretation. As noted, during most of the time the fields were active, Feature 57 was connected to them, and water from the field laterals flowed into Feature 57, depositing the lower sediments. However, also as mentioned, the elevated silts in the lower sediments in Feature 57 indicate the activity that generated silt was ongoing during this early use and continued after Feature 57 was no longer receiving water and sediments from the field system. The fact that the stratigraphy of Feature 57 matches the sediments in canal 33, the head of the system of shared sediments, suggests the water and sediments flowed directly through a canal into Feature 57. This is in contrast to tail water passing through a field where it would drop much of its original sediment load.

The flow from the field laterals into Feature 57 may not have served any purpose related to the irrigation water; rather, there may have been some desire to have water flow through Feature 57 to aid in its primary function, whatever that may have been.

Another point to note is that with all the other individual fields identified within this local area, at least five of which (field Features 322, 321, 320, 327, and 330) were irrigated by sublaterals originating off canal Feature 33, only field Feature 327 and/or Feature 320 had any connection to a feature like Feature 57. There was no indication at the distal end of any of the other fields that tail water had been accommodated for in any way.

Feature 57 as Artificial Wetland or Cienega Garden

Discussions about the possible uses of Feature 57 also generated the idea that it may have been constructed to function as a wetland. In this scenario, the feature would have been a cienega-like garden plot created to grow crops, such as cattails (*Typha*), for their edible rhizomes, as well as for leaves and stalks that could serve utilitarian purposes. Russell (1908:133, 155) notes that cattail stems were used by the historic Akimel O'odham inhabiting the middle Gila River Valley, in the vicinity of Snaketown, as both basket foundations and as building material. Additionally, cattail pollen was used for yellow face paint (Russell 1908:161). Other mesic plants, such as sedges (*Cyperaceae* sp.), might also have been grown to provide an easy source of basket weaving or boat building material or for the sedge seeds, a source of food for the Hohokam and other groups in Arizona (Bohrer 1970).

Initially, the thought of Feature 57 as a small artificial wetland, or cienega, was compelling. The presence of a mesic garden plot would explain not only the placement of Feature 57 adjacent to a canal and the seemingly permanent inundation, but also the origin and deposition of the gray-tan silts, which could be interpreted as muck that formed in the plant root zone. This author is not aware of a prehistoric artificial wetland or cienega having been reported in the Greater Southwest; however, Dillehay et al. (2005) report prehistoric artificial wetlands in the Andes that were constructed to enhance agricultural potential.

If Feature 57 had been part of a constructed wetland, high levels of mesic pollen types, such as cattail, sedge, and other wetland plants, would be expected. Further, if Feature 57 had served as a garden, the sediment would have been heavily disturbed by both the extensive roots of the crop and by agricultural activity, particularly if cattail rhizomes were being harvested. After the pollen and stratigraphic data had been analyzed, the hypothesis of an artificial wetland was discarded. The results of the pollen analysis indicated no trace of mesic vegetation within Feature 57; in fact, very little was found throughout the entire project area (see Chapter 7). The undisturbed stratigraphy also offers evidence that the function of Feature 57 was not as an aquatic garden.

Feature 57 as a Boat or Raft Slip

The possibility that Feature 57 was designed for the purpose of parking and loading rafts was originally introduced as a humorous suggestion and from a lack of more traditional possibilities that demonstrated a cogent fit with the growing data set against the other. This interpretation is offered again with due caution and trepidation, yet it seems worth entertaining until more data are recovered from other such features or until someone uncovers a Hohokam raft. To date, only one possible raft, or 'balsa,' has been reported in any excavations in Hohokam contexts. Hodge (1893:325-326) reporting on artifacts recovered from canals:

> The only specimens collected from the canal excavation were a few potsherds, quite a large quantity of cottonwood pollen comparatively well preserved, a few small fresh-water univalves, and the remains of a bundle of fagots or reeds that had apparently floated down with the current. The finding of these last-mentioned remains suggested the possibility of the irrigating canals having also been used in conducting a rude system of navigation by means of balsas or cane rafts.

Hodge (1893:326-327) continues, offering an explanation for what might have been transported on the rafts:

> ...balsas or cane rafts in transporting bowlders [sic] and other material from the river to be manufactured into cutting and chipping tools, etc. It was also observed that all the unfinished stone implements found at Los Muertos (except the lamelliform tools of shale or slate, such as knives and hoes), whether of diorite, granite, or sandstone, were smoothly water-worn, and consequently the products of the river-bed nine or ten miles distant, and were not conveyed from the Maricopa mountains, situated only about five miles to the westward. The existence of these thousands of water-worn tool-stones and the absence of the ill-shaped fragments of basalt from the mountains, however, is not advanced as evidence that navigation existed among these people. River cobbles are much better adapted for fashioning into implements than the rough stones found on the slopes of the basaltic Maricopa range, previously men-

> tioned as the rock deposit nearest to the Los Muertos ruins. Therefore, notwithstanding that the difference in distance from Los Muertos to the river and to these mountains is fully four miles, river bowlders would doubtless have been procured in preference to the clumsy natural chippings from the mountains, even if the facilities for a system of water transportation were lacking. It would, therefore, not necessarily be an indication of particular advancement on the part of these people if they did construct rude craft as a means of water communication from the river to their pueblos. In fact, having exercised their ingenuity to such an extent as is exhibited by their canal construction, one would expect this next step as a matter of course, particularly where the extreme necessity for such navigation, however primitive, had arisen...The location of the towns usually at the farthest possible distance from the river would of itself seem to demonstrate the independence of their builders toward the source of water supply and deposits of raw material. Again, countless bowlders or cobbles are unearthed at each of the pueblos excavated, which clearly exhibited faults in chipping or flaking, and had apparently been rejected as unfit for use. Had the natives been without ready means of transportation, this rough or primary chipping of the stones would most probably have been done at or near the river rather than at the places where they were to be used, ten or twelve miles away, to which point they must necessarily be conveyed by hand.

The only other mention of any type of boat in the Hohokam archaeological record is a note regarding the name of the site Las Canopas, AZ T:12:137 (ASM), in Hackbarth (1997:18):

> Midvale (n.d.) stated that Cushing initially referred to the site as "Las Canoas" to commemorate the discovery of a canoe in a prehistoric canal that served the site, but no evidence of this name was found in the Cushing records summarized by Hinsley and Wilcox (1995). The name canoas appears again on an ASU site card completed by Midvale and Morris (1963).

Unfortunately, it appears that no one has found further mention of the alleged canoe, or the canoe itself, in any Hohokam collections. Despite the very thin evidence for the existence of a Hohokam transportation system using reed balsas to cross the Salt and Gila rivers and to transport goods along the canals, the idea is worth considering. Virtually all the groups living in the deserts west of the Phoenix Basin utilized reed balsas for crossing the Colorado and lower Gila rivers. The Mohave utilized reed balsas apparently made of cattail (Kroeber 1925:739). These rafts were large enough to carry four to six adults and were so easy to make that, "If the current carried it far downstream [while crossing the river] it was easier to put a new one together than to drag the old one up against the current" (Kroeber 1925:739). The Mohave also made 1-m-diameter ceramic pots to float children and goods across the rivers (Kroeber 1925:739).

In summarizing the use of tule rafts by the California tribes, Kroeber (1925:813) states that, "The balsa has a nearly universal distribution...it is reported from the...Luiseño, Diegueño and Colorado River tribes." The Cocopa, who lived along the lower Colorado River and the delta, used a wide range of boats, including the ubiquitous balsas and large ollas and baskets to transport children and small items. They also used dugouts, raft formed of logs, or brush tied together (Drucker 1941:124). Spier (1933:76-77) reports similar conveyances were used by the Maricopa and Halchidhoma. The people inhabiting the coastal areas of the northern Sea of Cortez, where much of the Hohokam shell originated, utilized balsas. Farther down the Mexican coast, the Seri also utilized the balsa (Bowen 1983:239, Figure 5; Felger and Moser 1985:132, Figures 10.6-10.7). Seri balsas were made from *Phragmites* grass or giant cane (*Arundo*) (Felger and Moser 1985:131). Balsas were also utilized by peoples living in the Great Basin for transportation and for gathering various resources in the lakes (Lowie 1924; Simms 2008).

It is well established that the Hohokam were trading through the territories of Patayan peoples from the lower Colorado River and the coast of the Sea of Cortez, all of whom made and used balsas and a range of other types of watercraft (see above). Further connection between the Patayan and Hohokam is indicated by the evidence that Patayan peoples may have been living at Las Colinas, AZ T:12:10 (ASM) (Beckwith 1988:201-224). In sum, the Hohokam were not only in contact with peoples utilizing the easily made balsa for transportation, but, as noted by Hodge (1893), they were in a position to make the most of a raft for transportation of goods along the canals. The location of Feature 57 near fields suggests that baskets of corn or other produce may have been loaded onto a raft that was then drawn along a towpath to Pueblo Grande, or points westward.

One compelling point in favor of this explanation for the use of Feature 57 is that it would help explain the results of the pollen analysis. The lack of any aquatic pollen remains is puzzling for a feature such as this. However, as a raft slip, there would be a desire to keep the water free of any cattail or other aquatic plants, so they did not impede the access by the balsa and to the balsa for loading and unloading. There does remain at least one flaw with this interpretation, however. It does not offer an easy explanation for the introduction of the copious quantities of silt found in Feature 57.

Feature 57 as a Soaking Pool for Processing a Variety of Materials

Feature 57 may have been a pool used for soaking materials to render them supple or malleable prior to processing. For instance, Barrows (1900) notes that the Cahuilla soaked agave leaves to separate the fibers from the pulp. This same practice was carried out in Mexico, where Mixtec sandalmakers would soak agave leaves for about month, scrape them to free the fibers, and then soak the fibers for a week, thus obtaining clean white fibers (Campbell 1997). Agave fibers were extracted by the Hohokam and other Southwestern groups to make string, rope, nets, and cloth (Haury 1950; Noble 1991:23). Gourds, used by the Hohokam as vessels (Gronemann 1994; Haury 1950:425), are more easily cleaned and cut if they are soaked (Gibson 2007). Other plants related to basketweaving may have also been soaked for processing, such as devil's claw, beargrass, and cattail (among the Papago, see Castetter and Underhill 1935:58; among the Hohokam, see Gregonis and Reinhard 1979). In other cases, food stuffs were soaked prior to cooking. Castetter and Underhill (1935:46) remarked that among the Papago:

> Gruel or bread was the basis of every meal and the usual addition was boiled dehydrated vegetables. All greens like aloe (*Agave americana*) and cholla joints (*Opuntia* sp.) had been pit-baked before storing, while root crops and the cultivated squash and beans had been simply sun-dried. All of these were taken from the storage jars and soaked both to freshen them and to remove dirt, then boiled with water and salt.

Animal hides were often soaked in the tanning process. Rea (1998:91-92) notes that the O'odham tanned hides by first soaking the hide for two or three days. The Tohono O'odham are reported to have first soaked a hide in water overnight before dressing it (Castetter and Underhill 1935:69). Additionally, when a warrior made a shield, he first soaked a hide in water and then cut out the shape that was then hardened on hot ashes. The Papago also stored dried sinew, which was soaked before being used, "sinew was obtained principally from the back of a deer but also from the leg. It was rolled and stored and when wanted was soaked, a very fine strand loosened with the teeth, and pulled off" (Castetter and Underhill 1935:62-63). It is of note that *Physa virgata*, the gastropod found in Feature 57 is noted for being able to tolerate polluted water. If Feature 57 did serve as a hide and or other product soaking pond, the water may have been less than pristine in this location, yet perfectly fine for this gastropod.

Finally, Feature 57 could have been created, in part, for utilization in the preparation of clay for ceramic production. As it is mined, clay often requires grinding and separation of inclusions and the coarser fractions. To effectively shape clay, historic potters (and presumably prehistoric ones as well) removed impurities through washing, soaking, and filtering; these same practices are continued by modern potters (Peterson 1984; Shepard 1956). If clays were soaked and processed along the edge of Feature 57, this might account for the accumulation of the silt.

Final Note

Excavations along Hohokam canals have uncovered several canal-related features. Numerous headgate features have been reported throughout Hohokam canal systems; canal repair features have also been reported with some frequency. Other canal-related features are less commonly recorded and less well understood. The canal systems of the Hohokam have been the subject of extensive research, but many of the canal-related features remain to be studied. At Snaketown, Haury (1976:132-141) fully excavated an approximately 80-m-long section of a Pioneer period canal, canal Feature 1. In that distance, four separate canal-related secondary feature types were recorded, including four dipping pools, manifest as low basins excavated into the bottom of the canal that would have held water for some time after the canal was no longer being supplied with water from the Gila River. One of these had a "dipping station," consisting of a formed ledge or step complete with a "shelf" to hold an olla while it was being filled (Haury 1976:Figures 8.25-8.26). A short channel or groove was found in the northern uphill side of the canal, later interpreted as a walk-in feature (B. Bradley 1999). Two turn-outs were located on the downhill side of the canal that would have provided water for fields below. Two alignments of postholes and associated "shallow troughs" were assumed to have been related to water control devices (Haury 1976:134).

A number of other canal-side and canal-related features have been reported from many Hohokam sites. Headgate features are relatively common in the literature (for example, Ackerly et al. 1987, 1989; Miles et al. 2010), and settling basins (Motsinger 1993; Nials and Fish 1988) and reservoirs (Ackerly et al. 1987; Bayman 1993; Crown 1987b; Hodge 1893) have been reported from a number of locations.

Other canal-related features are only reported occasionally, such as canal-side basins (Nials and Fish 1988), one of which was plastered and may have been a dipping pool; the use of the other basins remains unknown. B. Bradley (1999) reported the walk-in at this same site together with dipping pools, and pointed out the similarities to a similar set of features at Snaketown.

It may be that features like Feature 57 are more common than thought, but are only rarely found due to the methods commonly used to explore canals. Headgates might be more commonly reported than other features, as the intersections of canals are often targeted for excavation, while canal midsections are often not. The enigma of Feature 57 continues; any and all offers of interpretation are welcome!

HOHOKAM IRRIGATED FIELDS AT AZ U:9:28 (ASM), PHX SKY TRAIN PROJECT

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The prehistoric farmers of the lower Salt River Valley and the middle Gila River Valley maintained enormous agricultural systems incorporating thousands of cultivated hectares irrigated by hundreds of kilometers of canals (Midvale 1965, 1968; Turney 1929; Woodson 2010a). Over the past century, our understanding about how the canals that fed the fields were constructed and maintained has grown significantly (Ackerly and Henderson 1989; Ackerly et al. 1987; Haury 1976; Howard 1993; Howard and Huckleberry 1991; Huckleberry 1999a, 2011a; Masse 1976; Miles et al. 2010; Nials and Gregory 1989; Turney 1929; Woodbury 1960; Woodson 2010a, 2010b). However, despite the fact that Hohokam agricultural systems have been studied for more than a century, surprisingly few actual field surfaces have been documented, and even fewer have been studied in any detail. This includes all elements of the fields, such as the structure of field shapes, their surfaces, any secondary features, such as borders, berms, planting pits, and furrows, and studies of the soils from identifiable field surface strata. In contrast to irrigated fields, many dryland agricultural surfaces, terraces, rock-pile fields, and so forth have been well documented throughout southern Arizona (Dart 1983; Doolittle and Neely 2004; Field 1992; Fish 2000; Homburg 1997; Sandor 2010; Sullivan 2000; Welch 1994). A number of possible irrigated field surfaces have been noted during the course of excavating other features (for example, Masse 1976:35), and more recently, some field surfaces have been studied in detail, primarily descriptions of the geophysical properties of their soils (Huckleberry 2011a; Miles et al. 2010; Phillips 1998; Sandor 2010; Schaafsma and Briggs 2007).

While these recent discoveries and studies have provided insight into the field soils, there remains a lack of information regarding the field form and construction. This leaves knowledge regarding the physical construction, shape, use, and maintenance of field surfaces in the Hohokam cultural area largely unexplored. Recent studies along the Santa Cruz River in the Tucson area have revealed detailed complexes of fields dating to the Early Agricultural period (1200 B.C.-A.D. 50) (Herr 2009a, 2009b). Study of these fields is ongoing. Although these Early Agricultural period fields predate Hohokam era (A.D. 500-1450) fields by some margin, when the studies are completed, they will likely offer insights into the long-term development of field systems and changes in anthropogenic field environments from the Early Agricultural period to the later Hohokam sequence.

A large part of the reason for the gap in knowledge regarding Hohokam fields is the fact that historic and modern activities, most notably agricultural plowing, have churned up the prehistoric field surfaces to create the most recent agricultural field surfaces in a continuing tradition of agriculture in the Salt and Gila River valleys. By their nature, canals are deeper than field surfaces, and therefore, are less likely to have been completely disturbed by historic and modern activities. In the few locations where prehistoric field surfaces remain intact is the rare opportunity to study these fields in detail. This was the case during the PHX Sky Train project, although even here, only one field surface was well preserved, while at least 11 others were removed or heavily impacted by modern and historic activities.

FIELDS STUDY OVERVIEW

It is important to begin with an understanding of what field areas and smaller individual field plots are from an ecological perspective. A field or field plot is an anthropogenic landscape patch, a small area that has been modified by farmers in the attempt to provide the optimal microenvironment for the specific suite of plants desired. To maintain this patch successfully through years of differing weather patterns that any climate encompasses requires a significant amount of knowledge about the local environment and the needs imposed by the range of crops the farmer could potentially desire to cultivate. With those data sets in mind, the farmer must then manipulate the soil, moisture, and light, as needed, to meet the requirements of the desired crop in that location.

Embedded within the structure of each field is information regarding the strategy the farmer used to construct and create that specific field in a particular location. Further, field form may potentially reflect information about the types of crops grown in them and the local division of land use between families and other social groups. Anthropogenic changes made to local soils can inform about the soil engineering strategies utilized to create better soils (Huckleberry 2011a; Schaafsma and Briggs 2007) or mistakes made by farmers that may have degraded their soils. Ethnographic data have shown that modern indigenous farmers look for a suite of environmental factors prior to constructing a new field, including local hydrology, surface soils, local slope and aspect, and existing natural vegetation as an indicator of water availability (Sandor et al. 2007).

Many additional fields need to be investigated to begin answering detailed questions about Hohokam field structure; however, these questions can begin to be addressed with current data. The PHX Sky Train project uncovered portions of several Hohokam fields associated with Canal System 2 just west of prehistoric Pueblo Grande, AZ U:9:1 (ASM) (see Figure 1.2). These are the first field surfaces to be investigated along Canal System 2 in the central Phoenix Basin. The field features uncovered during this project provide a view into agricultural practices of the people farming the Salt River Valley between A.D. 900 and 1150. Results of the analysis of these fields is provided here, and their structure is discussed in comparison with other Hohokam fields described in studies conducted along Cave Creek and the Gila River. This overview provides the beginnings of an understanding of Hohokam field structure in a variety of locations and contexts in the Phoenix Basin.

Several previous studies have described Hohokam field surfaces and structure from three separate field systems in the Phoenix Basin. Three of the studies cited here focused on a system of silt fields along Cave Creek in the northern Phoenix Basin, and two describe fields along the Gila River on Gila River Indian Community (GRIC) lands. These studies have revealed that fields described in each location are unique in construction and in their operation (Huckleberry 2011a; Miles et al. 2010; Phillips 1998; Sandor 2010; Schaafsma and Briggs 2007). This variability is not surprising, as the fields were situated on different landscapes with different soil types and water availability. The systems differ from the fields analyzed here, providing a view of a regional agricultural knowledge base that could accommodate and adapt to the multiple landscapes within the Phoenix Basin.

Previously Recorded Hohokam Field Surfaces

A set of large fields along Cave Creek Wash in the northern Phoenix Basin has been the focus of several studies that revealed the significant soil engineering capabilities of the Hohokam farmers (Huckleberry 2011a; Phillips 1998; Schaafsma and Briggs 2007). The natural soils bordering that particular reach of Cave Creek were too sandy to support crops, even with irrigation (Schaafsma and Briggs 2007). The abundant water of Cave Creek, however, made this a desirable location. To take advantage of the water and the location, the water-holding capacity of the soil had to be increased. To accomplish this, fine-textured sediments were harvested from both overbank floodwaters and floodwaters directed into canals and spread over field areas by means of a system of brush and stone weirs, which slowed the water and harvested the silt, building up large deposits of fine-grained soils reminiscent of an inland delta over the sandy substrate (Huckleberry 2011a; Schaafsma and Briggs 2007). These fields were in use and continually expanded for some 550 years from about A.D. 700, until their abandonment roughly A.D. 1250 (Huckleberry 2011a).

The fields varied in size from 2.1 ha up to 18.2 ha in extent. No specific divisions into smaller plots within the field areas were detected, other than lines of stone remaining where silt-catching weirs had been in place (Huckleberry 2011a; Phillips 1998; Schaafsma and Briggs 2007). These weirs may or may not have served to divide the field area into plots, but the linear form does not suggest this function. The surfaces observed in these fields were relatively well preserved, as successive layers of sediment rapidly accumulated, preserving multiple thin surface layers below newly captured sediments. This scenario is in marked contrast to most field environments in which the same surface is tilled, walked on, and planted annually. The silt fields of the northern basin appear to have been formed from the directed flow of sediments, forming successive delta-like deposits. This seeming freeform of field shape is in contrast to the commonly described rectangular or square pattern of multiple fields in a field system (for example, Nials and Gregory 1989:Figure 4.2), each of which would have had a lateral canal to irrigate it.

Miles et al. (2010) describe a canal-irrigated field area divided into five individual fields, all of which lie within a larger field complex along the prehistoric Santan Canal off the Gila River at site GR-441, Locus G. These fields were utilized between A.D. 750 and A.D. 1250, a time that overlaps closely with the Cave Creek fields and the PHX Sky Train fields. The GR-441 excavations identified and examined five fields in detail; these were part of a larger field system that extends well beyond the boundaries of the project area. The fields at GR-441 were large rectangular to square areas measuring roughly 65 m by 75 m. The field areas were defined by the spaces between lateral canals and the dark sediments of the field surfaces. The surfaces were 20-30 cm thick. During the excavations, GRIC investigators found no evidence of secondary field features, such as furrows, bunds, or water spreaders. Examination of the laterals revealed indications of numerous water control features, suggesting the use of a headgate or tapon structure to divert canal water onto the fields at selected points from either of the two laterals on opposite sides of the field. While the fields from GR-441, Locus G are more similar to the PHX Sky Train fields than those from Cave Creek, there are significant differences, as described below.

PHX SKY TRAIN PROJECT FIELDS

During the PHX Sky Train project, a section of prehistoric field systems associated with Canal System 2 was uncovered (Figure 5.1; see also Figure 2.7), providing a prime opportunity to study both the methods utilized in managing water in the irrigation system, from the larger canals to the fields, as well as an opportunity to examine the physical construction of the field surfaces themselves. This study focused on field surfaces and their associated soil properties. Particle-size and soil chemistry were used to trace linked canal and field features (see "Life History of Sediment Deposition for Feature 57," Chapter 4, this volume). Ostracode, pollen, and phytolith analyses were used to inform on water conditions and botanical content within one field (Table 5.1). Luminescence (OSL) dating samples taken from various points within the field ditch system indicate it was in use sometime in the interval between A.D. 1000 and A.D. 1150 (see Chapter 9).

The best-preserved field area discovered during the PHX Sky Train excavations consisted of seven distinct fields: Features 320, 321, 322, 323, 324, 327, and 330 (see Figure 5.1). These were each defined by a series of field ditches or sublaterals running in a generally northeast to southwest direction. The space between the sublaterals defined the irrigated field surface. Six of the seven defined field surfaces were relatively long, narrow rectangular areas, ranging in size from 25.0 m by 6.0 m to 15.5 m by 4.0 m, with a mean area of 118.5 m^2 (Table 5.2). One field, Feature 324, was notably smaller, measuring 11.0 m by 5.5 m; however, the full extent may have originally been similar to the other fields, but it was likely truncated by construction of 43rd Street, which overlay the field. Although the field surfaces west of sublateral Feature 53 had been removed by historic and modern activities, their shape and extent could be defined based on the space between the field ditches, the bases of which were lower than the field surfaces, and thus, were preserved.

Initial stripping operations east of 43rd Street revealed dark sediments filling two field ditches, Features 33 and 29, and even smaller ditch-like features or furrows that extended from Feature 29, forming a comb-shaped pattern (see Figure 5.1; also, Figure 2.8). As stripping progressed to the southeast and the extent of Feature 29 was fully defined, it became clear that undisturbed sediments from field surfaces remained above the comb-shaped structure. Feature 33 was pursued eastward to the edge of the project area, and turnouts for two additional sublateral and "comb" features, Features 44 and 45, were defined.

Here, modern/historic overburden seemed somewhat shallower, suggesting the potential for intact field surfaces. Consequently, mechanical stripping stopped, and trenches were hand-excavated to define any field surfaces preserved above the comb structures. Field surfaces were identified in association with sublateral Features 44 and 45; the fields irrigated by Features 44 and 45 were numbered Features 320 and 327, respectively. Field surfaces were definable in three field features, Features 320, 327, and 330. Field Feature 320 was well preserved, Feature 327 was in fair condition, and Feature 330 was heavily disturbed by intrusive modern trash pits and utility trenches inside the project area, and it extended beyond its limits. Thus, later sampling efforts were focused on field Feature 320.

Irrigation water was supplied to the six eastern field features, Features 320, 321, 322, 323, 327, and 330, by water flowing from Feature 23, a small canal that ran from an unknown source to the northeast (Chapter 3, this volume). This canal shared an alignment with the later channel, Feature 22, until reaching a point near the western side of Block 7 (see Figure 5.1), where Feature 22 curved to the northwest, and Feature 23 continued its trajectory southwest, bringing water to field lateral Feature 33. Feature 33 ran to the east, curving slightly southeast, providing water to a series of at least five sublaterals, Features 53, 29, 44, 45, and 58. It is unknown how far Feature 33 continued to the east, as it extended beyond the project boundary.While the intersection of Features 33 and 58 was outside the project boundary, reasonable projections indicate they were connected. Canal Feature 23 continued straight after the intersection with Feature 33, likely becoming the field lateral for field Feature 323, as well as possibly collecting and returning unused water to canal Feature 26, with which it appeared

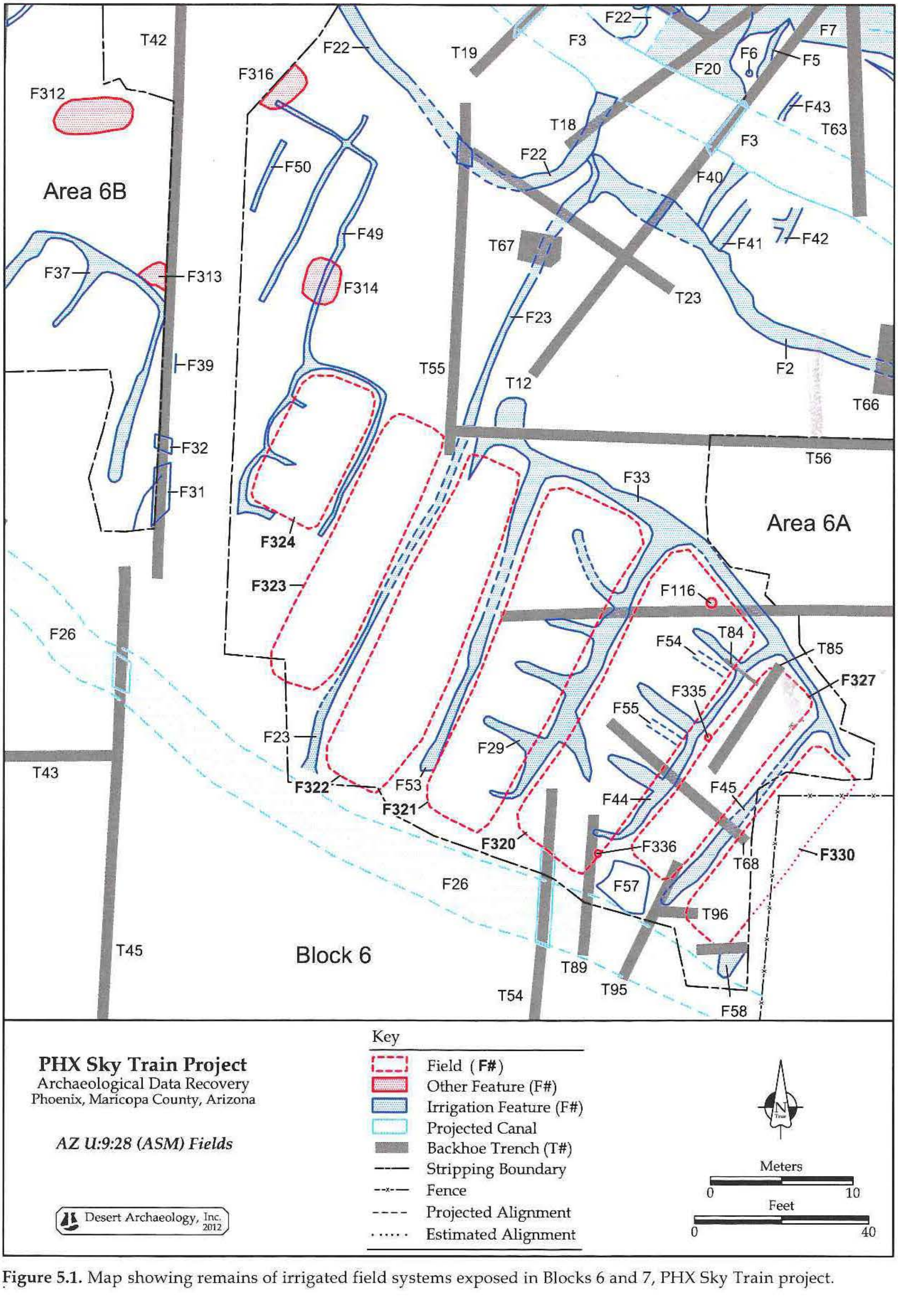


Figure 5.1. Map showing remains of irrigated field systems exposed in Blocks 6 and 7, PHX Sky Train project.

Table 5.1. Special samples concordance list for agricultural field features, AZ U:9:28 (ASM), PHX Sky Train project.

Feature	Sample ID	FN	Comments[a]	Soil	Pollen	Ostra-code	Phyto-lith
Agricultural Field Contexts, Ditches							
29	A	1096	Silt halo, 1 cm above ditch base	X	–	X	–
29	B	1097	Rose-colored clay, weak in profile, 5 cm above ditch base	X	–	X	–
29	C	256	BSS 29-1: Silt loam, 20 cm above canal base	X	–	X	–
29.02	A	1098	Silt halo, 1 cm above ditch base	X	–	X	–
29.02	B	1099	Rose-colored clay, 6 cm above ditch base	X	–	X	–
29.02	C	263	BSS 29.02-2: Silt loam, 12 cm above ditch base	X	–	X	–
44	A	1155	GS/P #17: Feature 44 just upstream of junction with Feature 44.02, silt halo	–	–	X	–
44.01	B	1156	GS/P #18: Feature 44.02 from just past (downstream) intersection with Feature 44, rose-colored clay	–	–	X	–
Agricultural Field Contexts, Field							
0	SL20a	1364	GS/P #5: Area of Feature 320 just south of Feature 44.01; sediments above field surface	X	X	–	X
320	SL20b	1365	GS/P #6: Feature 320 just south of Feature 44.01; upper 5 cm of field soil	X	X	–	X
320	SL20c	1370	GS/P #11: Feature 320 just south of Feature 44.01; lower 5 cm of field soil	X	X	–	X
0	SL20d	1366	GS/P #7: Area of Feature 320 just south of Feature 44.01; sediments below field surface	X	X	–	X
0	SL21a	1367	GS/P #8: Collected midway between Feature 44.01 and Feature 44.02; sediment above field soils	X	X	–	X
320	SL21b	1368	GS/P #9: Collected midway between Feature 44.01 and Feature 44.02; upper 5 cm of field soils	X	X	–	X
320	SL21c	1371	GS/P #12: Collected midway between Feature 44.01 and Feature 44.02; lower 5 cm of field soils	X	X	–	X
0	SL21d	1369	GS/P #10: Collected midway between Feature 44.01 and Feature 44.02; alluvium below field soils	X	X	–	X
320	SL22a	1372	GS/P #13: Feature 320 area, alluvium above field soils, collected from just north of Feature 44.02	X	X	–	X
320	SL22b	1373	GS/P #14: Feature 320 field soils sample, collected from just north of Feature 44.02	X	X	–	X
0	SL22c	1374	GS/P #15: Feature 320 area, alluvium from below field soils, collected from just north of Feature 44.02	X	X	–	X
0	SL30a	1387	GS/P #40: Above field soils	X	–	–	–
320	SL30b	1388	GS/P #41: Field soils	X	X	–	–
0	SL30c	1389	GS/P #42: Below field soils	X	–	–	–
0	SL31a	1390	GS/P #43: Above field soils	X	–	–	–
320	SL31b	1391	GS/P #44: Field soils	X	X	–	–
0	SL31c	1392	GS/P #45: Below field soils	X	–	–	–
0	SL32a	1393	GS/P #46: Above field soils	X	X	–	–
320	SL32b	1394	GS/P #47: Field soils	X	X	–	–
0	SL32c	1395	GS/P #48: Below field soils	X	X	–	–
320	SL33b	1397	GS/P #50: Field soils	–	X	–	–
0	SL34a	1399	GS/P #52: Above field soils	–	X	–	–
320	SL34b	1400	GS/P #53: Field soils	–	X	–	–
0	SL34c	1401	GS/P #54: Below field soils	–	X	–	–
320	SL1	1375	PS #1: South edge of field channel Feature 44.01 and the north edge of soils making up the north edge of the field cell	–	X	–	–
320	SL4	1378	PS #4: Field soils	–	X	–	–

Table 5.1. Continued.

Feature	Sample ID	FN	Comments[a]	Soil	Pollen	Ostracode	Phytolith
320	SL5	1379	PS #5: Field soils	–	X	–	–
320	SL6	1380	PS #6: Field soils	–	X	–	–
320	SL7	1381	PS #7: Field soils at the north edge of Feature 44.02	–	X	–	–
320	SL8	1382	PS #8: Field soils, upper 5 cm of field, directly above PS #9	–	X	–	–
320	SL9	1383	PS #9: Field soils, lower 5 cm of field, directly below PS #8	–	X	–	–
0	SL10	1384	PS #10: Collected from alluvium below field channel 44.02; control sample from natural alluvium	–	X	–	–
0	SL11	1385	PS #11: Collected from below field soils; control sample from alluvium	–	X	–	–
0	SL12	1386	PS #12: Collected from field soils; control sample from alluvium	–	X	–	–

[a]GS/P = grain size and/or pollen sample; BSS = bulk soil sample; PS = pollen sample.

Table 5.2. Measurements of defined field areas, PHX Sky Train project.

Feature	Average Length (m)	Average Width (m)	Area (m^2)
320	22.5	8.0	176.4
321	24.5	7.0	168.1
322	25.0	6.0	147.0
323	20.0	5.0	92.5
324	11.0	5.5	59.3
327	16.5	4.0	65.3
330	15.5	4.0	61.5

to articulate, although this connection was not certain.

Westernmost field Feature 324 was irrigated by water from the eastern channel of Feature 49, which, in turn, was likely fed by canal Feature 22 (see Figure 5.1). Feature 50, an isolated ditch fragment, was probably connected to Feature 49, irrigating a field to the west of it. Both ditches were almost entirely removed by the construction of 43rd Street; only the bottom 5 cm of the ditches remained. Feature 49 intruded through the fill of pithouse Features 314 and 316. The floors of both structures were below the canals and remained intact. Ditch Feature 37 located southwest of Feature 49 was likely connected to the same system that fed Feature 49. The southern portion of this field system was better preserved than the northern portion, likely due to the southward slope of the prehistoric surface, bringing the features deeper and out of the modern construction horizon.

Feature 37 appears to define spaces for three fields; one field is predicted to have been present west of each of its sublateral extensions. These areas were not given feature numbers, as it was impossible to confirm with certainty that these were fields, because modern construction had removed the bulk of the soils that would have contained these features. Farther northwest, a field may have been present on the eastern side of canal Feature 35; however, all that remained was a portion of an apparent sublateral and field furrow. In total, seven possible fields were identified: three associated with ditch Features 49 and 50, three with ditch Feature 37, and one with ditch Feature 35.

Investigation of the fields that were present provided insight regarding the construction and irrigation of Hohokam fields during the Sedentary period near the heart of the Hohokam cultural area. Two different methods of field construction were observed during this project. Most features were common to all the fields; sublaterals extended along and defined the long axis of each field, with the width defined by the space between sublaterals. The sublaterals generally ran from northeast to southwest, following the slope of the land. All seven defined field surfaces were contiguous with a very slight gradient. The highest field surface was the westernmost, and the lowest was the eastern field surface.

The sequence would have appeared as a set of seven rectangular, shallow terraced fields. Canal Feature 23 may have followed a local low fold in the land, and field Features 324 and 323 may have both been irrigated by lateral Feature 49. This is suggested by the eastward orientation of the furrows in Feature 324 and by the fact that there is a sublateral on the eastern side of Feature 324. If Feature 323 was irrigated by canal Feature 23 there would have been no obvious need for the easternmost lateral of Feature 49.

Four of the fields were rectangular and had a dedicated lateral running the full length of the long side. They were likely irrigated by water overflowing from the field side of the lateral and spreading across the field. This appears to differ somewhat from previously recorded fields in which the water entered at the highest corner and spread over the surface from there (Doolittle 2000:Figure 10.29). Although sufficiently detailed evidence was not present to conclusively determine exactly how the water entered these fields, the interpretation that water entered along the whole of the long side is strongly suggested by the sets of furrows found in the bottoms of three of the fields. The surfaces of field Features 320, 321, and 324 were furrowed, forming the comb-shaped pattern noted during stripping over Feature 29 (see Figure 2.8). These furrows appear to have been designed to distribute water evenly over the field surface, entering along the length of the sublateral on the long axis. These furrows were initially assumed to be secondary sublaterals off sublaterals, that is, part of the field ditch system, and they were assigned feature numbers accordingly, for example, secondary Feature 29.01.

While this numbering system was retained for simplicity, the furrow features raise an important question regarding where ditches end and where the field begins. This is particularly relevant to the current context for two reasons. First, due to the long canals that cross through many sites in the Phoenix Basin, canals have separate site numbers from the sites they cross; thus, where to delineate sites? Second, as canals split and enter fields, there may not be an obvious point where one feature type ends and the other begins. Is a flooded field a flat pond at the end of a canal, and therefore a water feature, or a field? This is admittedly a rhetorical question but one that is relevant to the current discussion. It is clear that the canal/ditch features reach to the edges of the fields, but once in the fields, the distinction becomes blurred.

While a convincing argument could be made to either treat the furrows as the end point of the canals, or as secondary features of the fields, these features are treated here as aspects of the field structure. This interpretation was adopted because examination of field Feature 320, discussed below, showed that the furrows were designed to overflow onto the field surface. This is to say that they were no longer features designed to transport water along their length, but structures designed to assist in flooding the field surface. A further note regarding the furrows is that they were clearly maintained over the use-life of the field, as evidenced by the continuity of sediment stratigraphy from ditch/lateral to field surface. These features were preserved during seasonal planting, harvesting, and other field activities. By changing our perspective on these, we gain insight about construction of field surfaces in the Hohokam agricultural systems.

Field Feature 320

After discovery and exposure of sublateral Feature 29, it was seen that intact field surfaces might still be preserved in association with sublateral Feature 44, the upper end of which had been discovered while following lateral Feature 33. Subsequently, Trench 68 was excavated to confirm the presence of the sublateral, and a balk was left intact between Trench 68 and the alignment of canal Feature 33. Hand trenches were then excavated to intersect field furrows associated with Feature 44 (Trench 83), and to expose the intersection of sublateral and furrow (Trench 84) (Figures 5.2-5.4). The trenches were profiled, and samples were collected for analysis from the field surface, as well as from the sediments above and below the field soils (see Table 5.1). After these excavations were completed, the area along the length of Feature 44 was stripped to reveal the intersections of the furrows with the lateral. All the intersections were excavated by hand. No indication of water control features was found.

Feature 320 was defined by the space bounded by lateral and sublateral Features 33, 29 and 44 (see Figure 5.1). Irrigation water was supplied to the field by Feature 44. The field measured roughly 22.5 m by 8.0 m, with an area of 176.4 m^2. The field surface was characterized by a layer of visibly darker brown sediments in direct association with the furrows. The color was darkest close to the furrows and gradually lightened between furrows. The field surface was visible across the majority of the field, ranging in thickness from 10 cm to 25 cm, and averaging 16 cm deep. Soil texture was a medium loam.

The surface of the field had four furrows situated roughly perpendicularly to sublateral Feature 44; the longest measured 4.9 m in length. The end of Feature 44 turned about 70 degrees and functioned as the final furrow at the southern end of the field. This was the shortest furrow, estimated to have been 2.5 m long, although its exact length could not be determined as it was truncated by Trench 89. The furrows reached just over half the width of the field, reaching an average of 4.4 m over the 8-m width. Each furrow contained a similar sequence of soil stratigraphy as that found in lateral Features 44 and 33. This same sequence of deposition was noted in all the laterals that originated from Feature 33, indicating that field Features 320, 321, 322, 327, and 330 were irrigated at the same time. As mentioned, no indications of water control features were noted at proximal ends of the furrows or of lateral Feature 44.

The location of the project adjacent to Pueblo Grande eliminated the possibility of collecting any true "control" samples, that is, soils with no anthro-

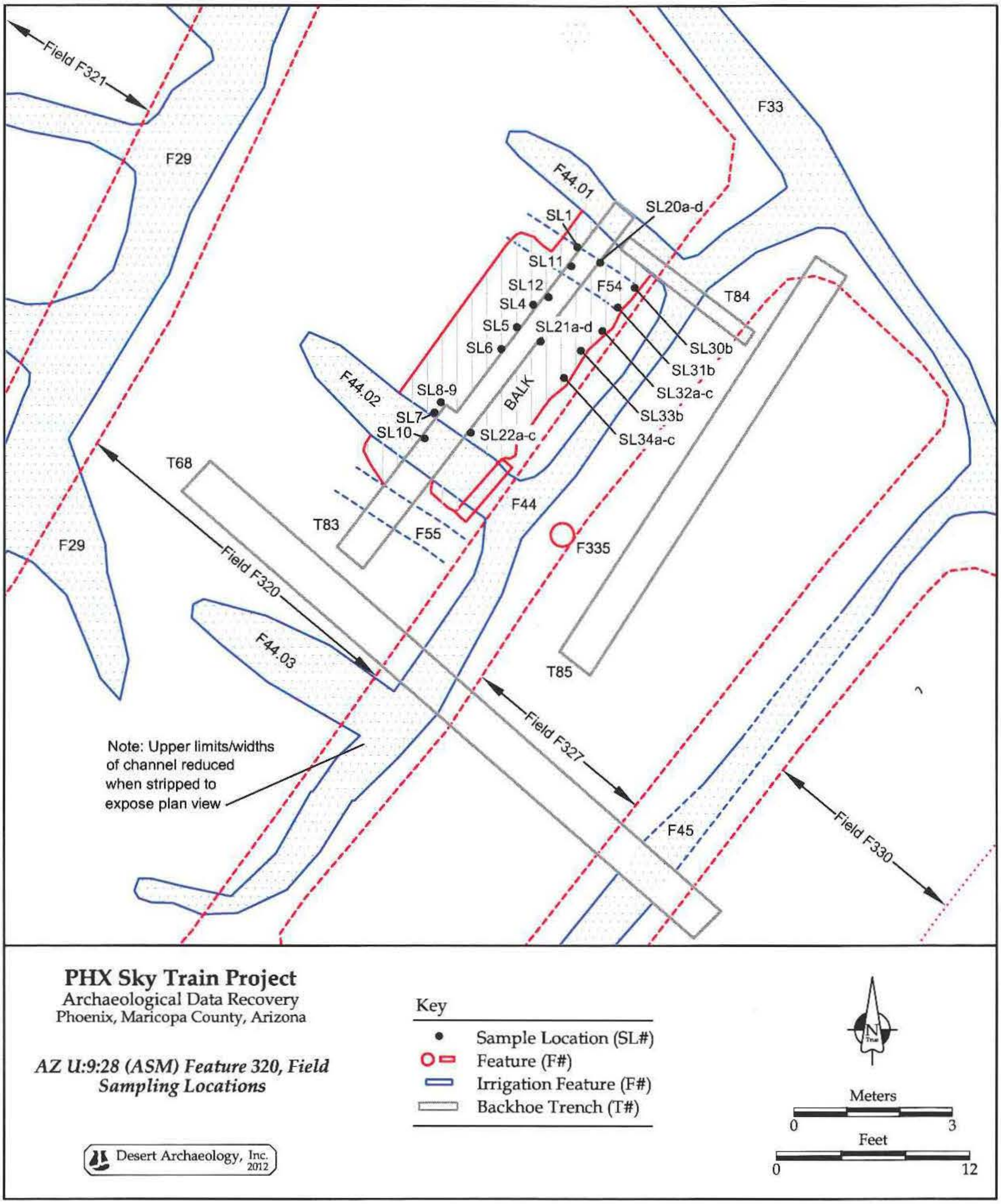
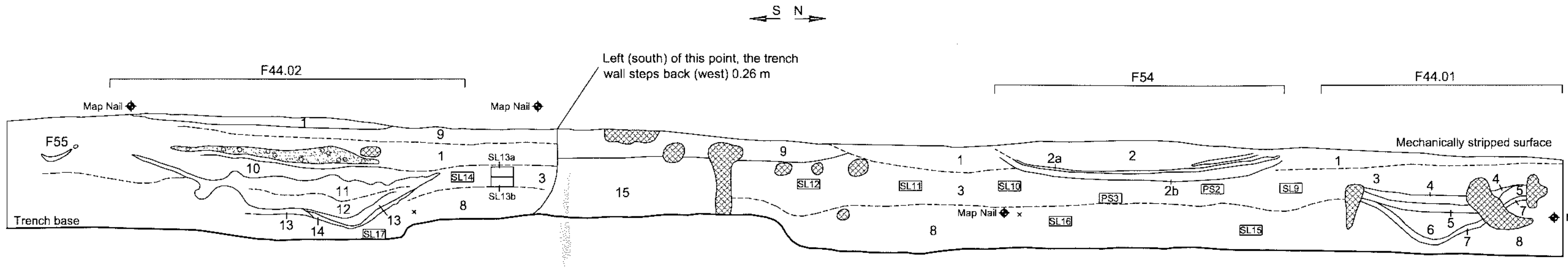


Figure 5.2. Plan view of field Feature 320, showing trenches used to define the feature and sampling locations, PHX Sky Train project.

pogenic influence. The soils both above and below the field surface were clearly impacted and altered from their natural condition by agricultural activities both prior to and after the development of the field system studied here. Evidence for prior agricultural activity was seen as traces of possible field laterals below field furrow Feature 44.04 in the west profile of Trench 89. The fieldhouses to the northwest, Features 312, 314, and 316, whose occupation preceded use of the field system discussed here (see Chapter 9), also implies the presence of earlier fields. Evidence for later agriculture was noted in several areas on the project. Most specifically, fragments of later ditches/furrows were noted in the fill above



Stratum Descriptions (by H. Schaafsma)

1. Brown clay loam; slightly blocky structure; few large sand grains
2. Brown silty loam; no strong structure; moderate number of large sand grains; silt laminae present on right side

2a. Dark brown blocky clay

2b. Grayish-brown fine sandy silts

3. Grayish-brown clay loam; no structure; light scatter of large-grained sands; Feature 320 field soils
4. Mottled brown clay and gray-brown silty clay
5. Mottled brown clay and rose-colored clay; blocky structure
6. Dark brown clay; blocky structure
7. Light tan sandy silt
8. Dark tan loam; natural alluvium
9. Medium brown to reddish-brown clay loam; slightly blocky; few large sand grains
10. Reddish-brown clay loam; disorganized
11. Rose-colored clay; 4-5 cm gradation to 12
12. Dark brown clay; 4-5 cm gradation to 11
13. Similar to 10
14. Tan/light brown silt
15. Similar/same as 1; prehistoric disturbance

Key

- Gravel/large grained sand
- Charcoal
- Rodent disturbance
- SL# Sample Location

PHX Sky Train Project
Testing and Data Recovery
Phoenix, Maricopa County, Arizona

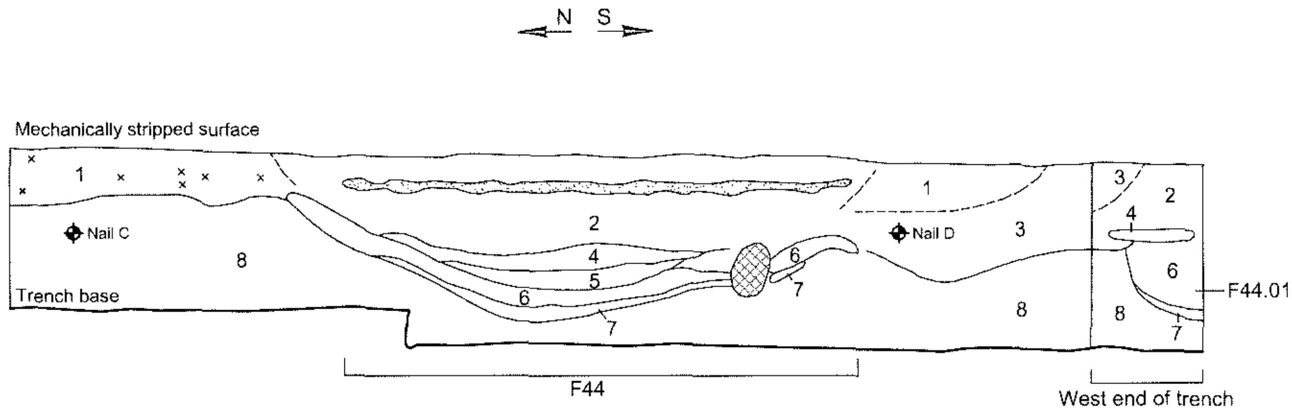
AZ U:9:28 (ASM)

Features 44.01, 44.02, 54, 55, and 320, Trench 83

Meters 0 0.6
Feet 0 2.4

Desert Archaeology, Inc. 2012

Figure 5.3. Profile of hand Trench 83, west wall, showing strata defining field Feature 320 and field ditches/furrows, Features 44.01, 44.02, 54, and 55, PHX Sky Train project.



Stratum Descriptions (by H. Schaafsma)

1. Brown silty clay with scatter of large sand grains and charcoal flecks
2. Similar to 1 but lacks charcoal flecks and sand grains, except a layer of abundant large-grained sand near the top; postabandonment flood deposit
3. Brown silty clay with charcoal flecks; stratum is likely the edge of the field surface to the south
4. Mottled dark brown and rose-colored clay
5. Mottled mix of tan clay silts and brown silty clay
6. Dark brown clay
7. Light tan sandy silt
8. Dark tan sandy loams; natural alluvium

Key

- Rodent disturbance
- Sand
- Charcoal

PHX Sky Train Project
Testing and Data Recovery
Phoenix, Maricopa County, Arizona

AZ U:9:28 (ASM)

Feature 44 and Feature 44.01, Trench 84

Meters
0 0.5
Feet
0 2

Desert Archaeology, Inc. 2012

Figure 5.4. Profile of hand Trench 84, south wall, at the intersection of lateral Feature 44 and field furrow Feature 44.01, PHX Sky Train project.

Feature 320 in Trench 83 (see Features 54 and 55 in Figure 5.3), indicating this location continued to be utilized as a field area after Feature 320 and its contemporaries were no longer in use. Further evidence of agricultural activity prior to and following construction and use of Feature 320 was maize pollen in both overlying and underlying sediments (Chapter 7, this volume).

Figure 5.5. Photograph of field soils extending both directions from furrow Feature 44.02, PHX Sky Train project.

Despite these apparently homogenizing conditions, the soils both above and below Feature 320 differed somewhat from the identified field surface. The field surface was apparent as a stratigraphic layer distinctly darker than the surrounding sediments. The darker band was located at the same level as the top of the furrows and extended between them, showing continuity throughout the field (Figure 5.5).

Fifty pollen and soil samples were collected during excavation. Pollen analysis was conducted on 27 samples from field soil contexts and three from sediments below the field (see Table 5.1; see also Chapter 7). Eleven samples were analyzed for phytoliths (Chapter 8, this volume), and 20 were analyzed for soil properties. The soil samples were sent to IAS Laboratories in Phoenix for processing and analysis. Samples were analyzed for physical properties, including texture, bulk density, total carbon, organic carbon, total and available phosphorus; methodologies followed IAS protocols (Table 5.3). A variety of collection and laboratory problems resulted in no results for soil nitrogen and spotty results for total carbon. Soil chemical properties tested for included pH, electrical conductivity (EC), sodium adsorption ratio (SAR), moisture content, total dissolved solids, and cation bases, including calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K); methodologies followed IAS protocols (Table 5.4).

RESULTS AND DISCUSSION

Data collected during excavation indicate that all the soils surrounding Feature 320 were, to varying degrees, affected by agricultural activities. This likely holds true for most of the soils exposed around all field and possible fields encountered during this project. Overall results of the soil analysis indicate little difference between the field surface of Feature 320 and the earlier and later sediments, those below and above (Figure 5.6). The results of the soil texture analysis showed that all three sampled strata were relatively uniform, consisting primarily of medium loam to silty loam (see Table 5.3). The field soils had the greatest textural variability, including medium loam, silty loam, and clay loam. The greater variability in textures found on the fields likely reflects the differing sediment textures noted in the laterals/furrows, which ranged from silt to dense clays (see Figures 5.3 and 5.4), as well as how the furrows distributed the water. The data suggest a trend of higher clay content closer to the furrows and higher silt and fine sand content between furrows. Although more samples would be needed to confirm this trend, it suggests that higher velocity water over-topped the furrows carrying the larger particles to the middle of the field, while the greater proportion of fine clays settled closer to the furrows as the water slowed and percolated into the field.

The greater variability in field soil texture contrasts with the field soils analyzed by Miles et al. (2010). They found that sediments in the GRIC Santan fields were more uniform in texture than the surrounding control samples, and suggest this was due to each Santan field being flooded uniformly, rather than flooded through the use of furrows (Miles et al. 2010:29). The fields studied at Cave Creek were primarily medium to clay loam, with more variability than the other field systems considered here. This variability is expected in the Cave Creek fields due to the methods used to actively capture flood sediments (Schaafsma and Briggs 2007).

Table 5.3. PHX Sky Train project, Feature 320 field soil properties: texture, bulk density, carbon, and phosphorus.

Feature	Sample ID	Texture[a] Sand (%)	Silt (%)	Clay (%)	Soil Classification	Bulk Density[b] (gm/cm³)	Total Carbon[c] (%)	Organic Carbon[d] (%)	Total Phosphorus[e] (%)	Available Phosphorus[f] (ppm)
Sediments Above Agricultural Field Surface										
320	SL20a	40	46	14	Loam	1.44	ND[g]	0.6	0.9	12.0
320	SL21a	44	44	12	Loam	1.52	1.1	0.6	0.9	5.2
320	SL22a	32	48	20	Loam	1.44	ND	0.7	0.9	6.5
320	SL30a	32	48	20	Loam	1.45	0.2	0.6	0.9	5.4
320	SL31a	30	50	20	Silt loam	1.47	0.0	0.9	1.0	8.9
320	SL32a	32	50	18	Silt loam	1.47	0.3	0.7	0.9	7.7
Sediments From Agricultural Field Surface										
320	SL20b	32	54	14	Silt loam	1.41	0.3	0.6	0.9	4.9
320	SL21b	48	42	10	Loam	1.50	ND	0.5	0.8	4.9
320	SL22b	26	42	32	Clay loam	1.40	0.3	1.1	0.9	7.5
320	SL30b	24	52	24	Silt loam	1.38	0.2	0.9	0.9	4.8
320	SL31b	40	46	14	Loam	1.55	ND	0.4	0.8	5.8
320	SL32b	32	52	16	Silt loam	1.44	0.2	0.6	0.9	5.1
320	SL20c	44	44	12	Loam	1.44	0.4	0.7	0.8	4.6
320	SL21c	46	46	8	Loam	1.46	0.4	0.5	0.8	4.3
Sediments From Below Agricultural Field Surface										
320	SL20d	50	42	8	Loam	1.52	ND	0.5	0.8	3.9
320	SL21d	50	42	8	Loam	1.52	0.1	0.5	0.8	3.4
320	SL22c	38	46	16	Loam	1.47	ND	0.6	0.8	5.3
320	SL30c	34	50	16	Silt loam	1.47	ND	0.7	0.9	4.8
320	SL31c	40	46	14	Loam	1.54	0.1	0.6	0.8	5.3
320	SL32c	38	46	16	Loam	1.49	ND	0.6	0.8	5.9

[a]Hydrometer method (Gee and Bauder 1986).
[b]Brady 1974:50-51.
[c]Analysis by combustion (Carter 1993).
[d]ASTM D2974-00, Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.
[e]WREP 125 (Gavlak et al. 1994).
[f]Olsen bicarbonate method (Jones 1999).
[g]ND means none detected.

Table 5.4. PHX Sky Train project, Feature 320 field soil chemical properties: pH, electrical conductivity, sodium adsorption ratio, and bases in saturation paste extract.

Feature	Sample ID	pH[b]	EC[b] (dS/m)	Saturated Paste[a]: Cations SAR	Sodium (mg/l)	Calcium (mg/l)	Manganese (mg/l)	Potassium (mg/l)	Moisture (%)	Total Dissolved Solids (ppm)
Sediments Above Agricultural Field Surface										
320	SL20a	7.7	5.8	13.4	1485.8	548.0	236.0	171.6	1.20	3700
320	SL21a	7.9	5.0	13.7	1306.4	418.0	164.6	124.8	1.20	3200
320	SL22a	8.0	2.1	7.8	453.1	156.0	58.1	78.0	1.30	1300
320	SL30a	7.8	4.0	10.2	871.7	304.0	152.5	148.2	1.50	2600
320	SL31a	7.8	3.6	8.9	761.3	306.0	148.8	117.0	1.60	2300
320	SL32a	7.8	3.4	8.4	740.6	344.0	148.8	101.4	1.10	2200
Average values:		7.8	4.0	10.4	936.5	346.0	151.5	123.5	1.32	2550
Sediments of the Agricultural Field Surface										
320	SL20b	7.7	6.0	12.7	1465.1	536.0	281.9	167.7	1.30	3800
320	SL21b	7.8	4.7	13.8	1370.8	466.0	167.0	101.4	1.00	3000
320	SL22b	7.8	3.0	10.1	710.7	234.0	84.7	70.2	1.50	1900

Table 5.4. Continued.

Feature	Sample ID	pH[b]	EC[b] (dS/m)	SAR	Saturated Paste[a]: Cations Sodium (mg/l)	Calcium (mg/l)	Manganese (mg/l)	Potassium (mg/l)	Moisture (%)	Total Dissolved Solids (ppm)
320	SL30b	7.7	3.4	9.1	765.9	294.0	146.4	109.2	1.30	2200
320	SL31b	7.8	3.8	8.5	765.9	344.0	163.4	117.0	0.89	2400
320	SL32b	7.7	4.1	8.8	860.2	422.0	177.9	97.5	1.00	2600
320	SL20c	7.8	6.1	13.0	1478.9	538.0	262.6	148.2	1.10	3900
320	SL21c	7.8	5.2	14.4	1446.7	490.0	165.8	101.4	0.86	3300
Average values:		7.8	4.5	11.3	1108.0	415.5	181.2	114.1	1.12	2888
Sediments Below Agricultural Field Surface										
320	SL20d	7.8	5.8	12.7	1403.0	566.0	217.8	101.4	0.91	3700
320	SL21d	7.8	5.4	12.6	1304.1	562.0	152.5	62.4	1.00	3500
320	SL22c	8.0	1.7	10.2	446.2	94.0	30.3	31.2	1.00	1100
320	SL30c	7.7	3.5	8.5	749.8	334.0	151.3	85.8	1.30	2200
320	SL31c	7.8	3.9	8.4	770.5	362.0	164.6	93.6	1.20	2500
320	SL32c	7.6	4.3	8.4	894.7	516.0	204.5	89.7	0.91	2800
Average values:		7.8	4.1	10.1	928.1	405.7	153.5	77.4	1.05	2633

[a]WREP 125 (Gavlak et al. 1994).
[b]Saturated paste extract, analyzed by probe or conductance bridge.

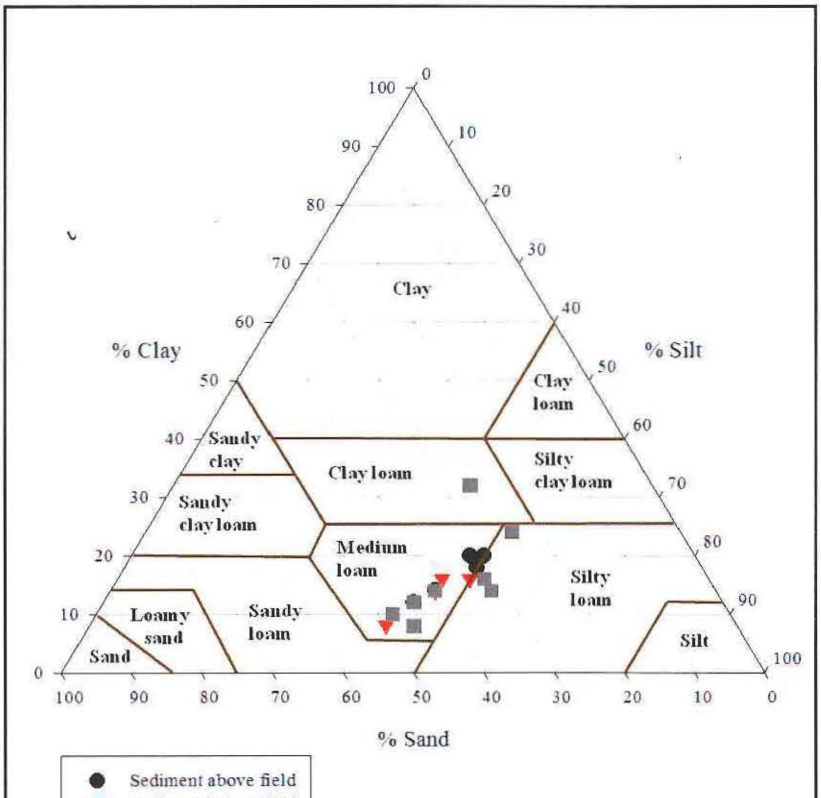


Figure 5.6. PHX Sky Train project Feature 320 soil texture graph. (Comparison of sediments from above, below, and within the field surface revealed no significant texture differences. This is likely due, at least in part, to the high probability that all the soils observed had been part of previous and later field systems.)

Despite the differences in morphology and construction of all three field systems, it is remarkable how similar the soil properties are. This speaks to the soil engineering skills of the Hohokam farmers. In each case, field soil textures were close to the medium loam, silty loam, and clay loam spectrum. From an agricultural perspective, soils of this texture range are desirable due to their relatively high available water capacity, obviously critical in the hot desert environment.

The bulk densities of all three strata were similar, averaging 1.46 gm/cm^3 above the fields, 1.45 gm/cm^3 on the field, and 1.50 gm/cm^3 below the field (see Table 5.3). As with texture, the field surface sediments had the greatest range in bulk density, ranging from 1.38 gm/cm^3 to 1.55 gm/cm^3, while the lower strata varied the least. All the variations were small and within the range suitable for healthy root growth. Measurements of total carbon were lacking in several samples from each of the three strata.

The results showed a generally low total carbon count in all three strata, averaging 0.28 percent (with one sample from the upper sediments excepted with a reading of 1.4 percent). Organic carbon was similarly low in each of the sediments, all averaging 0.6-0.7 percent.These results are consistent with typical desert soils, which generally contain less than 1.0 percent organic carbon (Sowell 2001). The levels of phosphorus showed a typical trend with depth, with higher levels decreasing with depth (West and Klemmedson 1978); the upper sediments averaged 7.6 ppm, the field average was 5.2 ppm, and lower sediments averaged 4.8 ppm. All of these values are sufficient for healthy crop growth.

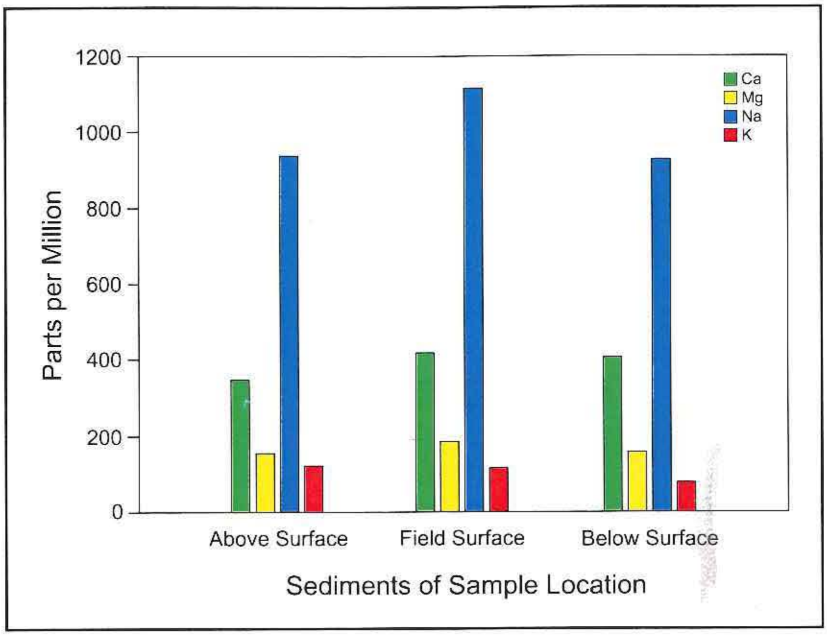


Figure 5.7. Bar chart comparing cation concentrations in soils from above, below, and within the Feature 320 field surface, PHX Sky Train project.

Soil chemical properties of all three strata followed the relative uniformity found in tests of the physical properties of the soil. The pH of all three soils averaged 7.8, a pH level that would not limit the availability and uptake of micronutrients (Homburg et al. 2004), a condition common in desert soils where pH values often exceed 8. Measurements of electrical conductivity were highest in the field soils, averaging 4.5, and the values showed less variation across the field group relative to those collected above and below the field soils (see Table 5.4). Similarly, sodium adsorption ratios were higher in the field soils than in the other strata. Not surprisingly, these values reflected the concentration of cations throughout the soils; calcium, manganese, and sodium were all higher, on average, in the field soils as well. The largest differences were in elevated sodium and calcium concentrations on the field compared to the surrounding soils (Figure 5.7; see also Table 5.4). However, these differences were not large; no statistical differences were found between each group's mean values. Potassium values, though, were significantly lower, on average, than either field or above field soils, a statistically significant difference. The sodium content, as measured by electrical conductivity and sodium adsorption ratios, was high enough to cause some potential loss of productivity in certain salt-sensitive crops, such as beans and squash; moderately salt tolerant corn might have been mildly affected, while salt-tolerant crops, such as cotton, would not have been affected (Sandor 2010:33). Although the sodium levels were elevated relative to the other cations (Ca, Mg, and K), the soils would have supported crops when irrigated.

In summary, soils from the field surface of Feature 320 were texturally fine for practicing agriculture; also, they were not too sodic (SAR 11.3) or alkaline (pH 7.8). With good soils, the work left for the farmers was to ensure sufficient water flow for the crops. While there is not yet an apparent reason why some of the fields mapped during this project contained furrows and others did not, although it can be assumed that at least some farmers preferred this method to the flat field. It is also possible that the fields with furrowed bottoms were for cultivation of specific crops. Unfortunately, only being able to sample one field, no comparisons are available.

The thought that fields might have been cultivated for specific crops is, however, countered by the pollen results of the project (see Chapter 7). These indicate Feature 320 was intensively cultivated, with multiple crops grown, including maize, cotton, squash, and possibly cholla and prickly pear. Pollen suggestive of field weeds, possibly grown for grain or greens, were also abundant. Further, based on results of phytolith analysis (see Chapter 8), amaranth, possibly domesticated, was likely among the greens/grains grown.

CONCLUSIONS

One of the first things that can be concluded from the three field systems from differing locations is that the fields reflect the Hohokam farmer's adaptability to various environments. Rather than discovering what a "Hohokam field" looks like, we have discovered that Hohokam farmers were extremely knowledgeable regarding their environments and had multiple techniques for engineering their environments to produce a habitat for their crops and, therefore, themselves.

As noted, the field represents an anthropogenically engineered environment; an archaeological field is an artifact containing information regarding the human endeavors surrounding its construction. The three sets of fields considered here provide a glimpse into the diversity of construction techniques utilized by the Hohokam farmers within the Phoenix Basin. While both the fields and field plots described on the GRIC and in the PHX Sky Train study generally conform to the idea of contiguous square or rectangular plots individually irrigated by a dedicated field lateral, they exhibited significant differences.

The GRIC fields were roughly square in form and large, each field plot measuring roughly 4,875 m^2. No evidence of secondary field features, such as furrows, bands, or water spreaders, was noted. The lateral canals contained abundant evidence of headgate or tapon structures to divert water from the canals into the fields. In contrast, the fields in the PHX Sky Train project area, while rectilinear, were long, narrow rectangles rather than squares, and they were much smaller, averaging only 118 m^2. They also contained secondary features in their structure in the form of furrows to aid in spreading water within the field plots.

Even the method of introducing water into the fields differed between the GRIC fields and those in the current study. At the PHX Sky Train project area fields, water appears to have flowed into the field plots all along the long axis of each field in this system, regardless of whether there were field furrows or not, unlike the point introduction of water described for the GRIC fields. Further, while careful investigations were conducted at many of the canal intersections in this system, no evidence of water control features was discovered in these fields.

The fields along Cave Creek differ in virtually every respect from both GRIC and PHX Sky Train fields. No rectilinear structure was documented in the Cave Creek fields; rather, the farmers appear to have utilized the surface, perhaps using the shifting locations of the silt tripping weirs as temporary field plot boundaries. The necessity of shifting the location of the weirs as the silt accumulated would not have allowed for long-term rectangular boundaries. Also, the larger field area continued to expand, and more silts were captured, further shifting boundaries.

Whether the differing size and shape of the fields along the Gila River and at the PHX Sky Train, Salt River locations reflect divisions of the land based on different land tenure practices between the two locations or differences based on varied agricultural practices and goals, is not yet known. However, intriguing questions are raised regarding social, agricultural, and ecological aspects of field structure. Some of the structural questions can be at least partially addressed regarding the fields along Cave Creek in that the changing shape and size of the fields pose a possible inhibitor to rectilinear field plot shape. Questions regarding how field areas were divided between social groups are not yet able to be addressed; more studies are needed.

Despite the obvious differences, some important commonalities have been revealed. The primary commonality is that the soils of all three field systems have virtually the same soil texture, a texture that, at least in the Cave Creek fields, had to be fully engineered and was likely manipulated to some degree in the GRIC fields. Based on pollen data, at least the major crops grown in each location were similar, indicating that the differences were not driven primarily by crop specialization. Again, these questions will have to be addressed by further research.

PALEOECOLOGY OF IRRIGATION CANALS AND WATER CATCHMENTS AT AZ U:9:28 (ASM), PHX SKY TRAIN PROJECT

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Prehistoric irrigation in Arizona is well known, and several workers have set the fundamentals for its understanding (Ackerly 1989b; Haury 1976; Mabry 2005; Nials and Gregory 1989). The incorporation of micropaleontology as a tool for reconstructing aquatic environments associated with irrigation systems has proven its value in understanding anthropogenic effects in the environment (Adams et al. 2002). Mabry (2008) and Palacios-Fest and Davis (2008) demonstrated how the evolution of water management over the past 3.5 millenia may be inferred using the sedimentary, biological, and archaeological records. Over the years, this author has committed to reconstructing the paleoenvironmental history of irrigation canals and reservoirs associated with human activity using ostracodes, mollusks, and calcareous algae (see Palacios-Fest 2002).

To date, most paleoenvironmental studies have focused on larger distribution canals. For the first time, however, the PHX Sky Train project uncovered a network of small canals that fed agricultural fields in the lower Salt River Valley. These features are the primary focus of this study, whose purpose is to reconstruct the paleoenvironmental history of the irrigated field network. The paleoecology of two water catchment features is also examined to inform on their possible functions. In the following sections, evidence is provided for the paleoecological behavior of ostracodes, mollusks, and calcareous algae in the PHX Sky Train features, using them as proxies of environmental change.

Ostracodes are microscopic crustaceans characterized by a hinged bivalve carapace made of calcite and ranging in size between 0.5 and 2.0 mm. The carapace is the only body part that preserves in the geologic record (Horne et al. 2002; Pokorný 1978). In continental waters, they are primarily benthic, although some species are nektic and may swim around the vegetation (Forester 1991). This group colonized continental aquatic systems as early as the Carboniferous, but thrived in the oceans since the Cambrian. Today, ostracodes are diverse and abundant in marine and nonmarine environments. Paleontologists have devoted more time to the study of ostracodes than biologists, which explains the inadequately understood ecology of ostracodes. However, recent progress on the application of ostracodes as indicators of hydrogeologic variations provide a rationale for studying the ecology of wetlands, lakes, springs and seeps, and streams, including irrigation canals (De Deckker 1983; Forester 1983, 1986; Holmes and Chivas 2002; Palacios-Fest 1994, 2008; Palacios-Fest et al. 1994, 2001).

Mollusks include the bivalve clams and mussels (Pelecypoda), and the univalve snails (Gastropoda). Mollusks are soft-bodied and unsegmented, with a body organized into a muscular foot, a head region, a visceral mass, and a fleshy mantle that secretes a shell of proteinaceous and crystalline calcium carbonate (aragonite) materials. Both marine and nonmarine species exist. The nonmarine species, subject of this study, include several families of snails (Planorbidae, Ancylidae, Lymnaeidae, Pupillidae) and at least one family of clams (Sphaeridae).

The associations of mollusks in the sediments reflect the water quality, salinity, and streamflow (Dillon and Stewart 2003; Rutherford 2000). For example, the occurrence of only juveniles in a sample is interpreted as the introduction of early stage specimens during warm or warming months (Rutherford 2000). If the population reaches stability and adults are encountered, it is assumed that the feature held water for a relatively prolonged period. Some species, like *Pisidium* sp. and *Laevapex* (*Ferrisia*) *hendersoni*, require well-oxygenated, lotic (flowing) waters and prefer neutral to alkaline pH, but cannot be very tolerant to organic pollution present in the marsh. By contrast, other species, like *Planorbella scalaris* and *Physa virgata*, can tolerate poorly oxygenated (but not disoxic), lentic (standing) waters, and can tolerate some organic pollution and eutrophic conditions (Dillon and Stewart 2003). *Planorbella scalaris* and *Physa virgata* prefer lakes, wetlands, ponds, and the calmest areas of coastal rivers. Together with ostracode signatures, mollusks are used here to integrate the paleoecological characteristics of PHX Sky Train project features.

The calcareous remains of *Chara*, known as gyrogonites (fertilized female gametangia), occurred infrequently in sampled contexts from the PHX Sky Train project area. These microfossils may be used to reconstruct the alkalinity, time of colonization, and paleohydraulics of the marsh. Charophytes are small branching algae, normally living in carbonate-rich freshwater. Modern examples are known as "stoneworts," because they have a partial carbonate skeleton. They look like small subaqueous "horsetails." The Characeae or Charophyta are a strange and isolated group of aquatic plants growing entirely under water. Modern species prefer ponds or lakes, although they are occasionally found in running water, and they have a partiality for somewhat brackish conditions, such as freshly dug ditches in marshes near the sea. In overgrown waters, they soon give way before more vigorous vegetation, such as cattails. They commonly pioneer the colonization of habitats like recently dug canals and ditches (Allen 1950).

Ecologically, the Charophyta promote water clarity, enhance fish population, and stabilize the bottom surface. In clear still water, masses of orange-red antheridia (the male reproductive organs) are abundant and visible (Allen 1950). The average height of these plants is 30-46 cm, although occasionally, they are just a few centimeters. Charophytes usually grow in shallow waters (less than 60 cm deep), but sometimes they may occur at much greater depths (Allen 1950). Many modern charophytes have a short season between spring and late summer just before the aquatic system dries out (Allen 1950); therefore, they prefer warm to early warm temperatures (Allen 1950). Gyrogonites are used here to complement the microinvertebrate record.

MATERIALS AND METHODS

Forty-nine sediment samples collected from nine prehistoric features within AZ U:9:28 (ASM) were selected for micropaleontological analysis using ostracodes, mollusks, and calcareous algae to reconstruct their paleoenvironmental history. These include 28 samples from canals and ditches that fed agricultural fields (Figure 6.1), 13 samples from catchment Feature 7 and associated canal Feature 25, and 8 samples from the unusual manufactured "pond," designated Feature 57 and associated canal Feature 26 (Table 6.1).

Samples were prepared following routine micropaleontological analysis (Forester 1988; Palacios-Fest 1994): air-dried, weighed, and soaked in boiling water with 1 gm of Alcanox to disaggregate the sediments. The samples were let sit at room temperature for five days, stirring the samples once a day. Using a spinning washer lid on a 230 US Std sieve, the samples were wet-sieved. Then, a set of three sieves were used to separate the coarse (> 1 mm), medium (> 106 µm), and fine (> 63 µm) sand fractions to help identify the systems paleohydraulics (see Table 6.1).

The textural terminology for gravel-free detrital sediments of Folk et al. (1970) is used here. The very fine sand and silt and clay fractions were washed-out at this stage. Therefore, the particle-size analysis departs from the formal USDA procedure (United States Department of Agriculture [USDA] 2003), and it is used only as a rough reference in this study. The possible discrepancy between the approach used in this investigation and that of the USDA is the result of grouping the very fine sands with the finer fractions, which, in fact, change the total percentage of sand, but does not affect the actual behavior of sands in the ecosystem. The value of the approach used here is that it provides a simple way to process the data. More detailed particle-size analysis may be conducted using the appropriate research methods. Data were subsequently plotted by feature (Figure 6.2). The mineral composition characterizing the canals is shown in Table 6.2.

Sediment fractions were analyzed using a low-power microscope. All samples were examined to identify fossil contents and faunal assemblages. Total and relative abundance were recorded. Based on Delorme (1969, 1989), standard taphonomic parameters, such as fragmentation, abrasion, disarticulation (carapace/valve [C/V] ratios), and adulthood (adult/juvenile [A/J] ratios), were recorded to establish the synecology (ecology of the communities), as opposed to the autoecology (ecology of single species) of the features (Adams et al. 2002). However, autoecology was implemented to integrate the environmental framework. The specimens were placed in micropaleontological slides and preserved in the Terra Nostra Earth Sciences Research LLC collection.

The taphonomic parameters were used to recognize degrees of transport and/or burial characteristics, like desiccation and sediment compaction. The rates of fragmentation, abrasion, and disarticulation are realistic indicators of transport; these parameters commonly show increasing damage with increasing transport. One must be cautious in using this criterion, although the nature of the deposits suggests that microinvertebrates may reflect the hydraulic properties of the ecosystem. Other features, such as encrustation and coating, were used to determine authigenic mineralization or stream action, respectively. The redox index and color of valves reflected

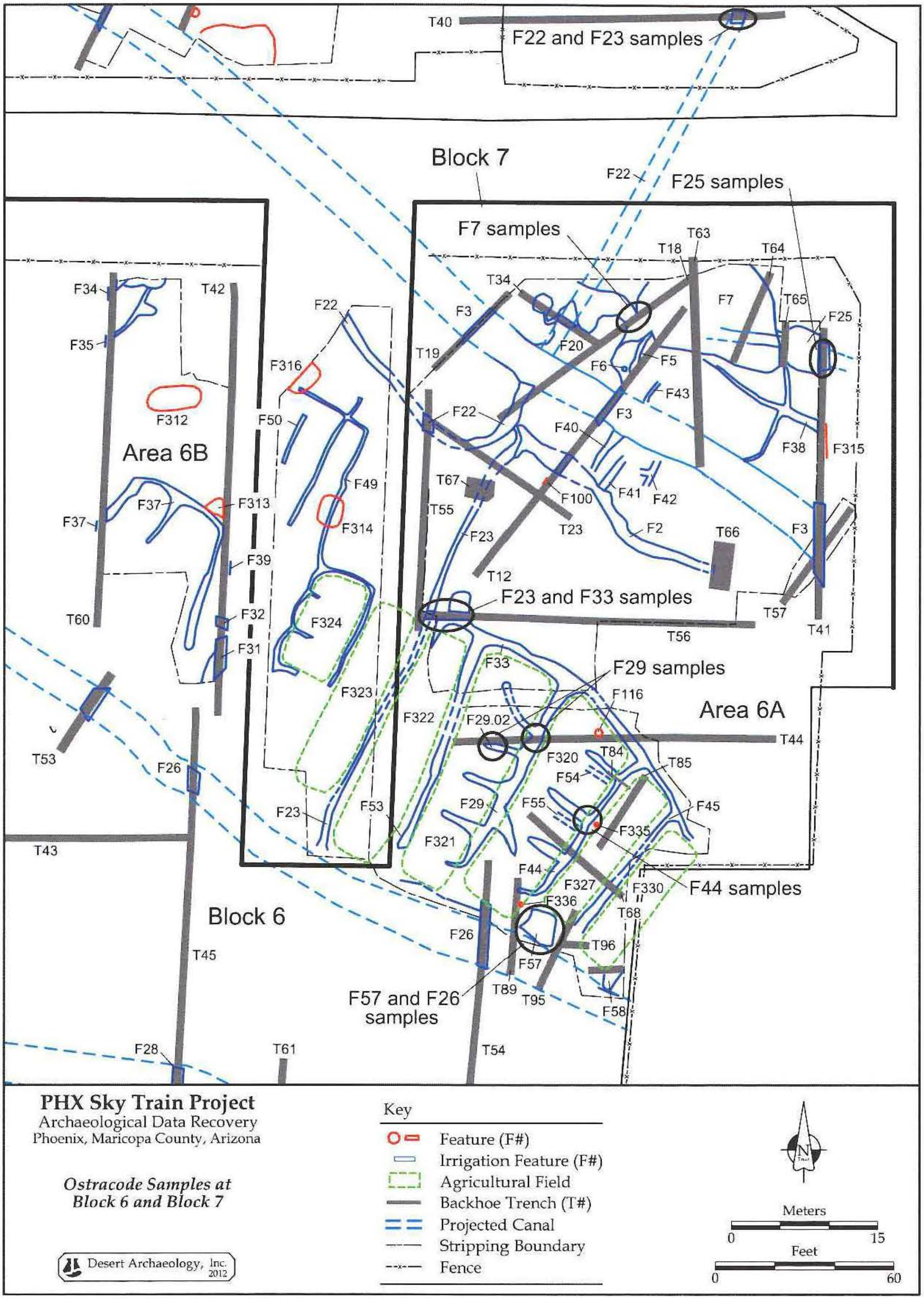

Figure 6.1. Map showing locations where sediment samples were collected for this paleoecological analysis, PHX Sky Train project.

burial conditions. The A/J and C/V ratios were used as indicators of biocenosis (Palacios-Fest et al. 2001).

Based on the faunal composition, a paleosalinity index was developed. The paleosalinity index considers the salinity tolerance of the species present in the features, based on current knowledge of their ecological requirements (Palacios-Fest 1994). The equation used for the present study is:

SI = [4(% *Limnocytherestaplini*)
+ 3(% *Cyprideisbeaconensis*)
+ 2(% *Cypridopsisvidua*)
+ (% *Candonapatzcuaro*)]
- [(% *Potamocyprissmaragdina*)
+ 2(% *Ilyocyprisbradyi*)
+ 3(% *Herpetocyprisbrevicaudata*)
+ 4(% *Physocypriapustulosa*)]

Continental ostracodes inhabit waters of different hydrochemical composition, but at the species level, many are very sensitive to water chemistry. Ostracode assemblages can be used to recognize the three major water types defined by Eugster and Hardie (1978):

Type I: Ca^{2+}, Mg^{2+}, and HCO_3^- -dominated water; typically freshwater or very low salinity conditions
Type II: Ca^{2+} -enriched/HCO_3^- - depleted water; additionally containing the combinations of Na^+, Mg^{2+}, SO_4^{2-}, or Na^+, Mg^{2+}, Cl^-; ranges from low salinity to hypersaline conditions
Type III: Ca^{2+} -depleted/HCO_3^- + CO_3^{2-} (alkaline)-enriched water; usually containing combinations of Na^+, Mg^{2+}, Cl^-, or Na^+, Mg^{2+}, SO_4^{2-}; ranges from low salinity hypersaline conditions

The application of this model to paleoenvironmental reconstructions is better known for ostracodes. This spectrum clearly shows that water chemistry plays a major role in the geographic distribution of ostracodes. In addition to water chemistry, temperature is another factor that affects the distribution of these organisms, as the latitudinal distribution of ostracodes demonstrates. Many species respond to temperature through both reproductive and survival ability (De Deckker and Forester 1988; Delorme and Zoltai 1984; Forester 1987). For example, *Cytherissa lacustris* is limited to water temperatures lower than 23°C, and is common in subpolar regions, whereas *Limnocythere bradburyi* is restricted to warm temperatures of low to mid-latitudes (Delorme 1978; Forester 1985). Their sensitivity to temperature makes ostracodes very useful for paleoenvironmental reconstructions (Cohen et al. 2000; Palacios-Fest 2002). After the ecological requirements of ostracodes are determined, paleoenvironments can be reconstructed from the geologic record (Delorme 1969; Holmes and Chivas 2002; Palacios-Fest 1994).

RESULTS

The sample identification number, stratigraphic level, bulk and fraction weights, absolute and relative fraction content, textural classification, and color (and color code) of sediment residuals are presented in Table 6.1. Sedimentary characteristics, by feature and general type, are discussed below. The sections that follow summarize the paleontological composition of canals and catchments in detail.

The Sedimentary Record

Field Canals and Ditches

Feature 23 is a small primary canal that feeds agricultural field systems. The canal feeds multiple fields via ditch Feature 33, which, in turn, feeds the field-specific ditches, Features 29 and 44 (see Figure 6.1). Sampled at Trenches 40 and 56 (see Figures 3.18 and 3.19), Feature 23 contains brown (7.5YR 4/4 to 7.5YR 4/3 to 7.5YR 5/4) to dark brown (7.5YR 3/3) gravelly silt to silty clay. The dominant minerals recognized in Feature 23 are quartz, feldspars, and gneiss. Biotite, carbonate nodules, and root casts are less abundant. Other minerals like schist, charcoal, and rock and shell (mollusk and ostracode) fragments are rare or very rare (see Table 6.2).

Feature 22 is a small primary canal that shares the same alignment but postdates Feature 23, turning northwest to feed field systems northwest of the Feature 23-fed fields. At Trench 40, it consists of brown (7.5YR 5/4) to strong brown (7.5YR 4/6) silty clay dominated by quartz, feldspars, and gneiss. Biotite, carbonate nodules, and root casts follow in abundance, while muscovite, schist, charcoal, and rock and shell (mollusk and ostracode) fragments are rare to very rare. The water source for Features 22 and 23 is unknown. These channels appear to be among the earliest canals in the project area (Chapter 3, this volume).

Feature 33 is a small canal/ditch fed by Feature 23 to supply field ditch Features 29 and 44. Many of these smaller ditches exhibited subextensions that formed a comb-like pattern (for example, Feature 29.02), presumably to better irrigate the intervening field space. At Trench 56 (see Figure 3.19), Feature 33 is composed of brown (7.5YR 4/4) to very dark brown (7.5YR 3/2) sandy gravel to finely laminated silt to clay. Quartz, feldspars, and gneiss are the most

Table 6.1. Sample identification numbers, stratagraphic position, bulk and fraction weight, and textural classification of materials analyzed from canal and water catchment features at AZ U:9:28 (ASM), PHX Sky Train project.

Sample ID	Desert Archaeology, Inc. Sample No.	Feature No.	Stratigraphic Level (stratum)	Elevation (mbd)	Distance Above Canal Base (m)	Bulk Weight (gm)	Fraction Weight (gm)	> 1mm (gm)	> 106 mm (gm)	> 63 mm (gm)	< 63 mm (gm)	> 1mm (%)	> 106 mm (%)	> 63 mm (%)	< 63 mm (%)	Textural Classification	Munsell's Color Name	Munsell's Color Code
Canals and Ditches Associated with Agricultural Fields																		
DAI-T40-23-293-1	1	23	5	10.28	0.02	99.5	57.8	33.2	20.6	4.0	41.7	33.4	20.7	4.0	41.9	Gravelly silt	Brown	7.5YR 4/4
DAI-T40-23-294-2	2	23	5	10.25	0.04	87.8	30.0	1.7	26.8	1.5	57.8	1.9	30.5	1.7	65.8	Finely laminated silt	Brown	7.5YR 4/4
DAI-T40-23-295-3	3	23	4	10.16	0.12	90.9	35.1	15.4	17.2	2.5	55.8	16.9	18.9	2.8	61.4	Sandy silt	Brown	7.5YR 4/3
DAI-T40-23-296-4	4	23	3	10.02	0.27	85.4	23.6	2.5	18.9	2.2	61.8	2.9	22.1	2.6	72.4	Sandy clay	Brown	7.5YR 5/4
DAI-T56-23-1000-1	1	23	II	11.17	-0.15	75.1	36.9	21.3	13.3	2.3	38.2	28.4	17.7	3.1	50.9	Gravelly silty clay	Brown	7.5YR 5/4
DAI-T56-23-1001-2	2	23	4	10.99	0.02	100.6	13.8	5.7	6.5	1.6	86.8	5.7	6.5	1.6	86.3	Silty clay	Brown	7.5YR 4/4
DAI-T56-23-1002-3	3	23	3	10.93	0.09	100.2	9.7	3.4	4.0	2.3	90.5	3.4	4.0	2.3	90.3	Silty clay	Brown	7.5YR 4/3
DAI-T56-23-1003-4	4	23	2	10.80	0.20	100.5	30.3	12.3	15.6	2.4	70.2	12.2	15.5	2.4	69.9	Silty clay	Brown	7.5YR 4/3
DAI-T56-23-1004-5	5	23	1	10.74	0.27	94.8	27.2	8.5	17.4	1.3	67.6	9.0	18.4	1.4	71.3	Sandy clay	Dark brown	7.5YR 3/3
DAI-T56-23-1005-6	6	23	1	10.70	0.31	91.9	21.5	4.5	15.1	1.9	70.4	4.9	16.4	2.1	76.6	Gravelly silty clay	Dark brown	7.5YR 3/3
DAI-T56-23-1006-7	7	23	1	10.63	0.39	100.5	19.9	1.5	13.6	4.8	80.6	1.5	13.5	4.8	80.2	Silty clay	Dark brown	7.5YR 3/3
DAI-T40-22-297-5	5	22	10	10.13	0.03	81.7	22.5	8.2	12.2	2.1	59.2	10.0	14.9	2.6	72.5	Sandy clay	Brown	7.5YR 5/4
DAI-T40-22-298-6	6	22	9	9.96	0.20	100.3	27.6	10.8	14.6	2.2	72.7	10.8	14.6	2.2	72.5	Sandy clay	Brown	7.5YR 5/4
DAI-T40-22-299-7	7	22	8	9.76	0.20	100.0	22.6	5.0	16.3	1.3	77.4	5.0	16.3	1.3	77.4	Sandy clay	Strong brown	7.5YR 4/6
DAI-T56-33-1011-1	1	33	III	11.18	-0.11	100.0	73.5	61.5	10.2	1.8	26.5	61.5	10.2	1.8	26.5	Sandy gravel	Brown	7.5YR 4/4
DAI-T56-33-1012-2	2	33	6	11.05	0.02	92.5	27.8	2.6	23.4	1.8	64.7	2.8	25.3	1.9	69.9	Finely laminated silt	Brown	7.5YR 4/4
DAI-T56-33-1013-3	3	33	5	10.99	0.09	100.0	37.0	14.0	20.1	2.9	63.0	14.0	20.1	2.9	63.0	Sandy silt	Brown	7.5YR 4/4
DAI-T56-33-1014-4	4	33	4	10.91	0.17	74.4	3.1	0.1	1.9	1.1	71.3	0.1	2.6	1.5	95.8	Clay	Brown	7.5YR 4/4
DAI-T56-33-1015-5	5	33	3	10.87	0.21	93.3	9.4	2.4	5.0	2.0	83.9	2.6	5.4	2.1	89.9	Silty clay	Brown	7.5YR 4/4
DAI-T56-33-1016-6	6	33	2	10.78	0.29	100.3	20.4	11.5	6.0	2.9	79.9	11.5	6.0	2.9	79.7	Silty clay	Very dark brown	7.5YR 3/2
DAI-T44-29-1096-A	A	29	A	10.87	0.01	100.1	14.1	2.7	10.4	1.0	86.0	2.7	10.4	1.0	85.9	Silty clay	Brown	7.5YR 4/4
DAI-T44-29-1097-B	B	29	B	10.83	0.05	100.1	3.3	0.4	1.5	1.4	96.8	0.4	1.5	1.4	96.7	Clay	Brown	7.5YR 4/3
DAI-T44-29-256-C	C	29	C	10.68	0.20	100.2	9.3	2.1	3.6	3.6	90.9	2.1	3.6	3.6	90.7	Silty clay	Brown	7.5YR 4/3
DAI-T44-29.02-1098-A	A	29.02	A	10.83	0.01	100.2	9.7	1.4	6.1	2.2	90.5	1.4	6.1	2.2	90.3	Silty clay	Brown	7.5YR 5/3
DAI-T44-29.02-1099-B	B	29.02	B	10.78	0.06	100.6	2.9	0.5	1.5	0.9	97.7	0.5	1.5	0.9	97.1	Clay	Brown	7.5YR 4/4
DAI-T44-29.02-263-C	C	29.02	C	10.72	0.12	100.1	16.6	4.9	5.2	6.5	83.5	4.9	5.2	6.5	83.4	Silty clay	Brown	7.5YR 4/3
DAI-F44-T84-1155-A	A	44	A	10.82	0.02	100.6	16.0	0.3	13.9	1.8	84.6	0.3	13.8	1.8	84.1	Finely laminated silt	Brown	7.5YR 5/4
DAI-F44-T84-1156-B	B	44	B	10.68	0.18	100.4	3.4	0.1	2.0	1.3	97.0	0.1	2.0	1.3	96.6	Clay	Dark brown	7.5YR 3/3
Water Catchments and Associated Canals																		
DAI-T41-25-1007-1	1	25	3	10.80	0.04	66.6	23.4	6.2	14.5	2.7	43.2	9.3	21.8	4.1	64.9	Silt	Brown	7.5YR 4/3
DAI-T41-25-1008-2	2	25	4	10.65	0.25	85.3	65.4	11.9	49.0	4.5	19.9	14.0	57.4	5.3	23.3	Sandy silt	Brown	7.5YR 4/4
DAI-T41-25-1009-3	3	25	6	10.51	0.38	100.2	24.5	0.3	22.3	1.9	75.7	0.3	22.3	1.9	75.5	Sandy clay	Dark brown	7.5YR 3/3
DAI-T41-25-1010-4	4	25	7	10.34	0.57	100.3	5.6	0.4	3.9	1.3	94.7	0.4	3.9	1.3	94.4	Clay	Very dark brown	7.5YR 3/2
DAI-T18-7-153-1	1	7	31	10.54	0.05	100.5	69.8	2.3	65.5	2.0	30.7	2.3	65.2	2.0	30.5	Clayey sand	Brown	7.5YR 5/4
DAI-T18-7-154-2	2	7	33	10.44	0.15	93.2	20.6	1.0	17.7	1.9	72.6	1.1	19.0	2.0	77.9	Sandy clay	Brown	7.5YR 5/4
DAI-T18-7-155-3	3	7	35	10.34	0.25	100.2	23.5	4.2	16.8	2.5	76.7	4.2	16.8	2.5	76.5	Sandy clay	Brown	7.5YR 5/3
DAI-T18-7-156-4	4	7	36	10.25	0.34	100.6	35.6	3.1	29.7	2.8	65.0	3.1	29.5	2.8	64.6	Sandy silt	Light brown	7.5YR 6/4
DAI-T18-7-157-5	5	7	37	10.17	0.42	92.0	45.7	0.4	41.9	3.4	46.3	0.4	45.5	3.7	50.3	Sandy silt	Light brown	7.5YR 6/4
DAI-T18-7-158-6	6	7	39	10.01	0.58	100.0	18.2	2.6	9.6	6.0	81.8	2.6	9.6	6.0	81.8	Silty clay	Brown	7.5YR 5/3
DAI-T18-7-159-7	7	7	40	9.96	0.63	100.5	5.0	0.4	3.2	1.4	95.5	0.4	3.2	1.4	95.0	Clay	Brown	7.5YR 4/3
DAI-T18-7-160-8	8	7	40a	9.86	0.73	100.1	4.1	0.1	1.4	2.6	96.0	0.1	1.4	2.6	95.9	Clay	Brown	7.5YR 4/3
DAI-T18-7-162-10	10	7	43	9.75	0.84	92.7	6.5	0.7	3.4	2.4	86.2	0.8	3.7	2.6	93.0	Clay	Brown	7.5YR 4/4
DAI-NA-26-1143-C3	C3	26	C3	10.90	0.60	100.4	3.3	0.5	1.7	1.1	97.1	0.5	1.7	1.1	96.7	Silty clay	Brown	7.5YR 5/4
DAI-NA-26-1144-C2	C2	26	C2	11.06	0.44	100.8	5.3	0.6	3.4	1.3	95.5	0.6	3.4	1.3	94.7	Silty clay	Brown	7.5YR 5/4

Table 6.1. Continued.

Sample ID	Desert Archaeology, Inc. Sample No.	Feature No.	Stratigraphic Level (stratum)	Elevation (mbd)	Distance Above Canal Base (m)	Bulk Weight (gm)	Fraction Weight (gm)	> 1mm (gm)	> 106 mm (gm)	> 63 mm (gm)	< 63 mm (gm)	> 1mm (%)	> 106 mm (%)	> 63 mm (%)	< 63 mm (%)	Textural Classification	Munsell's Color	
																	Name	Code
DAI-NA-26-1171-C1	C1	26	C1	11.35	0.14	100.6	3.8	1.9	1.2	0.7	96.8	1.9	1.2	0.7	96.2	Silty clay	Brown	7.5YR 4/4
DAI-NA-57-1120-D3	D3	57	D3	10.82	0.28	99.9	3.5	0.6	1.8	1.1	96.4	0.6	1.8	1.1	96.5	Silty clay	Brown	7.5YR 5/4
DAI-NA-57-1123-D2	D2	57	D2	10.96	0.14	100.2	4.6	0.8	3.0	0.8	95.6	0.8	3.0	0.8	95.4	Silty clay	Brown	7.5YR 5/4
DAI-NA-57-1125-D1	D1	57	D1	11.05	0.05	100.4	11.7	3.6	6.5	1.6	88.7	3.6	6.5	1.6	88.3	Silty clay	Brown	7.5YR 4/3
DAI-NA-57-1164-S2	S2	57	S2	10.72	0.05	100.6	13.2	6.3	5.8	1.1	87.4	6.3	5.8	1.1	86.9	Silty clay	Dark brown	7.5YR 3/3
DAI-NA-57-1168-S1	S1	57	S1	10.75	0.02	100.2	6.0	0.9	4.1	1.0	94.2	0.9	4.1	1.0	94.0	Silty clay	Brown	7.5YR 5/3

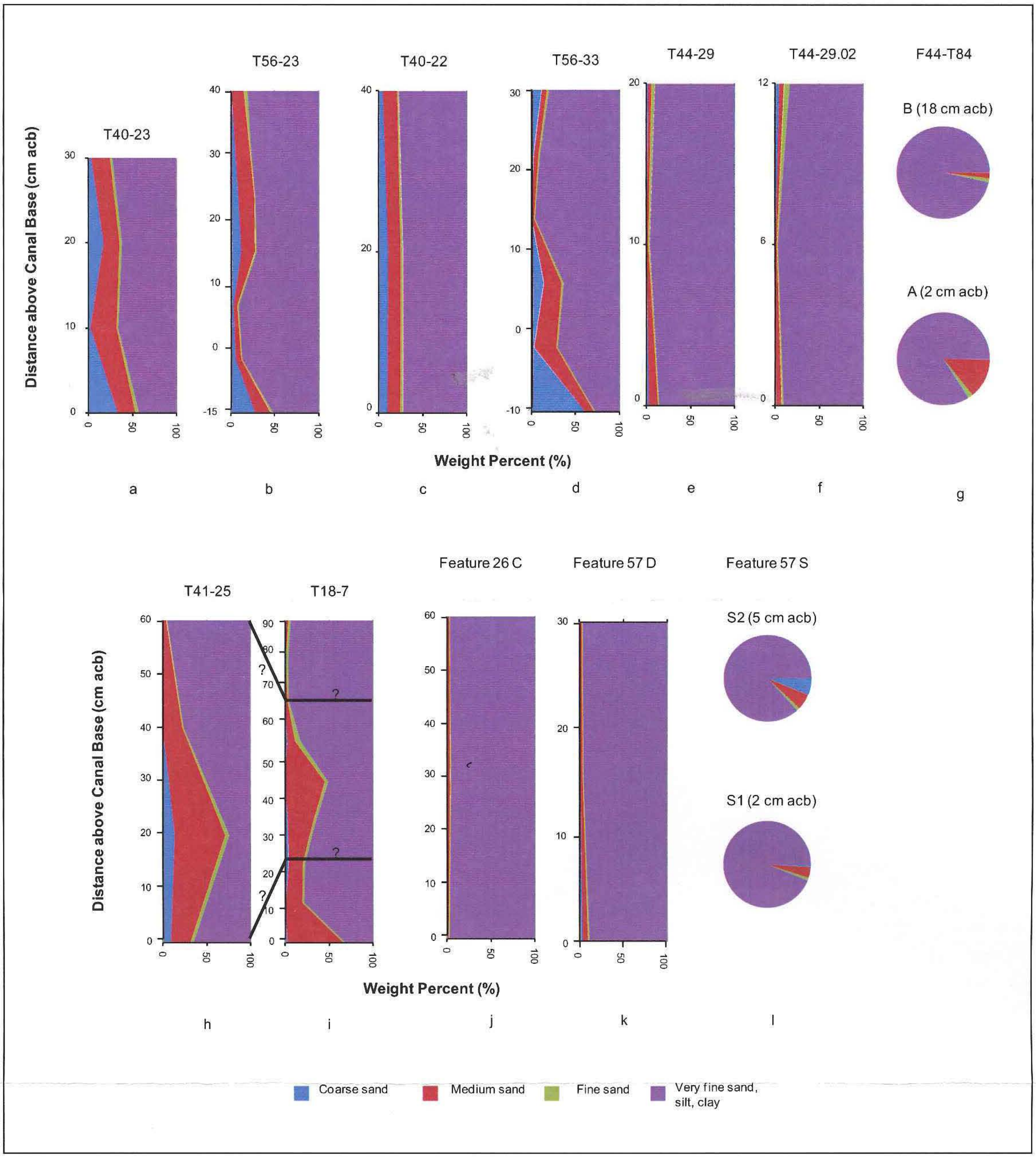

Figure 6.2. Particle-size diagrams for features studied from the PHX Sky Train project: (a) Feature 23, Trench 40; (b) Feature 23, Trench 56; (c) Feature 22, Trench 40; (d) Feature 33, Trench 56; (e) Feature 29, Trench 44; (f) Feature 29.02, Trench 44; (g) Feature F44, Trench 80; (h) Feature 25, Trench 41; (i) Feature 7, Trench 18; (j) Feature 26, Unit 26; (k) Feature 57 D, Unit 57; and (l) Feature 57 S, Unit 57.

Table 6.2. Mineralogical composition of analyzed samples, PHX Sky Train project. (No relative abundance counts were conducted.)

Sample ID	Quartz	Feldspars	Gneiss	Schist	Biotite	Muscovite	Calcareous Clasts	Root Casts	Charcoal	Igneous Rocks	Shell Fragments	Ostracode Fragments	Bone Fragments
DAI-T40-23-293-1	VA	C	A	R	–	–	VR	–	–	VR	–	–	–
DAI-T40-23-294-2	VA	A	C	R	R	–	VR	–	–	VR	VR	–	–
DAI-T40-23-295-3	VA	A	C	VR	R	–	MC	–	VR	VR	VR	VR	–
DAI-T40-23-296-4	VA	A	C	VR	R	–	MC	VR	VR	VR	VR	VR	–
DAI-T56-23-1000-1	VA	A	C	VR	VR	–	MC	–	–	VR	–	–	–
DAI-T56-23-1001-2	VA	A	C	–	VR	–	R	–	R	VR	MC	MC	–
DAI-T56-23-1002-3	VA	A	C	–	R	–	–	–	R	VR	MC	MC	–
DAI-T56-23-1003-4	VA	A	C	R	VR	–	R	VR	VR	VR	VR	–	–
DAI-T56-23-1004-5	VA	A	C	–	R	–	R	–	R	VR	MC	R	–
DAI-T56-23-1005-6	VA	A	C	–	R	–	MC	–	VR	VR	R	VR	–
DAI-T56-23-1006-7	VA	A	C	–	R	VR	–	–	R	VR	VR	VR	–
DAI-T40-22-297-5	VA	A	C	–	R	–	MC	R	VR	VR	VR	VR	–
DAI-T40-22-298-6	VA	A	C	–	R	–	MC	–	VR	VR	VR	VR	–
DAI-T40-22-299-7	VA	A	C	VR	R	VR	R	VR	VR	VR	VR	VR	–
DAI-T56-33-1011-1	VA	A	C	–	R	–	MC	–	VR	VR	–	–	–
DAI-T56-33-1012-2	VA	A	C	–	VR	–	R	–	R	VR	VR	MC	VR
DAI-T56-33-1013-3	VA	A	C	–	R	–	–	–	VR	VR	VR	–	–
DAI-T56-33-1014-4	VA	A	–	–	R	VR	C	–	VR	VR	VR	VR	–
DAI-T56-33-1015-5	VA	A	–	–	VR	–	–	–	VR	VR	VR	–	–
DAI-T56-33-1016-6	VA	A	C	R	R	–	R	VR	–	VR	R	VR	–
DAI-T44-29-1096-A	VA	A	C	–	VR	–	R	–	VR	VR	VR	VR	VR
DAI-T44-29-1097-B	VA	C	MC	–	MC	–	R	R	VR	VR	VR	VR	–
DAI-T44-29-256-C	VA	A	C	–	R	–	MC	R	VR	VR	VR	VR	–
DAI-T44-29.02-1098-A	VA	A	C	–	R	–	MC	R	VR	VR	MC	MC	–
DAI-T44-29.02-1099-B	VA	A	–	–	R	–	MC	R	VR	VR	VR	VR	–
DAI-T44-29.02-263-C	VA	A	C	VR	R	–	MC	R	VR	VR	VR	–	–
DAI-F44-T84-1155-A	VA	A	C	–	R	–	MC	R	VR	–	VR	–	–
DAI-F44-T84-1156-B	VA	A	C	–	R	–	MC	R	VR	–	VR	VR	–
DAI-T41-25-1007-1	VA	A	C	R	R	–	MC	R	VR	VR	–	–	–
DAI-T41-25-1008-2	VA	A	C	–	VR	VR	MC	–	VR	VR	VR	–	–
DAI-T41-25-1009-3	VA	A	MC	–	VR	VR	R	–	VR	VR	VR	VR	–
DAI-T41-25-1010-4	VA	A	MC	–	VR	VR	VR	–	VR	VR	R	VR	–
DAI-T18-7-153-1	VA	A	C	–	R	–	MC	R	–	VR	R	R	–

Table 6.2. Continued.

Sample ID	Quartz	Feldspars	Gneiss	Schist	Biotite	Muscovite	Calcareous Clasts	Root Casts	Charcoal	Igneous Rocks	Shell Fragments	Ostracode Fragments	Bone Fragments
DAI-T18-7-154-2	VA	A	C	–	R	–	MC	–	–	VR	R	VR	–
DAI-T18-7-155-3	VA	A	C	–	R	–	MC	–	R	VR	R	VR	–
DAI-T18-7-156-4	VA	A	C	–	R	–	MC	VR	VR	VR	R	VR	–
DAI-T18-7-157-5	VA	A	–	–	R	–	–	–	R	VR	R	VR	–
DAI-T18-7-158-6	VA	A	R	–	R	–	C	–	R	VR	R	VR	–
DAI-T18-7-159-7	VA	A	R	–	R	–	MC	R	VR	VR	VR	VR	–
DAI-T18-7-160-8	VA	A	–	–	R	–	MC	–	VR	VR	VR	VR	–
DAI-T18-7-162-10	VA	A	–	–	R	–	MC	R	–	VR	VR	VR	–
DAI-NA-26-1143-C3	VA	A	–	–	C	–	MC	MC	R	–	VR	VR	–
DAI-NA-26-1144-C2	VA	A	–	–	MC	–	C	C	R	–	VR	VR	–
DAI-NA-26-1171-C1	VA	A	–	–	R	–	R	VR	–	–	MC	R	–
DAI-NA-57-1120-D3	VA	A	C	–	C	–	R	R	VR	–	VR	VR	–
DAI-NA-57-1123-D2	VA	A	C	–	MC	–	MC	MC	VR	–	VR	VR	–
DAI-NA-57-1125-D1	VA	A	C	–	R	–	R	VR	–	–	VR	VR	–
DAI-NA-57-1164-S2	VA	A	C	–	VR	–	MC	R	VR	–	VR	VR	–
DAI-NA-57-1168-S1	VA	A	–	–	R	–	MC	MC	VR	–	VR	VR	–

Note: VA = very abundant; A = abundant; C = common; MC = moderately common; R = rare; VR = very rare.

abundant minerals, followed by biotite, carbonate nodules, and more rarely, charcoal and rock and shell (mollusk and ostracode) fragments. Extremely rare bone fragments were recorded from Feature 33.

Features 29 and 29.02 directly fed an agricultural field, Feature 321. Feature 29 is composed of brown (7.5YR 4/3 to 4/4) silty clay to clay; similarly, its subextension Feature 29.02 contains brown (7.5YR 4/3 to 5/3) silty clay to clay. The two features consist of quartz, feldspars, and gneiss associated with biotite and carbonate nodules, with minor occurrences of root casts, charcoal, rock and shell (mollusk and ostracode) fragments, and, very rarely, bone fragments.

Feature 44 is a small ditch that received its water supply from Feature 33 to feed field Feature 320. At Trench 44 (see Figures 5.2 and 5.4), the feature is composed of brown (7.5YR 5/4) to dark brown (7.5YR 3/3) finely laminated silt and clay. It contains abundant quartz, feldspars, and gneiss; biotite, carbonate nodules, and root casts are less abundant. Other minerals seldom occur in the feature.

The particle-size diagrams indicate alternating episodes of low to high or moderately high energy during canal operation (see Figure 6.2). For example, at Trenches 40 and 56, deposition of Feature 23 is characterized by two cycles of water discharge (see Figure 6.2a-b). Moderately slow streamflow entered the canal, and then decreased, depositing fine sediments. A second discharge introduced coarser sediments (sand), followed by a decrease in water input, permitting deposition of fine sediments. However, a poor microfossil record was recovered from Feature 23. Feature 22 at Trench 40, shows a steady slow streamflow throughout the sedimentary sequence (see Figure 6.2c). Microinvertebrates occurred throughout the canal history.

By contrast, Feature 33 at Trench 56 indicates water discharge occurred at least three times during the history of canal operation (see Figure 6.2d). At the base, moderately fast streamflow entered the canal. Discharge slightly decreased, depositing finely laminated silt. This pattern may be associated with short but moderately slow pulses of water input to the canal. A new moderately fast cycle deposited sandy silt to gradually decrease to, possibly, a stagnant environment. The end of the record shows a slight increase in streamflow. A poor microinvertebrate record was obtained from Feature 33.

Feature 29 at Trench 44 indicates a constant slow streamflow. The slight variation from silty clay to clay and silty clay again may suggest two pulses of water discharge (see Figure 6.2e; see also Figure 4.16). Sublateral Feature 29.02 at Trench 44 shows the same pattern of silty clay to clay to silty clay consistent with a permanent slow streamflow, only modified by two tenuous pulses of water input (see Figure 6.2f). The stratigraphic correlation between these two features is consistent with the physical evidence, indicating their contemporary use (see Figure 6.1).

Feature 44 at Trench 84, represented by two separate samples, shows an initial discharge introduced silty clay (silt halo). Later, but not contiguously, water velocity decreased, and a clay (rose-colored) unit accumulated on the upper portion of the ditch fill (see Figure 6.2g). It is inferred that moderately slow to slow streamflow entered the ditch during canal operation. (See Chapter 5, this volume, for additional details about this channel and its related field.)

Catchment Feature 7 and Associated Canal

Feature 7 is a probable catchment basin that, at Trench 18, consists of light brown (7.5YR 6/4) to brown (7.5YR 4/3 to 5/4) silt to silty clay. Quartz, feldspars, and gneiss are the most abundant minerals, followed by carbonate nodules, biotite, and root casts. Charcoal, rock, and shell (mollusk and ostracode) fragments rarely occur in the feature.

Feature 25, a medium-sized canal, directed water into Feature 7. At Trench 41, it contains brown (7.5YR 4/3) to very dark brown (7.5YR 3/2) finely laminated silt to silty clay. The dominant minerals are quartz, feldspars, and gneiss, associated with carbonate nodules, root casts, and biotite. Other minerals occur only rarely in the sediments.

Feature 25 at Trench 41 shows that, initially, the canal received a moderately slow streamflow, abruptly interrupted by a single, sharp water discharge introducing sandy silt. As water input receded, finer sediments accumulated in the canal until the canal became stagnant (see Figure 6.2h). Microinvertebrates occurred in the upper portion of Feature 25. Associated with Feature 25 is catchment Feature 7 that, by contrast, shows two pulses of water discharge. A fast streamflow discharged coarse sediments early in the history of the feature. Streamflow decreased, introducing finer sediments. Water input increased again, depositing sandy silt to gradually decrease until the end of the record accumulating clay (see Figure 6.2i).

If Feature 7 is the catchment of Feature 25, as interpreted by the field archaeologists and as could be inferred from the sedimentary records of this study, Feature 25 would chronologically correlate with the upper discharge cycle as shown in Figures 6.2h-i by the dashed lines (with question marks). The correlation would further suggest the sediments in canal Feature 25 were accumulated some time after the canal was cleaned out, leaving no evidence of the previous cycle. However, as discussed in Chapters 3 and 4 (this volume), petrographic analysis of Feature 7 sediments at Trench 18 established that these derived from flooding on the piedmont rather than from the Salt River (that is, via canal Feature 25). While excavations determined conclusively that the Features 7 and 25 shared a relationship, the petrographic results imply the sampled locations for the two features accumulated at separate points in time. Regardless, a good indicator of the water storage (reservoir) function of Feature 7 is the continuous and relatively diverse microinvertebrate composition found at Trench 18.

Catchment Feature 57 and Associated Canal

A man-made pond and its potential source complete this section. Sediments in the apparent pond, Feature 57, were all brown (7.5YR 5/4) to dark brown (7.5YR 3/3) silty clay. The sediments contain quartz, feldspars, and gneiss, followed by carbonate nodules, root casts, and biotite. Charcoal, rock, and shell (mollusk and ostracode) fragments occur randomly in the sediments. The southern end of Feature 57 opens into Feature 26, a medium-sized canal, composed of similar brown (7.5YR 5/4 to 4/4) silty clay. These sediments contain quartz and feldspars, with minor occurrence of biotite, carbonate nodules, and root casts. Other minerals are rare to very rare in the canal.

The two sets of samples from Feature 57 indicate the feature slowly flooded over time, evidently from canal Feature 26 (see Figure 6.2j-l; sampled strata are listed in Table 4.1). Near the edge of the pond, deposition of the S1 and S2 strata indicate slow streamflow initiated filling of the "pond" (see Figure 6.2l). Inflow increased, depositing slightly coarser sediments. Stratum S offered optimal conditions for microinvertebrates. Closer to the center of the pond, deposition of strata D1-D3 show that the basin was filled through a moderately slow streamflow, accumulating silty clay (see Figure 6.2k). Gradually, water input velocity decreased, establishing an optimal environment for microinvertebrates. Similarly, the fine particle size composition of Feature 26 is consistent with a slow streamflow as it fed Feature 57 (see Figure 6.2j). Additionally, the canal contains a diverse microfossil record of ostracodes, mollusks, and calcareous algae.

The Biological Record

Biologically, microinvertebrate abundance[1] (Table 6.3), diversity (Tables 6.4 and 6.5), and adulthood (A/J) and disarticulation (C/V) ratios (Tables 6.6 and 6.7) were used for the paleoenvironmental reconstruction. Table 6.3 shows that ostracodes are the dominant microfossils, accompanied by mollusks and seldom of calcareous algae. With a few exceptions, the taphonomic parameters indicate little to no fragmentation and abrasion (< 2 percent) during deposition of sediments.

Eight ostracode species were identified, including *Limnocythere staplini, Cyprideis beaconensis, Cypridopsis vidua, Candona patzcuaro, Potamocypris smaragdina, Ilyocypris bradyi, Herpetocypris brevicaudata*, and *Physocypria pustulosa* (Figures 6.3-6.5; see Tables 6.4 and 6.6). The ecological factors controlling the occurrence of these species are listed in Table 6.4.

Identified mollusk species included the Physiidae *Physa virgata*, the Lymnaeaidae *Stagnicola elodes*, the Planorbidae *Gyraulus parvus, Planorbella scalaris*, and two terrestrial snails, the Pupillidae *Gastrocopta tappaniana* and *Pupoides* sp. (see Tables 6.5 and 6.7). Their ecological requirements are summarized in Table 6.5. However, all species are extremely rare, limiting their value as environmental proxies.

Extremely rare (< 3) gyrogonites of *Chara globularis* Thuillier (Wood 1967) occurred in Features 26 and 57. The occurrence of calcareous algae typically indicate a Ca-rich, high-pH, lotic (flowing) environment. In spite of their presence in these features, their abundance is not significant to discuss its potential value as a paleoenviromental proxy. Therefore, mainly ostracodes, and to lesser extent mollusks, are the source of information for the interpretation below.

Paleoenvironmental Histories of Sampled Contexts

The paleoenvironmental reconstructions provided below are based on the presence/absence, abundance, and paleoecological needs of the microinvertebrates identified across the study area.

Field Canals and Ditches

The two small canals (primary laterals), Features 22 and 23, were part of an array of smaller organized ditches that irrigated a series of presumed agricultural fields. The source to these canals is unknown. They may have drained into Feature 26. Is it possible to establish a paleoecological relationship among these canals?

The stratigraphically older Feature 23 contains extremely rare to rare (1-18) specimens of ostracodes at the base and top of the canal fill in Trench 40, including *Limnocythere staplini* and *Candona patzcuaro*

[1]Abundance explanation (number of individuals): Extremely abundant (> 1,001), very abundant (501-1,000), abundant (101-500), moderately abundant (51-100), common (21-50), rare (6-20), and extremely rare (< 5).

Table 6.3. Paleontological composition and taphonomic characteristics of microinvertebrates and calcareous algae of analyzed samples, PHX Sky Train project.

Sample ID	Ostracodes (No.)	Mollusks (No.)	Gyrogonites (No.)	Taphonomy Fragmentation (%)	Abrasion (%)	Encrustation (%)	Coating (%)	Redox Index	Color
DAI-T40-23-293-1	–	–	–	–	–	–	–	–	–
DAI-T40-23-294-2	1	–	–	0	0	0	0	0	White
DAI-T40-23-295-3	–	–	–	–	–	–	–	–	–
DAI-T40-23-296-4	18	–	–	2	2	0	0	0	White
DAI-T56-23-1000-1	–	–	–	–	–	–	–	–	–
DAI-T56-23-1001-2	5	1	–	90	30	0	0	0	White
DAI-T56-23-1002-3	2	–	–	20	20	0	0	0	Clear
DAI-T56-23-1003-4	–	–	–	–	–	–	–	–	–
DAI-T56-23-1004-5	9	2	–	10	10	0	0	0	Clear
DAI-T56-23-1005-6	25	3	–	2	2	0	0	0	Clear
DAI-T56-23-1006-7	13	1	–	10	10	0	0	0	Clear
DAI-T40-22-297-5	9	–	–	30	15	0	0	0	White
DAI-T40-22-298-6	30	–	–	–	–	–	–	–	–
DAI-T40-22-299-7	16	–	–	2	2	0	0	0	Clear
DAI-T56-33-1011-1	–	–	–	–	–	–	–	–	–
DAI-T56-33-1012-2	–	1	–	100	30	0	0	0	White
DAI-T56-33-1013-3	–	–	–	–	–	–	–	–	–
DAI-T56-33-1014-4	1	–	–	2	2	0	0	0	Clear
DAI-T56-33-1015-5	–	–	–	–	–	–	–	–	–
DAI-T56-33-1016-6	10	1	–	5	5	0	0	0	Clear
DAI-T44-29-1096-A	–	1	–	15	15	0	0	0	White
DAI-T44-29-1097-B	4	–	–	15	15	0	0	0	Clear
DAI-T44-29-256-C	3	–	–	2	2	0	0	0	Clear
DAI-T44-29.02-1098-A	2	3	–	25	15	0	0	0	Clear
DAI-T44-29.02-1099-B	6	–	–	5	5	0	0	0	Clear
DAI-T44-29.02-263-C	–	–	–	–	–	–	–	–	–
DAI-F44-T84-1155-A	–	–	–	–	–	–	–	–	–
DAI-F44-T84-1156-B	7	–	–	10	10	0	0	0	Clear
DAI-T41-25-1007-1	–	–	–	–	–	–	–	–	–
DAI-T41-25-1008-2	–	–	–	–	–	–	–	–	–
DAI-T41-25-1009-3	154	4	–	2	2	0	0	0	Clear
DAI-T41-25-1010-4	4	–	–	2	2	0	0	0	Clear

Table 6.3. Continued.

Sample ID	Ostracodes (No.)	Mollusks (No.)	Gyrogonites (No.)	Taphonomy Fragmentation (%)	Abrasion (%)	Encrustation (%)	Coating (%)	Redox Index	Color
DAI-T18-7-153-1	4	–	–	10	10	0	0	0	Clear
DAI-T18-7-154-2	89	1	–	2	2	0	0	0	Clear
DAI-T18-7-155-3	13	1	–	2	2	0	0	0	Clear
DAI-T18-7-156-4	5	2	–	10	10	0	0	0	Clear
DAI-T18-7-157-5	2	–	–	10	10	0	0	0	White
DAI-T18-7-158-6	83	–	–	2	2	0	0	0	Clear
DAI-T18-7-159-7	42	8	–	2	2	0	0	0	Clear
DAI-T18-7-160-8	14	–	–	2	2	0	0	0	Clear
DAI-T18-7-162-10	11	–	–	2	2	0	0	0	Clear
DAI-NA-26-1143-C3	8	2	3	5	5	5	5	0	White
DAI-NA-26-1144-C2	87	1	–	5	5	5	5	0	White
DAI-NA-26-1171-C1	70	–	–	5	5	5	5	0	White
DAI-NA-57-1120-D3	28	–	–	5	5	0	0	0	Clear
DAI-NA-57-1123-D2	159	–	–	2	2	0	0	0	Clear
DAI-NA-57-1125-D1	28	1	–	2	2	0	0	0	Clear
DAI-NA-57-1164-S2	53	1	1	5	5	0	0	0	Clear
DAI-NA-57-1168-S1	17	–	–	5	5	5	5	0	White

Table 6.4. Ecological requirements of ostracode species recovered from AZ U:9:28 (ASM), PHX Sky Train project.

Species	Habitat	Permanence	Temperature		Salinity	Chemistry	
Limnocythere staplini	Lakes, ponds	Permanent or ephemeral	2-32°C	Eurythermic	500-40,000 mg L^{-1}	0.30-10.0 meq L^{-1}	Freshwater to Ca-rich
Cyprideis beaconensis	Springs, streams, lakes	Permanent	2-32°C	Eurythermic	100-4,000 mg L^{-1}	0.10-50 meq L^{-1}	Freshwater to Ca-rich
Cypridopsis vidua	Springs, streams, lakes	Permanent or ephemeral	2-32°C	Eurythermic	100-4,000 mg L^{-1}	0.10-50.0 meq L^{-1}	Freshwater to Ca-rich
Candona patzcuaro	Springs, streams, lakes	Permanent or ephemeral	2-32°C	Eurythermic	200-5,000 mg L^{-1}	0.5-30 meq L^{-1}	Freshwater to Ca-rich
Potamocypris smaragdina	Lakes, ponds, canals	Permanent	18-32°C	Thermophilic	50-4,000 mg L^{-1}	0.20-5.0 meq L^{-1}	Freshwater to Ca-rich
Ilyocypris bradyi	Streams, lakes, ponds	Permanent	6-18°C	Eurythermic	100-4,000 mg L^{-1}	0.10-50.0 meq L^{-1}	Freshwater to Ca-rich
Herpetocypris brevicaudata	Springs, streams, lakes	Permanent	14-28°C	Thermophilic	100-4,000 mg L^{-1}	0.10-50.0 meq L^{-1}	Freshwater to Ca-rich
Physocypria pustulosa	Lakes, ponds	Permanent	2-32°C	Eurythermic	30-1,000 mg L^{-1}	0.30-10.0 meq L^{-1}	Freshwater to Ca-rich

Sources: Delorme 1989; Forester 1991; Forester et al. 2005; Palacios-Fest 1994.

Table 6.5. Ecological requirements of mollusk species recovered from AZ U:9:28 (ASM), PHX Sky Train project.

Species	Habitat	Permanence	Salinity[a]		Chemistry (in HCO_3/Ca)[a]
Physa virgata	Streams, lakes, ponds, canals	Permanent or ephemeral	10-5,000 mg L^{-1}	1-5 mg L^{-1}	Freshwater to Ca- or HCO_3-rich
Stagnicola elodes	Streams, lakes, ponds, canals	Permanent or ephemeral	1,000-2,000 mg L^{-1}	1-2 meq L^{-1}	Freshwater to Ca- or HCO_3-rich
Planorbella scalaris	Weedy species in swamps, ponds, lakes (lentic)	Permanent (oligotrophic environments)	10-800 mg L^{-1}	N/A	Freshwater to Ca- or HCO_3-rich
Gyraulus parvus	Streams, lakes, ponds, canals	Permanent or ephemeral or moist soil	10-5,000 mg L^{-1}	1-5 mg L^{-1}	Freshwater to Ca- or HCO_3-rich
Gastrocopta tappaniana	Calcareous hygric conditions, frequent in alvars	Moist soils	N/A	N/A	N/A
Pupoides sp.	Terrestrial	Moist soils	N/A	N/A	N/A

Sources: Bequaert and Miller 1973; Miksicek 1989; Vokes and Miksicek 1987; Webb 1942.
[a]Sharpe 2002.

Table 6.6. Total and relative abundance of ostracode species recovered, including adult/juvenile (A/J) and carpace valve (CV) ratios, PHX Sky Train project.

Sample ID	Distance Above Canal Base (m)	Bulk Weight (gm)	Ostracodes (No.)	Dry-Mass Ostracodes (gm)	*Limnocythere staplini*				*Cyprideis beaconensis*				*Cypridopsis vidua*				*Candona patzcuaro*				*Potamocypris smaragdina*				*Ilyocypris bradyi*				*Herpetocypris brevicaudata*				*Physocypria pustulosa*				Paleosalinity Index
					No.	%	A/J	C/V	No.	%	A/J	C/V	No.	%	A/J	C/V	No.	%	A/J	C/V	No.	%	A/J	C/V	No.	%	A/J	C/V	No.	%	A/J	C/V	No.	%	A/J	C/V	
DAI-T40-23-293-1	0.02	99.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAI-T40-23-294-2	0.04	87.8	1	0.01	-	-	-	-	-	-	-	-	-	-	-	-	1	100.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
DAI-T40-23-295-3	0.12	90.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAI-T40-23-296-4	0.27	85.4	18	0.21	6	33.33	1.00	-	-	-	-	-	-	-	-	-	12	66.67	0.09	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200
DAI-T56-23-1000-1	-0.15	75.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAI-T56-23-1001-2	0.02	100.6	5	0.05	-	-	-	-	-	-	-	-	-	-	-	-	5	100.00	0.40	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
DAI-T56-23-1002-3	0.09	100.2	2	0.02	-	-	-	-	-	-	-	-	-	-	-	-	2	100.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
DAI-T56-23-1003-4	0.20	100.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAI-T56-23-1004-5	0.27	94.8	9	0.09	-	-	-	-	-	-	-	-	-	-	-	-	9	100.00	0.22	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
DAI-T56-23-1005-6	0.31	91.9	25	0.27	2	8.00	1.00	-	-	-	-	-	-	-	-	-	23	92.00	0.09	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	124
DAI-T56-23-1006-7	0.39	100.5	13	0.13	2	15.38	1.00	-	-	-	-	-	-	-	-	-	11	84.62	0.18	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	146
DAI-T40-22-297-5	0.03	81.7	9	0.11	-	-	-	-	3	33.33	-	-	-	-	-	-	6	66.67	0.17	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	167
DAI-T40-22-298-6	0.20	100.3	30	0.30	3	10.00	1.00	-	7	23.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3.33	1	-	-	-	-	-	2	6.67	1	-	77
DAI-T40-22-299-7	0.20	100.0	16	0.16	-	-	-	-	1	6.25	1	-	-	-	-	-	15	93.75	0.13	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	113
DAI-T56-33-1011-1	-0.11	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAI-T56-33-1012-2	0.02	92.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAI-T56-33-1013-3	0.09	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAI-T56-33-1014-4	0.17	74.4	1	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100.00	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-100
DAI-T56-33-1015-5	0.21	93.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAI-T56-33-1016-6	0.29	100.3	10	0.10	-	-	-	-	-	-	-	-	2	20.00	1.00	-	8	80.00	0.38	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	120
DAI-T44-29-1096-A	0.01	100.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAI-T44-29-1097-B	0.05	100.1	4	0.04	1	25.00	1.00	-	-	-	-	-	1	25.00	0.00	-	2	50.00	0.50	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200
DAI-T44-29-256-C	0.20	100.2	3	0.03	1	33.33	0.00	-	-	-	-	-	-	-	-	-	1	33.33	0.00	0.00	-	-	-	-	1	33.33	0	-	-	-	-	-	-	-	-	-	100
DAI-T44-29.02-1098-A	0.01	100.2	2	0.02	-	-	-	-	-	-	-	-	-	-	-	-	2	100.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
DAI-T44-29.02-1099-B	0.06	100.6	6	0.06	-	-	-	-	-	-	-	-	1	16.67	1.00	-	5	83.33	0.20	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	117
DAI-T44-29.02-263-C	0.12	100.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAI-F44-T84-1155-A	0.02	100.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAI-F44-T84-1156-B	0.18	100.4	7	0.07	-	-	-	-	-	-	-	-	2	28.57	1.00	-	5	71.43	0.40	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	129
DAI-T41-25-1007-1	0.04	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAI-T41-25-1008-2	0.25	85.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAI-T41-25-1009-3	0.38	100.2	154	1.54	24	15.58	1.00	-	-	-	-	-	3	1.95	1.00	-	119	77.27	0.15	0.00	-	-	-	-	8	5.19	1	-	-	-	-	-	-	-	-	-	133
DAI-T41-25-1010-4	0.57	100.3	4	0.04	-	-	-	-	-	-	-	-	-	-	-	-	4	100.00	0.50	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
DAI-T18-7-153-1	0.05	100.5	4	0.04	-	-	-	-	-	-	-	-	-	-	-	-	4	100.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
DAI-T18-7-154-2	0.15	93.2	89	0.95	13	14.61	1.00	-	-	-	-	-	2	2.25	0.50	-	73	82.02	0.19	0.00	-	-	-	-	-	-	-	-	-	-	-	-	1	1.12	1	-	140
DAI-T18-7-155-3	0.25	100.2	13	0.13	1	7.69	1.00	-	1	7.69	-	-	-	-	-	-	11	84.62	0.09	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	138
DAI-T18-7-156-4	0.34	100.6	5	0.05	1	20.00	1.00	-	1	20.00	-	-	-	-	-	-	3	60.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200
DAI-T18-7-157-5	0.42	92.0	2	0.02	-	-	-	-	-	-	-	-	-	-	-	-	1	50.00	0.00	0.00	-	-	-	-	1	50.00	1	-	-	-	-	-	-	-	-	-	-50
DAI-T18-7-158-6	0.58	100.0	83	0.83	6	7.23	1.00	-	1	1.20	-	-	2	2.41	1.00	-	74	89.16	0.18	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	127
DAI-T18-7-159-7	0.63	100.5	42	0.42	-	-	-	-	1	2.38	-	-	-	-	-	-	41	97.62	0.10	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	105
DAI-T18-7-160-8	0.73	100.1	14	0.14	-	-	-	-	2	14.29	-	-	-	-	-	-	12	85.71	0.25	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	129
DAI-T18-7-162-10	0.84	92.7	11	0.12	-	-	-	-	-	-	-	-	-	-	-	-	11	100.00	0.36	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100

Table 6.6. Continued.

					Limnocythere staplini				*Cyprideis beaconensis*				*Cypridopsis vidua*				*Candona patzcuaro*				*Potamocypris smaragdina*				*Ilyocypris bradyi*				*Herpetocypris brevicaudata*				*Physocypria pustulosa*				
Sample ID	Distance Above Canal Base (m)	Bulk Weight (gm)	Ostracodes (No.)	Dry-Mass Ostracodes (gm)	No.	%	A/J	C/V	No.	%	A/J	C/V	No.	%	A/J	C/V	No.	%	A/J	C/V	No.	%	A/J	C/V	No.	%	A/J	C/V	No.	%	A/J	C/V	No.	%	A/J	C/V	Paleosalinity Index
DAI-NA-26-1143-C3	0.60	100.4	8	0.08	–	–	–	–	–	–	–	–	2	25.00	0.50	–	5	62.50	0.25	0.00	–	–	–	–	1	12.50	–	–	–	–	–	–	–	–	–	–	88
DAI-NA-26-1144-C2	0.44	100.8	87	0.86	1	12.50	1.00	–	–	–	–	–	16	18.39	0.81	–	64	73.56	0.17	0.00	2	2.30	–	–	2	2.30	–	–	1	1.15	–	–	–	–	–	–	150
DAI-NA-26-1171-C1	0.14	100.6	70	0.70	6	6.90	1.00	–	–	–	–	–	3	4.29	1.00	–	61	87.14	0.08	0.00	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	123
DAI-NA-57-1120-D3	0.28	99.9	28	0.28	3	10.71	1.00	–	–	–	–	–	4	14.29	0.50	–	21	75.00	0.29	0.00	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	146
DAI-NA-57-1123-D2	0.14	100.2	159	1.59	9	5.66	0.67	–	–	–	–	–	2	1.26	0.50	–	131	82.39	0.09	0.02	15	9.43	0.27	–	1	0.63	–	–	–	–	–	–	1	0.63	1	–	94
DAI-NA-57-1125-D1	0.05	100.4	28	0.28	4	14.29	0.75	–	–	–	–	–	–	–	–	–	24	85.71	0.29	0.08	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	143
DAI-NA-57-1164-S2	0.05	100.6	53	0.53	4	7.55	0.75	–	–	–	–	–	–	–	–	–	48	90.57	0.06	0.00	–	–	–	–	–	–	–	–	–	–	–	–	1	1.89	1	–	113
DAI-NA-57-1168-S1	0.02	100.2	17	0.17	–	–	–	–	–	–	–	–	–	–	–	–	17	100.00	0.29	0.00	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	100

Table 6.7. Total and relative abundance of mollusk species recovered, including adult/juvenile (A/J) ratios, PHX Sky Train project.

					Physa virgata			*Stagnicola elodes*			*Planorbella scalaris*			*Gyraulus parvus*			*Gastrocopta tappaniana*			*Pupoides* sp.		
Sample ID	Distance Above Canal Base (m)	Bulk Weight (gm)	Mollusks (No.)	Dry-Mass Specimens/gm	No.	%	A/J	No.	%	A/J	No.	%	A/J	No.	%	A/J	No.	%	A/J	No.	%	A/J
DAI-T40-23-293-1	0.02	99.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T40-23-294-2	0.04	87.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T40-23-295-3	0.12	90.9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T40-23-296-4	0.27	85.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T56-23-1000-1	-0.15	75.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T56-23-1001-2	0.02	100.6	1	0.01	–	–	–	–	–	–	–	–	–	1	100.00	1	–	–	–	–	–	–
DAI-T56-23-1002-3	0.09	100.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T56-23-1003-4	0.20	100.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T56-23-1004-5	0.27	94.8	2	0.02	1	50.00	–	1	50	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T56-23-1005-6	0.31	91.9	3	0.03	1	33.33	–	–	–	–	1	33.33	–	1	33.34	–	–	–	–	–	–	–
DAI-T56-23-1006-7	0.39	100.5	1	0.01	–	–	–	1	100	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T40-22-297-5	0.03	81.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T40-22-298-6	0.20	100.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T40-22-299-7	0.20	100.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T56-33-1011-1	-0.11	100.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T56-33-1012-2	0.02	92.5	1	0.01	–	–	–	–	–	–	–	–	–	–	–	–	1	100	1	–	–	–
DAI-T56-33-1013-3	0.09	100.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T56-33-1014-4	0.17	74.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T56-33-1015-5	0.21	93.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T56-33-1016-6	0.29	100.3	1	0.01	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	100	1
DAI-T44-29-1096-A	0.01	100.1	1	0.01	–	–	–	–	–	–	–	–	–	1	100.00	–	–	–	–	–	–	–
DAI-T44-29-1097-B	0.05	100.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T44-29-256-C	0.20	100.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T44-29.02-1098-A	0.01	100.2	3	0.03	–	–	–	–	–	–	–	–	–	3	100.00	–	–	–	–	–	–	–
DAI-T44-29.02-1099-B	0.06	100.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T44-29.02-263-C	0.12	100.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-F44-T84-1155-A	0.02	100.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-F44-T84-1156-B	0.18	100.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T41-25-1007-1	0.04	66.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T41-25-1008-2	0.25	85.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T41-25-1009-3	0.38	100.2	4	0.04	3	75.00	1	1	25	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T41-25-1010-4	0.57	100.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T18-7-153-1	0.05	100.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T18-7-154-2	0.15	93.2	1	0.01	1	100.00	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T18-7-155-3	0.25	100.2	1	0.01	1	100.00	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T18-7-156-4	0.34	100.6	2	0.02	1	50.00	–	1	50	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T18-7-157-5	0.42	92.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T18-7-158-6	0.58	100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T18-7-159-7	0.63	100.5	8	0.08	6	75.00	–	–	–	–	1	12.50	1	1	12.50	1	–	–	–	–	–	–
DAI-T18-7-160-8	0.73	100.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-T18-7-162-10	0.84	92.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-NA-26-1143-C3	0.60	100.4	2	0.02	2	100.00	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-NA-26-1144-C2	0.44	100.8	1	0.01	1	100.00	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-NA-26-1171-C1	0.14	100.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-NA-57-1120-D3	0.28	99.9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-NA-57-1123-D2	0.14	100.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-NA-57-1125-D1	0.05	100.4	1	0.01	1	100.00	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-NA-57-1164-S2	0.05	100.6	1	0.01	1	100.00	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DAI-NA-57-1168-S1	0.02	100.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

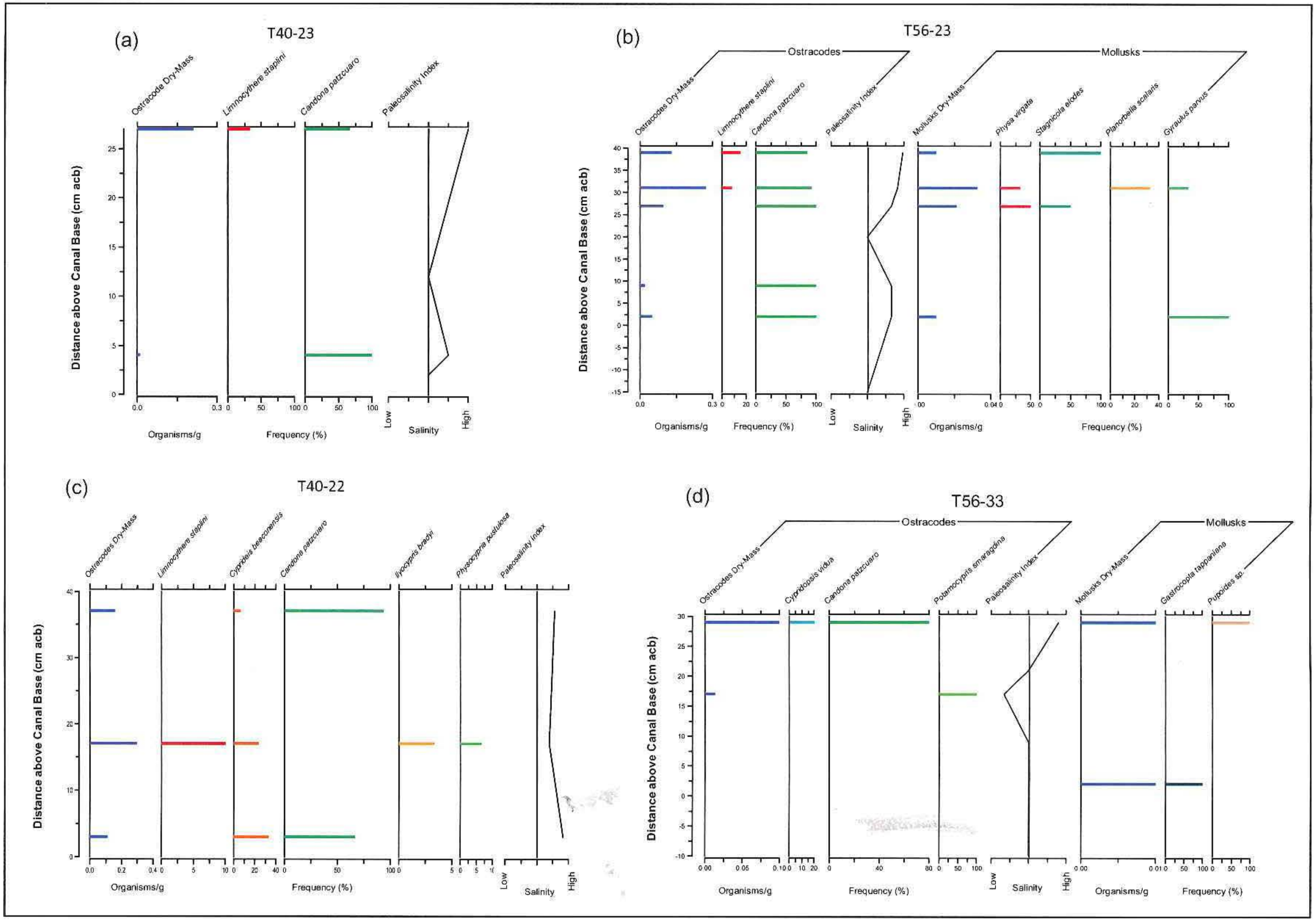

Figure 6.3. Ostracode paleoecology and relative abundance diagrams, including the paleosalinity curve for field canals and ditches: (a) Feature 23, Trench 40; (b) Feature 23, Trench 56; (c) Feature 22, Trench 40; (d) Feature 33, Trench 56;

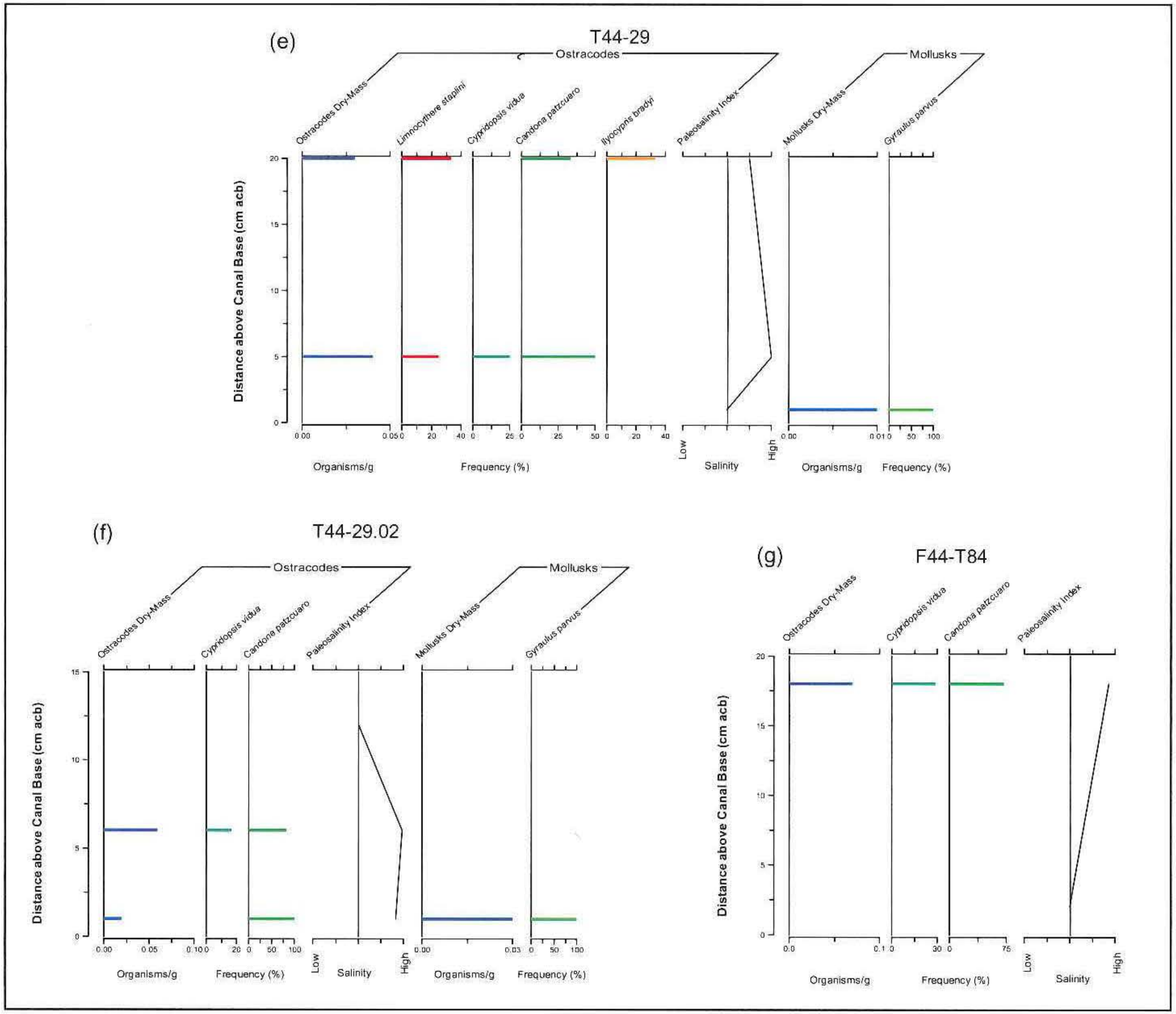

Figure 6.3. (cont'd.) Ostracode paleoecology and relative abundance diagrams, including the paleosalinity curve for field canals and ditches: (e) Feature 29, Trench 44; (f) Feature 29.02, Trench 44; (g) Feature F44, Trench 80, PHX Sky Train project.

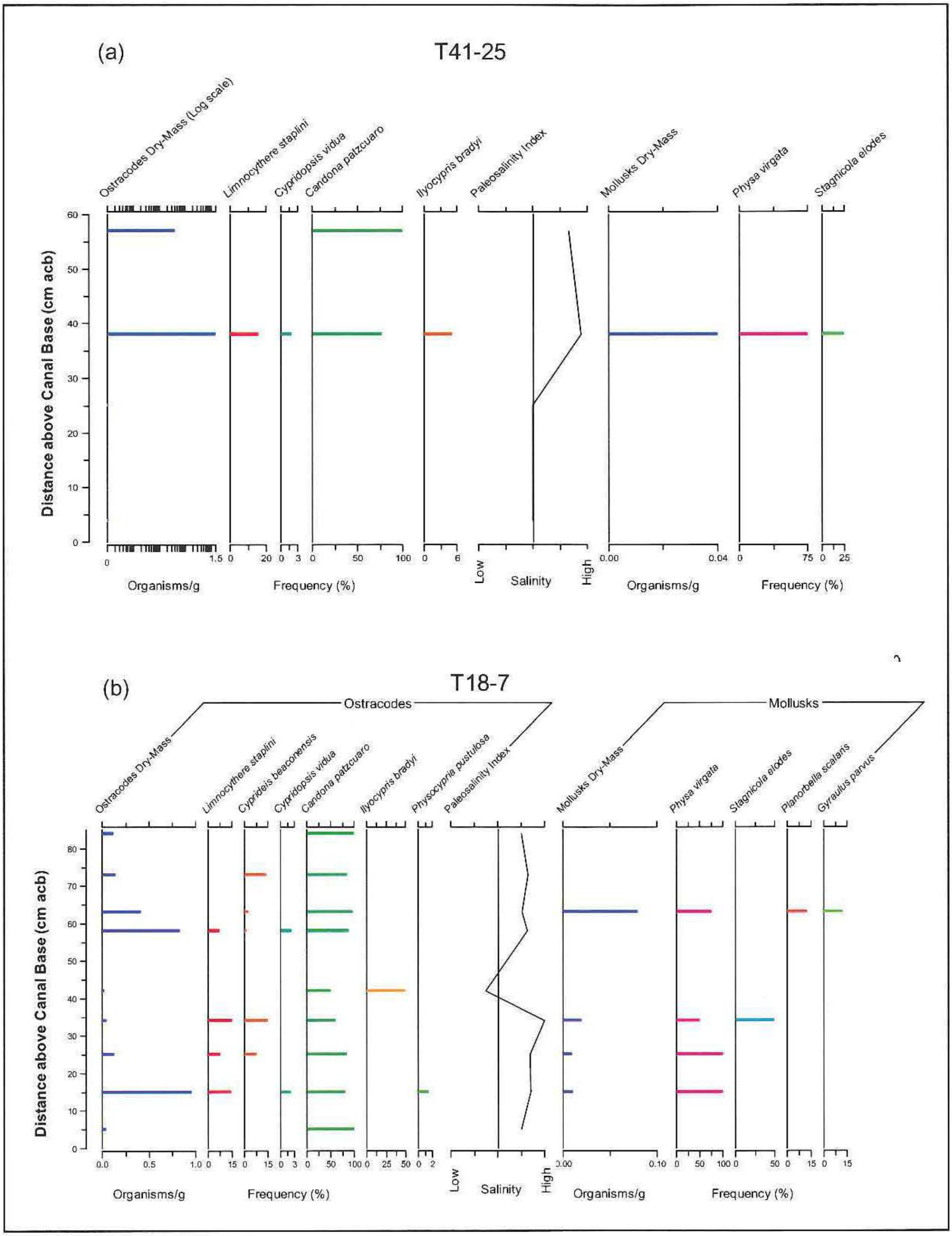

Figure 6.4. Ostracode paleoecology and relative abundance diagrams, including the paleosalinity curve for catchment Feature 7 and associated canal Feature 25: (a) Feature 25, Trench 41; (b) Feature 7, Trench 18, PHX Sky Train project.

(see Figure 6.3a). By contrast, the same feature at Trench 56 contains a more diverse and richer assemblage, composed of the ostracodes *Limnocythere staplini* and *Candona patzcuaro* and the aquatic gastropods *Physa virgata, Stagnicola elodes, Planorbella scalaris,* and *Gyraulus parvus* (see Figure 6.3b). The

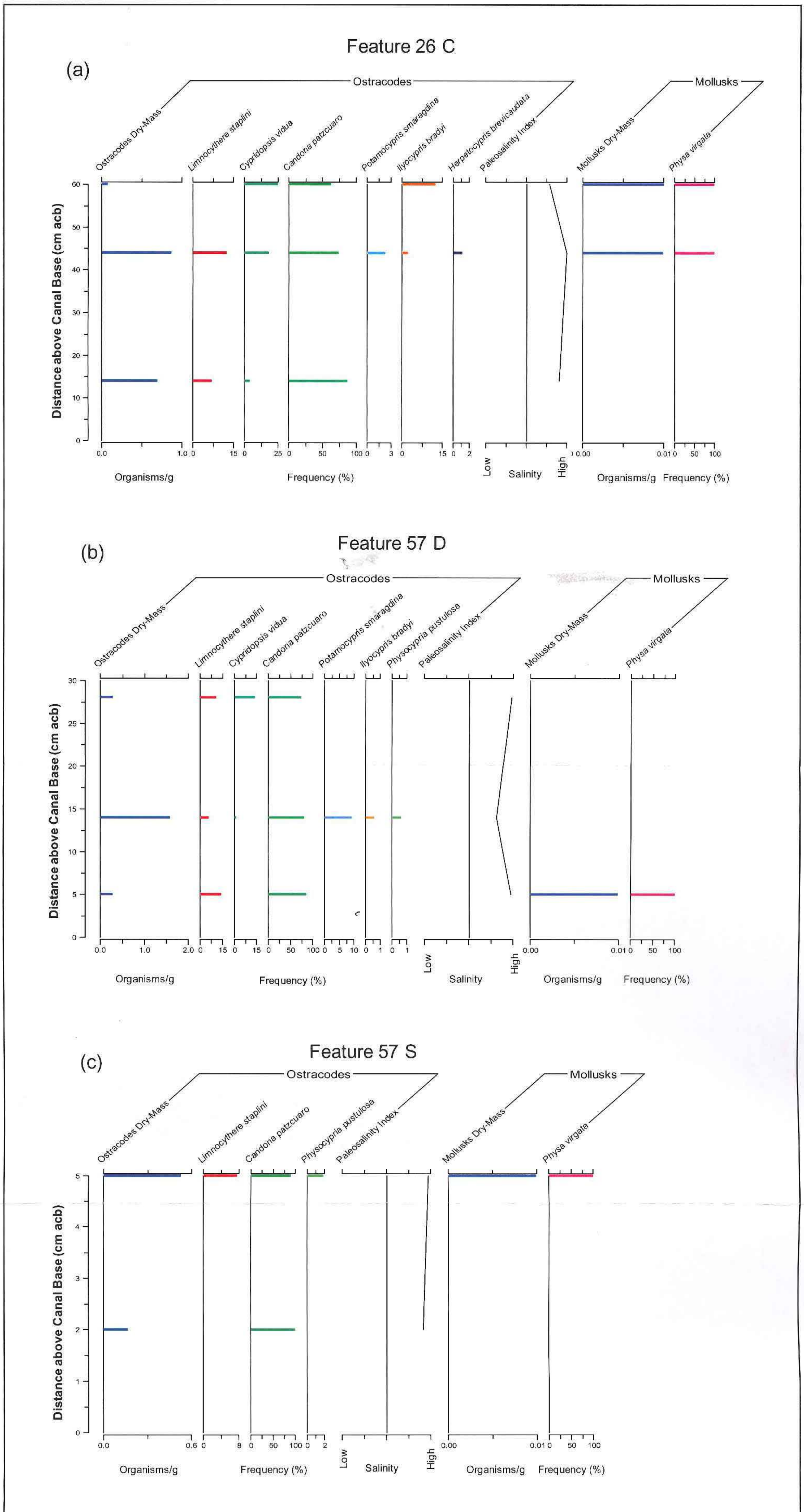

Figure 6.5. Ostracode paleoecology and relative abundance diagrams, including the paleosalinity curve for catchment Feature 57 and associated canal Feature 26: (a) Feature 26, Unit 26; (b) Feature 57 D, Unit 57; (c) Feature 57 S, Unit 57, PHX Sky Train project.

sedimentological and paleoecological signatures recorded from Feature 23 indicate the microfauna were introduced early into the canal by a moderately slow streamflow, but did not establish a biocenosis. Later, *C. patzcuaro* settled an incipient community as streamflow decreased.

The occurrence of mollusks and ostracodes at Trench 56 in finer sediments is consistent with episodes of stagnant or slow flow that allowed some species to create a community. The aquatic conditions, however, did not last long enough to allow the assemblage to mature. Based on the ostracode assemblages recorded from Feature 23 in Trenches 40 and 56, it is inferred that the water was relatively saline, as suggested by the occurrence of *Limnocythere staplini*. However, the mollusk diversity may indicate that salinity did not exceed 800 mg L^{-1} total dissolved solids (TDS), the maximum tolerance of *Planorbella scalaris* (see Table 6.5). This contradictory association of *L. staplini* and *P. scalaris* suggests the water source was fresher as it entered the canal and gradually salinized on site through evaporation (see Figures 6.3a-b).

Scattered, rare to common ostracodes occurred in Feature 22 at Trench 40 (see Figure 6.3c). Its poor biological record contrasts with its diversity. Five ostracode species (*L. staplini*, *Cyprideis beaconensis*, *C. patzcuaro*, *Ilyocypris bradyi*, and *Physocypria pustulosa*) were recovered, indicating a biocenosis dominated by *C. patzcuaro*. Fine sediments in the stratigraphic sequence provided the appropriate environment for microinvertebrates to settle (see Figure 3.18); however, mollusks were absent.

The particle-size diagram (see Figure 6.3c) indicates a continuous slow streamflow consistent with the profile that shows some lenses of coarser sediments occasionally interrupting the sandy clay deposits. The highly dominant assemblage of *C. patzcuaro* and *C. beaconensis* juveniles may indicate that fine sediments were deposited intermittently and that water did not remain in the canal for a long time. The remaining species were represented by scarce adults that could have been reworked, as shown by the high degree of fragmentation and abrasion early in the canal history (see Table 6.3). Similar to Feature 23, Feature 22 appears to have been fed by relatively dilute to relatively saline water throughout the stratigraphic record. The absence of mollusks cannot be explained. Co-occurrence of *P. pustulosa*, *L. staplini*, and *C. beaconensis* may indicate a dilute water input, as *P. pustulosa* salinity range does not exceed 1,000 mg L^{-1} TDS to increase beyond that value as the species disappeared (see Figure 6.3c).

Of the 26 irrigation features identified in the project area as ditches, three were analyzed for microinvertebrates, Features 33, 29, and 44. Feature 33, fed by Feature 23, contains a poor faunal record (see Figure 6.3d). Three ostracode species occurred: *Cypridopsis vidua*, *C. patzcuaro*, and *Potamocypris smaragdina*. Two terrestrial gastropods or their fragments were identified: *Gastrocopta tappaniana* and *Pupoides* sp. The fragmentary record of *G. tappaniana* indicates the specimen was reworked by a moderately fast streamflow near the base of the canal fill. Ostracodes and mollusks were introduced as the canal was flooded. The only species capable of settling a biocenosis was *C. patzcuaro* at the end of the canal history. The poor faunal and fragmentary record is consistent with the particle-size diagram showing a moderately fast streamflow decreasing over time (see Figure 6.2d). Streamflow did not permit microinvertebrates to settle a biocenosis until the end of the record. Due to the moderately fast streamflow and the poor biological record, the paleosalinity index shows that ostracodes did not preserve in the sediments until the water receded. The single specimen of *P. smaragdina* cannot generate a valuable signature for salinity, as the specimen was reworked to the site of deposition. The paleosalinity index curve, however, may be a good indication of the ephemeral nature of Feature 33.

Two small ditches that form the comb-like pattern of the agricultural field are Features 29 and 29.02, also fed by Features 23 and 33. The faunal assemblage of these features resembles that of Feature 23, being dominated by *C. patzcuaro*; however, Feature 29 contains a more diverse composition including extremely rare to rare specimens of *L. staplini*, *C. vidua*, and *I. bradyi*. Additionally, a single juvenile of the aquatic gastropod *Gyraulus parvus* was identified (see Figure 6.3e). By contrast, Feature 29.02 is very limited in microinvertebrates content. Extremely rare specimens of *C. vidua* occurred in an environment where *C. patzcuaro* was also extremely rare to rare. *G. parvus*, the snail, was represented by a single juvenile specimen (see Figure 6.3f). The extremely poor record of mollusks indicates the specimens were reworked early into the ditches but failed to settle a community. This interpretation is consistent with the moderately low to moderately high fragmentation and abrasion (15-25 percent) recorded among mollusks and ostracodes (see Table 6.3).

The particle-size analysis indicates a slow streamflow entered the ditches (see Figures 6.2e and 6.2f). The poor microinvertebrate record may be related to the poor occurrence of these species in the source canal Feature 23 and the short-term water permanence, as indicated by the highly juvenile-dominated population (an indication that *C. patzcuaro* was unable to mature in an ephemeral system). The paleosalinity indices of Feature 29 and Feature 29.02 suggest that moderately saline water entered the canals; however, the apparent ephemeral nature of this system limits further interpretation.

Two samples from ditch Feature 44 collected from distant strata cannot provide information about the history of streamflow. Instead, they indicate two distinct episodes of water discharge that introduced no, or extremely rare, microinvertebrates (see Figure 6.3g). The lower silt halo stratum (A) is unfossiliferous, while the upper rose-colored clay (B) contains rare ostracodes (< 7 specimens). *C. vidua* and *C. patzcuaro* were transported to the site.

The slow streamflow (indicated by the pie diagram; upper part of Figure 6.2g) may be responsible for reworking shells, as suggested by the moderately low fragmentation and abrasion recorded from the specimens (see Table 6.3). It is inferred that the assemblage did not establish a biocenosis. Sample A from Feature 44 is unfossiliferous, just as sample A from Feature 29, but differs from sample A from Feature 29.02, which contains extremely rare juveniles of *C. patzcuaro*. Sample B from Feature 44 shows a similar composition to samples B from Features 29 and 29.02. Technically, it may be concluded that the two strata are similar across Features 29, 29.02, and 44, which, in turn, may imply that all three features are contemporary. No interpretation is warranted based on the paleosalinity index. The system appears to be too ephemeral to sustain life.

Catchment Feature 7 and Associated Canal

Feature 25, a medium-sized canal, is inferred to have been a water source to possible catchment Feature 7. Initially, a moderately fast water discharge entered the canal, as discussed in the previous section (see Figure 6.2h). Biologically, Feature 25 contains a contrasting assemblage. After streamflow receded, an abundant and moderately diverse fauna entered and established in the canal. The ostracodes *L. staplini*, *C. vidua*, *C. patzcuaro*, and *I. bradyi* co-occur with the aquatic gastropods *P. virgata* and *S. elodes* during deposition of Stratum 6, to decline to a monospecific assemblage of *C. patzcuaro* at Stratum 7 (see Figure 6.4a). The faunal assemblage established a biocenosis at Stratum 6. Lack of microinvertebrates due to moderately fast streamflow did not generate a paleosalinity index curve at the base of the stratigraphic sequence. Later, a relatively saline trend is inferred by the occurrence of salinity-tolerant species (*L. staplini* and *C. vidua*). Salinity, however, did not exceed 2,000 mg L^{-1} TDS, the maximum tolerance of *S. elodes* (see Figure 6.4a and Table 6.5).

Feature 7 is identified as a relatively deep, constricted area shaped like an elongated pool, and filled with alternating beds of sand, silt, and clay. Field observations indicate this feature was once fed by Feature 25. The diverse and abundant microinvertebrate record obtained from Feature 7 supports the hypothesis of a confined water body (catchment) that held water for a prolonged time. All samples contained extremely rare to moderately abundant ostracodes, and only four contained extremely rare to rare mollusks. The ostracodes present in the stratigraphic sequence include *L. staplini*, *C. beaconensis*, *C. vidua*, *C. patzcuaro*, *I. bradyi*, and *P. pustulosa*. The following gastropods were also identified in Feature 7: *P. virgata*, *S. elodes*, *P. scalaris*, and *G. parvus* (see Figure 6.4b).

As shown by the particle-size diagram (see Figure 6.2i), Feature 7 recorded at least two water discharge cycles. Early, as the basin was filled, coarse sediments were deposited soon after introducing microinvertebrates. Flow continued, but water velocity decreased, allowing ostracodes and mollusks to establish a biocenosis. Approximately 40 cm above the base of the feature at Trench 18, another moderately fast discharge entered the catchment area. Ostracode abundance and diversity increased compared to the earlier event. Mollusks, however, occurred once at about 63 cm above the base of the feature. *C. patzcuaro* is the dominant species throughout the stratigraphic column. *L. staplini* is more common in the lower half of the deposits, while *C. beaconensis* appears to replace it in the upper half. *C. vidua* is extremely rare throughout. *I. bradyi* and *P. pustulosa* were once introduced to the system but failed to settle.

As mentioned, mollusks occurred more often in the lower portion of the stratigraphic column. Juveniles of *P. virgata* and *S. elodes* were the only two species present. The sole interval where mollusks appeared in the upper portion of the deposits also contained juveniles of *P. virgata* and *S. elodes* and adults of the other two species, *P. scalaris* and *G. parvus*.

Based on the paleosalinity index, fluctuating conditions prevailed in Feature 7 over time. Most of the record shows relatively saline conditions; however, the occurrence of *P. pustulosa* near the base of the stratigraphic unit indicates a pulse of dilute water input not exceeding 1,000 mg L^{-1} TDS. Later, near the end of the record, *P. scalaris* advocates for low salinity, as its maximum tolerance is 800 mg L^{-1} TDS (see Figure 6.4b, Tables 6.4 and 6.5).

Catchment Feature 57 and Associated Canal

Feature 26 is a medium-sized canal that traverses the entire project area south of canal Feature 3 (see Figure 3.5). The canal enters Block 6 south of the prehistoric field systems, where it appears to overflow into Feature 57 located on its northern edge near the end of Feature 44 in the block. In three strata identified as C1, C2, and C3 (see Table 4.1), Feature 26 contains a rare to moderately abundant ostracode fauna, extremely rare mollusks (*P. virgata*), and extremely rare gyrogonites of *Chara globularis*. The ostracodes identified were *L. staplini*, *C. vidua*, *C. patzcuaro*, *Potamocypris smaragdina*, *I. bradyi*, and *Herpetocypris brevicaudata*, scattered throughout the stratigraphic column (see Figure 6.5a).

The particle-size diagram may not reflect the exact sedimentary stratigraphic sequence, as C1 appears to be a clay lense at the base of a silt halo, while the other two strata were identified in the field as lower gray silt (C2) and upper gray silt (C3) (see Figure 6.2j). However, the patterns offer a rough signature of a slow streamflow that correlates well with the microinvertebrate signature. Early during canal operation (C1), a limited assemblage of *C. patzcuaro*, *L. staplini*, and *C. vidua* entered the system. This assemblage is similar to that of Feature 44, described earlier. The apparently constant slow streamflow provided a stable environment for microinvertebrates and calcareous algae.

Further, the paleosalinity index shows a relatively saline environment, where a diverse ostracode assemblage settled. All species present, including mollusks and calcareous algae, have high salinity ranges. However, based on the ostracode abundance and adulthood ratios it may be inferred that salinity remained roughly 1,000 mg L^{-1} TDS (see Figure 6.5a, Tables 6.6 and 6.7).

As Stratum C2 accumulated, all six species of ostracodes and mollusks (*P. virgata*) established a biocenosis. Less diverse than C2, Stratum C3 contained a moderately abundant ostracode fauna (*C. vidua*, *C. patzcuaro*, and *I. bradyi*), extremely rare mollusks (*P. virgata*), and extremely rare gyrogonites of *C. globularis*. In spite of the rare occurrence of *C. globularis*, its presence indicates alkaline, lotic conditions in Feature 26. Calcareous algae were only recorded in Features 26 and 57.

Feature 57 is inferred to be a man-made pond characterized by a roughly rectangular shape in plan view (see Figure 4.7) and fan- to funnel-shaped in cross section (see Figure 4.8). Field observations indicate the basin is fed through overflow from Feature 26. For this study, two sets of samples were analyzed for microinvertebrates, near the shoreline (S1 and S2), and near the depocenter (D1-D3). A co-lateral objective of this analysis is to determine the biological relationship between the "S" and "D" units, as well as to compare the biological composition of Feature 57 to Features 29 and 29.02.

S1 and D1 are essentially the same stratum through the profile, although D1 is much thicker (see Stratum 4 in Figure 4.9). Biologically, S1 contains rare ostracodes (*C. patzcuaro*), and D1 includes common *C. patzcuaro* and extremely rare specimens of *L. staplini* and the snail *P. virgata* (see Figures 6.5b-c). S2 seems to correspond with D2 and D3, inasmuch as it consists of silty clay. However, S2 is too thin to differentiate "lower" from "upper" strata, as was possible to do in the case of D2 and D3. The faunal record of S2 and D2/D3 indicates a close correspondence between S2 and D3 with respect to ostracodes (same three species: *L. staplini*, *C. vidua*, and *C. patzcuaro*). Mollusks (*P. virgata*) occurred in S2 but not in D2/D3, and a single specimen of the gyrogonite *C. globularis* was recorded from S2.

The occurrence of *C. globularis* in S2 is consistent with its presence in Feature 26, the source of water to Feature 57. Additionally, the ostracode assemblages of Features 26 and 57 resemble those in Features 29 and 29.02, suggesting similar conditions. However, the increasing diversity found in Feature 26 and Feature 57 upper strata may be explained by water permanence. The particle-size diagrams (see Figures 6.2k and 6.2l) support this interpretation.

The paleosalinity record of Feature 57 (S and D strata) corresponds well with the salinity trend inferred for Feature 26. Occurrence of *P. pustulosa* in D2 may indicate a short pulse of dilute water input to the basin (see Figures 6.5b-c).

DISCUSSION AND CONCLUSIONS

Were the sampled canals long-lived, or were juvenile and adult microfauna introduced during short episodes of water discharge into the canals? In addition to these questions developed during this study, are the main questions posed by archaeologists for the project. Does the microinvertebrate paleoecology show a pattern across the field canal system indicating interconnectivity? Is it possible to trace the faunal composition from the shallow to the deep parts of the enigmatic pond (Feature 57)?

To respond to these questions, the particle-size and paleoecological analyses were integrated. It is not uncommon to find canals with a poor microinvertebrate record. Previous results indicate that less than 50 percent of canal samples contain enough organisms to infer the paleoecological characteristics of these man-made features. Mollusks and ostracodes are vulnerable to the energy of discharge, availability of organisms at the source of water, and water permanence. Shell fragments were recorded from all samples. The taphonomic characteristics of mollusks and ostracodes are the primary source to infer variations in streamflow.

The canal paleohydrology and history indicates alternating episodes of low to moderately low and moderately high water discharge over time. Control of canal streamflow appears to be the alternative used by farmers during operations. The prehistoric canals show evidence of headgate operation. For example, the two cycles of water input evident in Feature 23 at both Trench 40 and Trench 56 are consistent with the alternating pattern of canal operation also revealed at other irrigation systems in southern Arizona (Howard 1993; Huckleberry 1991). The irrigation network shows similar patterns across the site, permitting microinvertebrates to settle in some of them, including catchment Feature 7 and enigmatic pond Feature 57.

Previous studies of irrigation canals in the Phoenix Basin show that *C. patzcuaro* is a common species dominating the ostracode faunal assemblages. At Las Acequias, AZ U:9:214 (ASM), Pueblo Blanco, AZ U:9:95 (ASM), and Pueblo del Rio, AZ U:12:116 (ASM), Palacios-Fest (1994, 1997, 2005) found that *C. patzcuaro* frequently indicates a moderately dilute to moderately saline aquatic environment. Most frequently, a *C. patzcuaro* biocenosis consists of a population formed by 30-40 percent adults, indicating the stability of the environment. Variability of the inferred salinity range results primarily from the adulthood ratios. An exclusively adult or juvenile population probably reflects stressing conditions limiting the species to form a biocenosis. A balanced assemblage, in which adults and juvenile valves are recovered in a 1:5 or 1:6 (adults:juveniles) proportion, indicate the species succeeded and lived in the canal for at least the length of the species's life cycle (Brouwers 1988). For example, *C. patzcuaro* is known to require up to three months to reach maturity (Palacios-Fest 1994). Its occurrence and dominance throughout the irrigated field system at U:9:28 may indicate that the canals were active for at least the period of the species's life cycle. However, the limited record of other species and their restricted occurrence as adults or juveniles poses a contradictory signal.

Explaining the absence or near-absence of microinvertebrates requires considering some biological and ecological needs of ostracodes and mollusks. Ostracodes require at least one week of permanent water to hatch and develop an incipient population of juvenile individuals. After they hatch, they need 4-26 weeks to complete their life cycle, depending on the species (Delorme 1969). First, they need to be introduced into the system. If the water source does not contain ostracodes, it is unlikely a population will settle. These microcrustaceans, however, may be introduced into the system in the feet or feces of waterfowl. Ostracodes produce weather-resistant eggs that allow them to survive the digestive tract of birds or other animals that swallow them (Pokorný 1978; Whatley 1983). *Limnocythere staplini*, a short-term species, frequently occurs in canals and reservoirs in the Phoenix Basin (see Palacios-Fest 2002 and references therein). In contrast, *Cyprideis beaconensis* and *Candona patzcuaro* are mid-term species requiring from 90 days to 1 year to complete their life cycles (Heip 1976; Forester, personal communication 1990). Even if the water body lasted less than a month, juveniles would occur if they were introduced from the water source, as is the case of *C. beaconensis* (no adults identified but once). The most likely explanation for the absence or near-absence of ostracodes is that the water source itself was deprived of these organisms.

Mollusks were also nearly absent. As with ostracodes, no other explanation is possible, especially because the life cycles of these organisms are longer, implying that water permanence is more critical to them than to ostracodes (Rutherford 2000). The limited occurrence of *Physa virgata* or *Gyraulus* sp., two common gastropods in standing water bodies, is significant, because it implies the standing water body did not last long enough to accommodate the species. Apparently, mollusks were also introduced into the systems but failed to settle a community.

With respect to the water "quality" microinvertebrates were exposed to, it is inferred that the irrigated field system at U:9:28 was dominated by relatively saline water over time. However, in most features, salinity fluctuated by about 1,000 mg L^{-1} TDS, ranging from 800 mg L^{-1} TDS to 2,000 mg L^{-1} TDS (see Tables 6.4 and 6.5).

To summarize, the PHX Sky Train project area field canal system appears to be a network of short-lived canal operations that introduced most of the microinvertebrates but allowed only *C. patzcuaro* to settle an incipient biocenosis. It is inferred that the canals held water for about three months (*C. patzcuaro*'s life cycle). By contrast, catchment Feature 7 and enigmatic pond Feature 57 probably remained active longer than three months, as several species coexisted with *C. patzcuaro*.

More importantly, the faunal assemblage identified from the canal network shows that microinvertebrates moved or were transported from one canal to the other and to the catchments (reservoirs) during water management operations. The sedimentary and stratigraphic records at pond Feature 57 coincide with the paleoecological signature, showing continuity between the shallow (S) to the deep (D) units part of this feature.

ARCHAEOPALYNOLOGY OF PHX SKY TRAIN FEATURES

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In this chapter, results are presented from 60 pollen samples excavated from primarily later pre-Classic (A.D. 800-1150) contexts as part of the archaeological data recovery for the PHX Sky Train project, Phoenix, Arizona. Half of the 60 project pollen samples are from a canal-irrigated field cell, Feature 320, 16 samples come from two water-holding features, and 14 samples were collected from pithouses and associated contexts (Table 7.1). The project area is west of the large Hohokam village of Pueblo Grande, AZ U:9:1 (ASM) (circa A.D. 500-1400), which was located near the head of an extensive network of irrigation canals.

The Salt River corridor around Pueblo Grande contains some of the most disturbed archaeological real estate in Arizona, due to cumulative impacts from repeated flooding along the Salt River and more than 1,000 years of prehistoric farming and Hohokam development, followed by historic urban construction. Virtually no native vegetation remains in the project area. Reconstructed perspectives of Hohokam landscapes show that Pueblo Grande straddled a botanical ecotone between creosotebush (*Larrea*) north of the river and a desert saltbush (*Atriplex*) community, with mesquite (*Prosopis*), closer to the river (see Kwiatkowski 1994). Riparian habitat existed in stringers of cottonwood (*Populus*) and willow (*Salix*), with cattail (*Typha*), reed (*Phragmites*), and other aquatic plants that followed the active river channels.

The excavation of a canal-irrigated field system in the PHX Sky Train project area provides an important contribution to Hohokam archaeology, as this is the first prehistoric field to be exposed in plan view in the Salt River Valley. Key agricultural research questions for the archaeopollen investigation are what crops were grown and if there is information about farming practices, such as crop rotations and seasonal signatures. Also emphasized is cholla pollen as evidence of a potential cultivated native food resource. Several archaeobotanists suspect that prehistoric cholla farming was widespread and common throughout the Southwest (Bohrer 1991; Fish 1984:119-120; Hodgson 2001:115-116; Smith 2002). Understanding the functions of the two water catchment features and their interface with canals is another important research theme. Pollen data from 11 excavated structures and three pits add a perspective on subsistence and activities around habitations. Because most of the project pollen samples are from the field area, palynological issues and techniques concerning agricultural studies are introduced in the following section.

AGRICULTURAL POLLEN INVESTIGATIONS: ASSUMPTIONS AND TECHNIQUES

Pollen evidence of farming is generally more difficult to recover and interpret than pollen from habitation or processing features, even in well-preserved agricultural contexts. Gardens and fields are open-air sites where environmental pollen rain dilutes cultural expressions, and physical and biological soil processes degrade pollen. Pollen spectra from such contexts are predicted to display cultigens and inflated frequencies of weed taxa, such as cheno-am (Fish 1994:56; Gish 1985). However, agricultural studies have not produced consistent evidence of farming. Instead, the most important drivers of a sensible pollen signature are farming history and field productivity (Gish 1985:346).

Palynologists are well aware that field soil samples preserve a low level of crop pollen, and various techniques have been invented to optimize recovery (Dean 1998; Gish and DeLanois 1993). In this analysis, two extended microscopy techniques were used on the field samples. Single microscope slides were first examined using standard analysis, and were then scanned at 100x magnification to count all cultigen and cholla pollen grains. Finally, the laboratory extractions were divided, and half was sieved through screens of 45-micron (μm) mesh to concentrate and count only large pollen grains, which includes most cultigens. The two microscopy techniques are referred to as X-scan for the 100x magnification counts and LFS for the large fraction scans of split samples. Both techniques are explained in detail below.

Table 7.1. Number of pollen samples, by context, PHX Sky Train project.

Block and Area	Feature Number	Context	Number of Pollen Samples	Chronology
6A	320	Field strata	17	Sedentary period, Sacaton phase
		Above field sediments	5	
		Below field sediments	4	
	0	Control samples from natural	3	
	320	alluvium beneath field sediments	1	
	57	Water catchment feature	10	
7A	7	Water catchment feature	6	Sedentary-early Classic periods, Sacaton-Soho phases
5A	300	Floor samples from pithouses	1	Sedentary-Classic transition, late Sacaton-early Soho phases
	301		1	
	302		1	
	307		1	
6B	312		1	Early Sedentary period, early Sacaton phase
	313		1	
	314		1	
	316		1	
3A	306		1	Colonial period, Santa Cruz phase
	310	Pit with trivets	1	
3B	318	Pithouse floor	1	Early Classic period, Soho phase
	326	Possible storage pit	1	
	329	Adobe structure	1	
	334	Possible storage pit	1	

METHODS

Pollen Extraction

Pollen was extracted from 60 sediment samples at the Laboratory of Paleoecology, Northern Arizona University, Flagstaff, by the procedure recommended by Smith (1998). Subsamples (20 cc volume) were taken from the sample bags, weighed, and spiked with a known concentration (37,168 grains) of *Lycopodium* spores. The addition of exotic tracer spores enables pollen concentration calculations, and it also serves as an independent check on pollen degradation resulting from laboratory procedures.

The samples were pretreated with warm hydrochloric acid (10 percent solution) to dissolve caliche and sieved through 180-µm mesh screen to remove coarse material, such as rocks, roots, coarse charcoal, and so forth. The fine fractions were mixed with warm sodium hexametaphosphate (less than 2 percent solution) and allowed to settle for 8 hours in 1-liter beakers; the muddy liquids were then decanted. The timed decants were repeated using only distilled water until liquids were clear after 8 hours of settling time. The mix-and-decant cycles are an efficient non-toxic way to remove organic and inorganic particles lighter than pollen. Samples were subsequently treated for 24 hours with hydrofluoric acid, rinsed in distilled water, and floated in lithium polytungstate (1.9 specific gravity). The heavy liquid separates pollen grains and particles lighter than approximately 1.9 specific gravity from heavier fractions. The light component was recovered and acetolyzed, which reduces organics, and the residues were rinsed with distilled water and alcohol. Samples were finished in glycerol and stored in vials.

Microscopy

Gish analyzed 58 of the project samples using the following procedures, and Smith analyzed two pilot samples using only the standard analysis.

Standard Analysis

Two hundred grain counts of combined arboreal and non-arboreal pollen were obtained from each sample. The pollen identifications were made at 400x magnification. Pollen aggregates were recorded during both the standard counts and the lower magnification scanning.

Pollen aggregates are clumps of the same pollen type, which can indicate the close proximity of source plants or direct introduction of plant parts into a context through cultural activities (Gish 1991).

Aggregates are recorded as single grains during the counts to avoid overrepresentation of a category, and the tabulation involves both frequency and size (Appendix D:Table D.3 legend). Only small aggregates of 20 grains or less are specifically counted. Larger aggregates are estimated due to the overlapping masses of pollen grains.

During the counts, occurrences of *Lycopodium* tracer spores were tabulated to calculate pollen concentrations. The concentrations were calculated two ways, by volume of soil processed (20 cc for each sample) and by weight of each sample. The following formula was used:

$$\frac{\frac{\text{number of introduced spores (37,168)} * 200}{\text{grain count}}}{\text{number of spores counted} * \text{sample volume (or weight)}}$$

More than 45 pollen taxa were recorded in the counts, scanning, or large-fraction scanning (see following sections). The taxa designations follow those in standard usage for archaeological and geomorphological pollen samples from the Southwest.

One noteworthy algal form was observed in many project samples (Figure 7.1), and its presence was systematically recorded. It occurred most frequently in samples from Feature 57, an apparent man-made pool, and it is presumed to have been a living organism when the features were utilized rather than a redeposited fossil. It is noteworthy because it is the same alga seen at other Hohokam sites, such as at La Cuenca del Sedimento, AZ U:9:68 (ASM) (Gish 1989:248-250, Figure 10.1).

It is designated a "polyad," although, in its strictest definition, this term applies to pollen grains not algae. The polyad could be a colony of algal cells or

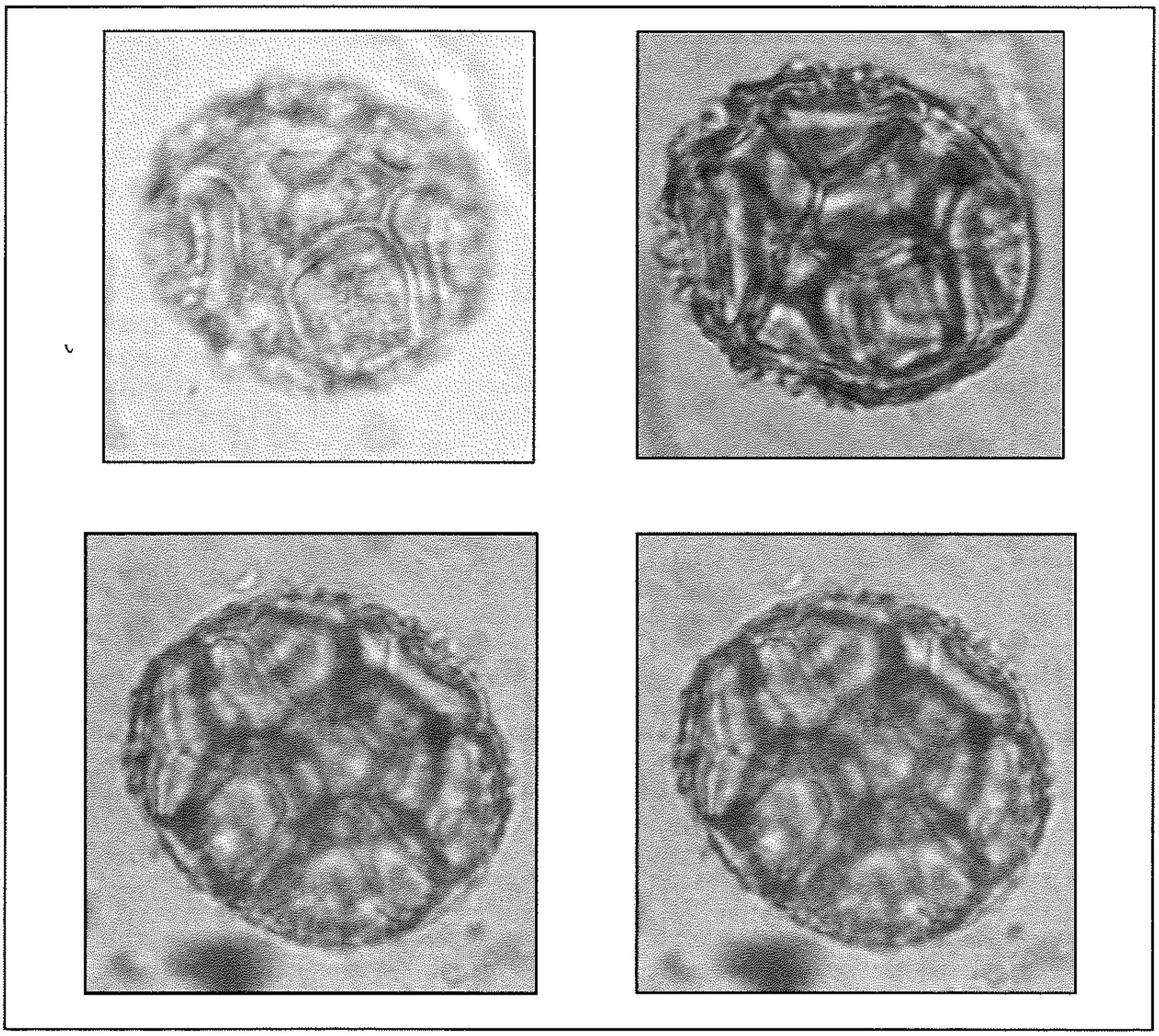

Figure 7.1. Microphotographs of algal "polyad" forms identified by J. Gish in pollen samples from the PHX Sky Train project. (Size of individual polyads within range of 13.2 microns by 17.6 μm to 39.6 μm by 48.4 μm.)

a single cell with protective plates, such as in a coccolithophore. Each polyad usually has 8-12 (or sometimes up to 16) tightly joined and frequently five-sided cells/plates. Each cell/plate has a central pore/opening surrounded by rod-like projections of variable heights, but mostly from 0.5-3.0 µm high. Sometimes single cells/plates occurred that were not part of a polyad. The overall size of the polyads ranged from 17.6 µm by 13.2 µm to a large size of 48.4 µm by 39.6 µm, which is larger than most coccolithophores.

Until a definite identification of the polyad is available, its full significance is difficult to determine. Still, when the polyads are found in non-irrigation features, such as houses, they suggest the features could have been flooded prehistorically. Flooding could have been a cause of feature, or even site, abandonment. Further, some algae are specific to certain ranges of water temperature and salinity, so identification of the algal form could provide additional insight into irrigation conditions at Hohokam sites. Further, many algae, including coccolithophores, can be bloom-forming, and some blooms can be toxic to invertebrates and vertebrates. If the Hohokam were using canals and water catchment pools for drinking water, particularly during an algal bloom, they could have experienced illnesses, which might also have been a cause of site abandonment. For these reasons, further investigations of algae in Hohokam sites appears warranted, although they are beyond the scope of the current study.

X-scan Cultigen and Cholla Concentrations

After the standard analysis, each slide was completely scanned at 100x magnification to find additional taxa not observed previously; these taxa are indicated by an "X" in the Appendix D pollen tables. To calculate the concentrations of cultigen and cholla pollen, all occurrences of maize, cotton, and cholla seen during 100x scanning were tabulated separately, and the number of *Lycopodium* spores during a single transect of the slide at 400x magnification was tabulated separately. A microscope slide coverslip can be 100 percent covered in approximately 41 transects at 400x magnification. Therefore, the tracer population of one microscope slide is estimated by multiplying the number of tracer spores counted in one transect by 41. The tracer population can then be applied to the number of cultigen and cholla grains documented during the 100x scan. This simple procedure is modified from the Intensive Systematic Scanning (ISM) developed by Dean (1998), and it is used to estimate cultigen and cholla pollen concentration in each sample, which provides a way to compare cultigen abundance between contexts and other field sites.

Large Fraction Scanning of Feature 320 Field Samples

The 30 field samples from Feature 320 were also subjected to LFS. This procedure was conducted after the standard analysis and the X-scans were completed. LFS involves thinning the remaining residue in the sample vial with alcohol and decanting it through a fine, 45-µm mesh sieve to concentrate pollen that is larger than 45 µm in size. This larger material is pipetted off the screen surface with a disposable pipette, and transferred to a slide, which is then prepared, as usual, for microscopic examination. In some cases here, two slides were used, due to the abundance of material. A portion of the residue that goes through the screen is kept to check the effectiveness of the separation, if necessary. Because this process modifies the pollen extracted residue, each sample is first split so that a small portion of unmodified residue is retained for curation.

The goal of LFS was to expand the evidence for cultigens in the field samples. Cultigens and cacti pollen are larger than 45 µm in size, making this technique very effective for concentrating the evidence of these categories, which proved to be the case in the project samples. Maize (*Zea*), squash (*Cucurbita*), cotton (*Gossypium*), and cholla (*Opuntia* [*Cylindropuntia*]) all were recorded. Additionally, numerous large aggregates of several pollen categories were observed. Some of the largest, such as those in the cheno-am and *Tidestromia* types, were dense and aligned and clearly reflected anther fragments. Some aggregates reached an estimated 1,000 grains in size.

RESULTS

All the pollen data are documented in Appendix D: detailed sample provenience information (Table D.1), the standard microscopy raw counts and summary measures of pollen concentration and taxon richness (Table D.2), pollen aggregates documented during standard microscopy (Table D.3), X-scan pollen data (Table D.4), and LFS results (Table D.5). A summary diagram of the pollen data represented as percentages is presented in Figure 7.2. In Figure 7.2, concentrations and presence of cultigen and cholla pollen from Feature 320 is based on combined results from X-scan and LFS techniques, but taxon presence in the other features is graphed from X-scan data, as LFS was applied only to Feature 320

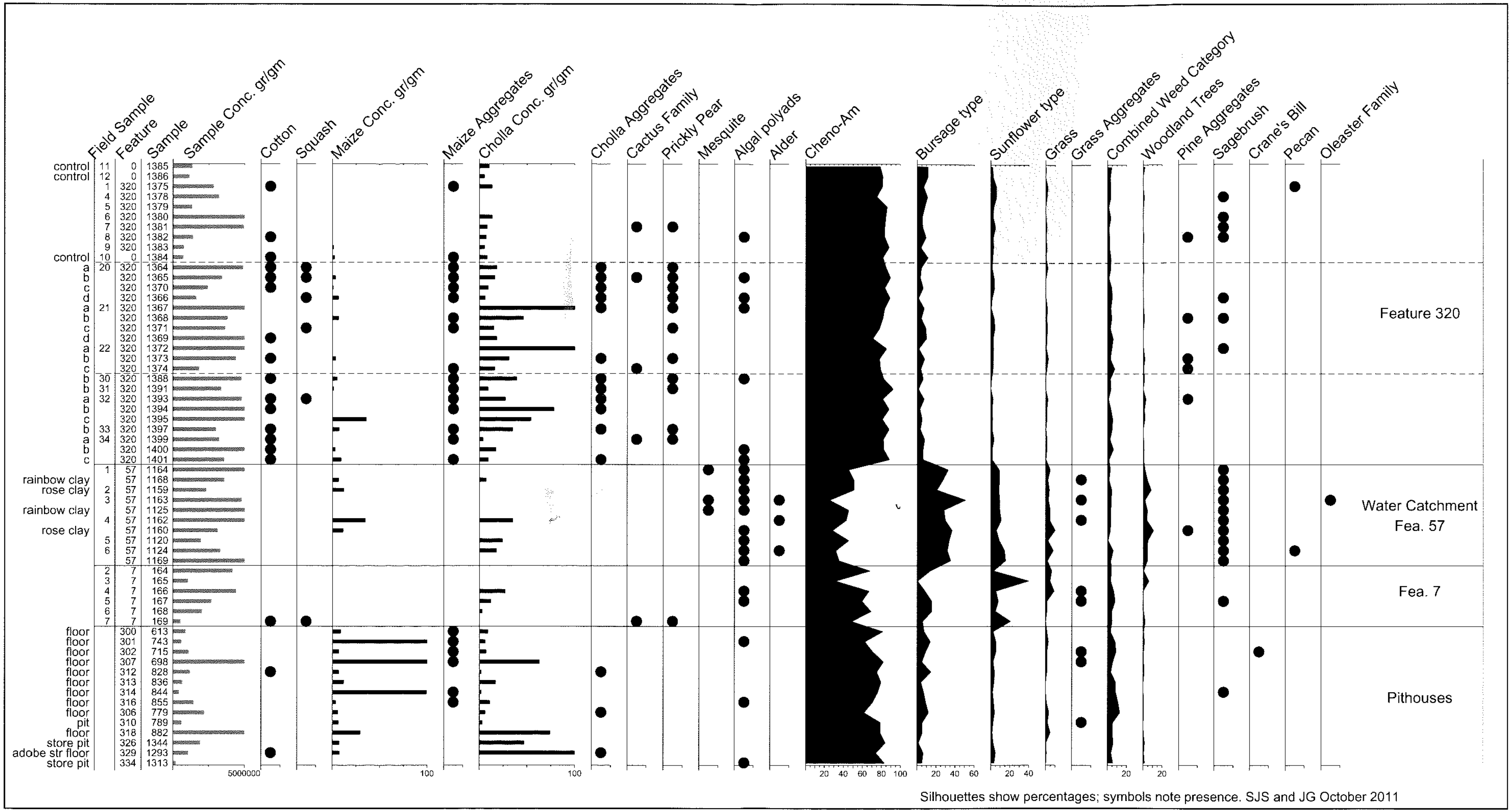

Figure 7.2. Summary pollen percentages diagram with X-scan concentration data for maize and cholla, PHX Sky Train project.

samples. The results, organized by context, are discussed in the following sections.

Field Area Feature 320

Half the 60 project pollen samples were collected from one field area, Feature 320, within a complex of fields and canals (see Figures 2.7 and 5.1). The pollen sampling was concentrated within and adjacent to two trenches, Trenches 83 and 84, in an approximately 5-m by 5-m area that defined a field cell bounded by two field ditches, Features 44.01 and 44.02 (Figure 7.3; also Chapter 5, this volume). Distribution ditch Feature 44 defined the southeastern edge of the cell. Eighteen field sampling stations are represented (see Figure 7.3) where single samples were collected or sets of two to four samples were excavated in a vertical sequence through field and non-field strata.

As discussed, the field samples were analyzed with more intensive procedures than other contexts and the extended microscopy was successful in documenting a rich record of cultigens. Most of the cultigen pollen was identified during LFS, especially maize, which is common (80 percent ubiquity; n = 30) and abundant (Table 7.2). Pollen aggregates of maize are also frequent (47 percent ubiquity; n = 30). Cotton was identified in 15 of the 30 field samples (50 percent ubiquity), and squash is relatively rare, occurring in only five samples (17 percent ubiquity). Cholla ubiquity is 97 percent (n = 30), and cholla aggregates occur in 40 percent of the field samples; prickly pear, the other local cactus, occurs in 40 percent of samples.

The view from the X-scan data is less robust than the LFS results. For example, cotton pollen was identified in only one sample during X-scans (and one in the standard count), as opposed to 14 samples during LFS (see Table 7.2). Maize was documented in 13 samples during X-scans and 24 samples using the LFS technique. There is also a surprising lack of correspondence between high to low X-scan cultigen concentrations and LFS counts. The highest maize concentration calculated is 36 grains per gram from Field Sample SL32c, yet only three LFS grains were counted in the same sample. Three LFS samples produced 32-36 maize grains (SL32a, SL32b, and SL34a), yet no X-scan maize was documented in the same samples. The purpose of the X-scans is to use the artificial tracer grains spike as a control to estimate the absolute abundance of cultigen pollen (Dean 1998), which, in part, is influenced by the texture and chemistry of sample sediments, but that should also reflect crop productivity among sample locations. It is unclear what causes the contrasts between the two techniques, and a valuable test would be to compare X-scan and LFS data on samples processed with tracer grains larger than the 45-µm screen mesh used in the LFS procedure. This would allow pollen concentration calculations on LFS data.

Regardless of the methodological issues, however, the LFS results emphasize an inherent caveat in pollen analysis. Each plant species utilizes a unique pollination ecology that influences the probability that grains will become incorporated in sediment in sufficient quantity to be recovered and recognized by palynologists. Plants that produce small amounts of pollen, like cotton, are more difficult to discern in the archaeological record than prodigious pollen producers, such as cheno-am. The significant LFS recovery of cotton pollen in the Feature 320 field cell emphasizes that previous pollen studies using only standard analysis techniques have likely missed traces of plants important in Hohokam economies.

There are two dimensions to the Feature 320 sampling scheme: (1) vertical soil profiles to examine fine-scale stratigraphic changes in pollen spectra (see Chapter 5, for a discussion of subsurface field soils); and, (2) spatial definition by three sampling transects that cut across the field cell (see Figure 7.3). Summary pollen data are compiled in Table 7.2 for all the field samples, organized first, spatially, except for three control samples, and second, by depth and relationship to subsurface strata. The transect sample groups are labeled as Field Samples 1-9 and Field Samples 20-22, which were collected from opposite faces of Trench 83, and Field Samples 32-34, which were collected southeast of Trench 83 next to Feature 44. Table 7.2 includes both X-scan and LFS data in addition to pollen percentages from a combined weed category and for cheno-am, which likely represents field weeds and native saltbush. Sample group averages for most of the pollen categories are also included in Table 7.2.

Feature 320 Spatial Patterns

The sampling transects produced a strong spatial pattern consisting of increasing abundance and frequency of cholla, cotton, maize, and aggregates of maize and cholla, with proximity to Feature 44 (see Figure 7.2; see Table 7.2). Weed and cheno-am pollen are also enriched in the transects nearest to Feature 44. This clear pattern suggests that locations closest to the distribution canal benefitted from more water, either directly through proximity to the gates filling the field ditches or indirectly from canal seeps and leaks. More water apparently produced higher crop yields, which registered in enriched cultigen pollen representation. This interpretation is supported by the frequency of the water indicator algal polyads, which are highest in the transect next to Feature 44, Field Samples 30-34.

Another spatial pattern is a higher frequency of squash and prickly pear in the Field Samples 20-22

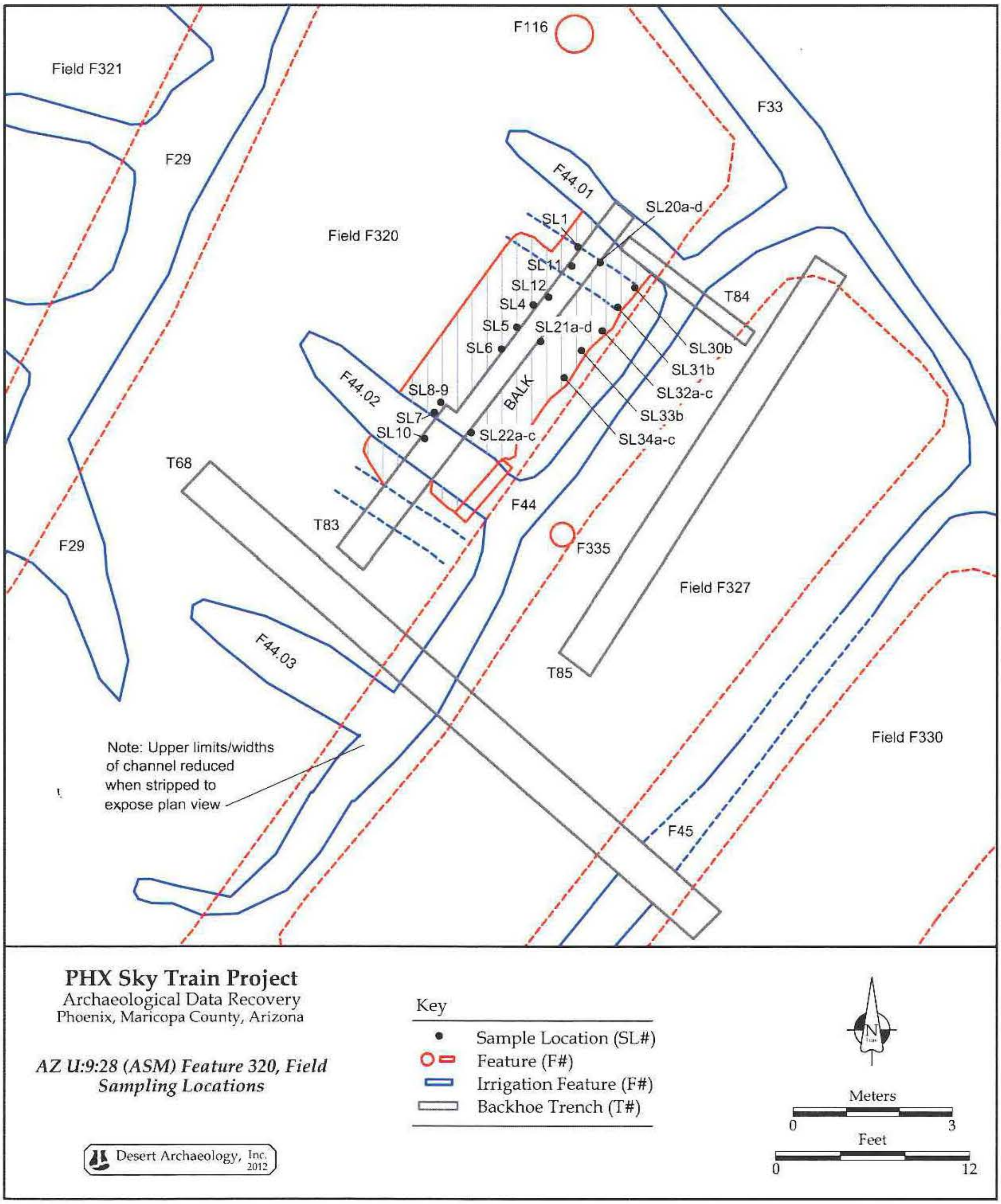

Figure 7.3. Field Feature 320 pollen sampling locations, PHX Sky Train Project

transect, which may represent multi-cropping or a period when more squash and prickly pear were grown in this portion of the cell.

Feature 320 Vertical Soil Profiles

Cultigen pollen is evident throughout all vertical levels of Feature 320, including the control samples from natural alluvium (see Table 7.2). In part, this result is interpreted to reflect smearing of subsurface microstratigraphy due to bioturbation. The project area encompasses a complex agricultural landscape with a long history. Prehistoric remodeling of canals and fields, centuries of field maintenance, planting, irrigation, and harvesting, and probably multiple annual crops must have caused significant ground

Table 7.2. Summary pollen data from Feature 320 field samples, PHX Sky Train project.

					Percentages from Standard Analysis		Pollen Concentration (gr/gm from X-scan)		Numbers of Grains and Aggregates (size only) from LFS						
Field Number (FN)	Field Sample	Context	Sample Concentration (gr/gm)	Algal Polyads[a]	Cheno-am %	Weeds %[b]	Maize	Cholla	Maize	Maize Aggregates	Squash	Cotton	Cholla	Cholla Aggregates	Prickly Pear
Transect: Controls															
1384	SL10	Natural alluvium	7,096	–	81.5	3.5	2.2	7.7	7	2-5	–	4	45	–	–
1385	SL11		13,455	–	78.5	4.5	–	10.1	2	–	–	–	12	–	–
1386	SL12		11,435	–	81.5	3.0	–	5.2	–	–	–	–	14	–	–
Transect averages:			**10,662**		**80.5**	**3.7**	**0.7**	**7.7**	**3**	**1-2**	**–**	**1.3**	**–**	**–**	
Transect: Field Samples 1-9															
1375	SL1	Field soils	28,383	–	81.0	3.0	–	13.4	6	1	–	2	19	–	–
1378	SL4	Field soils	32,041	–	75.0	3.5	–	–	–	–	–	–	–	–	–
1379	SL5	Field soils	13,262	–	86.0	1.0	–	–	–	–	–	–	5	–	–
1380	SL6	Field soils	54,982	–	84.5	3.5	–	13.4	–	–	–	–	5	–	–
1381	SL7	Field soils	49,393	–	83.5	1.5	–	7.5	–	–	–	–	1	–	C
1382	SL8	Upper 5 cm field soils	13,882	LFS	83.5	2.0	–	7.2	11	–	–	1	38	–	–
1383	SL9	Lower 5 cm field soils	7,616	–	88.0	2.0	1.2	4.8	1	–	–	–	10	–	–
Transect averages:			**28,508**		**83.1**	**2.4**	**0.2**	**6.6**	**2.6**	**0.1**	**–**	**0.3**	**–**	**–**	
Transect: Field Samples 20-22															
1364	SL20a	Above field soils	48,970	–	85.0	3.5	–	17.9	5	2-5	1	1	22	6-10	LFS
1365	SL20b	Upper 5 cm field soils	34,162	X	89.5	1.5	3.2	15.9	41	6-10	1	2	160	11-15	LFS
1370	SL20c	Lower 5 cm field soils	24,293	–	83.5	4.5	1.0	9.2	28	6-10	–	8	93	6-10	LFS
1366	SL20d	Below field soils	16,195	X	89.0	5.0	6.3	6.3	6	–	1	–	34	2-5	LFS
1367	SL21a	Alluvium above field soils	132,271	X	83.5	3.5	–	–	9	–	–	–	36	1	LFS
1368	SL21b	Upper 5 cm field soils	38,199	–	81.5	4.5	6.5	45.7	1	–	–	–	17	–	–
1371	SL21c	Lower 5 cm field soils	36,439	–	78.0	3.0	–	15.2	1	1	1	–	14	–	LFS
1369	SL21d	Alluvium below field soils	62,783	–	71.0	6.0	–	18.4	–	–	–	1	2	–	–
1372	SL22a	Above field soils	142,406	–	85.5	4.5	–	104.2	1	–	–	–	18	–	–
1373	SL22b	Field soils	44,064	–	78.0	3.0	3.4	30.8	11	–	–	2	47	1	LFS
1374	SL22c	Alluvium below field soils	18,184	–	79.0	7.5	–	15.5	5	2-5	–	–	17	–	–
Transect averages:			**54,361**		**82.1**	**4.2**	**1.9**	**35.6**	**9.8**	**1-3**	**0.4**	**1.3**	**41.8**	**2-4**	

Table 7.2. Continued.

Field Number (FN)	Field Sample	Context	Sample Concentration (gr/gm)	Algal Polyads[a]	Percentages from Standard Analysis: Cheno-am %	Weeds %[b]	Pollen Concentration (gr/gm from X-scan): Maize	Cholla	Numbers of Grains and Aggregates (size only) from LFS: Maize	Maize Aggregates	Squash	Cotton	Cholla	Cholla Aggregates	Prickly Pear
Transect: Field Samples 30-34															
1388	SL30b	Field soils	47,805	LFS	82.5	3.0	4.9	38.9	13	2-5	–	4	83	2-5	LFS
1391	SL31b	Field soils	33,606	–	92.5	3.5	1.4	8.6	10	2-5	–	–	72	6-10	LFS
1393	SL32a	Above field soils	47,959	–	81.5	1.0	–	26.6	32	2-5	3	2	20	1	–
1394	SL32b	Field soils	51,266	–	88.0	3.5	–	78.1	33	2-5	–	2	77	2-5	–
1395	SL32c	Below field soils	146,909	–	81.0	5.5	35.8	53.7	3	-	–	–	13	2-5	–
1397	SL33b	Field soils	29,926	–	88.0	5.0	7.0	35.2	14	1	–	3	115	2-5	LFS
1399	SL34a	Above field soils	32,278	–	82.0	2.5	–	4.1	36	6-10	–	3	65	–	X
1400	SL34b	Field soils	70,931	X	82.5	6.0	2.9	17.3	13	-	–	1	47	–	–
1401	SL34c	Below field soils	35,756	X	88.5	1.5	9.2	9.2	9	1	–	4	43	2-5	–
Transect averages:			55,160		85.2	3.5	6.8	30.2	18.1	2-4	0.4	2.1	59.4	2-4	

[a]Algal polyads and prickly pear combine counts, X-scan and LFS identifications noted by C, X, or LFS.

[b]Weeds is a combined category that sums values from the following 12 taxa: wild lettuce (*Lactuca* type), buckwheat, globemallow, spiderling, summer poppy, spurge family, pink family, mustard family, spectacle pod, pea family (Papilionoideae), Indian wheat, and ground cherry. Other weedy taxa (rock purslane, evening primrose, *Gaura* type, and four-o'clock type) are not included in the weed sums because they occur only in the X-scans or in LFS.

disturbance and churned sediment, which contributed to blurring the agricultural pollen stratigraphy. However, not all of the cultigen occurrence is attributed to bioturbation, and it is probable that maize, cotton, and squash were cultivated before and after the main use of the field cell.

A series of two to four samples from stratigraphic columns was collected to bracket field soils and, at a finer scale, to investigate upper and lower levels of the field soils. Six sampling stations are represented, and the results are summarized in Table 7.3. One notable profile trend is for the progressive decrease in pollen concentration with depth. Decreasing concentrations occur in the following field sample sets: SL8 and SL9, SL20a-d, SL21 a-c (but not SL21d), and SL22a-c. The loss of pollen with depth is a natural phenomenon typical of terrestrial contexts, where a preservation gradient results from the cumulative effects of physical and biological processes. However, it is interesting that profiles from the field samples SL30-SL34 transect do not follow this pattern. Pollen concentrations in the SL32 set are highest in the sample from below field soils, while in the SL34 series, the maximum concentration is in the field soil level. One theory for the contrast is that the SL30-SL34 sediments are upside down, perhaps from ditch clean-out deposits dumped onto the transect location. Whatever the cause, the results suggest sediments adjacent to the distribution ditch are in some way mixed or disturbed, which may also relate to the higher expressions of cultigen pollen at this location.

A second vertical trend is for combined weed percentages within a series to be highest in the deepest sample below the field soils, with a single exception from the field sample 34 series. The high weed values may reflect the field area before intensive cultivation. The field soil samples, shown as shaded rows in Table 7.3, generally register the highest LFS counts of cultigen pollen within a series, which highlights the subsurface agricultural strata as a distinct zone. The sample groups from field sample 21 and 32 are exceptions. Overall, the detailed view of soil profiles shows that agricultural pollen is concentrated in field soils, but may also cut across stratigraphic boundaries. The mixed pollen signal could result from several scenarios from preferential migration of pollen in certain soil textures to centennial-scale farming disturbance.

Three sets of sample couplets target the upper and lower 5-cm intervals of agricultural soils: SL8 and SL9, SL20b and SL20c, and SL21b and SL21c. LFS counts of maize are higher in the upper field horizon in two of the sets (see Table 7.2); LFS counts of cholla are higher in the upper field soils in all three sets. This pattern may indicate that the most productive zone was a later agricultural phase within the upper 5 cm of field soils. There is, however, no comparable trend in the occurrence of cotton and squash, and the decrease might simply reflect the natural preservation gradient discussed above.

Missing Agave

Agave is an interesting missing crop in the Feature 320 results. Flotation samples analyzed from Soil Systems, Inc., excavations at Pueblo Grande produced more agave than maize (Miller 1994:184-186, 1995). The majority of features represented in Miller's (1994, 1995) studies were dated to the Classic period, but agave ubiquities were comparable between Classic features and a modest set of pre-Classic features. The agave materials identified included fibers, hearts, and even quids (Miller 1994). Miksicek (1995:131) speculated that the Salt River Hohokam canal communities farmed agave on the unique habitats created by canal berms. His theory was based on the Salt River McDowell-to-Shea project, where almost one-fourth of 48 Classic period canal flotation samples contained agave materials (Miksicek 1995).

Pollen is not typically a reliable sensor of archaeological agave, because the primary products utilized were the flowers and the heart, which were harvested just before the plant flowered (Hodgson 2001). In fact, three pollen studies of Pueblo Grande habitation features did not register any agave pollen (Anderson, Smith, and Kwiatkowski 1994; Gish 1979; Smith 1995), contrasting with abundant agave macro remains (Miller 1994, 1995). However, agave pollen has been identified in contexts where agave flowers and pollen apparently became part of the sedimentary record (Smith 2006, 2007).

An association between agave and canals was noted in a pollen study near Marana, where Smith (2006) found agave in two out of three canal samples. The density of canals in the PHX Sky Train project area should have provided optimal niches for canal-berm agave gardens, although no agave pollen was recovered. Given the intensive sampling of the Feature 320 field cell and the two water features, as well as the LFS technique for concentrating large grains, which would have included agave, agave was probably not grown in the field cell or along the adjacent distribution ditch, Feature 44.

Comparison with Regional Field Studies

Pollen data from the PHX Sky Train project contribute the only pollen concentration data targeting field cultigens from a canal-irrigated field system within the Hohokam Salt River core. In Table 7.4, the recovery of maize pollen from the Feature 320 field cell is compared with three other pollen studies

Table 7.3. Highest large fraction scan cultigen counts and percentages of combined weed category within a sample series. (Field soil sample rows are shaded.)

Field Sample Series	Context	Pollen Concentration (gr/gm)[a]	Maize	Cotton	Squash	Cholla	Weeds %[b]
SL8	Upper 5 cm field soils	13,900	11	1	–	38	–
SL9	Lower 5 cm field soils	7,600	–	–	–	–	–
SL20a	Above field soils	49,000	–	–	1	–	–
SL20b	Upper 5 cm field soils	34,200	41	2	1	160	–
SL20c	Lower 5 cm field soils	24,300	28	8	–	93	–
SL20d	Below field sediment	16,200	–	–	1	–	W
SL21a	Alluvium above field soils	132,300	9	–	–	36	–
SL21b	Upper 5 cm field soils	38,200	–	–	–	–	–
SL21c	Lower 5 cm field soils	36,400	–	–	1	–	–
SL21d	Alluvium below field soils	62,800	–	(X-scan)	–	–	W
SL22a	Above field soils	142,400	–	–	–	–	–
SL22b	Field soils	44,100	11	2	–	47	–
SL22c	Alluvium below field soils	18,200	–	–	–	–	W
SL32a	Above field soils	48,000	32	2	3	–	–
SL32b	Field soils	51,300	33	2	–	77	–
SL32c	Below field soils	146,900	–	–	–	–	W
SL34a	Above field soils	32,300	36	3	–	65	–
SL34b	Field soils	70,900	–	–	–	–	W
SL34c	Below field soils	35,800	–	4	–	–	–

[a]Pollen concentration is rounded to nearest 100 grains.

[b]W notes highest values of weeds within a series. Weeds combines values from the following 12 taxa: wild lettuce (*Lactuca* type), buckwheat, globemallow, spiderling, summer poppy, spurge family, pink family, mustard family, spectacle pod, pea family (Papilionoideae), Indian wheat, and ground cherry. Other weedy taxa (rock purslane, evening primrose, *Gaura* type, and four o'clock type) are not included in the weed sums, because they occur only in the X-scans or in LFS.

from dry-farmed fields in central Arizona, which were also analyzed using pollen concentration data.

The range of cultigen pollen recovery from the different field systems shows that the strongest agricultural signature is from the irrigated Feature 320 field cell. More maize in an irrigated system is predicted over dry-farmed fields, especially in the intensively farmed Hohokam Pueblo Grande neighborhood. Cotton pollen is documented in two of the dry-farmed field systems, but the highest concentration of cotton pollen is from Feature 320. Squash and agave are not included in Table 7.4, although both crops were grown at select sites in the studies compared. Squash pollen is documented only from the Feature 320 field and agave from Richinbar Ruin (50 percent ubiquity, $n = 8$). Agave was apparently a specialty crop on Perry Mesa, which is located in the headwaters of the Agua Fria River.

Water Catchment Features 57 and 7

Feature 57 is located in Block 6 downslope from Feature 320 and adjacent Feature 26, a moderate-sized canal. The cross-section shape of Feature 57 resembles a flared bowl approximately 3-4 m in diameter, with an inner, deeper pool approximately 1 m in diameter characterized by rose and rainbow-colored clays (Chapter 4, this volume). Tail water from the field system may have flowed into Feature 57, and/or canal water may have been directed into the depression. Feature 7 is located in Block 7 north of Features 320 and 57, on the northern side of main canal Feature 3. Feature 7 is a deep, elongated pool that captured water from canal Feature 25 at one time and that also contained clean-out and bank maintenance deposits (see Chapter 4).

Analysis and interpretation of the two water catchments is approached through comparison of contextual categories (Table 7.5). Summary pollen measures in Table 7.5 exclude LFS data from Feature 320 to maintain consistency among methods, and as a result, taxon ubiquities for Feature 320 samples are much lower than the LFS-based ubiquities presented in Table 7.2. In Figure 7.2 and Table 7.5, comparisons among contexts emphasize how different the water catchment pollen spectra are from field and house floor samples. Both Features

Table 7.4. Archaeological field pollen studies from central Arizona.

Project and Reference	Sites	Description	No. of Samples Analyzed[a]	No. of Samples with Maize (% Ubiquity)[b]	Maize Concentration from ISM[c]	No. of Samples with Cotton (% Ubiquity)	Cotton Concentrate from ISM
U.S. Highway 60 near Superior (Smith 2010b)	Nicholas Ranch Complex, AZ U:12:73/150 (ASM) Loci A and B	Dry-farmed terraces defined by rock alignments	15	6 (40%)	0.6-1.5 gr/gm	4 (27%)	0.6-1.1 gr/gm
	Nicholas Ranch Complex, AZ U:12:73 (ASM)/150 Loci C, D, and E		12	2 (17%)	0.5 and 0.6 gr/gm	–	–
	Gravelly Horseman, AZ 12:41 (ASM)/108		12	2 (17%)	0.6 and 0.7 gr/gm	–	–
Agua Fria National Monument (Smith 2007, 2009)	Richinbar Ruin	Terraces defined by rock walls	8	1 (10%)	1.8 gr/gm	–	-
	La Plata Ruin	Terraces defined by rock walls	4	2 (50%)	1.7 and 6.9 gr/gm	–	–
	La Plata Mesa	Terraces and inter-terrace spaces	12	4 (33%)	0.8-4.5 gr/gm	1 (8%)	0.6 gr/gm
Feature 320 (PHX Sky Train, this project)	AZ U:9:28 (ASM)	Canal-irrigated field cell	17	9 (53%)	1.0-7.0 gr/gm	1 (6%)	1.6 gr/gm
Totals			80 samples analyzed	26 samples with maize	range = 0.5 to 7.0 gr/gm	6 samples with cotton	range = 0.6-1.6 gr/gm

[a]Surface and control samples excluded.

[b]Ubiquity as percent of samples analyzed; Feature 320 ubiquities based on X-scan data.

[c]ISM concentrations are derived from the Intensive Systematic Scanning microscopy method developed by Dean (1998). The concentrations express the abundance of recovered maize and cotton pollen grains (grains per gram of sample sediment). The ubiquity and concentration measures for Feature 320 are derived from the X-scan data only (excludes LFS data) to maintain methodological consistency among studies.

Table 7.5. Comparison of pollen results, by contexts, PHX Sky Train project.

	Feature 320 Field Cell		Water Catchments		Pithouses[a]
Pollen Taxa	Samples from Field Soils	Natural Alluvium below Fields	Feature 57	Feature 7	Floor Samples
Number of samples	17	3	10	6	10
% Ubiquity from X-scan Data					
Maize	53	33	40	33	100
Cotton	6	–	–	17	10
Squash	–	–	–	17	–
Cholla	88	100	50	83	100
Prickly pear	6	–	–	17	–
Algal polyad	12	–	90	33	20
% Aggregate Ubiquity from Standard Analysis					
Maize aggregates	29	–	–	–	60
Cholla aggregates	12	–	–	–	30
Average Pollen Concentration from X-scans (gr/gm)					
Maize	1.9	< 1.0	6.5	–	40.9
Cotton	< 1.0	–	–	–	< 1.0
Cholla	20.1	7.7	8.3	6.9	19.6
Average Sample Pollen Concentrations from Standard Analysis (gr/gm)					
Pollen concentration (gr/gm)	35,897	10,662	59,859	24,738	21,588
Average Pollen % from Standard Analysis					
Cheno-am	83.9	80.5	40.3	62.0	73.8
Bursage/ragweed type	6.1	11.5	33.0	10.5	8.8
Sunflower	3.0	2.2	10.2	15.9	3.4
Grass	1.1	< 1.0	4.7	3.9	1.9
Weeds[b]	3.2	3.7	3.3	5.7	7.5
Woodland trees[c]	< 1.0	< 1.0	5.2	1.9	< 1.0

[a]The Classic period adobe structure Feature 329 is excluded.

[b]Weeds is a combined category that sums values from the following 12 taxa: wild lettuce (*Lactuca* type), buckwheat, globemallow, spiderling, summer poppy, spurge family, pink family, mustard family, spectacle pod, pea family (Papilionoideae), Indian wheat, and ground cherry. Other weedy taxa (rock purslane, evening primrose, *Gaura* type, and four o'clock type) are not included in the weed sums, because they occur only in the X-scans or in LFS.

[c]Woodland trees is a combined category that sums values from pine, pinyon type, ponderosa type, juniper, and oak.

57 and 7 are characterized by lower cheno-am, but higher sunflower family, ragweed, and grass percentages, compared with other contexts.

Contrasts are evident between Features 57 and 7. Feature 57 produced the maximum ubiquity of algal polyads (90 percent) and project maximum percentages of bursage/ragweed and woodland tree pollen. Sample pollen concentrations are also maximum in Feature 57, compared with other contexts. It is also notable that sponge spicules were recovered from Feature 57 clay samples, indicating an aquatic environment (Chapter 8, this volume).

No riparian or aquatic pollen, such as willow or sedge, was identified in any of the water catchments samples, but the spike of ragweed/bursage type in Feature 57 is interpreted as a wetland signal. The bursage/ragweed taxon refers to a subdivision of the sunflower family characterized by a tri-lobed grain with short spines. The low-spine type in Feature 57 probably represents ragweed (possibly *Ambrosia psilostachya*), a plant typical of disturbed and damp soils. If the ragweed interpretation is correct, the environmental signal would correspond to ephemeral saturated soil conditions, such as fine-grained bottomland sediments soaking up monsoon rain, or an episodic inundation from canal water. The implication for seasonal or a short period of wet soil conditions might complement the algal polyad signal in that an algal bloom might have occurred in an ephemeral pool that was heated quickly by desert temperatures.

The high pollen percentages of woodland trees in Feature 57 are another possible water indicator. A modern study of biological remains, including pollen in dirt-lined canals in the Gila River floodplain near Sacaton, Arizona, found that representation of extralocal woodland conifers was sensitive to canal rank (Adams et al. 2002:38). In the modern study, a large main canal was discriminated by higher percentages of woodland trees, compared with lower percentages in the smaller distribution canals. The spike of woodland tree pollen in Feature 57 and contrasting low percentages from the field (see Table 7.5) is consistent with canal water flooding Feature 57 versus tail water from the upslope system of fields and ditches.

The summary pollen measures from Feature 7 (see Table 7.5) indicate a unique context lacking the water indicators of Feature 57, except perhaps for algal polyads. Feature 7 was sampled to test pollen assemblages for hydrological information, but unfortunately, as determined later, the sampling location was filled with local sheetwash sediment (see Chapter 4). The Feature 7 pollen assemblages are consistent with sheetwash mixing pollen from local surfaces and deposits into the feature depression. The moderate ubiquity of algal polyads indicates canal-related sediment and microfossils, such as clean-out deposits, were nearby, and the presence of cultigens suggests cultural middens, or possibly fields, contributed materials that became part of Feature 7.

Habitation Features

Summary pollen measures from habitation features are most similar to field samples (see Table 7.5), especially the high ubiquities of maize and cholla. However, the absolute abundance of maize from any context is greatest in pithouse floor samples. Maize concentrations of 100 gr/gm or greater were documented from three pithouses, Features 301, 307, and 314. Experimental pollen washes of shucked maize cobs show that only trace amounts of maize pollen are left on kernels (Geib and Smith 2008). The abundance of maize in the project floor samples suggests maize on the stalk, or at least cobs enclosed by leaves, might have been processed inside houses, or blessings with maize pollen may have been a common household ritual. Two other resources are visible inside structures. Cotton was identified in pithouse Feature 312 and adobe structure Feature 329, and high cholla concentrations were calculated from two pithouses, Features 307, 318, and, especially, Feature 329. Aggregates of cholla pollen also occur in three structures, Features 312, 306, and 329.

The occurrence of cotton pollen in structure floor samples is interesting, because cotton plants are insect pollinated and produce small amounts of poorly dispersed pollen. It is unlikely that substantial amounts of cotton pollen would be blown into structures or persist on seeds or the hairy fibers. Products, such as the green bolls, which were prized as a sweet delicacy (Huckell 1993:175-176), or even cotton flowers, may have been brought inside project structures. Given the evidence for cotton agriculture from Feature 320, it is also probable that cotton seeds were eaten. Historically, Hopi and southern Arizona Pima and Tohono O'odham Indians ate cotton seeds by roasting them to make a pop-cotton and by mixing cooked seeds with corn or mesquite to make thick tortillas (Huckell 1993:175-176).

Pollen results from all habitation features are summarized in Table 7.6 in terms of maize and cholla pollen concentration (calculated from X-scans), cheno-am percentages, and other taxa interpreted as significant. The features are organized by spatial location, which also correlates to chronological categories. No strong spatial or temporal patterns are evident in the results, with the possible exception of the occurrence of maize pollen aggregates in houses from Areas 5A and 6B. These same areas are also characterized by high values from two weed types, spiderling and globemallow. The pattern of higher weed values and maize pollen aggregates suggests a strong farming signature that might discriminate these structures as fieldhouses. Additional support for viewing structures in Areas 5A and 6B as seasonal fieldhouses are the generally low sample pollen concentrations and low values of cholla pollen. Previous research has identified low sample pollen concentrations and low cholla representation as two markers that distinguish fieldhouses from more substantial structures (Fish 1984:134; Smith 2010a).

There are specific structures with overall high sample pollen concentrations and high values of maize and cholla. These include Feature 307 in Area 5A, Feature 318 in Area 3B, and the Classic period adobe structure Feature 329 in Area 3B. The floor sample from Feature 329 registered the only project cattail pollen, which is likely related to use of canal water in adobe construction. The overall lack of riparian pollen in the PHX Sky Train project samples is notable given the floodplain setting and the density of canals and irrigated fields. Three of the habitation features registered algal polyads, and two of the same samples yielded relatively high percentages of woodland trees (pithouse Feature 301 and store pit Feature 334). This may be the project water signature reflecting domestic use of canal water and construction mud.

CONCLUSIONS

The primary research theme for the archaeopollen investigation of the PHX Sky Train project was to examine how the canal-irrigated field cell Feature 320 might have functioned. Because pollen evidence of agriculture is rare in open-air field contexts, two extended microscopy techniques were used, X-scan and LFS, to maximize the probability of finding culti-

Table 7.6. Summary of significant pollen results from 10 pithouses, 1 adobe structure, and 3 pits, PHX Sky Train project. (Shaded cells note values significantly higher than habitation feature averages, and the * symbol notes occurrence of aggregates.)

Area	Feature Number	Chronology	Comments	Pollen Concentration (gr/gm)[a]	Maize Concentration (gr/gm)[b] (average = 31 gr/gm)	Cholla Concentration (gr/gm) (average = 31 gr/gm)	Cheno-am % (average = 76%)	Other
5A	300	Transition to Classic, late Sacaton to early Soho phase	-	8,660	9*	9	82*	-
	301			5,810	111*	6	63*	3% grass, 4% globemallow, algal polyad, 2% woodland trees
	302		-	10,980	7*	7	71*	4% spiderling, aggregate of Indian wheat
	307		-	51,620	126*	63	82*	-
6B	312	Early Sedentary, early Sacaton phase	-	11,760	7	2*	75*	Cotton
	313		Small house	6,440	12	17	80*	5% spiderling
	314		Small house	4,020	100*	2	76*	4% globemallow, 4% spiderling
	316		Small house	14,340	4*	11	71*	3% globemallow, 7% spiderling, algal polyad
3A	306	Colonial, Santa Cruz phase	-	21,800	6	6*	62*	4% grass, 6% spiderling
	310, pit		-	6,000	7	3	79*	-
3B	318	Early Classic, Soho phase	Small pithouse with significant disturbance	80,450	29	74	79*	-
	326, store pit		Possibly reused as post base	18,960	7	47	84*	4% spiderling
	329, adobe structure		-	10,630	8	186*	74*	Cotton, cattail
	334, store pit		Ceramic sherds and other trash	1,910			83*	5% spiderling, algal polyad, 2% woodland trees

[a]Sample pollen concentration rounded to nearest 10 grains.
[b]Maize and cholla concentrations from X-scan calculations are rounded to nearest whole number.

gens and to enable estimates of cultigen pollen concentration. The LFS procedure was more effective than the X-scan method for finding large, rare pollen types, especially cotton, and the success of the technique emphasizes natural biases inherent in archaeopollen studies. Plants that produce small amounts of pollen, like cotton, are harder to discern than plants that are prodigious pollen producers, like cheno-am. The economic role of cotton and other rare cultigens are almost certain to have been underrepresented by conventional pollen studies at Salt River Hohokam sites.

The Feature 320 field cell was clearly intensively cultivated, and multiple crops were grown throughout the history of the field, including maize, cotton, squash, and possibly cholla and prickly pear, but not agave. The most intensive farming period may have been the latest, represented by the upper 5 cm of field soils. Two or more annual crops were probably grown, although it is impossible to separate such a practice from planting multiple crops in the same field during the same season. The strongest pattern in the field pollen data was spatial, expressed as high numbers of cultigen pollen along the sample transect next to distribution ditch Feature 44. The results suggest greater yields were obtained from microhabitats closest to canals and ditches, perhaps due to seeps and leaks.

The pollen spectra from water catchment Features 57 and 7 are distinct from the field and habitation contexts. Feature 57 recorded the strongest water signature of all contexts sampled, and was composed of high values of woodland tree pollen, a probable ragweed or low-spine composite type, and algal polyads. Feature 57 was apparently filled from canal Feature 26, but the pollen results suggested that ephemeral or temporary water pooled within the depression versus a perennial reservoir effect. Feature 7 produced a mixed pollen spectra from fields, canal deposits, and perhaps middens, which was interpreted to reflect sheetwash input from local surfaces.

Pollen samples from the habitation contexts record a strong focus on maize and cholla, with rare evidence for cotton. No LFS microscopy was used to examine samples from houses, and given the field results, it is likely that cotton was important in project area houses. High maize pollen concentrations, but low concentrations of cholla, and generally low sample pollen concentrations from pithouses in Areas 5A and 6B, is a consistent pattern seen in Hohokam fieldhouses. Pithouse Feature 307 in Area 5A may be an exception. Other potentially more permanent and substantial residences include Feature 318 and the single Classic period adobe structure, Feature 329.

BIOSILICATE ANALYSIS AT AZ U:9:28 (ASM), PHX SKY TRAIN PROJECT

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INTRODUCTION

The primary objective of this study was to identify cultigens and native plants that produce edible seeds, fruit, leaves, and/or roots in 11 samples collected from Hohokam field Feature 320 and seven samples collected from man-made pond Feature 57 at AZ U:9:28 (ASM), based on phytolith analysis. Floristic differences among the various samples were also addressed. Other biosilicates, including diatoms, algal statospores, and sponge spicules, were analyzed to obtain as much archaeological/paleoenvironmental information as possible.

PHYTOLITH FORMATION

Growing plants typically absorb water containing dissolved silica through their roots. Microscopic silica bodies are subsequently produced by the precipitation of hydrated silicon dioxide ($SiO_2.nH_2O$) within the plant's cells, cell walls, and intercellular spaces. Silica bodies with characteristic shapes and sizes are called opal phytoliths (Wilding and Drees 1971). The term phytolith is derived from the Greek words *phyton*, meaning plant, and *lithos*, meaning stone. Opal is the common name for amorphous, hydrated silica dioxide. Opaline bodies formed in plants without specific shapes are simply plant opal.

Phytoliths form in most plants and are produced in a multitude of shapes and sizes, and many phytolith types are specific to particular groups of plants. A phytolith type is considered characteristic if it is common in one specific taxon but also produced in very limited amounts in one or more other taxa. A phytolith type is "diagnostic" if its shape and/or size are specific to a particular taxon. Fortunately, many phytoliths are resistant to weathering and are preserved in most soils for long periods of time.

PHYTOLITH STABILITY

The dissolution and stability of phytoliths in soils and sediments is not currently fully understood. However, laboratory experiments demonstrate that the solubility of silica is a function of temperature, particle size, pH, and the presence of a disrupted surface layer. Studies show that the solubility of amorphous silica increases linearly with temperature starting at 0 degrees centigrade. Particle size is another factor affecting stability, as opal dissolution increases with decreasing size (Wilding et al. 1977, 1979). Pease (1967) found a slight increase in phytolith solubility in the pH range of 5.0 to 8.5, an additional increase between 8.5 and 9.0, and a large increase beginning at 9.0. Opal stability is also a function of the presence of certain metallic ions and sesquioxides, such as iron and aluminum oxides. The adsorption of aluminum and iron ions onto the surface of opal will decrease silica dissolution due to the formation of relatively insoluble silicate coatings, while the presence of sesquioxides may increase dissolution of phytoliths due to the adsorption of monosilicic acid (Wilding et al. 1977).

ARCHAEOLOGICAL PHYTOLITH RESEARCH IN THE GREATER SOUTHWEST

The most comprehensive analysis of maize phytoliths was conducted by Bozarth (1996, 1997b) on Southwestern varieties of the five types of maize: flour, flint, dent, sweet, and popcorn. Those studies demonstrated that cobs produce at least two types of diagnostic phytoliths. Another type of diagnostic maize phytolith is a bilobate short-cell with notches on its sides, non-indented rounded or slightly pointed ends, and a narrow-ridged top perpendicular to the side notches. It is produced in various aerial parts of the plant, such as husks, leaves, leaf sheaths, and so forth, but not in the cob. Relatively large elongate bodies, in which one side is distinctly wavy and the other side is flat, are formed in the nodes and internodes of maize. Those with troughs (concave areas between wave peaks) more than 4.0 micrometers (μm) deep were observed only in maize. Virtually identical phytoliths are produced in non-hybrid, heirloom maize varieties from the Great Plains (Bozarth 1993b).

Maize cob phytoliths have been recovered in various features in pre-Classic sites, for example, AZ U:8:224 (ASM); CTC, AZ U:2:95 (ASM); Damview, AZ U:2:106 (ASM); and Scorpion Point Village, AZ U:2:80 (ASM) (Bozarth 1992b, 1994), as well as Classic period sites, for example, AZ U:8:187 (ASM); AZ U:8:195 (ASM); AZ U:8:221 (ASM); Roadhouse Ruin, AZ U:2:73 (ASM); No-see-um, AZ U:2:76 (ASM); and Little House, AZ U:2:85 (ASM) (Bozarth 1992b, 1994, 1996, 1997), in Arizona. Cob phytoliths were also identified in ceramic and ground stone washes at a Hohokam site, Will E. Coyote, AZ U:10:127 (ASM), in Arizona (Bozarth 2000a), in addition to Late Archaic and Early and Late Pit House sites—Forest Home, LA 78089; Wood Canyon, LA 99631; and Beargrass, LA 12115— in southwestern New Mexico (Bozarth 2000a). Cob phytoliths have also been found in two prehistoric sites in the Southeast (Bozarth 1998a, 1999). Ridged bilobate maize phytoliths have been identified in pre-Classic sites—AZ U:8:213 (ASM), Damview, and Scorpion Point Village (Bozarth 1992b, 1994, 1996)—and Classic sites, for example, AZ U:8:187 (ASM), AZ U:8:195 (ASM), AZ U:8:221 (ASM), and No-see-um (Bozarth 1994) in Arizona, as well as a Late Archaic site, Forest Home, in southwestern New Mexico (Bozarth 2000a).

A comparative analysis by Piperno (1984) on maize and grasses native to lower Central America and northern South America demonstrated that a classification system based on criteria of three-dimensional morphology, in addition to size, could be used to identify cross-shaped maize phytoliths at archaeological sites. It was shown that Variant 1 (mirror image) extra-large (20.6-25.2 μm) cross-shaped phytoliths were absent from, and Variant 1 large (16.0-20.6 μm) cross-shaped phytoliths occurred only rarely in the many wild grass species studied. However, analysis of Panicoid grasses native to Arizona has shown that Variant 1 crosses greater than 18.0 μm are not diagnostic of maize (Bozarth 2005).

Husks produce cross shapes that are predominately Variant 6, irregularly trapezoidal to rectangular. These Variant 6 cross shapes are larger than those from leaves and are extremely thick, averaging some 11.0 μm. Husk phytoliths may be identifiable when isolated from sediment if recovered in number (Piperno 1988).

Diagnostic phytoliths are also formed in the pods of Southwestern varieties of common beans (*Phaseolus vulgaris*) and tepary beans (*P. acutifolius*) (Bozarth 1996). These distinctive phytoliths, which consist of silicified hooked hairs, are also produced in common beans from the Great Plains (Bozarth 1986, 1990). Bean phytoliths were identified in isolates from pre-Classic and Classic sites in the lower Verde River valley in central Arizona, for example, CTC; Scorpion Point Village; Roadhouse Ruin; and Cow Wallow, AZ U:2:61 (ASM) (Bozarth 1996, 1997).

Taxonomic phytolith classification has also demonstrated that scalloped, spheroidal phytoliths formed in the rinds of squash (*Cucurbita argyrosperma, C. moshata,* and *C. pepo*) are diagnostic of that genus in the Greater Southwest (Bozarth 1996) and the Great Plains (Bozarth 1985a, 1986, 1987a). Additionally, there are two other types of phytoliths formed in squash fruits that are characteristic of the genus (Bozarth 1996). Squash rind and flesh phytoliths were recovered from a Late Archaic site (Wood Canyon) in southwestern New Mexico (Bozarth 2000a).

Analysis of Southwestern reference species has also shown that agave produces a type of phytolith that is characteristic at the genus level. This type of phytolith has been recovered in a Classic period fieldhouse (Crash Landing, AZ U:2:78 [ASM]) in the lower Verde River valley (Bozarth 1996, 1997). An agave phytolith was also identified in a wash of ground stone recovered from a Hohokam site (Will E. Coyote) in Arizona (Bozarth 2000b).

Comparative analyses of reference materials has also demonstrated that diagnostic phytoliths are produced in certain wild edible plant materials native to the Greater Southwest, including hackberry fruits (*Celtis reticulata*) (Bozarth 1997), Christmas cholla fruits (*Opuntia leptocaulis*), and prickly pear fruits (*Opuntia phaeacantha)* (Bozarth 2000a).

PHYTOLITH MORPHOLOGY AND TAXONOMY OF NATIVE PLANTS

Monocotyledons, particularly the Poaceae, produce a wide variety of morphologically distinctive phytolith forms. The most taxonomically useful types of grass phytoliths are silicified short cells that range in length from 10 μm to 35 μm. Several types of trapezoidal circular, rectangular, and elliptical short cells are diagnostic of the Pooideae (Brown 1984; Twiss 1987), a grass subfamily adapted to cool temperatures and high available soil moisture (Twiss 1987). Saddle-shaped bodies occur most commonly in the Chloridoideae (Brown 1984; Mulholland and Rapp 1992; Twiss 1987), a grass subfamily that flourishes in areas with warm temperatures and low available soil moisture. Saddle-shaped phytoliths are similar in appearance to double-edged battle axes formed by two opposite convex edges and two opposite concave edges. However, a few saddle-shaped phytoliths have only one concave side or lack them entirely (Brown 1984). The distinguishing characteristic of Chloridoid short cells is the upward and outward flare of the two convex edges from the main body (Mulholland and Rapp 1992).

Bilobate and cross-shaped phytoliths are formed in the Panicoideae (Brown 1984; Mulholland and Rapp 1992; Twiss 1987), a grass subfamily that thrives in warm temperatures and high available soil moisture (Twiss 1987). Bilobates with raised lobe edges and indented, concave, or pointed ends are common in the Panicoid subfamily. Similar short cells are formed in *Leersia orysoides* (Bamboo subfamily) and *Hilaria jamesii* (Chloridoid subfamily). However, *L. orysoides* does not exhibit lateral symmetry as do the Panicoids. Bilobates with raised lobe edges and round or flat ends that are vertically and laterally symmetrical in side view are also formed in the Panicoids.

Bilobate phytoliths with raised lobe edges and round ends are also formed in three-awn grasses (*Aristida* spp.), a genus in the Chloridoid subfamily (Gould and Shaw 1983). However, bilobates formed in *Aristida* differ from Panicoid bilobates in that the raised edges on the bottom (the longer part) slope down at the ends. Additionally, they are asymmetrical in side view, as the top of the shaft is more concave than the bottom (Bozarth 1998b). Needle grass (*Stipa* spp.), a genus in the Pooid subfamily (Gould and Shaw 1983), also produces bilobates (Bozarth 1998b), although these bilobates differ from those produced in Panicoids and *Aristida* by not having raised lobe edges on the bottom and ends that are round, flat/pointed. Further, many have a small lobe on one side in the middle. Unlike most Pooids, *Stipa* species grow in dry areas (Pohl 1968).

There are several other types of phytoliths in addition to short cells that are produced in grass species. Long cells are relatively long (30-150 µm), elongate bodies with smooth or wavy edges (Twiss 1987). Bulliform cells are large keystone-shaped cells. Trichomes are silicified prickly hairs composed of two parts, an outer sheath and an inner core. The outer sheath dissolves soon after being deposited on the soil, while the inner core remains well preserved. Silicified stomata are taxonomically useful at various levels, but these are typically not well preserved.

Grass floral bracts produce at least three distinctive types of phytoliths not formed in other parts of the plant. Dendriforms are cylindrical bodies of varying length, with radiating protrusions or spines. Asteriforms consist of platy bodies with peg-like protrusions. Scutiform phytoliths are saucer-shaped bodies with a unique, slanted apex (Piperno 1988). Scutiforms appear to be diagnostic of Pooideae, whereas dendriforms are formed in most, if not all, native grasses. These three types of phytoliths can be used to identify areas and/or artifacts used to process native grass seeds (Bozarth 1998b).

Non-grass monocots also produce numerous taxonomically valuable phytoliths. Sedge (*Cyperus*) produces distinctive phytoliths in the form of cone-shaped bodies with round wavy margins. These phytoliths occur both singly and in multiples. Truncated cones with multiple peaks and round wavy bases are formed in bulrush (*Scirpus pallidus*). Both of these phytolith types appear to be diagnostic of the genera that produce them (Bozarth 1995). Polyhedral plates with rounded apexes and verrucate sculpturing are formed in the inflorescences of *Cyperus* (Ollendorf 1992).

Several types of phytoliths are formed in woody dicotyledons (deciduous shrubs and trees) and herbaceous dicotyledons (forbs). The two most common types of diagnostic dicot phytoliths are flat or cupped polyhedrons with five to eight sides and anticlinal cells (Bozarth 1992a; Geis 1973; Rovner 1971; Wilding and Drees 1971; Wilding et al. 1977). Anticlinal cells have wavy, undulating walls with the appearance of jigsaw puzzle pieces. Most of these polyhedral and anticlinal phytoliths consist only of silicified cell walls and are not well preserved in sediment (Bozarth 1992a; Wilding and Drees 1974). However, flat polyhedrons with five to eight sides filled with coarse verrucae (bumps) appear to be unique to Ulmaceae (elm family) (Bozarth 1985b, 1992a). Other phytolith types formed only in dicots include branched elements with spiral thickening and honeycomb-shaped assemblages (Bozarth 1992a; Geis 1973; Wilding and Drees 1973, 1974).

Several species of arboreal dicots produce opal spheres that range in diameter from 1 µm to 50 µm (Wilding and Drees 1973, 1974). Opal spheres are also produced in conifers (Klein and Geis 1978), but are much smaller (3-8 µm). Opaque opal spheres have been extracted from the A horizon of several forested soils in Ohio, demonstrating that they are well preserved (Wilding and Drees 1973, 1974). Wilding and Drees (1973) reported opaque bladed forms in white oak (*Quercus alba*). Similar particles were observed in isolates from a soil formed under deciduous forest.

Distinctive spinulose spheres are produced, albeit extremely rarely, in the leaves of chinkapin oak (*Quercus muehlenbergii*), northern red oak (*Q. rubra*), and white oak (*Q. alba*), as well as the endocarp of black walnut (*Juglans nigra*) (Bozarth 2001). Spinulose spheres have been recovered with deciduous tree phytoliths in late Pleistocene and Holocene loessal sites in Nebraska (Bozarth 1998c, 1998d, 2000c). Spinulose spheres are commonly formed in certain Neotropical palms (Piperno 1988).

Phytolith analysis of 21 dicot species native to the central Great Plains shows that diagnostic phytoliths are generally not formed in edible fruits, nuts, and seeds. Most of the fruits and nuts studied were from trees and shrubs, including shagbark hickory (*Carya ovata*), hackberry (*Celtis occidentalis*), hazelnut (*Corylus americana*), persimmon (*Diospyros* *virginiana*), black walnut (*Juglans nigra*), sandhill plum (*Prunus angustifolia*), wild plum (*P. americana*), choke cherry (*P. virginiana*), currants (*Ribes odoratum*), elderberry (*Sambucus canadensis*), white oak (*Quercus alba*), and burr oak (*Q. macrocarpus*). Herbaceous species studied include Palmer's pigweed (*Amaranthus palmeri*), rough pigweed (*A. retroflexus*), lamb's quarters (*Chenopodium album*), marsh elder (*Iva annua*), ground cherry (*Physalis virginiana*), Pennsylvania smartweed (*Polygonum pensylvanicum*), devil's claw (*Proboscidea louisianica*), and wild grape (*Vitis riparia*). Fruit from a cactus prickly pear (*Opuntia macrorhiza*) was also analyzed. Of these 21 species, diagnostic phytoliths were formed only in hackberry fruits. These phytoliths, produced in the fruit stone, are in the form of platelets with irregular edges and echinate (spiny) sculpturing on one side (Bozarth 1987b).

Other dicots produce phytoliths diagnostic at various taxonomic levels. Opaque platelets with systematic perforations and certain types of segmented hairs are diagnostic of Asteraceae (sunflower family). Certain types of stalked verrucate phytoliths are specific to hackberry, mulberry (*Morus*), false nettle (*Boehmeria*), or nettle (*Urtica*). Elongate verrucate phytoliths with one or both ends tapering to a point are unique to clearweed (*Pilea*) (Bozarth 1985b, 1992a). Phytoliths with deeply scalloped surfaces of contiguous concavities are diagnostic of *Cucurbita* spp. (Bozarth 1987a).

Several types of phytoliths are produced in the pine family (Pinaceae). Silicified, irregularly shaped, polyhedral cells are the most common taxonomically useful Pinaceae phytolith type. This type of phytolith is produced in red spruce (*Picea rubens*), black spruce (*P. mariana*), white spruce (*P. glauca*), Englemann spruce (*P. engelmannii*), and jack pine (*Pinus banksiana*) (Bozarth 1988, 1993a; Klein and Geis 1978; Norgren 1973). Blocky polyhedra with smooth surfaces and at least eight non-parallel sides are characteristic but not diagnostic of Pinaceae, because they are also produced, although relatively infrequently, in grasses (Bozarth 1993a).

In contrast to those that are smooth, polyhedrons with bordered pit impressions on the surface are unique to the Pinaceae. This type of phytolith is abundant in pine (*Pinus*), spruce (*Picea*), Douglas-fir (*Pseudotsuga menziesii*), and less commonly in larch (*Larix*), hemlock (*Tsuga*), and fir (*Abies*) (Klein and Geis 1978). Douglas-fir needles produce distinctive, branched, silicified particles (Brydon et al. 1963). This same type of phytolith was also reported in Douglas-fir by Garber (1966) as irregular shapes with spiny processes and by Norgren (1973) as amoeboid bodies with tapering, conical protrusions. Thin plates with wavy margins on all four sides are formed in needles of white spruce and appear to be unique to that species. Phytoliths with spiny irregular bodies are commonly formed in needles of jack pine and appear to be diagnostic of that species (Bozarth 1993a).

OTHER BIOSILICATES

Two groups of algae produce siliceous bodies, both of which are quite distinct from phytoliths. The Chrysophyceae (golden algae) produce spherical cysts with siliceous walls. These statospores are smooth, spiny, or bumpy and have a distinctive bottle-shaped opening through which motile spores are released. Freshwater forms of Chrysophyceae are more common than marine forms, and many prefer relative cool to cold temperatures (Bold and Wynne 1978). Jones et al. (1964) demonstrated that statospores can be useful in interpreting changes in ecology.

Diatoms are another type of algae (division Chrysophycophyta, class Bacillariophyceae) that produce siliceous cell walls (Bold 1967), which preserve well in sediment. Diatoms occur in both marine and freshwater habitats and in some moist and dry habitats where the light, temperature, and chemical conditions are suitable for their growth (Patrick and Reimer 1966). Diatoms may comprise from one-third to half the opal isolate of soils developed under ponded or poorly drained conditions (Wilding and Drees 1971).

Freshwater sponges are plant-like animals that produce distinctive silicified spicules. Sponge spicules are identified microscopically based on the presence of an axial canal (Baker 1959; Jones and Beavers 1963). Complete spicules have tapering cylindrical forms that terminate in a pointed end (Jones and Beavers 1963). Abundant sponge spicules in soils are indicative of an aquatic habitat favorable for sponge growth (Jones et al. 1964). An abundance of undamaged sponge spicules suggests formation on or near the site (Smithson 1959). For example, the presence of freshwater sponge spicules in loess is evidence that the eolian sediment was derived from floodplains (Jones and Beavers 1963).

METHODS

Biosilicates were extracted from 5-gm sediment samples. This procedure consists of seven basic steps: (1) removal of carbonates with dilute hydrochloric acid; (2) removal of colloidal organics, clays, and very fine silts by deflocculation with sodium pyrophosphate, centrifugation, and decantation through a 7-µm filter; (3) oxidation of the sample to remove organics; (4) introduction of "spike" spores; (5) heavy-liquid flotation of phytoliths from the heavier

Table 8.1. Biosilicate frequencies for an irrigated field and a pond feature at AZ U:9:28 (ASM).

Feature	320	320	320	320	320	320	320	320	320	320	320	57	57	57	57	57	57	57
Field Number (FN)	1364	1365	1370	1366	1367	1368	1371	1369	1372	1373	1374	1164	1168	1163	1125	1162	1120	1124
Feature Type	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Field	Pond	Pond	Pond	Pond	Pond	Pond	Pond
Stratum	5	50	50	5	5	50	50	5	5	50	5	39	59	59	59	69	59	59
Sample	SL20a	SL20b	SL20c	SL20d	SL21a	SL21b	SL21c	SL21d	SL22a	SL22b	SL22c	SL1a	SL1b	SL3a	SL3b	SL4a	SL5a	SL6a
Context	Above field	Upper 5 cm	Lower 5 cm	Below field	Above field	Upper 5 cm	Lower 5 cm	Below field	Above field	7 cm field	Below field	Shallow end	Shallow end	Deeper basin	Deeper basin	Below mano	Deeper basin	Near F 26
Phytolith Sum	246	233	235	248	226	215	224	56	233	230	215	230	215	212	220	224	220	238
Phytolith Concentration	85,469	12,381	16,759	16,326	27,839	6,333	6,163	1,518	26,869	77,913	22,849	100,532	44,140	638,356	78,447	275,927	91,723	115,175
Grass Subfamilies																		
Arundinoids (*Aristida*)	0.4	0.4	–	–	0.4	–	–	–	–	0.9	–	1.2	0.4	1.4	–	1.8	–	–
Chloridoids	5.5	1.7	0.4	1.6	1.7	0.5	–	–	4.2	14.3	3.2	7.3	2.6	19.2	0.8	13.8	3.5	1.2
Panicoids	1.2	0.4	0.4	–	0.9	-	–	–	0.4	3.0	0.4	–	0.9	0.5	–	1.8	0.4	–
Pooids	13.9	1.3	2.9 {1}	1.6	6.1	2.2	0.4	–	6.4	13.5	3.2	14.9	4.3	25.8	5.3	23.1	6.6	4.1
Stipa	–	–	0.4	–	–	–	–	–	0.8	–	–	–	–	–	–	–	–	0.4
Oryzopsis-type	–	–	–	–	–	–	–	–	–	–	–	0.4	–	–	–	–	–	–
Other Grass Phytoliths																		
Long cells	52.0	62.2	59.3	54.5	60.9	63.0	57.7	53.4	61.9 {1} [1, 2, 2]	61.7 {1} [6, 6.5, 11]	54.8	47.2	62.3 {1}	37.6	57.9	34.7	61.0	67.8
Bulliform	7.9	11.8	13.7	12.3	9.6	13.4	15.9	6.9	6.4	1.3	5.5	5.2	7.4	4.7	7.7	6.7	13.6	13.6
Trichomes	15.5	12.6	15.8	10.3	12.2	7.1	4.8	6.9	13.6	3.0	13.2	11.7	11.3	8.9	15.8	14.2	8.3	8.3
Tracheids	–	–	–	0.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grass Inflorescence																		
Asteriforms	–	–	–	–	0.4	–	–	–	–	–	–	–	–	(1)	–	(2)	–	–
Dendriforms	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Deeply lobed bodies	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cyperaceae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Asteraceae																		
Dyssodia	1.2	3.8	4.1	14.6	4.3	6.7	–	22.4	5.1	0.4	14.6	0.4	0.9	–	0.8	–	1.8	0.4
Opaque perforated platlets	–	1.3	–	0.8	–	0.9	1.3	–	–	–	–	–	–	–	0.4	–	–	0.4 (1)
Trees and Shrubs, Dicots																		
Polyhedra	–	–	–	-	–	0.4	–	–	–	–	–	–	–	–	–	–	–	–
Small (< 8 u) smooth spheres	–	–	–	-	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Large (> 8 u) smooth spheres	–	–	–	-	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Spinulose spheres	–	–	–	0.4	0.4	–	–	1.7	–	–	–	–	–	–	–	–	–	–
Carbon spheres	–	–	–	-	–	–	–	1.7	–	–	0.4	0.8	0.4	–	–	–	–	–
Unknown phytoliths	–	2.5	0.4	1.6	1.3	1.8	1.8	3.4	–	1.7	2.7	3.6	2.6	1.4	0.4	3.6	1.3	2.1
Other biosilicates																		
Sponge spicules	2.4	2.1	2.5	2.0	1.7	4.0	1.3	3.4	1.3	–	1.8	7.3	6.9	0.5	10.5	0.4	3.5	1.6
Algal statospores	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Diatoms	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.4	–	–	–

( ) = scanning data; { } = charred phytoliths; [number, mean size, largest] = aggregate data.

clastic mineral fraction using zinc bromide concentrated to a specific gravity of 2.3; (6) washing and dehydration of isolate with butanol; and, (7) dry storage in a 1-dram glass vial.

After thorough mixing, a representative portion of the isolate was mounted on a microscope slide in immersion oil under a 24-mm by 40-mm cover glass and sealed with clear nail lacquer. A minimum of 200 phytoliths, in addition to other biosilicates (diatoms, algal statospores, and sponge spicules), were taxonomically classified in each isolate with adequate concentrations. The rest of the slide was then scanned for economic species. Biosilicates were studied with a Zeiss microscope at a magnification of 625x. The biosilicate data were presented in computer-generated frequency tables (Table 8.1); culturally significant scanning data are indicated with numbers in parentheses.

Spike tablets containing 18,583 *Lycopodium* (clubmoss) spores per tablet were introduced into the soil/sediment sample prior to the flotation to verify phytolith extractions and for quantitative evaluation of microfossil concentrations. Phytolith concentrations per gram were calculated by multiplying the number of phytoliths counted by the number of *Lycopodium* spores added, divided by the number of *Lycopodium* spores counted, which is then divided by five, the weight of the samples, in grams. This calculation is the same as that reported by Pearsall (1989) except the number of microfossils per sample is divided by the sample weight to give the number of microfossils per gram.

Phytolith aggregates (two or more phytoliths silicified together) should also be evaluated in archaeological studies. Phytolith research in the Near East indicates the formation of silica skeletons (phytolith aggregates) may be related to the growing environment (Rosen 1992). It has been shown that this process is enhanced by irrigation and that the presence of large phytolith aggregates can be used as evidence for ancient irrigation in the Near East (Rosen 1994). The presence of phytolith aggregates may also indicate prehistoric irrigation in other areas such as the Greater Southwest.

Phytolith Classification

Taxonomic classification of appropriate reference collections is the key to meaningful archaeological phytolith analysis and palynology. The classification of phytoliths was based on comparative analyses of an extensive reference collection consisting of both domesticated and wild species. The domesticated phytolith collection consists of 120 samples from 26 Southwestern cultigens, including various parts of grain amaranth (*Amaranthus cruentus* and *A. hypochondriacus*), jack beans (*Canavalia ensiformis*), chile (*Capsicum annuum*), squash (*Cucurbita pepo, C. maxima, C. mochata,* and *C. mixta)*, cotton (*Gossypium hirsutum* var. *puntatum*), sunflowers (*Helianthus annuus* var. *macrocarpa*), gourds (*Lagenaria siceraria*), tobacco (*Nicotiana rustica*), tomatillo (*Physalis philadelphica* var. *philadelphica*), tepary beans (*Phaseolus acutifolius*), common beans (*P. vulgaris*), and the five kernel types of maize (*Zea mays*).

The nondomesticated phytolith collection is based on 118 samples from 83 species native to the Greater Southwest, including two species of agave (*Agave crysantha* and *A. murpheyi*), careless weed (*Amaranthus palmeri*), wild gourd (*Cucurbita digitata*), wild buffalo gourd (*C. foetidissima*), and wild tobacco (*Nicotiana trigonophylla*). Analysis of the domesticated and nondomesticated phytolith collections for the Lower Verde Archaeological project (Bozarth 1997) resulted in the most extensive and comprehensive phytolith classification of Southwestern cultigens and selected wild edible plant species.

RESULTS AND DISCUSSION

Biosilicates were well preserved in all 18 samples analyzed, including 11 samples collected from prehistoric field Feature 320 surrounded on three sides by irrigation canals (see Figure 7.3) and seven samples from a nearby man-made pond, Feature 57 (Chapter 4, this volume). The biosilicate data are presented in Table 8.1. The following section summarizes the results.

Field Feature 320

Field Samples SL20a-d

No evidence of food-producing plants was found in this set of samples that includes samples collected above the field surface, the upper 5 cm of field, the lower 5 cm of field, and below field. However, there were differences among the samples. For example, the above field sample had a much higher phytolith concentration, at 85,469, than the other samples, showing that it was collected in a much more stable surface. The other three samples were from levels that aggraded more rapidly based on concentrations of 12,381, 16,759, and 16,326.

The relative frequency of sponge spicules is similar throughout this sequence (2.4, 2.1, 2.5, and 2.0 percent, respectively, from top to bottom) suggesting pot irrigation was not practiced, perhaps because the field, which is actually more the size of a garden (approximately 4.5 m by 4.5 m), was small enough that canal water infiltrated into it. This may explain why most of the other fields/gardens are approximately the same size. The high frequency (14.6 percent) of *Dyssodia* phytoliths in the sample collected below field (SL20d) indicate this was the driest level, as two of three *Dyssodia* species native to Maricopa County are adapted to dry conditions (Kearney and Pebbles 1951).

Field Samples SL21a-d

No evidence of cultigens or native food-producing plants was found in these samples collected above the field, upper 5 cm of field, lower 5 cm of field, and below field. As in field samples SL20a-d, the above field sample (SL21a) had the most stable surface, based on its relatively high phytolith concentration (27,839).

In contrast, the least stable surface was in the below field sample, with a concentration of only 1,518. This low concentration was probably the result of rapid aggredation from sheet flooding from the Camelback-Papago Buttes piedmont. The relatively high frequency of sponge spicules (3.4 percent) in the lowest sample is artifically high given the low phytolith concentrations due to increased aridity and loss of short cells due to coarse sand. The similarity in phytolith concentrations (6,333 and 6,163) in the two field samples shows that the degree of flooding was fairly constant when this level was deposited. The high frequency of *Dyssodia* phytoliths (22.4 percent) suggests the below field level was the driest as was the case in the SL20a-d samples.

Field Samples SL22a-c

As in field samples SL20a-d and SL21a-d, no evidence of cultigens was found in the phytolith analysis. The most stable surface in this set of samples was the field sample (SL22b) with a phytolith concentration of 77,913, as compared to the above field sample with a concentration of 26,869 and the below field sample with a concentration of 22,849. The presence of six aggregates of native grass long cells provides evidence for irrigation at this level. There was no evidence of pot irrigation, based on the absence of sponge spicules in the field sample. Again, the highest frequency of *Dyssodia* occurred in the below field sample, indicating that level was the driest.

Pond Feature 57

Pond Samples SL1a-b, SL3a-b, SL4a, SL5a, and SL6a

No phytolith evidence of cultigens was found in the samples analyzed from Feature 57 (SL1a-b, SL3a-b, SL4a, SL5a, and SL6a in Table 8.1; sample locations are shown in Chapter 4). However, differences in phytolith concentrations demonstrate that surface stabilities varied through time. Sample SL1a, collected in gray-tan silty clay in the upper edge of the pond (northwestern shallow end) was a more stable surface than the lower shallow end sample (SL1b) in "rainbow" clay based on a phytolith concentration of 100,532 vs 44,140. A lower gray-tan silty clay sample (SL3a) from the deeper basin was the most stable of all the pond samples, with a concentration of 638,356. The lower lower sample (SL3b) collected in heavy "rainbow" clay in the deeper basin had a phytolith concentration of only 78,447. The higher concentrations in the SL1a and SL3a samples show that the gray-tan silty clays stratum was vegetated and deposited after abandonment of the irrigation system. The frequency of sponge spicules (10.5 percent) is probably the highest in this sample, as it was collected in the low area of the pond and held water longer. In contrast, the low frequency (0.5 perecent) of sponge spicules in the SL3a sample shows this level was not flooded for any length of time.

The mano sample (SL4a), collected in gray-tan soil mottled with dark brown clay, was also in a stable surface based on a phytolith concentration of 275,927. Sample SL5a, in upper gray-tan silty clay in the deeper basin, was collected in a more rapidly aggrading surface, based on a lower phytolith concentration of 91,723. The last sample (SL6a), collected near the intersection with canal Feature 26 in gray-tan soils, had a phytolith concentration of 115,175, which is very similar to that for SL1a (100,532), which was also collected in gray-tan silty clay. The location of Feature 57 adjacent to a large irrigation canal, Feature 26, suggests it was an extension of the canal to facilitate infiltration of irrigation water to the nearby field/garden to the northeast.

CONCLUSION

In summary, no cultigen phytoliths were found in any of the 18 samples studied. However, the size of the fields, approximately 4.5 m by 4.5 m, is more indicative of gardens, in which specialized crops may have been grown. A high frequency of cheno-am pollen and aggregates larger than six grains observed in the biosilicate field isolates suggests amaranth, possibly domesticated, was grown for grain and/or greens. Grain amaranth (*A. hypochondriacus*) has been recovered from both pre-Classic (Elson et al. 1995) and Classic period sites (Bohrer 1962; Elson et al. 1995) in the Tonto Basin. The biosilicate data and the fairly consistent size of the gardens suggest water from the irrigation canals infiltrated the gardens, thereby eliminating the need for the more laborious pot irrigation.

HABITATION AND ACTIVITY AREAS AT THE PHX SKY TRAIN 44TH STREET STATION

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As anticipated at the outset of the PHX Sky Train project, irrigation-related features dominated the feature types documented during the project. However, a surprising number of prehistoric habitation features were also discovered. Of the 99 archaeological features identified in the study area, 24 represented prehistoric habitation features, defined broadly here to include architectural structures and associated extramural features (Tables 9.1-9.2). All were assigned the Pueblo Grande site designation, AZ U:9:1 (ASM). Relatively detailed descriptions of these archaeological features and their excavations are provided in this chapter. Because these features were not scattered indiscriminately across the project area, the descriptions below are organized by "Area," a term roughly synonymous with an archaeological locus in that the features tended to be spatially and temporally discrete. Interestingly, these areas also appear to represent loci with differing intensities of habitation and/or activity. A synopsis of each habitation area follows, in addition to more detailed descriptions of the features associated with each.

AREA 3A

Area 3A was located in the southwestern corner of Block 3, lying between the canal alignments, Features 14 and 26 (Figure 9.1; see also Figure 2.3). The locus was comprised of a single pithouse, Feature 306; a small pit, Feature 308; and a shallow basin containing three molded adobe trivet feet, Feature 310. Together, these features represented a seemingly isolated habitation area. Pithouse Feature 306 was relatively large, and while pit Feature 308 was generally unremarkable, the possible cache of trivets contained in Feature 310 suggests the area saw at least some additional activity. Diagnostic ceramics from the pithouse and trivet pit indicate use of this area during the earlier Santa Cruz phase, A.D. 850-900.

Architecture

Feature 306

Feature 306 was a relatively large house-in-pit style structure with a caliche-plastered floor (Figure 9.2). The structure was rectangular to subrectangular in plan, 5.2 m by 2.3 m at its maximum extent, with a floor area of 11.3 m^2. The remains of a hearth and possible entry appeared to orient the structure to the southwest. Feature 306 was originally exposed in backhoe Trench 6. Overlying sediment was later mechanically stripped away to a level approximately 15 cm above the floor of the feature to expedite further excavation. A 1-m by 2-m control unit, Unit 6, was placed on the eastern side of Trench 6, where two levels of undifferentiated house fill were excavated and screened. Artifact density was very low. The remainder of the feature was exposed through the excavation of two additional units located on either side of the trench. Each of the additional units was excavated in one level and was not screened, although artifacts in contact with the floor were mapped and collected. Five possible postholes and a hearth, Feature 306.01, were also recorded; the hearth and one posthole were excavated. An intrusive pit, Feature 308, was also identified and was excavated separately.

The house pit was excavated into the underlying substrate of sterile alluvium and subsequently lined with a 1- to 2-cm-thick layer of caliche plaster. The preservation of the floor was generally poor, and the surface exposed was patchy (Figure 9.3). Five relatively large (16 cm average diameter) possible postholes were identified, and they seem generally consistent in size and location with internal roof support posts. However, their concentration in a relatively small area was somewhat peculiar, as all five postholes were identified in the eastern half of the structure, while no corresponding posts were seen in the western half. There was no evidence of pit walls, wall grooves, or postholes along the pe-

Table 9.1. Summary of characteristics of sampled habitation structures, PHX Sky Train project.

Feature	Area	Structure Type	Plan Shape	Maximum Length (m)	Maximum Width (m)	Depth of Fill (m)	Floor Area (sq.m)	Entry Length (m)	Floor Features
300	5A	Pithouse	D-shaped	2.45	2.20	0.14	4.74	0.30	None
301	5A	Pithouse	Oblong	3.30	2.17	0.09	5.38	–	None
302	5A	Pithouse	Oblong	3.55	2.25	0.12	6.28	0.80	1 floor pit, 3 postholes
306	3A	Pithouse	Subrectangular	5.20	2.30	0.12	11.27	0.30	1 hearth, 5 postholes, 2 floor trenches
307	5A	Pithouse	Subrectangular	3.65	2.40	0.14	7.64	–	1 hearth, 1 posthole
312	6B	Pithouse	Oblong	5.55	2.50	0.07	12.11	0.20?	1 hearth
313	6B	Pithouse	N/A, remnant	> 2.15	> 1.75	0.03	> 2.34	–	1 hearth
314	6B	Pithouse	Oblong	3.90	2.20	0.04	7.81	–	1 hearth
316	6B	Pithouse	Oblong	3.65	2.05	0.06	6.74[a]	–	1 hearth
318	3B	Pithouse	Subrectangular	3.10	2.30	0.25	6.36	–	1 hearth
329	3B	Adobe structure	Rectangular	6.50	4.65	0.22	8.29[b]	–	1 hearth

[a]Floor area is the excavated area; actual area was probably circa 7.40 m2 before stripping took one edge.

[b]Floor area in main room.

Table 9.2. Summary characteristics of sampled extramural features, PHX Sky Train project.

Feature	Area	Feature Type	Maximum Length (m)	Maximum Width (m)	Depth/ Thickness (m)	Description
303	5A	Pit	0.85	> 0.60	0.54	Circular to oval pit with steeply sloped sides and a flat bottom; uniform fill; low to moderate artifact density; not burned
304	5A	Pit	0.81	0.81	0.72	Deep conical pit, circular in plan, with inward-sloping sides; caliche and a large sherd at base may have been intentionally placed; lens of carbonized material overlaid the caliche and sherd; intruded pithouse Feature 302
305	5A	Puddling pit	0.44	0.44	0.05	Circular basin-shaped pit lined with 3-5 cm of caliche material; uniform fill; no artifacts present; not burned
308	3A	Pit	0.56	0.50	0.15	Shallow pit, roughly circular in plan, with irregularly sloped walls and base; not burned; intruded pithouse Feature 306
309	5A	Artifact concentration	7.80	4.00	0.39	Large dense deposit of discarded artifacts in a variable matrix, probably a midden
310	3A	Trivet pit	0.75	0.65	0.18	Shallow circular depression containing three molded low-fired adobe feet; pit/depression not oxidized or burned
311	5A	Pit	0.40	0.35	0.29	Circular basin-shaped pit with fine ashy fill; few artifacts; intruded probable entry to pithouse Feature 307
325	3B	Pit	0.50	0.40	0.18	Shallow basin-shaped pit; few artifacts; not burned
326	3B	Pit	1.00	0.76	0.38	Deep, circular pit or posthole with shallow basin along one edge; rock and stone artifacts abundant; possibly part of the support system for Feature 329
332	3B	Pit	0.58	0.56	0.22	Circular basin-shaped pit; uniform fill; not burned; artifacts at/near base suggest use as a cache
333	3B	Pit	0.90	0.70	0.38	Oval basin with steeply sloping sides and a flat cobble at the base; contiguous with Feature 334, forming a double-basined pit; fine light gray sediment thinly lined the walls and base
334	3B	Pit	1.03	0.75	0.29	Oval basin with steeply sloping sides and a flat cobble at the base; contiguous with Feature 333, forming a double-basined pit; light whitish-gray sediment thinly lined the walls and base
337	3B	Pit	1.30	–	0.67	Steeply sloped basin filled with bands of gravelly silt and clay loam; few artifacts; not burned; possibly a borrow pit
338	3B	Artifact concentration	0.25	0.25	0.15	Small concentration of pottery sherds, most of which formed a partial plain ware bowl

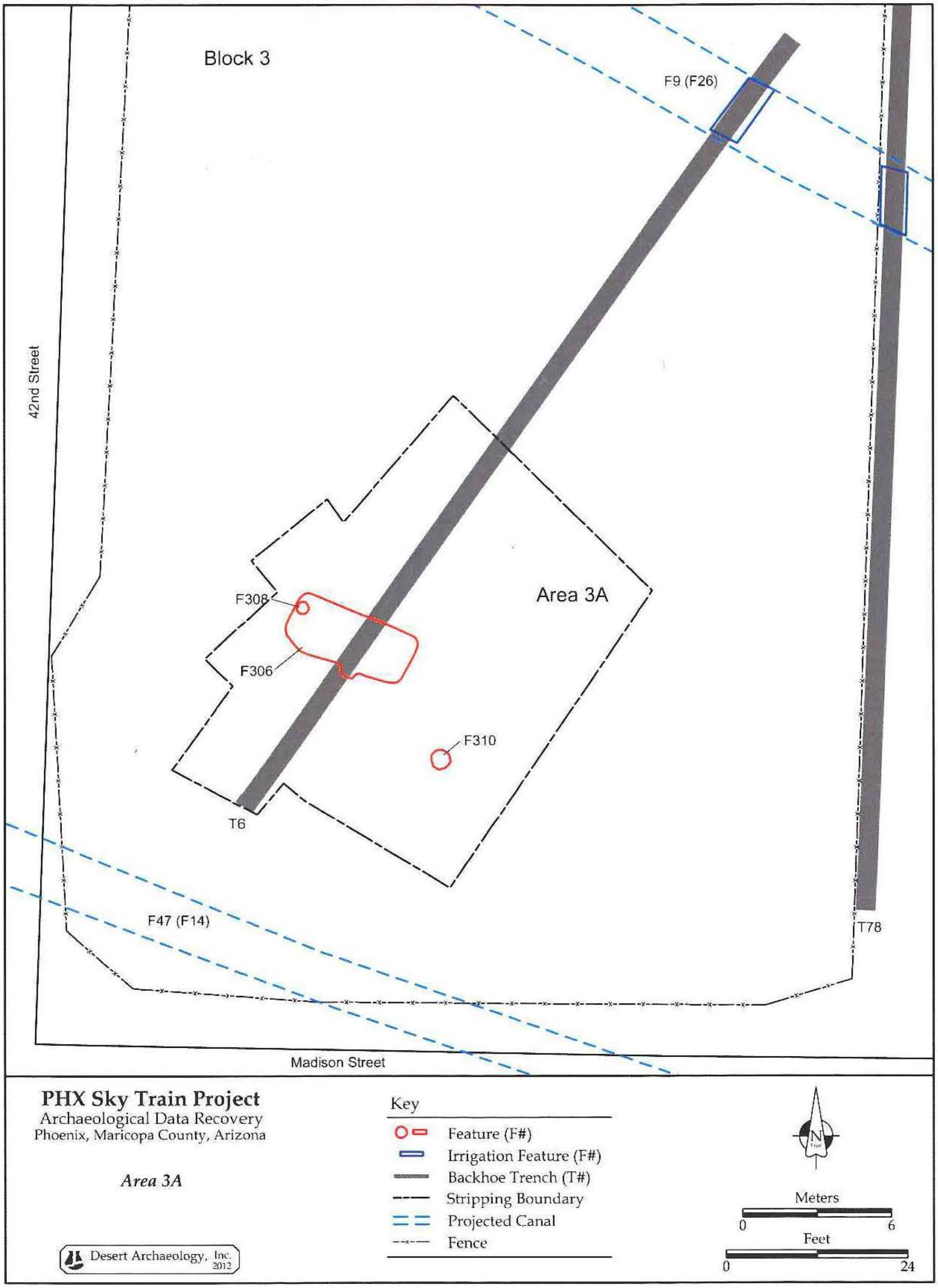

Figure 9.1. Map of Area 3A, PHX Sky Train project.

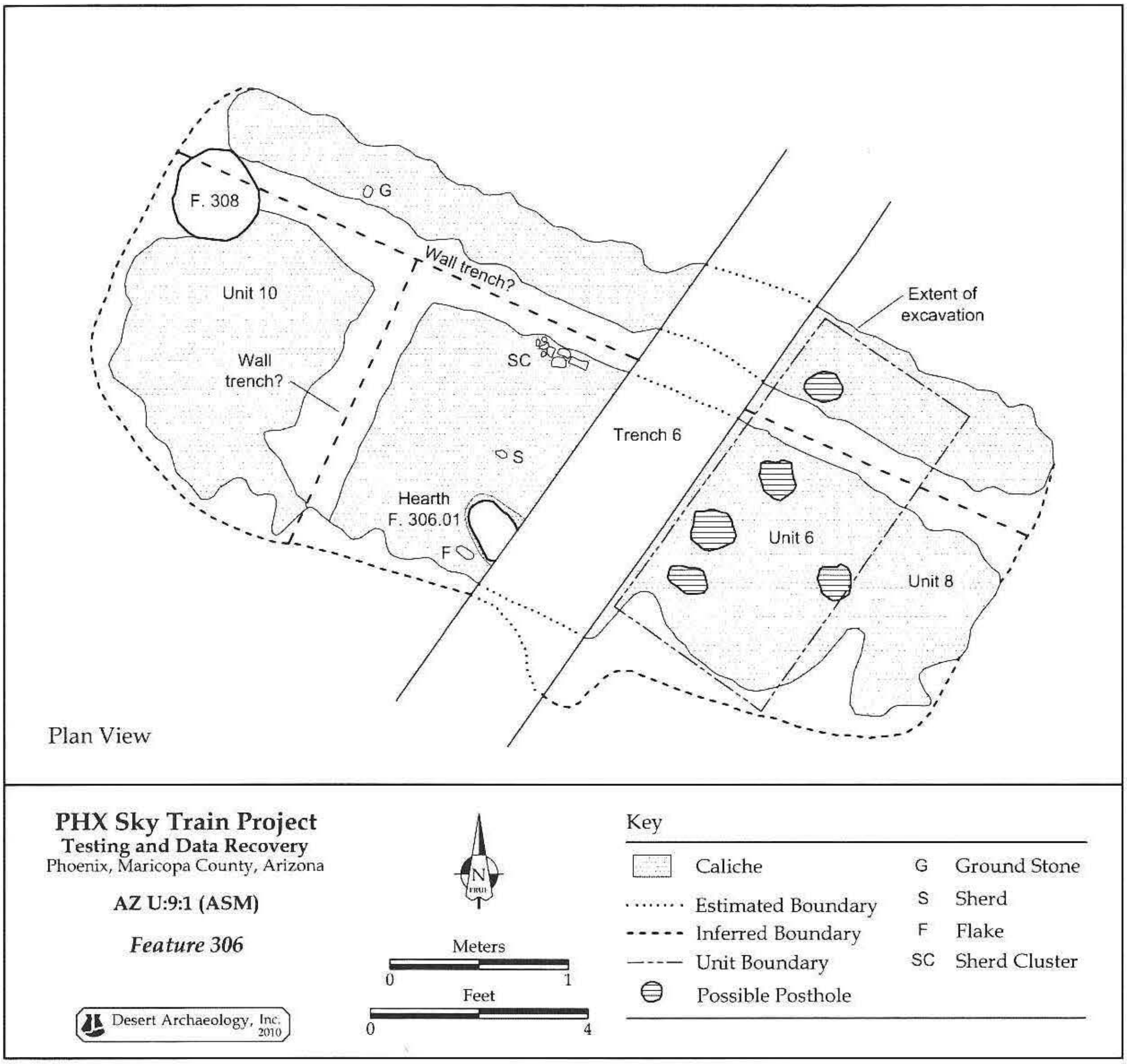

Figure 9.2. Plan view of Feature 306, Area 3A, PHX Sky Train project.

rimeter of floor. The only evidence of an entry was a caliche surface, similar to the main floor of the feature, which appeared to protrude beyond the southern outline of the structure on the eastern side of the backhoe trench. This small patch of caliche, taken together with the location of the hearth, suggested the entry opened to the southwest and was almost completely removed by trenching.

The hearth, Feature 306.01, was centrally located relative to the long axis of the structure and just inside (15 cm) the southern edge of the floor. Roughly one-third of this floor feature had been clipped by the backhoe trench that exposed Feature 306. The hearth was an oval basin, measuring 35 cm in length, 20 cm in width, and 10 cm in depth. Its interior surface had been plastered with a thin layer of caliche-rich adobe; this material extended up and over the top of the hearth basin creating a collared rim. The hearth fill consisted of loose grayish-brown ashy silt. Several ceramic sherds, a piece of flaked stone, and a flattish cobble exhibiting polish/wear were contained in the fill. One of the sherds was later identified as Late Gila Butte or Santa Cruz red-on-buff.

Beyond the postholes mentioned above, the floor was also perforated by two narrow trenches that ran perpendicular to one another and that cut through the caliche floor of the structure (see Figures 9.2-9.3). These trenches proved rather enigmatic. While they did not appear intrusive, neither did they appear to represent a particular secondary feature or an element of house construction. Located well inside the edge of the prepared floor, it seems unlikely that these represented traditional wall trenches. Although the trenches were not excavated, their profiles were exposed in several cuts where they appeared to be filled with the same fill as the house.

Figure 9.3. Photograph of Feature 306, Area 3A, facing west, PHX Sky Train project.

The trenches had a roughly 18-cm-deep, basin-shaped cross section; the trench edges were rough, but measured at least 18 cm in width, although it was somewhat wider in places.

These shallow trenches may represent an attempt to remodel the structure, perhaps reducing its size. Remodeling might also explain the concentration of posts in the eastern half of the structure; perhaps they also represented an attempted repair or remodel. Because the trenches were not excavated, it is impossible to determine if they obscured any postholes along their length, or if they possessed any other element that might have aided in discerning their function. Additional theories about the function of these trenches involved the possibility that they were intrusive; unfortunately, the potential function of such intrusive trenches proved equally enigmatic. Another possibility was that these features were small irrigation ditches, such as seen in other parts of the project area; however, the trenches did not contain any water-lain sediments. The trenches may also have been some part of an undetected overlying feature or structure. While it is possible that these interior features were intrusive in some way, it was their relatively tight alignment with the orientation of the pithouse that seems to indicate the trenches were somehow related to the construction or use of Feature 306.

The house pit was filled with light grayish-brown, compact, fine sandy silt with a moderate amount of small gravel inclusions. Charcoal flecking was minor throughout the fill, and a few small pieces of daub were observed; caliche nodules from the decaying floor were also present. The minor amount of charcoal and daub observed in the excavated fill suggested it contained some structural debris, but beyond these inclusions, there was little evidence of roof/wall construction materials. Root and rodent disturbance was described as minor. A later pit, Feature 308, intruded the northwestern corner of the pithouse; its intrusion was also a minor disturbance.

The floor assemblage included a cluster of sherds (nine pieces from the same plain ware vessel), a small ground stone handstone near the rear wall, one large flake, and a buff ware sherd. Although the presence of these possibly useful artifacts suggests Feature 306 might not have been completely cleaned out when abandoned, it is equally possible they represent a light scatter of incidental trash that accumulated after the structure was abandoned. There was no evidence of structural burning, and neither the fill nor the floor showed any signs of oxidation; the structure may have simply collapsed after abandonment. Later, a small pit, Feature 308, was excavated through the collapsed remains of the structure.

Extramural Features

Feature 308

Feature 308 was a small pit that intruded through the fill and floor of pithouse Feature 306; the feature also intruded through one of the enigmatic trenches noted in the floor of that structure. The pit was originally identified during the excavation of pithouse Feature 306, and it was initially bisected. When excavation established that Feature 308 was intrusive, the remaining fill was also excavated. All excavated fill was screened. The pit measured 56 cm by 50 cm in plan, and extended 15 cm in depth. Fill consisted of brown sandy silt slightly darker than the fill of the house and the trench through which it intruded. The pit contained a moderate amount of charcoal, but no evidence of in situ burning was noted. The only artifacts in the fill were two thumbnail-sized plain ware sherds. What function the pit may have served is unknown.

Feature 310

Feature 310 consisted of a shallow depression containing a trivet set of three molded, low-fired adobe feet (Figures 9.4-9.5). The feature was located approximately 3.5 m southeast of pithouse Feature 306, and was discovered during mechanical strip-

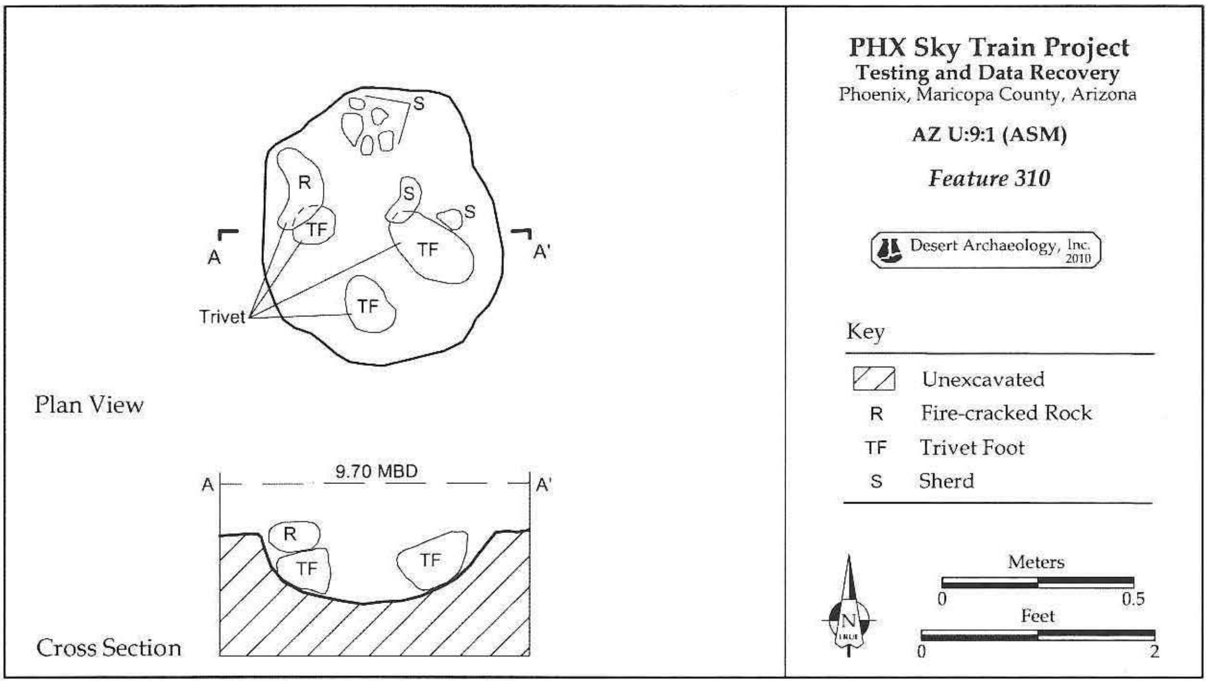

Figure 9.4. Plan view and cross section of Feature 310, Area 3A, PHX Sky Train project.

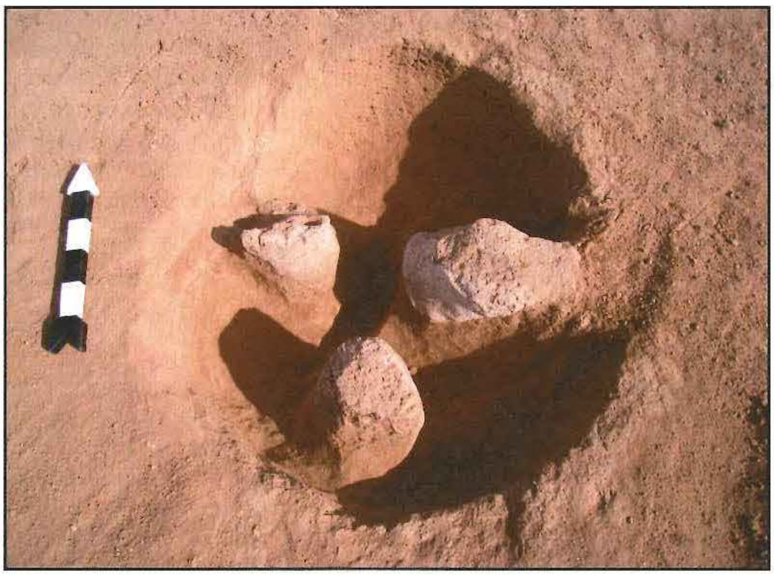

Figure 9.5. Postexcavation photograph of Feature 310, Area 3A, showing trivet feet in situ, PHX Sky Train project. (The rock that completed the trivet foot at upper left was removed prior to this photograph.)

ping of the area to further expose the pithouse and its immediate surroundings. Sediment surrounding the trivet feet was carefully excavated and screened. A few ceramic sherds were recovered and collected, in addition to the best-preserved trivet foot and a ground stone fragment used to complete one of the feet.

The edge of the depression, or "pit," in which the trivet feet was discovered was difficult to discern. The depression appeared to be roughly circular and basin-shaped, measuring 75 cm by 65 cm in plan and 18 cm in depth. The trivet feet appeared to be in situ, in that they were primarily upright, appropriately positioned for use, and the least substantial of the three was partially supported or bolstered by a flat-sided stone. Because the fill of the pit in which the trivet set was found was barely distinguishable from its surroundings and there was no oxidation present or other evidence of burning, these feet do not appear to have been used in situ for cooking over a fire. The use of a stone to lend additional support to the decaying feet suggests this trivet set may have been near the end of its use-life prehistorically. Given that the feet appear to be positioned for use and the fill surrounding them was relatively clean, it seems likely that the feet may have been partially buried for stability and subsequently used as a simple support, such as a potrest. Alternatively, the trivet feet may have been merely cached or stored in the pit for later use.

The pit contained a small cluster of ceramic sherds, but did not generally appear to be filled with discarded refuse. Similarly, despite their deteriorating state of preservation, the trivet feet did not appear to have been carelessly discarded.

Area Age and Activity

Diagnostic ceramics from Features 306 and 310 were solely Late Gila Butte Red-on-buff and/or Santa Cruz Red-on-buff (Chapter 10, this volume). These ceramics place their use firmly in the Santa Cruz phase, probably earlier in that phase, circa A.D. 850-900, given the presence of Late Gila Butte styles. A plain ware assemblage dominated by sand-tempered pottery and moderate quantities of Hohokam buff ware are also consistent with this age.

Area 3A is interpreted as a fieldhouse locale, based on the relative isolation and lightweight construction of its pithouse and, as related in later chapters, a limited inventory of associated artifacts. Stone artifacts recovered from the house included a handstone, a lapstone, several flakes, a core, and a core hammer that had also been used as a handstone polisher. The items are what would be expected for expedient manufacture and maintenance of tools needed for a variety of low-level cutting and grinding tasks. The ceramic assemblage from Area 3A included a small number of buff ware bowls and larger numbers of buff and plain ware jars. The vessel types suggest only basic culinary activities were performed at the house, with some dry storage, possibly of locally derived produce. The presence of maize and cholla pollen in both the pithouse and trivet pit, in addition to high field weed pollen values, supports the idea that the fieldhouse lay amidst agricultural fields.

AREA 3B

Area 3B was located in the northwestern corner of Block 3, west of canal Feature 3 (Figure 9.6; see also Figure 2.3). The locus included an adobe-walled structure, Feature 329; a poorly preserved pithouse, Feature 318; six extramural pits, Features 325, 326, 332, 333, 334, and 337; and a concentration of pottery fragments, Feature 338. Like Area 3A, this collection of features seems to represent an isolated habitation area. The adobe structure, though, was a relatively substantial residence, and the number of surrounding features, as well as an artifact assemblage several magnitudes larger than other areas, indicate this small locus was quite active. Notable among the extramural features were three cobble-bottomed pits, Features 326, 333, and 334. Pits of this type were also found in the main village of Pueblo Grande (Mitchell and Merewether 1994). The adobe architecture of Feature 329 clearly indicates a Classic period occupation.

Architecture

Feature 318

Feature 318 was a small, poorly defined pithouse first identified in Trench 73 (Figure 9.7). The hearth and a portion of the floor were exposed in the eastern wall of the trench; a smaller, less well-defined stain in the western wall was also thought to be related. A 1-m by 2-m control unit was placed on the eastern side of Trench 73, from which 25 cm of undifferentiated house fill was excavated in two levels. Because a large amount of upper level historic disturbance was encountered in the control unit, the area east of Trench 73 was mechanically stripped to 10 cm above the level of the floor. An additional unit exposing the remainder of the eastern half of the structure was excavated by hand. West of the backhoe trench, a third unit exposed the rest of the structure; this final unit was excavated in two 12-cm levels. All excavated fill was screened.

Feature 318 was a subrectangular house-in-pit style structure with an unprepared, irregular floor that sloped up slightly toward the pit walls. The floor, where discernible, was compacted fine gravelly silt, similar to the substrate into which the house pit was excavated. Walls, identified by the absence of fill, gradually sloped up from the floor. The house pit showed no evidence of formal preparation. No postholes were identified. The only floor feature was a small informal hearth, Feature 318.01, ash filled and lightly oxidized. No entry was identified; however, based on the location of the hearth, an entry could have been oriented toward the south and removed by the backhoe trench. Overall, the structure measured 3.10 m long, 2.30 m wide, and 6.36 m^2 in area.

Excavated feature fill was grayish-brown to brown compact silt, while later intrusions were filled with darker grayish-brown, compact clayey silt containing a small amount of historic debris; rodent and root activity mixed the two to some degree. Gravels were common throughout the fill; charcoal was sparse. Artifact density was moderate. Ceramics, flaked stone debitage, animal bone, freshwater shell, and a ceramic figurine or effigy head were recovered. Although a thin layer of ash covered the floor area surrounding the hearth, there was no evidence of burning in the structure. A few plain and red ware sherds, most smaller than 5 cm^2, were clustered on the floor surface.

Feature 318 was a small, lightly constructed house in a shallow pit. While the hearth implies it was used for habitation, the lack of intramural fea-

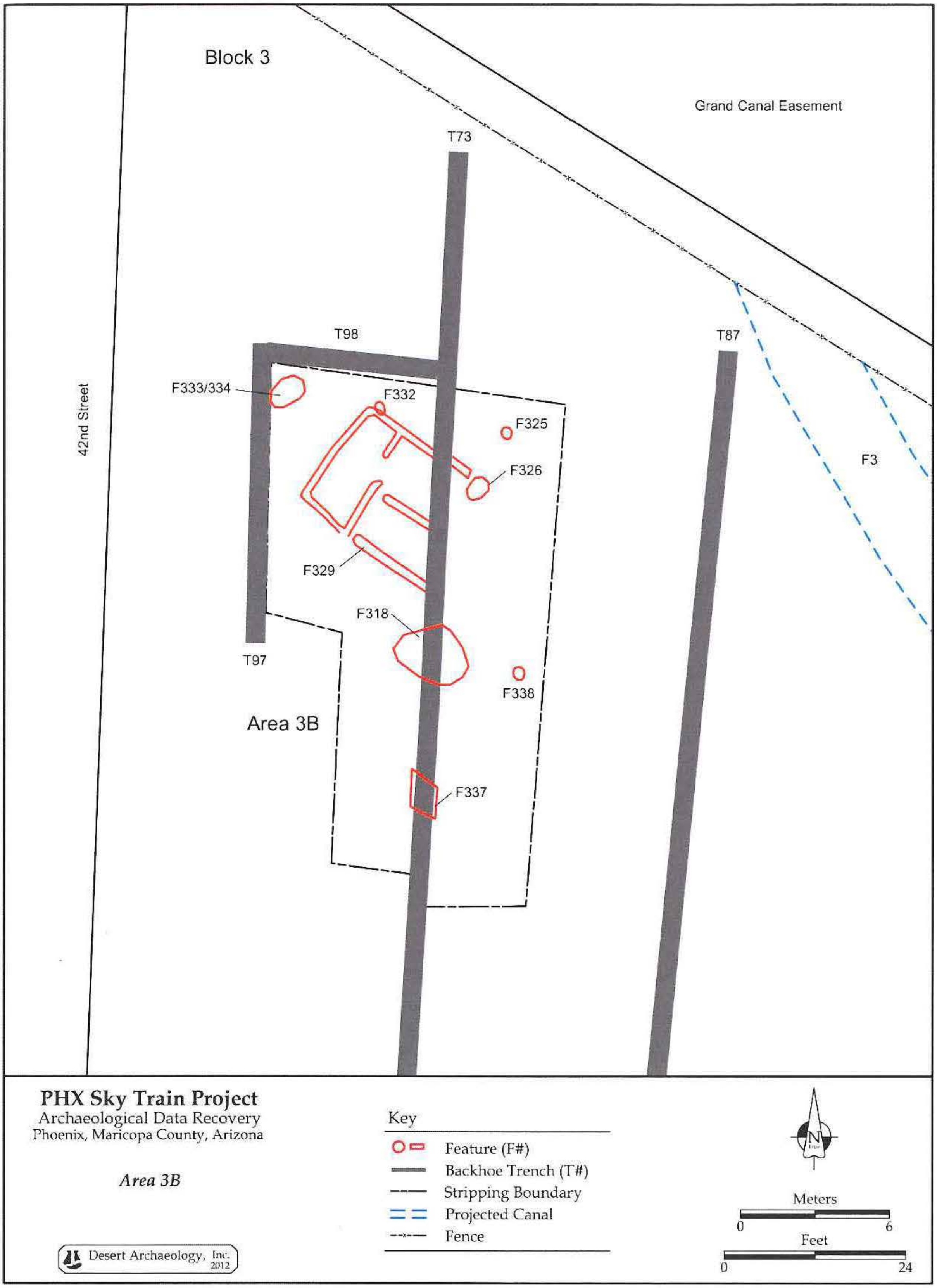

Figure 9.6. Map of Area 3B, PHX Sky Train project.

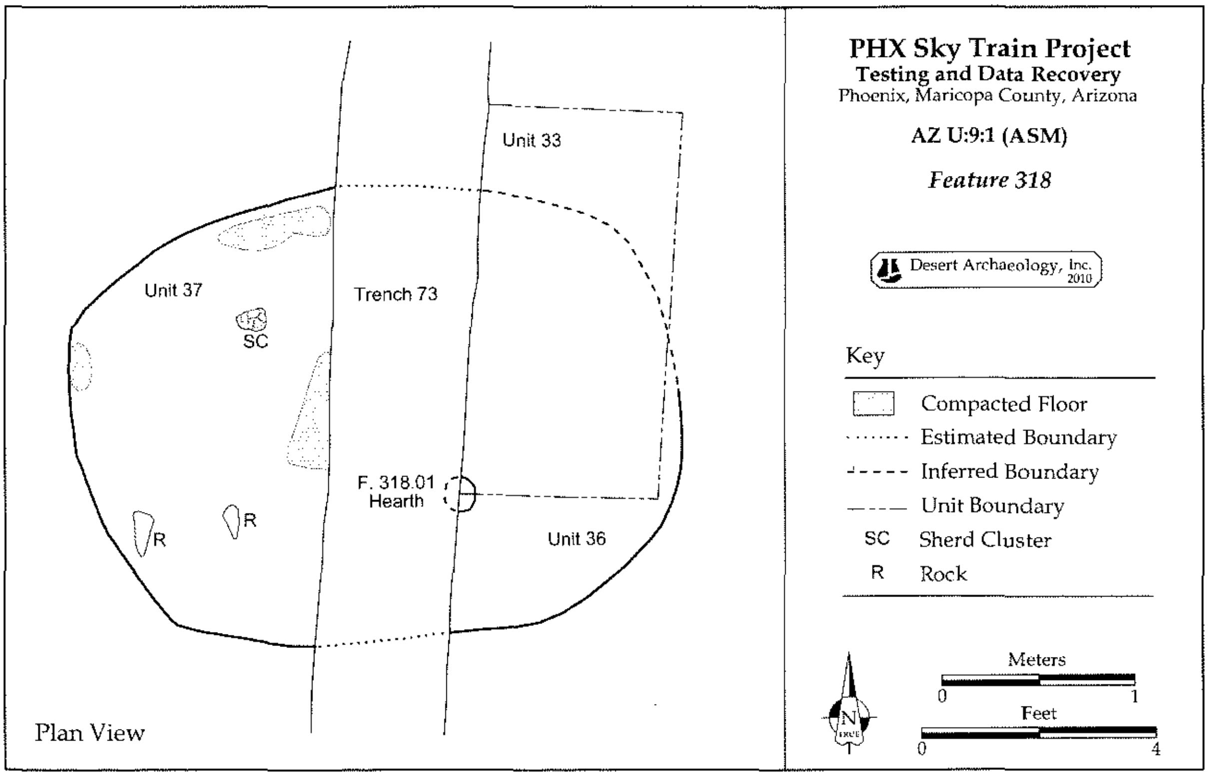

Figure 9.7. Plan view of Feature 318, Area 3B, PHX Sky Train project.

tures and its light construction suggest its use was temporary or intermittent, possibly as a secondary habitation, but more likely as a storehouse. Very high pollen concentrations and high values of maize and cholla pollen in the sample from the floor (Chapter 7, this volume) support this latter interpretation. No useful artifacts remained on the floor. Because there was no evidence the structure burned, it may have simply collapsed. The resulting depression was filled with prehistoric refuse.

Feature 329

Feature 329 was a small adobe-walled structure comprised of one main room with a relatively intact floor and hearth; additional wall segments extended off the main room possibly defining two adjoined extramural spaces (Figures 9.8-9.9). The feature was initially identified during mechanical stripping around pithouse Feature 318. Feature 329 appeared as a relatively large area containing darker soil, a concentration of artifacts, and faint soil distinctions that suggested possible adobe wall alignments. Two initial 1-m by 2-m control units were excavated to explore the area. One straddled a hearth, Feature 329.01, while the other straddled the southern wall of the main room, chiefly exposing an area outside the structure. The remainder of the structure was exposed with four irregularly shaped units that were generally arranged to explore and define not only the main room of the structure but the other associated spaces that faint wall remnants suggested were present (see Figure 9.8). One of these units, Unit 40, included several hand-trenches that were excavated to examine walls in cross section. Approximately 14-37 cm of fill was excavated from units in one to three levels, and all excavated fill was screened.

Excavated fill was generally comprised of sandy silt to silty sand, variably brown to reddish-brown throughout most of the structure, with darker grayish-brown material filling the main room. Inclusions of charcoal and small gravels were noted throughout; more concentrated patches of dark gray to black charcoal-infused and oxidized soil were also present. These darker materials were concentrated in the main room of the structure. Burned material was primarily concentrated in and around the hearth where a considerable amount of ash appeared to have been left on the floor around the well-used hearth.

In general, there was little indication in the fill or on the floor that the structure was destroyed by fire; rather, the fill appeared to represent unburned structural debris. In the main room, this debris appeared to have mixed with the burned refuse around the hearth. Overall, the lowest portions of Feature 329 were fairly well preserved. The impact of bioturbation on this feature was minor; similarly, the

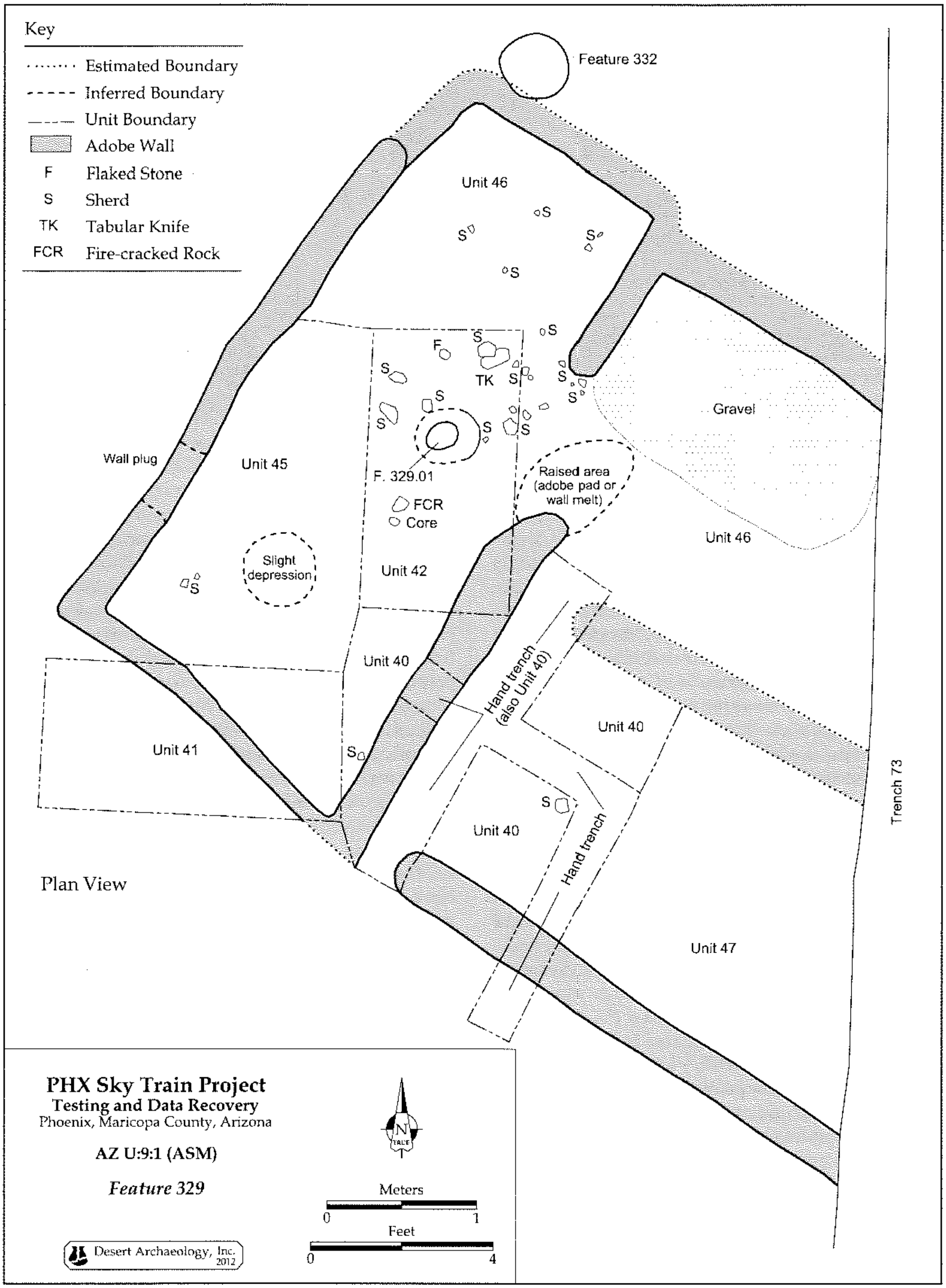

Figure 9.8. Plan view of Feature 329, Area 3B, PHX Sky Train project.

Figure 9.9. Photograph of Feature 329, Area 3B, facing east, PHX Sky Train project.

later intrusion of pit Feature 332 was a minor disturbance (see Figure 9.8). Truncation of the feature's remains through later near surface/upper level disturbances was the main impact on the feature.

While Feature 329 was an adobe-walled structure, the main room of the structure had been slightly excavated into the underlying natural substrata, which here, consisted of sandy silt alluvial deposits. The long western wall and the shorter northern wall of the main room were relatively thin and appear to be backed by natural sediments; that is, the base of these walls appeared more likely to be thickly adobe-lined pit walls than the heavier footers of freestanding adobe walls. Similarly, the short southern wall of the main room was lightly built and may have been supported at the base by a low pit wall. It was the easternmost walls of the structure that were more massive. Likely due to the arrangement of surrounding occupational spaces, these walls appear to have been freestanding. The structure did not appear to have filled with large amounts of adobe wall melt, suggesting the upper reaches of the walls were more lightly built, although no postholes were observed to indicate Feature 329 used any jacal-like construction techniques.

The walls themselves appeared to be constructed of a very compact, dense clay loam adobe. In cross section, the material appeared massive and uniform, with no obvious indication of coursing. The freestanding eastern walls began in a shallow (≤ 5 cm deep) footer trench, creating a simple basin-shaped cross section at the base of the walls (Figure 9.10). As mentioned, the adobe in many of the walls surrounding the main room may line a low pit wall. Unfortunately, these walls were not preserved to a height that would allow a determination of how the walls would have continued above the prehistoric ground surface. None of the walls were preserved to a great height. The maximum preserved height of any wall above floor surface was 27 cm, while the average preserved height was more often in the range of 10-20 cm.

The floor of the structure was not plastered, although its surface was hard and very well compacted. Construction of the adobe superstructure may have contributed a certain amount of finer silt-clay material to the area, leading to a floor that may have compacted better than the natural substrate alone might have.

The position of the hearth and entry within the main room suggests the structure may have been oriented to the east-southeast, although the room itself opens into an inadequately defined room or a partially enclosed space. While entry to the main room of the structure was through the north-central portion of its eastern wall, it is unclear how the overall structure was accessed. An exterior eastern wall to the larger structure was not present. It may have been obliterated by the excavation of Trench 73, otherwise rendered imperceptible (weathered or prehistorically disturbed), or it was never constructed. The northern wall was roughly continuous, running along the main room of the structure and partially enclosing a space beyond. Likewise, the western (northwestern) wall also appeared continuous except for a small possible breach near the westernmost corner. The interior of this wall was well preserved and relatively uniform except a small (approximately 50 cm) gap that seemed slightly disturbed, or at least texturally different.

This disturbance suggested a previous entry may have been plugged, although it is also possible this portion of the wall had merely been repaired. Interestingly, there was a small depression just inside the structure near this possible breach, suggesting the potential for a hearth, although there were no obvious signs that this depression had ever functioned in this fashion. The presence of a plugged second entry would, of course, suggest possible remodeling of the structure. It was only the southern wall that possessed a very narrow, approximately 30-cm-wide breach just outside the southeastern corner of the main room. Similarly, the central wall was not attached to the main room (see area of the western hand trench in Figure 9.8). Together, these two gaps form a very narrow corridor between the entry of the main room and the area outside the structure to the southwest. This seems a very narrow passage through which to enter the heart of the structure, but it may not have been the only point of entry. Regarding the entry of the main room, it appeared

Figure 9.10. Close-up cross-sectional view of the front (eastern) wall in the main room of Feature 329, Area 3B, facing west, PHX Sky Train project.

to be a simple opening, possibly with a very slight (2-cm-high) step, a pad of adobe, down into the room. While the pad might have been an intentional construction, reinforcing the passageway in and out of the room against wear and tear, it might also simply have been unintentional slop from wall construction or later adobe melt. Regardless, the adobe pad did not extend across the entirety of the opening to the room.

East of the main room, the walls of the structure appeared to at least partially enclose two additional spaces. These "rooms" did not possess well-preserved floors. Like the main room, the floor surface in each was not plastered; however, unlike the main room, neither floor was compacted. The surfaces exposed in these two spaces were more characteristic of extramural surfaces; that is, a surface subject to a considerable amount of cultural activity but also subject to rougher use (causing wear and tear), possibly open, and therefore, vulnerable to natural weathering. The floor in the northernmost adjunct room possessed an odd rectilinear patch of gravelly soil adjacent to the northern wall. It appeared as though a more gravelly natural substrate had been exposed during construction of the northern wall, or perhaps, later weathering exposed the underlying gravel. Regardless, there was no evident cultural reason for the gravel to be present.

No secondary features were exposed in either adjunct space, and no particular assemblage of artifacts was found to suggest what sort of activities might have taken place in these areas. Based on the character of these two spaces, this portion of the structure may not have been roofed. The apparent absence of an easternmost wall also suggests these spaces might not have been fully enclosed.

The hearth located in the main room, Feature 329.01, was the structure's only intramural feature. Although this clay-lined feature was not particularly well preserved, the fragments that remained suggested what had once been a well-prepared hearth. The hearth appeared to have once had a collar raised slightly above floor level, but this rim had been almost completely truncated to floor level through use. The base of the basin had lost almost all of its smoothed interior surface, and much of the fired clay lining at the base had been removed, likely through extensive use and repeated cleaning. The feature was filled with brown to grayish-brown silty sand that contained a considerable amount of charcoal, ash, and several ceramic sherds. The fill of the feature appeared to be in situ fill mixed with a certain amount of refuse and/or structural debris from the collapse of the house. As mentioned, a fair quantity of ash and refuse was distributed around the exterior of the hearth. The inhabitants of the structure took usable artifacts with them at abandonment, leaving this deposit of refuse around the hearth.

With little evidence of burning in the house fill, the structure may have simply collapsed after having been abandoned. The structure eventually filled with unburned structural collapse, although a fair amount of incidental refuse also was discarded in the area. Later, pit Feature 332 was excavated through the edge of the former structure.

Extramural Features

Feature 325

Feature 325 was a roughly elliptical basin-shaped pit. The feature was exposed during mechanical stripping of the area northeast of Feature 329. The pit measured 50 cm by 40 cm in plan, and was 18 cm deep. Pit walls were unprepared and unburned. The fill was compact brown clay loam containing a considerable amount of gravel; root and/or rodent disturbance was minor. This feature was initially bisected and profiled before being completely excavated. Fill from the western half of the feature was collected as a flotation sample, and the remainder was screened. Only three artifacts were discovered in the fill, two ceramic sherds and one marine shell fragment. Given its compact clay-rich fill and proximity to the adobe structure, Feature 325 might have been used as a pit for mixing adobe or clay plaster; an alternate function for the pit was not immediately apparent.

Feature 326

Feature 326 was a relatively deep rock-filled pit with an irregular shape (Figures 9.11-9.12). The feature was exposed during mechanical stripping on the eastern side of the adobe structure Feature 329. Feature 326 measured 1.00 m by 76 cm in plan, and 38 cm in depth. The pit was comprised of two adjoining depressions: one deep and circular and the other a shallow basin. The deeper portion contained numerous rocks and ended at a large flat stone with a slightly indented surface. The shallow area of the pit contained only a few pieces of stone. The rocks included unmodified stone (n = 19) and both broken and unbroken stone artifacts (n = 23), including flakes, shatter, cores, manos, handstones, lapstones, and metate and other ground stone fragments. None of the stones appeared thermally altered.

Although not located within the identified walls of neighboring Feature 329, Feature 326 may have contained a post that supported some element of the inadequately defined extramural space east of that structure. This possibility was suggested by the roughly circular arrangement of the fill rocks (chinking stones?) within the deeper basin, particularly near the top of the pit, along with the indented stone at the base (socket stone?). Alternately, Feature 326 may originally have been used for the same purpose as the double-basin pit represented by Features 333 and 334 to the northwest, but after this function ceased, was utilized to store or cache usable stone and artifacts. Alternatively, Feature 326 reflects both functions, the deeper pit held a post supported by the basal stone and surrounding chinking rocks, around which usable stone was stored. If a post had been present, it was clearly removed prehistorically, at which time, any stone tools cached at the side of the post could easily have slid into the abandoned pit or posthole. In sum, Feature 326 may have been a "pit" with two functions or originations, one as a posthole and the other as a cache.

Feature 332

Feature 332 was a small pit exposed during mechanical stripping above the northwestern corner of Feature 329 (see Figure 9.6). The pit was later found to partially intrude the adobe wall of that structure. Feature 332 was circular in plan, roughly 57 cm in diameter, with a steeply sloped basin, 22 cm in depth. It was filled with relatively uniform grayish-brown fine sand containing a moderate amount of fine gravel and pebbles. A few small pieces of charcoal were also noted in the fill, although there was

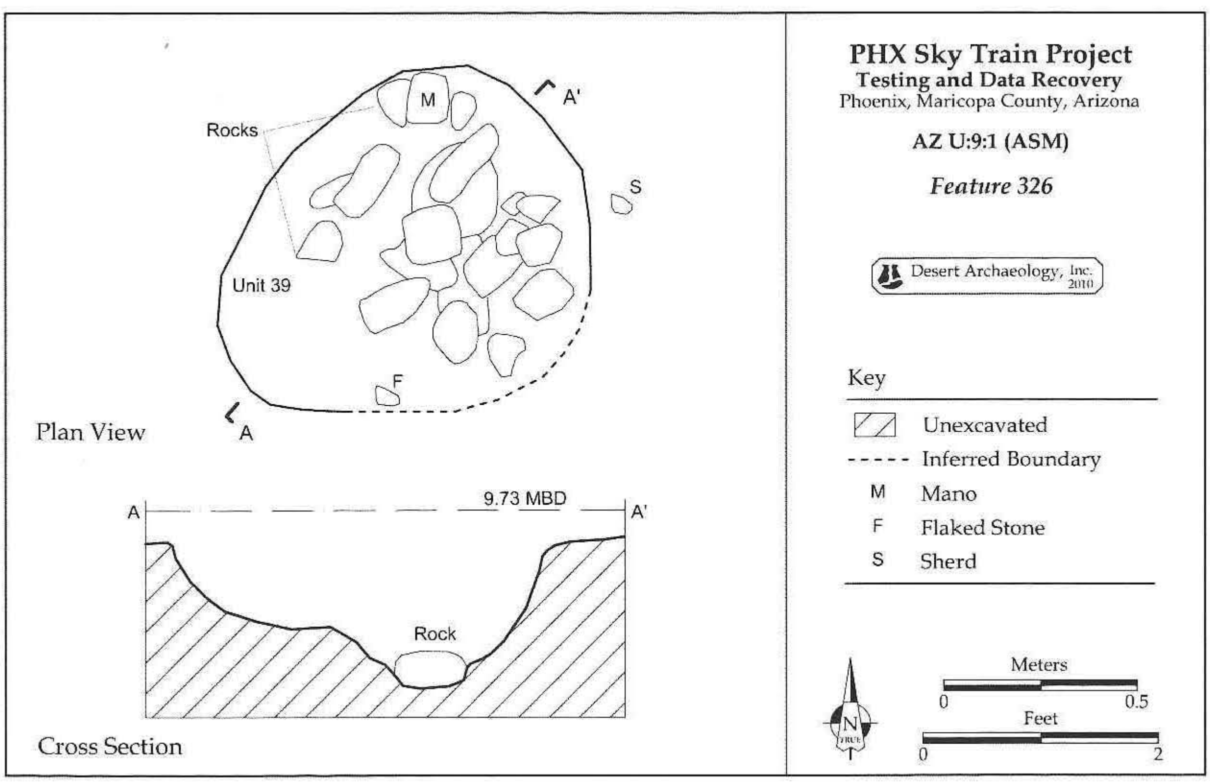

Figure 9.11. Plan view of Feature 326, Area 3B, PHX Sky Train project.

Figure 9.12. Photograph of Feature 326, Area 3B, after excavation, with roughly half of the recovered rock laid to the side, facing south, PHX Sky Train project

no evidence of in situ burning. Several large artifacts were recovered from the base and sides of the pit, including a mano, a ground stone abrader, a core scraper, a flake, and a plain ware sherd. The presence of potentially useful tools near the base of the feature suggests the items may have been stored in the pit. Alternatively, because several pits in the vicinity had cobbles at their base, it is possible the stone artifacts lined the base of the pit in a similar fashion. A final alternative is that the abandoned pit was filled with a small amount of trash that happened to include a few discarded tools.

Feature 333/334

Features 333 and 334 comprised an unusual double-basined pit; each basin was thinly lined with an unidentified material and had a large flattish cobble at its base (Figures 9.13-9.14). The feature was exposed during mechanical stripping northwest of Feature 329, and then designated as two features, as the fill of each was slightly different, and Feature 334 appeared to intrude on Feature 333 (see Figure 9.13). However, after excavation, it seemed as if the two features represented separate parts of a single pit. Similar to Feature 326, Feature 333/334 was comprised of two adjoining basins; here, however, each basin was distinct.

This distinction was made, in part, due to the strange lining of the pits. Each pit was outlined by a halo of light gray or whitish sandy soil. This sediment did not appear to be sand mixed with caliche or ash, although its texture was oddly granular. The granular texture was reminiscent of mineral build-up in sand, such as occasionally seen in leach fields. Approximately 10 cm of this material lined the pits and even formed a low wall between the two basins, which was why it initially appeared the smaller Feature 334 intruded on the larger Feature 333 when, in fact, Feature 334 was a slightly elevated basin within a larger pit. The slight wall of lining material also allowed the fill of each basin to be slightly different in composition, which added to the illusion that one part of the feature intruded on the other. A large flattish cobble (30-40 cm diameter) was intentionally "inlaid" in the bottom of each basin, with its flattest surface facing up. Thus, all that would have been seen of these large cobbles was a relatively flat stone surface nearly flush to the base of each basin. The pit lining surrounded the inset cobbles, but was not present beneath them, indicating application or build-up of the lining after the cobbles had been set.

Overall, the Feature 333/334 pit, including the lining, measured roughly 1.7 m in length and 1.1 m in width in plan view. The side walls of the basins were steeply sloped. Feature 333, the western basin, measured 90 cm by 70 cm in size and 38 cm in depth; this basin was filled with grayish-brown sandy silt. Feature 334, the eastern basin, measured 1.03 m by 75 cm in size and 29 cm in depth; this basin was filled with brown fine silty sand. The fill of each basin contained some small pieces of caliche, burned earth/adobe fragments, and minor charcoal flecking. Artifact density was high on both sides of the feature. Artifacts from the pit(s) included ceramic sherds, flaked stone debitage, cores, a few pieces of ground stone, and a tabular tool blank. Judging from the high density and condition of artifacts, it appears that, once abandoned, this feature was filled with discarded refuse.

Feature 337

Feature 337 was a pit originally defined as a small canal or ditch. Identified in both walls of Trench 73, the basin-shaped feature exhibited loosely banded stratigraphy comprised of alternating bands of gravelly silt and clay loam. Mechanical stripping of the area revealed the feature was not linear, but rather, a finite, irregularly shaped pit or depression. In the trench walls, the pit measured roughly 67 cm in depth and at least 1.70 m in width; the pit was not fully exposed in plan. Only a few ceramic sherds

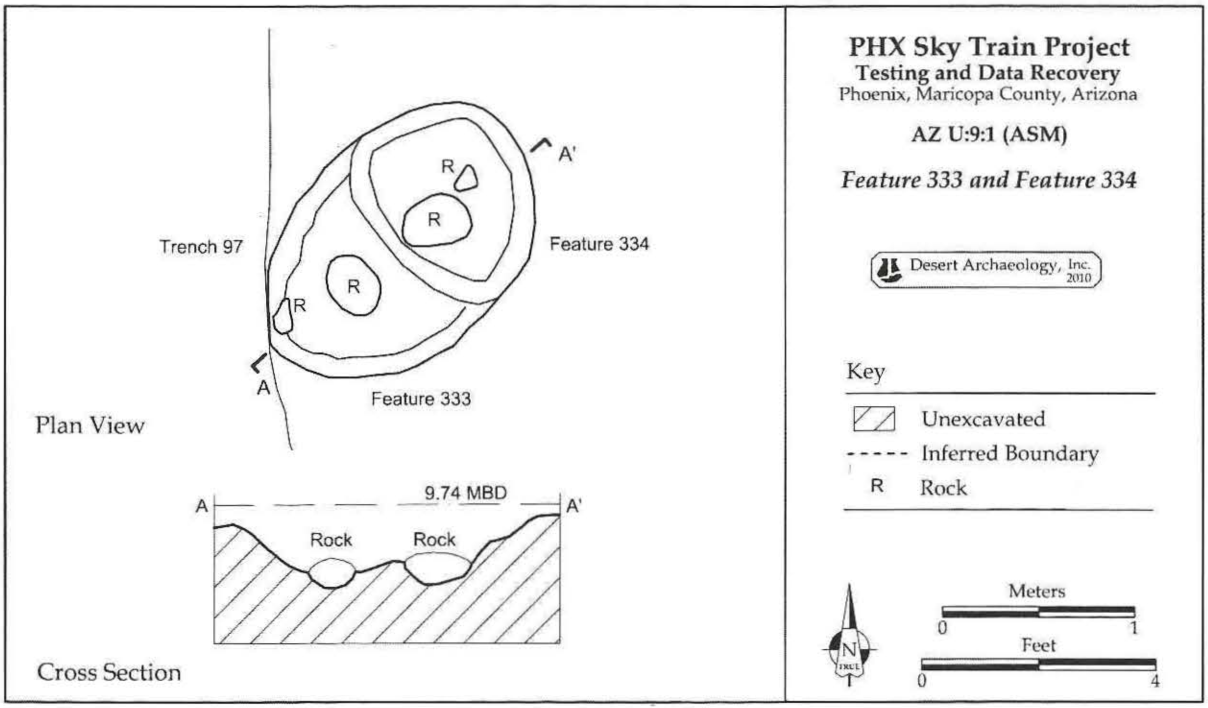

Figure 9.13. Plan view of Features 333 and 334, Area 3B, PHX Sky Train project.

Figure 9.14. Photograph of Features 333 (lower left) and Feature 334 (upper right), Area 3B, following excavation, facing north, PHX Sky Train project. (Note the discoloration of Feature 334's rim and basin.)

were noted in the pit fill. This pit may have originated as a borrow pit, which filled gradually through natural processes.

Feature 338

Feature 338 was a very tight concentration (25 cm diameter) of ceramic sherds, which included pieces that comprised approximately two-thirds of a plain ware bowl. The concentration was exposed during mechanical stripping east of pithouse Feature 318. No pit outline was discernible around the concentration of sherds. The overall depth of the deposit was roughly 15 cm. Because this collection of sherds derived from more than one vessel, the concentration seemed to represent a very discrete deposit of ceramic trash rather than a single broken vessel or pot-break.

Area Age and Activity

The substantial architecture of Feature 329, the variety of extramural features, and an abundant artifact assemblage indicate Area 3B was a permanently or semipermanently inhabited residential locus. Because no aspect of the associated ceramic assemblage indicated temporal depth, a short-lived occupation by a single large household is inferred. These aspects, in conjunction with the location of Area 3B at some distance from the main village of Pueblo Grande, allow the area to be characterized as a farmstead, as defined by Crown (1983). Occupation during the late Soho phase (A.D. 1250-1300) can be projected, based on the thick-walled adobe architecture and a ceramic assemblage that contained abundant quantities of Classic period red ware and very low numbers of Hohokam buff ware (none diagnostic), but no Salado Polychrome pottery (after Craig 1995). Although agriculture was undoubtedly a focus of activity for the residents of Area 3B, the types and forms of recovered artifacts indicate time was also spent in a variety of other tasks, some to meet routine domestic needs (food preparation, tool maintenance and manufacture, hunting) and others to possibly supplement the household economy (shellworking, fiber processing/spinning, pottery manufacture) (Chapters 10-14, this volume).

A singular activity is proposed for the curiously lined cobble-bottomed pits, Features 333 and 334. In their discussion of cobble-bottomed pits at Pueblo Grande, Mitchell and Merewhether (1994:98) mention 21 pits containing basal cobbles and having a whitish lining. They suggest these pits were used to process ground corn, observing that soaking or applying liquids to corn meal might account for the appearance of the "leached" lining. This idea has considerable merit, but instead, the authors of this chapter suggest it was dried maize that was soaked to create nixtamal, also known as hominy, or masa, when ground.

Preparation of nixtamal involves soaking and boiling or steeping dried maize in an alkaline solution. The alkali (wood ash or slaked lime) enhances some of the corn's properties, such as its flavor and nutritive value, as well as inducing a chemical change that allows the ground nixtamal to form a dough suitable for making tortillas; untreated corn meal will not form a dough.

Regarding Feature 333/334, a scenario is envisioned in which a large clay pot was rested on the basal cobble, water and hot stones were added, followed by dried corn kernels and wood ash. The mixture would be left to steep/soak overnight. The next day, the liquid would be drained and the corn rinsed several times. It is this process, either draining the liquid, rinsing, and/or removing the corn from the pot, that likely caused the formation of the "lining" on the walls of the pit. The pit would serve to retain heat during the soaking process and to contain some of the resultant spillage or overflow from handling the wet corn.

Contributing to the idea that Feature 333/334 was used to process maize into nixtamal/masa is the occurrence of two comal fragments in the Area 3B ceramic assemblage. In turn, comales, griddles used to cook flat breads, imply the appearance of tortillas in the local diet. As observed by Haury (1945:110), the tradition of making flat breads with a comal was almost certainly imported from the south sometime during late prehistoric times. The presence of baking slabs in Area 3B suggests these flat breads had become a part of daily fare, possibly even a specialty food prepared by the area's residents to share with others.

AREA 5A

Area 5A was located on the northern side of canal Feature 3 in the south-central portion of Block 5 at the northeastern side of the PHX Sky Train project area (see Figure 2.5). The locus included four pithouses, Features 300, 301, 302, and 307; four prehistoric pits, Features 303, 304, 305, and 311; and a trash concentration, Feature 309 (Figure 9.15). The structures generally appeared lightly built, although most had relatively well-prepared caliche floors. Their entryways all appeared to face a common extramural area, suggesting a courtyard configuration. However, as discussed, the houses were not all occupied at the same time and use of the area was probably more transitory than the spatial configuration might imply. Diagnostic ceramics indicate this occupation or use occurred during the later Sacaton or earlier Soho phase, circa A.D. 1050-1175.

Architecture

Feature 300

Feature 300 was a small house-in-pit style structure (Figure 9.16), first identified in both faces of Trench 25 as a thin caliche-rich surface with a few associated artifacts. Sediment overlying the feature was mechanically stripped to within 28 cm of the floor. The trench roughly bisected the feature area. A 1-m by 2-m control unit was placed on the eastern side of the trench; fill from this unit was excavated in two levels and screened through ¼-inch mesh. The remainder of the structure was exposed with the excavation of two additional units, one on either side of the trench. Fill from these two units was not screened; however, artifacts observed during excavation were collected.

While not well preserved, Feature 300 appeared D-shaped, with the presumed front of the structure being slightly flattened; an entry appeared to protrude toward the east. The pithouse measured 2.45 m in maximum length, 2.20 m in width, and had an area of 4.74 m^2, excluding the entry area. Centered along the eastern wall of the feature, the probable entry was defined by an irregularly shaped patch of caliche adobe that extended roughly 30 cm from the approximated front wall of the structure; this entry was estimated to measure up to 65 cm in width.

The floor of Feature 300 was lightly dished or basin shaped. It was lined with caliche-rich adobe that ranged from 4 cm thick at its edges to 1 cm thick

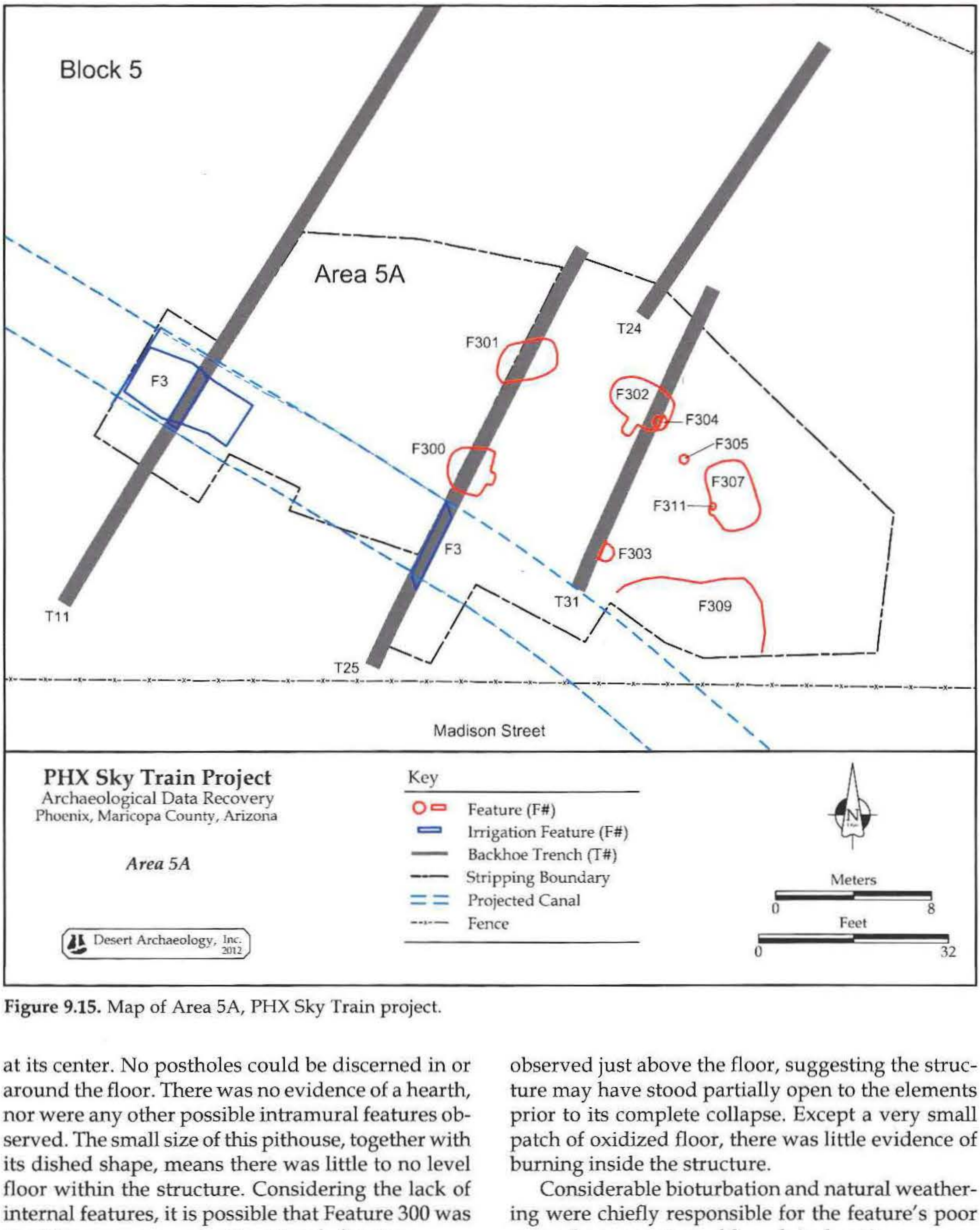

Figure 9.15. Map of Area 5A, PHX Sky Train project.

at its center. No postholes could be discerned in or around the floor. There was no evidence of a hearth, nor were any other possible intramural features observed. The small size of this pithouse, together with its dished shape, means there was little to no level floor within the structure. Considering the lack of internal features, it is possible that Feature 300 was used for some purpose other than habitation.

The feature was generally filled with brown, compact, fine sandy silt lightly flecked with charcoal and containing small amounts of fine or pea-sized gravel and caliche granules. This fill was barely distinguishable from the surrounding strata. A very thin slip of water-lain sediment was occasionally observed just above the floor, suggesting the structure may have stood partially open to the elements prior to its complete collapse. Except a very small patch of oxidized floor, there was little evidence of burning inside the structure.

Considerable bioturbation and natural weathering were chiefly responsible for the feature's poor state of preservation, although its location near canal Feature 3 may have exacerbated these impacts. Unfortunately, the depth of modern ground disturbance made it difficult to determine the temporal relationship of Feature 300 and canal Feature 3. However, neither the construction nor the operation of the canal appeared to have had an effect on the

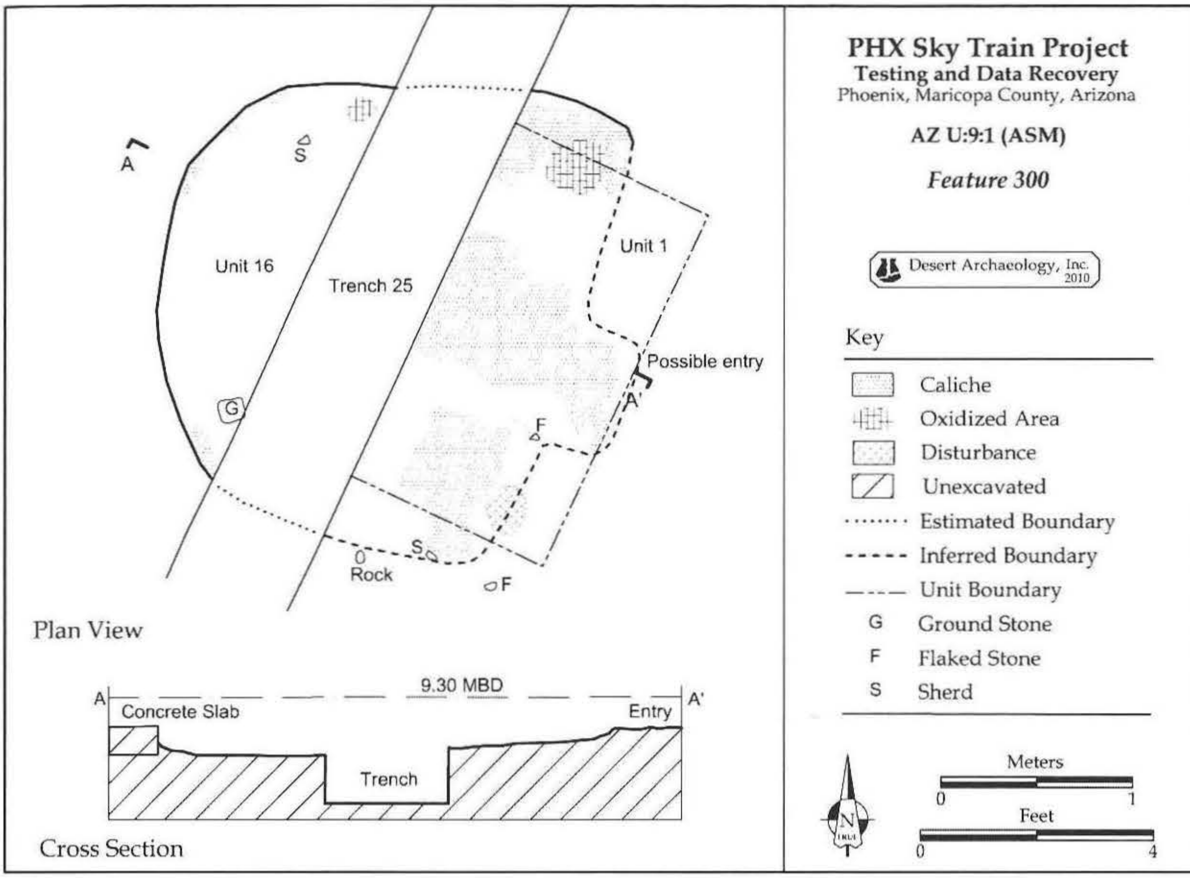

Figure 9.16. Plan view and cross section of Feature 300, Area 5A, PHX Sky Train project.

structure. While a thin skim of water-lain sediment was observed just above the floor of Feature 300, this did not appear to be canal sediment. However, it remains possible that backdirt from the initial construction of the canal could have capped the remains of the structure. A large slab of modern concrete was buried at the western edge of Feature 300 (see Figure 9.16), but fortunately, it missed intruding the structure.

The quantity of recovered artifacts was relatively small, although a variety of artifact types was represented within the small assemblage. For example, a bone awl fragment and a shell bead were collected, in addition to small quantities of ceramic, flaked stone, and ground stone tools and debris. A mano was the only whole artifact found on the floor. While Feature 300 was not trash filled and it largely lacked a floor assemblage, either a small amount of refuse had been left behind at the time of abandonment, or it was discarded in the feature shortly thereafter. After abandonment, the structure may have stood open briefly before simply collapsing, filling the house pit with unburned structural debris. The remaining slight depression may have accumulated a small amount of incidental refuse.

Feature 301

Feature 301 was a poorly preserved, house-in-pit style structure (Figure 9.17) first identified in both faces of Trench 25. Sediment overlying the feature was mechanically stripped to within 25 cm of the floor surface exposed in the trench. A 1-m by 2-m control unit placed on the eastern side of the trench was excavated to the floor in two screened levels. Because few artifacts were recovered from the unit and the outline of the structure was still not visible, the area of Feature 301 was again mechanically stripped to within 10 cm of the floor. Although still not exhibiting a clear outline, the remainder of the structure was exposed by hand-excavation of two additional units, one on either side of the trench. Fill excavated from the unit on the eastern side of Trench 25 was screened, while fill from the unit on the western side of the trench was not screened. All observed artifacts were collected.

Feature 301 appeared to be an oblong structure roughly 3.30 m long, 2.17 m wide, and covering an area 5.38 m^2 in size. An entry to the structure was not preserved. However, excavators conjectured it may have been oriented toward the south, given that

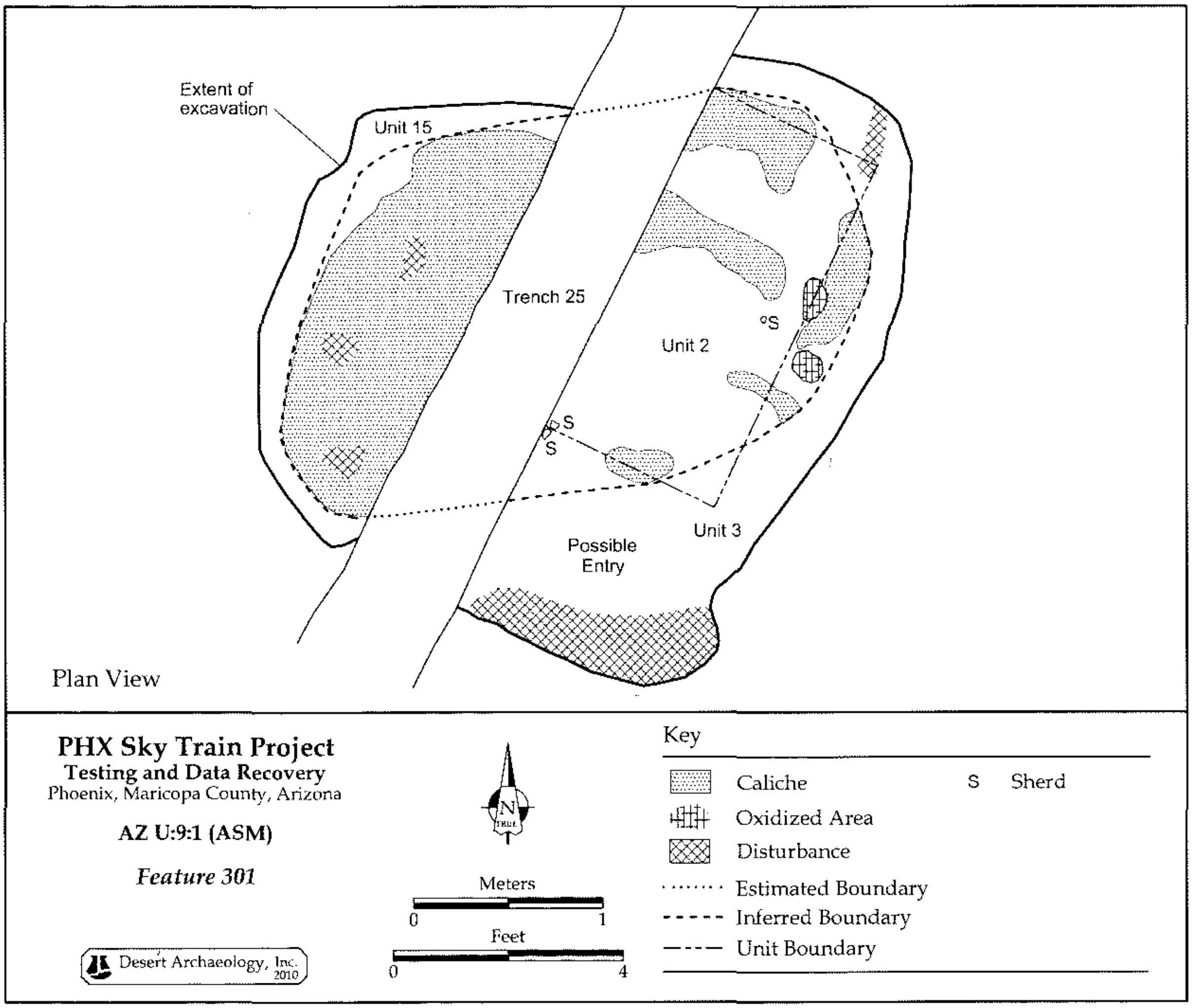

Figure 9.17. Plan view of Feature 301, Area 5A, PHX Sky Train project.

the northern edge of the floor was comparatively easy to distinguish, appeared relatively intact, and had no northward protrusions suggesting an entry. In contrast, the southern edge was difficult to distinguish; therefore, any entry, if present, could also have been obscured. Note that this conjecture assumes the entry would have been positioned along the long axis of the structure, as is common among Hohokam pithouses.

Patches of floor materials were widespread across the structure, although the surface itself was in poor condition. The entire floor had once likely been lined with a caliche-rich adobe that measured at least 1 cm in thickness. Some patches of floor showed signs of burning; these oxidized patches were somewhat better preserved. No postholes could be discerned in or around the floor. There was no evidence of a hearth or any other possible intramural features.

While small in size and lacking internal features, Feature 301 was likely more habitable than Feature 300, being at least somewhat larger and possessing a level floor. However, as with Feature 300, this small structure may have been used for some purpose other than habitation.

The house fill was light brown, moderately compact, sandy loam with some small gravel inclusions; light charcoal flecking was present throughout. In general, this fill was not unlike the surrounding natural sediment. An increase of charcoal and ash just above the floor, together with occasional oxidized patches of floor material, suggested Feature 301 may have been destroyed by fire, although this burning may not have been particularly intense. There was no obvious evidence of other burned materials in the fill, such as oxidized soil or burned daub, perhaps suggesting the superstructure of Feature 301 might have leaned more heavily on brush for its construction.

Considerable bioturbation and natural weathering were chiefly responsible for the poor state of preservation of the feature. Regarding modern disturbances, during the course of excavation, the site was looted after working hours. A number of floor artifacts that had been left in situ across the site were gouged out of floors by the vandals, who dislodged the artifacts and probed underneath, presumably seeking reconstructible vessels and other "valuables." The vandalized materials were almost exclusively floor contact sherds, most of which were tossed aside but still present, while others were missing, either stolen or tossed farther afield. From the Feature 301 floor assemblage, one sherd and a piece of schist were exposed on the floor when the vandals struck; both went missing.

Artifact density and diversity were low to moderate throughout the feature. Excavation of Feature 301 yielded primarily ceramic sherds, although smaller amounts of flaked stone debitage and a shell fragment were also collected. A few artifacts were in direct contact with the floor: four plain ware sherds and an unmodified piece of schist. As mentioned, the schist and one of these sherds were lost to looting.

The inhabitants of Feature 301 left behind no usable artifacts at the time of abandonment. A small amount of trash may have been discarded in the structure prior to its collapse. The structure was destroyed by a fire of sufficient intensity to partially oxidize the interior of the structure and likely cause the collapse of the superstructure. After the burned and unburned structural debris settled, the slight depression that remained accumulated a small amount of refuse.

Feature 302

Feature 302 was a small house-in-pit style structure (Figure 9.18) initially identified as a thin caliche-rich surface in both sides of Trench 31, southeast of pithouse Feature 301. Sediment overlying the structure was mechanically stripped to within 10 cm of the floor seen in the trench profile. A 1-m by 2-m control unit placed on the western side of the trench was excavated in two levels, and fill was screened through ¼-inch mesh. The remainder of the structure was exposed using two additional units, one on either side of the trench. Like the control unit, the western unit was excavated in two levels and screened. A very small portion of Feature 302 remained east of the trench, where it was also intruded upon by a small pit, Feature 304. This intrusive pit was excavated prior to exposing the remainder of the pithouse. After the pit excavation was complete, the remaining east-side house fill was excavated in two unscreened levels. Any artifacts observed during this excavation were collected.

Feature 302 was an oblong to subrectangular structure measuring roughly 3.55 m in length, 2.25 m in width, and covering an area of 6.34 m^2, excluding the perceived entry. Definition of this entry was not certain. A compact "dirty" surface with small traces of caliche and a few flat-lying sherds just beyond the outline of the structure's floor suggested that a generally unprepared, low-ramped entry protruded away from the structure there. The possible entry was centrally located along the southwestern wall, where it occupied an estimated area 80 cm long and 60 cm wide.

The floor of the structure was in poor condition, especially along the northern side, but still appeared to have once been lined with caliche-rich adobe averaging 3 cm in thickness (Figure 9.19). In the eastern half of the structure, where preservation was generally better, three similarly sized postholes (9 cm average diameter) and a length of floor groove were identified along the periphery of the prepared floor. Where discernible, the groove ran an estimated 1.9 m length and measured roughly 10 cm in width. Unfortunately, no additional postholes or construction elements could be discerned in or around the floor.

No evidence of a hearth was observed, although a single intramural pit, Feature 302.01, was identified just west of center inside the structure. The pit had been excavated through the caliche floor into the natural substrate beneath. While the pit was originally considered a potential hearth or central post, excavation revealed a small, shallow, dish-shaped pit, measuring 30 cm in diameter and 9 cm in depth. With no evidence of preparation or in situ burning and fill very similar to the rest of the structure, Feature 302.01 appeared to be a simple pit. Alternatively, the pit could have functioned as a potrest.

The pit contained no artifacts, and, given the similarity in fill, the pit likely stood empty when the structure was abandoned and only filled when the structure collapsed. Of the structures in this area, Feature 301 and Feature 302 are most similar to one another. Like Feature 301, Feature 302 was small but still probably represented a habitation structure. While these features appear to represent "houses," the lack of hearths and the dearth of intramural features suggest these structures may not have been intensely inhabited.

The house pit fill was light brown, moderately compact, silty sand with some small gravel inclusions. Sparse charcoal flecks and caliche granules were also present; these were more notable near the floor of the structure and were likely the result of disturbed floor becoming mixed with the house fill through bioturbation. There was no evidence the structure burned, either in the fill or on the floor of the structure. Considerable bioturbation and natural weathering were primarily responsible for the

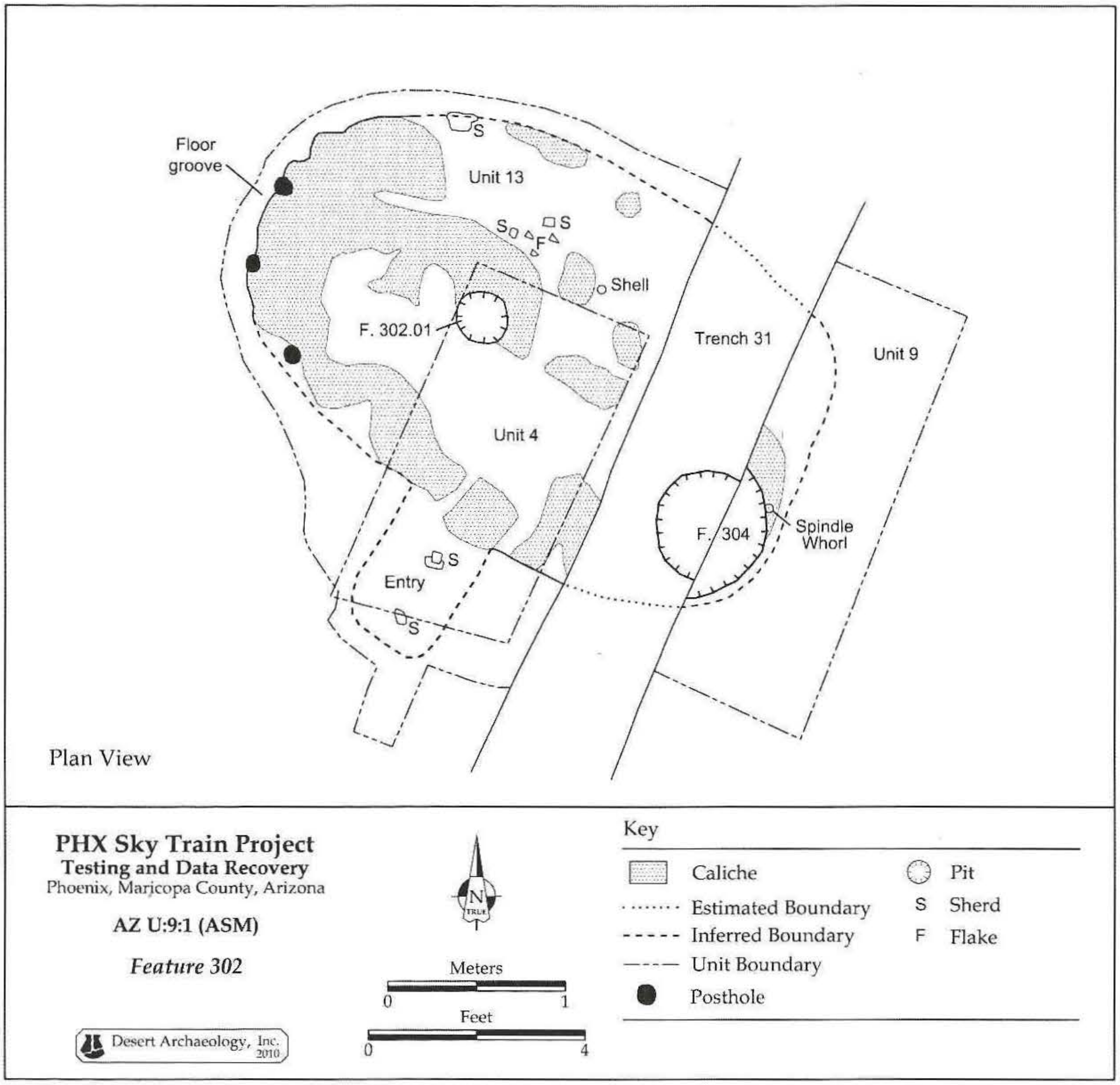

Figure 9.18. Plan view of Feature 302, Area 5A, PHX Sky Train project.

poor state of preservation of Feature 302; the intrusion of pit Feature 304 was a comparatively minor disturbance.

The density and diversity of artifacts recovered from this feature were relatively low. Material collected consisted primarily of ceramic sherds, flaked stone debitage, and a few freshwater shell fragments. A small number of artifacts were found on the floor of the structure, which appeared to represent incidental trash, except a modeled ceramic spindle whorl recovered from the eastern floor near intrusive Feature 304.

Generally speaking, the inhabitants of the structure left behind no usable artifacts at the time of abandonment but may have left an incidental amount of refuse on the floor or a small amount of trash may have been discarded in the structure prior to its collapse. The still usable spindle whorl found on the floor of the structure may have escaped the notice of departing residents. The structure was not destroyed by a fire, but rather, appears to have simply collapsed, filling the house pit. After the unburned structural debris settled, the slight depression that remained may have accumulated a small amount of refuse. Later, pit Feature 304 was excavated through the remains of the collapsed structure.

Feature 307

Feature 307 was a house-in-pit style structure (Figures 9.20-9.21) initially encountered at the edge of a mechanically stripped unit being used to ex-

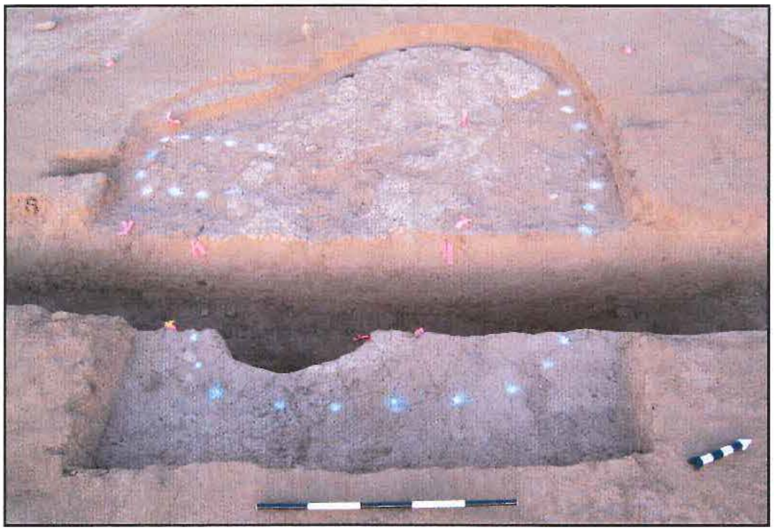

Figure 9.19. Photograph of Feature 302, Area 5A, facing just north of west, PHX Sky Train project. (Note the thick caliche floor exposed in the trench cut. White spray-painted dots outline the poorly preserved edges of the pithouse floor and entryway.)

plore the substrate north from the trash concentration Feature 309. Once seen, the strip unit was discontinued, and mechanical stripping was then used to remove overlying sediment to within 15 cm of the exposed floor. House fill in a 1-m by 2-m control unit placed north of the strip unit edge was subsequently excavated in two levels and screened through ¼-inch mesh. This unit revealed a continuous floor surface and a hearth, Feature 307.01. The remainder of the structure was subsequently exposed with two additional units, one on either side of the control unit.

Excavation of the northwestern unit began as a short hand-trench (see Figure 9.20), designed to aid in further defining the limits of the structure. Like the control unit, the northwestern unit was excavated in two screened levels. The small portion of Feature 307 that remained southeast of the control unit was excavated in a single level, and the excavated fill was not screened; any artifacts observed during excavation were collected. A pit, Feature 311, was identified during the course of excavation. It was determined to be intrusive, and was excavated separately.

Well prepared and relatively well preserved, Feature 307 was a subrectangular pithouse measuring roughly 3.65 m in length, 2.40 m in width, and 7.64 m^2 in area. An entry to the structure was not preserved, although an orientation toward the southwest is speculated based on the location of hearth. The floor was almost entirely lined with a caliche-rich adobe that averaged 3 cm in thickness. The floor exhibited a few burned or oxidized patches, but generally, the house appeared unburned. Although not excavated, a probable posthole near the center of the pithouse may represent a central roof support. No other postholes were discerned in or around the floor. Possible small wall posts along the edge of the floor were noted; however, none of these could be confirmed due to rodent disturbance and the degraded edge of the caliche floor.

Feature 307.01 was a nicely plastered hearth with its clay lining extending roughly 10 cm away from the rim of the basin. The hearth lacked a formal raised collar, although the rim of the basin was slightly elevated ($\leq$ 2 cm) to just above the level of the floor. The transition from rim to floor level was smooth. The hearth was oxidized, but not heavily. It was also not heavily worn. Although the clay lining of the hearth was smooth, it apparently had been shaped with a rounded object, possibly an egg-sized pebble, which left a honeycomb pattern of rounded impressions, or "dimples," that gave the hearth basin a faceted appearance. The care with which these dimples were arranged suggests the patterning was intentional. Whether these impressions were intended to be decorative or functional is not known; however, it was difficult to deny the visual appeal of the technique. The hearth was filled with ashy, grayish-brown fine sandy silt; no artifacts were contained in the fill.

The location of the hearth in the structure, roughly centered near the western wall, suggested the orientation of Feature 307 was toward the southwest. Unfortunately, a small intrusive pit, Feature 311, coincided with the location where the entry was expected (see Figure 9.20). Although clear evidence of an entry was lacking, slight protrusions of prepared floor near Feature 311 hinted that the entry might have been located there. Considering the edge of the floor was otherwise relatively well defined and showed no other obvious signs of giving way to an entry elsewhere, it seems safe to presume that entry was gained through the disturbed western wall, even if the exact location is uncertain.

Except the hearth, no other intramural features were recorded. However, the unexcavated intramural feature recorded as a posthole could have been a small intramural pit, as was the case in Feature 302, Feature 302.01.

Feature 307 was filled with uniform light brown sandy silt containing a small amount of charcoal flecking. No structural debris was noted within the fill. Relative to other features in Area 5A, artifact density was high, implying the house pit had been

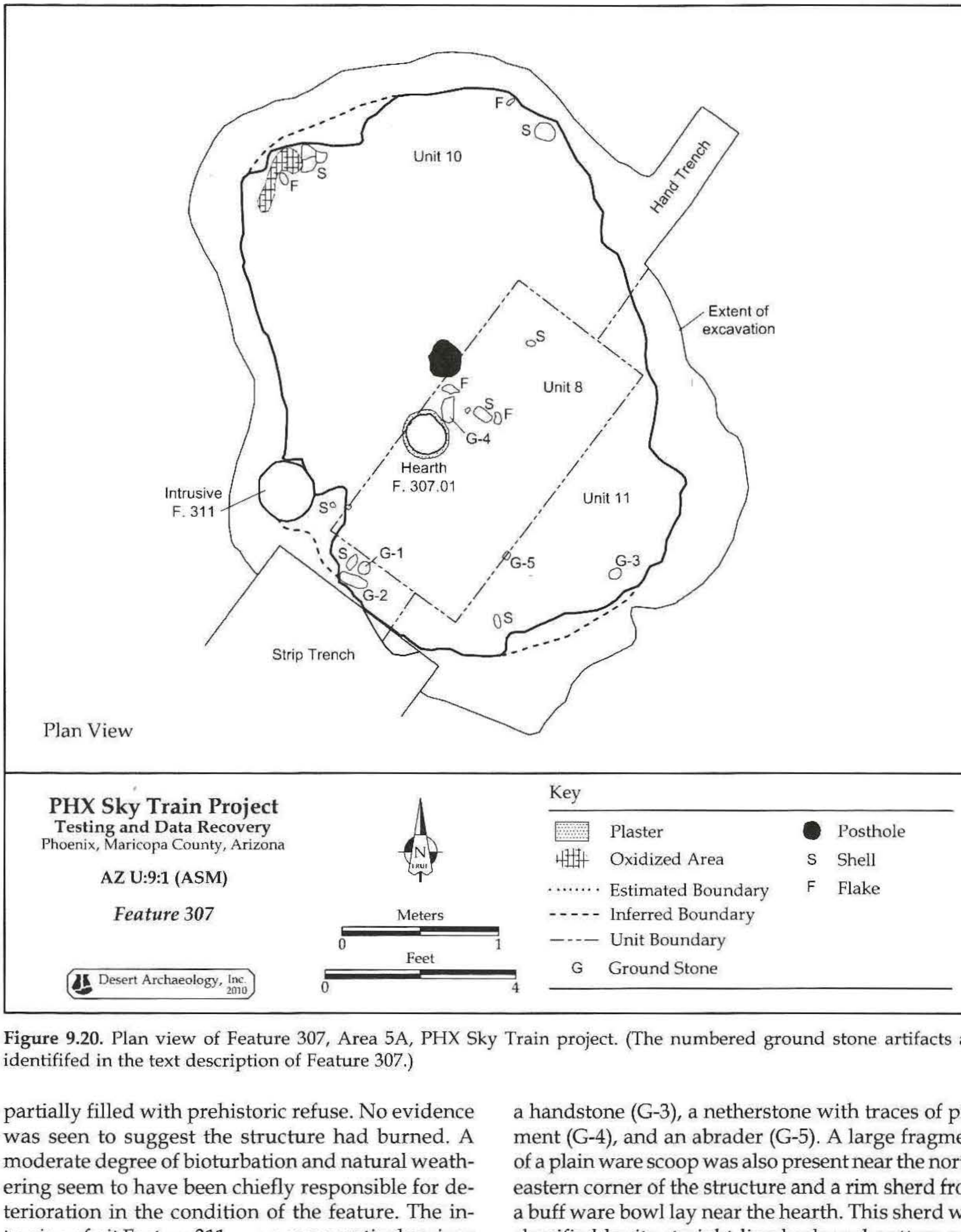

Figure 9.20. Plan view of Feature 307, Area 5A, PHX Sky Train project. (The numbered ground stone artifacts are identififed in the text description of Feature 307.)

partially filled with prehistoric refuse. No evidence was seen to suggest the structure had burned. A moderate degree of bioturbation and natural weathering seem to have been chiefly responsible for deterioration in the condition of the feature. The intrusion of pit Feature 311 was a comparatively minor disturbance.

Beyond the artifacts noted in the fill, several artifacts were present on the floor of the structure (see Figure 9.21). Most notable among these were a number of usable ground stone artifacts, including two polishers (G-1 and G-6 in Figure 9.20), a mano (G-2), a handstone (G-3), a netherstone with traces of pigment (G-4), and an abrader (G-5). A large fragment of a plain ware scoop was also present near the northeastern corner of the structure and a rim sherd from a buff ware bowl lay near the hearth. This sherd was classified by its straight-line hachured pattern and separation of the design field from the rim as Late Sacaton or Casa Grande red-on-buff. However, that the sherd was from a bowl indicates it was more likely made during the late Sacaton phase, because Casa Grande Red-on-buff bowls are known to be extremely rare (Wallace 2001).

Figure 9.21. Photograph of Feature 307, Area 5A, prior to excavation of the hearth, facing northeast, PHX Sky Train project.

Feature 307 was the most substantial structure in Area 5A. Although not much larger in size than the other features, the quality of its construction and the presence of a hearth suggest a level of investment in this structure the others lacked. Despite this apparent inequality, Feature 307 was still a relatively small habitation structure. While the other structures could have been used for habitation, one or more of them may have been used for other purposes, perhaps by the residents of Feature 307.

The inhabitants of Feature 307 appear to have left behind a small number of usable artifacts at the time of abandonment. That usable tools were left suggests residents of the structure may have intended to return to it. However, the structure appears to have collapsed and buried the tools contained within, a double loss for any returning resident. After the structural debris settled, the depression that remained seems to have been used for refuse disposal. A pit was later excavated through the remains of the collapsed structure.

Extramural Features

Feature 303

Feature 303 was a small pit overlain by a lens of sheet trash. The feature was initially seen in the eastern face of Trench 31 and then thought to possibly be an extramural surface. A 1-m by 2-m control unit was used to explore the feature. After the pit outline became apparent, it was excavated separately, and all fill was screened through ¼-inch mesh. Outside the pit, the control unit revealed heavy rodent disturbance and thinly scattered artifacts.

Feature 303 had steeply sloping sides that curved sharply to a flat bottom and that was probably circular in plan prior to being cut by Trench 31. It measured 85 cm along the trench face, extended 60 cm away from the trench, and was 54 cm deep. The pit was filled with uniform brown silt that had been heavily disturbed by rodent activity. There was no evidence of in situ burning, although a small concentration of ash was noted in the central part of the pit. Most artifacts, primarily ceramic sherds, were recovered from near this small ash concentration. The size and shape of Feature 303 suggests it might have originally been dug for use as a storage pit (see Henderson 2003a:246-248). The perceived surface around the top of this pit may reflect this activity; that is, the surface might have developed as a result of foot traffic from residents accessing the pit. After this function ceased, Feature 303 appears to have been used for trash disposal.

Feature 304

Feature 304 was a deep pit that intruded pithouse Feature 302. It was initially identified in the eastern side of backhoe Trench 31 along with the floor of the pithouse. After the pit outline became apparent during mechanical stripping above the house, it was excavated separately. To expedite its excavation, the fill was not screened, although artifacts, of which there were very few, were collected as encountered. A lens of carbonized material near the base of the pit was collected as a flotation sample.

Feature 304 was circular in plan with sides that sloped steeply inward from an 81-cm-diameter top to a 55-cm-diameter base, forming a conical pit with a flat bottom. The pit appeared to be filled primarily with redeposited house fill and structural debris, which included pieces of the caliche-rich floor material. The structural debris was mixed with light gray-brown, compact, silty sand with inclusions of small gravel and small pieces of charcoal. A considerable amount of rodent activity in the feature was the primary source of disturbance. A few small sherds and pieces of flaked stone were collected; these likely derived from the fill of the house through which the pit was dug. The base of the pit contained a layer of caliche floor fragments and a large red ware sherd; the placement of this material seemed intentional. Above this "lining," a 2- to 3-cm-thick lens of fine carbonized material was present. Additionally, fill near the charcoal lens appeared heat-affected. With at least some evidence of in situ burning, it appears this pit may have functioned briefly as a roasting pit. Perhaps the pit was an impromptu construction with pieces of floor material and sherds used in lieu of rock to line the pit and retain some heat. Analysis of botanical material recovered from the carbon lens revealed a maize cupule, an agave heart fragment, and ocotillo wood fragments were present. Maize and agave were both prime food choices for roasting. The ocotillo was likely used as fuel, producing the noted fine carbonized lens.

Feature 305

Feature 305 was a circular, basin-shaped puddling pit located between pithouse Features 302 and 307. The pit measured roughly 44 cm in diameter and 5 cm in depth. The feature was exposed during mechanical stripping, which, along with modern disturbances, likely truncated the feature to some degree. The pit was lined with approximately 3-5 cm of a caliche-rich material, similar in composition to the floor material seen in all structures in this area. The pit may have been used to prepare or mix the floor material. Alternatively, it may have been a lined extramural pit, perhaps a basin to hold foodstuffs during processing or preparation. The remainder of the pit was filled with a brown compact sandy loam containing a moderate amount of fine gravel, very similar to the surrounding stratigraphy. The small amount of fill excavated from the pit was not screened, although it was easily seen that no artifacts were present.

Feature 309

Feature 309 was a large amorphous area identified during stripping that seemed to be home to an above average amount of prehistoric refuse. Located between canal Feature 3 and pithouse Feature 307 (see Figure 9.15), this concentration of material may represent the area's local trash dump. In addition to collecting material during mechanical stripping, Feature 309 was also sampled with excavation of a 1-m by 2-m control unit. The overall size of the trash concentration was approximately 7.8 m by 4.0 m, and the deposit of refuse was likely around 39 cm in depth. Excavation of the control unit was initiated after some of the upper level material had been stripped away but roughly 31 cm of sediment was excavated in two screened levels. Although artifacts were found throughout the unit, the uppermost 20-25 cm of the unit contained the main deposit of artifacts, with lesser amounts of material below, likely resulting from a certain amount of mixing between the main trash deposit and the relatively sterile underlying alluvium.

Feature 309 was generally comprised of grayish-brown silt loam containing a moderate amount of pea gravel and charcoal flecking. Patchy areas with more intense charcoal flecking were noted, as were patches of oxidized soil, suggesting a certain amount of informal in situ burning also occurred in the area. However, the predominant characteristic of the feature was its above average artifact density. The area did not contain overwhelming amounts of material, but, compared with the relative dearth of material from the area in and around the neighboring pithouses, the quantity of material from Feature 309 was striking. Ultimately, Feature 309 likely contains refuse cleared away and discarded by the inhabitants of those nearby houses.

Pottery sherds were the most common artifacts in the Feature 309 assemblage, followed closely by flaked stone debitage. A few ground stone items were also present, including an open trough metate, an unfinished pestle, a polisher, and a piece of an incised tablet. Six Late Sacaton or Casa Grande red-on-buff sherds were included among the ceramics. All but one of these were from bowls, which, as discussed, implies that the sherds were more likely Late Sacaton Red-on-buff.

Feature 311

Feature 311 was a small pit identified during excavation of pithouse Feature 307, where it appeared to intrude on the entry of the structure. The pit was excavated separately from the pithouse, with its fill screened through ¼-inch mesh. Excavation revealed a roughly circular basin-shaped pit, measuring 40 cm by 35 cm in size and 29 cm in depth. The pit was filled with unconsolidated, gray, fine ashy silt very lightly flecked with charcoal. The pit contained a small number of artifacts: 6 sherds, 2 flakes, and 1 rabbit bone. Although containing some trash, the ashy fill and some minor evidence of in situ burning suggested that Feature 311 might have functioned as a parching pit or a little-used hearth.

Area Age and Activity

Area 5A included two more solidly built, though still relatively insubstantial, pithouses, Features 302 and 307, and two smaller, even less substantial pithouses lacking hearths, Features 300 and 301. A midden, a storage pit, and several other pits used to process various materials completed the feature inventory. Except Feature 307, which contained a moderate amount of trash, quantities of artifacts from the structures were no greater than that recovered from pithouse Feature 306 in Area 3A. The low artifact quantities, in conjunction with the insubstantial quality of the houses, implies their use as seasonal fieldhouses. Use as fieldhouses was also suggested by the palynological evidence (see Chapter 7).

Roughly contemporary, with some sequential use of the houses is indicated by diagnostic attributes of the ceramic assemblage and aspects of feature fill. Diagnostic buff ware ceramics, almost all classified as either Late Sacaton or Casa Grande style (Chapter 9, this volume), together with low proportions of buff ware and red ware, indicate a single component occupation during the Sedentary-Classic period transition, circa A.D. 1050-1175. Modest quantities of trash in pithouse Feature 307 implies it was abandoned prior to at least one or two of the other houses.

Attributes of Area 5A closely approximate the pattern documented by Henderson (2003a) in a study of Hohokam fieldhouses on the lower Salt River floodplain. The pattern consists of spatially proximate and contemporary pithouses, one larger, better constructed, and usually containing a hearth, and the other smaller and lacking a hearth. The form and content of the larger houses suggested their use as seasonal fieldhouse habitations; those of the smaller pithouses implied ancillary roles. A storage pit was often found near the pair of structures, suggesting this was also a component of the fieldhouse complex. There were cases in which fieldhouses presumed to be habitations had been built over one another or were situated closely enough to indicate their sequential use. Examples of this pattern were found throughout Canal System 2 across the time that fieldhouses were common. The picture that emerged was one of household-managed farms, at least among the pre-Classic Hohokam.

Although seasonal occupation is inferred at Area 5A, the presence of a midden suggests a relatively consistent presence while inhabitants used the farm site. During this time, it appears that residents engaged heavily in tool manufacture, possibly for use both on-site and in the fields, as well as in some part-time crafts, such as yarn spinning. Processing of plant materials also occurred; cotton, maize, agave, cactus, and field weed seeds were all represented among the botanical remains.

AREA 6B

The remaining excavated pithouses, Features 312, 313, 314, and 316, were located amidst the agricultural field systems west of Block 7 in the area designated 6B (see Figures 2.7 and 5.1). Feature 312 was a larger, moderately well-preserved pithouse, while the others were small and fair to poorly preserved. Preservation of features in this area was compromised by modern constructions, especially 43rd Street. Each of the three smaller houses also had a prehistoric irrigation ditch intruding through its fill, indicating the houses were abandoned prior to development of the local field system(s). Pithouse architecture in this area was generally insubstantial, implying all were used as seasonal fieldhouses.

Architecture

Feature 312

Feature 312 was a house-in-pit style structure (Figure 9.22) located near the northeastern corner of Block 6, west of 43rd Street. The edge of the hearth and a rough outline of the structure were exposed during mechanical stripping to reveal the system of small irrigation canals and field laterals identified in the area's trenches. Feature 312 was surrounded by small field laterals but directly impacted by none (see Figure 2.7); however, the structure was transected by a modern utility trench containing a small PVC line (Figure 9.23). The structure was exposed through the excavation of three shallow units; 1-8 cm of fill was excavated and screened through ¼-inch mesh. A 1-m by 2-m control unit was placed east of the intrusive utility trench, with the remainder of the structure exposed in two additional units, on either side of the utility trench.

Feature 312 was an indistinct, oblong structure measuring 5.55 m in length, 2.50 m in width, and covering an area of 12.11 m^2. The outline of the house was not clear, but the location of its hearth, Feature 312.01, and faint suggestion of an entry oriented the structure toward the north.

The floor was comprised of a compact fine sandy silt surface, light grayish-brown in color, and embedded with a few charcoal flecks and caliche granules. The floor appeared unburned. Partially due to the lack of preparation, the floor surface was not well preserved. Rodent activity had further disturbed much of the floor. Except the hearth, no intramural features or elements of construction were observed. A small fragmentary protrusion of compact surface north of the hearth was the only suggestion of a possible entry.

Feature 312.01 was a clay-lined hearth with a very low collar that extended roughly 10 cm away from the rim of the basin (see Figure 9.23). This collar was slightly elevated to just above the level of the floor ($\leq$ 2 cm), although the transition from collar to floor level was not well preserved. The interior of the

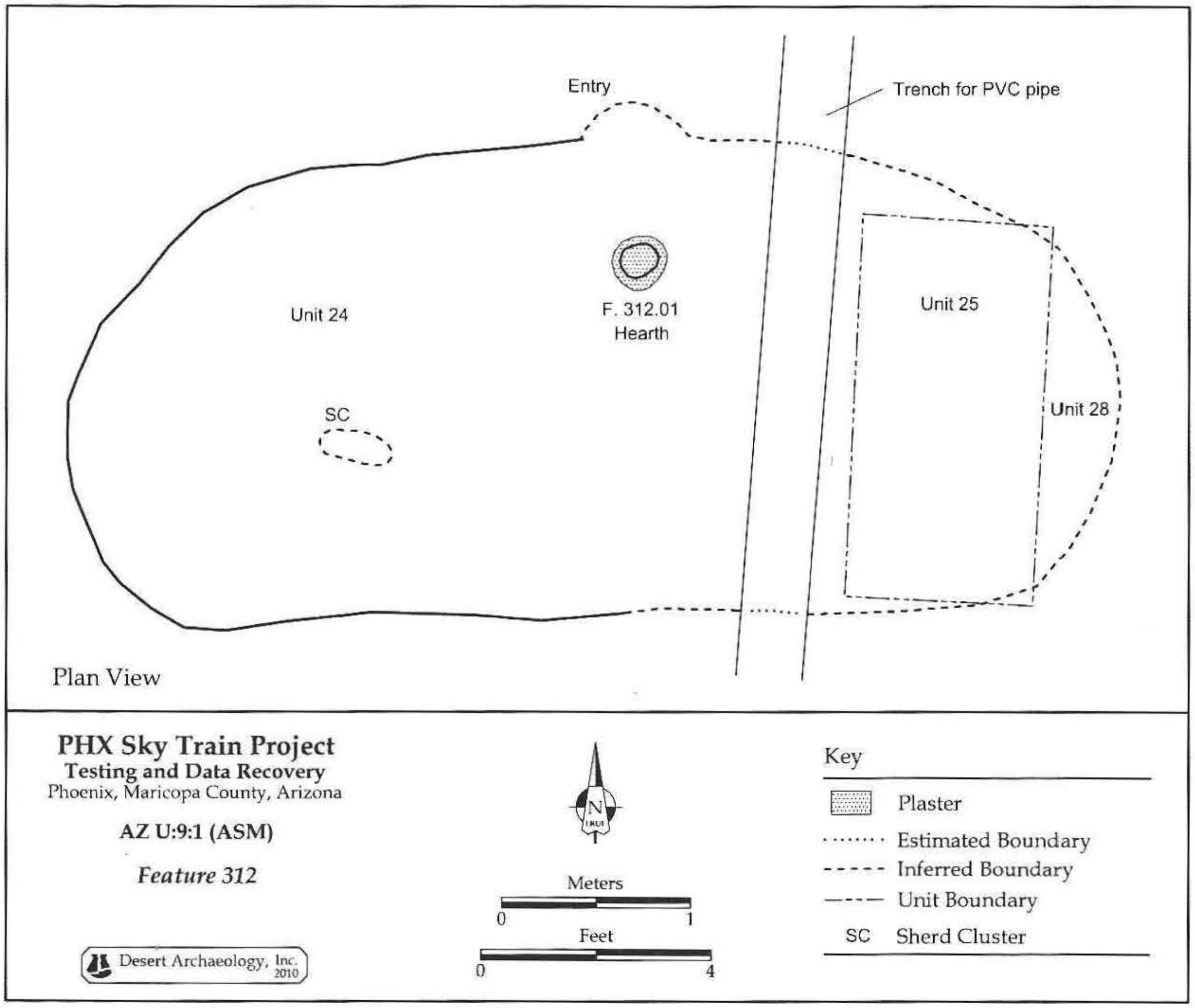

Figure 9.22. Plan view of Feature 312, Area 6B, PHX Sky Train project.

hearth was not particularly well smoothed, exhibiting a number of rough finger impressions, especially around the rim. Although the hearth was oxidized from repeated use, its interior was not heavily worn or damaged. The hearth was filled with general house fill, suggesting it had been cleaned out prior to the structure being abandoned.

Feature 312 was filled with a light grayish-brown sandy silt lightly intermixed with fine gravels and caliche granules. A few flecks of charcoal and small fragments of unburned daub were the only notable cultural inclusions observed in the house fill. There was no evidence on the floor or in the fill to suggest the house had burned. Artifact density in the fill was very low, with only a few ceramic sherds, pieces of flaked stone debitage, and *Anodonta* shell collected. A small cluster of sherds on the floor surface was collected separately. Analysis later determined this cluster consisted of seven pieces from a small fragment of a plain ware bowl. Natural weathering and bioturbation, primarily rodent activity, were chiefly responsible for any deterioration in the condition of the feature. The intrusion of the modern utility alignment was minor in comparison.

The inhabitants of Feature 312 left behind no usable artifacts at the time of abandonment. Thereafter, the structure appears to have simply collapsed. After the structural debris settled, the remaining depression accumulated a small amount of refuse. Given the level of agricultural activity in this area, the remains of Feature 312 may have quickly become lost in the surrounding fields.

An archaeomagnetic sample collected from the oxidized rim of the hearth returned a date with three statistical options, A.D. 910-1150, A.D. 1100-1390, and A.D. 1435-1790. The earliest option is the more likely age estimate given evidence elsewhere in this area that suggests most activity in Area 6B occurred prior to the Classic period.

Feature 313

Feature 313 was the remnant of a pithouse (Figure 9.24) located in Block 6 amidst the canals and

Figure 9.23. Photograph of Feature 312, Area 6B, facing west-southwest, PHX Sky Train project.

Figure 9.24. Photograph of Feature 313, Area 6B, facing northwest, PHX Sky Train project. (The linear feature on the left side of the photograph is field ditch Feature 37; the bulge in the alignment marks sediments that pooled across the remnant structure. The hole near the right side of the sherd-lined hearth is a rodent burrow.)

field laterals exposed there (see Figure 2.7). The feature was initially seen as a very large sherd with a small deposit of ash underneath in the western side of Trench 42. No staining or floor surface was visible in the west trench profile, and no trace of the feature could be seen in the eastern trench wall due to modern disturbance. When the area west of Trench 42 was mechanically stripped to expose field laterals in the area, there was still no indication of a larger feature. The remains of the structure were eventually exposed with the excavation of single screened unit placed to investigate the area surrounding the sherd. Excavation revealed that the large sherd was mortared into a compact floor surface, creating a shallow, sherd-lined hearth. The excavated triangular remnant of house floor measured 2.15 m by 1.75 m, covering an area roughly 2.34 m^2. The floor remnant was intruded by field lateral Feature 37.

The floor was a compact fine sandy silt surface, brown in color, and embedded with a few charcoal flecks and caliche granules. This surface was very difficult to discern from its surroundings. Except the hearth, no intramural features or elements of construction were observed. With no preserved entry and poor overall preservation, it was not possible to determine which direction the structure was oriented.

The hearth, Feature 313.01, was a rather unique construction. A large rim sherd from a plain ware bowl had been placed in a depression to form the base of the shallow hearth (see Figure 9.24). The edge of the sherd was lightly mortared in at floor level, which both kept the sherd in place and that covered the sharp edge of the sherd. The mortar appeared to be earthen adobe or simple mud in that it did not appear to have a composition much different than that of the unprepared floor. The small amount of material that held the sherd in place at the floor level formed a very slightly raised rim, but there was no evidence of a more formal built-up collar. The very small amount of fill excavated from above the sherd was a loose ashy silt. There was a halo of oxidized or reddened soil surrounding the sherd, indicating it had been used as a hearth. The sherd appeared to have cracked in situ but held in place, and the cracked hearth continued to be used. The small amount of ash seen underneath the sherd in profile appears to have filtered through the cracks in the sherd. When the sherd was removed, ash was only found in the areas directly underneath cracks. There was no evidence beneath the sherd to indicate it was placed there to repair a previous hearth.

The structure was filled with brown fine sandy silt very similar to the surrounding stratum. Minor charcoal flecking and a small amount of fine angular gravel and caliche granules were the only noted inclusions. No evidence was seen to suggest the structure had burned. Except a small cluster of unrelated plain ware sherds on the floor surface adjacent to the hearth, no artifacts were present in the house fill. Minor bioturbation was noted; the intrusion of field lateral Feature 37 and an indeterminate amount of modern disturbance were primarily responsible for the fragmentary state of Feature 313.

The inhabitants of Feature 313 left behind no usable artifacts at the time of abandonment. The structure appears to have simply collapsed thereafter. Later, the area was claimed by irrigated fields fed by field laterals, including the lateral that cut through the remains of Feature 313.

Feature 314

Feature 314 was a house-in-pit style structure (Figure 9.25) identified during mechanical stripping to trace field laterals within the bounds of 43rd Street west of Block 7 (see Figure 2.7). The feature was initially seen as a dark oval stain transected by field lateral Feature 49. A 1-m by 2-m control unit was excavated across the width of the stain where the suggestion of a hearth was seen. This unit revealed a slightly compacted floor surface surrounding a well-prepared hearth, Feature 314.01. The remainder of the structure was exposed using two additional units, one on either side of the control unit. Approximately 4 cm of fill was excavated in a single level from each unit; all excavated fill was screened through ¼-inch mesh. Sediment associated with field lateral Feature 49, which clearly originated above the structure fill, was pedestaled during these excavations, and was only removed to floor level after final photographs were taken of the structure. The base of the lateral terminated just above the structure floor.

Feature 314 was difficult to discern but generally appeared to be an oblong structure measuring roughly 3.9 m in length and 2.2 m in width, covering an area 7.81 m^2. An entry was not preserved; however, based on the location of the hearth, the structure may have been oriented to the northwest. The structure floor was a relatively unremarkable surface, comprised of the brown sandy silt stratum into which the house pit was excavated. The area around the hearth was quite compact, but the rest of the floor was not notably so. The floor exhibited a few patches of oxidized surface, suggesting the structure may have been at least partially destroyed by fire. Except the hearth, no other intramural features or postholes were identified. Patches or concentrations of charcoal in the fill were thought to represent burned structural material, such as posts, but these possible posts did not appear to have burned in place, as the carbon patches did not continue into the floor.

In contrast to the barely perceptible floor, Feature 314.01 was a remarkably well-prepared hearth. Measuring roughly 26 cm in diameter and 10 cm in depth, the hearth was clay-lined with a slightly raised collar ($\leq$ 2 cm) that extended roughly 8-10 cm away from the rim of the basin. There were also faint traces suggesting the clay plaster may have extended at least a short distance beyond the collar, although there was no clear evidence of a formal apron. The interior of the hearth was generally well smoothed, but the surface still exhibited a number of rough impressions. The hearth was oxidized, as was the area around the hearth. Some of this more remote oxidation could relate to the demise of the structure, however, rather than to use of the hearth. The hearth was filled with ashy grayish-brown silty sand. No artifacts were observed in the fill, although a small piece of fire-cracked rock was noted.

The structure was filled with mottled reddish-brown and grayish-brown sandy silt containing a small amount of gravel and a moderate amount of carbonized material. Patches of charcoal or ash and small pieces of burned daub in the fill were thought to represent burned structural debris. The thin layer of house fill contained a small number of artifacts, including ceramic sherds and flaked stone tools and debris. These flaked stone artifacts included a core, core hammer, and bifacial thinning flakes, suggesting the house, either occupied or abandoned, had been the locale of some stone tool manufacture.

A moderate degree of bioturbation and weathering were chiefly responsible for deterioration in the condition of the feature. The intrusion of field lateral Feature 49 was a relatively minor disturbance, but its presence and the irrigation it represents may have created an environment more hostile to the preservation of features, such as Feature 314. Direct erosion may not have affected features in this area, but moister conditions, percolation, or repeated saturation and desiccation may have exacerbated the weathering process.

Notwithstanding the presence of a few usable artifacts on or near the floor, Feature 314 seems to have been largely cleaned out prior to abandonment. Whether intentionally or not, the structure was destroyed by a fire of sufficient intensity to partially oxidize the floor of the structure. After some period of time, sufficient for the collapsed structure to have been buried, the irrigation lateral, Feature 49, was excavated across remains of the pithouse.

An archaeomagnetic sample was collected from the oxidized rim of the hearth. The sample returned a date with two statistical options, A.D. 935-1150 and A.D. 1100-1690. The second option can be dismissed given the intrusion of lateral Feature 49, which other chronological evidence indicates was constructed and used sometime during the interval between A.D.

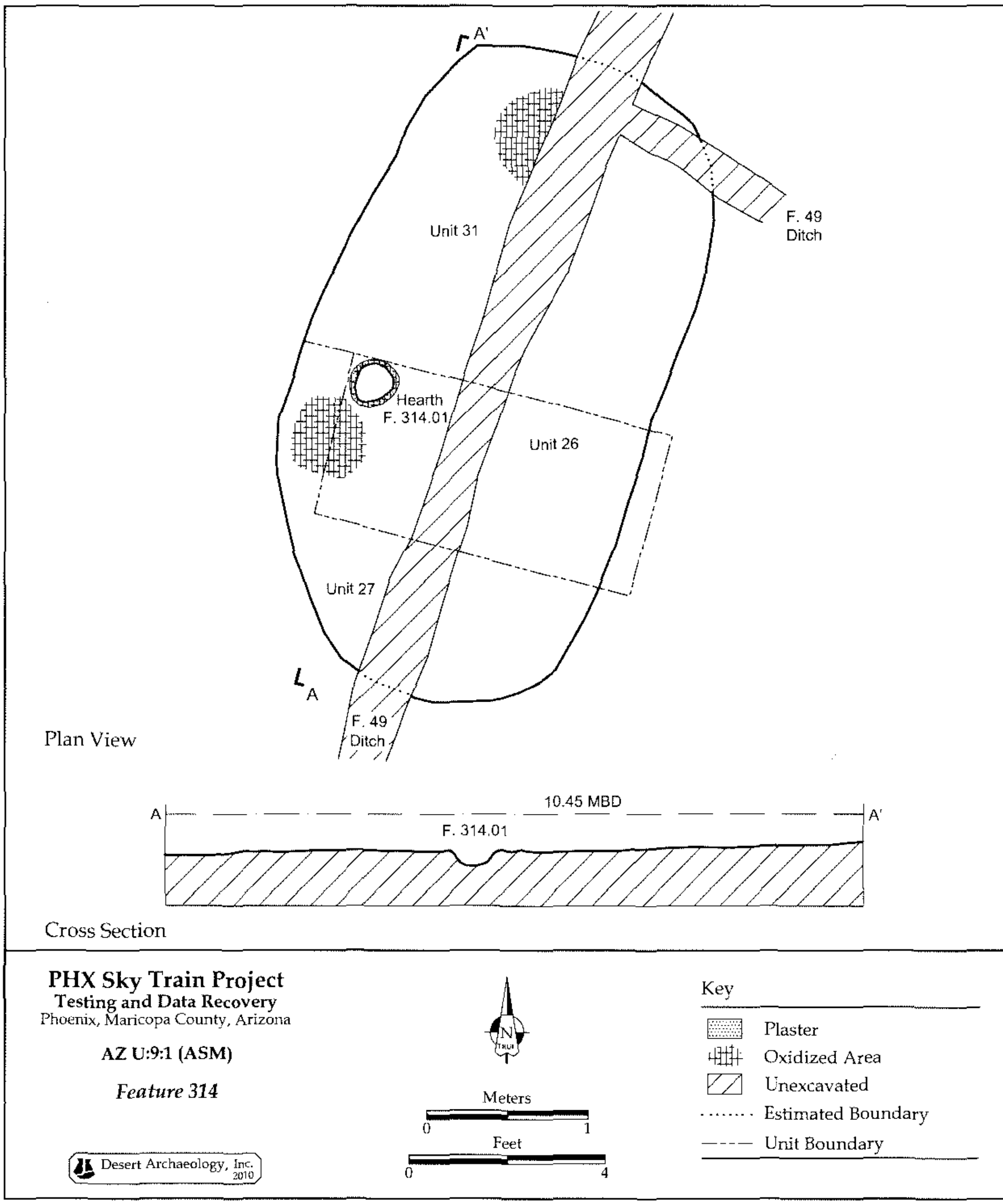

Figure 9.25. Plan view of Feature 314, Area 6B, PHX Sky Train project.

1000 and A.D. 1150. The age of the field system further requires that the age of Feature 314 occurred toward the earlier end of the A.D. 935-1150 option, suggesting the structure was probably occupied during the early Sacaton phase, A.D. 950-1000. Of note, the virtual geomagnetic pole (VGP) plots of the archaeomagnetic samples from Features 312 and 314 were statistically indistinguishable from each other at the 0.05 significance level ($p = 0.70$) (Stacey Lengyel, personal communication 2010), indicating the structures could be roughly contemporaneous.

Feature 316

Feature 316 was a house-in-pit style structure (Figure 9.26) initially exposed at the northern limit of

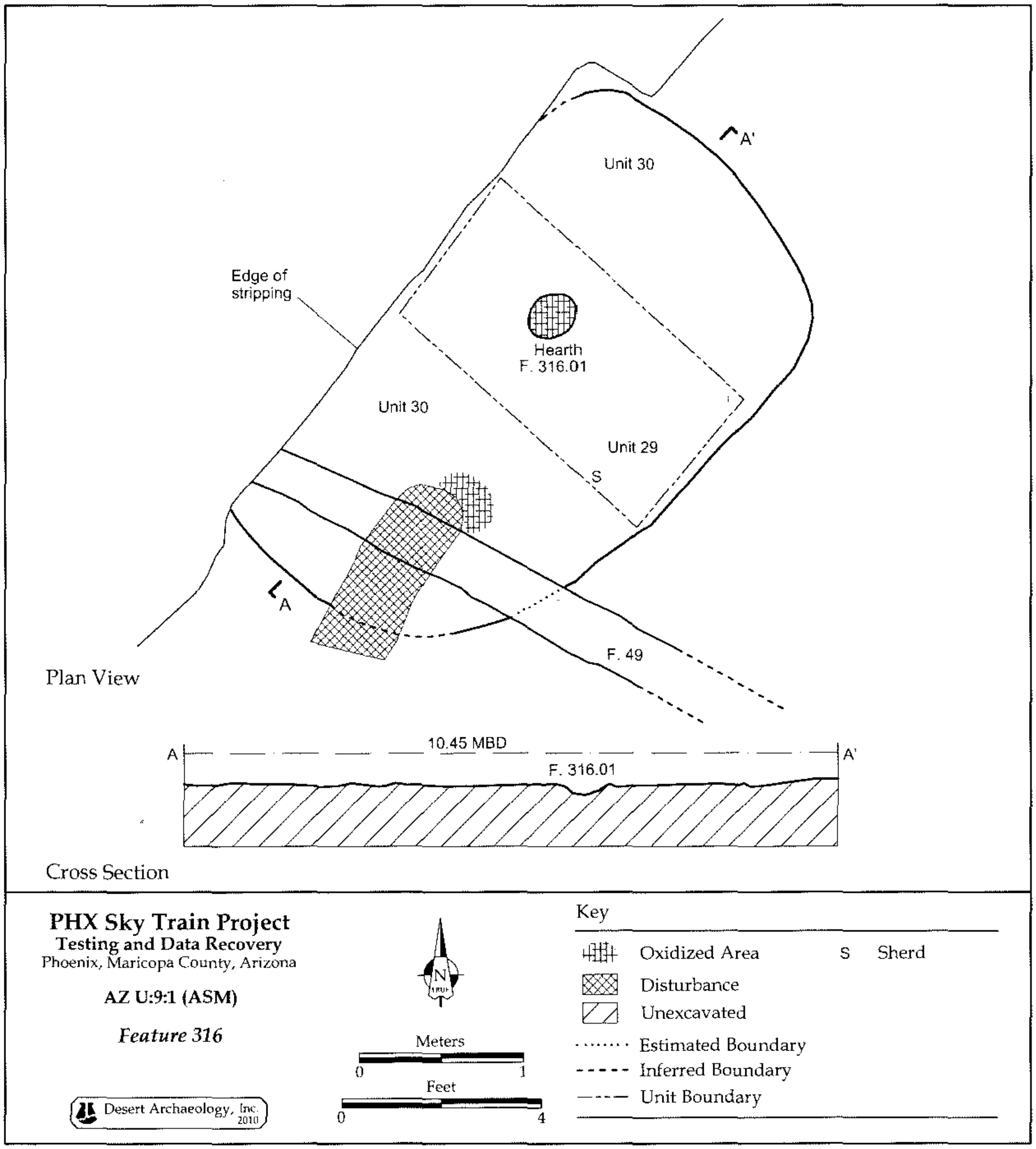

Figure 9.26. Plan view of Feature 316, Area 6B, PHX Sky Train project.

mechanical stripping within 43rd Street (see Figure 2.7). Like Feature 314, the darker oval stain of Feature 316 was intercepted while tracking field lateral Feature 49, which intruded the fill of the structure but not the floor. Excavation of a 1-m by 2-m control unit at the approximate center of the stain revealed a very slightly compacted floor surface surrounding a poorly preserved hearth, Feature 316.01. The remainder of the structure was exposed as a separate unit. Approximately 6 cm of fill was excavated in a single level from each unit; all excavated fill was screened.

Feature 316 was difficult to discern but generally appeared to be an oblong or subrectangular structure measuring 3.65 m in length and 2.05 m in width. Assuming symmetry, the floor can be estimated to have covered 7.40 m^2. Although an entry was not preserved, the location of the hearth suggests the structure was oriented to the northwest. The floor of the structure was a relatively unremarkable surface comprised of the same brown sandy silt sediment into which the house pit was excavated. The informal hearth was little more than an oxidized

PREHISTORIC CERAMICS FROM THE PHX SKY TRAIN PROJECT

T. Kathleen Henderson and Leslie D. Aragon
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Data recovery efforts conducted by Desert Archaeology, Inc., for the PHX Sky Train project resulted in the recovery of 2,090 prehistoric ceramic or clay artifacts. Pottery sherds comprised the majority of this total, with a few partial vessels, spindle whorls, comal fragments, an effigy head, and a molded adobe-clay trivet foot also included in the assemblage. The artifacts were recovered primarily from habitation contexts in Areas 3A, 3B, 5A, and 6B (Table 10.1), with the remaining assemblage coming from agricultural contexts, including canals, fields, and catchments. Results of the analysis of these artifacts are presented here. The objectives of the analysis were to use variability in relevant ceramic attributes to inform on the ages of investigated features, on site activities, and on occupant group interactions. These topics are explored as the characteristics of the PHX Sky Train ceramic assemblages are reviewed, following a discussion of analytical methods.

METHODS

Methods used in the current ceramic study generally follow the procedures developed by Desert Archaeology analysts (Heidke 1995; Stark 1995; Stark and Heidke 1992; Wallace 1995). Aragon conducted the analysis and recorded ceramic sherd and other artifact attributes, assisted by Henderson, who also identified buff ware ceramic types and generic temper sources of sampled sherds.

The sherds were initially sorted and grouped according to ware: plain, red, and buff. Sherds from each ware, except plain ware body sherds, were laid out on tables, arranged by site area, feature, and stratum. Sherd conjoins and matches (that is, sherds from the same vessel) were sought, and, when found, were coded using a specialized format that identified the sherds, contributing feature number(s), unit, context, and level. The matching sherds were bagged together for later coding as a single observation. The purpose of this procedure is to identify features or strata that accumulated trash at the same time, as well as the nature of their deposition.

After the initial sort, the attribute states of six variables were recorded for all sherds, including sherd size, ceramic ware, ceramic type, vessel part, vessel shape, and temper type. Finishing attributes, such as surface treatment and smudging, vessel form, and wall thickness, were coded for all plain ware rim, buff ware, and red ware sherds. Temper was distinguished using a 6-30x binocular microscope and classified according to the diagnostic minerals and rock fragments present in the ceramic paste. A generic temper source, based on descriptions of sand petrofacies in the Salt River and Gila River areas (Miksa et al. 2004), and of rock types in the Salt River area (Abbott 1994a; Schaller 1994), was coded for all sherds greater than 16 cm^2 in size. Metric attributes, such as vessel orifice diameter and aperture diameter, were recorded when rim sherds were large enough to allow these measurements. Descriptive and coded observations were made for all unusual artifacts, such as worked sherds, ceramic disks, comal fragments, and modeled whorls. Sherds from the same vessel were counted as one observation, with the actual number of pieces recorded in comments.

Hohokam Buff Ware sherds were typed using the definitions provided by Wallace (2001, 2004). Red ware sherds were distinguished from plain ware by the presence of a slip. Following the practice of Abbott (1994b) and Henderson (1995b), type distinctions among plain and red ware sherds were based on temper type rather than on traditional typologies. The technological attributes and tempering materials of these sherds suggest all were manufactured somewhere in the Phoenix Basin; that is, they are Hohokam types, for example, Gila Plain and its variants and Salt Red or Gila Red and their variants. The single Tusayan White Ware sherd in the assemblage was typed using descriptions provided by Hays-Gilpin and van Hartesveldt (1998), while the single Lower Colorado Buff Ware sherd was identified following descriptions provided by Clark and Watts (2011).

ASSEMBLAGE DESCRIPTIONS

As initial sorting and identification of ceramic types proceeded, it became evident that the scattered locations containing habitation and agricultural features within the PHX Sky Train project area were depression in the unprepared floor of the structure. It measured 25 cm by 20 cm in plan, 6 cm deep, and was filled with ashy, grayish-brown fine silty sand containing a few flecks and small pieces of charcoal. Except the hearth, no other intramural features or postholes were observed.

The structure was filled with grayish-brown sandy silt containing a small amount of gravel and a few flecks of charcoal. A few pieces of burned earth, possibly daub, were noted in the fill. Only one sherd and two pieces of flaked stone were present in the fill; a single plain ware sherd was found on the floor. The absence of a floor assemblage suggests the structure was cleaned out at abandonment and left to weather and collapse naturally. Sheetwash probably introduced the postabandonment fill through which lateral Feature 49 was cut.

Area Age and Activity

There is little mistaking that the Area 6B structures were fieldhouses. The structures were all lightweight constructions, contained few artifacts, and were situated in an area covered by agricultural fields. All contained hearths suggesting their use for habitation, albeit on a temporary, seasonal basis. The pithouses had been clearly cleaned out at abandonment, with the size and condition of recovered artifacts suggesting these were mainly detritus washed into the deteriorating structures. A possible exception is Feature 314, from which a small floor assemblage of flaked stone was collected. These artifacts suggest the house had been the locale of some stone tool manufacture.

Dating the structures was based on stratigraphic relationships and chronometric dates; no identifiable ceramic types were obtained from this area. The essential stratigraphic relationship is the intrusion of related field ditches through the fill of three of the four pithouses, Features 313, 314, and 316. Occupation of the houses clearly had to predate the operation of the ditch system. An age for this system is provided by canal Feature 22, which supplied water to the intruding ditches. An optically stimulated luminescence (OSL) sample from the lower fill of the canal provided an age of A.D. 1018-1160 (see Table 3.5). As discussed, the hearths of Features 312 and 314 yielded archaeomagnetic dates of A.D. 910-1150 and A.D. 935-1150, respectively. While there is ample room in the overlap of canal and hearth ages for the pithouses to have been occupied after A.D. 1000, it is more likely that their occupations were earlier in the range expressed by the archaeomagnetic dates, circa A.D. 940-1000, or the early Sacaton phase, because the houses had to have been buried to depths greater than 30 cm to allow for the height of the intruding ditches.

CHAPTER 10

PREHISTORIC CERAMICS FROM THE PHX SKY TRAIN PROJECT

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Desert Archaeology, Inc.

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METHODS

Methods used in the current ceramic study generally follow the procedures developed by Desert Archaeology analysts (Heidke 1995; Stark 1995; Stark and Heidke 1992; Wallace 1995). Aragon conducted the analysis and recorded ceramic sherd and other artifact attributes, assisted by Henderson, who also identified buff ware ceramic types and generic temper sources of sampled sherds.

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ASSEMBLAGE DESCRIPTIONS

As initial sorting and identification of ceramic types proceeded, it became evident that the scattered locations containing habitation and agricultural features within the PHX Sky Train project area were

Table 10.1. Prehistoric pottery recovered by the PHX Sky Train project, by ceramic ware, ceramic type, and habitation/agricultural area. (Excluded from this table are four non-pottery artifacts: two modeled spindle whorls, one effigy/figurine head, and one molded adobe-clay trivet foot.)

	Habitation Contexts				Agricultural Contexts			
Ceramic Ware and Type	3A	3B	5A	6B	6A	7A	Other[a]	Total
Plain Ware								
Plain ware, sand temper	23	431	67	14	34	2	47	618
Plain ware, fine-grained schist temper	3	298	185	7	16	10	83	602
Plain ware, mica-schist temper	1	93	7	–	4	5	7	117
Plain ware, indeterminate schist/gneiss temper	–	2	13	–	–	–	–	15
Plain ware, phyllite temper	3	19	73	5	15	3	21	139
Plain ware, sherd temper	–	65	32	3	–	–	9	109
Subtotal	30	908	377	29	69	20	167	1,600
Percentage of total	77%	78%	88%	88%	49%	65%	69%	77%
Red Ware								
Red ware, sand temper	–	144	4	–	4	1	7	160
Red ware, fine-grained schist temper	–	33	8	–	2	1	8	52
Red ware, mica-schist temper	–	11	4	–	2	–	2	19
Red ware, indeterminate schist/gneiss temper	–	–	1	–	–	–	–	1
Red ware, phyllite temper	–	2	7	1	4	–	1	15
Red ware, sherd temper	–	65	2	–	–	1	5	73
Subtotal	0	255	26	1	12	3	23	320
Percentage of total	0%	22%	6%	3%	8%	10%	9%	15%
Hohokam Buff Ware								
Post-Gila Butte	–	–	6	–	1	–	–	7
Gila Butte-Cañada del Oro (brown paste)	–	–	–	–	1	–	–	1
Early Gila Butte or Late Gila Butte	–	2	–	–	–	–	–	2
Late Gila Butte	1	–	–	–	–	–	–	1
Early Gila Butte or Late Gila Butte or Santa Cruz	–	–	–	–	–	–	1	1
Late Gila Butte or Santa Cruz	2	–	–	–	–	–	–	2
Santa Cruz	3	–	–	–	1	–	1	5
Late Gila Butte or Santa Cruz or Early Sacaton	–	–	1	–	–	–	–	1
Early Sacaton or Middle Sacaton 1	–	–	–	–	1	–	–	1
Late Sacaton or Casa Grande	–	–	8	–	3	1	1	13
Casa Grande	–	–	1	–	–	–	2	3
Middle Sacaton 1 or Middle Sacaton 2 or Late Sacaton or Casa Grande	–	–	–	–	3	–	3	6

Table 10.1. Continued.

Ceramic Ware and Type	Habitation Contexts 3A	3B	5A	6B	Agricultural Contexts 6A	7A	Other[a]	Total
Unidentified Hohokam painted buff ware	3	1	3	2	15	5	15	44
Unidentified Hohokam buff ware (lacks paint)	–	3	6	1	36	2	29	77
Subtotal	9	6	25	3	61	8	52	164
Percentage of total	23%	1%	6%	9%	43%	26%	21%	8%
Lower Colorado Buff Ware								
Indeterminate Lower Colorado buff ware	–	–	–	–	–	–	1	1
Subtotal	0	0	0	0	0	0	1	1
Percentage of total	0%	0%	0%	0%	0%	0%	0%	0%
Tusayan White Ware								
Tusayan Black-on-white	–	1	–	–	–	–	–	1
Subtotal	0	1	0	0	0	0	0	1
Percentage of total	0%	0%	0%	0%	0%	0%	0%	0%
Total Ceramics	39	1,170	428	33	142	31	243	2,086

[a]Ceramics collected from canals and nonfeature contexts.

temporally discrete. Therefore, the area assemblages are described separately, to better distinguish patterns in pottery use among them. Areas containing habitation contexts are discussed first, followed by areas containing agricultural features.

Area 3A

Thirty-nine pottery sherds, or collections of sherds from the same vessel, comprised the Area 3A ceramic assemblage (see Table 10.1). Most of these were collected from pithouse Feature 306 (Table 10.2), with the remainder from an extramural pit containing several trivet feet (Feature 310), one of which was collected and described below. No ceramics were collected from the third feature in this area, a small pit that intruded the pithouse.

The collection consists primarily of plain ware pottery (77 percent), although Hohokam Buff Ware is also fairly common (23 percent). Most of the plain ware were sand-tempered (77 percent), with far fewer cases tempered with fine-grained schist, mica-schist, and phyllite (see Table 10.1). Recognizable types among the buff ware were solely Late Gila Butte or Santa Cruz red-on-buff. These included one Late Gila Butte Red-on-buff sherd and one Santa Cruz Red-on-buff sherd collected from pit Feature 310, one Late Gila Butte Red-on-buff or Santa Cruz Red-on-buff sherd from the hearth in pithouse Feature 306, and two Santa Cruz Red-on-buff and one Late Gila Butte or Santa Cruz red-on-buff from the lower fill of the pithouse. The sherds demonstrate contemporaneity between the two features, and place their use firmly in the Santa Cruz phase (A.D. 850-950), probably earlier in that phase, circa A.D. 850-900, given the presence of one Late Gila Butte Red-on-buff sherd and shared Late Gila Butte or Santa Cruz stylistic traits on several other sherds; for example, banded layout with alternating free-floating fringe and flying bird motif. The prevalence of sand-tempered plain ware pottery and moderate quantities of Hohokam Buff Ware are also characteristic features of Colonial period assemblages (Cable et al. 1988; Henderson 1987).

A vessel form could be identified in 22 of the 39 cases: four bowls and 18 jars (Table 10.3). All the bowls were buff ware, which included two flare-rim types. Fourteen of the jars were plain ware, and four were buff ware. Two of the jars could be recognized as short-necked forms, and one jar was a short flare-rim form; all were plain ware. Collectively, the assemblage suggests a relatively restricted range of activities involving pottery in this area, with vessels seemingly restricted to cooking, serving, and dry storage functions.

The final artifact from Area 3A was a trivet foot collected from Feature 310. The piece was formed from a buff-colored, adobe-like earth/clay mix. It was roughly cylindrical with slight belling at the flattened base, it measured 17.5 cm in height, 13.5 cm in diameter, and it weighed 2.49 kg. The exterior surface had been hand smoothed, probably while wet or damp, creating a thin rind that varied 1-4 mm in thickness. This artifact is the easternmost of the three trivet feet depicted in Figure 9.5.

Area 3B

The largest number of PHX Sky Train project ceramic artifacts was collected from Area 3B ($n = 1{,}172$), which included an adobe structure, a pithouse, a variety of pits, and a concentration of ceramics. Most of the ceramics came from excavation of the adobe structure, Feature 329, followed by the pithouse, Feature 318 (Table 10.4). Collectively, these two features accounted for 78 percent of the Area 3B pottery assemblage, as well as the two non-vessel artifacts, a modeled spindle whorl and a zoomorphic effigy/figurine head. These large quantities indicate the two features, particularly the adobe structure, were trash filled, implying other habitation features were once in proximity to these structures.

The pottery collection consists primarily of plain ware (78 percent), with "Classic period" red ware

Table 10.2. Distribution of pottery, by ceramic ware, feature, and context, Area 3A, PHX Sky Train project.

Feature/Context	Plain Ware	Buff Ware	Total	Diagnostic Ceramics
Feature 306, pithouse				
House fill	23	4	27	1 Late Gila Butte or Santa Cruz red-on-buff, 1 Santa Cruz Red-on-buff
House floor	1	1	2	–
Hearth fill	2	2	4	1 Late Gila Butte or Santa Cruz red-on-buff
Subtotal	26	7	33	
Feature 310, pit fill	4	2	6	1 Late Gila Butte Red-on-buff, 1 Santa Cruz Red-on-buff
Total artifacts	30	9	39	

Table 10.3. Frequencies of pottery vessel forms, by habitation area, PHX Sky Train project.

Vessel Form	Area 3A	Area 3B	Area 5A	Area 6B
Indeterminate bowl	2	68	15	2
Plate or platter	–	–	3	–
Flare-rim bowl	2	1	–	–
Outcurved bowl	–	5	–	–
Semi-flare-rim, outcurved bowl	–	1	1	–
Hemispherical bowl	–	1	8	2
Straight-walled bowl	–	–	4	–
Low-shouldered bowl	–	–	1	–
Cauldron	–	1	–	–
Indeterminate jar	15	135	76	10
Flare-rim jar, height indeterminate	1	–	–	–
Short flare-rim jar	1	–	1	–
Short straight-collared jar	1	2	2	–
Incurved short straight-collared jar	–	1	–	–
Semi-flaring short straight-collared jar	–	1	–	–
Tall straight-collared jar	–	2	1	–
Semi-flaring tall straight-collared jar	–	2	–	–
Semi-flaring angled long-collared jar	–	–	–	–
Seed jar	–	–	2	–
Neckless or rimless jar	–	2	1	–
Indeterminate shaped scoop	–	2	3	–
Comal	–	2	–	–
Indeterminate effigy vessel	–	1	–	–
Total cases	22	227	118	14

Note: Excludes 1,485 cases registered as indeterminate form.

Table 10.4. Distribution of pottery, by ceramic ware, feature, and context, Area 3B, PHX Sky Train project. (The Area 3B assemblage also includes one modeled spindle whorl and one effigy figurine head not assigned a ceramic ware/type.)

Feature/Context	Plain Ware	Red Ware	Buff Ware	White Ware	Total	Diagnostic Ceramics
Nonfeature sheet trash	114	21	–	–	135	–
Feature 56, ditch fill	18	3	–	–	21	–
Feature 318, pithouse						
House fill	119	50	–	–	169	–
House floor	1	1	–	–	2	–
Subtotal	120	51	0	0	171	
Feature 329, adobe structure						
Sheet trash above house fill	25	10	–	–	35	–
Structure fill	529	137	6	1	672	2 Gila Butte Red-on-buff, 1 Tusayan Black-on-white
Structure floor	25	6	–	–	31	–
Hearth fill	4	–	–	–	4	–
Subtotal	583	153	6	1	743	
Feature 325, pit fill	1	1	–	–	2	–
Feature 326, pit fill	3	2	–	–	5	–
Feature 332, pit fill	1	–	–	–	1	–
Feature 333, pit fill	38	20	–	–	58	–
Feature 334, pit fill	17	4	–	–	21	–
Feature 337, pit fill	4	–	–	–	4	–
Feature 338, artifact concentration	9	–	–	–	9	–
Total artifacts	908	255	6	1	1,170	

also relatively abundant (22 percent). While sand was the most common material used to temper both the plain (47 percent) and the red ware (56 percent) (see Table 10.1), large numbers of plain ware were also tempered with fine-grained schist (33 percent), while crushed sherd temper was regularly present among red ware (25 percent). Buff ware was an uncommon occurrence in this assemblage. Among these, the only recognizable type was Gila Butte Red-on-buff, represented by two small sherds (5-16 cm^2) collected from the fill of Feature 329. The two Gila Butte sherds are assumed to be incidental inclusions in the adobe structure fill, given a preponderance of evidence indicating Classic period use of Area 3B. The only other decorated ceramic was a Tusayan Black-on-white bowl sherd, also collected from the structure fill in Feature 329.

Nineteen percent (n = 227) of the pottery assemblage was identified to at least a generic vessel form, such as bowl, jar, or scoop. Among these, jars outnumbered bowls roughly two to one, accounting for 65 percent of the identified assemblage (see Table 10.3). Most recognizable jars were either of the short- or long-necked variety, with only one neckless jar recorded. Somewhat greater variety was observed among bowls, although outcurved types were most commonly represented. Fragments from two scoops, two comals, and a possible effigy vessel were identified in addition to the bowls and jars.

The bowl-jar ratio varied according to ware. As shown in Table 10.5, plain ware and the few buff wares present were dominantly jars, while red ware was evenly divided between bowls and jars. One of the scoops was plain ware, while the other was a red ware; interestingly, both contained crushed sherd temper, perhaps indicating a potter(s) who specialized in this form. While the plain ware pattern is typical of all Hohokam periods, the buff ware and red ware pattern is consistent with later pre-Classic and Classic period trends in pottery ware/vessel production.

The types of vessels identified reflect the occurrence of culinary (cooking, mixing, serving), storage, and possibly ceremonial activities at Area 3B (Table 10.6). The variety expressed in the assemblage is consistent with expectations for an intensively occupied habitation loci. For comparison, see Henderson's (2003b) study of fieldhouse sites, where ceramic vessels associated with culinary activities dominated the assemblages.

Despite the large quantity of pottery collected from Area 3B, only one partial vessel was found. This vessel, roughly two-thirds of a plain ware bowl, comprised the larger part of the "ceramic concentration" identified as Feature 338. The bowl was a small, outcurved form with a relatively flat bottom. The orifice measured 17 cm in diameter, and the bowl stood 6 cm high. The piece was tempered with a mixture of granitic sand and fine-grained schist/gneiss, probably Camelback Buttes Petrofacies sand.

Table 10.5. Comparison of bowl and jar forms, by ceramic ware and habitation area, PHX Sky Train project.

	Bowl		Jar		
Ceramic Ware	*n*	%	*n*	%	Total
Area 3A					
Plain ware	–	0%	14	100%	14
Buff ware	4	50%	4	50%	8
Total forms	4	18%	18	82%	22
Area 3B					
Plain ware	13	14%	80	86%	93
Red ware	62	50%	61	50%	123
Buff ware	1	20%	4	80%	5
White ware	1	100%	–	0%	1
Total forms	77	35%	145	65%	222
Area 5A					
Plain ware	21	28%	53	72%	74
Red ware	2	9%	21	91%	23
Buff ware	9	50%	9	50%	18
Total forms	32	28%	83	72%	115
Area 6B					
Plain ware	3	30%	7	70%	10
Red ware	1	100%	–	0%	1
Buff ware	–	0%	3	100%	3
Total forms	4	29%	10	71%	14

Other noteworthy artifacts included a red ware bowl rim sherd that had evidently been used as a scoop, an unperforated sherd disk, a perforated sherd disk probably used as a spindle whorl, a modeled whorl or bead, an effigy or figurine head, and two comal fragments. All the items were recovered from the general area of Feature 329. Descriptions are provided in Table 10.7.

In addition to the relative abundance of Classic period red ware, evidence for the age of Area 3B includes the coursed-wall adobe architecture of Feature 329, an architectural style not seen until the later Soho phase (A.D. 1200-1300) and most commonly used during the Civano phase (A.D. 1300-1450) (J. Howard 1988). Although the very small quantity of buff ware and abundance of red ware suggests a Civano phase occupation, the complete absence of Salado polychromes from the large Area 3B assemblage suggests otherwise. In other project excavations, the senior author has found that, although numbers of Salado polychromes are usually low, at least a few inevitably occur in Civano phase assemblages. Their absence here may indicate deposition of the Area 3B assemblage occurred primarily during the later Soho phase, circa A.D. 1250-1300, prior to the introduction of Salado polychrome into the Phoenix Basin.

Table 10.6. Checklist of domestic activities suggested by vessel forms at habitation sites, PHX Sky Train project.

Vessel Form	Functional Category[a]	Area 3A	Area 3B	Area 5A	Area 6B
Scoop	Serving	–	X	X	–
Plate or platter	Serving, eating, cooking	–	–	X	–
Flare-rim buff ware bowl	Serving, eating	X	X	–	–
Flare-rim plain ware bowl	Food preparation[b], cooking	–	–	–	–
Outcurved red ware bowl	Serving, eating	–	X	–	–
Outcurved plain ware bowl	Food preparation[b], cooking	–	X	X	–
Hemispherical red ware bowl	Serving, eating	–	X	X	–
Hemispherical plain ware bowl	Food preparation[b], cooking	–	–	X	X
Straight-walled plain ware bowl	Food preparation[b], cooking	–	–	X	–
Neckless plain ware jar	Cooking	–	X	X	–
Short flare-rim plain ware jar	Cooking	X	–	X	–
Short-necked plain ware jar	Food preparation[b], dry storage	X	X	X	–
Tall-necked plain ware jar	Dry or liquid storage, transport	–	X	X	–
Seed jar	Dry storage	–	–	X	–
Effigy vessel	Ceremonial	–	X	–	–

[a]Based on studies by Crown (1984) and Stark (1995), except the ceremonial category.
[b]Preparation without heat; for example, soaking, rinsing, mixing of grains or other food items.

Table 10.7. Modified sherds and other ceramic artifacts from the PHX Sky Train project.

Area	Feature and Context	Modification or Artifact Type	Description
3B	329, sheet trash	Ground rim	Red ware bowl rim, 16-49 cm², rim lightly ground or worn on the exterior surface of the rim; possibly used as an expedient scoop [Not catalogued]
3B	329, upper structure fill	Unperforated disk	Plain ware body sherd, 4.6 cm diameter, chipped and ground into disk shape [Field No. 1268, Catalog No. 68]
3B	329, upper structure fill	Perforated disk (spindle whorl)	Plain ware body sherd, 5.8 cm diameter, 34.9 gm, chipped to circular shape, drilled from both sides to create biconically shaped hole, 6 mm diameter [Field No. 1234, Catalog No. 69]
3B	329, lower structure fill	Spindle whorl or bead	Modeled whorl or bead, spherical shape, plain paste with fine mica schist temper, 2.4 cm diameter, 1.8 cm height, 8.9 gm, 4 mm diameter spindle hole; possibly a bead given small size [Field No. 1215, Catalog No. 73]
3B	318, house fill	Effigy or figurine head	Zoomorphic effigy/figurine head, plain paste lightly tempered with fine sand, 3.6 cm tall, 2.7 cm wide, 11.7 gm, one "coffee bean" eye above snout and ear/horn extending from head on left side of face, right eye is missing and right ear/horn broken off; smoothed posterior side suggests it was once attached to a vessel of some kind [Field No. 861, Catalog No. 74]
3B	0, sheet trash overlying features	Comal fragment	Rim sherd from circular slab, 24 cm diameter, 1.7 cm thick, thickening to 2.3 cm at slightly upturned rim; hand-shaped, plain paste, sand-tempered with occasional sherd/grog, possibly local piedmont sand; indistinct impressions on slab base, though it is clear the slab was fashioned on some kind of material (mat?); upper surface is smooth and exhibits fire-clouding and possible oxidation [Field No. 1323, Catalog No. 75]
3B	0, sheet trash overlying features	Comal fragment	Slab interior fragment, roughly square 5.5 cm by 5.0 cm, 1.7 cm thick; hand-shaped, plain paste, with finely crushed schist temper; base exhibits woven mat impressions; top surface is lightly polished [Field No. 1327, Catalog No. 76]
5A	307, upper house fill	Perforated disk (spindle whorl)	Plain ware body sherd, 4.4 cm diameter, 17.1 gm, chipped and slightly ground to circular shape, drilled from both sides to form biconically shaped hole, 3 mm diameter [Field No. 677, Catalog No. 70]

Table 10.7. Continued.

Area	Feature and Context	Modification or Artifact Type	Description
5A	309, wall fall	Perforated disk (spindle whorl?)	Red-on-buff ware jar sherd, 4.6 cm diameter, 13.3 gm, shaped to a rough disk shape by chipping edges, hole drilled from both sides, 5 mm diameter; possibly incomplete given the irregular shape [Field No. 758, Catalog No. 71]
5A	302, house floor	Spindle whorl	Modeled spindle whorl, biconically shaped, plain paste with sand temper, 2.9 cm diameter, 1.5 cm thick, 7.8 gm, but one side has broken off, 4 mm diameter spindle hole [Field No. 665, Catalog No. 77]
Block 4	0, trench backdirt	Perforated disk (spindle whorl)	Red-on-buff ware bowl sherd, 5.6 cm diameter, 20.4 gm, ground to disk shape, hole drilled from interior, 5 mm diameter [Field No. 601, Catalog No. 72]

Area 5A

Area 5A yielded the second largest ceramic assemblage among PHX Sky Train project loci ($n = 429$, including one modeled spindle whorl), although it was only about one-third the size of the Area 3B assemblage (see Table 10.1). The Area 5A assemblage was distributed among pithouse, pit, midden, and nonfeature contexts (Table 10.8). The ceramic counts from three of the pithouses in this area were similar, with frequencies resembling those of pithouse Feature 306 in Area 3A, while the fourth pithouse, Feature 307, had more than twice as many ceramics than its counterparts. These greater numbers suggest Feature 307 was abandoned and subsequently used for some trash disposal by continuing or later inhabitants of Area 5A. Notably, this pithouse was situated just north of midden Feature 309, which yielded the largest quantity of Area 5A ceramics.

Plain ware pottery dominated the Area 5A ceramic assemblage (88 percent of the count) with low but equal occurrences of red ware and buff ware ceramics (6 percent each) (see Table 10.1). Unlike the two Block 3 areas, Area 5A plain ware was most commonly tempered with fine-grained schist (49 percent of plain), with phyllite temper also relatively common (19 percent of plain). Fine-grained schist and phyllite were also the most common tempering materials among the red ware (31 percent and 27 percent of red, respectively). Both of these rock types are found in the Phoenix Mountains to the north, suggesting an origin point for these ceramics. Additionally, the plain ware pattern has temporal significance. Studies at other sites in the area irrigated by Canal System 2 have shown that the occurrence of fine-grained schist and phyllite tempered pottery peaks during the Sedentary period, then steadily declines throughout the Classic period (Cable et al. 1988; Crown 1981; Henderson 1987).

All but one of the diagnostic buff ware ceramics had elements that could be found on either Late Sacaton Red-on-buff or Casa Grande Red-on-buff. The exception was a Casa Grande Red-on-buff sherd from the fill of pithouse Feature 302. The identified sherds, together with the proportion of schist/phyllite tempered plain ware and low proportions of both buff ware and red ware, indicate an assemblage deposited at the cusp of the Classic period, that is, the Sedentary-Classic transition, sometime between A.D. 1100 and 1200.

A vessel form could be identified in 118 cases (see Table 10.3). Although jars outnumbered bowls more than two to one, the bowls showed greater variety with outcurved, hemispherical, straight-walled, and low-shouldered forms being represented. Further, Area 5A was the only habitation area to have plates or platters, two plain ware and one buff ware. Where recognized, jars were still diverse, including at least one example of short flare-rim, short-necked, tall-necked, neckless, and seed jar types. Fragments from three plain ware scoops were also collected from Area 5A. Collectively, the assemblage suggests a relatively wide range of activities involving pottery in this area, including cooking, serving, storage, and transport functions (see Table 10.6). Spinning of yarns seems also to have been a part-time craft at Area 5A, as indicated by the presence of two perforated sherd disks, probably spindle whorls, and one modeled spindle whorl. Descriptions of these items are provided in Table 10.7.

Area 6B

Thirty-three pottery sherds were collected from the four pithouses that defined habitation Area 6B (Table 10.9). All but three sherds were plain ware. These were tempered with a variety of materials,

Table 10.8. Distribution of pottery, by ceramic ware, feature, and context, Area 5A, PHX Sky Train project. (The Area 5A assemblage also includes one modeled spindle whorl not assigned a ceramic ware/type.)

Feature/Context	Plain Ware	Red Ware	Buff Ware	Total	Diagnostic Ceramics
Nonfeature sheet trash	47	5	1	53	1 Late Sacaton or Casa Grande red-on-buff
Feature 300, pithouse					
House fill	17	2	1	20	–
House floor	6	–	–	6	–
Subtotal	23	2	1	26	
Feature 301, pithouse					
House fill	30	–	1	31	–
House floor	3	–	–	3	–
Subtotal	33	0	1	34	
Feature 302, pithouse					
Sheet trash over house	8	–	–	8	–
House fill	11	2	2	15	1 Casa Grande Red-on-buff
House floor	7	1	–	8	–
Subtotal	26	3	2	31	
Feature 307, pithouse					
House fill	68	3	8	79	1 Late Sacaton or Casa Grande red-on-buff, 1 Late Gila Butte or Santa Cruz or Early Sacaton red-on-buff
House floor	3	–	1	4	1 Late Sacaton or Casa Grande red-on-buff
Subtotal	71	3	9	83	
Feature 303, pit fill	22	1	–	23	–
Feature 304, pit fill	2	–	1	3	–
Feature 309, midden fill	148	11	10	169	6 Late Sacaton or Casa Grande red-on-buff
Feature 311, pit fill	5	1	–	6	–
Total artifacts	371	26	25	428	

although sand temper was most common (47 percent), followed by fine-grained schist and phyllite tempers (41 percent, collectively) (see Table 10.1). The two buff ware sherds in the assemblage had been tempered with crushed mica schist, while the single red ware sherd was tempered with phyllite. The proportions of sand and schist/phyllite tempered plain ware suggest an assemblage that could date to the later Colonial or early Sedentary period, assuming general contemporaneity of the houses.

Vessel form was identified in 14 of the 33 cases: 10 jars and four bowls (see Table 10.5). Seven of the jars were plain ware and three were buff ware; a more specific form could not be recognized in any of these cases. Three of the four bowls were plain ware, which included two hemispherical types. Of the two pieces from hemispherical bowls, one had been used for a purpose unrelated to the function of the original vessel. This was a large fragment that had been used to line the hearth of pithouse Feature 313 (Chapter 9, this volume). Given the low numbers of specific vessel forms, there is little to conclude about possible activities involving pottery at Area 6B.

Table 10.9. Distribution of pottery, by ceramic ware, feature, and context, Area 6B, PHX Sky Train project.

Feature/Context	Plain Ware	Red Ware	Buff Ware	Total
Feature 312, pithouse				
House fill	2	–	–	2
House floor	1	–	–	1
Subtotal	3	0	0	3
Feature 313, pithouse				
House fill	3	–	1	4
Hearth fill	1	–	–	1
Subtotal	4	0	1	5
Feature 314, pithouse				
House fill	22	–	1	23
Subtotal	22	0	1	23
Feature 316, pithouse				
House fill	–	–	1	1
House floor	1	–	–	1
Subtotal	1	0	1	2
Total artifacts	30	0	3	33

Except the possible temporal aspect of the plain ware proportions mentioned above, which should be viewed with caution, there is nothing in the Area 3B pottery assemblage to suggest an age for this area. As related in Chapter 9, dating of the Area 3B structures depended on a combination of stratigraphic relationships with agricultural features and archaeomagnetic dates from hearths in two of the pithouses. This temporal evidence indicated the pithouses were probably occupied during the early Sacaton phase (A.D. 950-1000). Additional attributes, including the small quantities of ceramics, implied seasonal use of the structures as fieldhouses.

Agricultural Areas and Other Contexts

A total of 416 ceramics was collected from PHX Sky Train project contexts considered agricultural in nature (Table 10.10). This count includes collections from features in Areas 6A and 7A and canals at various locations across the project area. Areas 6A and 7A circumscribe the principal agricultural components of the PHX Sky Train project. Area 6A includes the well-defined agricultural fields and canal-side basin, Feature 57, on the northern side of canal Feature 26 at the eastern edge of the PHX Sky Train project area (see Figures 2.7 and 5.1). Area 7A is roughly synonymous with Block 7, which was transected by canal Feature 3, with two water catchments/reservoirs on its northern side, Features 7 and 20, and scattered ditch segments elsewhere in the locus (see Figures 2.7 and 4.1).

All the features in these areas were defined through trenching and mechanical stripping, with hand-excavations only occurring in Area 6A at Feature 57, field Feature 320 (exposed in hand trenches), and a control unit in ditch Feature 33. The quantities of ceramics recovered from Area 6A reflects this excavation emphasis, with the bulk of pottery collected from Feature 57 (see Table 10.10). All but three of the ceramics from canal Feature 26 were also collected during the Feature 57 excavations. Elsewhere, the ceramics reflect items collected as uncovered during mechanical stripping or from trench exposures of the features.

These collections were largely made in the hopes of obtaining temporally diagnostic ceramics and some insight about activity outside the habitation areas. Unfortunately, this practice had little success. Most of the collected buff ware was either unpainted portions of vessels or had painted designs obscured through erosion. Distinctive vessel forms could be identified in relatively few cases (Table 10.11). However, although this assemblage has limited interpretive value, a few observations can be made.

First, the larger numbers of ceramics from Block 7 supports an observation that artifacts seemed more prolific in this area, particularly as compared to Block 6, the locale of recognizable fields. Material in Block 7 was most abundant along canal Feature 3, suggesting trash had been disposed of along the banks of this canal. Water catchments on the northern side of Feature 3 may also have drawn foot traffic, although why this would result in trash disposal is unknown.

Second, the few diagnostic buff ware types found during stripping generally correspond to the age of features found below. For example, the single Santa Cruz Red-on-buff sherd listed under Block 3 in Table 10.10 came from stripping above Area 3A, a Colonial period habitation area. Similarly, the diagnostic ceramics listed under Block 5 are the same types as those collected from Area 5A habitation features.

Feature 57 in Area 6A produced the most productive assemblage from a temporal perspective. This canal-side basin was located at the tail end of field Features 320 and 327. As discussed in Chapter 4 (this volume), the lowest strata in Feature 57 were the same as those observed in the ditches feeding the field system to the north, indicating its construction and initial use coincided with use of the nearby fields. The presence of several diagnostic buff ware sherds in the lowest sediments of this feature provided an important tool in determining the age of the fields.

Diagnostic buff ware in the lowest stratum, the groove or channel at the base of Feature 57, included three sherds classified as either Middle Sacaton Red-on-buff or Late Sacaton Red-on-buff or Casa Grande Red-on-buff, and one sherd classified as either Late Sacaton Red-on-buff or Casa Grande Red-on-buff. Important to note is that the inclusion of Casa Grande Red-on-buff in these classifications reflects conservatism in the type assignments. That is, each of the typed sherds includes an attribute that is among the inventory of elements or designs of the identified red-on-buff styles. For example, the largest buff ware fragment from this context, which actually consisted of eight sherds from the same vessel, displayed a rectilinear scroll in a sectioned layout. Use of the rectilinear scroll first appears in the Middle Sacaton 1 style, and its use continues in all subsequent buff ware styles. However, there are other decorative aspects of this fragment, such as the spacing and thickness of the line work and the rectilinearity of design, that suggest the vessel was painted in the Late Sacaton style. Additionally, the shallow curvature of the sherds comprising this fragment suggest these derived from a very large jar, possibly a Gila-shouldered jar, based on the design layout, a vessel form rarely represented among Casa Grande Red-on-buff. Another example is the sherd

Table 10.10. Distribution of ceramics from agricultural areas and contexts, PHX Sky Train project.

Feature/Context	Plain Ware	Red Ware	Buff Ware	Total	Diagnostic Ceramics
Area 6A					
Feature 29, ditch	2	1	2	5	–
Feature 33, ditch	8	1	1	10	–
Feature 44, ditch	2	2	–	4	–
Feature 320, field surface	2	2	1	5	1 Early Sacaton or Middle Sacaton 1 red-on-buff
Feature 335, pit	1	–	1	2	1 Gila Butte Red-on-buff (brown paste variant)
Subtotal	15	6	5	26	
Feature 57, pond/basin					
Upper fill	19	2	16	37	1 Late Sacaton or Casa Grande red-on-buff
Lower fill	22	2	14	38	1 Santa Cruz Red-on-buff
Groove/channel	7	1	18	26	3 Middle Sacaton or Late Sacaton or Casa Grande red-on-buff, 1 Late Sacaton or Casa Grande red-on-buff
Hand-trench fill	6	1	8	15	1 Middle Sacaton or Late Sacaton or Casa Grande red-on-buff
Subtotal	54	6	56	116	
Area 6A Total	69	12	61	142	
Area 7A					
Feature 2, ditch	–	–	1	1	1 Late Sacaton or Casa Grande red-on-buff
Feature 5, ditch	2	–	–	2	–
Feature 6, pit	2	–	–	2	–
Feature 7, catchment	9	–	6	15	–
Feature 20, catchment	4	3	1	8	–
Feature 23, canal	1	–	–	1	–
Feature 38, ditch	1	–	–	1	–
Feature 41, ditch	1	–	–	1	–
Area 7A Total	20	3	8	31	
Other Contexts					
Feature 3, canal	40	6	9	55	1 Late Sacaton or Casa Grande red-on-buff, 1 Casa Grande Red-on-buff
Feature 14, canal	4	1	3	8	–
Feature 17, canal	2	–	–	2	–
Feature 18, canal	4	–	–	4	–
Feature 22, canal	8	1	–	9	–
Feature 26, canal	27	3	22	52	1 Middle Sacaton or Late Sacaton or Casa Grande red-on-buff
Feature 28, channel	2	–	2	4	–
Feature 200, canal	2	–	–	2	–
Block 3, sheet trash	–	–	1	1	1 Santa Cruz Red-on-buff
Block 4, trench backdirt	–	–	1	1	1 Gila Butte or Santa Cruz red-on-buff[b]
Block 5, sheet trash	18	3	4	25	2 Middle Sacaton or Late Sacaton or Casa Grande red-on-buff, 1 Casa Grande Red-on-buff
Block 6, sheet trash	16	2	2	20	–
Block 7, sheet trash[a]	44	7	8	59	–
Other Contexts Total	167	23	52	242	
Agricultural Areas Total	256	38	121	415[c]	

[a]One indeterminate Lower Colorado Buff Ware was also recovered from this nonfeature context.
[b]This ceramic was a perforated disk/spindle whorl (see Table 10.7).
[c]Total count is 416 items when the single indeterminate Lower Colorado Buff Ware sherd is included.

Table 10.11. Frequencies of pottery vessel forms, by agricultural area and other contexts, PHX Sky Train project.

Vessel Form	Area 6A	Area 7A	Canal 3	Canal 22	Canal 26[a]	Block 3	Block 4	Block 5	Block 6	Block 7
Indeterminate bowl	9	4	2	–	1	–	–	1	2	5
Plate or platter	1	–	1	–	–	–	–	–	–	–
Flare-rim bowl	2	2	–	–	–	1	1	–	–	1
Outcurved bowl	–	4	–	–	–	–	–	1	–	2
Hemispherical bowl	–	–	1	–	1	–	–	–	–	–
Straight-walled bowl	–	1	–	–	–	–	–	–	–	1
Indeterminate jar	62	31	18	1	26	–	–	8	2	18
Short-necked jar	2	3	1	–	–	–	–	–	–	2
Tall-necked jar	2	3	1	1	1	–	–	1	–	2
Total cases	78	48	24	2	29	1	1	11	4	31
All bowls	12	11	4	0	2	1	1	2	2	9
All jars	66	37	20	2	27	0	0	9	2	22

[a]Includes sherds collected from associated alignments, Features 14, 17, and 18.

identified as Late Sacaton or Casa Grande red-on-buff. This ceramic was a jar rim and neck sherd banded by a rectilinear interlocking fret, a design common to both styles. The neck, however, was short and sloping, which is uncharacteristic of Casa Grande Red-on-buff jars. In sum, the diagnostic ceramics collected from the channel imply construction and initial use, and by extension, the nearby irrigated fields, sometime during the later Sacaton phase, circa A.D. 1050-1150.

An unusual aspect of the Feature 57 ceramic assemblage is the large proportion of buff ware sherds, 48 percent of the assemblage. This abundance raised the question of whether buff ware had been preferentially collected during the unscreened hand-excavations of the feature. Perusal of two sherd attributes, size and vessel part, by ceramic ware, indicates this was not the case. For example, plain ware sherds were smaller, on average, than buff ware, with 94 percent of the plain ware sherds measuring 5-16 cm^2, while 68 percent of buff ware were in this size group. The occurrence of plain ware rim sherds was only slightly more common than buff ware (11 percent versus 7 percent, respectively). If there had been bias in these collections, the preference would likely have been for larger plain ware sherds, particularly those for which vessel form could be deduced. While discounting collection bias, we can offer no explanation for why so many pieces of buff ware vessels were scattered in Feature 57. Perhaps these reflect some type of offering, as suggested in Chapter 4, in the discussion of the enigmatic basin, Feature 57.

TEMPER TYPES AND POTTERY SOURCES

Pottery from the PHX Sky Train project area was tempered with a variety of materials, including sand, fine-grained schist, mica-schist, and phyllite. Because the provenance of many of the sands and rock types in the Salt and Gila River valleys are known (Miksa et al. 2004; Schaller 1994), where the vessel was produced can be inferred from a pottery's temper. In turn, this information allows insight about groups with whom the prehistoric peoples who used the project area might have interacted, or specifically, from whom they obtained their pots.

The distribution of generic temper sources (TSG), by ceramic ware, is presented in Table 10.12 for sherds larger than 16 cm^2, which were analyzed in detail and where a temper source could be discerned. Cases in which TSG could not be identified included sherds tempered with crushed sherd and/or very sparsely with sand and that had too few sand grains or rock fragments to recognize petrofacies source (seven plain, 15 red), as well as cases tempered with an indeterminate schist/gneiss, that is, neither fine nor coarse, and lacking sand grains (six plain, one red). Petrographic analysis was performed on 36 sherds in the identified sample to verify/confirm the TSG assignments or, in a small number of cases, identify the temper source (Chapter 16, this volume). The petrographic analysis allowed inclusion of cases originally coded as indeterminate in the counts presented in Table 10.12. Importantly, the petrographic results indicate that pottery sourced by binocular analysis as "Camelback Buttes or Phoenix Mountains petrofacies" probably came from within the Camelback Buttes Petrofacies.

As shown in Table 10.12, material used to temper PHX Sky Train pottery derived from four source areas: the Phoenix Mountains, the Camelback Buttes Petrofacies, the South Mountain Petrofacies, and the middle Gila River Valley. Representation of these sources varies by ware, with plain ware most commonly tempered with material from the Phoenix Mountains or the Camelback Buttes Petrofacies (78

Table 10.12. Prehistoric pottery temper sources, by ware, PHX Sky Train project.

	Plain Ware		Red Ware		Buff Ware		Total	
Generic Temper Source	*n*	%	*n*	%	*n*	%	*n*	%
Salt River Valley								
Phoenix Mountains[a]	48	42.1	20	27.8	–	0.0	68	31.2
Camelback Buttes or Phoenix Mountains petrofacies[b]	31	27.2	1	1.4	–	0.0	32	14.7
Camelback Buttes Petrofacies	10	8.8	3	4.2	–	0.0	13	6.0
South Mountain Petrofacies	15	13.2	33	45.8	–	0.0	48	22.0
South Mountain or Montezuma petrofacies[c]	1	0.9	11	15.3	–	0.0	12	5.5
Gila River Valley								
Indeterminate Gila Basin mica-schist	4	3.5	3	4.2	30	93.8	37	17.0
Snaketown Petrofacies	1	0.9	–	0.0	2	6.3	3	1.4
Santan or Sacaton Mountains petrofacies	4	3.5	1	1.4	–	0.0	5	2.3
Total Ceramics	114	100.0	72	100.0	32	100.0	218	100.0

[a]Includes fine-grained schists (Squaw Peak schist) and phyllites.

[b]Most likely Camelback Buttes Petrofacies, based on petrographic results (Chapter 16, this volume).

[c]Distinguishes sand with high Estrella gneiss content, which indicates the pottery probably originated from the western end of the South Mountain Petrofacies.

percent of plain), red ware with South Mountain Petrofacies sands (61 percent of red), and buff ware with material exclusive to the Gila River Valley (100 percent). This pattern is not unexpected, however, because it has been well documented by Abbott (2000), who has demonstrated a robust trade in pottery vessels within and across canal systems in the Salt River Valley.

The more important finding is that the PHX Sky Train proportions closely resemble those from Pueblo Grande, AZ U:9:1 (ASM), proper, using data compiled from Abbott (ed. 1994:Tables 6.12 and 6.34). For example, at Pueblo Grande, 41 percent of plain ware contained Phoenix Mountains fine-grained schists and phyllite (42 percent in Table 10.12), 41 percent Camelback Buttes Petrofacies sands (combines Abbott's [ed. 1994] "Camelback Granite" and "Arkosic Sand with Squaw Peak Schist" categories) (36 percent in Table 10.12), and 60 percent of red ware contained South Mountain Petrofacies sands (combines Abbott's [ed. 1994] "South Mountain Granodiorite" and "Estrella Gneiss" categories) (61 percent in Table 10.12). This is also not an unexpected result, given that the PHX Sky Train project area lies on the western margin of Pueblo Grande. It provides confirmation that residents/farmers of this area were fully integrated with the larger village site.

FLAKED STONE ARTIFACTS FROM AZ U:9:1 (ASM) AND AZ U:9:28 (ASM), PHX SKY TRAIN PROJECT

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Investigations for the PHX Sky Train project resulted in the recovery of 663 flaked stone artifacts from seasonally occupied fieldhouses, farmsteads, and associated features. As these habitation-related features occur on the western margin of the large Hohokam village of Pueblo Grande, AZ U:9:1 (ASM), they are considered to be associated with that site. Analysis was conducted to characterize the assemblage in terms of raw materials and artifact types, and to address the research topic of land use and subsistence practices in the lower Salt River Valley. Specific issues pertaining to this research domain that can be addressed in the lithic analysis include feature function, subsistence activities, and changes through time. The technological behaviors reflected in the assemblage and comparisons made with similar occupation types in the valley provide insight into how the floodplain was used during the Sedentary and early Classic periods. A small flaked stone assemblage ($n = 27$) from canal sediments and associated irrigation features, designated as AZ U:9:28 (ASM), is also reported on here.

METHODS OF ANALYSIS AND ARTIFACT CLASSIFICATION

The entire flaked stone assemblage was analyzed to identify meaningful spatial and temporal patterns and to construct technological profiles useful for comparative studies. Artifact classification is based on the following typology developed by Sliva (1997, 2003, 2006b, 2013; see also Sliva and Ryan 2012) for use on all Desert Archaeology, Inc., projects. The typology uses a division of gross artifact classes that include cores, debitage, retouched flake implements, core tools, and core hammers, all differentiated based on blank type and the presence/absence of retouch. Attributes recorded for each artifact include maximum length (mm), weight (gm), raw material, presence or absence of cortex, and platform type (when applicable). Additional measurements taken for projectile points include base and blade width, neck width, blade thickness, and haft length.

Debitage includes complete flakes, fragmentary flakes, and shatter. Bifacial thinning flakes (BTF) are a special debitage type defined by a low platform angle, platform lipping, platform preparation, expanding flake margins, and a thin, curved cross section. Mass index (weight divided by maximum dimension) is calculated for the debitage to express relative flake thickness, with higher values indicating thicker, blockier flakes (Sliva 2006b:5).

Utilized flakes are unretouched pieces of debitage that exhibit edge damage or modification from use. Utilized edges are identified based on macroscopically visible wear traces, and their function is inferred. Presumably selected from the debitage based on their shape, size, and raw material qualities, utilized flakes are considered implements and are discussed as such here.

Retouched implements—flakes or cores with intentional modification through percussion flaking or pressure flaking—are identified based on specific retouch attributes and design elements (see Sliva 2006b:Tables 1.1-1.2). The resulting retouched edge or edges correspond to a technological type such as scraper, perforator, or denticulate (toothed edge). The tools are then grouped into a classification system developed to facilitate gross level analyses of technological behaviors, using a classification scheme segregating tools in terms of inferred function and the material worked, and are defined as follows (from Sliva 2013; Sliva and Ryan 2012). Single-function tools include projectile points and preforms, as they are designed for one function and that is to kill. Variable-function tools are general purpose tools that can be worked on a variety of material with a wide range of kinematics. These include scrapers, marginally retouched flakes, and general bifaces. Restricted-function tools have specialized working edges designed for specific uses, and include denticulates, perforators, drills, notches, concave sidescrapers, bifacial knives, and choppers. Because these categories are based on the designed edge, the grouping does not distinguish between flake tools and core tools.

Core hammers are cores that exhibit battering, indicating secondary reuse as hammers. These were generally not intentionally shaped for use as a hammer, and are considered separately from core tools.

ASSEMBLAGE DESCRIPTION

Raw material consisted largely of igneous material, and included rhyolite, basalt, and andesite (Table 11.1). The quality of the material varied, although the highest quality material in the assemblage included fine-grained basalt and igneous rock, and a very fine-grained basaltic andesite with a glassy appearance. Metamorphic rock made up almost one-quarter of the assemblage, and quartzite ranged from extremely fine-grained to coarse-grained. Together, chert, chalcedony, and jasper comprised almost 4 percent of the assemblage, and were present in the form of debitage, a projectile point, and two cores.

Flaked Stone Artifacts from Pueblo Grande, AZ U:9:1 (ASM)

The following descriptions of recovered flaked stone artifacts are organized by project-defined "areas," which contain spatially and temporally associated features (Chapter 9, this volume).

Colonial Period, Area 3A

Six flaked stone artifacts were recovered from pithouse structure Feature 306, dating to the late Gila Butte or Santa Cruz phase (Table 11.2). Artifacts from the fill of Feature 306 included two pieces of debitage, a bidirectional core, and a core hammer. The floor held a large flake (77.33 mm), and another flake was found in the hearth fill.

Sedentary Period, Area 6B

This seasonally occupied area in use during the early Sacaton phase yielded 24 flaked stone artifacts. The fill of pithouse Feature 314 contained nine pieces of debitage, a utilized core, and a core hammer. The floor of the structure held four pieces of debitage, a single-platform core, and a unifacial core chopper with use-wear. A bifacial thinning flake in the fill and one on the floor were both made of very fine-grained quartzite. The remainder of the assemblage consisted of debitage, found in the floor fill of pithouse Features 312 and 316.

Sedentary to Classic Transition, Area 5A

Flaked stone artifacts from this late Sacaton to early Soho transitional phase farmstead totalled 358. These were recovered from 4 pithouses, 1 extramural pit, 1 trash concentration, and nonfeature contexts. The debitage, constituting 94 percent of the assemblage, contained the smallest average flake size (40.07 mm) among the identified areas. Most of the flakes represented core reduction debitage, with only one bifacial thinning flake identified. Core types included 4 single-platform, 3 bidirectional, 3 multiple-platform, and 2 core fragments. Many of the cores were river cobbles that had flakes removed from one end.

The retouched tool assemblage was composed of four unifacially retouched flakes and two core tools (Table 11.3). Unifaces were in the form of two scrapers, a denticulated scraper, and a perforator; both of the core tools were scrapers. Three core hammers, recovered from nonfeature contexts, had an average size of 82.88 mm, and were all made from medium-grained igneous material.

The floor assemblages in pithouse Features 300, 302, and 307 all contained flaked stone artifacts, most of which were debitage (Table 11.4). These complete flakes were relatively large, measuring an average of 52.52 mm, and ranging from 25.52 mm to 77.20 mm. A core scraper found on the floor of Feature 307 was made from a fine-grained quartzite river cobble that may have been resharpened.

Classic Period, Area 3B

This Soho phase farmstead yielded 275 flaked stone artifacts recovered from two structures and four extramural pits. Debitage composed 90 percent of the assemblage. While a focus on hard-hammer core reduction is evident by the mean flake size (41.29 mm), a high mass index value (0.324), and a high frequency of cortical debitage (71 percent), some tool production is indicated by the presence of six bifacial thinning flakes, representing more than 2 percent of the debitage. The thinning flakes were found in the fill of Features 318 and 329, and were made of fine-grained igneous and basaltic andesite. Cores totalled 16, and included four each of single-platform, bidirectional, and multiple-platform types. A flake core, a tested cobble, and two core fragments were also recovered.

Several of the five identified utilized flakes displayed wear traces that suggested use in a transverse motion, possibly for scraping, and one appeared to have been used for slicing or graving. The lengths of the used flakes ranged from 47.46 mm to 70.99 mm, much larger than the average flake size for the area. Unifacially retouched flake tools consisted of a denticulated scraper, a notch, and a thick flake with steep marginal retouch. The denticulated scraper would have been useful for processing fibrous plants, and notches are useful tools for fiber processing and wood- or boneworking (Sliva 1997:42-43).

Table 11.1. Raw material distributions from habitation contexts, Pueblo Grande, AZ U:9:1 (ASM), and canal contexts, AZ U:9:28 (ASM), PHX Sky Train project.

	Pueblo Grande										U:9:28	
	Colonial		Sedentary		Sedentary-Classic		Classic		Total		Undated	
Raw Material	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Igneous, fine-grained	2	33.3	6	25.0	88	24.6	67	24.4	163	24.6	10	37.0
Igneous, medium-grained	2	33.3	7	29.2	92	25.7	79	28.7	180	27.1	7	25.9
Igneous, coarse-grained	–	–	–	–	1	0.3	7	2.5	8	1.2	3	11.1
Rhyolite, fine-grained	–	–	3	12.5	13	3.6	22	8.0	38	5.7	–	–
Rhyolite, medium-grained	–	–	1	4.2	9	2.5	10	3.6	20	3.0	–	–
Andesite	–	–	–	–	1	0.3	2	0.7	3	0.5	–	–
Basalt, fine-grained	–	–	2	8.3	24	6.7	16	5.8	42	6.3	1	3.7
Basaltic andesite, very fine-grained	–	–	–	–	6	1.7	9	3.3	15	2.3	3	11.1
Metamorphic, fine-grained	–	–	–	–	12	3.4	10	3.6	22	3.3	–	–
Metamorphic, medium-grained	–	–	–	–	3	0.8	6	2.2	9	1.4	–	–
Metasediment, medium-grained	1	16.7	–	–	–	–	1	0.4	2	0.3	–	–
Quartzite, super fine-grained	–	–	2	8.3	2	0.6	1	0.4	5	0.8	–	–
Quartzite, fine-grained	–	–	2	8.3	56	15.6	18	6.5	76	11.5	2	7.4
Quartzite, medium-grained	1	16.7	1	4.2	36	10.1	8	2.9	46	6.9	1	3.7
Quartzite, coarse-grained	–	–	–	–	–	–	2	0.7	2	0.3	–	–
Sedimentary	–	–	–	–	4	1.1	–	–	4	0.6	–	–
Chert	–	–	–	–	11	3.1	4	1.5	15	2.3	–	–
Chalcedony	–	–	–	–	–	–	9	3.3	9	1.4	–	–
Jasper	–	–	–	–	–	–	2	0.7	2	0.3	–	–
Quartz	–	–	–	–	–	–	2	0.7	2	0.3	–	–
Total	6	100.0	24	100.0	358	100.1	275	99.9	663	100.1	27	99.9

Table 11.2. Distribution of flaked stone artifacts across habitation contexts, Pueblo Grande, AZ U:9:1 (ASM), PHX Sky Train project.

	Colonial Period Area 3A		Sedentary Period Area 6B		Sedentary-Classic Transition Area 5A		Classic Period Area 3B		Total	
Artifact Class	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Debitage	4	66.7	20	83.3	337	94.1	248	90.2	609	91.9
Cores	1	16.7	1	4.2	12	3.4	16	5.8	30	4.5
Unifaces	–	–	–	–	4	1.1	3	1.1	7	1.1
Projectile point	–	–	–	–	–	–	1	0.4	1	0.2
Core tools	–	–	2	8.4	2	0.6	3	1.1	7	1.1
Core hammers	1	16.7	1	4.2	3	0.8	4	1.5	9	1.4
Total	6	100.1	24	100.1	358	100.0	275	100.1	663	100.2

Three core tools included a denticulate, a scraper, and a utilized core. The utilized core had one rounded edge, with use-wear suggestive of scraping or planing. Core hammers totalled four, three of which were recovered from Feature 329. One of these was also used as an anvil, evident by a succession of linear strike marks on a flat cortical surface. All the core hammers displayed moderate battering wear, with sizes ranging from 76.96 mm to 131.18 mm, and would have been suitable for both light-duty and heavy-duty tasks.

The only projectile point from Pueblo Grande is a Sedentary Side-notched point found in the fill of adobe structure Feature 329. Made from chert, the expertly manufactured point measured 29.15 mm, and was missing its distal end (Figure 11.1). This point type is commonly found at Sedentary period sites throughout southern Arizona (Sliva 2006a:Table 2.5). This particular point, with its downward-pointed ears forming a concave base, is most similar to examples documented at sites west of Phoenix, including the Cashion site, AZ T:11:39 (ASM), near Buckeye Hills (Antieau and Greenwald 1981:Plate 60, Form 8), and the Gatlin site, AZ Z:2:1 (ASM), in the Gila Bend area (Wasley and Johnson 1965:Figure 17g). This point may have been picked up from an earlier occupied site or locus and eventually discarded in the trash-filled structure. Notched points without serrations, assigned as Type 3, were found in pre-Classic and Classic period habitation areas at Pueblo Grande Ruin (Peterson 1994:Tables 3.29, 3.35). Although this point falls within the range of metrics reported for that assemblage, it is not known if any of the Type 3 points display similar notch and base shapes.

Flaked Stone Artifacts from AZ U:9:28 (ASM)

Twenty-seven flaked stone artifacts in this assemblage were recovered from canal sediments or irrigation ditches (Table 11.5). The 9 pieces of debitage consisted of eight complete core reduction flakes and one flake fragment. The flakes were large, ranging from 28.74 mm to 87.93 mm, with an average size of 52.73 mm. All but one piece of debitage had full or partial dorsal cortex coverage. The 10 cores included 4 single-platform, 3 multiple-platform, 2 bidirectional, and 1 core fragment. Most of the cores were river cobbles made from igneous material, and the only core that appears technologically exhausted is made of high-quality basaltic andesite.

Flaked stone implements consisted of one utilized flake and four core tools. The utilized flake was made of coarse-grained igneous material, measured 70.87 mm, and had a rounded and flaked edge, indicating it was used in a transverse motion. Core tools included two choppers, a scraper, and a denticulate. Three of these were made from fine- to medium-grained igneous material, and the bifacial core chopper was made from quartzite. The bifacial chopper and the core scraper both displayed use-wear. Use-wear is not macroscopically evident along the retouched edge of the large unifacial core chopper, but an area opposite the working edge had been ground, presumably to form a comfortable grip. The three core hammers in the assemblage were made of fine- and medium-grained igneous material, and displayed moderate battering wear.

DISCUSSION

Occupants of the various Sky Train habitation areas relied on readily available materials to provide a variety of retouched flake tools, core tools, core hammers, and large flakes suitable for use in unmodified form. River cobbles were often selected for reduction, and in many instances, reduction was limited to one area of the cobble. Given the shape and size of these cobbles, they could have been held comfortably in one hand while flakes were removed

Table 11.3. Flaked stone implements from habitation contexts, Pueblo Grande, AZ U:9:1 (ASM), PHX Sky Train project.

Artifact Type	Feature	Raw Material	Context	Maximum Length (mm)	Wear Traces and Inferred Activities
Colonial period, late Gila Butte or Santa Cruz phase, Area 3A					
Core hammer	306	Quartzite, medium-grained	Structure fill	75.22	Tested cobble with minor battering
Sedentary period, early Sacaton phase, Area 6B					
Core tools					
Unifacial core chopper	314	Igneous, medium-grained	Floor	115.20	-
Utilized core	314	Rhyolite, fine-grained	Floor fill	59.12	One area rounded with abrasion; scraping or planing
Core hammer	314	Rhyolite, fine-grained	Floor fill	86.95	Battering in several areas
Sedentary-Classic transition, late Sacaton or early Soho phase, Area 5A					
Unifaces					
Sidescraper	300	Igneous, fine-grained	Structure fill	56.14	-
Perforator	307	Igneous, fine-grained	Floor fill	54.94	-
Denticulated scraper	307	Metamorphic, fine-grained	Structure fill	58.92	-
Sidescraper	309	Igneous, medium-grained	Extramural pit	57.90	-
Core tools					
Core scraper/plane	307	Quartzite, super fine-grained	Floor	78.17	-
Core scraper/plane	309	Quartzite, fine-grained	Trash concentration	87.47	-
Core hammers					
Core hammer	0	Igneous, medium-grained	Sheet trash	96.94	-
Core hammer	0	Igneous, medium-grained	Sheet trash	79.50	-
Core hammer	0	Igneous, medium-grained	Sheet trash	72.21	-
Classic period, Soho phase, Area 3B					
Debitage					
Utilized flake	318	Igneous, fine-grained	Structure fill	53.38	Rounded and polished edge; scraping a soft material?
Utilized flake	318	Rhyolite, medium-grained	Structure fill	58.18	Rounded distal edge with flaking extending onto dorsal aspect; scraping
Utilized flake	326	Igneous, medium-grained	Extramural pit	70.99	Abrasion and flaking; scraping?
Utilized flake	329	Igneous, fine-grained	Structure fill	47.46	Distal edge rounded and polished, striations perpendicular to edge; scraping?
Utilized flake	329	Igneous, fine-grained	Structure fill	67.99	Lateral edge rounded and polished: scraping, slicing?

Table 11.3. Continued.

Artifact Type	Feature	Raw Material	Context	Maximum Length (mm)	Wear Traces and Inferred Activities
Unifaces					
Marginal retouch	329	Metamorphic, fine-grained	Structure fill	69.21	-
Notch	334	Igneous, medium-grained	Extramural pit	63.07	-
Denticulated scraper	334	Igneous, coarse-grained	Extramural pit	70.64	-
Biface					
Projectile point	329	Chert	Structure fill	28.97	-
Core tools					
Utilized core	329	Metamorphic, medium-grained	Floor fill	94.25	Edge is rounded with abrasion; scraping?
Core scraper/plane	332	Igneous, medium-grained	Extramural pit	140.70	-
Core denticulate	333	Quartzite, fine-grained	Extramural pit	125.89	-
Core hammers					
Core hammer	326	Igneous, medium-grained	Extramural pit	131.18	-
Core hammer	329	Igneous, medium-grained	Structure fill	97.05	Heavy battering
Core hammer	329	Basalt, fine-grained	Floor fill	76.96	Fits nicely in hand, good size for knapping
Core hammer/anvil	329	Igneous, fine-grained	Structure fill	97.25	A series of linear strike marks on one flat surface

Table 11.4. Contextual distributions of flaked stone artifacts from habitation contexts, Pueblo Grande, AZ U:9:1 (ASM), PHX Sky Train project.

Feature	Context	Debitage	Core	Uniface	Projectile Point	Core Tool	Core Hammer	Total
Colonial period, late Gila Butte or Santa Cruz phase, Area 3A								
306	Structure fill	2	1	–	–	–	1	4
306	Floor	1	–	–	–	–	–	1
306	Hearth	1	–	–	–	–	–	1
Sedentary period, early Sacaton phase, Area 6B								
312	Floor fill	5	–	–	–	–	–	5
314	Floor fill	9	–	–	–	1	1	11
314	Floor	4	1	–	–	1	–	6
316	Floor fill	2	–	–	–	–	–	2
Sedentary-Classic transition, late Sacaton or early Soho phase, Area 5A								
0	Sheet trash	11	6	–	–	–	3	20
300	Structure fill	8	–	1	–	–	–	9
300	Floor fill	6	2	–	–	–	–	8
300	Floor	3	–	–	–	–	–	3
301	Structure fill	3	–	–	–	–	–	3
301	Floor fill	4	1	–	–	–	–	5
302	Structure fill	11	–	–	–	–	–	11
302	Floor fill	6	–	–	–	–	–	6
302	Floor	5	–	–	–	–	–	5
307	Structure fill	94	1	1	–	–	–	96
307	Floor fill	51	1	1	–	–	–	53
307	Floor	1	–	–	–	1	–	2
309	Trash	131	2	1	–	1	–	135
311	Pit fill	2	–	–	–	–	–	2
Classic period, Soho phase, Area 3B								
318	Structure fill	74	–	–	–	–	–	74
318	Floor fill	16	–	–	–	–	–	16
326	Extramural posthole	12	1	–	–	–	1	14
329	Sheet trash	6	–	–	–	–	–	6
329	Structure fill	86	9	1	1	–	2	99
329	Floor fill	14	3	–	–	1	1	19
329	Floor	3	–	–	–	–	–	3
332	Pit fill	1	–	–	–	1	–	2
333	Pit fill	21	3	–	–	1	–	25
334	Pit fill	15	–	2	–	–	–	17
Total		608	31	7	1	7	9	663

from the other end. These cores were generally discarded with no effort, or need, to conserve the material.

To evaluate lithic assemblages from the Salt River floodplain, Greenwald (1996) presented a model for seasonal and long-term Hohokam occupation sites in the region. When comparing the flaked stone artifacts from seasonally occupied areas at Dutch Canal Ruin, AZ T:12:62 (ASM), Sliva (2003:177) determined that the assemblage did not fit well with the existing model, possibly due to its small sample size, and suggested using technological profiles based on artifact types and specific attributes to discern differences among assemblages. The Sky Train assemblage is assessed in this manner, with the technological profiles from discrete spatial and temporal units examined to identify behaviors and patterns (Table 11.6).

The small assemblages from the fieldhouse settlements (Areas 3A and 6B) occupied during the Colonial and Sedentary periods are characterized by large, thick flakes, and the only implements represented are core tools and core hammers. The bulk of the assemblage from habitation contexts was asso-

Figure 11.1. Sedentary Side-notched projectile point recovered from Feature 329, Pueblo Grande, AZ U:9:1 (ASM), (FN 1221, 2008-711-12), PHX Sky Train project.

ciated with farmstead settlements in Areas 5A and 3B, occupied during the Sedentary-Classic transition and the Soho phase of the Classic period. While the frequency of unifacially retouched tools at both of these areas is similar, core tools and tools with specialized working edges occur more frequently in the Soho phase. When considering the utilized flakes, implements compose more than 4 percent of the Classic period assemblage, in contrast to the late Sacaton to early Soho component, where they occur at a rate of less than 2 percent.

High quality raw materials, such as chert, chalcedony, and basaltic andesite, are seen more frequently in the Soho phase. Bifacial thinning flakes also occur more frequently, although strong evidence for point manufacture is lacking, given that all the thinning flakes are made of fine-grained igneous and quartzite and Hohokam projectile points are often manufactured from cryptocrystalline material. Based on the increase in specialized tools and tool manufacture debris, Area 3B may have been occupied for a longer span of time than the household represented in Area 5A.

Researchers have noted that core tools, hammers, and heavy tools are generally associated with plant processing sites and fieldhouses (Bernard-Shaw 1984:419-421), while lithic assemblages from farmsteads are expected to contain a more diverse assemblage, reflecting both subsistence and manufacturing activities (Greenwald 1996:201; Whittlesey and Ciolek-Torello 1992:110-111). The flaked stone assemblages from the various Sky Train settlement types generally follow this pattern. Processing tools and specialized tools recovered from the farmsteads could have been used in a broad range of activities. Core scrapers and tools with denticulated edges would have been useful for plant processing, and some of the scrapers, the perforator, and the notch could have also been used for hideworking, woodworking, or boneworking. In this aspect, the assemblage is similar to pre-Classic low intensity occupations at Dutch Canal Ruin, where a diverse range of activities was indicated by the presence of non-subsistence implements (Sliva 2003).

CONCLUSION

The flaked stone assemblage from the Sky Train habitation areas is consistent with those from seasonal or short-term occupations in the Salt River floodplain and elsewhere during the pre-Classic and the Classic period. Although the relatively small assemblages associated with these settlement types limit interpretations, the tool distributions and debitage attributes offer some insight into the activities conducted in the PHX Sky Train project area and changes through time. Overall, the retouched and utilized implements in all the areas are consistent with those needed for subsistence-related activities, such as scraping, slicing, shredding, and pounding. Manufacturing activities are also reflected in the farmstead assemblages, with tools whose possible

Table 11.5. Flaked stone artifacts recovered from canal contexts, AZ U:9:28 (ASM), PHX Sky Train project.

Feature	Feature Type	Debitage	Core	Utilized Flake	Core Chopper	Core Scraper	Core Denticulate	Core Hammer	Total
0	N/A	1	1	–	2	–	–	1	5
2	Ditch	1	3	–	–	–	1	1	6
3	Canal	–	3	–	–	–	–	1	4
5	Ditch	–	1	–	–	–	–	–	1
33	Ditch	–	1	–	–	1	–	–	2
56	Ditch	2	1	–	–	–	–	–	3
57	Catchment	5	-	1	–	–	–	–	6
	Total	9	10	1	2	1	1	3	27

Table 11.6. Technological profiles and debitage attributes for habitation areas, PHX Sky Train project.

			Complete Flakes			Bifacial Thinning Flakes			Cores			Designed Tool Function		
Period	Area	Total Flaked Stone	Total	Mean Size (mm)	Mean MI[a]	Total	Mean Size (mm)	Mean MI	Total	Mean Size (mm)	Total Retouched Tools	Variable	Restricted	Single
Colonial	3A	6	3	51.31	0.429	–	–	–	1	82.38	–	–	–	–
Sedentary	6B	24	101	44.40	0.354	2	13.85	0.019	1	82.10	1	–	100%	–
Sedentary/Classic	5A	358	157	40.07	0.267	1	12.94	0.013	12	93.19	6	67%	33%	–
Classic	3B	281	128	41.29	0.324	6	14.12	0.017	14	76.94	6	33%	50%	17%

[a]Mass index = Weight/maxiumum linear dimension.

uses include hideworking, boneworking, and woodworking. The greater frequency of flaked stone tools, specialized working edges, and tool manufacture debris seen in Area 3B provides evidence that occupation may have been most intensive during the early Classic period. Although there is little evidence for projectile point manufacture, the point discarded in the adobe structure in Area 3B indicates activities in this area were not solely limited to agricultural pursuits.

GROUND STONE ARTIFACTS AND ECOFACTS RECOVERED DURING EXCAVATIONS FOR THE PHX SKY TRAIN PROJECT

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Specific research issues guided the archaeological approach to the cultural remains uncovered during the PHX Sky Train project (Chapter 1, this volume). The issues most appropriately addressed with ground stone artifacts and ecofacts are related to technological constructs in the operation of fieldhouses and farmsteads on alluvial terraces in the Salt River Valley. The inhabitants of these small, agriculturally focused settlements used stone tools to process food, pigment, and other substances, to build and maintain structures, and to manufacture pottery and other items. Ecofacts in this project include only raw materials, which were brought to the settlement but not modified. Together, artifacts and ecofacts are referred to here as ground stone items, and they are considered clues to the lives and activities of inhabitants at the western margin of Pueblo Grande, AZ U:9:1 (ASM) (Table 12.1). The few artifacts found around the canals, assigned AZ U:9:28 (ASM), relate to the broader use of the project locale by local farmers.

The ground stone analysis approach used here is technological, and the artifact types were defined in accordance with Adams (2002). Briefly, the technological approach incorporates not only a typological description, but also a consideration of archaeological context, as well as how an artifact was designed, manufactured, used, redesigned, reused, or recycled. Through such an analysis, it is possible to track the "life history" of an artifact (Adams 2002:17-18; Schiffer 1987; Schlanger 1990). The life history framework evaluates whether morphological variations among items of the same type are the result of differences in their life histories or differences in their original design (Adams 2002:17-18). After these differences are understood, artifact designs can be used to evaluate different activities represented at a settlement and reconstruct the technological traditions of the inhabitants.

Because context is important to this analysis, it should be noted that, in most circumstances, whole ground stone items found within 5-10 cm of the floor and those found in roof/wall deposits are considered to have been associated with the occupation of a particular structure. In contrast, items from the upper fill of a structure were either associated with later occupation of nearby structures or were in sheet trash redeposited after the settlement was vacated.

Raw material selection is an important consideration in the manufacture of ground stone items. Attributes such as the hardness and durability of a stone may be important, as are its size, shape, and surface texture, depending on the intended function of an item. Specifically, this analysis strategy generates artifact level data related to the daily activities that occurred throughout the different time periods represented in the PHX Sky Train project area. These data were recorded and compiled as Appendix E (this volume). Artifacts and supporting documentation are curated at the Pueblo Grande Museum.

The project area was divided into spatially discrete areas that also have considerable temporal integrity (Chapter 9, this volume). Ground stone items were most abundant in Areas 3B, 5A, and 7A (Table 12.2). Those found in Areas 3A, 3B, 5A, and 6B were associated with structures and attendant features. Those found in Areas 6A and 7A and artifacts found in undesignated areas were sheet trash or were with isolated activities associated with canals and fields. Not all contexts could be dated.

HABITATION-ASSOCIATED ARTIFACTS

Ground stone artifacts were associated with a number of the habitation features in the PHX Sky Train project area. The Colonial period occupation represented in Area 3A dated the earliest of the excavated areas. Four ground stone artifacts were recovered from one pithouse and an extramural feature. One ground stone artifact was recovered from an early Sacaton phase pithouse in Area 6B. Twenty-two ground stone items were found in Area 5A pithouses and an artifact concentration, dating prima-

Table 12.1. Artifact types recovered from habitation contexts, Pueblo Grande, AZ U:9:1 (ASM), and canal contexts, AZ U:9:28 (ASM), PHX Sky Train project.

	U:9:1		U:9:28		Total	
	No.	%	No.	%	No.	%
Artifacts						
Abrader	4	6.6	–	–	4	5.2
Axe	1	1.6	–	–	1	1.3
Chopper	–	–	1	6.3	1	1.3
Disk	1	1.6	1	6.3	2	2.6
Handstone	5	8.2	–	–	5	6.5
Lapstone	3	4.9	1	6.3	4	5.2
Mano	10	16.4	3	18.8	13	16.9
Metate	5	8.2	2	12.5	7	9.1
Netherstone	7	11.5	1	6.3	8	10.4
Ornament	2	3.3	–	–	2	2.6
Pecking stone	–	–	1	6.3	1	1.3
Pestle	3	4.9	–	–	3	3.9
Pigment	1	1.6	–	–	1	1.3
Polisher	14	23.0	5	31.3	19	24.7
Pottery anvil	1	1.6	–	–	1	1.3
Tablet	1	1.6	–	–	1	1.3
Tabular tool	2	3.3	1	6.3	3	3.9
Whorl	1	1.6	–	–	1	1.3
Subtotal	61		16		77	
Ecofacts						
Raw material	9	12.9	–	–	9	10.5
Subtotal	9		–	–	9	
Total	70	81.4	16	18.6	86	

Note: counts above do not include eight unidentified fragments.

rily to sometime during the late Sacaton phase or the early Soho phase. Not including unidentified fragments, 38 ground stone items were recovered from an adobe structure and four small pits in Area 3B, where most contexts dated to the Soho phase.

Area 3A

The Colonial period occupation of Area 3A is represented in the ground stone assemblage by tools recovered from a probable fieldhouse that dates to sometime during the late Gila Butte phase or the early Santa Cruz phase. A handstone was on the floor and a lapstone was in a floor pit within pithouse Feature 306. The lapstone is a flat cobble used on both sides for smoothing small, hard objects, and an area on the side was secondarily used like a pestle for crushing substances on a flat surface. The handstone was used with a different netherstone, probably for processing small quantities of unidentified substances. A broken polisher in the fill of pithouse Feature 306 was originally a large handstone used for burnishing another stone surface and secondarily used as a pecking stone after flakes were removed to create an edge. This redesigned piece was also recorded as a flaked stone tool (Chapter 11, this volume). A broken netherstone was secondarily used to support one of three trivets in nearby pit Feature 310 (see Figure 9.1). These are not unexpected finds for a fieldhouse context. The items would have been useful for maintaining tools, or for idle time projects of a farmer.

Area 6B

The only ground stone artifact found in Area 6B was on the floor of an early Sacaton phase pithouse, Feature 314. It is a polisher that was redesigned as a pecking stone (see Table 12.2). The dark gray diorite selected for the polishing task was flakable, and this piece was also recorded as a flaked stone tool (see Chapter 11). The flaked edges are covered with impact fractures from use as a pecking stone. Both the polishing and pecking tasks were against stone surfaces. This piece, in addition to others (yet to be described) are interesting, because they were redesigned from tools that had received considerable use in completely different functions before becoming the raw material for a secondary use. The unanswerable questions include the following. Where were they originally used, and if they were locally used, what changed to make them expendable from their initial function? No unmodified polishers made from this material were found.

Area 5A

Pithouses and an artifact concentration in Area 5A date to sometime during the late Sacaton phase through the early Soho phase. The few artifacts recovered from pithouse Features 300 and 302 provide little information about attendant activities. A broken handstone was found in the fill of pithouse Feature 302, and a flat/concave mano was on the floor of pithouse Feature 300, although no compatible metate was recovered.

Thirteen ground stone items were recovered from the floor and upper fill of pithouse Feature 307 in Area 5A. Five of the eight artifacts associated with the floor are whole. A piece from a broken abrader was found on the floor that refits to a second piece found in an area between Features 300, 302, and 309 (see Figure 9.9). Even when refitted, these two pieces are not a whole abrader (Figure 12.1a). One of two

Table 12.2. Areas in which ground stone and ecofacts were found, PHX Sky Train project.

Artifacts	Area 3A	Area 3B	Area 5A	Area 6A	Area 6B	Area 7A	Block 5[a]	Other	Total	Column Percent
Abrader	–	2	2	–	–	–	–	–	4	5.2
Axe	–	1	–	–	–	–	–	–	1	1.3
Chopper	–	–	–	–	–	1	–	–	1	1.3
Disk	–	1	–	1	–	–	–	–	2	2.6
Handstone	1	1	3	–	–	–	–	–	5	6.5
Lapstone	1	2	–	–	–	1	–	–	4	5.2
Mano	–	5	5	1	–	2	–	–	13	16.9
Metate	–	1	3	–	–	2	1	–	7	9.1
Netherstone	1	4	1	–	–	1	1	–	8	10.4
Ornament	–	1	1	–	–	–	–	–	2	2.6
Pecking stone	–	–	–	–	–	1	–	–	1	1.3
Pestle	–	1	1	–	–	–	1	–	3	3.9
Pigment	–	1	–	–	–	–	–	–	1	1.3
Polisher	1	9	3	–	1	1	–	4	19	24.7
Pottery anvil	–	1	–	–	–	–	–	–	1	1.3
Tablet	–	–	1	–	–	–	–	–	1	1.3
Tabular tool	–	1	1	–	–	1	–	–	3	3.9
Whorl	–	1	–	–	–	–	–	–	1	1.3
Total	4	32	21	2	1	10	3	4	77	
Row percent	5.2	41.6	27.3	2.6	1.3	13.0	3.9	5.2		
Raw material	–	6	1	–	–	–	–	2	9	

Note: Does not include eight unidentified fragments.
[a]Artifacts recovered in Block 5 outside the bounds of Area 5A, primarily during stripping above canal Feature 3.

other broken ground stone pieces on the floor was a handstone; the other was a netherstone redesigned with a small cupule that contained tiny remnants of red pigment (Munsell Value 10R 4/8). The cupule may have been used as a container, because there is no wear to indicate use as a mortar.

Two of the whole floor artifacts, a handstone and trough mano, were used to process red pigment. The handstone was used on both opposing surfaces to grind red pigment (Munsell Value 10R 4/8) and then used again to process something that partially wore away the pigment stains. Various locations on the trough mano were used to abrade red pigment (Munsell Value 10R 3/6). The other whole floor artifacts in Feature 307 include two polishers and another abrader. The two polishers are handstones with use-wear most commonly seen on plastering stones. The floor of the pithouse was plastered, and these stones may have been part of that process. The abrader was used to smooth an unidentifiable contact surface.

Artifacts in the upper fill of pithouse Feature 307 are all broken and include two unidentified fragments, a trough mano, a trough metate, and an ornament. The ornament is a mica piece that appears to be very fragile and may have been to a larger notched piece. One large notch is clearly visible on one edge, a smaller one is on the opposite edge, and there may have been more (Figure 12.2). The mano and the metate were made from vesicular basalt, although it is unclear where they were used as whole food processing tools. Both were burned, possibly from secondary use in a roaster.

An artifact concentration, Feature 309 in Area 5A, contained six ground stone artifacts. Two more were in sheet trash covering the concentration. Another three pieces were recovered from sheet trash overlying other portions of area 5A. Four of the five recovered from the sheet trash are whole; the remainder from both sheet trash and the artifact concentration are broken.

The whole artifacts recovered from sheet trash in Area 5A include an unfinished pestle, two flat/concave manos, and an open-trough metate. The rhyolite cobble chosen for the pestle was modified with a pecked finger grip, and one end was partially pecked to create a workable surface that was never used. The unfinished pestle and the open-trough metate were found in fill above the artifact concentration. The open-trough metate was newly manufactured from a large, red, quartzite cobble, and was used only lightly (Figure 12.3). The surface has pigment in the crevices that is probably dried red paint (Munsell Value 10R 4/6), and it is hard to distin-

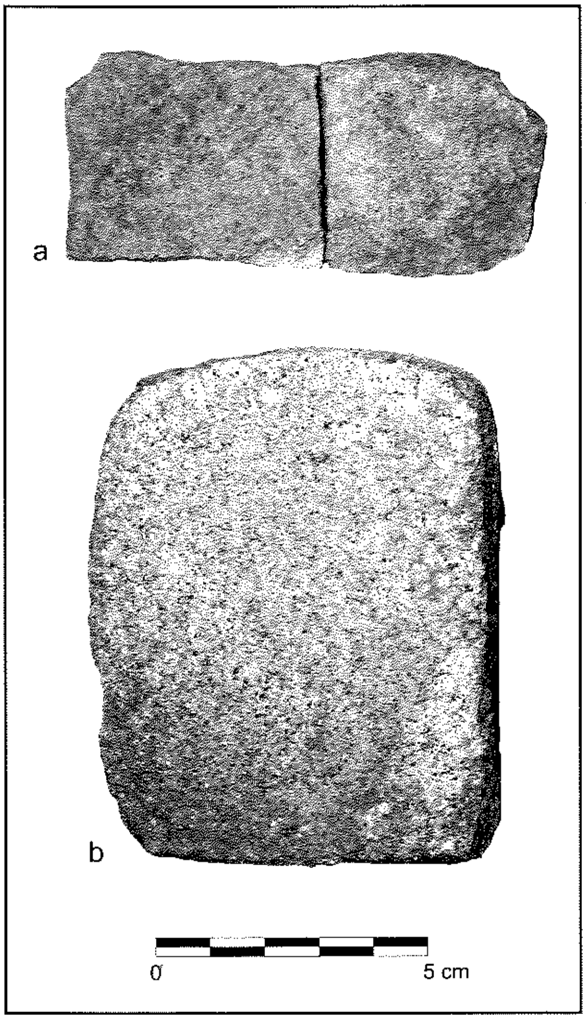

Figure 12.1. Abraders recovered from habitation areas, PHX Sky Train project: (a) two fragments from a larger abrader; one piece was found on the floor of pithouse Feature 307 and the other in an area between Features 300, 302, and 309 (FN 728, Catalog No. 2008-077-17); (b) a flat abrader found in sheet trash in an area between Features 300, 302, and 309 (Feature 0, FN 1326, Catalog No. 2008-077-15).

guish from the red of the quartzite. The center of the surface was worn relatively clean when something was subsequently ground, removing some of the dried paint. The metate bottom was concomitantly used as a netherstone, probably for processing an unknown substance with a small handstone. The netherstone surface had been previously pecked to roughen it. The two flat/concave manos were from the area between Features 300, 302, and 307. Both manos had finger grips, and were used enough to create moderate wear. One had been secondarily used to process red pigment (Munsell Value 10R 3/6) and then subsequently processed something that removed most of the pigment stain. This secondary use could have been with the open-trough metate.

In addition to raw material for temper, broken artifacts from the artifact concentration and sheet trash include two unidentified fragments, a trough metate, a tabular tool also used as a lapstone, a polisher, and part of an incised tablet (Figure 12.4). It is unclear what the entire tablet would have looked like, although this piece was clearly not the border of a palette, even though it was made from phyllite, which was commonly used to make palettes. The polisher was large, made from diorite, and was probably used to burnish other stone artifacts, such as axe heads (Figure 12.5a). The diorite was selected for use as a polisher, due to its fine-grained texture, which is also flakable. Flakes were removed, and the flake scars are covered with impact fractures from use as a pecking stone.

Area 3B

Ground stone artifacts recovered from Area 3B were primarily associated with an adobe structure, Feature 329, although others were found in pithouse Feature 318 and pit Features 332, 333, and 334. All of these features dated to the Classic period.

The five items on the floor of Feature 329 are a heavily used pottery polisher, a netherstone used for manufacturing, an abrader, processed red pigment, and unmodified phyllite that was probably intended for tool manufacture. The pigment is red, earthy hematite (Munsell Value 10R 4/6). The abrader may have originally been an axe head that broke at the poll side of the groove. The broken edge has been used like a wide scraper. Although not sharp enough to plane a surface, it would have abraded it. The use-wear extends around the perimeter of the break.

The 15 items in the Feature 329 fill were associated with activities postdating occupation of the structure. A heavily worn pottery polisher and a pottery anvil were found in the fill of the adobe structure, but their relation to the pottery polisher inside the structure is uncertain. The anvil has two pecked areas on the perimeter for finger grips and has opposing surfaces with light grinding to shape. The most distinctive use-wear is visible under 40x magnification as minute rounding of the asperities, probably from beating the clay against both surfaces. Two unmodified pieces of schist in the fill may have been for temper, and a third piece may have been raw material for tool manufacture. A piece of red hematite has abrasions from being ground to make powdered pigment, which could have been for painting or slipping pots (Munsell Value 10R 4/6). Together, the two pottery polishers, the pottery anvil, the schist, and the red pigment are the clearest indications of pottery manufacture in this assemblage.

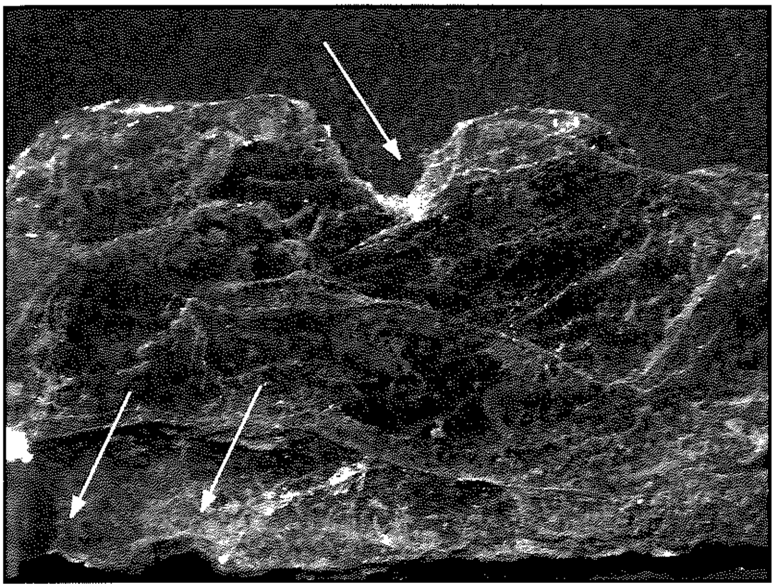

Figure 12.2. Tiny piece of notched mica recovered from the fill of pithouse Feature 307, PHX Sky Train project. (Arrows point to notches, 18x magnification) (FN 681, Catalog No. 2008-077-16).

Three larger polishers were also recovered from the fill of Feature 329. These were made from dark gray, fine-grained diorite, dacite, and diabase. One had multiple secondary uses as a lithic anvil on one side, as a flaked core, and an edge that was used as a scraper (Figure 12.5b). This tool was also recorded as flaked stone. A second polisher was used to polish another flat stone surface, and then secondarily used as a hammerstone with impact fractures concentrated in three areas. One side has pigment, probably from burnishing something with red paint or slip. Although it may be too big for pottery polishing, it could have been used to burnish plaster or hard wood. The third polisher was used for burnishing stone.

Other whole artifacts in the fill of pithouse Feature 329 included a disk and a lapstone. The disk may have been an unfinished whorl (Figure 12.6a). The lapstone was used on one side to smooth small, hard objects, such as the disk, the broken ornament, and the whorl

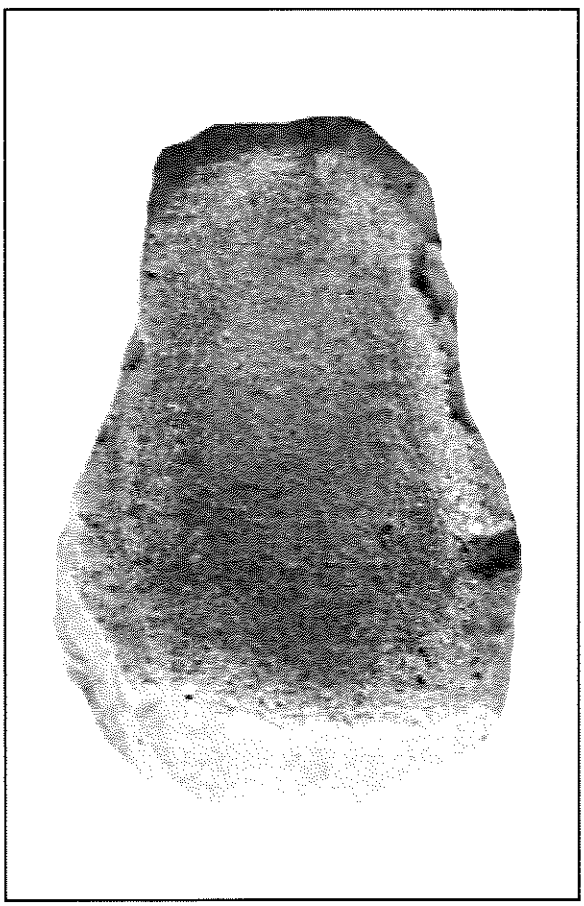

Figure 12.3. Open-trough metate secondarily used for pigment and found in sheet trash over an artifact concentration in Area 5A, PHX Sky Train project (FN 792, Catalog No. 2008-077-19).

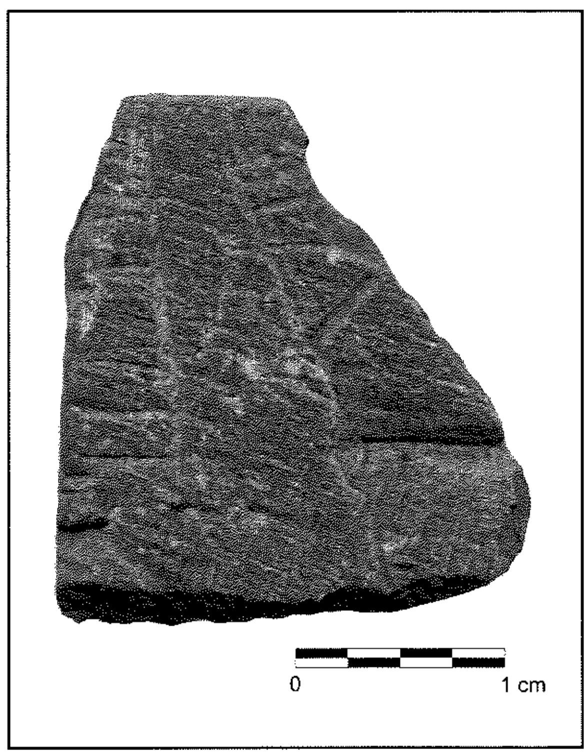

Figure 12.4. Fragment of an incised tablet found in an artifact concentration in Area 5A, PHX Sky Train project (FN 761.02, Catalog No. 2008-077-18).

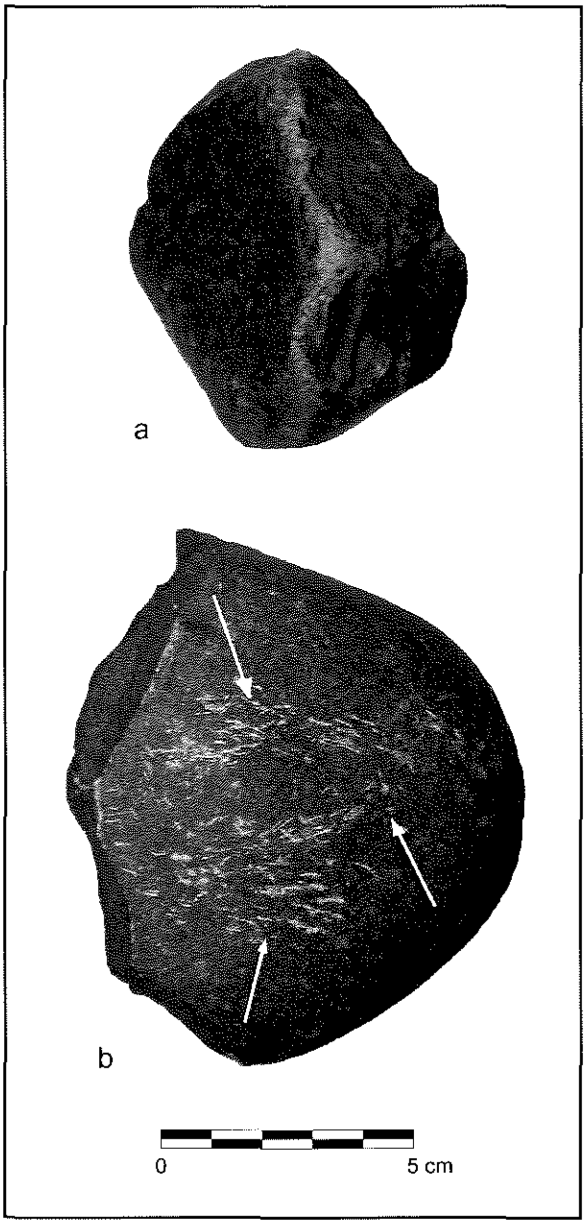

Figure 12.5. Polishers redesigned and secondarily used at habitation areas, PHX Sky Train project: (a) secondarily used as a core and a pecking stone recovered from sheet trash in Area 5A (FN 750, Catalog No. 2008-077-13); (b) secondarily used as an anvil and a scraper; note linear impact fractures distinctive to lithic anvils that intrude on the polishing surface; arrows point to scraping use-wear (Feature 329, FN 1271, Catalog No. 2008-077-23).

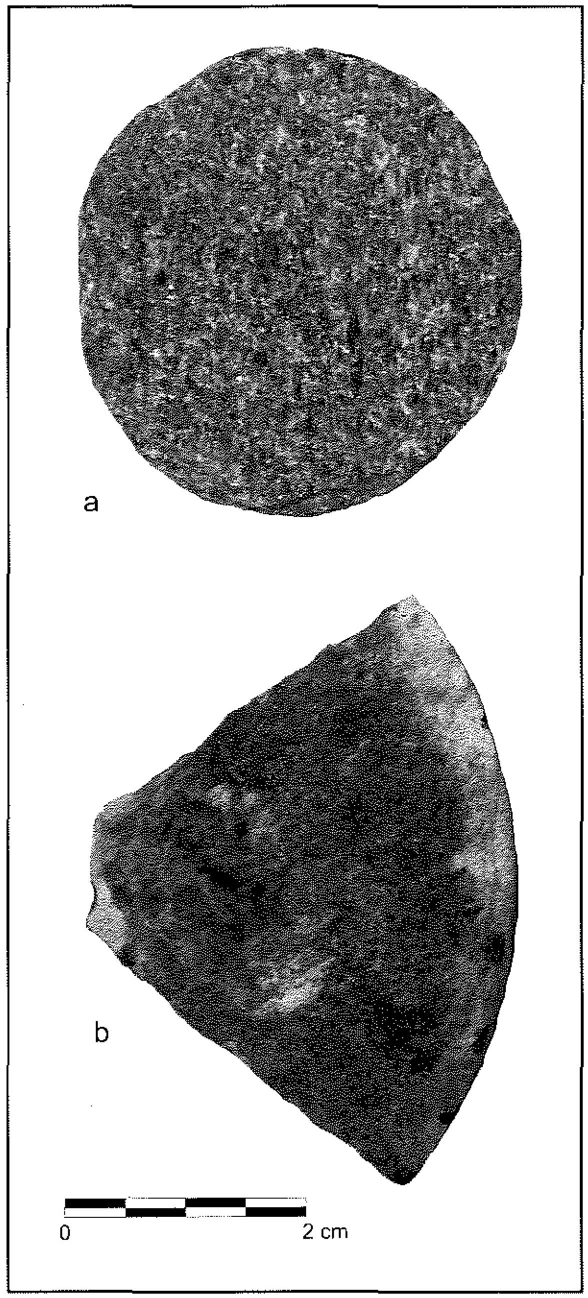

Figure 12.6. Disk artifacts recovered from habitation areas, PHX Sky Train project: (a) possible unfinished whorl recovered from the same fill (FN 1223, Catalog No. 2008-077-21); (b) whorl fragment found in the fill of adobe structure Feature 329 (FN 1240, Catalog No. 2008-077-22).

found in the same fill. Broken artifacts in the fill included a trough mano, a pendant, and a whorl. The broken ornament is a portion of a pendant with a biconical hole. There is no use-wear in the hole to indicate it had been worn. The whorl fragment is broken through the hole (Figure 12.6b). Both the pendant and the whorl may have been broken during manufacture. The striking fact about the artifacts associated with the adobe structure, both on the floor and in the fill, is that the activities represented are oriented more toward manufacturing than food processing. The only food-processing tool associated with Feature 329 is a broken mano. It had been used in a trough metate long enough to accumulate heavy wear, although the location of this food processing-activity is unknown.

Nine ground stone items were in pit Feature 326, which might have been an exterior support post for adobe structure Feature 329. The whole artifacts included a handstone, two netherstones, and a heavily used pottery polisher. One of the netherstones and the handstone are compatible, and they have use-wear consistent with processing small amounts of an unknown but probably herbal substance. The other netherstone was also used for processing but was not compatible with the handstone. The broken items were 2 trough manos, 1 trough metate, 1 lapstone, and 1 pestle. Both of the broken manos were secondarily used, one as a polisher and the other as a redesigned chopper, which was only lightly used, if at all. They are no longer functional as manos, but both could have continued in their secondary use. It is not possible to determine if either mano was used with the metate that is represented by only a fragment of the trough wall. When whole, the lapstone was used to shape other stone items and would have been good for manufacturing axe heads. The pestle was broken, but the end that remains was used against two different surfaces. It was first used in a smooth, stone mortar and secondarily against a rougher, flat surface. At some point, the pestle was also used as a handstone against a netherstone, probably in a two-step processing task of crushing and grinding. The presence of the pottery polisher, the compatible handstone and netherstone, the second usable netherstone, and the redesigned manos seems more compatible with interpretation of this pit as a storage location than as a posthole.

Three other pits in Area 3B may have been used to store items. A whole, flat/concave mano and an abrader were found in pit Feature 332. The mano is one of eight whole food-processing tools recovered from the site. The abrader was probably used to shape wood. Two pits, Features 333 and 334, were overlapping but seemingly autonomous pits (see Chapter 9). A tabular tool from Feature 334 was unfinished, with an edge that was partially ground and serrated on a piece of phyllite. A whole flat/concave mano, a floor polisher, and a broken netherstone were in Feature 333. The floor polisher had one flat surface with a central pecked area, which is a typical floor polisher attribute (Adams 2002:94-95; Woodbury 1954:90). The opposite surface and spots on the ends and edges were used to burnish stone. Random impact fractures were probably from expedient hammerstone use. The mano was an unmodified quartzite cobble that had only been lightly used. The netherstone was probably used in processing activities. Each pit had a cobble on the bottom of the pit (see Chapter 9), possibly reflecting their use for storage.

A few artifacts were recovered from sheet trash in Area 3B. Raw material for tool manufacture was recovered from sheet trash over the adobe structure, Feature 329. It is a large tablet of phyllite that would have been good for tabular knives or saws. An abrader and a floor polisher were found in sheet trash elsewhere in Area 3B. The polisher was used to burnish plaster and was made with finger grips and the distinctive central pecked area (Figure 12.7). The finger grips may have been secondarily used for powdering red pigment (Munsell Value 10R 4/8). If the pigment was from burnishing a colored plaster, the color would be visible in the interstices of the surfaces, even if it was secondarily used on something without color. The abrader was made from loosely cemented sandstone, which is useful for abrading surfaces but that does not allow for the buildup of distinctive use-wear (Figure 12.1b).

CANAL- AND FIELD SYSTEM-ASSOCIATED ARTIFACTS

Artifacts recovered from broad spatial areas in Blocks 6 and 7 were associated with a system of fields, canals, and water catchments (see Figure 2.7) assigned to site U:9:28, including canal Features 2 and 3 in Area 7A, catchment Feature 57 in Area 6A, sheet trash in Area 7A, and undesignated sheet trash broadly exposed during backhoe stripping across U:9:28. Distinguishing tools used in farming activities from those deposited as trash in these broad expanses is often difficult. The assumption here is that fragments were more likely to have been part of trash deposits, and whole and certain broken tools were more likely to have been left where they were used near the canals or in the fields.

Area 6A

Area 6A was an irrigated field system used sometime during the middle to late Sacaton phase, and ground stone artifacts were found within a catchment area, Feature 57, off canal Feature 26. A broken mano and a broken disk were recovered along with two pieces too broken to identify artifact type. The mano was made from rhyolite and was designed for comfortable holding, with finger grips and a modified proximal surface. Before it was broken, the mano had been used enough with a trough metate to create moderate wear. The disk is too fragmentary to be certain that it was part of a whorl, but it is phyllite, which was typically used for whorls. These broken pieces were probably from trash and not from activities associated with this catchment feature.

Area 7A

Eleven ground stone artifacts were found in Area 7A, which could have come from cleaning trash out of canals, especially the main canal, Feature 3. Eight

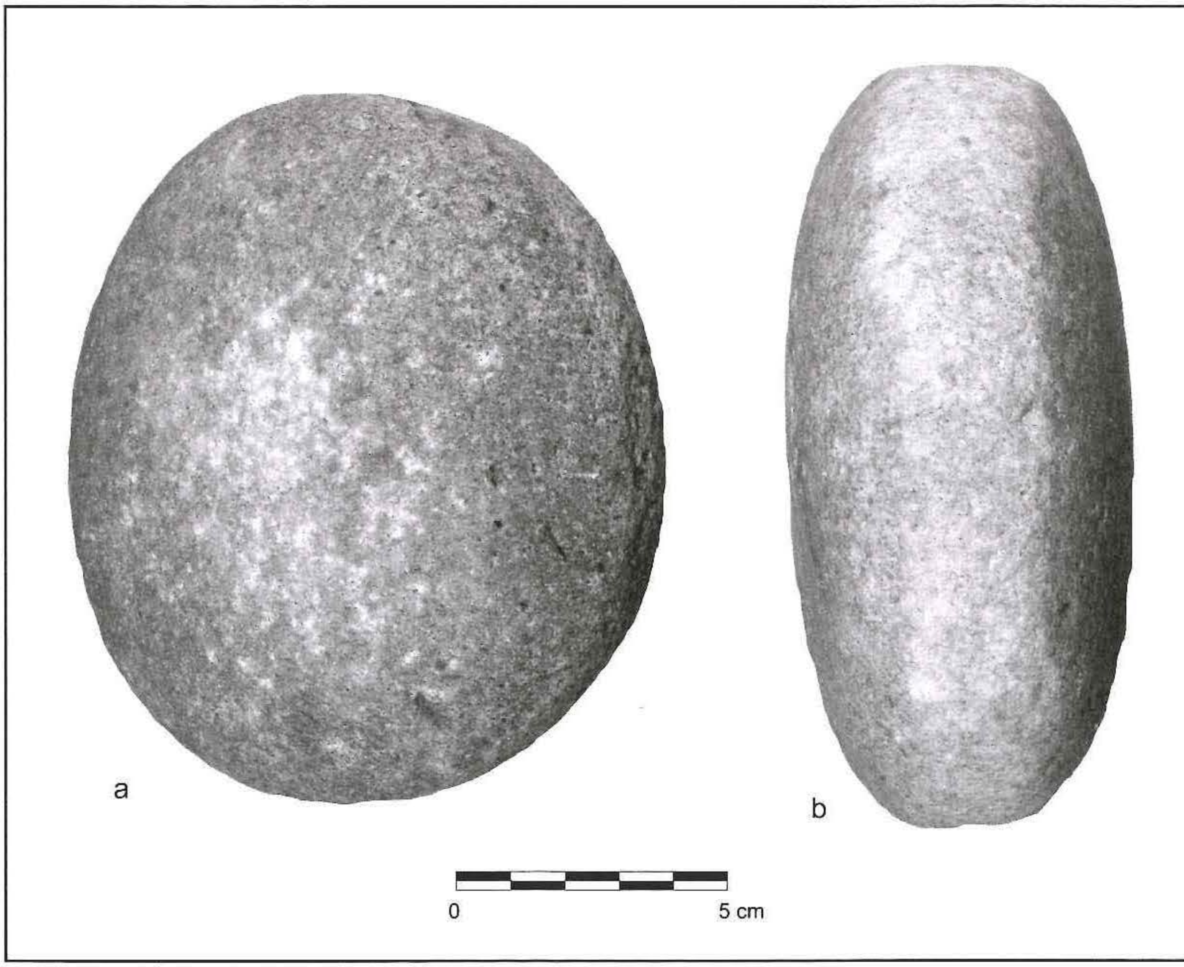

Figure 12.7. Floor polisher recovered from sheet trash in Area 3B, PHX Sky Train project: (a) surface has typical central pecked area and was used to burnish plaster; (b) encircling finger grip on the side of the floor polisher (FN 1322, Catalog No. 2008-077-14).

items are broken: 2 manos, 2 metates, 1 netherstone, 1 polisher, 1 tabular tool, and 1 unidentified fragment. All but the polisher were probably from canal or canal berm deposits. The polisher, in addition to a chopper, a lapstone, and a pecking stone, may have been associated with activities in the fields or along the canals. The polisher had been redesigned as a pecking stone, which, along with the chopper, may have been used in the initial stages of processing something grown in the fields or along the canals. The use-wear on the tool originally designed as a pecking stone is consistent with stoneworking activities, and may have been used in making or refurbishing tools used in field or canal maintenance.

Four polishers were found, two near canal Feature 2 and two near canal Feature 3. Their use near the canals was not for polishing, and like other large polishers from the project area, they had been redesigned and used as pecking and pulping stones. Fine-grained basalt/andesite and diorite rocks were chosen for the polishers due to their smooth texture, which also made them flakable. These polishers were also recorded as flaked stone tools. The secondary pounding activities were likely associated with whatever was growing along the canals, or they were used for refurbishing tools used in canal and field maintenance activities. Canal Feature 2 was not dated, but canal Feature 3, which runs through Blocks 7, 5, and 3, was used during the Classic period.

A netherstone, a pestle, and a metate fragment were found in sheet trash and were possibly associated with the use of Area 5A or with the nearby canal Feature 3. The metate fragment had been secondarily used to powder red pigment after it broke (Munsell Value 10R 4/4). Items found in sheet trash in undesignated areas included an unidentified ground stone fragment and an unmodified piece of phyllite. The phyllite may have been collected for use as pottery temper. A piece of hematite in the fill of a possible pithouse, Feature 315, was ground to create a red pigment (Figure 12.8). It was probably in sheet trash that filled the depression and not associated with use of the structure.

CONCLUSIONS

The first assumption made here about the current assemblage is that many of the items used in the PHX Sky Train project area are probably gone. A few were left on floors, cached in small pits, or left in the field. Some, perhaps most, were removed by their users as they moved from the fieldhouse to the main settlement, or from one farmstead to another. Others may have been lost in sheet flood events. A second assumption is that many of the tools were brought to this farming location from where they were initially made, and probably used. Half the ground stone items were secondarily used, and of those, 64 percent were used sequentially so that they were no longer usable in the activity for which they were designed (Table 12.3). Examples of this are seen with the nine large polishers made from fine-grained volcanic rock that were redesigned as pecking stones or hammerstones. The initial use was for polishing something large, perhaps making or maintaining axe heads. No whole axe heads or any other large stone objects that could have been polished with these tools were found, although a piece broken from an axe head was secondarily used as a scraper. Secondary uses of the redesigned polishers would have been fiber processing, pulping food, or tool maintenance, as needed, in this farming location.

Surprisingly, there is more evidence for manufacturing activities than for onsite food-processing activities (Table 12.4). No flat/concave metates were found, but five whole flat/concave manos were recovered. One was on a pithouse floor in Feature 300; others were stored in small pit Features 332 and 333. Two were found in sheet trash in Area 5A, and one had been secondarily used for pigment processing. Only one whole metate was recovered. It was a lightly used trough metate that ended up as a receptacle for red paint. The only whole trough mano was not compatible with this metate. Five trough metate fragments were found, and they were all in fill or sheet trash; one was secondarily used in a roaster. Six broken trough manos were recovered, three of which were secondarily used as a chopper, a polisher, and a lapstone. The other three were probably recycled as roasters. Two of the three broken trough manos in small pit Feature 326 were secondarily used, one as a chopper and the other as a polisher. Their secondary use—but not their initial use—was valuable enough for storage.

Evidence for manufacturing activities is diverse in such a small assemblage. Farming implements, such as digging sticks and wooden hoes, could have been manufactured or refurbished with the abraders. If stone hoes or axes were used in farming activities, they were not left behind. Pecking stones could have been used to make tabular tools, to sharpen choppers, and to redesign the large polishers and broken manos. Unfinished items included a pestle, a tabular tool, and possibly a whorl. An ornament and another whorl may have broken during manufacture, and raw material was collected for tools and temper.

Figure 12.8. Piece of hematite that was likely abraded to create red pigment; recovered from the fill of a possible pithouse, Feature 315, PHX Sky Train project (FN 849, Catalog No. 2008-077-20).

Unexpected finds included floor polishers and other handstones used to burnish plaster. Floor polishers are distinctive tools that are more common in Puebloan assemblages than in Hohokam assemblages. Only two were found, both in Area 3B. One was in sheet trash, and the other was in small pit Feature 333. Plastering stones associated with the plastered floor of pithouse Feature 307 did not have the distinctive central pecked areas typical of Puebloan floor polishers.

In conclusion, this small assemblage has provided some insights into the activities associated with this farming location, as well as into some spatial and temporal trends. Pigment-processing activities were most obviously associated with Area 5A, on the floor of pithouse Feature 307 and in sheet trash, contexts dated to the late Sacaton phase or the early Soho phase. Pottery manufacture was clearly associated with Area 3B, on the floor and in the fill of adobe structure Feature 329, which dated to the Soho phase. The redesigned polishers were more often in the fields or by canals than in the habitation areas. All the whole artifacts found in sheet trash in Area 5A, especially between Features 300, 302, and

Table 12.3. Specific attributes of the ground stone assemblage from habitation contexts, Pueblo Grande, AZ U:9:1 (ASM), and the canal/field area, AZ U:9:28 (ASM).

	Pueblo Grande		AZ U:9:18 (ASM)		Total	
Variable	No.	%	No.	%	No.	%
Context						
Adobe structure fill	18	25.7	–	–	18	20.9
Adobe structure floor	1	1.4	–	–	1	1.2
Pithouse fill	9	12.9	–	–	9	10.5
Pithouse floor	8	11.4	–	–	8	9.3
Pithouse interior features	17	24.3	–	–	17	19.8
Possible pithouse fill	1	1.4	–	–	1	1.2
Artifact concentration	4	5.7	–	–	4	4.7
Canal	–	–	5	31.3	5	5.8
Extramural feature	–	–	1	6.3	1	1.2
Sheet trash	12	17.1	10	62.5	22	25.6
Subtotal	70		16		86	
Condition						
Broken	24	36.9	12	75.0	36	44.4
Whole	41	63.1	4	25.0	45	55.6
Subtotal	65		16		81	
Burned						
Heat-cracked	4	6.2	–	–	4	5.1
Yes	7	10.8	1	7.1	8	10.1
No	54	83.1	13	92.9	67	84.8
Subtotal	65		14		79	
Design						
Expedient	29	56.9	8	57.1	37	56.9
Strategic	20	39.2	6	42.9	26	40.0
Incomplete	2	3.9	–	–	2	3.1
Subtotal	51		14		65	
Wear						
Heavy	14	25.5	–	–	14	20.6
Moderate	21	38.2	8	61.5	29	42.6
Light	14	25.5	5	38.5	19	27.9
Unused	6	10.9	–	–	6	8.8
Subtotal	55		13		68	
Use						
Single	18	35.3	4	40.0	22	36.1
Reused	2	3.9	–	–	2	3.3
Multiple	17	33.3	1	10.0	18	29.5
Redesigned	6	11.8	5	50.0	11	18.0
Uused	8	15.7	–	–	8	13.1
Subtotal	51		10		61	
Sequence						
Concomitant	9	40.9	1	16.7	10	35.7
Sequential	13	59.1	5	83.3	18	64.3
Subtotal	22		6		28	
Activities						
Processing	8	11.8	1	6.7	9	10.8
Food processing	15	22.1	5	33.3	20	24.1
Pigment processing	7	10.3	–	–	7	8.4
Manufacture	35	51.5	8	53.3	43	51.8
Paraphernalia	3	4.4	1	6.7	4	4.8
Subtotal	68		15		83	

Table 12.4. Activities in which ground stone items were used in habitation areas, Pueblo Grande, AZ U:9:1 (ASM), PHX Sky Train project.

Artifact	Processing	Food Processing	Pigment Processing	Manufacture	Pottery Manufacture	Stone Working	Unused	Multiple	Paraphernalia	Total
Abrader	–	–	–	4	–	–	–	–	–	4
Axe	–	–	–	–	–	–	–	1	–	1
Chopper	1	–	–	–	–	–	–	–	–	1
Disk	–	–	–	–	–	–	1	–	–	1
Handstone	1	–	1	–	–	–	–	1	–	3
Lapstone	–	–	–	–	–	2	–	2	–	4
Mano	–	8	1	–	–	–	–	3	–	12
Metate	–	1	–	–	–	–	–	2	–	3
Netherstone	2	–	1	1	–	2	–	1	–	7
Ornament	–	–	–	–	–	–	–	–	1	1
Pecking stone	–	–	–	–	–	1	–	–	–	1
Pestle	–	–	–	–	–	–	1	1	–	2
Pigment	–	–	–	–	–	–	–	–	1	1
Polisher	–	–	2	3	3	1	–	10	–	19
Pottery anvil	–	–	–	–	1	–	–	–	–	1
Raw material	–	–	1	–	–	–	7	1	–	9
Tabular tool	–	–	–	–	–	–	1	1	–	2
Whorl	–	–	–	1	–	–	–	–	–	1
Total	4	9	6	9	4	6	10	23	2	73
Row percent	5.5	12.3	8.2	12.3	5.5	8.2	13.7	31.5	2.7	

307, may be indicative of the location of outdoor work space for multiple activities that included making tools, mixing paint, and processing. One flat/concave mano and a trough metate might have been secondarily used together, and a remodeled polisher may have been the pecking stone used in the manufacture of the unfinished pestle found in this workspace. Elsewhere, one or two of the pecking stones or choppers could have been used for pulping fruits, but other than the whole flat/concave manos, there is very little evidence for the context or nature of food-processing activities. In keeping with the first assumption, many of the tools were probably removed from this farming location.

CHAPTER 13

MARINE AND FRESHWATER SHELL FROM THE PHX SKY TRAIN PROJECT

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The results of two separate studies of prehistoric shell material recovered during data recovery investigations for the PHX Sky Train project are presented here. The first study involves analysis of the relatively small quantity of shell collected from domestic contexts, primarily habitation structures and associated extramural pits assigned to Pueblo Grande, AZ U:9:1 (ASM). This assemblage offers an opportunity to examine the availability and usage of shell at a part of the Pueblo Grande settlement that is functionally distinct from the larger platform mound village. The second study includes the analysis of shell from samples collected from two water catchment features, Features 7 and 57, at AZ U:9:28 (ASM), specifically for their freshwater shell content. Analysis of shells from these samples informs on the aquatic environment of the two catchment features, thus helping in an understanding of their use and operation.

SHELL FROM DOMESTIC CONTEXTS WITHIN THE PHX SKY TRAIN PROJECT AREA

Archaeologists recovered 171 pieces of shell (number of identified specimens, or NISP), representing 64 individual artifacts (minimum number of individuals, or MNI) from domestic contexts. These contexts consist primarily of pithouse, adobe structure, and associated extramural pit fill (Table 13.1), although the count also includes a few pieces of shell from the fill of irrigation features that probably represent refuse unrelated to their irrigation function.

Seventeen of the artifacts, or roughly 27 percent of the assemblage, are Gulf of California (Panamic province) species (Table 13.2), while the bulk of the collection is local freshwater shells in the form of snails and clams. Only seven artifacts (11 percent) were identified as ornaments of personal adornment; these were made from four different marine genera. All were made from old shell, available as beach drift that did not retain the natural coloring. These were recovered from two habitation areas within the project area. The finished ornament forms include 2 whole shell beads, 1 complete whole shell pendant, 3 plain bracelets, and 1 fragment of a cut-shell disk that may have been a pendant that broke. Evidence of on site manufacturing was limited to one raw valve, but no in-process ornaments or reworked forms were identified, which suggests the ornaments probably came to the site in the finished form and that little small scale manufacturing for personal or household use occurred on site. Artifacts classified as unmodified fragments comprised 50 percent of the collection, with remnants of the freshwater clam *Anodonta californiensis* being the most abundant (Table 13.3). The remaining artifacts (n = 24) consisted of whole shells of freshwater pelecypods and gastropods that inhabited the local area.

Methods

Each shell specimen was examined with a 10x hand-lens. A set of linear measurements was obtained using a digital Vernier caliper, and were recorded to the nearest hundredth of a millimeter. The diameters of any perforations were measured and described. A detailed record for each specimen was developed that included a written description of the artifact, as well as attributes such as the condition, shape, and decorative motifs and technological features. A digital photograph of the finished ornaments and a representative sample of the native freshwater shell were also generated.

When possible, the relative completeness of the artifact was estimated. Ornaments were considered complete if a full set of linear measurements could be recorded. For fragmented material, the percentage of the original valve or ornament present was determined. Fragments that could be refitted were considered to be a single occurrence, with the number of fragments recorded. In some cases, shell fragments that do not refit but that display similar morphological characteristics were considered as coming from the same shell. This occurs frequently in the case of *Anodonta californiensis*, a freshwater clam that is extremely brittle when the shell dries out and that tends to fracture into many small pieces.

Table 13.1. Distribution of shell material from domestic contexts, PHX Sky Train project.

Area	Feature	Feature Type and Context	Artifact Type	Species	Number of Identified Specimens	Minimum Number of Individuals
1A	14	Canal fill	Unworked fragment	*Laevicardium elatum*	1	1
3B	0	Surface sheet trash	Worked fragment	*Laevicardium elatum*	1	1
3B	56	Ditch trash fill	Unworked fragment	*Anodonta californiensis*	5	1
3B	56	Ditch trash fill	Whole valve	*Helisoma* sp.	1	1
3B	318	Pithouse fill	Unworked fragment	*Anodonta californiensis*	5	1
3B	318	Pithouse fill	Whole valve	*Helisoma* sp.	3	2
3B	318	Pithouse fill	Unworked fragment	*Laevicardium elatum*	5	1
3B	318	Pithouse fill	Whole valve	*Physa virgata*	1	1
3B	318	Pithouse floor fill	Unworked fragment	*Anodonta californiensis*	1	1
3B	318	Pithouse floor fill	Whole shell bead	*Glycymeris* sp.	1	1
3B	318	Pithouse floor fill	Whole valve	*Helisoma* sp.	1	1
3B	325	Pit fill	Unworked fragment	*Laevicardium elatum*	1	1
3B	326	Pit fill	Unworked fragment	*Anodonta californiensis*	5	1
3B	329	Adobe structure fill	Unworked fragment	*Anodonta californiensis*	26	4
3B	329	Adobe structure fill	Whole valve	*Anodonta californiensis*	26	1
3B	329	Adobe structure fill	Whole valve	*Glycymeris* sp.	1	1
3B	329	Adobe structure fill	Whole valve	*Helisoma* sp.	13	13
3B	329	Adobe structure fill	Unworked fragment	*Laevicardium elatum*	2	1
3B	329	Adobe structure fill	Whole shell pendant	*Oliva* sp.	1	1
3B	329	Adobe structure fill	Whole valve	*Pisidium* sp.	1	1
3B	329	Adobe structure floor fill	Unworked fragment	*Anodonta californiensis*	5	2
3B	329	Adobe structure floor fill	Unworked fragment	*Laevicardium elatum*	3	2
3B	329	Adobe structure floor fill	Cut-shell solid disk	*Laevicardium elatum*	1	1
3B	333	Pit fill	Unworked fragment	*Anodonta californiensis*	5	1
3B	334	Pit fill	Unworked fragment	*Anodonta californiensis*	1	1
3B	334	Pit fill	Unworked fragment	*Laevicardium elatum*	1	1
5A	0	Surface sheet trash	Unworked fragment	*Anodonta californiensis*	1	1
5A	300	Pithouse fill	Whole valve	*Helisoma* sp.	2	2
5A	300	Pithouse floor fill	Whole shell bead	*Olivella dama*	1	1
5A	301	Pithouse fill	Unworked fragment	*Anodonta californiensis*	2	1
5A	301	Pithouse floor fill	Unworked fragment	*Anodonta californiensis*	1	1
5A	301	Pithouse floor fill	Whole valve	*Helisoma sp.*	1	1
5A	302	Pithouse fill	Unworked fragment	*Anodonta californiensis*	8	1
5A	302	Pithouse floor fill	Unworked fragment	*Anodonta californiensis*	2	2
5A	307	Pithouse fill	Unworked fragment	*Anodonta californiensis*	2	1
5A	307	Pithouse floor fill	Unworked fragment	*Anodonta californiensis*	12	2
5A	307	Pithouse floor fill	Plain bracelet	*Glycymeris* sp.	4	3
5A	309	Trash concentration	Unworked fragment	*Anodonta californiensis*	15	2
6A	57	Water catchment fill	Unworked fragment	*Laevicardium elatum*	1	1
6B	312	Pithouse floor fill	Unworked fragment	*Anodonta californiensis*	2	1
Total Artifacts					171	64

The ornament classification used is based largely upon that developed for the shell material from Snaketown, AZ U:13:1 (ASM) (Haury 1937, 1976). The identification to genus and, if possible, to species, for the marine shell were made according to Keen (1971). Definitions of the terminology used in the descriptions relating to the structural elements of the shell that were used during the analysis, as well as useful descriptive illustrations, can be found in Keen (1971) and Brusca (1980). Local freshwater shell and terrestrial gastropods were identified using Bequaert and Miller (1973), Drake (1959), and Cheatum and Fullington (1971).

Given the proximity of the Southwest region of the U.S. to the northern Gulf of California, many researchers have proposed that prehistoric people ob-

Table 13.2. Genera and species recovered from domestic contexts, the PHX Sky Train project.

Genus or Species	Number of Identified Specimens	Minimum Number of Individuals	Province
Marine			
Pelecypods (bivalves)			
Glycymeris sp.	6	5	Panamic and California
Laevicardium elatum	16	10	Panamic and California
Gastropods (univalves)			
Olivella dama	1	1	Panamic
Oliva sp.	1	1	Panamic
Freshwater and Terrestrial			
Pelecypods (bivalves)			
Anodonta californiensis	124	25	Native freshwater
Pisidium sp.	1	1	Native freshwater
Gastropods (univalves)			
Helisoma sp.	21	20	Native freshwater
Physa virgata	1	1	Native freshwater
Total	171	64	Native freshwater

tained their Panamic shell specimens along the northern Sonoran Coast within the northern Gulf region (Haury 1976; Hayden 1972). Haury (1976:307) notes that Cholla Bay, a smaller cove within the larger Adair Bay, could have provided many of the species found at Hohokam and earlier sites. Hayden (1972:78, 81) also indicated the area as a probable source of Hohokam shell, including the coastal area around and south of Puerto Peñasco (Rocky Point). Trails and petroglyphs of shells in the area, especially around the Sierra Pinacate, support this proposal (Hayden 1972:78). Either direct procurement or a trade network would be needed to serve as a mechanism for movement of the marine shells from their place of origin to be distributed throughout the prehistoric Southwest. The procurement of sea salt may have been tied into the expeditions to gather sea shells (Bayman 2008:78). A network of trails leads to the northern fringes of Mesoamerica and western Mexico (McGuire and Villalpando 2007:63), as well as to California and the Zuni area of New Mexico, providing pathways for trading of marine shells and finished ornaments (Doyel 2007:87, Figure 10.5).

The Gulf of California is a unique area, where the warm waters of the southern Panamic province meet cooler Pacific waters from the north off the western coast of the Baja Peninsula near Magdalena Bay, where they converge before they turn out to sea. These contrasting currents form two distinct biotic communities or zones, which support a diverse variety of shell species. Many species of shell occur in only one of these zones, or may have a restricted distribution and relative frequency in one zone or the other (Brusca 1980:18; Keen 1971:55). Both biotic communities were utilized by the Hohokam for procuring shell for ornament manufacturing.

Genera and Species

The types of shell artifacts recovered from domestic contexts are listed in Table 13.3 by genera and, if possible, to species. Two marine pelecypods (bivalves) and two marine gastropods (univalves) are represented from the current project area. *Laevicardium elatum*, a large pelecypod or bivalve, dominates the marine shell collection with 10 individuals (16 percent of the whole collection), followed by the pelecypod *Glycymeris* sp. (8 percent) and single occurrences of the gastropods, *Olivella dama* (2 percent) and *Oliva* sp. (2 percent). Among freshwater shells, *Anodonta californiensis* (39 percent) and *Helisoma* (31 percent) are the most abundant species, followed by single occurrences of *Pisidium* (2 percent) and *Physa virgata* (2 percent).

Marine Shells

Glycymeris are bivalve shells whose distribution is restricted to the warmer waters found in the Gulf of California, and they can still be found on the beach today. *Glycymeris* shells were frequently used by the Hohokam for manufacturing shell jewelry, especially bracelets. This is true in the current collection, where the finished artifact forms are dominated by *Glycymeris* bracelets. White, beach-drift specimens, which are dead shells, as well as those retaining their natural coloration, were selected, by size, for the manufacture of bracelets, whole shell beads, whole shell pendants, and ring/pendants. Fossilized shells were occasionally used by Hohokam artisans if access to the nicer shells was restricted. This is particularly noticeable from contexts dating to the Sedentary period (A.D. 950-1150), apparently due to the

Table 13.3. Shell artifacts from domestic contexts, by form, PHX Sky Train project.

	Marine Shell				Freshwater Shell				
	Pelecypods		Gastropods		Pelecypods		Gastropods		
Artifact Forms	*Glycymeris* sp.	*Laevicardium elatum*	*Olivella dama*	*Oliva* sp.	*Anodonta californiensis*	*Pisidium* sp.	*Helisoma* sp.	*Physa virgata*	Total MNI[a]
Finished									
Whole shell bead	1	–	1	–	–	–	–	–	2
Plain bracelet	3	–	–	–	–	–	–	–	3
Whole shell pendant	–	–	–	1	–	–	–	–	1
Cut-shell solid disk	–	1	–	–	–	–	–	–	1
Whole valves	1	–	–	–	1	1	20	1	24
Fragments									
Worked	–	1	–	–	–	–	–	–	1
Unworked	–	8	–	–	24	–	–	–	32
Total	5	10	1	1	25	1	20	1	64
Percent of total	8%	16%	2%	2%	39%	2%	31%	2%	100%

[a]MNI = Minimum number of individuals.

large demand for bracelets, which reduced the amount of available shells. No fossilized shell specimens were identified in the current collection.

The large Pacific cockle, *Laevicardium elatum*, is a bivalve that can attain lengths exceeding 150 mm; it is a light yellow color when fresh. It has morphological characteristics that aid in identifying smaller fragments of shells, including its relative thinness and large flattened side panels and distinctive vertical ribs, which are flat and relatively evenly spaced across the broad back of the shell. This valve was frequently used for carved shell ornaments, such as pendants and beads, although it was also used as a container (Nelson 1991). While the range of *Laevicardium elatum* extends northward to include the coast of southern California, specimens in the current marine assemblage are almost certainly of Mexican origin. Both *Glycymeris* and *Laevicardium* tend to dominate marine shell assemblages recovered from sites in the lower Salt River Valley (A. Howard 1988:464), which is also true in the current collection.

Gastropods, or univalves, have a single shell. Ornaments manufactured from univalves include rings and many styles of beads and pendants. Single occurrences of two marine gastropods were identified in the current collection, *Olivella dama* and *Oliva* sp. The identification of *Olivella dama* is based on the morphological characteristics of the shell, such as size, robustness, and the shape of the callus (Silsbee 1958). This shell species has a distribution throughout the Gulf of California and occasionally on the Pacific coast, and it is frequently found on the beach. *Olivella* shells were typically used in making several bead varieties, including whole shell, cylindrical- or barrel-shaped, and disk beads made from the side wall of the shell.

Oliva shells are well polished. They prefer a sandy substrate, where they plow about just beneath the surface, leaving a characteristic trail. The large shell is cylindrical, with a long aperture and a channeled suture on the low spire. The inner lip is wrinkled but does not have a wide callus area. The shell is typically uniformly colored over the entire body whorl except on the columellar area. The overall color is typically a dove gray to brown, with a creamy white background and patterned markings, which are used to determine species. The specimen in the current collection lacks the patterned markings and coloration, and thus, cannot be identified to species. These shells were typically used for whole shell pendants or beads, depending on size.

Freshwater Shells

Two genera of pelecypods are present in the current collection of freshwater shells. One has been identified as the freshwater clam *Anodonta californiensis*, and the other is a *Pisidium*. The nearby Salt River was probably the source of these. *Anodonta* is restricted to the Pacific drainage, where its main range is in the southwestern Molluscan Province. It was indigenous to most of the permanent rivers and streams of Arizona, such as the Colorado, Gila, San Pedro, and Santa Cruz, prior to the development of dams constructed during the early part of the twentieth century (Bequaert and Miller 1973:220-223). It is currently restricted to a short segment of the Black River in Eastern Arizona.

The reduction in distribution is thought to be due to the elimination of the native fish that served as the host for the glochidium stage of the clam's development cycle, which it parasitizes while transforming into the free living clam. Upon maturing, it breaks free from the host fish, falling to the bottom of the river where, if a suitable substrate is available, the clam rapidly grows into an adult. Juvenile *Anodonta* prefer a loose gravelly substrate, while the adults favor a muddy or sandy bottom (d'Eliscu 1972:58). When the specific host fish disappear from the habitat, the clam also becomes extinct.

Anodonta has been recovered from prehistoric and historic sites across the Phoenix Basin and the Salt/Gila River drainages (Haury 1976:308; Schroeder and Virden 1994:189; Vokes 1988:373), as well as in the Tucson Basin (Bequaert and Miller 1973:221; Lister and Lister 1989:Figure 3.35), suggesting it may have been a minor food source to supplement dietary needs. The clam may have been harvested from both rivers and canals for this purpose. Ornaments manufactured from *Anodonta* have also been recovered from archaeological contexts. The clam is very nacreous on the interior of the shell, which made it popular among consumers of shell ornaments. However, it becomes particularly fragile and brittle when dried, so artisans would have had to collect fresh specimens to use for ornament manufacturing, cutting the shell when it was still green and pliable to reduce breakage. Pockets of *Anodonta* have been recovered at other canal sites, including AZ U:9:69 (ASM) (Vokes and Miksecek 1987:181) and AZ U:9:46 (ASM) (Herskovitz 1981:76). Masse (1986) reported that it was the least abundant species in the Hohokam Expressway canals, although it was recovered from almost all the deposits sampled. Barber (1984:107) found remains of *Anodonta* from contexts dating from the Santa Cruz through the Soho phases during the Salt-Gila Aqueduct project.

A single occurrence of *Pisidium* sp. was recovered during the current investigations. *Pisidium* is a member of the family Sphaeriidae, and is a genus of very small freshwater clams also known as pill clams or pea clams. They are aquatic bivalves, which are widely distributed in western North America from

Canada to Mexico (Bequaert and Miller 1973:218). *Pisidium* prefer the muddy bottoms of lakes, ponds, or streams in permanent, but usually stagnant, bodies of water (Drake 1959:162). They have been known to survive for weeks in damp mud (Bequeart and Miller 1973:216), and as such, could have survived in the canals. *Pisidium* have been recovered from sediments derived from prehistoric canals in the Salt River Valley (Masse 1986:350; Vokes and Miksicek 1987:181-182). They were commonly found in association with *Physa* and *Gyraulus*, a genus closely related to *Helisoma*. The current specimen is what is referred to as a "dead" shell, and it is weathered. These, as well as the gastropods described below, do not appear to have been utilized by the Hohokam for either subsistence or ornamental purposes.

Two genera of freshwater gastropods comprise 45 percent of the freshwater collection. A single specimen of *Physa virgata* was recovered, as were 20 *Helisoma* shells. *Physa* are a small freshwater snail that prefer a habitat of shallow water, such as found in a pond, marsh, or slow-moving stream or river, where they crawl about on the aquatic vegetation or on the bottom debris (Cheatum and Fullington 1971). *Physa* have been reported from other archaeological contexts (Bequaert and Miller 1973:201-203; Drake 1959).

The bulk of the freshwater snail collection is represented by *Helisoma tenue*, which has a spiral-shaped shell and a large aperture. It is found in both fossil and recent form in Arizona. This specimen type also prefers living in the damp, wet zone at the edges of bodies of water, such as canal channels and cienegas. It is one of the most widely distributed snails in Arizona, usually found at low elevations (Bequeart and Miller 1973:108-109), and it may have been more abundant at lower elevations in the past (Drake 1959:150). These aquatic snails are frequently recovered from drift assemblages and have been recovered from canal sediments of the Hohokam Expressway (Masse 1986:350-351) and the Las Acequias-Los Muertos canal systems (Vokes and Miksicek 1987:180-181). The adult shell is large compared with some of the other local gastropods, but the shell is very fragile and breaks easily. The presence of both juvenile and adult specimens indicates an environment conducive to their growth.

Artifact Types

The current collection of shell artifacts is dominated by unmodified fragments of the freshwater bivalve, *Anodonta californiensis*. The finished specimens are manufactured only from marine shell (Figure 13.1; see Table 13.3), with seven artifacts represented.

Finished Shell Artifacts

The finished shell artifact forms are represented by two forms of beads, a pendant, plain bracelet fragments, and a fragment of a cut-shell disk (see Figure 13.1a-e). One additional shell fragment exhibits an edge that has been worked, although it could not be identified to form and function, and it is discussed with the fragmentary shell material.

Beads. Two whole shell beads manufactured from different shell species were identified. Whole shell beads are the easiest to make, because little modification to the shell is needed. Each of the beads was perforated in a different manner, with one manufactured from a univalve and the other from a bivalve. Neither of the beads was burned.

A single whole shell bead was recovered from floor fill of Feature 300, a pithouse dating to the late Sacaton-early Soho phase of the Sedentary-Classic period transition. *Olivella* beads were present in shell assemblages throughout the Hohokam sequence as well as earlier. The bead, made from *Olivella dama*, was created by removing the apex of the spire (Figure 13.1e). The interior columella was then removed to facilitate stringing the shell through the perforation, then out through the aperture. The lip of the perforation has chipped off at a diagonal, and shows some use-wear from stringing. The length of the bead is 14.57 mm.

The second whole shell bead was manufactured from a juvenile *Glycymeris* sp. shell (see Figure 13.1d). This small bead was recovered from the floor fill of Feature 318, a pithouse dating to the Soho phase of the Classic period. According to Nelson (1991:56), this particular artifact type does not seem to appear in shell assemblages until the Classic period, and thus, can be used as a temporal indicator. Approximately 60 percent of the shell is present. It broke longitudinally to the left of the umbo, down through the center of the valve. The beak of the umbo was perforated for suspension by abrading it. This created a flat grinding facet across the top of the hinge plate and flattened the beak of the umbo. This small bead measures 9.42 mm in length.

Whole Shell Pendants. The simplest pendant forms are whole shell, as they are the easiest to make because they rely on the coloration, shape, and texture of the shell for decoration. These are separated from the bead category, based on the size of the shell. They are typically recovered in single occurrences and only occasionally with other beads as part of a necklace.

A single whole shell pendant was identified in the current collection. It was a complete pendant manufactured from a large *Oliva* sp. shell (see Figure 13.1b), and it was recovered from the upper fill of Feature 329, an adobe structure dating to the Soho

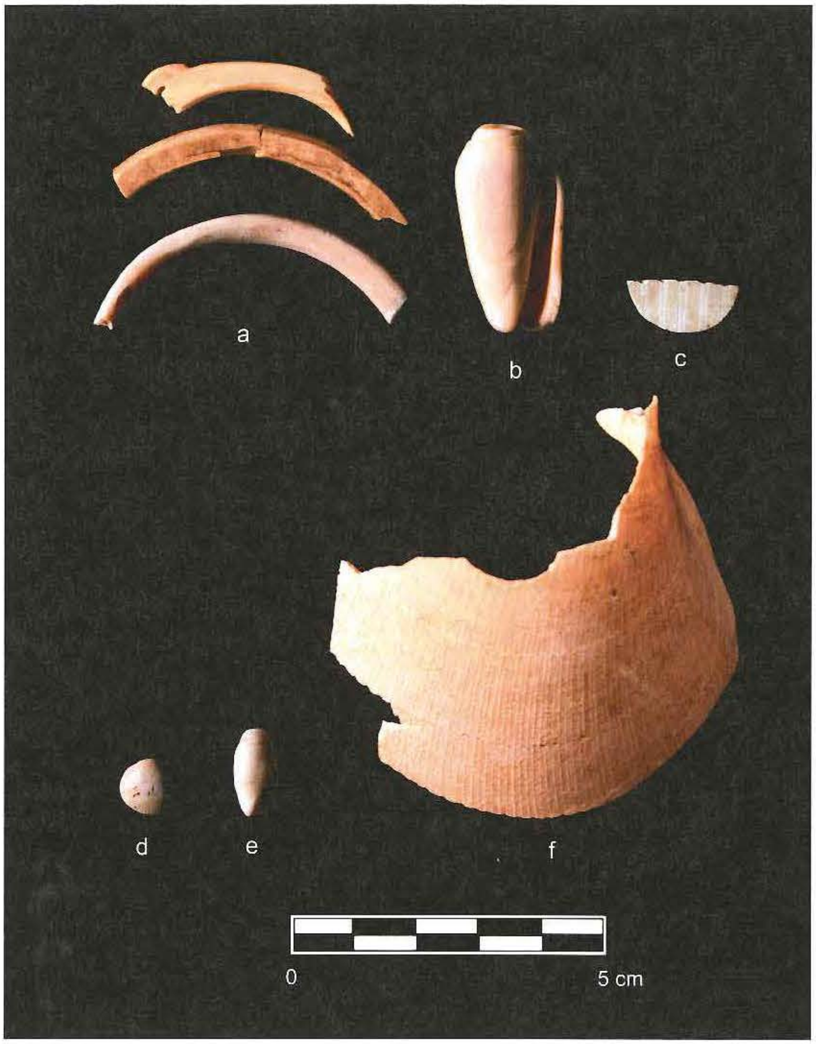

Figure 13.1. Marine shell artifacts from the PHX Sky Train project: (a) three *Glycymeris* sp. bracelet fragments (Catalog No. 1x); (b) *Oliva* sp. whole shell pendant (Catalog No. 2x); (c) *Laevicardium elatum* disk (Catalog No. 3x); (d) *Glycymeris* sp. shell bead (Catalog No. 4x); (e) *Olivella dama* whole shell bead (Catalog No. 5x); (f) *Laevicardium elatum* shell (Catalog No. 6x).

phase of the Classic period. According to Nelson (1991:18), whole shell pendants made from *Oliva* shells are not present in shell assemblages prior to the Soho phase of the Classic period, and thus, can be used as a temporal indicator. They tend to be rather scarce, but have a wide distribution, they occur late in the Hohokam sequence, and they are not generally found in mortuary contexts (Nelson 1991:51). The current shell specimen is a white beachdrift specimen, and thus, difficult to assign to species, because markings and colorations are used to distinguish them. The apex of the spire was ground down to the top of the body whorl to perforate the shell for suspension and the resultant edge was smoothed. The shell measures 32.27 mm in length, and is in good condition, with a glossy finish and only some minor cracking and worm damage. This is one of two ornaments from this feature.

Bracelets. Three plain bracelets manufactured from *Glycymeris* sp. shells were recovered from floor fill of Feature 307, a pithouse dating to the late Sacaton-early Soho phase. The pieces are remnants of three discrete bands (see Figure 13.1a).

One bracelet, FN 689, was a dorsal margin with umbo and a side margin, representing about 25 percent of the band. The umbo had been greatly reduced and shaped, grinding into a squarish knob. The back of the valve was reduced by flat grinding, which also perforated the umbo. The perforation had not been further modified. The other two bracelet fragments were both side and ventral margin fragments from different bracelets. One of the bands has a vertical face triangular profile, while the other two bands exhibit double-faceted triangular profiles. Two of the bands were unburned, while the third was burned. The width of the bands ranges from 4.68 mm to 7.81 mm, with a mean of 5.97 mm. The thickness ranges from 3.38 mm to 5.20 mm, with a mean of 4.37 mm.

According to the band chronology established by Haury (1976:313), the mean measurements for the three bracelets places them within the Type 2, or medium band, category, with perhaps some overlap with Type 3. Haury (1976) also noted that roughly 50 percent of the Type 2 samples he had measured (at that time) had umbones that were perforated. The earlier smaller bands had umbones that were seldom perforated, while the later, wider bands had umbones that were only occasionally perforated. According to Haury's (1976) category, the Type 2 bracelets are heavily represented in the late Pioneer, Colonial, and Sedentary periods, while the larger Type 3 band was dominant in the Sedentary period and carried over into the Classic period.

Cut-shell Disk. A single cut-shell disk manufactured from *Laevicardium elatum* was also recovered from the floor fill of Feature 329, the adobe structure (see Figure 13.1c). It was cut from the lower back of the valve, and is unburned. It may have been a pendant that broke; however, the portion that is present is not perforated. The ribs of the shell run perpendicular to the break; therefore, if it was a pendant, the ribs would run the length of the pendant when suspended, which enhances the decoration to the ornament. The cut edge was ground to vertical, and the surfaces slightly ground to flatten the piece. The portion of the artifact that is present measures 18.86 mm in length, 8.77 mm in width, and 1.18 mm in thickness.

Manufacturing Evidence

Evidence for manufacturing of shell ornaments by local artisans can be in the form of raw material, ornaments that were in the process of being manufactured but broke before they could be completed, and wastage or carved manufacturing debris from the reduction of the shell to form an ornament. Only a small amount of manufacturing evidence was found in the current collection, suggesting formal ornaments came to this site in a finished form.

A single whole valve of a nearly complete juvenile *Glycymeris* sp. shell was recovered from the structural fill of Feature 329. It is the size typically used for small whole shell beads; however, because this specimen has not been perforated, it would be considered raw material for ornament manufacturing.

Fragmentary Material

It is not unusual to have fragmented shell material as part of an artifact assemblage due to the fragility of shell, and 52 percent of the current collection is assigned to this category. The fragile nature of the shell lends itself to breakage, especially as the shells dry out, with some shell types more friable than others. Among the recovered pieces can be small fragments of ornaments, with worked edges, but broken into such small pieces that their form and function are unidentifiable. Other shell fragments are from raw material of valves that are used for manufacturing ornaments, used for utilitarian purposes, or perhaps for consumption as a food source and may exhibit no signs of modification by artisans.

Modified Marine Shell Material

A single piece of marine shell that appears to have been modified was recovered, but the form and function are unknown. A fragment of shell from the side margin of a large *Laevicardium elatum* valve, representing 30 percent of the valve, was recovered from sheet trash deposits in Area 3B. A portion of the body of the shell was also attached. Because the shell broke diagonally across the central body portion of the shell, this edge has not been modified. However, just below this edge is another edge that appears to have been cut. This may have been part of a perforated shell or a large bracelet that broke, but not enough is present to know for sure. The marginal edge is unmodified, and the ventral margin has also broken off. The recovery of this specimen from sheet trash and not from a specific feature suggests it may have been cultural debris that was dispersed on the site by other taphonomic processes, such as flooding.

Unmodified Marine Shell Material

Although lacking evidence of modification, two occurrences of *Laevicardium elatum* may represent utilitarian items. The two fragments were recovered from canal Feature 14 and catchment Feature 57. The piece of shell from Feature 14, FN 53 (see Figure 13.1f), is large, representing nearly 50 percent of the valve, and measuring 43.84 mm in length and 64.49 mm in width. Present is one side margin and the central body or back of the valve. The ventral, dorsal, and one side margin are missing; the edges are irregular from breakage, and have not been modified. The shell may have been used to scoop water from the canal or to clean mud out of the canal; however, no use-wear is present on the portion of shell that was recovered. If used as a scoop, the wear would have been on the ventral margin, which is missing. The shell is discolored but not burned, and it exhibits weathering.

The second fragment of *Laevicardium*, recovered from Feature 57, is much smaller, representing only 25 percent of the valve. Only the side margin is present, with the remaining shell missing. The edges are irregular from breakage, or are the natural margin edges and have not been modified. The shell is unburned but weathered. This valve may have been used as a scoop to retrieve water from the catchment; however, no use-wear is present on the portion of shell that remains. *Laevicardium* shells, both fragmented and whole, that have been identified as possible scoops have been recovered at La Ciudad, AZ T:12:12 (ASU) (Howard 1987:99), and Las Colinas, AZ T:12:10 (ASM) (Urban 1981:309), in the Salt River Valley, and Escalante Ruin, AZ U:15:3 (ASM), a large Classic period Hohokam site near Florence, Arizona (Debowski 1974:165, Plate 41).

Six unmodified fragments of *Laevicardium elatum* were recovered from four features in Area 3B (see Table 13.1). One small, unburned fragment from the fill of pit Feature 334 was extremely weathered and chalky. Another small, unburned fragment came from the fill of a small extramural pit, Feature 325, located east of Feature 329, an adobe structure; another was recovered from the fill of pithouse Feature 318. The remaining three fragments came from Feature 329, the adobe structure. Two fragments that do not refit but that are probably from the same valve were recovered from structural fill. About 40 percent of a shell is present that had not been modified; it is unburned. Three other small fragments, representing two individuals, were recovered from floor fill. Two of these fragments had been burned, while the third was not. None of the fragments are modified; rather, they have edges that are either the natural margin or are irregular from breakage. All the fragments from these features probably represent trash dumping episodes or cultural sheet trash.

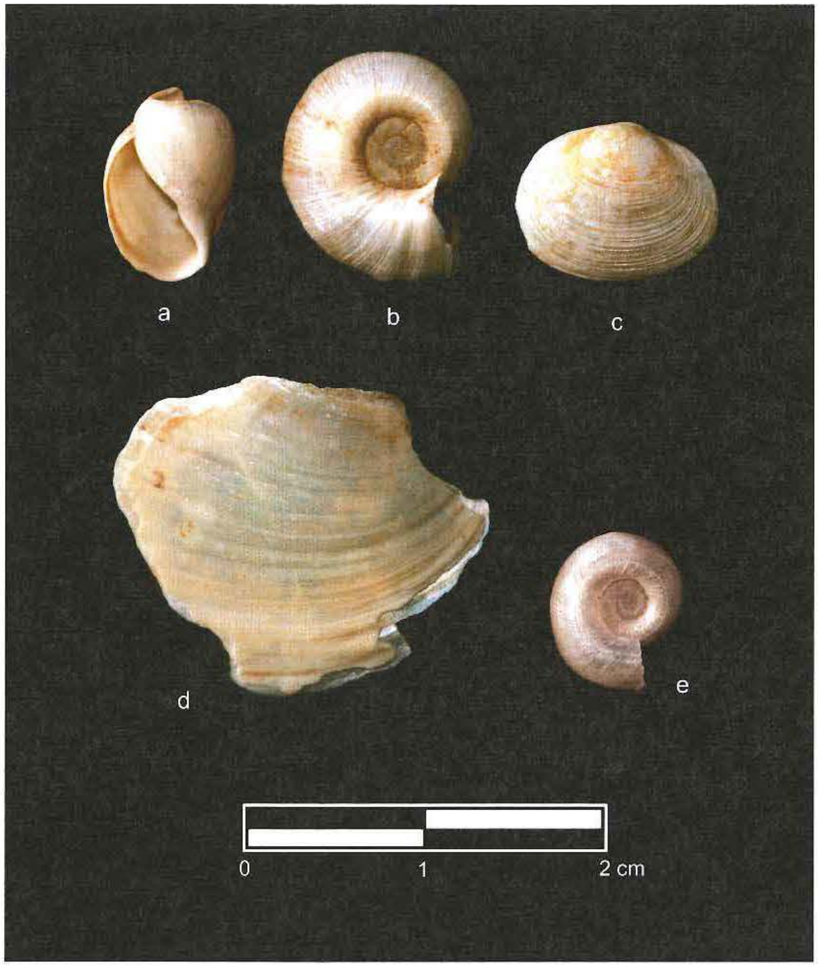

Figure 13.2. Freshwater shell artifacts from the PHX Sky Train project: (a) *Physa* whole shell (Catalog No. 7x); (b) adult *Helisoma* shell (Catalog No. 8x); (c) *Pisidium* valve (Catalog No. 9x); (d) *Anodonta* fragment (Catalog No. 10x); (e) juvenile *Helisoma* shell (Catalog No. 11x).

Unmodified Freshwater Shell Material

Freshwater shell, either fragmented or whole valves, dominated the collection (73 percent) (see Table 13.3). Freshwater shell was recovered from 12 of the 16 features where shell artifactual material was found (see Table 13.1).

Present are single occurrences of *Pisidium* and *Physa*. The *Pisidium* (Figure 13.2c) was recovered from the structural fill of Feature 329, the adobe structure. The *Physa* (Figure 13.2a) also came from structural fill, but of Feature 318, a pithouse. The presence of these freshwater specimens in the upper levels of structural fill is probably a result of water moving across the landscape (postabandonment), possibly from nearby canals.

The bulk of the freshwater shell material is roughly split between *Anodonta*, a freshwater clam (53 percent), and *Helisoma*, an aquatic snail (43 percent) (Table 13.4). None of the fragments or whole shells are modified or burned. It has been suggested that *Anodonta* was used as a food source, which may account for its presence in the fill of numerous pithouses, extramural pits, and the adobe structure. This shell species was also recovered from the fill of a trash concentration and a trash-filled ditch, further suggesting its use as a possible food source.

Although *Helisoma* has been found in archaeological contexts, it does not appear to have been utilized as a food source or for jewelry manufacturing like *Anodonta*. The proximity of large canal Feature 3 may have contributed to the deposition of *Helisoma* shells across the landscape of Areas 5A and 3B. Both *Helisoma* and *Anodonta* were found together in the fill of domestic Features 301, 318, and 329 (see Table 3.1). The adobe structure Feature 329 had *Helisoma, Anodonta*, and *Pisidium* shells in the upper structural fill, while Feature 318 had *Anodonta* and *Physa* in its upper structural fill, all of which suggest a possible flooding event, which deposited the shell in these upper levels. The abandonment and subsequent collapse of these structures would create a depression that could be easily filled with canal clean-out material or flood water. The presence of *Helisoma* in floor

Table 13.4. Distribution of shell genera, by feature type, from the PHX Sky Train project area.

	Pithouse	Adobe Structure	Pit	Canal/ Ditch	Catchment	Trash Concentration	Surface Sheet Trash	Total
Marine								
Glycymeris sp.	4	1	–	–	–	–	–	5
Laevicardium elatum	1	4	2	1	1	–	1	10
Olivella dama	1	–	–	–	–	–	–	1
Oliva sp.	–	1	–	–	–	–	–	1
Native Freshwater								
Anodonta californiensis	11	7	3	1	–	2	1	25
Pisidium sp.	–	1	–	–	–	–	–	1
Helisoma sp.	6	13	–	1	–	–	–	20
Physa virgata	1	–	–	–	–	–	–	1
Total	24	27	5	3	1	2	2	64

fill may reflect mixing of floor fill deposits due to rodent or other activity.

Discussion

The shell material recovered during the PHX Sky Train excavations is small in terms of formal artifacts, with a higher density of freshwater clams and snails. Only seven finished ornaments were recovered, dispersed among some of the habitation features that were investigated. No artifacts were recovered from floor contexts, and no paired ornaments were recovered. Only two habitation features, pithouse Feature 318 and adobe structure Feature 329, had multiple marine shell ornaments, with the remaining dispersed as single occurrences in their respective features. The recovered finished ornaments are typical of what is commonly associated with their respective phases and time periods.

All the shell was concentrated in just two areas, Areas 3B and 5A (see Table 13.1). Of the habitation features containing shell, Features 300, 301, 302, 307, and 309 are pithouses clustered together in Area 5A (see Figure 2.5), all assigned to the late Sacaton-early Soho phases of the Sedentary-Classic period transition. Only Features 300 and 307 had finished marine shell ornaments associated with them within this cluster, while the remaining structures only had local freshwater shell present. A single *Olivella* whole shell bead was recovered from the floor fill of Feature 300, while three *Glycymeris* bracelet fragments were recovered from the floor fill of Feature 307. One of the fragments was burned and cracking, suggesting it may have been part of a postabandonment trash dumping episode after the structure had collapsed. The presence of shell ornaments in only two of the structures could reflect differential access to shell jewelry or, more likely, the short use-life and function of the houses.

Other marine shell artifacts were recovered from a cluster of features dating to the Soho phase of the Classic period in Area 3B (see Figure 2.3). Feature 318, a pithouse, had a single whole shell *Glycymeris* bead recovered from floor fill. Unworked fragments of *Laevicardium* were recovered from Features 325 and 334, both small pits near the structures. Feature 329, the adobe structure, had the highest frequency of artifacts, as well as the most diverse array. Included are a cut-shell solid disk fragment of *Laevicardium*, an *Oliva* whole shell pendant, an unworked whole shell of a juvenile *Glycymeris*, and three unworked fragments of *Laevicardium*. However, most of these artifacts were recovered from the upper structural fill, suggesting a mixing of cultural material from postabandonment trash deposition.

Only two fragments of marine shell were recovered from non-domestic-related features. Single occurrences of *Laevicardium* shell were recovered from canal Feature 14 in Block 1 (see Figure 2.2) and Feature 57, a water catchment located in Area 6A (see Figure 2.7).

The low density of finished ornament forms in the current project area is a pattern noted elsewhere in similar locales where field systems and fieldhouses are present. Vokes (2003:202) noted that other shell assemblages associated with Hohokam farmsteads and small fieldhouse settlements tended to have fewer finished ornaments, compared with large settlements, such as villages and platform mounds. This pattern occurred at most of the loci at Dutch Canal Ruin, AZ T:12:62 (ASM) (Greenwald et al. 1994), where the shell assemblages were either limited to a few pieces of shell or were absent completely. This pattern was also exhibited among the fieldhouse sites and farmsteads investigated along the Salt-Gila Aqueduct, which also produced very little in the way of shell ornaments (Vokes 1984:540).

Although the respective shell assemblages were limited in numbers, the diversity of shell types and ornament forms that were present within the small assemblage is notable. For example, the current collection contains several ornament forms, such as bracelets, whole shell pendants, beads, and a cut-shell disk manufactured from four different varieties of marine shell. The assortment of shell species and ornament types probably reflects the close proximity to Pueblo Grande, where the inhabitants had access to a much larger variety of ornaments of personal adornment. This pattern likely played out across the Phoenix Basin, where inhabitants of the smaller settlements had access to shell ornaments through the markets at the larger, more central settlements associated with the canal systems (Vokes 2003:202).

Some small-scale manufacturing of marine shell ornaments for personal use likely occurred, as suggested by the presence of a raw valve of a juvenile *Glycymeris* shell and numerous unmodified fragments of *Laevicardium*, which are both shell varieties typically used for ornament manufacturing. However, it is also possible that the fragments of *Laevicardium* associated with the agricultural features were, instead, indicative of the use of this shell in a more utilitarian context. The use of *Laevicardium* shells as containers, and possibly dippers, has some history in the Southwest. Haury (1950:190) suggested that fragmentary material representing several large, unmodified valves recovered from very early deposits in Ventana Cave, AZ Z:12:5 (ASM), may have served such a purpose. Haury (1950) thought the function was utilitarian rather than decorative, due to the lack of manufacturing evidence at that particular early level of the cave deposits, and that they may have served as dippers to scoop water from the spring at the back of the cave. Gross (1989:477) also reported a *Laevicardium* valve with use-wear he attributed to use as a scoop, recovered from an inhumation at the Grand Canal site, AZ T:12:256 (ASM). The fragmentary material recovered from the canal and catchment within the current project area also may have served in a utilitarian function, which was to scoop water to put into containers, and possibly to assist in the clean-out of the canals and ditches.

The high density of freshwater shell material is not unusual for a site that is associated with agricultural activities. The presence of canals, ditches, water catchments, and field systems imply it would not be unusual to find associated freshwater fauna in feature fill. The presence would be fortuitous and perhaps a result of clean-out deposits of the various water channels. It has been previously suggested that *Anodonta* was used as a secondary food source and occasionally as raw material for ornament manufacturing. Therefore, the ubiquity of this freshwater clam across both domestic and non-domestic contexts could reflect its intentional harvesting as a secondary food resource, as well as deposition from overbank flooding or clean-out of the water and field systems.

MOLLUSCAN REMAINS FROM TWO WATER CATCHMENT FEATURES, AZ U:9:28 (ASM)

Native molluscan remains are often encountered in prehistoric water features, such as canals, ditches, reservoirs, or catchments. Their presence can be used to assist in the reconstruction of the aquatic environment of these features, as well as to help explain the use-history of these specialized cultural features (Vokes and Miksicek 1987; also, Chapter 6, this volume). Two PHX Sky Train features were sampled specifically for shell molluscan remains: Features 7 and 57, both identified as possible water-holding features.

Feature 7, located on the north side of canal Feature 3 in Block 7, had a relatively deep, constricted area shaped like an elongated pool. It was filled with alternating beds of sand, silt, and clay. It appeared that water was once directed into the feature via a canal, Feature 25, and that cleaning episodes had occurred, in addition to modification of the catchment area banks (Chapter 4, this volume). Investigators speculated that Feature 7 served as a reservoir for household water or subsistence use, prompting analysis of several strata that were laden with shells to better inform on its water-holding capabilities.

Feature 57 was an enigmatic pond-like feature that extended north from the edge of canal Feature 26 to near the end of ditch Feature 44 in Block 6. The feature was clearly attached to Feature 26, but it also contained sediments apparently related to the field area to the north (see Chapter 4). This suggested the feature may have been a collection area for run-off from the nearby field. Alternatively, its function might have been related to subsistence activities, such as the cultivation of cattails and/or reeds, or as an access point to draw water from Feature 26, among others. Again, analysis of mollusks from Feature 57 could inform on its aquatic environment, thereby providing clues about the possible functions of this curious feature.

Knowledge about modern non-marine mollusks is still somewhat incomplete, which, in turn, limits what can be inferred about populations of shells recovered from archaeological contexts. Thus, information from other locales outside the project area is occasionally used. Publications used for the current analyses to determine life cycles and ecology of living animals include Bequaert and Miller (1973), Drake (1959), Cheatum and Fullington (1973), Barber (1984), and McMahon (1975).

Sampling Strategy and Methods

The shell remains, all mollusks, were recovered through flotation of four judgmentally collected sediment samples (Table 13.5). Three of the samples were collected from obvious shell-bearing strata in Feature 7 (see Figure 4.4); the fourth sample was collected from the area of a step or "groove," located at the base of Feature 57, where it debouched into canal Feature 26 (see Figure 4.F57planview). An accumulation of "muddy" clay with shells could be seen at this location. Three 6-liter samples of dirt from Feature 7 was processed; the Feature 57 sample yielded 13 liters of sediment.

During the flotation process, small gastropods within the soil samples were lightweight and tended to float in the water as air became trapped in their small spires. The shells of most of these gastropods were very fragile; thus, the larger shells were hand-picked from the water during the flotation, as well as from the heavy fraction at the bottom of the flotation bucket. More fragmented shell remains settled into the heavy fraction, which was allowed to dry, and the shell pieces were later segregated from the dried sediments. A 10x hand-lens was used to scan the fraction, looking for whole mollusks. Several fragments were noted during sorting. If the fragments could be identified, they were counted but not measured. The intact specimens were then measured using either a vernier caliper or, if too small, using a metric ruler on graph paper. The grain size of these minute gastropods (from FN 1127, specifically) is bimodal, and proceeds from clay-silty to very fine sand, from 30-50 percent, respectively. The present collection of mollusks is quite small, as the density of shells per sample was fairly low (Table 13.6). The whole specimens were identified to taxa, and an attempt was made to distinguish juveniles from adults within each taxa.

Ecosystem of Identified Taxa

Each of the identified taxa requires a particular environment in which to thrive and reproduce.

Table 13.5. Sediment samples from catchment features analyzed for shell content, AZ U:9:28 (ASM).

Bag Number (FN)	Feature	Trench	Stratum	Sediment	Volume (l)	Comment
1036	7	63	8	Clay	6	Trench profile collection; 35-45 cm below top of feature
1037	7	63	7	Thinly bedded silt and clay	6	Trench profile collection; 30-35 cm below top of feature
1038	7	63	6	Thinly bedded silt and clay	6	Trench profile collection; 20-30 cm below top of feature
1127	57	N/A	N/A	Silty clay	13	Collected from "groove" at junction with canal Feature 26

Table 13.6. Mollusks recovered from Features 7 and 57, AZ U:9:28 (ASM).

Bag Number (FN)	Feature	Species	Number of Identified Specimens	Minimum Number of Individuals	Habitat	Size Range (mm)	Mean Size (mm)	Comments
1036	7	*Helisoma*	28	21	Aquatic	7.77-12.57	11.87	Mostly adults
1036	7	*Physa*	1	1	Aquatic	16.05	16.05	Adult
1037	7	*Helisoma*	29	26	Aquatic	5.42-15.85	13.06	Some juveniles and many adults
1038	7	*Hawaiia*	2	2	Terrestrial	1.07-1.94	1.51	-
1038	7	*Succinea*	2	2	Terrestrial	3.24-4.40	3.82	-
1127	57	*Physa*	4	3	Aquatic	10.35-11.01	10.68	Adults
1127	57	*Hawaiia*	15	10	Terrestrial	0.50-2.50	1.64	Mostly juveniles with a few adults
1127	57	*Physa*	20	15	Aquatic	1.50-4.00	3.13	3 adults, 12 juveniles

When the environment changes, the mollusks either adapt or die out. The following gives descriptions of the ecosystems required for the mollusks in the current collection. All the individual specimens are gastropods or snails; no bivalves or clams were present. Two of the gastropods are terrestrial, and two species are aquatic.

Family Zonitadae, *Hawaiia minuscula*

Several examples of this tiny land snail were recovered from samples in both Feature 7 (FN 1038) and Feature 57 (FN 1127). This gastropod is very common in Arizona, with a range that extends throughout North and Central America. It has been dispersed by humans to the Old World, as well as to islands in both the Caribbean and the Pacific Ocean (Bequaert and Miller 1973:145-146).

This snail has been recorded from several archaeological sites throughout southern Arizona (Barber 1984; Drake 1959; Vokes and Miksicek 1987:178). The contexts at these archaeological sites are anthropogenically influenced, and include prehistoric agricultural features and sites, fieldhouses and farmsteads, terraces, stone alignments, rock piles, and possible field areas (Vokes and Miksicek 1987:178). The *Hawaiia* snail prefers grassy or moderate arboreal vegetation (Drake 1959:150), or a more "weedy" environment, because it flourishes under agricultural disturbance. Overall abundance and shell size appear to increase in optimal habitats (Barber 1984; Miksicek 1984).

Family Succineidae, *Succinea* spp.

Succinea spp. is a terrestrial snail that is almost amphibious, and it is identified by its sinistral shell and a large aperture that opens to the right. They are generally found alive in the damp, wet zone on the substratum at the edge of bodies of water (Drake 1959:150). This small gastropod is difficult to identify to species, because identification is based on variations in the anatomy of the genitalia (Drake 1959:148; Vokes and Miksicek 1987:178). Therefore, reliance of identification to the genus level is based on the morphological characteristics of the shell itself. The range of this terrestrial snail extends throughout North and Central America, and it is frequently recovered from archaeological sites in southern Arizona.

Family Physidae, *Physa virgata*

The *Physa* is an aquatic snail with a dextral shell and a large aperture that opens to the left. The shell can be quite large, and it is globose (Cheatum and Fullington 1971:15). This particular mollusk prefers more swampy conditions or shallow ponds at the edges of lakes, meandering creeks, and rivers (Drake 1959:150), but it appears to have a high tolerance for a wide range of ecological habitats. In recent years, the live populations have been found to even be resistant to pollutants (Harmon 1974). It would have been endemic to water features, such as canals, ditches, and catchments found at U:9:28, living in the moist vegetation along the banks of these features. *Physa virgata* is widely distributed in Arizona (Bequaert and Miller 1973:201-203), mostly in areas with muddy bottoms. McMahon (1975) studied two populations of *Physa virgata* in Lake Arlington, Texas, and discovered that this species preferred a rocky substrate, which suggests the mollusk can adapt to its particular environment as needed.

McMahon (1975) also discovered that in the Lake Arlington population, *Physa virgata* was capable of producing three generations a year. Egg production appears to have been initiated whenever the water temperature rose above 13° C, so that the first egg-laying episode began around March, with a second generation in early summer and a third generation in late summer or fall (McMahon 1975:1170). The parent population seemingly dies back, leaving only a few hearty examples to overlap the next generation. The cooler winter temperatures appear to diminish the size of that particular population; conversely, the *Physa* readily adapt to the warmer summer temperatures, producing shells that are larger and exhibit faster growth rates. It has been suggested by Vokes and Miksicek (1987:185) that juvenile populations are generally smaller than 4 mm, and that adults range from 4 mm to 8 mm. This sizing method, or bimodal distribution, was used on the current *Physa* assemblage to distinguish between the juvenile and adult populations. This particular mollusk is often recovered from drift assemblages.

Family Planorbidae, *Helisoma tenue*

Helisoma is an aquatic snail that is somewhat large, but fragile, with a multispiral or discoidal shell that has a flattened spire (Cheatum and Fullington 1971:15). It is commonly found alive, and has a wide distribution across Arizona, especially at elevations from below 2,000 m to almost 3,000 m (Bequaert and Miller 1973:208), although apparently it may have been more abundant at lower elevations in the past (Drake 1959). It also is found in most of Mexico, New Mexico, southern California, and parts of Texas. Dead shells are often found together as drift assemblages. This aquatic snail prefers a wet environment, such as found under swampy conditions, or in shallow ponds at the edges of lakes, meandering creeks, and rivers (Drake 1959:150). Like the *Physa*, it would have been endemic to the local water features associated with the canals and field systems, living in moist vegetation along the banks (Vokes 1996:222).

Results

The results of the analysis for native mollusks from Features 7 and 57 are presented in Table 13.6. Of the 101 individual shells recorded, *Helisoma* is the most abundant ($n = 47$), followed by *Physa* ($n = 19$), *Hawaiia* ($n = 12$), and *Succinea* ($n = 2$). If the ecosystem needed to support the individual species is considered, then it is possible to speculate about the environmental conditions when the gastropods were deposited. However, taphonomic conditions can influence the deposition of any artifact, especially a lightweight snail. Wind, water, birds, and humans can transport these small shells.

The size distribution for some of the mollusks is somewhat continuous, with the presence of both juveniles and adults, indicating conditions, in some instances, for these gastropods were favorable for local breeding. The presence of only adults in a sample could suggest they either represent drift individuals or the environmental conditions changed and could only support one generation. The dearth of *Succinea* shells and the nearly equal size of the two suggest they were probably drift individuals.

Feature 7, Reservoir

Three samples from Feature 7 were collected from discrete strata located near the southern edge of the feature on the west trench wall of Trench 63 (Figure 4.4; see Table 13.6). Sample FN 1036 was collected from the lowest of the three sampled strata, and it contained a group of 21 *Helisoma* shells, all representing dead shells. The individuals were variable in size (see Table 13.6), which suggests the environment was optimum for their proliferation. The group may represent two generations. Most of the univalves were complete. A single *Physa*, an adult based on its size, was also recovered from this flotation sample. It is also a dead shell.

Sample FN 1037 was collected from the middle of the three strata; also not far from the southern edge of the feature. This sample produced the highest number of individuals recovered, while being the least diverse. Twenty-six *Helisoma* shells, all dead, were recovered from the flotation sample. The shells are variable in size, including some very large specimens (see Table 13.6), suggesting the environment was quite favorable to sustaining the species for at least two generations. This strata contained thin alternating layers of silt and clay, with a fragment of *Anodonta* noted, indicating this stratum contained moving water at some point(s) in time. The environment of the water feature later changed to the extent that it was no longer favorable for the mollusks, and they died after two generations.

Sample FN 1038, from the highest sampled strata, contained a low-density collection of two *Hawaiia* and two *Succinea*. Although identified as terrestrial, both snails are partial to moister or weedier environments. This suggests the stratum may have held more moisture, and possibly vegetation, perhaps due to the presence of the clay and standing water near the edge of the feature.

Although the collection of snails from Feature 7 is rather small, the accumulation of different deposits may reflect episodes of water coming into the feature and standing for some period of time. The large size of some of the *Helisoma* shells would indicate that environmental conditions were optimum for the growth and regeneration of this particular mollusk. The uppermost sampled stratum contained mollusks that prefer a damp, weedy environment, suggesting water ponded near the side of Feature 7, providing a place for vegetation to grow. The lowest sampled stratum contained only aquatic mollusks, primarily adults. This stratum also contained more clay, which could reflect episodes of standing water, followed by a period of drying. The sequence suggests Feature 7 was used to hold water, presumably funneled through canal Feature 25; the water level would drop either through use, evaporation, or soaking into lower sediments. Then after the water level dropped too low, more water would be added to the feature. The small sample size from the upper stratum suggests that this level of the feature may have been cleaned out prior to filling in of the feature postabandonment, or that it dried out quickly.

The layers of the different sediments, with their associated mollusks in Feature 7, suggests a sequence of water influx, standing water, and drying episodes occurred in this water catchment feature. The *Helisoma* shells are variable in size, ranging from 5.42 mm to 15.85 mm in length; the presence of both juveniles and adults suggests the environment was optimum for producing multiple generations. Also, the large size of the univalves suggests warm water temperatures may have promoted the growth of the adults. The examples of *Helisoma* in the current collection are much larger than those reported in other assemblages; for example, those from the Las Acequias, AZ U:9:44 (ASU), and Los Muertos, AZ U:9:56 (ASM), collection (Vokes and Miksicek 1987: Table 12.2).

Feature 57, Pond

A small group of 18 *Physa* and 10 *Hawaiia* specimens was recovered from the heavy fraction of

Table 13.7. Number of mollusk valves per sample liter from Features 7 and 57, AZ U:9:28 (ASM).

Bag Number (FN)	Feature	Volume (l)	Number of Valves (MNI) per Liter			
			Hawaiia	*Helisoma*	*Physa*	*Succinea*
1036	7	6	–	3.50	0.17	–
1037	7	6	–	4.30	–	–
1038	7	6	0.34	–	–	0.34
1127	57	13	0.77	–	1.38	–

sample FN 1127 (see Table 13.6), collected from the lowest deposits of Feature 57, at its junction with canal Feature 26. This sample exhibited the lowest density of shells per liter of soil (Table 13.7), but contained a higher density of juveniles. Roughly 10 more fragments, representing an unknown portion of unknown shells, were present, although they were not measured because they could not be identified to a particular taxa. Three of the *Physa* were large enough to be considered adults or young adults, while the remaining represent juveniles. The *Hawaiia* are also primarily represented by juvenile individuals. The appearance of mainly juvenile mollusks suggests the substrate at this particular location was optimum for reproduction, and the juveniles represent a new generation or early-stage individuals that appeared during warm or warming months (Palacios-Fest 2010).

Enough mud and vegetation must have been present to provide the type of environment that appeals to the *Hawaiia* and that would support these mollusks. The presence of both *Physa* juveniles and adults at the same location would suggest enough water of the proper temperature was at least occasionally present at this location to provide a stable enough environment to produce two generations of the *Physa* snail. This could occur during spring or summer rains, when the water temperature is warmer. However, the microenvironment along this edge of the "pond" may have changed fairly quickly, preventing the mollusks from growing much beyond the juvenile stage.

Discussion

The mollusks recovered from flotation samples collected from Features 7 and 57 can help recreate possible uses for these two particular features, as well as seasonality of use. The presence of aquatic snails indicates both of these features held water at some point for varying lengths of time. Feature 7 may have contained standing water long enough to support vegetation growing along the sides of the feature. This provided a viable habitat for the *Hawaiia* and *Succinea* snails, both of which prefer a wet, muddy zone, with vegetation or rootlets to which they can attach themselves. The lower strata also show an episode of possible faster moving water, followed by an episode of standing water, which could reflect refilling the reservoir. The presence of a group of *Helisoma* shells in the middle stratum that contained both adults and juveniles indicates the microenvironment of the water catchment was stable for some time, long enough to support two generations of mollusks. The lowest sampled stratum, containing primarily adult *Helisoma* shells, also appeared to have contained standing water at some time. This also suggests the environment was habitable for only a single generation of mollusks before becoming unsuitable. Alternatively, the group of shells may represent a colony of floaters that washed into the feature from canal Feature 25, and subsequently settled near the southern edge of the reservoir.

The mollusks recovered from the lower sediments of the junction at Feature 57 and canal Feature 26 suggests a deposit of mud and vegetation created a very suitable habitat for the growth of juvenile *Hawaiia* and *Physa* shells. The flow of water from the canal into the "pond" might have provided a wet environment for the growth of grasses and other possible vegetation along the banks of both features, which would have been favorable for sustaining the *Hawaiia* snails, while the warmth of the spring or early summer sun would have provided the impetus needed for the first generation of the mollusks to grow. The dearth of adult mollusks at this location suggests the environment quickly shifted to a less desirable one, and the population quickly died out. This may have been due to a lack of water in the feature, caused by canal dry-out.

FAUNAL MATERIAL FROM THE PHX SKY TRAIN PROJECT

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Desert Archaeology, Inc.

Data recovery efforts conducted by Desert Archaeology, Inc., for the PHX Sky Train project resulted in the recovery of a relatively small faunal assemblage. A brief description of the 44 bone specimens obtained from these excavations is provided here (Table 14.1), including 41 specimens from prehistoric contexts assigned to AZ U:9:1 (ASM) and three specimens from a historic feature assigned to AZ T:12:258 (ASM). Although the small sample size precludes extensive interpretation of this material, the prehistoric faunal assemblage can inform on hunting activities in areas dedicated primarily to agricultural production on the periphery of a large village site. The findings of this study indicate that residents living on the margin of the village of Pueblo Grande, AZ U:9:1 (ASM), followed a fairly typical Hohokam subsistence strategy that focused on the procurement of locally available small game animals.

ANALYTICAL METHODS

Most of the faunal specimens from the PHX Sky Train project were collected during the dry screening of excavated sediments using ¼-inch mesh. A few zooarchaeological specimens were also collected during hand-excavations. Bones found during the hand-excavation of structure floors or in trench walls were typically left in place until they had been mapped and photographed.

Taxonomic identifications of the faunal material were determined primarily using published reference manuals (Elbroch 2006; Gilbert 1993; Olsen 1964, 1968). Some specimens were also analyzed using the comparative collection available at Desert Archaeology's Tucson laboratory. During analysis, each specimen was identified to its lowest taxonomic level. A faunal specimen was considered identifiable if it could be assigned to at least the order level. Unidentifiable remains largely consisted of long bone shaft fragments or small pieces of poorly preserved bone that lacked distinguishing anatomical characteristics to allow identification to a taxonomic order. Specimens determined to be unidentifiable were separated into rough size categories, based on the shape and thickness of the bone.

Once identified to taxon, information was recorded for each specimen, including anatomical element, side, completeness, portion, and degree of fusion. Evidence of burning, natural surface modifications, carnivore and rodent gnawing, and cultural modifications were also coded, and the absolute length of each specimen was recorded.

The zooarchaeological data were quantified using the number of identifiable specimens (NISP). NISP is generally calculated by totaling the number of bone fragments identified to a specific taxon. For this analysis, the bone counts for each taxon were slightly modified to represent counts based on refitted bone elements and potential refit estimates for individual elements rather than the actual number of bone fragments. This modified NISP represents a more accurate way to quantify the faunal material, because it helps mitigate the effects of postdepositional bone breakage resulting from excavation and handling.

CONTEXT AND COMPOSITION OF THE FAUNAL ASSEMBLAGE

The PHX Sky Train project faunal remains derived from a relatively small number of contexts and site areas (Table 14.2). Only areas 3B and 5A yielded prehistoric faunal bone, with area 3B accounting for 86 percent of the prehistoric assemblage. This disproportion cannot be attributed to excavation effort, because an equal, if not greater, quantity of fill was excavated and screened from area 5A features relative to area 3B (Chapter 9, this volume). Function also does not seem to play a role, as both areas contained an assortment of habitation structures, extramural pits, and trash concentrations. Rather, the disparity in bone recovery between the two areas likely reflects the amount of time prehistoric inhabitants spent at each area, with habitation being longer or more entrenched at area 3B than area 5A. Notable in this regard is the fact that no faunal remains were recovered from excavated pithouse structures in areas 3A and 6A, supporting the view that these were temporally occupied fieldhouses.

Of the 41 bones recovered from prehistoric contexts, 33 percent (n = 14) of the mammalian remains

Table 14.1. Summary of faunal remains from the PHX Sky Train project.

Site/Taxon	NISP[a]	% of NISP
AZ U:9:1 (ASM)		
Mammals		
Lagomorphs (Order Lagomorpha)		
Desert cottontail (*Sylvilagus audubonii)*	3	7
Jackrabbit (*Lepus* sp.)	5	11
Rodents (Order Rodentia)		
Western harvest mouse (*Reithrodontomys megalotis*)	1	2
Deer mouse (*Peromyscus* sp.)	1	2
Ground squirrel (*Spermophilus* sp.)	1	2
Rock squirrel? (cf. *Citellus* sp.)	1	2
Indeterminate small rodent	2	5
Unidentified Mammalia		
Very small mammals (rodent-sized)	1	2
Small mammals (rabbit-sized)	7	16
Medium mammals (carnivore-sized)	11	25
Large mammals (ungulate-sized)	6	14
Unspecified mammal	2	5
AZ T:12:258 (ASM)		
Mammals		
Ungulates (Order Artiodactyla)		
Cattle (*Bos taurus)*	1	2
Unidentified Mammalia		
Large mammals (ungulate-sized)	2	5
Total	44	100

[a]NISP = Number of identifiable specimens.

Table 14.2. Contexts from which faunal remains were recovered, the PHX Sky Train project.

Area	Feature	Feature Type and Context	NISP[a]	% of NISP
AZ U:9:1 (ASM)				
5A	300	Pithouse fill	1	2
5A	309	Trash concentration fill	1	2
5A	311	Pit fill	1	2
3B	318	Pithouse fill	12	27
3B	326	Pit fill	1	2
3B	329	Adobe structure fill	22	50
3B	329	Adobe structure floor	1	2
3B	334	Pit fill	2	5
AZ T:12:258 (ASM)				
B4	115	Pond fill	3	7
Total			44	100

[a]NISP = Number of Identifiable specimens.

Table 14.3. Identifiable mammalian remains from prehistoric contexts, PHX Sky Train project.

Taxon	NISP[a]	% of NISP
Mammals		
Lagomorphs (Order Lagomorpha)		
Desert cottontail (*Sylvilagus audubonii*)	3	21
Jackrabbit (*Lepus* sp.)	5	36
Rodents (Order Rodentia)		
Western harvest mouse (*Reithrodontomys megalotis*)	1	7
Deer mouse (*Peromyscus* sp.)	1	7
Ground squirrel (*Spermophilus* sp.)	1	7
Rock squirrel? (cf. *Citellus* sp.)	1	7
Indeterminate small rodent	2	14
Total	14	100

[a]NISP = Number of identifiable specimens.

could be identified to a taxonomic order, or lower (Table 14.3). Identified specimens include desert cottontail (*Sylvilagus audubonii*), jackrabbit (*Lepus* sp.), indeterminate small rodent (order Rodentia), western harvest mouse (*Reithrodontomys megalotis*), deer mouse (*Peromyscus* sp.), ground squirrel (*Spermophilus* sp.), and possible rock squirrel (cf. *Citellus* sp.). Lagomorphs comprise more than half the identified assemblage, with 57.1 percent (n = 8) of the mammalian bone. Jackrabbits are slightly more abundant than cottontails (62.5 percent versus 37.5 percent of the identified lagomorph remains, respectively). These small game animals were probably locally hunted in the riparian and desert scrubland environs that surrounded the prehistoric settlement.

The remaining three specimens in the assemblage derived from a single historic context, pond Feature 115 near the southwestern corner of Block 4 (see Figure 2.4). The specimens included a cervical vertebra from a domesticated cow (*Bos taurus*) and two unidentified large mammal (ungulate-sized) bones, probably skeletal pieces from the same animal. The vertebra provided undisputable evidence that this was indeed a historic feature (see "Historic Features" section in Chapter 2, this volume). Because these historic specimens have no bearing on prehistoric activity, they have been excluded from the following statistical descriptions for the Sky Train project faunal remains.

Approximately 14 percent (n = 6) of the total assemblage is composed of rodent remains. Ethnographic accounts have reported that larger rodent species, such as squirrel and woodrat, were regularly captured and consumed by the Pima (Rea 1998; Russell 1975) and the Papago (Castetter and Bell 1942). Although the residents of the PHX Sky Train project area may have occasionally procured rodents as a food source, the deer mouse, western harvest mouse, and indeterminate small rodents that were recovered appear to be intrusive in origin. This conclusion is based on the fact that the remains are relatively well preserved and show little signs of the weathering or caliche-coating typically associated with culturally derived faunal material.

Medium mammals dominated the unidentified fragments from the Sky Train project. Of the specimens identified only to a size category, 11 of 27 (41 percent) were from medium mammals (carnivore-sized). Small mammals (rodent- or rabbit-sized) made up 30 percent (*n* = 8) of the size-class assemblage, and large mammals (ungulate-sized) accounted for the remaining 29 percent (*n* = 7).

BONE SURFACE MODIFICATIONS

A majority of the faunal specimens (*n* = 28, or 67 percent) in the PHX Sky Train project assemblage exhibit some form of environmental modification to the bone surface (Table 14.4). Root-etching is the most prevalent, with 57 percent (*n* = 16) of the modified bones showing evidence of taphonomic loss due to root disturbance. Caliche-coating and erosion are also fairly common, affecting 43 percent (*n* = 12) and 29 percent (*n* = 8) of the modified bone assemblage, respectively. In several instances, caliche-coating on specimens occurred in combination with either erosion (*n* = 1, or 4 percent) or root-etching (*n* = 4, or 14 percent). Root-etching occurred in combination with erosion in five specimens (18 percent). Seven percent (*n* = 2) of the environmentally modified portion of the assemblage exhibits evidence of rodent gnawing.

Thirteen specimens (31 percent) were burned (Table 14.5). The degree of burning ranged from partially charred to calcined. Nine of these bones (69 percent), including a calcined jackrabbit calcaneus and a partial cottontail femur, as well as a charred fragment of a jackrabbit femur, were recovered from an adobe structure, Feature 329. The remaining burned specimens were collected from either pithouses or a trash concentration in proximity to pithouses. Four of the burned bones (31 percent) were calcined, indicating they were burned at very high temperatures (Lyman 1994:389-390). The presence of burned bone in archaeological settings is often inferred to be the direct result of cooking activities. However, a variety of activities are likely responsible for the burned bone recovered from archaeological assemblages. Burning may result from bones being tossed into the cooking fire after consumption of the meat, trash burning, using bone as fuel for fires, or the intentional burning of pithouses after abandonment (Haury 1976:115; Lyman 1994: 388).

Table 14.4. Environmental modifications in the PHX Sky Train project faunal assemblage.

Modification	NISP[a]	Percent
Caliche-coating only	7	25
Caliche-coating with root-etching	4	14
Caliche-coating with erosion	1	4
Root-etching with erosion	5	18
Root-etching only	7	25
Erosion only	2	7
Rodent gnawing only	2	7
Total	28 (67%)[b]	

[a]NISP = Number of identifiable specimens.
[b]Percent total reflects environmentally modified portion of the assemblage.

Table 14.5. Degree of burning in the PHX Sky Train project faunal assemblage.

Degree of Burning	NISP[a]
Partially charred	2
Charred	2
Charred/Calcined	2
Calcined	4
Blue/gray	3
Total	13 (31%)[b]

[a]NISP = Number of identifiable specimens.
[b]Percent total reflects burned portion of the assemblage.

Only two of the zooarchaeological specimens (5 percent) in the Sky Train assemblage show evidence of human modification other than burning. In both cases, the artifacts are fragments from the distal ends of bone awls or hairpins, and both were recovered from structural fill, pithouse Feature 300, and adobe structure Feature 329. Bone awls/hairpins were produced from the long bones of large animals. The metapodials of artiodactyls, such as deer, were typically used, the distal end of the bone serving as the handle, and the proximal end of the bone ground to a point (Thiel 2001).[1]

INTERSITE COMPARISONS

Although the sample size from the PHX Sky Train project is small, it contributes to current understanding of existing patterns of hunting and consumption within the broader context of the agricultural community to which it belonged. An examination of the extant literature suggests the low

[1]Note that when referring to a complete awl, the terms are reversed; that is, the pointed end of the tool is distal and the handle of the awl is proximal (Thiel 2001).

density and low diversity of faunal bone within the Sky Train assemblage is characteristic of farmstead and fieldhouse sites in the area. For example, excavations at Dutch Canal Ruin, AZ T:12:62 (ASM), Murphy's Addition, AZ T:12:43 (ASM), and La Cuenca del Sedimento, AZ U:9:68 (ASM), produced very few faunal remains, with lagomorphs accounting for most of the identifiable assemblages (see Dean 2003). These small sites all represent short-term habitations near major canal-fed agricultural fields. The paucity of artiodactyls and the abundance of lagomorphs remains in the assemblage suggest an intensive agricultural use of the land.

Patterns of faunal use were similar between fieldhouse sites and the large village of Pueblo Grande (James 1994). Like the less intensively occupied sites mentioned above, lagomorphs were the major quarry at Pueblo Grande, accounting for 34 percent of the total identifiable remains from that site, while artiodactyls made up only a little more than 1 percent. Non-mammalian taxa comprised 35 percent of Pueblo Grande's identifiable remains, suggesting the inhabitants of the central village may have enjoyed a larger resource area, as well as year-round access to a greater number of microenvironments than did populations at peripheral farmsteads and fieldhouses (Dean 2003). However, because assemblage richness (number of discrete taxa) can be affected by assemblage size (Grayson 1984), the absence of non-mammalian remains in the PHX Sky Train project area could be a sampling issue. As such, it may not reflect any meaningful behavioral pattern of faunal use.

CONCLUSIONS

Due to the small size of the faunal assemblage recovered during the PHX Sky Train project, only the most general trends in faunal utilization practices can be discussed here. The presence of high frequencies of lagomorphs and low quantities of artiodactyls suggests a hunting strategy similar to other fieldhouse and farmstead sites in the Phoenix area. These small game species likely provided a ready source of meat that could be acquired with minimal effort within the agricultural environment of the PHX Sky Train project area. Although this assemblage represents only the limited faunal use that occurred during short-term occupation of the site, when efforts were focused on agricultural production, it still makes an important contribution to current understanding of the general hunting economy of Hohokam agricultural communities.

CHARRED PLANT MACROREMAINS FROM THE PHX SKY TRAIN PROJECT

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Archaeological excavations for the PHX Sky Train project along the western edge of the site of Pueblo Grande, AZ U:9:1 (ASM), within an area dominated by prehistoric canals, AZ U:9:28 (ASM), yielded 33 flotation samples and nine hand-collected macrobotanical specimens for paleobotanical analysis (Tables 15.1-15.2). Most of the assemblage (18 productive flotation samples) represents late Sedentary or early Classic period (late Sacaton-early Soho phase, A.D. 1100-1200) or Classic period (Soho phase, A.D. 1150-1300) food plant remains. Four other samples were recovered from purely Sedentary period (Sacaton phase, A.D. 1000-1150) contexts, and two samples were recovered from Colonial period (late Gila Butte-early Santa Cruz phase, A.D. 800-900) contexts. Analyses of flotation samples from a prehistoric canal, Feature 3 of U:9:28, yielded wood charcoal but no food plant tissues.

In all instances, the range of plants that occurred in flotation samples from various components were consistent with the use of locally available resources that were present on, or within 1 km of, the site. The primary emphasis among food plants was on maize, agave, mesquite pods, and weeds that grow well within, or on the margins of, irrigated fields. Wood charcoals were overwhelmingly local tree species, primarily indeterminate tree legumes and mesquite, with modest amounts of kindling and house construction material. The range of food plant remains represented in those components is consistent with the overall impression that pithouses and an adobe structure within this area at the edge of Pueblo Grande were probably seasonally occupied farm structures.

Colonial and Sedentary period contexts yielded few charred plant remnants. The only food plant taxon in the Colonial period component was pigweed seed, a floodplain weed. Sedentary period samples also yielded agricultural commensals, including goosefoot and tansy mustard; agave caudex tissue was also observed.

Late Sedentary and Classic period components in the PHX Sky Train project area yielded a broader range of food plant tissues, including maize, cotton, agave, hedgehog cactus, pigweed, goosefoot-pigweed, tansy mustard, mesquite pod fragments, globemallow seeds, and an unidentified grass seed. Although only two Colonial period samples and four Sedentary period samples were analyzed, the identified taxa and their ubiquities are consistent with one of two findings that are not mutually exclusive.

In the first scenario, the broader range of plants indicates that later farmhouses were used more intensively. For example, residents of the greater Pueblo Grande community may have spent more time at these houses during the later occupations. In this instance, the earlier occupation houses may have been abandoned daily, or only occupied during the critical episodes of planting and harvesting during the late spring and late summer seasons.

The other possibility is that the food plant remains in more recent components represent an effort to deliberately cultivate a broader range of plants. In short, the occurrence of a few field weeds in the older components may represent incidental use of these plants, secondary to the basic purpose of farming. In contrast, late-Sedentary and Classic components at the margins of Pueblo Grande may have been more diverse because an effort was made to maximize yields from both maize and the commensal weeds that grew in or around irrigated fields.

PROCEDURES

The procedures used for field collecting archaeological plant remains followed standards described in Pearsall (1989:16, 19-23). Flotation samples were processed at the Desert Archaeology, Inc., laboratory using a recirculating flotation tank and catchment system fitted with a fine synthetic mesh similar to organza. The collected light fractions were air-dried and stored in ziplock plastic bags.

Only charred plant remains were identified. Noncharred remains recovered from open-air archaeological sites are probably of recent origin and bear no relationship to the prehistoric contexts in which they occur (Miksicek 1987; Minnis 1981). Identifica-

Table 15.1. General characteristics of flotation samples from the PHX Sky Train project.

Feature	Feature Type	FN	Volume (l)	Weight (gm)	Insect Fragments	Snails	Phase
Pueblo Grande, AZ U:9:1 (ASM)							
300	Pithouse	610	6.0	11.8	0	1-50	Late Sacaton-Early Soho
301	Pithouse	617	6.0	22.4	1-50	1-50	Late Sacaton-Early Soho
301	Pithouse	626	6.0	11.8	0	0	Late Sacaton-Early Soho
302	Pithouse	636	6.0	10.6	1-50	1-50	Late Sacaton-Early Soho
302	Pithouse	711	6.0	9.9	0	0	Late Sacaton-Early Soho
304	Small extamural pit	670	3.0	8.5	0	0	Late Sacaton-Early Soho
306	Pithouse	675	5.0	12.8	0	1-50	Late Gila Butte-Santa Cruz
306.01	Hearth in pithouse	799	3.0	4.9	0	1-50	Late Gila Butte-Santa Cruz
307	Pithouse	663	6.0	14.1	0	1-50	Late Sacaton-Early Soho
307	Pithouse	690	6.0	14.1	0	1-50	Late Sacaton-Early Soho
307.01	Hearth in pithouse	736	2.0	3.9	0	0	Late Sacaton-Early Soho
309	Artifact concentration/trash	773	6.0	14.1	0	1-50	Late Sacaton-Early Soho
311	Small extramural pit	742	6.0	35.9	0	1-50	Late Sacaton-Early Soho
312	Pithouse	829	7.0	10.7	0	1-50	Early Sacaton
312.01	Hearth in pithouse	830	2.5	1.9	0	1-50	Early Sacaton
313	Pithouse	895	9.0	11.7	0	1-50	Early Sacaton
313.01	Hearth in pithouse	897	1.0	0.3	0	0	Early Sacaton
314	Pithouse	893	6.0	10.3	0	0	Early Sacaton
314	Pithouse	1202	2.5	1.4	0	0	Early Sacaton
314.01	Hearth in pithouse	1201	2.0	1.2	0	0	Early Sacaton
316	Pithouse	890	5.0	8.1	0	0	Early Sacaton
316	Pithouse	891	5.0	9.7	0	0	Early Sacaton
316.01	Hearth in pithouse	899	3.0	5.6	0	1-50	Early Sacaton
318	Pithouse	1207	4.0	10.3	0	0	Soho
318.01	Hearth in pithouse	898	1.0	0.1	0	0	Soho
326	Post hole	1206	5.0	13.3	0	1-50	Soho
329	Adobe structure	1258	5.0	5.5	0	0	Soho
329	Adobe structure	1259	6.0	45.4	0	0	Soho
329	Adobe structure	1265	6.0	62.6	0	0	Soho
329.01	Hearth in adobe structure	1257	9.0	81.7	0	1-50	Soho
334	Small extramural pit	896	6.0	10.8	0	1-50	Soho
AZ U:9:28 (ASM)							
3	Canal	94	6.0	59.0	0	0	Indeterminate Classic period
3	Canal	1032	3.0	27.6	0	1-50	Indeterminate Classic period

Table 15.2. Hand-collected macrobotanical specimens from the PHX Sky Train project.

Site	Feature	FN	Weight (gm)	Description	Phase
Pueblo Grande, AZ U:9:1 ASM)	307	693	0.9	*Acacia-Prosopis* sp. wood charcoal	Late Sacaton-Early Soho
	309	784	4.7	Desert tree legume wood charcoal	Late Sacaton-Early Soho
	311	740	5.8	*Acacia-Prosopis* sp. wood charcoal	Late Sacaton-Early Soho
	314	843	10.7	Charred dirt	Early Sacaton
	326	1343	t[a]	*Prosopis* sp. seed fragment	Soho
	329	1229	5.2	Desert tree legume wood charcoal	Soho
	329	1291	14.1	Desert tree legume wood charcoal	Soho
	333	1355	5.5	*Prosopis* sp. wood charcoal	Soho
AZ U:9:28 (ASM)	57	1178	t	Desert tree legume wood charcoal	Middle-Late Sacaton

[a]Trace quantity (< 0.1gm).

Table 15.3. Charred seed and agave tissue frequencies from analyzed flotation samples, PHX Sky Train project.

		Crops		Agave and Cactus		Agricultural Weeds				Arboreal	Other Weeds and Grasses		
Feature	FN	*Gossypium hirsutum* (Cotton)	*Zea mays* (Maize)	*Agave* sp. (Agave, Caudex or Stalk Tissue)	*Echinocereus* sp. (Hedgehog Cactus)	*Amaranthus* sp. (Pigweed)	Cheno-ams (Goosefoot or Pigweed)	*Chenopodium* sp. (Goosefoot)	*Descurainia* sp. (Tansy Mustard)	*Prosopis* sp. (Mesquite)	*Sphaeralcea* sp. (Globemallow)	Gramineae (Grass Family)	Unidentified Seed Fragment
Pueblo Grande, AZ U:9:1 (ASM)													
300	610	0	1	0	0	38	0	0	0	0	0	0	0
301	617	0	0	0	0	0	0	0	0	0	0	0	1
301	626	0	0	0	0	0	0	0	1	0	0	0	0
302	636	0	1	3	0	0	0	0	0	0	0	0	0
304	670	0	1	1	0	0	0	0	0	0	0	0	0
306	675	0	0	0	0	1	0	0	0	0	0	0	0
306.01	799	0	0	0	0	1	0	0	0	0	0	0	0
307	663	0	0	0	0	0	12	0	0	0	0	0	1
307	690	1	0	1	3	0	0	0	0	1	0	2	0
309	773	0	0	0	0	0	0	0	0	1	0	0	0
311	742	0	0	0	0	1	0	0	0	0	0	0	0
312.01	830	0	0	0	0	0	0	0	0	0	0	0	1
316	890	0	0	2	0	0	0	0	0	0	0	0	0
316	891	0	0	0	0	0	0	1	0	0	0	0	0
316.01	899	0	0	0	0	0	0	0	1	0	0	0	0
318	1207	0	1	3	0	0	0	0	0	0	0	0	0
318.01	898	0	0	1	0	0	0	0	0	0	0	0	0
326	1206	0	0	1	0	0	0	0	0	2	0	0	0
326	1343	0	0	0	0	0	0	0	0	1	0	0	0
329	1258	0	0	0	0	4	0	0	1	0	1	0	0
329	1259	0	1	9	0	12	0	0	2	0	1	0	0
329	1265	0	0	0	0	0	0	0	0	1	0	0	0
329.01	1257	0	0	15	0	0	0	0	0	0	0	0	0
334	896	0	1	0	0	0	0	0	0	0	0	0	0
AZ U:9:28 (ASM)													
3	94	0	0	0	0	0	0	4	0	0	0	0	0

Table 15.4, respectively. The identified taxa, their general occurrence within Arizona, and their range of uses, are described below. The contents of hand-collected macrobotanical samples are described in Table 15.2.

Agave sp., Agave, Agavaceae

Agave tissue comprised of marginal caudex and floral stalk tissue was observed in six macrobotanical specimens and 14 flotation samples. Agave occurs in Arizona at elevations from 500 ft through 7,500 ft (Kearney and Peebles 1973:192-195). The primary known ethnohistorical uses of the plant include manufacturing fiber and textiles from the leaves, long poles for harvesting saguaro fruit from the floral stalks, and food from the baked central caudex ("heart") of the plant (Ferg 2003; Gasser 1982; Moerman 1998:52-54; Rea 1997:250-253). It is common in Southwestern archaeological assemblages during and after the eleventh century A.D., leading many to suggest it was an important prehistoric Hohokam cultivar (Gasser and Kwiatkowski 1991) whose production was managed by specialists (Gasser and Miksicek 1985).

Table 15.4. Wood charcoal frequencies from analyzed flotation samples, PHX Sky Train project.

Feature	FN	*Atriplex* (Saltbush)	*Fouquieria* (Ocotillo)	*Phragmites* (Common Reed)	Desert Tree Legume (any of *Acacia* sp., *Cercidium* sp., *Olneya* sp., or *Prosopis* sp.)	*Prosopis* (Mesquite)	*Acacia-Prosopis* (Acacia or Mesquite)	Unidentified
Pueblo Grande, AZ U:9:1 (ASM)								
300	610	0	0	0	20	0	0	0
301	617	0	0	0	5	0	0	0
301	626	0	0	0	17	0	0	0
302	636	4	0	2	11	0	0	0
302	711	0	0	0	3	0	0	0
304	670	0	19	0	0	0	0	0
306	675	0	0	0	0	0	0	0
307	663	0	0	0	20	0	0	0
307	690	1	0	0	19	0	0	0
307	693	0	0	0	0	0	1	0
307.01	736	0	0	0	1	0	0	0
309	773	0	2	0	18	0	0	0
309	784	0	0	0	1	0	0	0
311	740	0	0	0	0	0	1	0
311	742	0	0	0	0	0	20	0
312	829	0	0	0	5	0	0	0
313	895	0	0	3	7	0	0	0
313.01	897	0	0	10	0	0	0	0
314	893	0	2	0	0	0	0	0
314	1202	0	0	0	1	0	0	0
314.01	1201	0	0	4	0	0	0	0
316	890	0	0	0	10	0	0	0
316	891	0	0	0	8	0	0	0
316.01	899	0	0	0	2	0	0	0
318	1207	0	0	0	20	0	0	0
326	1206	0	0	0	20	0	0	0
326	1343	0	0	0	1	0	0	0
329	1229	0	0	0	1	0	0	0
329	1258	0	0	0	15	0	0	0
329	1259	0	2	0	8	0	0	1
329	1265	0	0	0	0	0	20	0
329	1291	0	0	0	1	0	0	0
329.01	1257	0	4	0	1	0	0	0
333	1355	0	0	0	0	1	0	0
334	896	0	0	0	14	0	0	0
AZ U:9:28 (ASM)								
3	1032	0	0	0	0	0	0	20
57	1178	0	0	0	1	0	0	0

Amaranthus sp., Pigweed, Amaranthaceae

Pigweed grows throughout Arizona at elevations from 1,000 ft to 8,000 ft (Kearney and Peebles 1973:265-267). They typically flower in the summer after seasonal rains promote conditions favorable for growth, and they ripen in late summer to early fall. Rea (1997:200) noted that Palmer amaranth was the favored potherb, or *quelite*, among the Gileños (Gila Pima or Pima Indians of the Gila River), and the ripe seeds were consumed. Moerman (1998:65) noted that the ripe seeds were typically ground into a meal and combined with other ingredients or cooked whole in stews.

Chenopodium sp., Goosefoot, Chenopodiaceae

Goosefoot seeds were observed in two flotation samples. Goosefoot commonly occurs at elevations from 2,500 ft through 9,000 ft, and it flowers from June through September (Kearney and Peebles 1973:253). Until recently, the seeds were commonly consumed by southwestern Native Americans, and the greens were used as a potherb (Minnis 1991:240; Moerman 1998:154-157; Rea 1997:202-203). Rea (1997:202-203) suggested that goosefoot use has recently dropped off among Gileños because goosefoot's availability falls between the more productive pigweed and saltbush harvests. Goosefoot is nutritionally advantageous; the consumption of modest amounts of pigweed greens in a basal maize-bean diet can dramatically improve the total quality of the diet (Food and Agricultural Organization of the United Nations 1992:131). The inclusion of goosefoot in preparations involving the common bean (*Phaseolus* sp.) may also extend the shelf life of cooked food (Logan et al. 2004).

Cheno-ams, Undifferentiated Goosefoot or Pigweed

A portion of a small lenticular seed resembling goosefoot or pigweed was observed in one sample, but it could not be identified with precision. For potential uses, see the discussions of *Amaranthus* sp. (pigweed) and *Chenopodium* sp. (goosefoot).

Descurainia sp., Tansy Mustard, Cruciferae

Tansy mustard flowers in the spring from March through April (Kearney and Peebles 1973; Parker 1990:146-147). Ethnographically documented uses of the plant are numerous (Moerman 1998:197-198), with the seeds used as a flavoring agent, and the greens as a potherb. It was observed in four flotation samples.

Echinocereus/Mammillaria sp., Hedgehog Cactus, Cactaceae

Hedgehog or pincushion cactus seeds were observed in one flotation sample. Hedgehog and pincushion cacti are common at elevations from 1,000 ft to 6,000 ft in Arizona, with hedgehog growing better at the higher end of the range. Ethnographic overviews indicate the fruit was consumed fresh, or dried and stored for subsequent consumption, and the seeds were parched and ground into meal (Castetter and Underhill 1935; Moerman 1998:206-207, 335). The fruit is small, and because cacti generally grow in dispersed clusters, considerable effort was probably required to harvest large quantities.

cf. *Gossypium* sp., (resembles) Cotton, Malvaceae

One domesticated cotton seed fragment was observed in the assemblage. Wild and domesticated forms were available in the prehistoric southwest. Wild cotton (*Gossypium thurberi*) grows throughout southern Arizona, at elevations from 2,500 ft through 5,000 ft (Kearney and Peebles 1973:553); domesticated cotton (*G. hirsutum*) is the form grown by native Pimans in commercial cotton enterprises (Rea 1997:308-310). Traditional uses include fiber manufacture from the bolls and the use of the seeds as food (Rea 1997:309).

Gramineae, Grass Family

One unidentified wild grass seed was observed in one flotation sample. It was not identifiable to genus.

Prosopis sp., Mesquite, Leguminosae

Mesquite seeds were observed in four flotation samples. Mesquite is common in areas with high water tables and along streams at elevations up to 6,000 ft in Arizona (Kearney and Peebles 1973). In prehistoric Arizona, it was an ideal supplemental food for agricultural subsistence, because moisture stress that could reduce crop yields actually stimulates mesquite pod production (Felker et al. 1981:91-92). The effect is to offset, to some degree, crop yield reductions caused by inadequate or sporadic precipitation. The most commonly documented ethnographic or ethnohistorical use was to make a flour from the mesocarp (Doelle 1976; Gasser 1982:226-228), although the seeds were also consumed at times (Minnis 1991:240).

Sphaeralcea sp., Globemallow, Malvaceae

There are 17 species of mallow in Arizona, and these grow at elevations from 2,000 ft to 6,000 ft (Kearney and Peebles 1973:540-547). Globemallow seeds were used by some Navajo as an emergency food to avoid famine (Moerman 1998:539-540), and the leaves and roots were used medicinally. Rea (1997:154) noted that mallows may have been used by Gileños to treat digestive ailments, using a preparation made from the roots.

Zea mays, Maize, Gramineae

Maize (*Zea mays*) cupule fragments were observed in six flotation samples. Maize is the well-known cultigen that originated in Mexico, and was transmitted to southern Arizona by 2,200 B.C. (Diehl 2005). For its first 2,700 years of use in Arizona, it was not the primary food resource. Rather, it was one among many wild and cultivated resources that were used in a pattern of mixed foraging and horticulture (Diehl and Waters 2006). As yields from improved varieties increased, maize edged out most wild plant taxa in importance. By the eighth century A.D., flour-kernelled hybrids were introduced to the Southwest (Adams 1994; Galinat 1988; Upham et al. 1987, 1988). The observed cupule fragments are by-products from the consumption of maize as food, although the dried cobs may also have been burned as fuel.

Acacia-Prosopis sp., Acacia or Mesquite, Leguminosae

Many wood charcoal specimens in the assemblage were too small, or were sufficiently distorted (carmelized in some cases, badly cracked in others), to permit identification to species. They were, however, distinct enough to narrow the range of possibilities to acacia (*Acacia* sp.) or mesquite (*Mesquite* sp.). Regarding their suitability as a source of heat, there is little practical difference between them, despite the fact that mesquite is generally otherwise preferred because the smoke is more pleasant. Either could have been used for pithouse construction or for tool handles.

Atriplex sp., Saltbush, Chenopodiaceae

Saltbush wood charcoal was observed in two flotation samples. Saltbush is a common woody shrub at elevations below 6,000 ft throughout Arizona (Kearney and Peebles 1973). Its growth habit, a many-branched shrub with thin, brittle branches, makes it an ideal source of kindling. There are a variety of documented uses of the wood throughout Arizona, from arrow poison (derived from diseased shrubs) to dye. If the leaves, which would not be expected to preserve well in archaeological deposits, were also used, a variety of medicinal uses were possible (Moerman 1998:115-117).

Desert Tree Legume

Wood charcoal fragments from unidentifiable desert tree legumes were, numerically, the overwhelming majority of charcoal fragments in the assemblage. These fragments were generally too small to permit observation of sufficient cross section anatomical detail to resolve identification to genus or species. In some cases, they were badly distorted, usually carmelized or cracked. These could be any of acacia (*Acacia* sp.), ironwood (*Olneya* sp.), mesquite (*Prosopis* sp.), or paloverde (*Cercidium* sp.).

Fouquieria sp., Ocotillo, Fouquieriaceae

Ocotillo wood charcoal was observed in five flotation samples. Ocotillo grows in southern Arizona at elevations below 5,000 feet (Kearney and Peebles 1973), in both the Arizona Uplands and the Lower Colorado River subdivisions of the Sonoran Desertscrub biotic province (Turner and Brown 1994). Ethnographically documented local uses include fuel, architectural construction, and to make fences to protect garden plots from rodents (Moerman 1998:234).

Phragmites sp., Common Reed, Gramineae

Charred common reed stem fragments were observed in four flotation samples. Common reed grows around the world in floodplain contexts that are frequently or constantly saturated (Kearney and Peebles 1973:89). The prehistoric uses of this plant are legion, including the manufacture of arrow foreshafts, basketry, pipe stems, prayer sticks (among the Navajo), reed cigarettes, and roof matting, to name a few (Moerman 1998:394-395). When dried, it was also undoubtedly useful as kindling.

Prosopis sp., Mesquite, Leguminosae

Mesquite wood may be the most common wood in prehistoric flotation samples in southern Arizona, and a record documenting its frequent use extends back through the San Pedro phase (1,200-800 B.C.). It was regularly used in pithouse construction. Mesquite pitch and slender branches have been used as a binder and to make arrows, respectively (Moerman 1998:436-439). It, along with other desert tree legumes of the Sonoran Desert, including also acacia, ironwood, and paloverde, is an outstanding fuel because it is hard, heavy, and resinous. High specific gravities (a measure of density) are a characteristic of good fuel woods. *Prosopis juliflora*, a common plant throughout southern Arizona, has a high specific gravity (0.7 or higher), and it is among the most useful and most prolific fuel woods in the region (National Academy of Sciences 1980:152-153).

CHARRED PLANT REMAINS AND SUBSISTENCE ON THE MARGINS OF PUEBLO GRANDE, AZ U:9:1 (ASM)

In this study, the ubiquity index is used as a measure of the abundance of food plant taxa. The ubiquity index (see Minnis 1981; Popper 1988) is a number that ranges from zero to one, given by the formula $U_{taxon} = n_{taxon}/N_{total}$, where: U_{taxon} is the ubiquity of an individual plant, such as maize (U_{maize}), n_{taxon} is the number of samples in which that taxon was present, and N_{total} is the total number of samples in the temporal component (2 Colonial, 4 Sedentary, 9 Sedentary-Classic, and 9 Classic) that contained at least one charred seed of any kind. The ubiquities of seed and food-related tissues in PHX Sky Train flotation samples are listed, by temporal component, in Table 15.5. No charred seeds, maize cupules, or agave tissues were observed in the canal sample.

Hohokam research has established, in unaccountably numerous sources, a focus on irrigation agriculture as early as the Colonial period, roughly the 8th century A.D. and beyond, if not earlier. To the extent that Hohokam farmers are direct lineal descendants, in general, of antecedent prehistoric Early Agricultural period farmers, one could argue that, by the Hohokam Colonial period, irrigation-based farming had been established for thousands of years.

General Summary

Noting that the greatest ubiquities are in maize (U = 0.33), agave (U = 0.33-0.44), and agricultural weeds, such as goosefoot and pigweed, farming and harvesting locally available floodplain weeds (whose yields were undoubtedly increased by irrigation) and agave were clearly the preeminent subsistence activities at the margin of Pueblo Grande.

Despite the well-established fact of Hohokam use of maize, beans, and squash among the Phoenix Basin and Tucson Basin Hohokam (Gasser 1982), the two earliest components of the PHX Sky Train macrobotanical assemblage contained no charred maize or other cultigens. The only food tissue recovered from the late Gila Butte-Santa Cruz phase samples (A.D. 750-950) was pigweed (see Table 15.5). Subsequent Sedentary period early Sacaton phase (A.D. 950-1100) occupations also lacked maize, although the range of plants used broadened to two agriculturally commensal weeds, goosefoot and tansy mustard, and agave.

The more heavily sampled late Sacaton-early Soho phase (A.D. 1100-1300) occupations yielded a broader range of seeds and edible tissues. Cotton and maize were present in modest amounts. Agave and hedgehog cactus, goosefoot and pigweed, tansy mustard, mesquite seeds (evidence of use of the pods), and a wild grass were also observed. All of these resources were almost certainly available within 1 km of irrigated fields. Finally, the Classic period Soho phase component yielded maize, agave, hedgehog, and one agricultural weed (tansy mustard), as well as mesquite and globemallow. No goosefoot or pigweed was observed in the Classic period samples.

Taxa Ubiquities and Implications for Seasonality and Feature Uses

The kinds of plants identified in the PHX Sky Train macrobotanical assemblage are consistent with a late spring to early fall resource set. The most important food plants observed, based on their ubiquities, were agricultural plants (principally maize), mesquite pods, agave, and high-density weeds that thrived on the margins of irrigated fields (goosefoot, pigweed, and tansy mustard). The ubiquities of agricultural plants were, by comparison with samples from the nearby Dutch Canal Ruin, AZ T:12:62 (ASM) (Diehl 2003), much lower in the PHX Sky Train assemblages, and the range of identified seed and food plant taxa was much narrower in this area peripheral to the village of Pueblo Grande. To the extent that the Dutch Canal Ruin assemblages may be said to represent the remnants of people who, for most loci at that site, were seasonal residents, the Pueblo Grande assemblage seems more consistent with the remnants left by seasonal use of fieldhouses as short-term summer residences. Details supporting these findings are discussed below.

Table 15.5. Ubiquities of agave tissue, seeds, and maize cupules in flotation samples from habitation contexts, Pueblo Grande, AZ U:9:1 (ASM), PHX Sky Train project.

	Colonial	Sedentary	Sedentary-Classic	Classic
	Late Gila Butte-Santa Cruz	Early Sacaton	Late Sacaton-Early Soho	Soho
Number of Samples	2	4	9	9
Cotton	0	0	0.11	0
Maize	0	0	0.33	0.33
Agave	0	0.25	0.33	0.44
Hedgehog cactus	0	0	0.11	0.22
Pigweed	1.00	0	0.22	0
Goosefoot-pigweed	0	0	0.11	0
Goosefoot	0	0.25	0	0
Tansy mustard	0	0.25	0.11	0.22
Mesquite	0	0	0.22	0.33
Globemallow	0	0	0	0.22
Grass family	0	0	0.11	0
Number of taxa	1	3	8[a]	6

[a]Eight or nine taxa, depending on whether the goosefoot-pigweed were just pigweed (eight taxa), or if some of them were goosefoot (nine taxa).

Most of the PHX Sky Train macrobotanical data represent late Sedentary-early Classic and Classic period components, with nine productive samples from each. Three food plant types consistently occurred in roughly one-third to two-fifths of the samples (see Table 15.5). Maize and agave are common in both the late Sacaton-early Soho (U_{maize} = 0.33, U_{agave} = 0.33), and Soho phase components (U_{maize} = 0.33, U_{agave} = 0.44). Mesquite was almost as ubiquitous during both phases ($U_{mesquite}$ = 0.22-0.33). Agriculturally commensal weeds, including goosefoot, pigweed, goosefoot-pigweed, and tansy mustard occurred inconsistently, with the greater variety ($U_{goosefoot\text{-}pigweed}$ = 0.11, $U_{pigweed}$ = 0.22, $U_{tansy\ mustard}$ = 0.11) observed during the late Sacaton-early Soho phase. Of the agricultural weeds, only tansy mustard ($U_{tansy\ mustard}$ = 0.22) occurred in the Soho phase samples. Hedgehog cactus was also observed in both the late Sacaton-early Soho phase ($U_{hedgehog\ cactus}$ = 0.11) and Soho phase ($U_{hedgehog\ cactus}$ = 0.22) components. Finally, cotton (U_{cotton} = 0.11) was observed in the earlier of those two components.

Most of the observed resources were consistently available—ripe, ready for harvesting, and available for consumption or storage during the summer or early fall. Maize, cotton, goosefoot, pigweed, and goosefoot-pigweed, were dependent on irrigation or monsoon rains to promote germination and growth. These would have been first available in late August or early September, depending on timing of the earliest summer storms.

The earliest occurring resources were globemallow and tansy mustard. These could have been present in the late spring, concomitant with the time of canal and field preparation for growing maize, cotton, or beans and squash, assuming the latter were probably used. Globemallow and tansy mustard may have sprouted in March or April, if sufficient precipitation occurred in February, to yield ripe seeds from May through June. However, delayed or inadequate winter rains would have retarded mallow and tansy germination until the onset of summer monsoon rains or until the first irrigation episodes.

Mesquite phenology is somewhat more variable. When winter rains are heavy, mesquites in Tucson have been observed to yield two crops of pods. The first becomes available in late May, if winter rains have been above average, and the second occurs in August, after summer monsoon storms replenish soil moisture and groundwater. The timing and availability of mesquite pods also seems to differ with distance to subsurface water and the size of catchments. Gradual bajada slopes south of Tucson are replete with mesquite, but only one harvest occurs per year. Mesquites that are located along major drainages, however, may tap reliable sources of groundwater, and may yield two crops of pods per year. In either event, mesquite was a late-spring or mid-summer resource that was available before maize, beans, squash, or cotton ripened. Its timing was, if farmers were running low on the previous year's stored foods, quite fortuitous.

The PHX Sky Train assemblage may be compared to the assemblage from the nearby Dutch Canal Ruin (Diehl 2003; Henderson, ed. 2003), a Colonial and Sedentary period Hohokam site with analyzed macrobotanical assemblages that span the interval from A.D. 750-1450 (Henderson 2003b:145). Dutch Canal Ruin was interpreted as a seasonal farming settlement, based on the relatively low recovery rates for decorated ceramics at that site (Henderson 2003a:260-262, 2003b:146), the low frequency and variety of flaked stone (Sliva 2003), and the narrow range of macrobotanical tissues observed in each Dutch Canal Ruin component (Diehl 2003).

The Pueblo Grande assemblage was quite similar to the Dutch Canal Ruin assemblage (Table 15.6). The concordance of three independent lines of evidence at Dutch Canal Ruin supported the recognition of seasonally occupied fieldhouses at that site. The concordance of the paleobotanical evidence from Dutch Canal Ruin and Pueblo Grande therefore supports the recognition of seasonally occupied fieldhouses at the western margin of Pueblo Grande (beyond the foregoing recognition of the limited range of taxa and the implied late spring through summer resource use pattern).

WOOD CHARCOAL USE ON THE MARGINS OF PUEBLO GRANDE, AZ U:9:1 (ASM)

Wood charcoal from the PHX Sky Train loci indicates an intensive use of locally available woods, principally hardwood tree legumes. No upland taxa, such as juniper, pine, or oak, occurred in the assemblage. The woods represent a mixed range of activities that probably include both burned architectural debris and fuel wood remnants. All the wood charcoals were available within 1 km of the loci. Because woods, even deadwood, remains freestanding and intact for a considerable amount of time, wood charcoals do not provide, in this instance, any information relevant to the assessment of seasonality or the nature of occupation within the PHX Sky Train project area. There was no significant temporal variation in wood use. These findings are generally similar to the results of the wood charcoal analysis from the Dutch Canal Ruin (Diehl 2003), except that larger wood charcoal fragments were recovered from that site, and most of the wood from there was identified as mesquite. Details supporting the foregoing findings are discussed below.

Twenty-nine flotation samples and eight macrobotanical specimens from the PHX Sky Train project yielded wood charcoal fragments, for a total of 356 pieces of charcoal. Of those, 21 were of an unidentified diffuse to semi-diffuse porous dicot that did not resemble any of the other identified taxa. The most common observed wood type was indeterminate desert tree legume (DTL), that is, acacia, ironwood, mesquite, or paloverde. These specimens were too small or too fragmentary to be assigned to one of those genera, but were consistent with any of them and not with other taxa. DTL accounted for 64 percent of the wood charcoal observed (*n* = 230 fragments). The secondmost abundant taxon was acacia-mesquite, which accounted for 12 percent of the assemblage (*n* = 42 fragments). These were larger fragments of desert tree legume, with sufficient cross section surface area to rule out ironwood or paloverde, but not to distinguish between acacia and mesquite, which are quite similar in appearance at low magnification.

Low density woods commonly used for non-load bearing roof and wall construction were represented by ocotillo (8 percent; *n* = 29 fragments) and common reed (5 percent). The remainder of the assemblage was comprised of the unknown semi-diffuse porous wood (*n* = 21 fragments) and trace amounts of agave floral stalk tissue (*n* = 9 fragments), and saltbush (*n* = 5 fragments), and mesquite (*n* = 1 fragment).

Overall, the assemblage is wholly dominated by dense, hard woods of the acacia, ironwood, mesquite, or paloverde type. As noted in the taxonomic review, these types of woods have high specific gravities, and they are sufficiently resinous to burn well. They are legion in Hohokam sites, and regularly occur both as intact remnants of vertical or horizontal construction elements within houses, as well as dispersed charcoal in hearths, roasting pits, and burned house fill. All were available in the immediate vicinity of Pueblo Grande.

There was little noteworthy temporal variation in wood use (Table 15.7). In most periods, DTL dominated, followed by acacia-mesquite. Soft, porous types, such as ocotillo or reeds, comprised most of the rest of the assemblage. An empirically trivial exception was provided by the Gila Butte-Santa Cruz phase component, which was represented only by a single fragment of agave floral stalk. A more problematic exception is provided by the samples from canal Feature 3. Twenty of 21 charcoal fragments were of the unidentified, semi-diffuse porous wood charcoal. It is not one of the identified taxa, and thus, must represent some other Sonoran Desert tree or woody shrub. As it is represented by only two samples, however, the dominance of the unknown taxon may be an empirical result of the limited number of samples from the canal.

CONCLUSIONS

The PHX Sky Train macrobotanical assemblage and the plant remains recovered from habitation features associated with nearby canals are consistent with four findings. First, all of the identified seed and wood charcoal taxa were from resources that were available within 1 km of the site. Second, the food

Table 15.6. A comparison of Sedentary and Classic period macrobotanical assemblages at the Dutch Canal Ruin, AZ T:12:62 (ASM), and habitation contexts at the margin of Pueblo Grande, AZ U:9:1 (ASM).

	Sedentary			Sedentary-Classic	Classic	
	Early Sacaton	Early Sacaton	Late Sacaton	Late Sacaton-Early Soho	Soho	Soho
Site	Dutch Canal	Pueblo Grande	Dutch Canal	Pueblo Grande	Dutch Canal	Pueblo Grande
Number of samples	11	4	3	9	4	9
Cotton	0	0	0	0.11	0	0
Maize	0.64	0	0.33	0.33	0.25	0.33
Agave	0.09	0.25	0	0.33	0.50	0.44
Hedgehog cactus	0	0	0	0.11	0	0.22
Prickley pear cactus	0.09	0	0	0	0	0
Saguaro cactus	0	0	0.33	0	0	0
Pigweed	0	0	0.33	0.22	0	0
Goosefoot-pigweed	0.18	0	0	0.11	0	0
Goosefoot	0	0.25	0	0	0	0
Peppergrass	0.09	0	0	0	0	0
Tansy mustard	0	0.25	0	0.11	0	0.22
Mesquite	0	0	0	0.22	0.25	0.33
Dock	0	0	0	0	0.25	0
False Purslane	0.09	0	0	0	0	0
Globemallow	0	0	0	0	0	0.22
Purslane	0.09	0	0	0	0	0
Sunflower family	0.09	0	0	0	0	0
Grass Family	0.09	0	0	0.11	0	0
Number of taxa	9	3	3	8	4	6

Note: Additional taxa = prickly pear cactus (*Opuntia* sp.), saguaro cactus (*Carnegiea gigantea*), peppergrass (*Lepidium* sp., similar and related to tansy mustard), dock (*Rumex* sp.), false purslane (*Trianthema* sp.), purslane (*Portulaca* sp.), and sunflower family (Compositae, cf. tribe Helianthae).

Table 15.7. Proportional frequencies of wood charcoal types from PHX Sky Train habitation and canal contexts, by temporal component.

Phase	No. of Fragments	Percent of No. of Fragments for This Phase							
		Agave	Saltbush	Ocotillo	Common Reed	Tree Legume	Acacia-Mesquite	Mesquite	Unidentified
Habitation contexts									
Gila Butte-Santa Cruz	1	1.00	0	0	0	0	0	0	0
Early Sacaton	54	0.04	0	0.04	0.31	0.61	0	0	0
Late Sacaton-Early Soho	165	0	0.03	0.13	0.01	0.70	0.13	0	0
Soho	115	0.05	0	0.05	0	0.70	0.17	0.01	0.01
Canal									
Indeterminate Classic	21	0	0	0	0	0	0.05	0	0.95

plant remains indicated a primary emphasis on agriculture, because maize and field weeds comprised the most ubiquitous and common plants in the assemblage, followed closely by cotton, agave (which may have been cultivated, as indicated by Gasser and Kwiatkowski [1991]), and mesquite pods. Third, the food plant remains are consistent with a seasonal, and possibly intermittent, occupation of the PHX Sky Train habitation structures from late spring through late summer or early autumn. Fourth, and finally, these findings, taken together, suggest the structures and their associated features were fieldhouses or farmhouses that saw a narrower range of activities, briefer occupations, or more intermittent occupations, than were observed in fieldhouses associated with another nearby site, the Dutch Canal Ruin.

PETROGRAPHIC ANALYSIS OF CERAMIC SAMPLES FROM THE PHX SKY TRAIN PROJECT

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In this study, 36 pottery samples collected during PHX Sky Train project excavations were examined through thin section petrography. The samples were from habitation features located on the western margin of Pueblo Grande, AZ U:9:1 (ASM). The sherds were initially characterized through binocular microscopy to classify the temper and its geologic source. If possible, a petrofacies was suggested for the origin of the sand temper, based on the Gila and Phoenix Basin petrofacies model developed by Miksa et al. (2004). Petrographic analysis was conducted to verify these assignments. This included both qualitative descriptions and point counting of the sand grains. The point-count data were examined in a discriminant model with sand data to predict the petrofacies from which the sand derived. Final assignments for the samples incorporated all the available data: binocular, petrographic, and geological. The resulting provenance information provided insight into the production and exchange of ceramics in the Phoenix Basin during the Hohokam sequence.

GEOLOGIC SETTING

The Phoenix Basin is characterized by numerous mountain ranges separated by sediment-filled basins. To the north are the Phoenix and McDowell mountains, and to the east are the Goldfield and Superstition mountains. South are the Santan and Sacaton mountains, with the Picacho Mountains farther south; the South and Sierra Estrella mountains are to the west (Chronic 1983:69-73). Two rivers, the Gila River and the Salt River, flow through the basin and join near the Sierra Estrella Mountains. Other water sources include the Agua Fria River to the northwest, Cave Creek to the north, the Verde River to the northeast, and Queen Creek to the east. The Santa Cruz River joins the Gila River south of the Phoenix metropolis.

Most of the mountains are composed of Archaean metasedimentary and metavolcanic rocks, along with Archaean and Proterozoic granitoid and metamorphic rocks. Both units contain schists, and the former also features phyllites. Cretaceous and Tertiary granites, often pink in color, appear in the Santan and Sacaton mountains, and to some extent, in the Picacho Mountains. Tertiary white granites and granodiorites are found primarily in the South and Picacho mountains. Volcanic rocks of Tertiary age are found in several ranges, including the Goldfield, Superstition, and Santan mountains. Finally, Tertiary sedimentary rocks crop out in the Goldfield and surrounding mountains (Miksa et al. 2004). The erosion of these various ranges has resulted in areas with unique sand compositions. These zones are called petrofacies, and they have been mapped through extensive petrographic analysis of collected sands.

The PHX Sky Train project area is located along the Salt River on a piedmont, which extends from Papago Buttes to the northeast. This area is within the Camelback Buttes (I) Petrofacies (Miksa et al. 2004) (Figure 16.1). Sands in this petrofacies are characterized by granite-derived quartz and feldspar grains and fragments of granite and quartz-feldspathic gneiss. Volcanic rock fragments are rare. Across the Salt River is the South Mountain (Q) Petrofacies, comprised predominantly of quartz and feldspars resulting from the breakdown of plagioclase-rich granite and hornblende-rich granodiorite. A range of metamorphic rock fragments, schist, phyllite, gneiss, and amphibolites are also present, along with a trace amount of various volcanic rock fragments. Local sand resources would have derived predominantly from the Camelback Buttes Petrofacies, although a very small part of the South Mountain Petrofacies could also have potentially provided raw materials for pottery production.

BINOCULAR ANALYSIS

Examination of the sherd collection from the PHX Sky Train project revealed a range of temper types and materials. The type of temper (TT) was given one of several designations, for example, sand, sand plus grog (crushed sherd), schist/gneiss (lithic meta-

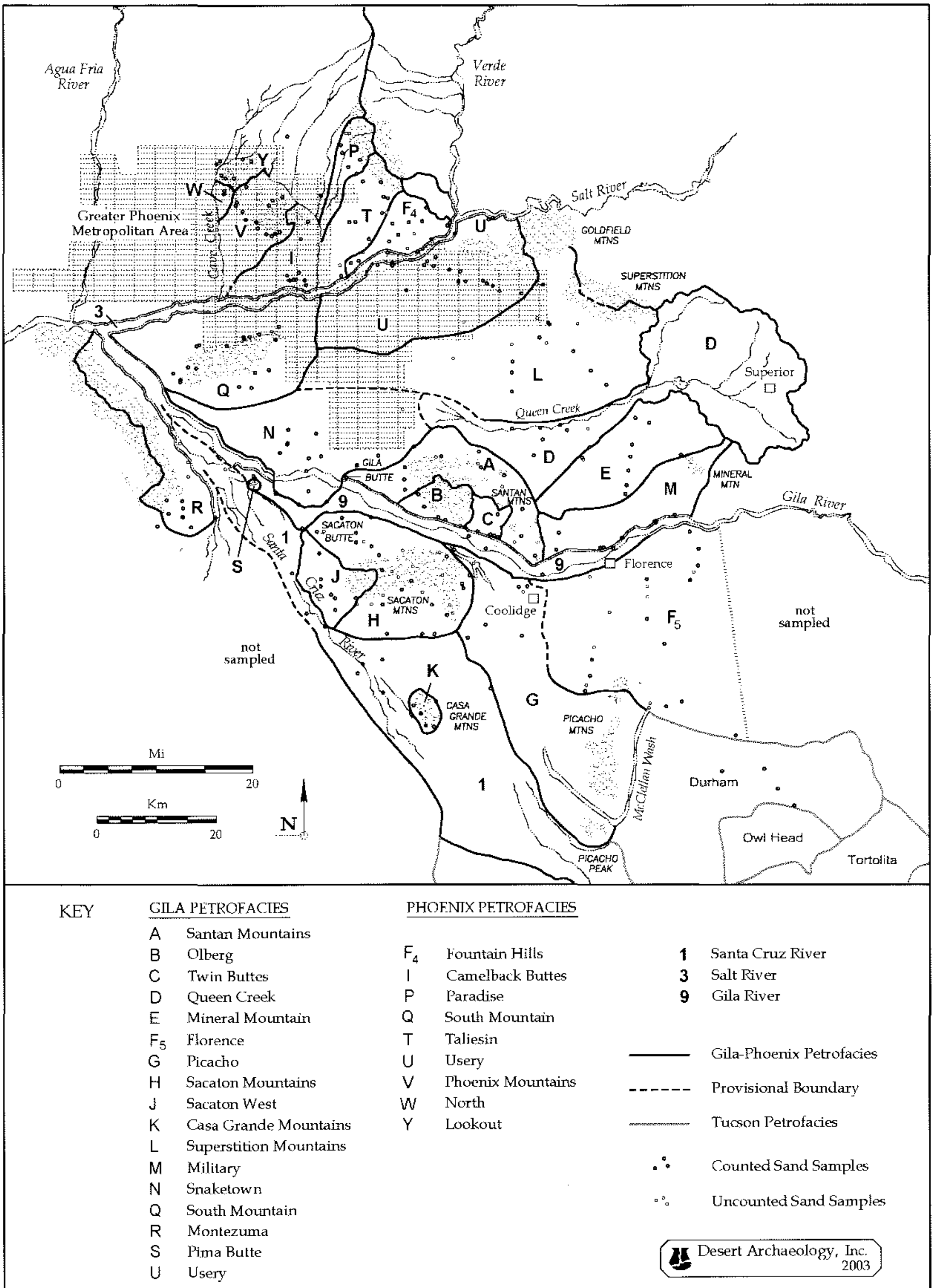

Figure 16.1. Phoenix and Gila Basin petrofacies map.

morphic tectonic [LMT]) fragments, and so forth. The sand was subsequently assigned to a petrofacies, or several petrofacies, called a temper generic source (TSG). Occasionally, a specific petrofacies could not be determined. In these cases, the geologic characteristics of the sand grains were noted, such as granitic sand or quartz and feldspar grains with granite and/or gneiss. This information provided a more narrow range of petrofacies for the origin of the sand temper. Both the TT and TSG assignments were used to guide the selection of samples for petrographic analysis.

Of the 24 plain ware and 12 red ware submitted for analysis (Table 16.1), 24 were tempered with sand (67 percent), 4 with sand and grog (11 percent), 2 with grog, schist, and sand (6 percent), 3 with small amounts of LMT and sand (8 percent), and 3 with moderate LMT and sand (8 percent). A specific petrofacies, South Mountain, was assigned to the sand temper in eight of the sherds (22 percent). South Mountain or Montezuma (R) petrofacies sand was thought to be present in four sherds (11 percent). Sand from either the Camelback or Phoenix Mountains (V) petrofacies was identified in 11 of the samples (31 percent). The temper in two sherds was given a general assignment of "Granitic, white" (petrofacies H, J, Q, or R) (6 percent), while for a single sample, the temper was characterized generally as "Granitic" (petrofacies A, C, H, or S) (3 percent). Finally, three categories designated temper that contained granite or its derived minerals, but was not clearly from a known petrofacies. Three sherds had granite and/or gneiss temper similar to the Camelback Buttes Petrofacies sand (-9A) (8 percent), three contained a granite-derived monomineralic sand (-9B) (8 percent), and four had monomineralic sand similar to the South Mountain Petrofacies sand (-9C) (11 percent). Petrographic analysis aimed to confirm these assignments and to provide a petrofacies designation for those samples with sand derived from an indeterminate source.

PETROGRAPHIC ANALYSIS

Examination of thin sections of the 36 sherd samples submitted for analysis comprised both a qualitative and quantitative approach. Each section was prepared in the typical fashion, which included feldspar staining and a cover slip. Lavayén conducted the analysis and recorded attributes of the sand temper, including sorting, grain size and shape, and descriptions of the textures and mineralogy of the rock fragments. The sections were also point counted to acquire quantitative data on the frequency of different inclusion types. The Gazzi-Dickinson method was utilized (Lombard 1987; Miksa and Heidke 2001). This procedure involves point counting the monocrystalline mineral grains and the grains in coarse-grained rocks as the mineral phase to which they belong, while fine-grained rocks are classified according to their fabric, internal texture, and mineral composition.

This method works to reduce the effects of sand maturity, so that minerals in coarse-grained rocks are counted in a similar manner whether they are still a part of the rock or have separated out due to the distance the grains have travelled from the source. This is particularly important when comparing sand-tempered sherds and sand collected recently, because the exact location along a wash where the potter collected the sand is unknown. During point counting, a petrofacies assignment was given to the sand component of the temper.

The sand temper point-count data were compared with similar data acquired from sands collected in the Phoenix Basin (Miksa 1995a, 1995b; Miksa et al. 2004). During petrographic analysis of the ceramic thin sections, the presence of pink granite, granodiorite, and phyllite indicated most of the sand appeared similar to that found in the Phoenix area (see Phoenix Petrofacies, Figure 16.1). Therefore, the discriminant model to assess the petrofacies assignments of the sand temper utilized only the Phoenix area sands (see Table F.1 for parameter definitions and Table F.2a-c for data). Discriminant analysis is used to classify the sherd samples (input for evaluation as unweighted "unknowns" by the model), using point-count data from sand samples to create a known set of sand compositions for comparison. The discriminant analysis output, especially the Mahalanobis distance from the group centroid and the posterior probability of group membership, can be used to evaluate the strength of the discriminant model classification for each sherd sample (Klecka 1980).

To establish a Phoenix petrofacies only discriminant model, the sand samples were initially run by themselves, with several parameters selected, based on known lithic and mineralogical differences between the various petrofacies (Table 16.2) (Miksa et al. 2004). Definitions for these parameters are provided in Table F.1. Because the sands had been point counted by a different petrographer than the person counting the sherds, the metamorphic parameters were combined. This is because an examination by Lavayén of the sand samples highlighted that the classification of these fragments was different between the two petrographers. To ensure the model ran successful with the sand temper point-count data, the metamorphic categories were collapsed into a single parameter (Lm). However, this affects

Table 16.1. List of samples submitted for petrographic analysis, the PHX Sky Train project.

Sample Number	Feature Number	Field Number	Observation	Ceramic Type	Vessel Shape	Temper Type	Temper Source Generic[a]
COP10-0025	329	1267	21	Plain, sand group	Jar	Sand	Q
COP10-0026	0	1321	11	Plain, sand group	Jar	Sand	Q
COP10-0027	0	1321	18	Plain, sand group	Bowl	Sand	Q
COP10-0028	0	1321	17	Plain, sand group	Jar	Sand	Q
COP10-0029	329	1281	10	Plain, sand group	Jar	Sand	Q
COP10-0030	318	873	1	Plain, sand group	Bowl	Sand	Q
COP10-0031	329	1234	4	Red, sand group	Bowl	Sand	Q
COP10-0032	329	1267	6	Red, sand group	Bowl	Sand	Q
COP10-0033	329	1281	11	Red, sand group	Jar	Sand	Q or R
COP10-0034	329	1225	4	Red, sand group	Bowl	Sand	Q or R
COP10-0035	329	1250	2	Red, crushed sherd group	Bowl	Sand	Q or R
COP10-0036	329	1267	7	Red, sand group	Bowl	Sand	Q or R
COP10-0037	304	666	1	Plain, crushed sherd group	Jar	Sand with low LMT[b]	V or I
COP10-0038	307	676	4	Plain, crushed sherd group	Jar	Grog and sand	V or I
COP10-0039	318	873	3	Plain, sand group	Jar	Sand	V or I
COP10-0040	303	802	2	Plain, sand group	Jar	Sand	V or I
COP10-0041	329	1250	1	Plain, schist/gneiss group	Jar	Sand with low LMT	V or I
COP10-0042	329	1267	14	Plain, crushed sherd group	Jar	Sand	V or I
COP10-0043	329	1267	15	Plain, crushed sherd group	Jar	Grog, schist, and sand	V or I
COP10-0044	329	1267	20	Plain, crushed sherd group	Jar	Sand with low LMT	V or I
COP10-0045	332	1315	1	Plain, schist/gneiss group	Bowl	LMT and sand	V or I
COP10-0046	0	1321	1	Plain, schist/gneiss group	Jar	LMT and sand	V or I
COP10-0047	307	656	3	Plain, crushed sherd group	Jar	LMT and sand	V or I
COP10-0048	329	1267	10	Red, sand group	Bowl	Sand	-9A (I?)
COP10-0049	329	1267	25	Plain, sand group	Jar	Sand	-9A (I?)
COP10-0050	329	1281	8	Plain, sand group	Jar	Sand	-9A (I?)
COP10-0051	0	647	2	Plain, sand group	Jar	Sand	-9B
COP10-0052	0	748	6	Plain, sand group	Jar	Sand	-9B
COP10-0053	303	802	3	Plain, sand group	Jar	Sand	-9B
COP10-0054	303	802	4	Plain, sand group	Jar	Sand	-9C (Q?)

Table 16.1. Continued.

Sample Number	Feature Number	Field Number	Observation	Ceramic Type	Vessel Shape	Temper Type	Temper Source Generic[a]
COP10-0055	0	1321	20	Red, crushed sherd group	Bowl	Grog and sand	Granitic, white (H, J, Q or R)
COP10-0056	333	1347	6	Red, sand group	Bowl	Sand	Granitic, white (H, J, Q or R)
COP10-0057	0	1321	2	Plain, sand group	Jar	Grog, schist, and sand	Granitic (A, H, C or S)
COP10-0058	318	877	1	Red, sand group	Jar	Sand	-9C (Q?)
COP10-0059	329	1267	13	Red, crushed sherd group	Jar	Grog and sand	-9C (Q?)
COP10-0060	329	1281	3	Red, crushed sherd group	Jar	Grog and sand	-9C (Q?)

[a]A = Santan Mountains; C = Twin Buttes; H = Sacaton Mountains; I = Camelback; J = Sacaton West; Q = South Mountain; R = Montezuma; S = Pima Butte; V = Phoenix Mountain.

[b]LMT = quartz-feldspar-mica tectonite (schists or gneisses).

Table 16.2. Point-count parameters and calculated parameters used for each discriminant analysis model, PHX Sky Train project. (Parameter definitions are provided in Table F.1.)

Parameters	K	Kspar	Micr	Tplag	TMusc	Tbiot	Tchlor	Mica	Pyr	Hmin	Lm	Lv	Lscaco
Generic discriminant analysis: all petrofacies	–	X	X	X	X	X	X	–	X	–	X	X	–
Lithic discriminant analysis (F4, P, V, Y) [a]	X	–	–	X	–	–	–	X	X	X	X	X	–
Mineralic discriminant analysis (I, Q, R, T, U, W) [a]	–	X	X	X	–	–	–	X	X	X	X	X	X

[a]F4 = Fountain Hills; I = Camelback Buttes; P = Paradise; Q = South Mountain; R = Montezuma; T = Taliesin; U = Usery; V = Phoenix Mountains; W = North; Y = Lookout.

the ability of the discriminant model to distinguish among petrofacies characterized by different types of metamorphic rocks.

The initial discriminant model was designed to separate the lithic-rich petrofacies (F4, P, V, Y) from the mineral-rich petrofacies (I, Q, R, T, U, W). The lithic-rich petrofacies were then analyzed in their own discriminant model to separate them; a similar model was run for the mineral-rich petrofacies. The overall success rate of these models in assigning sands to their correct petrofacies was 87 percent (Table 16.3). This suggests the sands are distinct in composition and the chosen parameters correctly encapsulate this variability. This sand discriminant model was utilized to assess the petrofacies assignments of the sand temper in the PHX Sky Train sherd samples.

RESULTS

The final temper classification for the sherds is based on the totality of the evidence: binocular analysis and visual inspection of the sherd and its temper, petrographic analysis, point-count data, comparison of qualitative aspects of a sample to sands in the petrofacies to which it has been assigned, and the results of statistical analyses. To be characterized as belonging to a petrofacies, the sherd must have not only the same proportion of a grain type as the sands from its assigned petrofacies, but similar grain size, type, and morphology as well. All the information is used to establish the final designation for a sample. For the analyzed sherd samples, the point-count data are provided in Table F.3a-c, with the parameter definitions in Table F.1. The qualitative information recorded during the petrographic analysis is given in Table F.4a-b, with the codes provided in Table F.5.

The characterization of eight sherds during the binocular analysis as containing sand from the South Mountain Petrofacies was confirmed during the petrographic analysis and by the discriminant model results (Table 16.4). This is their final designation. A group of four sherds was thought to contain either South Mountain or Montezuma petrofacies sand. The petrographic analysis of these samples suggested they were tempered with South Mountain Petrofacies sand; this was supported by results from the discriminant model. Two samples containing sand temper that was classified as "Granitic, white" (petrofacies H, J, Q, or R) were also shown to have sand from the South Mountain Petrofacies. Sample COP10-0055 also had inclusions of grog, some of which had a similar sand temper and some of which had a more micaceous temper. This micaceous component probably led the discriminant model to assign the sample to the Camelback Petrofacies.

Three samples categorized as having a monomineralic sand similar to the South Mountain Petrofacies sand (-9C) were determined to have sand from this petrofacies; however, the fourth sample with this designation had sand from the Camelback Buttes Petrofacies (see below). The discriminant model predicted two of the -9C samples to the Camelback Buttes Petrofacies. This is probably due to the metamorphic rock fragments being grouped together for statistical analysis; therefore, although the gneiss found in both petrofacies was not separated by the model, it is petrographically distinct. Two of these samples, COP10-0059 and COP10-0060, also had grog temper with a variety of inclusions in their paste.

Overall, the sherds with South Mountain Petrofacies sand fall into two groups, those with a more granodiorite sand composition (COP10-0026 to -0028, COP10-0030, COP10-0032 to -0036) and those with a more gneissic sand composition (COP10-0025, COP10-0029, COP10-0031, COP10-0055 to -0056, COP10-0058 to -0060). Geologically, this indicates two sources for the sand, with the granodiorite sand (South Mountain Granodiorite) deriving from the eastern half of South Mountain, possibly across from Pueblo Grande, and the gneissic sand (Estrella Gneiss) from the western half of South Mountain at some distance from the site.

Table 16.3. Cross-tabulation of Phoenix area discriminant analysis results, PHX Sky Train project.

		Lithic				Mineralic					Total in Petrofacies	Percent Correct
		F	P	V	Y	I	Q	T	U	W		
Lithic	F	**6**	0	0	0	–	1	1	–	–	8	75.0
	P	0	**5**	0	0	–	–	–	–	–	5	100.0
	V	0	0	**15**	0	–	–	–	–	–	15	100.0
	Y	1	0	0	**5**	–	–	–	–	–	6	83.0
Mineralic	I	–	1	–	–	**6**	1	0	1	0	9	67.0
	Q	–	–	–	–	0	**15**	0	1	0	16	94.0
	T	–	–	–	–	0	0	**9**	1	0	10	90.0
	U	2	–	–	–	1	0	0	**9**	0	12	75.0
	W	–	–	–	–	0	0	0	0	**3**	3	100.0
											73	Total correct
											84	Total samples
Total assigned to petrofacies		9	6	15	5	7	17	10	12	3	87	Percent correct

Note: Rows represent the a priori petrofacies membership assigned by petrographers. Columns represent group membership calculated by the discriminant functions. Samples inside of the matrix for each generic model, but not on the diagonal, are errors at the specific level. Samples on the diagonal are correctly classified. Samples outside the matrix formed by each generic group of petrofacies are errors at the generic level.

Table 16.4. Sample inventory, binocular temper characterizations, petrographic assignments, discriminant analysis results, and final temper determination for analyzed samples, PHX Sky Train project.

Sample Number	Ware	Temper Type	Temper Source Generic[a]	Petrofacies Assigned by Petrographer	Petrofacies Assigned by Discriminant Model	Final Petrofacies Assignment
COP10-0025	Plain	Sand	Q	Q	Q	Q
COP10-0026	Plain	Sand	Q	Q	Q	Q
COP10-0027	Plain	Sand	Q	Q	Q	Q
COP10-0028	Plain	Sand	Q	Q	Q	Q
COP10-0029	Plain	Sand	Q	Q	Q	Q
COP10-0030	Plain	Sand	Q	Q	Q	Q
COP10-0031	Red	Sand	Q	Q	Q	Q
COP10-0032	Red	Sand	Q	Q	Q	Q
COP10-0033	Red	Sand	Q or R	Q?	Q	Q
COP10-0034	Red	Sand	Q or R	Q	Q	Q
COP10-0035	Red	Sand	Q or R	Q	Q	Q
COP10-0036	Red	Sand	Q or R	Q	Q	Q
COP10-0037	Plain	Sand with low LMT[b]	V or I	I	I	I
COP10-0038	Plain	Grog and sand	V or I	R	U	I
COP10-0039	Plain	Sand	V or I	Unknown	U	I
COP10-0040	Plain	Sand	V or I	Q	U	I
COP10-0041	Plain	Sand with low LMT	V or I	Unknown	I	I
COP10-0042	Plain	Sand	V or I	Unknown	I	I
COP10-0043	Plain	Grog, schist, and sand	V or I	Unknown	V	I
COP10-0044	Plain	Sand with low LMT	V or I	I	I	I
COP10-0045	Plain	LMT and sand	V or I	I	I	I
COP10-0046	Plain	LMT and sand	V or I	Unknown	I	I
COP10-0047	Plain	LMT and sand	V or I	V	W	V
COP10-0048	Red	Sand	-9A (I?)	R?	U	I

Table 16.4. Continued.

Sample Number	Ware	Temper Type	Temper Source Generic[a]	Petrofacies Assigned by Petrographer	Petrofacies Assigned by Discriminant Model	Final Petrofacies Assignment
COP10-0049	Plain	Sand	-9A (I?)	Unknown	U	I
COP10-0050	Plain	Sand	-9A (I?)	Unknown	U	I
COP10-0051	Plain	Sand	-9B	Unknown	U	I
COP10-0052	Plain	Sand	-9B	I?	U	I
COP10-0053	Plain	Sand	-9B	I?	U	I
COP10-0054	Plain	Sand	-9C (Q?)	Unknown	U	I
COP10-0055	Red	Grog and sand	Granitic, white (H, J, Q or R)	Q	I	Q
COP10-0056	Red	Sand	Granitic, white (H, J, Q or R)	Q	Q	Q
COP10-0057	Plain	Grog, schist, and sand	Granitic (A, H, C or S)	T?	Q	Granitic
COP10-0058	Red	Sand	-9C (Q?)	Q	I	Q
COP10-0059	Red	Grog and sand	-9C (Q?)	Q	I	Q
COP10-0060	Red	Grog and sand	-9C (Q?)	Unknown	Q	Q

[a]A = Santan Mountains; C = Twin Buttes; H = Sacaton Mountains; I = Camelback Buttes; J = Sacaton West; Q = South Mountain; R = Montezuma; S = Pima Butte; T = Taliesin; U = Usery; V = Phoenix Mountain; W = North.
[b]LMT = quartz-feldspar-mica tectonite (schists or gneisses).

The 11 sherds characterized as containing sand from either the Camelback Buttes or Phoenix Mountains petrofacies were given various petrofacies assignments during the analysis (see Table 16.4). This was due, in part, to the variability seen in the temper, and the presence of schist and grog with a range of tempers. Seven of these samples contained sand with fragments of gneiss, some altering granite, and variable amounts of schist (COP10-0037, COP10-0041 to -0046). The appearance of the gneiss and presence of altering granite suggest this sand derives from the Camelback Buttes Petrofacies, a designation supported by the discriminant model. The schist is rounded and appears natural to the sand, indicating that for some of the sherds, the sand probably originated closer to the Squaw Peak schist outcrops in the Phoenix Mountains or adjacent to the Camels Head Formation, which contains various schistose rocks.

COP10-0043, which was tempered with a small amount of fine-grained sand, included more metamorphic grains than granite inclusions, particularly in the grog, and was thus assigned by the discriminant model to the Phoenix Mountains Petrofacies. The sand in this sample and in COP10-0042 is so fine-grained that it may derive from a point near the Salt River. COP10-0041 actually contains less gneiss and more granite fragments, but the amount of schist suggests a source in the Camelback Buttes Petrofacies, but probably near the Phoenix Mountains Petrofacies. The high quantity of schist in COP10-0047 suggested the sand did, in fact, derive from the Phoenix Mountains Petrofacies, although the discriminant model assigned it to the North (W) Petrofacies, which contains more phyllite. The collapsed metamorphic parameter utilized during the discriminant analysis affected this outcome, but petrographically, the sand was clearly from the Phoenix Mountains Petrofacies.

Three samples with the Camelback Buttes or Phoenix Mountains petrofacies designation contained an altering granite temper with few metamorphic fragments (COP10-0038 to -0040). The characteristics of the temper suggest its origin is closer to Papago Buttes, a granitic outcrop. This dominant granitic signature and lack of gneiss led the discriminant model to assign these samples to the Usery (U) Petrofacies, which is characterized by granite-derived monomineralic sand. However, an examination of the granite fragments from Usery Petrofacies sand samples revealed different textures and characteristics than the sand in the sherds. Granite grains in the Camelback Buttes Petrofacies were closer in texture and types of feldspar to the granite fragments in the sand temper. This was verified by examination of four sediment samples from water catchment Feature 7, also excavated during the current project (Chapter 4 and Appendix C; this volume). This Camelback Buttes Petrofacies sand was also utilized for tempering sherds that had been characterized during the binocular analysis as granite and/or gneiss temper similar to the Camelback Buttes Petrofacies sand (-9A) and a granite-derived monomineralic sand (-9B), along with a single sherd categorized as -9C.

Sample COP10-0057 was unique, as the sand temper was composed of unaltered granite fragments and lacked metamorphic grains. Although similar in appearance to the Camelback Petrofacies granite, it was difficult to be certain of its attribution. This is largely due to the prevalence of granite throughout the Phoenix Basin. As granite is present in sand from several petrofacies, assigning an entirely granite-tempered sherd to a specific source is challenging. The sand probably derives from near the granite outcrops in the Phoenix Mountains, or possibly to those in the Usery or McDowell mountains.

DISCUSSION

The results of the petrographic analysis suggest plain and red ware sherds recovered during the PHX Sky Train project were produced with sand from several sources, even within areas defined by the petrofacies model. Sherds with South Mountain Petrofacies sand were divided into two subgroups, those with gneiss-rich sand from the Estrella Gneiss outcrops in the western half of the petrofacies, and those with granodiorite-rich sand from the eastern half of the South Mountains. Similarly, those sherds tempered with Camelback Buttes Petrofacies sand exhibited a range from altered granite-dominated to those with a higher percentage of metamorphic rock fragments. This suggests several sand resources were utilized within a confined area.

The addition of grog temper was seen for both plain and red ware sherds, and was often present when the amount of sand was low. Surprisingly, the grog could exhibit temper similar to or different from the sherd, suggesting a range of pottery was utilized as grog. While the schist inclusions were natural to the sand, this does not preclude the intentional selection of a sand rich in schist grains for pottery production. In fact, such schist-rich sands were only utilized for the production of plain ware vessels. This information highlights the technological choices made by the potters.

A thorough examination of ethnographic literature has established that most potters will travel 3 km or less to collect sand temper (Heidke 2011:Table 4.10). Based on this, pottery tempered with sand resources found within 3 km of Pueblo Grande are considered "local" productions. The site is located within the Camelback Buttes Petrofacies, and a 3-km radius around the site is still within this petrofacies (Figure 16.2). Pottery tempered with sand compositions found outside of this area are considered "nonlocal" vessels. Therefore, 47 percent (17 of 36 samples) of the analyzed pottery from the PHX Sky Train project was likely locally produced (Table 16.5). Two samples, one granite-dominated and the other schist-rich could potentially have also been made at the site. The other half of the samples, also 47 percent (17 of 36 samples), were manufactured with sand outside the 3-km zone, and are probably non-local, especially those with a gneissic sand temper. The most interesting result is that the South Mountain Petrofacies sources were used primarily for red ware pottery, with the exception of six plain ware sherds. This division, however, does not relate to whether a granodiorite-rich or gneiss-rich sand was used, as both were seen in the plain and red wares. Sand from the Camelback Buttes Petrofacies was utilized exclusively for plain ware pottery, probably locally produced at Pueblo Grande. This may suggest that plain ware pottery was made at the site, while red ware pottery was brought to the site through exchange from manufacturing locations across the Salt River.

Another petrographic study of pottery from Pueblo Grande supports these results (Schaller 1994). Twenty-seven percent (31 of 113) of the plain ware samples contained local Camelback granite or Camelback granite plus Squaw Peak schist (Table 16.6). This latter temper is undoubtedly similar to that seen in samples in the current study with increased amounts of schist, and is suggested to derive from near the border of the Camelback Buttes and Phoenix Mountains petrofacies. However, 26 percent (29 of 113) were tempered with Squaw Peak schist only, often appearing to derive from streambeds near the outcrops (Schaller 1994:83). Other samples, 36 percent (41 of 113), also featured metamorphic rock temper, such as micaceous schist and phyllite. A small number of samples, 11 percent (12 of 113), were tempered with South Mountain granodiorite and Estrella gneiss, a common temper for sherds found at the sites of Villa Buena, AZ T:12:9 (ASM), and Los Cremaciones, AZ T:12:220 (ASM), in the South Mountain Petrofacies (Schaller 1994:86). The 10 analyzed red ware samples contained micaceous schist. A few of the examined sherds had grog temper. These results confirm the utilization of local sand resources at Pueblo Grande, in addition to the presence of pottery with materials from areas to the north and south.

The petrographic analysis of 15 plain ware samples from Dutch Canal Ruin, AZ T:12:62 (ASM), west of Pueblo Grande, revealed a majority (73 percent, 11 of 15 samples) were produced with sand from the South Mountain Petrofacies (Miksa et al. 2004). Like Pueblo Grande, Dutch Canal Ruin is located within the Camelback Buttes Petrofacies on the northern side of the Salt River across from the South Mountain Petrofacies (Figure 16.3). Surprisingly, none of the analyzed samples contained sand from the Camelback Buttes Petrofacies. This absence may reflect shifting patterns in pottery exchange or

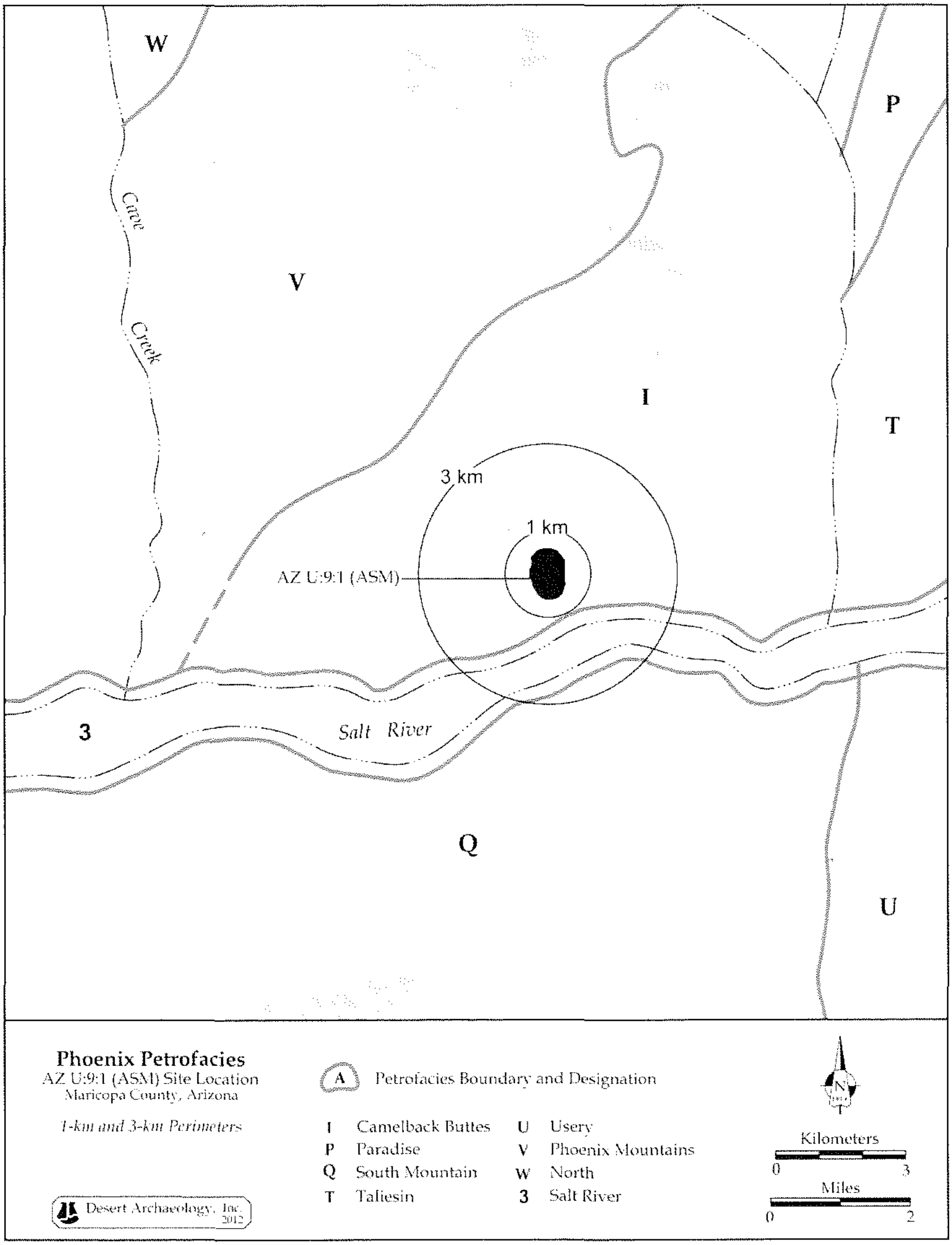

Figure 16.2. Location of Pueblo Grande, AZ U:9:1 (ASM), with circles of 1- and 3-km radii.

Table 16.5. Provenance of analyzed sherds by ware, showing accuracy of temper groups investigated, PHX Sky Train project.

Petrofacies	Thin Sections Interpreted Accuracy	Sherds Analyzed Petrographically by Ware		
		Plain Ware	Red Ware	Total
South Mountain				
Sand/Q	8/8 (100%)	6	2	8
Sand/Q or R	4/4 (100%)	–	4	4
Sand/Granitic, white	1/1 (100%)	–	1	1
Sand and grog/Granitic, white	1/1 (100%)	–	1	1
Sand/-9C	1/2 (50%)	–	1	1
Sand and grog/-9C	2/2 (100%)	–	2	2
Camelback				
Sand/I or V	3/3 (100%)	3	–	3
Sand and grog/I or V	1/1 (100%)	1	–	1
Grog, schist, and sand/I or V	1/1 (100%)	1	–	1
Low LMT/I or V	3/3 (100%)	3	–	3
Moderate LMT/ I or V	2/3 (67%)	2	–	2
Sand/-9A	3/3 (100%)	3	–	3
Sand/-9B	3/3 (100%)	3	–	3
Sand/-9C	1/2 (50%)	1	–	1
Phoenix Mountains				
Moderate LMT/I or V	1/3 (33%)	1	–	1
Granitic				
Grog, schist, and sand/Granitic	1/1 (100%)	1	–	1
Total		25	11	36

Table 16.6. Previously reported petrographic data from plain and red ware sherds from sites along the Salt River.

Temper	Site/Ware					
	Pueblo Grande Plain[a]	Pueblo Grande Red	Dutch Canal Ruin Plain	Beeline Hwy Plain	Pueblo Blanco Plain	Pueblo Blanco Red
South Mountain Petrofacies		–	11	–	4?[c]	3?[c]
South Mountain granodiorite[b]	4					
Estrella gneiss[b]	8					
Camelback Buttes Petrofacies		–	–	–	–	–
Camelback granite[b]	18					
Squaw Peak schist + Camelback granite[b]	13					
Phoenix Mountains Petrofacies		–	–	–	–	–
Squaw Peak schist[b]	29					
Fountain Hills Petrofacies	–	–	–	–	2	3
Taliesin Petrofacies	–	–	2	21	7	4
Paradise Petrofacies	–	–	–	18	13	1
McDowell Mountain phyllite/schist	–	–	–	12	–	–
Granitic or granite-gneiss	–	–	2	–	4	–
Micaceous schist	10	10	–	4	–	–
Phyllite	31	–	–	–	–	–
Total	113	10	15	55	30	11

[a]Those with a "?" in Schaller (1994) were excluded.
[b]Designations used by Schaller (1994).
[c]Assignment to South Mountain was not definitive.

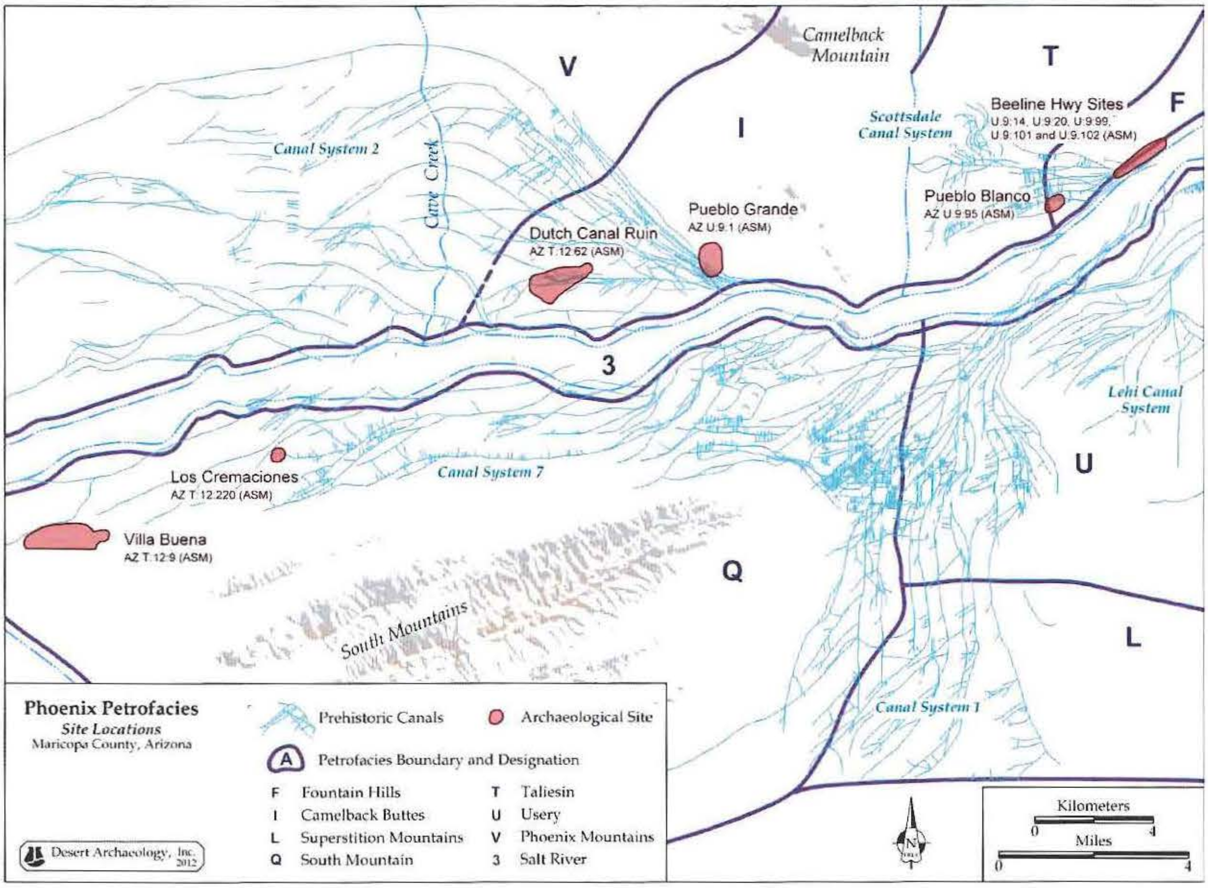

Figure 16.3. Map showing sites with petrographic analysis of plain and red wares.

acquisition across time, because Dutch Canal Ruin contexts date largely to the Colonial or early Sedentary period (see Henderson 2003b), while those from Pueblo Grande, including the current project, are dated to the later Sedentary-Classic period transition or to the Classic period (Chapter 9, this volume). Alternately, the contrast may reflect functional differences among the sites, as Dutch Canal is thought to have been a seasonally occupied agricultural site, while Pueblo Grande was a sizable permanently settled village.

Petrographic analysis of plain and red ware pottery from Pueblo Blanco, AZ U:9:95 (ASM), located northeast of Pueblo Grande within the Scottsdale Canal System, provides additional information about pottery production and exchange in this area (Miksa 1995b). Pueblo Blanco lies inside the Fountain Hills Petrofacies on the northern side of the Salt River. The results showed pottery found at Pueblo Blanco was manufactured with sand from several petrofacies, Fountain Hills (F4), Paradise (P), Taliesin (T), and probably South Mountain. The unassigned granitic sand temper may have derived from near the Usery (U) Mountains across the river and is possibly local. Of note was the use of grog for producing some of the red ware samples. The discovery of pottery deriving from a broad range of production locations at a single site gives some idea of the extent of exchange in this area.

Finally, farther east of Pueblo Grande, several sites—AZ U:9:14 (ASM), AZ U:9:20 (ASM), AZ U:9:99 (ASM), AZ U:9:101 (ASM), and AZ U:9:102 (ASM)—along the Beeline Highway had recovered ceramics that were examined petrographically (Miksa 1995a). Most of the sites are within the Paradise, Taliesin, or the Usery petrofacies. The results revealed that plain ware found at these sites was produced with sand from the Taliesin and Paradise petrofacies. Additionally, sherds contained schist and phyllite from the McDowell Mountains, material likely derived from the same petrofacies. Some of the plain and red ware samples also featured grog temper. These results provide additional evidence for the presence of production locations in the Taliesin and Paradise petrofacies.

CONCLUSION

The petrographic analysis of ceramic samples from the western margins of Pueblo Grande supported the binocular designations for most samples and clarified the provenance for those whose specific sand source was indeterminate. This was accomplished through both qualitative and quantitative analyses, including utilization of a discriminant model based on sands collected in the Phoenix Basin. A model with only these sands was established to assess the petrofacies assignments of the analyzed sherds. The results showed that much of the red ware pottery from the PHX Sky Train project area was produced with sand from across the Salt River in the South Mountain Petrofacies. Conversely, plain ware pottery derived predominantly from locally available sand resources in the Camelback Buttes Petrofacies.

These results support those found during a previous study at Pueblo Grande. Pottery with South Mountain Petrofacies sand was also found at Dutch Canal Ruin and possibly Pueblo Blanco, but not at sites farther east. These sites featured pottery with Paradise and Taliesin sand temper, which was seen at Pueblo Blanco, but rarely at Pueblo Grande or Dutch Canal Ruin. Similarly, pottery with Camelback Buttes Petrofacies sand, identified at Pueblo Grande, was not found at the other sites along the Salt River. The combined results from these petrographic studies reveal a network of pottery production locations and the exchange of pottery within intraregional spheres.

RESEARCH SUMMARY AND CONCLUSION

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Desert Archaeology, Inc.

Desert Archaeology, Inc.'s, data recovery investigations for the PHX Sky Train project were designed to provide new insight and understanding about Hohokam irrigation and land use at the western margin of Pueblo Grande, AZ U:9:1 (ASM). The study was structured around two research topics that could potentially be addressed by data recovered by the project. The primary topic, "History and Development of Prehistoric Irrigation in the Salt River Valley," derived from the expectation that archaeological resources within the PHX Sky Train project area would consist primarily of larger Hohokam canals that, together with others located farther south, form the backbone of Canal System 2, the largest prehistoric irrigation system on the northern side of the lower Salt River. While it was thought unlikely that residential features associated with the primary village of Pueblo Grande would be uncovered, there remained potential for encountering agriculturally focused features, such as fieldhouses, processing pits, and the like, within the irrigated lands west of Pueblo Grande. In recognition of this potential, the secondary research topic, "Prehistoric Land Use and Subsistence Practices in the Salt River Valley," was proposed to guide the study of non-irrigation features.

As it happened, project excavations uncovered a surprising diversity of features: (1) small, medium, and large canals, some of which distributed water locally, while others carried water to more distant points; (2) agricultural fields and the systems of ditches that irrigated them; and, (3) several small habitation areas belonging to the local farmers of the area. The discovery of a few other rarer features, such as water catchments and reservoirs and a canal-side basin that seems to have served multiple purposes, further illustrated that people used the watercourses and local terrain in a variety of ways despite the intrusion of several large Canal System 2 canals through the area. Collectively, these findings blur the distinctions between the two proposed research topics. Within the project area, land use, subsistence practices, and irrigation are inextricably intertwined. Prehistoric irrigation did not just run through the project area, it was being used throughout the area. Additional details about these uses are provided as the research results of the PHX Sky Train project are summarized here.

ABOUT THE LARGEST PHX SKY TRAIN CANALS

Research questions posed under the topic of prehistoric irrigation were, ironically, narrowly focused on furthering current understanding of the operation, capacity, age, and longevity of discovered canals. These aspects of the PHX Sky Train canals were addressed mainly through geoarchaeological analysis (Chapter 3, this volume). This analysis combined geomorphology, stratigraphy, sedimentology, and chronometry to provide insights into canal construction, use history, and flow capacity of the represented Canal System 2 canals. Canal dimensions were used to estimate former water velocity, discharge, and irrigation capacity of the larger canals, which, in turn, were used to correlate the three largest PHX Sky Train canals, Features 3, 200, and 201, to downstream canal segments within Canal System 2. These aspects are discussed at length in Chapter 3; here, the more salient results of that analysis are touched upon.

Feature 3 was the northernmost of canals found in the PHX Sky Train project area, extending roughly 300 m across Blocks 3, 5, and 7 (see Figure 3.5). The canal is a continuation of the alignment identified as Canal 2 of AZ U:9:28 (ASM) by the 1970s Hohokam Expressway project (Masse 1976). Within the project area, Feature 3, on average, measured 4.2 m in width and 1.8 m in depth, with a truncated cross-sectional area of 5.0 m^2. Although excavated into relatively coarse piedmont sediments, Feature 3 exhibited fine-textured alluvial channel fill. The lower half of the channel contained alternating thin beds of silt and silty clay that conformed to the parabolic channel shape, indicating active but slow streamflow within the alignment. The upper half contained postabandonment fill consisting of relatively uniform clay loam. Although occasional dredging presumably occurred, no discontinuities were observed in the channel fill to suggest any major alterations during the use of this canal. Stratigraphic and chronometric evidence indicate Feature 3 is Classic period in age, with initial construction occurring in the interval between A.D. 1150-1200, and final operation at the Soho-Civano phase transition, circa A.D. 1250-1300.

Feature 201 was the southernmost of the fully exposed canals in the PHX Sky Train project area. A short segment of this canal passed through the far southwestern corner of Block 4 (see Figure 3.5), roughly 8 m south of Feature 200. Size, location, and stratigraphy suggest Feature 201 is a downstream segment of Hohokam Expressway project Canal 10 of AZ U:9:2 (ASM). Within the project area, this large canal had been excavated through Lehi Terrace sediment; its truncated parabolic channel measured 3.8 m in width and 1.5 m in depth, with a cross-sectional area of 3.8 m^2. While this large area indicates Feature 201 had the potential to support relatively rapid streamflow, the channel deposits were fine textured, mostly bedded silt and clay, indicating slow streamflow. Thin silt lenses in the middle and lower channel conformed to the parabolic shape of the channel, indicating through-flowing water within the alignment. A thick máss of angular clayey sediments on the northern wall of the channel, interpreted as clean-out deposits, imply a major dredging episode that resulted in overall reduction of the original channel size. Although no chronometric information is available, data from other projects (Howard 1991b; Masse 1976) suggest Feature 201 is Sedentary period (A.D. 950-1150) in age.

Feature 200, the largest PHX Sky Train canal, also passed through the far southwestern corner of Block 4 and had been excavated into Lehi Terrace sediment, 8 m upslope of Feature 201. The canal is a downstream segment of the "North Canal" at Park of Four Waters (Woodbury 1960), also identified as Canal 11 of U:9:2, Hohokam Expressway project (Masse 1976). In its single exposure within the PHX Sky Train project area, Feature 200 measured 7.4 m in width and 2.5 m in depth, with a truncated cross-sectional area of 12.3 m^2. The deep and broad channel was filled with relatively uniform fine sandy deposits. Although active use sediments, consisting of stratified fine sands and sandy silt, could be distinguished in the lower third of the channel, the upper two-thirds was filled with a massive deposit of uniform loamy fine to medium sand. The uniformity of these sediments and their lateral extension beyond the upper edges of the channel indicate a single depositional event, interpreted as the result of uncontrolled Salt River flooding. The canal was not cleaned out after this filling, indicating the flood event terminated the use of the canal. The Park of Four Waters North Canal is widely recognized as Classic period (A.D. 1150-1450) in origin (Howard 1991b; Masse 1976; Woodbury 1960). Optical luminescence (OSL) dating of sediment from the lower part of the flood deposit in Feature 200 places its termination in the interval A.D. 1221-1341. However, it seems unlikely that the devastating flood occurred within at least the first hundred years of this interval, given the large populations living along and utilizing the northern reaches of Canal System 2 during this time.

The predominance of fine-textured deposits in Features 3 and 201 suggests the headworks for these canals were located some distance upstream, as most of the sand that would have been introduced into the alignment by the Salt River had fallen out of suspension before reaching the PHX Sky Train area (see Chapter 3). A longer distance to the river is conceivable for Feature 3, given its location at a higher elevation above the river, allowing its alignment to have extended farther upstream before engaging the river. In contrast, the current proximity and lower elevation of Feature 201 relative to the river makes a longer distance to headworks seem unlikely. A case in point is the slightly higher position of Feature 200, just 8 m upslope, which contains the stratified silts and sands typical of large main canals located close to their headworks.

That Feature 201 does not contain the sands seen in Feature 200 implies two possibilities. As suggested in Chapter 3, the paucity of coarse-textured alluvium might reflect a system of weirs and headgate structures upstream of Feature 201 that prevented coarse sand and fine gravel from entering the alignment. The second possibility is that Feature 201 did, in fact, extend farther upstream than is presently possible. However, to achieve proper gradient, this would require the northern bank of the active Salt River channel to have been farther south than known today, or in the Historic era prior to the flood of 1890, or even at the time that Feature 200 was constructed. If the latter is true, abandonment of Feature 201 and construction of the closely proximate Feature 200 could have been related to the same event, that is, a flood at the end of the Sedentary period that resulted in the river channel shifting northward, consequent erosion and removal of the upstream headworks of Feature 201, which, in turn, prompted construction of Feature 200 in its place.

The three large PHX Sky Train canals are segments of main canals located in the upper, higher elevation portion of Canal System 2. All three could be correlated with downstream canal segments previously excavated within Canal System 2. Of these, Feature 200 is the most well-known, being part of the 15-km-long prehistoric Canal Bueno, as named by Midvale (1968), and traceable all the way to Las Colinas, AZ T:12:10 (ASM). Feature 201, which closely parallels Feature 200 to the south, was recognized by Howard (1991b) as a Sedentary period version of Canal Bueno. Feature 3 is linked to an unnamed canal that traversed Grand Canal Ruins, AZ T:12:256 (ASM), north of the modern Grand Canal. The correlations described in Chapter 3 confirm Howard's (1990) curvilinear model of downstream reduction in canal cross-sectional area, in which channel area decreases rapidly downstream of the headworks and then more gradually farther down the alignment. Based on these correlations, there appears to have been no major diversion of water within the upper 8 km of the three linked canals, indicating these were designed to reach farms and settlements located in the middle to terminal portions of Canal System 2, well beyond the PHX Sky Train project area.

The function of the large canals was to supply irrigation and domestic needs of Sedentary and Classic period communities located on the piedmont north of the Salt River. Features 3 and 201 were capable of supporting approximately 700-800 ha of irrigated crops, while Feature 200 had an irrigation potential of about 3,000 ha. Assuming roughly 0.4 ha of irrigated land was required per person to fulfill basic subsistence needs (Woodson 2010b:74), Features 3 and 201 could have supported populations of 1,840-1,880 persons, respectively, while Feature 200 could numerically support a population of approximately 7,570. For comparison, when incorporated in 1881, the population of Phoenix numbered approximately 2,500. Whether or not the prehistoric canals actually supplied the estimated acreage depends, in part, on the availability of river water. Fine alluvial grain sizes in the channels of Features 3 and 201 suggest the last episodes of canal use were characterized by shallow water depths, indicating less than optimal streamflow.

The PHX Sky Train project provided the first clear evidence of a Salt River flood filling several kilometers of a major Hohokam canal, Feature 200, with sediment, leading to its abandonment. The stratigraphic and sediment data obtained from Feature 200 provided insight into what a destructive flood deposit within a large Hohokam canal looks like and how it changes downstream within the canal alignment. OSL dating of the flood sediment places the flood event in the middle to late Classic period. This ability to both recognize and date episodes of uncontrolled flooding in Hohokam canals is essential for testing hypotheses that link destructive flooding to agricultural instability and demographic decline.

LOCAL IRRIGATION AND WATER USES

Beyond the three large Canal System 2 trunk canals, there were smaller PHX Sky Train canals indicating irrigation of more local areas. First among these was Feature 26, a moderately sized canal that traversed the entire project area south of canal Feature 3 (see Figure 3.5). Correlating with Hohokam Expressway project Canal 1 of U:9:28 (Masse 1976) (see Figure 2.9), Feature 26 entered the project area south of the irrigated field systems in Block 6, then ran northwest through Blocks 3 and 1. Near the western edge of Block 1, earlier (Feature 18) and later channels (Feature 17) of Feature 26 branched apart. Also related to Feature 26 was Feature 14, a medium canal traced across the western portion of the PHX Sky Train project area south of Feature 26.

Although Feature 14 could not be tracked eastward south of Madison Street, it must have connected with Feature 26, because no other canal alignments were identified south of Feature 26 in the eastern part of the project area. Additionally, the channel cross-sectional area of Feature 26 is 2.5 m^2 in Block 6, upstream from where it branched into Features 17 and 18, which had channel cross-sectional areas measuring 0.4 m^2 and 0.6 m^2, respectively. This substantial decrease in the Feature 26 cross-sectional area across the span of the project area further supports a branching relationship between Features 26 and 14.

The operational history of this network was suggested by the sediments found in each channel. Channel fill in Feature 26 was characterized by a thin basal layer of coarse sand overlain by dark brown silty clay, indicating relatively low-energy, controlled streamflow. Like Feature 26, Feature 14 was filled with silt and clay, which, in addition to a low sand content, suggested controlled, relatively slow-moving water in this canal. In contrast, the fill of Features 18 and 17 contained considerably more gravel and sand than seen in Feature 26 farther upstream, suggesting not only higher water velocity but also a discontinuity within the canal system. This pattern of variable water velocity suggested Feature 26 delivered water down the Feature 14 alignment in its later use, while Features 17 and 18 represented earlier episodes of use within the Feature 26 system. However, fine-textured deposits in the uppermost part of Feature 17 suggested these might also be coeval with later uses of Feature 26. Regardless of the connectivity of these canals, the earlier use of Feature 26 was characterized by relatively ample streamflow whereas its later use was characterized by limited water depths and reduced water velocity.

Chronometric, stratigraphic, and ceramic evidence suggested initial construction of the Feature 26 network during the middle Sedentary period (circa A.D. 1000-1050), with evident remodeling and continued use during the early Classic period (A.D. 1150-1300). Based on its cross-sectional area, Feature

26 had the potential to support approximately 270 ha of irrigated land when run at half capacity across this span of time. However, combined estimated irrigated acreage for Features 14 and 17, whose operation may have overlapped, comes to only about half that of Feature 26, suggesting the possibility that additional turn-outs or branches were present on the southern side of the distribution canal in portions of the project area unavailable for study.

Whether from Feature 14 or Feature 26, a remnant of such a turn-out is suggested by the small canal, Feature 10, recorded in the northwest corner of Block 4 (see Figure 3.5). The trajectory of all these canals suggests that most associated fields were located west of the PHX Sky Train project area. It is also possible that the area between Feature 26 and Feature 14 and south of Feature 14 were irrigated via overbank wild flooding from the distribution channels. Unfortunately, evidence of this possibility was lacking, perhaps having been removed or obscured by historic agriculture and more recent land-leveling activity.

Even more proximate to the village of Pueblo Grande, and certainly the most significant find of the PHX Sky Train project, were the irrigated fields exposed in the east-central portion of the project area (see Figures 2.6 and 3.5). Nearly all elements of the field systems were represented, including primary laterals, laterals, and ditch sublaterals that directly fed the fields. Seven distinct fields comprised the best-preserved field system (see Figure 5.1), although additional fields were indicated by trace remnants of ditches and ditch segments. OSL dates from various points within the irrigation system, in conjunction with stratigraphic and ceramic evidence, indicates these field systems were constructed and used during the middle to late Sedentary period, A.D. 1000-1150.

Irrigation water was supplied to the fields by water flowing from Features 22 and 23, two small canals that ran directly downslope from an unknown source to the northeast. Both canals contained relatively coarse-textured, stratified sediments, suggesting relatively rapid, episodic, short-lived flows. Periodicity of flow was also indicated by stratified sands and fine gravel in Feature 33, the main lateral branching from canal Feature 23, with additional finer textured sediments, indicating moderation in water velocity as it entered the sublaterals that directly watered the fields. These sublaterals extended along and defined the long axis of each field, with the width defined by the space between sublaterals. The sublaterals generally ran northeast to southwest following the slope of the land. All seven defined field surfaces were contiguous with a very slight gradient, with the highest field surface being the westernmost and the lowest, the eastern field surface. The sequence would have appeared as a set of seven rectangular, shallow terraced fields.

Each field had a dedicated sublateral running the full length of the long side and were likely irrigated by water overflowing from the field side of the lateral and spreading across the field, as suggested by the sets of furrows found in the bottoms of three of the fields. These furrows formed the comb-shaped pattern noted during stripping (see Figure 2.8). The furrows appear to have been designed to distribute water evenly over the field surface.

Soils both above and below recognizable field surfaces had been clearly impacted and altered from their natural condition by agricultural activities both prior to and after the development of the field system. Evidence for prior agricultural activity was seen as traces of possible field laterals below field furrow Feature 44.04 in field Feature 320. Fieldhouses to the northwest, whose occupation preceded use of the field system, also implied the presence of earlier fields. Fragments of later ditches and furrows in the fill above Feature 320 indicated this location continued to be utilized as a field area following burial of the Feature 320 field surface. Further evidence of agricultural activity prior to and following construction and use of Feature 320 was maize pollen in both overlying and underlying sediments.

Soils from the Feature 320 field surface were texturally and organically satisfactory, and neither too sodic nor alkaline, for practicing agriculture (Chapter 5, this volume). Pollen assemblages from the field indicate intensive cultivation, with multiple crops grown, including maize, cotton, squash, cholla, and prickly pear. Field weeds, possibly grown or encouraged for grain or greens, were also abundant.

A different form of water management was illustrated on the eastern side of the project area in the form of the catchment/reservoir, Feature 7. Feature 7 was a very large shallow basin with deep interior pools that contained stratified beds of gravel, sand, silt, and clay indicating multiple pulses of flooding. Along with the thick beds of clay and silt, abundant assemblages of ostracodes and gastropods indicated the basin retained water for sustained periods of time. The project found that Feature 7, which may have originated as a smaller basin or pool, was initially filled by river water delivered by Feature 25, a medium canal correlating with Hohokam Expressway project Canal 4 of U:9:28.

An OSL date from the lowermost channel fill of Feature 25 suggests initial filling and use during the early Sedentary period. The canal was eventually abandoned, and sometime during the early Classic period, Feature 7 was cleaned out, expanded, and modified to collect seasonal runoff through a natural channel rather than canal water. While Feature 7 was supplied, at least in part, through natural processes, it was evident that prehistoric inhabitants also manipulated its capacity to hold water. Such a reserve would prove useful in augmenting the local water supply, especially when nearby canals ran low. The utility of the feature for water storage was further supported by the excavation of an adjacent, replacement catchment basin, Feature 20. Although Feature 7 functioned primarily as a reservoir, its area may also have been used as an informal agricultural field, especially later in its use-life when the basin would have been shallower and the water it collected spread over a larger area.

The curious canal-side basin, Feature 57, suggested additional uses of the watercourses that passed through the PHX Sky Train project area. Positioned at the distal end of the irrigated field system in Block 6, Feature 57 was an odd construction, roughly rectangular in plan and fan-shaped in cross section (see Figure 4.8), that led into Feature 26. A channel-like groove transected the basin along the "vein" of the fan; this groove exhibited two relatively sharp descents, one near the upper limit of the basin and the other where Feature 57 joined Feature 26. The groove was filled with gravelly sand not seen elsewhere in the lower strata of the feature, which, in addition to multiple embedded flat-lying sherds, suggested possible intentional placement of the material at the time of feature construction.

Above the groove, the lowest strata exhibited the same strata sequence seen in the adjacent field system, implying Feature 57 served, at least initially, as a field tail water return. However, when the flow of field sediments into Feature 57 stopped, the basin continued to be used. An as yet unresolved activity resulted in the buildup of a thick, finely laminated deposit of silt. The well-preserved lamina indicated stable conditions within the feature, although the volume of silt generated seems to have been so great that it periodically slumped into canal Feature 26, necessitating intermittent cleaning. This thick silt deposit did not appear to have derived from the adjacent field systems, nor did the silt enter Feature 57 from Feature 26, implying some activity that would result in the generation of silt. Based on various lines of evidence, the basin might have been used as a boat or raft slip, or as a feature for soaking potter's clay, hides, or other products (Chapter 4, this volume). Also evaluated, but largely rejected, was the idea of use of Feature 57 as an artificial wetland for growing mesic plants, or as a canal walk-in or dipping pool (see Chapter 4).

While the functions of Feature 57 remain unresolved, there is little doubt that this basin feature was used for purposes in addition to its irrigation-related function. Further, features like Feature 57 may be more common than presently indicated, but are rarely found due to the methods commonly used to explore canals (see Chapter 4). Similar to the fields, it was the horizontal exposure adjacent to a canal midsection that was essential to its discovery. Future horizontal exposures of canal alignments could yield similar finds and perhaps eventually reveal the function of a feature such as Feature 57.

FARMERS ON THE OUTSKIRTS OF PUEBLO GRANDE

Four habitation areas that included architectural structures and associated extramural features were also encountered in the PHX Sky Train project area. Three of these areas, 3A, 5A, and 6B, were interpreted as fieldhouse loci, based on the lightweight construction of their pithouses, generally limited artifact inventories, and low numbers and low diversity of associated features (Chapter 9, this volume). Artifact types suggested low-intensity activity at these locales, commonly involving basic culinary tasks and expedient tool maintenance and manufacture. Pollen samples from the areas yielded results consistent with use of the structures as fieldhouses. All were pre-Classic in age (A.D. 800-1150), varying from the middle Colonial in Area 3A, to the early and later Sedentary periods in Areas 6B and 5A, respectively. Occupation of Area 5A seems to have coincided with the operation of the Block 6 fields, suggesting this was the locale of the farmers who constructed, irrigated, and cultivated the fields.

The occurrence of the fieldhouse loci was not unexpected, as research elsewhere has demonstrated a proliferation of seasonal fieldhouses throughout the agricultural lands of Canal System 2 during the pre-Classic. An important question, however, is why these temporary dwellings were present at all, given that the PHX Sky Train project area is less than a half-mile from the Pueblo Grande village proper. Without the modern streetscape, an individual could have walked from the village to the PHX Sky Train fields in 20-30 minutes. The distance would seem to obviate the need for a temporary shelter.

A solution is offered in a recent comprehensive study of Hohokam fieldhouses on the northern side of the Salt River (Henderson and Clark 2004). Two important patterns were documented. First, pairs of pithouses, one large and one smaller and less formal, were repeatedly observed in fieldhouse settings. The morphology and content of the larger houses suggested their use as temporary habitations, while those of the smaller pithouses implied ancillary roles. A storage pit was found near the pair of structures in several cases, suggesting this was also a component of the fieldhouse complex. The construction of several facilities in one place suggested advanced planning in the establishment of the farm site, and given that labor was invested in even a modest infrastructure, Henderson and Clark (2004) inferred that the sites were intended to be used, albeit on temporary occasions, for some appreciable time.

Second, as seen at Area 5A, there were cases indicating sequential use of fieldhouses in the same area. Coupled with the evidence suggesting labor investment in the farm site, the cases implied not only continuity in their use, but also continuity of users. Drawing on analogous patterns of pithouse replacements within courtyard groups at Hohokam villages, widely viewed as a sign of multigenerational households who held rights to the land upon which they resided (Craig 2004; Henderson 1987, 2001; Wallace 1995; Wilcox et al. 1981), Henderson and Clark (2004) concluded that the evidence for fieldhouse continuity in users indicated individual household ownership of the fieldhouse or farm site and associated land.

Thus, the fieldhouse becomes a tangible symbol of a village household's claim to specific tracts of irrigated land. The houses have value and purpose beyond their use as temporary dwellings to be used during the agricultural season. The PHX Sky Train fieldhouse areas presumably represent the farms of households residing at Pueblo Grande, although this cannot be directly demonstrated.

The fourth habitation area, Area 3B, was markedly different from its fieldhouse counterparts. The substantial adobe-walled structure, variety of extramural features, and abundant artifact assemblage suggested a permanently inhabited, albeit short-lived residential locus. The size of the adobe structure further implied occupation by a single large household. Based on these characteristics, along with its location in what can be characterized as an agricultural site west of the Pueblo Grande settlement, the area was interpreted as a farmstead. Although agriculture was undoubtedly a focus of activity for the residents of Area 3B, the types and forms of recovered artifacts indicated time was also spent in a variety of other tasks, some to meet routine domestic needs, such as food preparation, tool maintenance and manufacture, and hunting, and others to supplement the household economy, including crafting shell ornaments, fiber processing and spinning, and pottery manufacture. The adobe architectural style and attributes of the ceramic assemblage indicated a short-lived occupation toward the end of the early Classic period, circa A.D. 1250-1300.

With Area 3B so near to Pueblo Grande, one is naturally led to consider how these farmers might have interacted with the neighboring villagers. In many ways, the material remains suggest the farmstead's household would have been largely sufficient, although surplus produce and hand-made crafts were probably traded for items they could not produce themselves. Noteworthy in this regard are the results of pottery sourcing, which indicate Area 3B residents obtained pottery vessels from the same sources, and in similar proportions, as those found at Pueblo Grande. The results imply regular interaction with the villagers and their trading partners.

Another avenue of interaction, as well as a supplement to household resources, is suggested by the residue-lined, cobble-bottomed pits found at the locus. The pits may have been used to process dried maize to create nixtamal, which, in its ground form, is known as masa (see Chapter 9). Masa is the essential ingredient of tortillas. The concept that nixtamal or masa was being prepared is supported from another direction, that is, the introduction of the comal into the repertoire of the Classic period cook. The presence of these tortilla baking slabs at Area 3B suggests the flat breads had become a part of daily fare.

Regarding the topic of farmstead-village relationships, the proposed nixtamal preparation pits were large for their purpose, suggesting a scale of production beyond that required for daily consumption. In the context of Pueblo Grande, whose prominence among Canal System 2 settlements suggests the probability of the village being a focal point for system-wide gatherings, Area 3B residents may have prepared large quantities of masa and tortillas to share with or sell to those coming to the site for special activities. In essence, nixtamal/masa and tortilla preparation as a sort of cottage industry for the local farmer-baker, not unlike the present-day Amish, who do well selling pies to tourists.

Unfortunately, this conclusion is mostly conjectural. Additional study of the so-called "leach" pits must be conducted to resolve their function. However, if not tortillas, then some other products might have been used to more fully intertwine the Area 3B farmers within the social fabric of Pueblo Grande.

CONCLUDING REMARKS

The PHX Sky Train project provided a remarkable opportunity to reinvestigate Hohokam canals near the headwaters of Canal System 2, last studied more than 30 years ago during the Hohokam Expressway project (Masse 1976, 1988) and, even earlier, by Woodbury (1960, 1961) at Park of Four Waters. This previous work can be considered among the first scientific studies of Hohokam canals, introducing many of the techniques and analytical tools currently used to study them. There have been advancements across time, especially regarding canal chronometry, and it is true that all cannot be learned about a canal in a few exposures. Each new exposure adds incrementally to our understanding about the construction, operation, capacity, correlations across space, and age of individual canals. In this way, the PHX Sky Train project has provided new insights into previously studied canals, not only for some of the largest that existed within Canal System 2, but also for smaller canals constructed for local use.

The PHX Sky Train project was also fortunate in its discovery of irrigated agricultural fields. Until now, the occurrence of irrigated fields in the Salt River Valley has been largely deduced from characteristics of soils exposed in trench profiles. For the first time, all the elements of the fields could be seen, including their shapes, sizes, surfaces, and relationship to the canals and ditches that irrigated them. These attributes, together with textural, chemical, and paleoecological content of identified PHX Sky Train field soils, provide baseline data for future comparison with other fields, when found. Over time, discoveries like this will provide a view of how the Hohokam conducted the irrigated farming for which they are so well known.

Another important aspect of the PHX Sky Train fields is the fact that their presence was entirely unexpected. Despite centuries of abandonment and, especially, historic and modern modifications to the landscape, this project demonstrated that fields of the ancient farmers can still be found below the modern-day ground surface. Their discovery highlights the benefit of mechanically stripping large areas to chase the not-quite-explicable irrigation feature and to horizontally expose smaller canal alignments both at their intersections and along large sections of their length.

Finally, the other water features found during the project, such as the catchment-cum-reservoirs and the enigmatic canal-side basin, reveal the Hohokam's intimate knowledge of their landscape and how to manipulate it to best advantage. The findings highlight why study of the irrigated spaces between prehistoric settlements is crucial to fully understanding how the Hohokam managed to thrive for so many centuries in their desert environment.

APPENDIX A

PARTICLE-SIZE DATA, PHX SKY TRAIN PROJECT

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Table A.1. Granulometry for PHX Sky Train canal Features 3, 200, and 201.

Feature	Sample	16 mm	4 mm	2 mm	1 mm	0.5 mm	< 0.5 mm	% Sand	% Silt	% Clay	Texture[a]
3	1	–	–	–	–	–	100.0	4.1	69.0	26.9	sil
3	2	–	–	–	–	–	100.0	19.3	68.8	11.9	sil
3	3	–	–	–	–	–	100.0	9.1	52.2	38.6	sicl
3	4	–	–	–	–	–	100.0	13.5	70.7	15.8	sil
3	5	–	–	–	–	–	100.0	0.0	15.5	84.5	c
3	6	–	–	–	–	–	100.0	1.9	35.5	62.7	c
3	7	–	–	–	–	–	100.0	0.7	67.4	31.9	sicl
3	8	–	–	0.4	0.3	–	99.3	9.2	61.5	29.3	sicl
3	9	–	–	0.5	0.8	1.4	97.3	10.6	56.5	32.9	sicl
3	10	–	–	1.2	0.5	1.0	97.3	11.6	58.2	30.2	sicl
3	11	–	–	1.2	0.2	2.1	96.5	4.4	43.4	52.1	sicl
3	12	–	1.4	–	–	–	98.5	7.3	59.4	33.3	sicl
3	13	–	–	1.0	0.3	0.2	98.6	12.8	60.1	27.2	sicl
200	1	–	–	–	–	0.2	99.8	46.0	41.0	12.9	l
200	2	–	–	–	–	0.0	100.0	71.9	23.8	4.4	sl
200	3	–	0.3	0.1	0.5	1.8	97.3	22.2	59.2	18.5	sil
200	4	–	–	0.3	3.4	9.6	86.7	48.8	42.3	8.9	l
200	5	–	–	0.2	0.9	2.2	96.7	29.5	59.1	11.4	sil
200	6	–	–	0.3	1.6	9.1	89.0	43.4	44.5	12.1	l
200	7	–	–	0.2	0.3	3.9	95.5	33.6	52.4	14.0	sil
200	8	–	–	1.1	10.2	13.9	74.7	47.7	42.0	10.4	l
200	9	–	–	0.3	2.3	7.7	89.7	41.6	43.9	14.5	l
200	10	–	–	1.6	5.0	7.8	85.6	47.4	41.1	11.4	l
200	11	–	–	0.6	4.7	12.7	82.0	42.5	43.0	14.4	l
200	12	–	–	–	–	–	100.0	6.6	66.0	27.4	sicl
200	13	–	–	–	–	–	100.0	1.3	51.1	47.6	sicl
200	14	–	–	–	0.1	0.2	99.7	11.4	68.3	20.3	sil
200	15	–	–	–	–	–	100.0	13.1	62.9	24.0	sil
200	16	–	–	0.1	–	–	99.8	16.4	63.5	20.1	sil
200	17	–	–	0.3	0.4	1.1	98.2	20.0	67.0	13.0	sil
201	1	–	1.5	–	–	–	98.5	5.6	75.9	18.4	sil
201	2	–	–	–	–	–	100.0	1.9	81.9	16.2	sil
201	3	–	–	–	–	–	100.0	1.6	82.4	16.0	sil
201	4	–	–	–	–	–	100.0	3.9	68.3	27.8	sicl
201	5	–	–	–	–	–	100.0	13.7	71.2	15.1	sil
201	6	–	–	–	–	–	100.0	34.9	54.1	11.0	sil
201	7	–	–	0.2	–	–	99.8	4.2	65.4	30.4	sicl
201	8	–	–	–	–	–	100.0	1.8	41.9	56.3	sicl

[a]c = clay; l = loam; sil = silt loam; sicl = silty clay loam.

Table A.2. Textural data (% sand, silt, and clay) for selected PHX Sky Train canals.

Feature	Trench	Stratum	Depth Above Base (m)	Sample	Sand (%)	Silt (%)	Clay (%)	Sand: Silt + Clay	Texture[a]	Interpretation
14	28	2	0.48	S-6	14	38	48	0.16	c	Postabandonment?
14	28	2/5	0.38	S-5	14	40	46	0.16	c	Postabandonment?
14	28	6	0.28	S-4	12	42	46	0.14	sicl	Canal use
14	28	9	0.16	S-3	16	48	36	0.19	sicl	Canal use
14	28	10	0.11	S-2	24	42	34	0.32	cl	Canal use
14	28	11	0.05	S-1	28	44	28	0.39	cl	Canal use
17	13	2	0.52	S-6	36	30	34	0.56	cl	Postabandonment
17	13	3 (g)	0.40	S-5	36	28	36	0.56	cl	Postabandonment?
17	13	3 (f)	0.33	S-4	76	10	14	3.17	sl	Canal use
17	13	3 (d)	0.25	S-3	68	20	12	2.13	sl	Canal use
17	13	3 (b,c)	0.15	S-2	74	12	14	2.85	sl	Canal use
17	13	3(b)	0.06	S-1	54	24	22	1.17	scl	Canal use
18	26	2	0.64	S-10	24	32	44	0.32	c	Postabandonment?
18	26	3	0.53	S-9	26	32	42	0.35	c	Postabandonment?
18	26	4	0.43	S-8	32	32	36	0.47	cl	Canal use
18	26	5	0.37	S-7	32	32	36	0.47	cl	Canal use
18	26	6	0.31	S-6	60	30	10	1.50	sl	Canal use
18	26	7a	0.23	S-4	84	12	4	5.25	ls	Canal use
18	26	7b	0.27	S-5	80	6	14	4.00	sl	Canal use
18	26	8	0.18	S-3	48	44	8	0.92	l	Canal use
18	26	9	0.10	S-2	68	26	6	2.13	sl	Canal use
18	26	10	0.03	S-1	50	38	12	1.00	l	Canal use
22	40	8	0.41	S-3	36	40	24	0.56	l	Canal use
22	40	9	0.22	S-2	38	36	26	0.61	l	Canal use
22	40	10	0.06	S-1	38	38	24	0.61	l	Canal use
23	40	6	0.41	S-7	24	44	32	0.32	cl	Postabandonment?
23	40	3	0.26	S-6	44	44	12	0.79	l	Canal use
23	40	4	0.13	S-5	80	12	8	4.00	ls	Canal use
23	40	5	0.07	S-4	58	34	8	1.38	sl	Canal use
26	53	2	0.69	S-6	16	46	38	0.19	sicl	Canal use?
26	53	2	0.53	S-5	10	48	42	0.11	sic	Canal use?
26	53	3	0.30	S-4	14	30	56	0.16	c	Canal use
26	53	4	0.15	S-3	22	42	36	0.28	cl	Canal use
26	53	5	0.10	S-2	38	46	16	0.61	l	Canal use
26	53	6	0.04	S-1	26	42	32	0.35	cl	Canal use
33	56	1	0.45	S-6	44	40	16	0.79	l	Canal use?
33	56	2	0.30	S-5	14	34	52	0.16	c	Canal use
33	56	3	0.23	S-4	20	38	42	0.25	c	Canal use
33	56	4	0.18	S-3	36	44	20	0.56	l	Canal use
33	56	5	0.12	S-2	50	34	16	1.00	l	Canal use
33	56	6	0.05	S-1	46	40	14	0.85	l	Canal use

[a]c = clay; sic = silty clay; cl = clay loam; sicl = silty clay loam; l = loam; ls = loamy sand; sl = sandy loam; scl = sandy clay loam.

MICRO-HOLE LUMINESCENCE DATING OF IRRIGATION CHANNEL FEATURES IN PHOENIX, ARIZONA

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Eight principal sediment samples from within irrigation channel features were collected by the author on 14 September 2009 (Table B.1) and transported to the Desert Research Institute in Reno, Nevada. The goal of this sample collection was to determine the burial age (time of last exposure to daylight) of the sediments, using single-grain-quartz (SGQ) photon-stimulated-luminescence (PSL), often termed OSL (Berger 1986) dating. This approach is also termed micro-hole PSL dating here, because for some samples, there may be more than one grain per hole emitting acceptable signals. SGQ luminescence dating results have been previously obtained on such material from this region and from irrigation channel features in Santa Fe, New Mexico (Berger et al. 2009). These efforts have shown that, for such deposits and in situations for which radiocarbon (^{14}C) dating is limited or absent, SGQ PSL dating can be usefully precise and suitably accurate.

SAMPLES

Sampling beds were selected after consultation with members of the Desert Archaeology, Inc., research team. After sampling, 4-inch nails with identity ribbons were placed within the various trench walls at the exact center of each luminescence sample location. Samples extracted during the daytime were collected in light-tight tins, so that only the two ends of the tin's contents were exposed to light. These end materials (1.5-2.0 cm thick) were removed in the darkened laboratory. Some samples were collected at night, because the target bed texture and consistency precluded removal of a sample without fracturing or crumbling. When sampling at night, a spectrally filtered LED headlamp and hand-lamp were used. After removing a minimum of 5 cm of trench face material in the dark, the target material for each sample was placed into a 4-layer opaque plastic bag.

Corresponding to each of the eight luminescence samples, two to four smaller samples were collected to provide information about the in situ saturation water concentrations and the primary radio elements in the sediment adjacent to, above, and below the luminescence sample. Use of these smaller samples is outlined in Table B.2 (see Footnote a).

LUMINESCENCE DATING METHODS

PSL dating (Aitken 1998) determines the last exposure to daylight of feldspar and/or quartz grains in unheated sediments. This provides a unique dating tool for Quaternary sediments. PSL is very sensitive to daylight, with as much as 90 percent of the quartz signal capable of removal in only 5-15 seconds of full sunlight exposure (Godfrey-Smith et al. 1988). However, single grains are not always exposed to full sunlight when transported in fluvial or sheetwash systems (Wallinga 2002), or if transport occurs in darkness. Thus, in water-borne sediment, such as infill deposits within irrigation channels, one can typically expect a mixed-age population of grains in any hand-sized sample.

The efficacy of the use of single grains of quartz sand for dating the time elapsed since the last daylight exposure (burial age) for irrigation channel features was demonstrated clearly by Berger et al. (2009). They obtained an accurate age estimate for a sample of circa 100 year age (the international 'a' for 'annum' is used here), and age estimates up to circa 400 a for irrigation ditch infill sediments within the Santa Fe area. Because feldspar grains can often contain an unstable component, leading to age underestimates (Aitken 1998), quartz grains are preferred. Therefore, sand-sized grains of quartz were also used in this project. The size fraction chosen and the dating experiments performed are listed in Table B.3.

The basic principles of luminescence dating are outlined here. After burial, low-level, ambient ionizing radiation—primarily from the decay of potassium (K), uranium (U), and thorium (Th) isotopes within the sediment—provides an effectively constant (over the Quaternary) dose rate (D_R) to buried mineral crystals. This ionizing radiation dislodges electrons from lattice mineral sites into lattice charge traps, either light-sensitive or not, some of which can be stable for more than a million years. Under photonic stimulation in the laboratory, a fraction of the trapped light-sensitive charges recombine with opposite charges at certain lattice sites, releasing photons. The intensity of this PSL is related to the time since last daylight exposure, which, in suitable settings, is equivalent to the last burial time. This PSL is scaled in the laboratory by use of calibrated radiation sources to yield a paleodose (D_E, or 'equivalent dose') value. That is, D_E, in units Gy or Gray, is a measure of the total absorbed energy from ionizing radiation that is stored in the crystal since the last daylight exposure, and D_R, unit Gy/ka, is a measure of the annual rate of storage of ionizing radiation energy in the crystal. The burial age, then, is $t = D_E/D_R$, in calendar years.

The burial dose rate will not be constant if there have been radioisotope decay series disequilibria in the deposits (Olley et al. 1996), although this is uncommon and rare within medium-fine sandy, silty deposits. In PSL dating of sand, the use of thick-source-alpha-particle counting (TSAC) (Huntley et al. 1986) for determination of the U and Th contri-

Table B.1. Luminescence sample locations, PHX Sky Train project.

Site	Sample	Feature	Trench	Stratum	MBGS[a]	Comment (by T. K. Henderson)
AZ U:9:2 (ASM)	FNX09-1	200	62	3	2.50	Western wall profile
	FNX09-2	200	62	8a	1.98	Western wall profile
AZ U:9:28 (ASM)	FNX09-3	26	50	4-6	1.00	Correlates with Feature 26, Trench 53, Strata 4-6
	FNX09-4	22	55	3	0.56	Correlates with Feature 22, Trench 40, Stratum 9
	FNX09-5	23	56	3	0.78	-
	FNX09-6	29	44	4	0.53	Basal stratum, also called "silt halo"
	FNX09-7	26	54	3-4	0.85	Correlates with Feature 26, Trench 53, Strata 3-4
	FNX09-8	25	41	4	1.02	-

[a]Meters below ground surface (pre-excavation), sample midpoint.

Table B.2. Dosimetry data and dose rates, PHX Sky Train project.

Sample	Water[a]	K_2O (wt.%)	C_t[b] $ks^{-1} \cdot cm^{-2}$	U (ppm)	C_{th}[b] $ks^{-1} \cdot cm^{-2}$	Th (ppm)	Dose rate[c] (Gy/ka)
FNX09-1	0.08±0.02	1.70±0.05	0.5957±0.0084	2.31±0.25	0.318±0.029	9.11±0.84	2.741±0.091
		2.14±0.05	0.730±0.060	2.83±0.30	0.390±0.040	11.2±1.50	
FNX09-2	0.10±0.02	2.52±0.05	0.5793±0.0077	2.93±0.20	0.227±0.023	6.50±0.65	3.225±0.098
		2.24±0.05	0.765±0.065	2.95±0.20	0.411±0.043	11.2±1.20	
FNX09-3	0.08±0.02	2.23±0.05	0.6362±0.0083	3.25±0.22	0.245±0.020	7.02±0.71	3.22±0.12
		3.03±0.40	0.6614±0.0080	2.78±0.15	0.327±0.020	9.37±0.30	
FNX09-4	0.08±0.02	2.66±0.05	0.6928±0.0088	3.51±0.23	0.270±0.026	7.75±0.75	3.56±0.12
		2.91±0.25	0.721±0.055	3.13±0.60	0.343±0.022	9.84±0.50	
FNX09-5	0.08±0.02	3.09±0.05	0.6943±0.0091	3.11±0.25	0.320±0.029	9.17±0.83	3.744±0.090
		2.81±0.05	0.705±0.016	2.93±0.20	0.352±0.020	10.08±0.50	
FNX09-6	0.08±0.02	2.47±0.05	0.6786±0.0091	2.83±0.25	0.337±0.029	9.67±0.83	3.352±0.080
		2.62±0.05	0.7152±0.0060	3.16±0.20	0.336±0.020	9.65±0.40	
FNX09-7	0.12±0.02	4.01±0.05	0.4081±0.0074	1.67±0.19	0.207±0.022	5.93±0.63	3.85±0.10
		2.39±0.17	0.765±0.037	3.10±0.20	0.392±0.020	11.23±0.50	
FNX09-8	0.08±0.02	3.05±0.05	0.5808±0.0077	3.52±0.22	0.277±0.025	7.96±0.71	3.54±0.11
		2.82±0.24	0.644±0.045	3.03±0.36	0.280±0.020	8.02±0.50	

[a]Estimated ratio of water/mass of dry sediment that could represent the long-term average, based on measured 'as-collected' and laboratory saturation values. Uncertainties here and elsewhere are reported at $\pm\sigma$. The second row for each sample provides the corresponding average of the measured values for sediment lying above and below the PSL sample, and within 25-30 cm of that sample. 30 cm is about the range of γ rays in typical sediment. Data in the second row are used to calculate the so-called 'environmental' or γ dose-rate component.

[b]Total and thorium count rates from finely powdered samples for thick-source-alpha-particle-counting (TSAC) method (Huntley and Wintle 1981). $C_u = C_t - C_{th}$. These values are inserted directly into the dose-rate equations of Berger (1988), as updated by Berger (2006).

[c]A small cosmic ray component is included, estimated from the burial depth of the PSL sample (Prescott and Hutton 1988).

Table B.3. Sample size fractions and PSL experiments, PHX Sky Train project.

Sample	Size (μm)	Treatment[a]	SAR Experiment[b]
FNX09-1 to FNX09-8	125-185	NM + 50% HF	SG/300 μm

[a]'NM' is non-magnetic; 'HF' is hydrofluoric acid at 47% concentration and 50-minute exposure. After HF treatment, IR (infrared) tests were performed on representative multigrain subsamples to check for the presence of any residual feldspar. All samples indicated that no significant feldspar remained.

[b]Single-grain (SG) SAR using discs with 300-μm diameter holes.

butions to the dose rate is more accurate, when disequilibrium occurs, than are the more commonly used procedures that determine only the concentrations of the parent nuclides (that is, neutron activation analysis [NAA] or inductively-coupled-plasma-mass-spectrometry [ICP-MS]). Further, TSAC is used routinely to check for radon loss within samples, thus indirectly providing one check on the presence or absence of decay-series disequilibrium.

The single-aliquot-regenerative-dose (SAR) PSL procedure (Murray and Wintle 2000, 2003), and its extension to single grains, is now an established method for dating quartz-bearing silts and sands (reviews by Duller 2004; Fuchs and Owen 2008; Jacobs 2008; Jacobs and Roberts 2007; Lian and Roberts 2006; Preusser et al. 2008; Rittenour 2008). Most quartz grains release 3-6 PSL signals having different release rates (Jain et al. 2003, 2005). The preferred component for SAR dating is the 'fast' component (Murray and Wintle 2000; Wintle and Murray 2006), a signal usually released in the first 0.8 seconds of typical blue-diode stimulation, and much quicker under laser stimulation. A dating precision of approximately 10 percent (sometimes better) can routinely be attained with multigrain SAR quartz methods (Murray and Olley 2002) applied to eolian sand. The SAR age range for quartz is generally from as little as 8 years (Ballarini et al. 2003, 2007) to roughly 150 ka (Murray and Olley 2002) for normal radioactivity sediment.

In the SAR method, each aliquot (a small disc containing grains on its surface) yields a distinct D_E value, and thus, a distinct age estimate. The immediate advantage of SAR is that, by pooling these individual D_E values, using a weighted mean, a greater precision in age estimation can be estimated. However, there is an even more profound advantage to the use of SAR when one grain per aliquot is used. Micro-hole SAR avoids the risk of obtaining only mixed-age (too old) estimates for those samples, such as fluvial samples, for which only a fraction of the grains have been exposed to daylight before final burial. While using several grains per aliquot may occasionally allow resolution of last-burial-age D_E values from mixed-age D_E values, the probability of that declines rapidly as the fraction of daylight-shielded grains increases in a sample. The concepts and advantages of single-grain dating are expounded clearly by Olley et al. (1999), Bøtter-Jensen et al. (2003), Duller (2004, 2008), and Berger et al. (2009).

An important way to visualize the D_E data obtained from SAR dating experiments can be a histogram plot, but a more realistic plot is a transformed-probability-density (TPD) plot (Berger 2010) used here. This plot is analogous to a histogram plot, but having a kind of weighting, in which the least precise or largest-error-bar D_E values have the least probability of representing age-estimate components. Technically, the form of the plot proposed by Berger (2010) is not a probability plot, but rather, is a type of weighted frequency plot. This plot can be used when D_E values are > 0 and when the absolute errors in D_E values appear to increase with D_E value; that is, when the relative errors are roughly similar or constant. Thus, the weighting is by inverse variance of the relative errors, not by inverse variance of the absolute errors. A TPD plot, and even a PD plot, is superior to a conventional histogram plot here, because a histogram plot is appropriate only when all data have equal errors, which is rare in SAR dating. D_E distributions are presented here as TPD plots, as a visual aid to recognizing the presence and range of any cluster of youngest-age D_E values, and thus, as a visual aid for deciding which method to use for the calculation of a mean D_E value in the estimation of a burial age.

The basic concept in the use of this plot is illustrated in Figure B.1, with data in the form of the familiar (unweighted) histogram plot. Here, the eolian sample (inset) has essentially one age component. That is, there is a tight, effectively Gaussian (statistically normal) distribution of D_E values. On the other hand, for the fluvial sample, many grains will retain a relict-age signal (they are not exposed to much, or any, daylight during final transport to the burial horizon), leading to a positively skewed distribution. In this case, only the D_E values defining the lowest-D_E (lowest age) cluster (component) yield the true burial age.

LUMINESCENCE DATING PROCEDURES

Quartz-rich fractions were prepared by destroying any carbonates and organic material with 1N HCl acid and 30 percent H_2O_2, with dionized-water rinses between and after. Then, wet sieving was used to select grain-sized fractions close to the maximum size permitted with the available standard micro-hole discs. These discs have holes of 300 μm diameter; therefore, grains up to about 225 μm can be used without risk of having the grains become stuck in the holes after experiments. In this project, the maximum grain size chosen was 185 μm. Frantz isodynamic magnetic separation was applied to the selected grain-sized fraction to obtain non-magnetic subfractions, which were then treated with 48 percent HF acid for dissolution of feldspars (Aitken 1998). After HF acid treatment, representative multigrain aliquots of each sample were tested for the possible presence of residual feldspar by first administering a 10 Gy radiation dose, and after a 2-day delay, stimulating the aliquots with infrared (IR) light at 80°C. (Note: only feldspar responds to such IR stimulation).

In addition to these post-HF, IR multigrain tests for feldspar contamination, during SGQ SAR analysis, a high temperature (100°C) IR wash step (Berger, Doran, and Thomsen 2010) was included to ensure

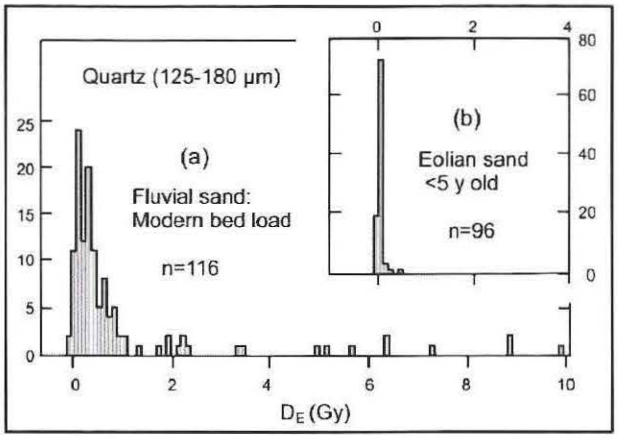

Figure B.1. Examples of the shapes of histograms of D_E values for small (60-100 grains) single aliquots of quartz grains from: (a) a modern fluvial bedload sand, and (b) a modern (< 5 years) eolian sand (modified from Olley et al. 1998).

that any remaining small feldspar signal is removed or minimized. Further, some SAR steps were added at the end of the PSL readout sequence. These steps permit comparison of post-irradiation B-PSL signals (ostensibly from quartz) with and without prior IR washing. Thus, this expanded SAR readout sequence facilitated identification and rejection of any micro-hole signals coming from residual feldspar fragments.

During SAR runs, the main parameters included the choices of preheating temperatures (PH) (180°C, 200°C, etc.) and cut-heating temperatures (160°C or 180°C) (Wintle and Murray 2006). In this project, choices were based on SGQ dose-recovery tests at different preheats, with cut heat at 160°C. There was no difference in dose-recovery ratio (it should be unity within 1σ errors) among micro-hole tests at 200°C, 220°C, and 240°C, so for dating, a preheating of 200°C was used, in conjunction with a cut-heating of 160°C. Use of cut-heating no higher than 20° below the preheating temperature has been recommended (Wintle and Murray 2006), and for young samples, 160°C is usually effective.

Several quality control criteria were used to reject D_E values. Data rejection criteria were similar to those in common practice (Wintle and Murray 2006), with small changes outlined by Berger, Doran, and Thomsen (2010) and Berger, Murray, Thomsen, and Domack (2010). In the SAR procedure, the net signal from each shine curve was obtained by using the ELS (early-light-subtraction) procedure (Berger, Doran, and Thomsen 2010; Berger, Murray, Thomsen, and Domack 2010) (Figure B.2). The use of the ELS data processing procedure enhances isolation of the desired fast component of the quartz signal. The plot for the L/T (test-dose-normalized net luminescence) ratio corresponding to that in Figure B.2 is shown in Figure B.3. Another example of such data is shown in Figures B.4 and B.5. In the data processing, a conservative internal (instrumental) random error of 12 percent was used, based on the systematic micro-hole reproducibility tests of Thomsen et al. (2007).

The SGQ experiments were repeated for each sample, using a larger number of grain holes the second time.

Two numerical approaches to calculation of youngest age D_E value were utilized. The first is a relative-error-weighted-mean calculation (REWM) (Berger 2010), in which the weighting is by inverse relative error (variance), rather than inverse absolute error, as with the conventional weighted mean. The second approach was the use of the 3-parameter minimum-age-model (MAM-3) (Galbraith et al. 1999). The reasons for the preference of one or the other approach with data from this project are discussed below.

In determining the effective dose rate to each PSL sample, K was measured by commercial atomic-absorption-spectrophotometry (AAS) or a suitable commercial ICP-MS procedure (ALS-Chemex). U and Th contributions were obtained by use of TSAC (see Table B.2:Footnote c). A small cosmic-ray dose-rate component was estimated using the calculation procedure of Prescott and Hutton (1988) (Table B.2:Footnote c), and dependent primarily on sample depth. Estimates of the past average water concentration (inter-granular water attenuates the dose rate to each grain) was by the traditional method of Berger (Berger and Péwé 2001; also, see Table B.2:Footnote a). The assigned uncertainty in each water/sample weight ratio is conservative.

RESULTS

Dose-rate data are listed in Table B.2, with details in footnotes. Dose rates for these samples are comparable to those typically reported (2-4 Gy/ka) for most terrestrial sediments (Aitken 1985, 1998). PSL data and calculated ages are listed in Table B.4, with details in footnotes. The PSL age estimates range from about 800 a to roughly 1100 a (before 2010). The interpretative basis for these different age estimates and some caveats are discussed below.

DISCUSSION

Two micro-hole experiments were run for all samples. The first, using only three of 100-hole (300 μm diameter by 300 μm deep) discs, was intended to check the response (sensitivity) of each sample. Based on the results from this short experiment, a second experiment was run using five to eight discs.

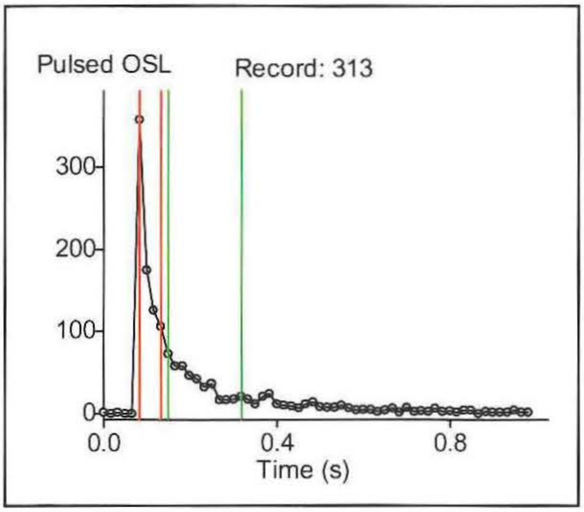

Figure B.2. Laser shine curve for the un-normalized (L) natural (after heating, but before any laboratory radiation does) signal from grain hole 3/77 of sample FNX09-2 (40/600 in Table B.4. The red interval shows the chosen range for signal estimation, and the green interval shows the chosen range for background (ELS) subtraction. For each shine curve, the net signal is used in calculation of the normalized (L/T ratio) signal. The corresponding test-dose (T) shine (normalization shine) is not shown.

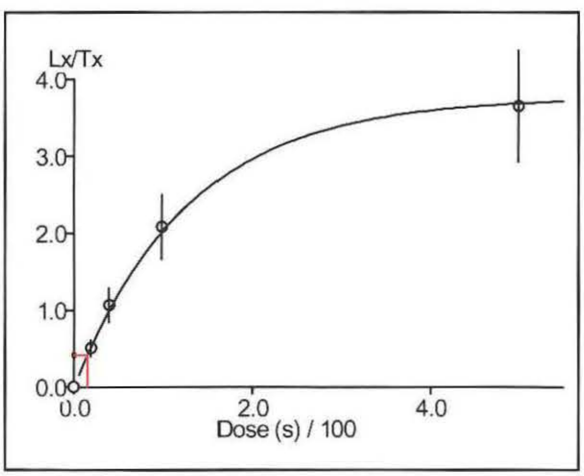

Figure B.3. SAR dose-response or build-up curve of L/T ratios for the grain hole (3/77) of Figure B.2, showing the interpolation (horizontal red line) of the y-axis L_0/T_0 ratio and the resultant D_E value (vertical red line). Here the x-axis dose units in 100s of seconds have not yet been scaled to Gy. The coincidence of the x-axis zero-dose open circle (recuperation L/T) with the y-axis zero indicates that recuperation is zero for this grain. Error bars are $\pm 1\sigma$.

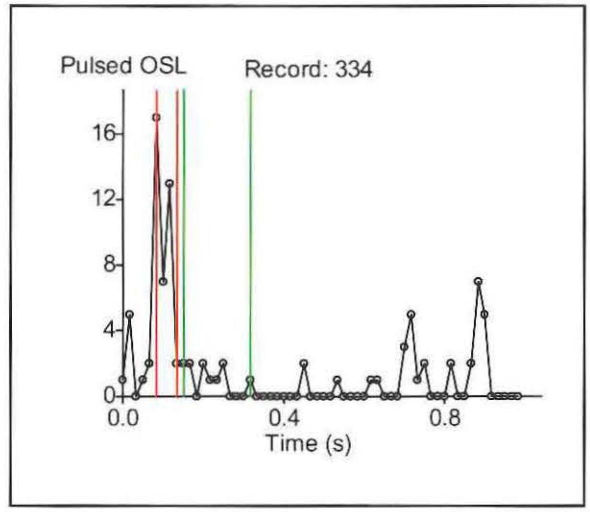

Figure B.4. Laser shine curve for the un-normalized (L) natural signal from grain hole 3/98 of Sample FNX09-2 (40/600 in Table B.4).

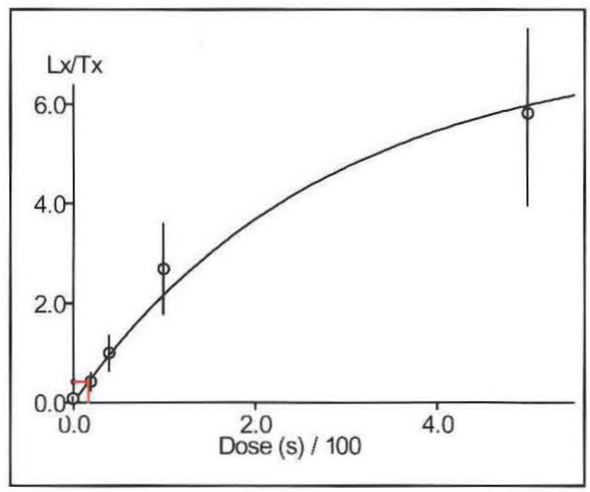

Figure B.5. SAR dose-response or build-up curve of L/T ratios for the grain hole (3/98) of Figure B.4.

Because all of these samples had a fortuitously high response (10-15 percent), data from the short runs could also be used for age estimation. Note that the relatively high response (compared to quartz from some other regions of the planet) and the use of only 125-185 µm grain diameters permits the occurrence of more than one emitting grain per hole. That is, if only 10 percent of the quartz grains are emitting, and if a maximum of three to four grains (smallest in the 125-185 µm range) per hole is obtained, there is a finite, but small, probability that some holes could provide mixed-age signals, if those three to four grains were not all of the same last-daylight-exposure age. This possibility might account for some of the smear in the burial-dose (D_E) distributions below, although this would likely be a minor effect.

In this context, the discussions below illustrate each burial-dose distribution and show the mathematical models available to calculate a minimum- or youngest-age estimates (see concept in Figure B.1). In most samples, there is a reasonably clear isolation of a population of youngest-age grains.

Table B.4. Single-grain (micro-hole) luminescence data, with age estimates, PHX Sky Train project.

Sample	Heating[a] (°C)	Yield[b]	ELS D_E [c] (Gy)	MAM D_E [d] (Gy)	ELS Age[e] (ka)	MAM Age[e] (ka)
FNX09-1	200/160	46/300	3.53±0.24(42)	$3.39^{+0.32}_{-0.25}$	-	-
		64/500	3.06±0.18(a) 3.54±0.22(b)	$2.63^{+0.38}_{-0.73}$	-	-
		Weighted mean MAM =		3.19±0.34		1160±130
FNX09-2	200/160	34/300	2.27±0.20(31)	$2.45^{+0.20}_{-0.22}$	-	-
		40/600	2.43±0.15(39)	-	-	-
		Average ELS =	2.35±0.18		729±60	
FNX09-3	200/160	38/300	3.04±0.22(37)	-	-	-
		81/600	3.37±0.15(77)	$3.34^{+0.15}_{-0.13}$	-	-
		Average ELS =	3.21±0.19		996±70	
FNX09-4	200/160	30/300	3.15±0.28(28)	$2.94^{+0.32}_{-0.39}$	-	-
		68/800	3.40±0.19(64)	$3.30^{+0.22}_{-0.15}$	-	-
		Average ELS =	3.28±0.23		921±71	
FNX09-5	200/160	29/300	3.12±0.36(a) 4.90±0.59(b)	$3.04^{+0.67}_{-0.95}$	-	-
		79/800	3.46±0.18(59)	$3.22^{+0.27}_{-0.30}$	-	860^{+75}_{-80}
FNX09-6	200/160	30/300	3.16±0.27(28)	-	-	-
		76/800	3.43±0.17(68)	3.33±0.21	-	993±67
FNX09-7	200/160	28/300	3.68±0.32(a) 4.40±0.35(b)	3.96±0.48	-	-
		80/800	4.34±0.27(73)	3.64±0.22	-	945±62
FNX09-8	200/160	45/300	3.67±0.24(38)	3.70±0.28	-	-
		66/500	3.54±0.18(a) 3.89±0.18(b)	$3.80^{+0.12}_{-0.24}$	-	1072^{+48}_{-76}

[a]This is the preheating (10 second hold) followed by the cut heating (0 second hold) (Murray and Wintle 2000; Wintle and Murray 2006).

[b]This is the number of D_E values meeting the data-acceptance criteria (see text), followed by the total number of grain holes (micro-hole SAR).

[c]ELS is early-light-subtraction (see Figures B.2 and B.4). The D_E value is the relative-error weighted mean (REWM) (Berger 2010) of the number of values in parenthesis. REWM is calculated when the relative errors in D_E values approximate a constant, that is, when the absolute error increases with D_E value, as it does for all these samples. The "a" or "b" refers to the different horizontal bars in some of the weighted-frequency plots. The calibration factors for the ^{90}Sr-^{90}Y beta sources were determined with the aid of gamma-irradiated quartz (150-225 μm) from Risø National Laboratories, Roskilde, Denmark.

[d]MAM is Minimum-Age-Model (3-parameter) of Galbraith et al. (1999), using an Excel© version courtesy of Sebastien Huot for the multigrain data set. Absence of an estimate ("-") indicates that the MAM calculation failed (usually because of a runtime error in the Excel macro) or was not applied.

[e]Calculated by dividing the D_E value by the respective dose rate in Table B.2. Age estimates are calculated only for preferred means (or MAMs) of D_E values, so that there is only one age estimate listed for each sample.

Sample FNX09-1

Ironically, the D_E distribution from the short experiment (Figure B.6:top left) appears to provide a clearer, less ambiguous, resolution of a youngest-age population than does the distribution from the longer experiment (see Figure B.6:bottom left). While the author prefers the use of the REWM D_E estimates when they agree (within 1σ) with the less-precise MAM estimates, the ambiguities among the REWM and MAM estimates for this sample (see Table B.4) motivate choosing a conservative estimate: the approximate weighted mean of the MAM estimates. This is because although the REWM "b" estimate (Table B.4:3.54 Gy, third row) is identical to the 3.53 Gy estimate from the short run (Table B.4:top row), the selection of the upper range limit to the "b" bar is relatively subjective. Therefore, the preferred age estimate for this sample is based on the MAM mean, and is 1160±130 a (before 2010, see Table B.4).

Sample FNX09-2

The TPD distributions for this sample (Figure B.6:right side) are unambiguous, and the preferred

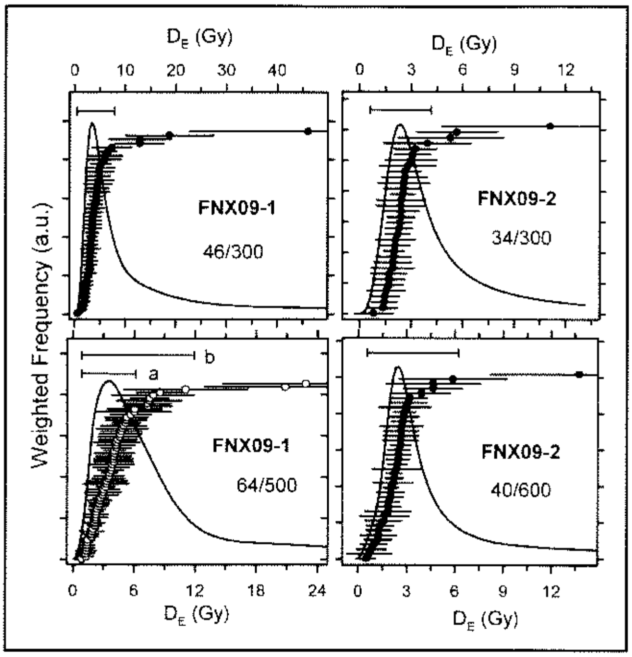

Figure B.6. TPD plots (solid curves) for D_E values from samples FNX09-1 and -2, with a ranked series of D_E values and errors. The horizontal bars represent the range of D_E values chosen for calculation of the relative error weighted means listed in Table B.4. As discussed in the text, selection of the upper end of this range is somewhat subjective for some of the samples, such as lower left in this figure.

age estimate (729±60 a) derives from the average of the REWM D_E values from the short and long experiments. This estimate is circa 400 years younger than that for Sample FNX09-1. Sample FNX09-2 should give a younger age because it occurs higher in the canal infill stratigraphy. Does this younger age represent a younger canal usage? That depends on the known archaeology. This younger infilling may represent only some flooding event in the region.

Sample FNX09-3

The TPD distribution plots for this sample (Figure B.7:left side) are as straightforward to interpret as those for Sample FNX09-2. The corresponding age estimate (996±70 a, see Table B.4) is based on the average of the REWM values from the short and long experiments.

Sample FNX09-4

Similar to those for Sample FNX09-3, the TPD plots for Sample FNX09-4 (Figure B.7: right side) provide an age estimate of 921±71 a (see Table B.4), based on the average REWM D_E value of 3.28 Gy. For this sample, the MAM and REWM estimates agree within 1σ, but the author prefers the average REWM estimate.

Sample FNX09-5

The TPD plots for this sample (Figure B.8:left side) provide a less clear visual resolution of a youngest age population of grains than do some of the other samples. The plot for the long experiment (see Figure B.8:lower left) appears to provide a clearer resolution. However, due to the evident presence of an overlapping subpopulation (see Figure B.8:right side of main peak in lower left plot), the author prefers the use of the less precise MAM D_E value, with the consequent age estimate (860^{+75}_{-80} a, see Table B.4). This could effectively be reported at 860±78 a.

Sample FNX09-6

In this case (see Figure B.8:right side), the TPD plots indicate fairly good visual resolution of the youngest age populations. Because the MAM model produces a relatively high precision symmetrical D_E estimate (3.22±0.21 Gy, see Table B.4) that is statistically in close agreement with the two separate REWM estimates, the preferred age estimate is 993±67 a.

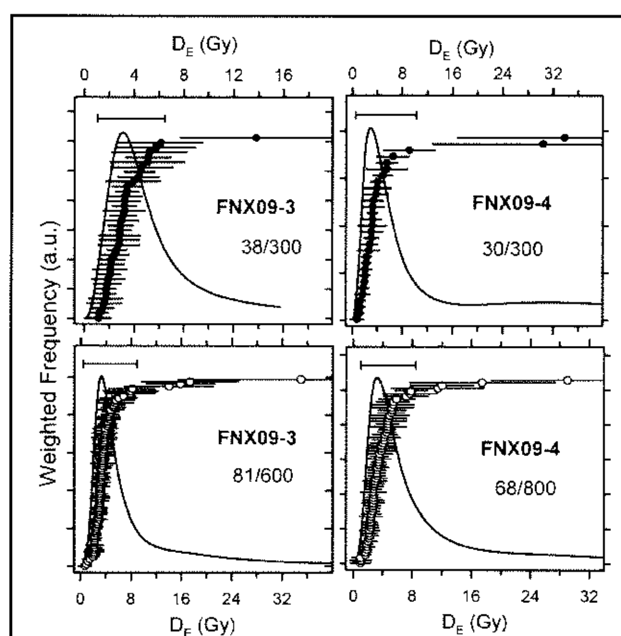

Figure B.7. TPD plots and ranked D_E values for Samples FNX09-3 and -4.

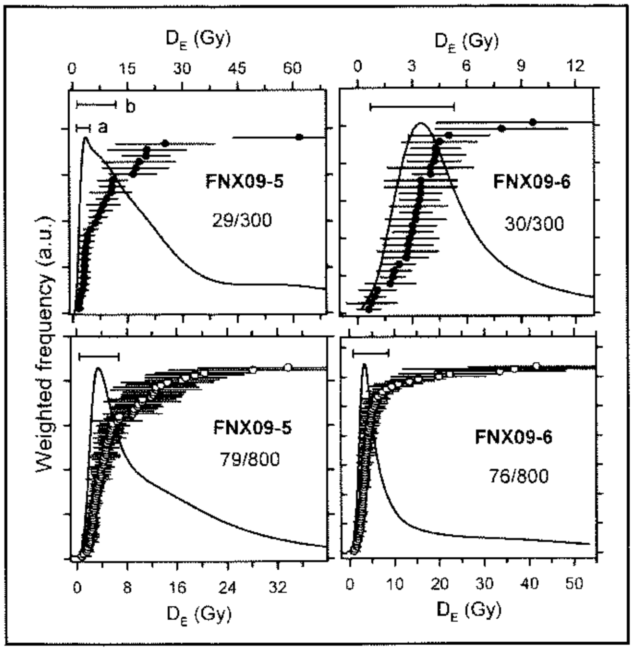

Figure B.8. TPD plots and ranked D_E values for Samples FNX09-5 and -6.

Sample FNX09-7

As in some of the other samples, there is significant ambiguity in the selection of the appropriate upper range for the youngest age peak in the short-run TPD plot (Figure B.9:upper left). For this reason, and because the REWM estimate (4.34±0.27, see Table B.4) from the long experiment (see Figure B.9:lower left) is unexpectedly closer to the "b" estimate from the short run (see Figure B.9:upper left), the relatively high precision (because of the number of D_E values) MAM estimate (3.64±0.22 Gy, see Table B.4) is preferred. The corresponding age estimate is 945±62 a.

Sample FNX09-8

In Sample FNX09-8, the ambiguity in one of the TPD plots' youngest age range selection favors the preference of the MAM esti-

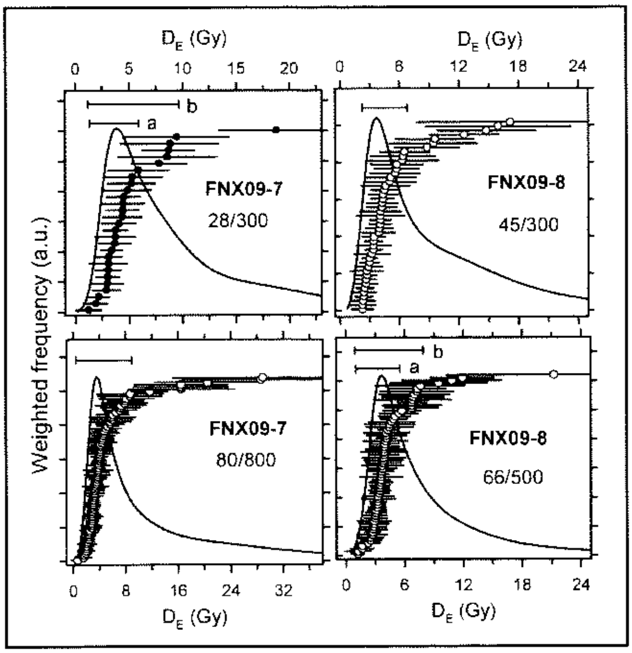

Figure B.9. TPD plots and ranked D_E values for Samples FNX09-7 and -8.

mate from the long experiment (see Figure B.9:right side). The corresponding age estimate is 1072^{+48}_{-78} a (see Table B.4).

CONCLUSIONS

The results confirm that quartz from this region has very favorable PSL properties, such as good sensitivity, high yield, and dominance of the fast component, for micro-hole sediment dating.

With one exception, Sample FNX09-1, the age estimates from the basal beds in each trench (canal feature) are consistent with each other 950-1000 a before 2010 A.D., within 1σ. However, at 2σ, the age estimate for Sample FNX09-1 is consistent with the other basal bed estimates.

The age estimate for Sample FNX09-2 (729±60 a) is stratigraphically consistent with the estimate for the deeper (basal) Sample FNX09-1, in the trench of profile Feature 200.

Acknowledgements

Berger thanks the Desert Research Institute (DRI) and the U.S. National Science Foundation for support of the infrastructure of DRI's E. L. Cord Geochronology Laboratory.

APPENDIX C

PETROGRAPHIC ANALYSIS OF SEDIMENT SAMPLES FROM A WATER CATCHMENT FEATURE, PHX SKY TRAIN PROJECT

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Desert Archaeology, Inc.

Four samples of sediments from a large water catchment basin, Feature 7, excavated within AZ U:9:28 (ASM), were examined. The feature was part of a larger site that included canals, ditches, and agricultural fields. Canal Feature 25 appears to have directed water into the catchment basin, which was probably used to store water, possibly for domestic or irrigation purposes. Evidence of periodic cleaning of the basin and modifications to its banks was present. Layers of alternating clay, silt, and sand comprised the fill of the basin. The analyzed sediments derived from two coarse sand layers and two finely laminated sand layers. The goal of the analysis was to describe the constituents of the samples to determine if the sediment derived from sheetwash from the nearby mountains, sediments from the Salt River brought to the basin by a canal, or a mixture of the two.

GEOLOGICAL SETTING

The Phoenix Basin is characterized by numerous mountain ranges separated by sediment-filled basins. To the north are the Phoenix and McDowell mountains, while to the east are the Goldfield and Superstition mountains. South are the Santan and Sacaton mountains, with the Picacho Mountains farther south, and to the west are the South and Sierra Estrella mountains (Chronic 1983:69-73). Two rivers, the Gila and the Salt, flow through the basin and join near the Sierra Estrella Mountains. Other water sources include the Agua Fria River to the northwest, Cave Creek to the north, the Verde River to the northeast, and Queen Creek to the east. The Santa Cruz River joins the Gila River south of the Phoenix metropolitan area.

Most of the mountains are composed of Archaean metasedimentary and metavolcanic rocks, along with Archaean and Proterozoic granitoid and metamorphic rocks. Both units contain schists, and the former also features phyllites. Cretaceous and Tertiary granites, often pink in color, appear in the Santan and Sacaton mountains, and to some extent, in the Picacho Mountains. Tertiary white granites and granodiorites are found primarily in the South and Picacho mountains. Volcanic rocks of Tertiary age are found in a number of ranges, including the Goldfield, Superstition and Santan mountains. Finally, Tertiary sedimentary rocks outcrop in the Goldfield and surrounding mountains (Miksa et al. 2004).

The site is located along the Salt River on a piedmont, which extends from Papago Buttes and Camelback Mountain to the northeast, and is composed primarily of alluvial fan deposits (Chapter 3, this volume). On the southern edge are flood deposits from the Salt River. This area is within the Camelback Buttes Petrofacies (I) (Miksa et al. 2004). Sands in this petrofacies are characterized by granite-derived quartz and feldspar grains and fragments of quartz-feldspathic gneiss. Volcanic rock fragments are rare. The Salt River (Petrofacies 3) transports primarily quartz and feldspar grains from a granitic source, in addition to some volcanic rock fragments. Metamorphic rock fragments are rare.

BINOCULAR ANALYSIS

The samples were initially examined under a binocular microscope to characterize their inclusions, focusing on grain sizes, shapes, and colors. Overall, the sand grains have a limited range of colors: beige, earthy-brown, and buff with some rose, gray, and white. The sand grains are mostly silty to fine sand in size, with the clay and silt fractions present in moderate proportions. The grains are typically subangular to subrounded. The dominant grain types are quartz and feldspar (plagioclase and potassium feldspar). Mica flakes are often present in percentages of 1-2 percent, and are yellow-bronze to brown in color, appearing shattered. The quartz grains have an orange or pink coating that may be due to the content of iron oxides in the grains. The principal difference between the sand samples is the content of biotite; COP10-3 is the sample with the lowest content of biotite. Notably, these sands do not appear to be similar to sand from the Salt River, which are often multicolored with a diverse range of grain types.

PETROGRAPHIC ANALYSIS

Preparation of the four sediment samples was minimal to preserve all the clay, silt, and sand components (Table C.1). Each sample was placed into a mold filled with resin to create a block for sectioning. The thin sections were prepared in the standard way and were stained for feldspar identification. Each thin section was analyzed petrographically, and information about the inclusions was recorded along with their percentage, sorting, and size range.

RESULTS

The results of the petrographic analysis revealed that most samples contained a high percentage of silt and sand, with COP10-1 and COP10-4 having

Table C.1. Sediment (sand) sample inventory, PHX Sky Train project.

Sample Number	Field Number (FN)	Feature	Trench	Stratum[a]	Description
COP10-1	149	7	18	31	Coarse sand
COP10-2	150	7	18	33	Laminated fine sand
COP10-3	151	7	18	36	Sand with some gravel
COP10-4	152	7	18	37	Laminated fine sand

[a]See also Figure 4.3.

the most sand (Table C.2). The percentage of clay in the samples was generally below 20 percent. The sorting of the inclusions, from clay to medium sand, was typically poor. These characteristics suggest lenses of autochthonous fine-grained sediments, with some variability based on the rate of water movement and period of settling.

The inclusions were predominantly quartz and feldspar grains, with minor amounts of biotite, opaques, epidote, pyroxenes, and amphiboles (Table C.3). These grains were usually low to medium in sphericity and angular to subangular in roundness. Alkali granite fragments—comprising mostly quartz, potassium feldspar and little plagioclase—were the principal lithic grains, with less common quartzite, granite grading to gneiss, and schist.

DISCUSSION

The dominance of alkali granite fragments and their derivatives (for example, quartz and feldspar) provides the best clue to the origin of these sediments. Along with these igneous inclusions are trace amounts of metamorphic rock fragments, such as gneiss and schist. Together, these grains indicate the most likely source for the sediments is the local granitic sources, such as Camelback Granite, which constitutes the base of Papago Buttes. A less likely source may be the Tovrea Granite pluton located southwest of Papago Park. This component is compositionally similar to Camelback Granite, except it contains less biotite and has more plagioclase feldspar than Camelback Granite. The low presence of micas in the analyzed samples indicates the Papago Buttes are more likely the principal source, while the Tovrea Granite makes up a smaller component. The composition of the Salt River, also located close to the site, does not match the components seen in the sediment samples.

Sand grains derived from granite comprise the widespread sandy facies, a distinctive unit formed due to certain conditions of sedimentation and reflecting a particular process or environment of the basin fill (Reynolds and Bartlett 2002). The low relief erosional surface, which was carved into the bedrock and is beveled across the mid-Tertiary units and structures in the Phoenix Basin, is usually overlain by 15-60 m of Late Tertiary to Quaternary sediments. These sediments are subdivided into three main units, from oldest to youngest: basin fill, Salt River gravels, and alluvium. These three units differ from each other because they posses different sedimentologic characteristics, distributions, mechanisms of deposition, and ages. This sandy facies differs from Salt River sands, both in terms of the degree of consolidation, as well as the uniformity in composition of the sands.

For this study, only the most recent sediments at the top, the alluvium strata, are important. Within the project area, the erosion of the Papago Buttes is likely to have created the sediments that are filling the catchment basin. The granitic bedrock that comprises the base of the Papago Buttes has been affected by a combination of differential weathering and erosion. In the mineralic components from the granite breakdown, according to their chemical properties, with quartz and plagioclase feldspar being the most resistant to decay. Conversely, the potassium feldspar grains are more affected by processes of weathering, erosion, and hydrolysis, eventually becoming absorbed into the soil or becoming a component of clay. When the processes of sedimentation are active, the remaining granitic components become part of alluvial material that has been eroded and transported. Thus, in the area of interest, the uppermost alluvium material is composed of sand and gravel in addition to some moderate content of silt and clay. This is often the result of deposition due to small (intermittent) streams creating alluvial fans when they reach an area of low relief. The sand sediments closely reflect the bedrock material that has been eroded, resulting in mostly quartz and plagioclase grains and a few granitic rock fragments.

CONCLUSION

The catchment basin, Feature 7, found at U:9:28 appears to have received most of its sediment, at least from the sampled strata, from local alluvial processes. While the basin has a canal feeding it, either

Table C.2. Description of samples, PHX Sky Train project.

Sample Number	Percent of Clay	Percent of Silt	Percent of Sand	Sorting	Size Range
COP10-1	2-10	20-40	≥ 50	Poor to medium	Silt to fine sand
COP10-2	10-20	≥ 50	10-20	Poor	Silt to very fine sand
COP10-3	Circa 10	30-50	30-40	Poor	Silt to medium sand
COP10-4	2-10	Circa 40	Circa 50	Poor	Silt to medium sand

Table C.3. Description of inclusions, PHX Sky Train project.

Sample Number	Sphericity	Roundness	Sand Components[a]	Lithic Grains
COP10-1	Low to medium	Subangular	Qtz (≥ 50%), plag (20-50%), kspar (10-20%), bio (1-3%), op (1-2%), ep (trace), py/am (trace)	Alkali granite, quartzite, and quartz-feldspathic schist; subrounded; medium in size, present from 2-5%
COP10-2	Low to medium	Angular to subangular	Qtz (up to 60%), plag (10-20%), kspar (2-10%), bio (circa 2%), op (1-2%), ep (trace), py/am (trace to 1%)	Mostly alkali granite; subangular, fine to medium sand in size, present from trace-1%
COP10-3	Low to medium	Subangular	Qtz (30-50%), plag (20-40%), kspar (10-20%), bio (trace to 1%), op (circa 2%), ep (trace), py/am (trace)	Mostly alkali granite and granite grading to gneiss; subangular; medium sand in size; present in percentages not greater than 5%
COP10-4	Low to medium	Angular to subangular	Qtz (circa 50%), plag (20-40%), kspar (10-20%), bio (1-2%), op (circa 2%), ep (trace), py/am (trace)	Mostly alkali granite and granite grading to gneiss, trace schist; subangular, medium sand in size, present in percentages not greater than 5%

Note: Plagioclase feldspars are moderately sericitized in all sand samples. There is also a constant presence of intergrowth textures that reflect the igneous character of the sands.

[a]qtz = quartz; plag = plagioclase; kspar = potassium feldspar; bio = biotite (often grading to chlorite); op = opaques; ep = epidote; py = clinopyroxene; am = amphibole (mostly hornblende).

this canal was not directing water from the Salt River, or the strata analyzed were the result of periodic infilling of the basin due to heavy rains. If the basin was not receiving water and sediments from the Salt River, it may have been designed to collect sheetwash for agricultural or other purposes. A similar basin was found at Las Colinas, AZ T:12:10 (ASM), and analysis of sediments and pottery by non-destructive XRF suggested it may have been used to create clay for ceramic production (Crown et al. 1988). This is just one possible explanation for the function of the catchment basin under study.

POLLEN DATA, PHX SKY TRAIN PROJECT

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Table D.1. Pollen sample provenience information for PHX Sky Train samples.

Feature Number	Field Number (FN)	Pollen Sample Weight (gm)	Area	Field Sample	Context	Context Comments	Period	Phase	Age (A.D.)
320	1364	25.3	6A	SL20a	Above field soils	GS/P #5: Area of Feature 320 just south of Feature 44.01; sample from sediments above field soil	Sedentary	Sacaton	1000-1150
320	1365	27.2	6A	SL20b	Field	GS/P #6: Feature 320 just south of Feature 44.01; sample from upper 5 cm of field soil	Sedentary	Sacaton	1000-1150
320	1370	30.6	6A	SL20c	Field	GS/P #11: Feature 320 just south of Feature 44.01; sample from lower 5 cm of field soil (total field soil depth at this point ~ 10 cm)	Sedentary	Sacaton	1000-1150
320	1366	30.6	6A	SL20d	Below field soils	GS/P #7: Area of Feature 320 just south of Feature 44.01; sample from sediments below field surface	Sedentary	Sacaton	1000-1150
320	1367	28.1	6A	SL21a	Above field soils	GS/P #8: Collected midway between Feature 44.01 and Feature 44.02; Feature 320 area, alluvium above field sediments	Sedentary	Sacaton	1000-1150
320	1368	27.8	6A	SL21b	Field	GS/P #9: Collected midway between Feature 44.01 and Feature 44.02; Feature 320, upper 5 cm of field soil	Sedentary	Sacaton	1000-1150
320	1371	25.5	6A	SL21c	Field	GS/P #12: Collected midway between Feature 44.01 and Feature 44.02; Feature 320, lower 5 cm of field soil	Sedentary	Sacaton	1000-1150
320	1369	29.6	6A	SL21d	Below field soils	GS/P #10: Collected midway between Feature 44.01 and Feature 44.02; Feature 320 area, alluvium below field soil	Sedentary	Sacaton	1000-1150
320	1372	26.1	6A	SL22a	Above field soils	GS/P #13: Feature 320 area, alluvium above field soils, collected from just north of Feature 44.02	Sedentary	Sacaton	1000-1150
320	1373	24.1	6A	SL22b	Field	GS/P #14: Feature 320 field soils sample (field soil depth at this point is 7 cm - one sample collected from top to bottom), collected from just north of Feature 44.02	Sedentary	Sacaton	1000-1150
320	1374	29.2	6A	SL22c	Below field soils	GS/P #15: Feature 320 area, alluvium from below field soils, collected from just north of Feature 44.02	Sedentary	Sacaton	1000-1150

Table D.1. Continued.

Feature Number	Field Number (FN)	Pollen Sample Weight (gm)	Area	Field Sample	Context	Context Comments	Period	Phase	Age (A.D.)
320	1375	29.1	6A	SL1	Field	Pollen #1: Collected at south edge of field channel 44.01 and north edge of Feature 320 field soils	Sedentary	Sacaton	1000-1150
320	1378	29.0	6A	SL4	Field	Pollen #4: field soils	Sedentary	Sacaton	1000-1150
320	1379	29.5	6A	SL5	Field	Pollen #5: field soils	Sedentary	Sacaton	1000-1150
320	1380	33.8	6A	SL6	Field	Pollen #6: field soils	Sedentary	Sacaton	1000-1150
320	1381	30.1	6A	SL7	Field	Pollen #7: field soils at the north edge of Feature 44.02	Sedentary	Sacaton	1000-1150
320	1382	31.5	6A	SL8	Field	Pollen #8: field soils; upper 5 cm of field; directly above PS#9	Sedentary	Sacaton	1000-1150
320	1383	30.5	6A	SL9	Field	Pollen #9: field soils; lower 5 cm of field; directly below PS#8	Sedentary	Sacaton	1000-1150
0	1384	29.4	6A	SL10	Control	Pollen #10: collected from alluvium below field channel 44.02; CONTROL sample from natural alluvium	Sedentary	Sacaton	1000-1150
0	1385	32.5	6A	SL11	Control	Pollen #11: collected from below field soils; CONTROL sample from natural alluvium	Sedentary	Sacaton	1000-1150
0	1386	32.5	6A	SL12	Control	Pollen #12: collected from below field soils; CONTROL sample from natural alluvium	Sedentary	Sacaton	1000-1150
320	1388	31.1	6A	SL30b	Field	GS/P #41: field soils	Sedentary	Sacaton	1000-1150
320	1391	31.6	6A	SL31b	Field	GS/P #44: field soils	Sedentary	Sacaton	1000-1150
320	1393	31.0	6A	SL32a	Above field soils	GS/P #46: above field soils	Sedentary	Sacaton	1000-1150
320	1394	29.0	6A	SL32b	Field	GS/P #47: field soils	Sedentary	Sacaton	1000-1150
320	1395	25.3	6A	SL32c	Below field soils	GS/P #48: below field soils	Sedentary	Sacaton	1000-1150
320	1397	27.6	6A	SL33b	Field	GS/P #50: field soils	Sedentary	Sacaton	1000-1150
320	1399	32.9	6A	SL34a	Above field soils	GS/P #52: above field soils	Sedentary	Sacaton	1000-1150
320	1400	26.2	6A	SL34b	Field	GS/P #53: field soils	Sedentary	Sacaton	1000-1150
320	1401	29.7	6A	SL34c	Below field soils	GS/P #54: below field soils	Sedentary	Sacaton	1000-1150
57	1164	26.2	6A	SL1a	Water catchment	GS/P #26: Feature 57 all gray-tan silty clay from upper edge of channel, northwest quarter, shallow end	Sedentary	Sacaton	1000-1150
57	1168	23.0	6A	SL1b	Water catchment	GS/P #29: Feature 57 rainbow clay from upper edge of channel, northwest quarter, shallow end	Sedentary	Sacaton	1000-1150

Table D.1. Continued.

Feature Number	Field Number (FN)	Pollen Sample Weight (gm)	Area	Field Sample	Context	Context Comments	Period	Phase	Age (A.D.)
57	1159	24.8	6A	SL2b	Water catchment	GS/P #21: Feature 57 rose-colored clay, northeast quarter, shallow end	Sedentary	Sacaton	1000-1150
57	1163	22.1	6A	SL3a	Water catchment	GS/P #25: Feature 57 gray-tan strat near bottom (deep end) of feature	Sedentary	Sacaton	1000-1150
57	1125	26.6	6A	SL3b	Water catchment	BSS 57.09: Heavy "rainbow" clay at bottom (deep end) of feature	Sedentary	Sacaton	1000-1150
57	1162	26.0	6A	SL4a	Water catchment	GS/P #24: Feature 57 gray-tan mottled with dark brown clay, bottom of this sediment from directly below mano	Sedentary	Sacaton	1000-1150
57	1160	26.6	6A	SL4b	Water catchment	GS/P #22: Feature 57 rose-colored clay, from near bottom of deepest part of basin, under mano	Sedentary	Sacaton	1000-1150
57	1120	19.1	6A	SL5a	Water catchment	BSS 57.04: upper gray/tan silt at east side of Feature 57/26 junction	Sedentary	Sacaton	1000-1150
57	1124	24.9	6A	SL6a	Water catchment	BSS 57.08: lower gray/tan soils with plant/leaf impressions	Sedentary	Sacaton	1000-1150
57	1169	22.6	6A	SL6b	Water catchment	GS/P #30: lower silts, lower "leafy" soil	Sedentary	Sacaton	1000-1150
7	164	25.5	7A	2	Water catchment	Strat 33: very fine sand with siltier areas; 0.15 m above feature base	Sedentary-early Classic	Sacaton-Soho	950-1200
7	165	26.0	7A	3	Water catchment	Strat 35: clay; 0.25 m above base (pilot samples analyzed 6/3/09)	Sedentary-early Classic	Sacaton-Soho	950-1200
7	166	33.6	7A	4	Water catchment	Strat 36: sandy silt, 0.34 m above base	Sedentary early Classic	Sacaton-Soho	950-1200
7	167	30.9	7A	5	Water catchment	Strat 37: fine sand, 0.42 m above base	Sedentary-early Classic	Sacaton-Soho	950-1200
7	168	26.2	7A	6	Water catchment	Strat 39: sandy silt, 0.58 m above base	Sedentary-early Classic	Sacaton-Soho	950-1200
7	169	26.0	7A	7	Water catchment	Strat 40: clay; 0.63 m above base (pilot samples analyzed 6/3/09)	Sedentary-early Classic	Sacaton-Soho	950-1200
300	613	29.6	5A	–	Pithouse	Floor composite	Sedentary-Classic transition	Late Sacaton-early Soho	1100-1200
301	743	32.8	5A	–	Pithouse	Floor composite	Sedentary-Classic transition	Late Sacaton-early Soho	1100-1200

Table D.1. Continued.

Feature Number	Field Number (FN)	Pollen Sample Weight (gm)	Area	Field Sample	Context	Context Comments	Period	Phase	Age (A.D.)
302	715	28.2	5A	–	Pithouse	Floor composite	Sedentary-Classic transition	Late Sacaton-early Soho	1100-1200
307	698	28.8	5A	–	Pithouse	Floor composite	Sedentary-Classic transition	Late Sacaton-early Soho	1100-1200
312	828	31.6	6B	–	Pithouse	Floor composite	Sedentary (early)	Early Sacaton	950-1000
313	836	27.5	6B	–	Pithouse	Floor composite	Sedentary (early)	Early Sacaton	950-1000
314	844	31.9	6B	–	Pithouse	Floor composite	Sedentary (early)	Early Sacaton	950-1000
316	855	30.5	6B	–	Pithouse	Floor composite	Sedentary (early)	Early Sacaton	950-1000
306	779	31.0	3A	–	Pithouse	Floor composite	Colonial	Santa Cruz	850-900
310	789	31.0	3A	–	Pit with trivets	Pit fill (wall scrape)	Colonial	Santa Cruz	850-900
318	882	30.8	3B	–	Pithouse	Floor composite	Classic (early)	Soho	1200-1300
326	1344	28.0	3B	–	Storage (?) pit	Pit fill (wall scrape)	Classic (early)	Soho	1200-1300
329	1293	30.4	3B	–	Adobe structure	Floor composite	Classic (early)	Soho	1200-1300
334	1313	29.0	3B	–	Storage (?) pit	Pit fill (wall scrape)	Classic (early)	Soho	1200-1300

Table D.2. Summary pollen concentration measures[a], scan

Feature	Field Number (FN)	Field Sample	Sample Weight (gm)	Tracers	Pollener Sum *us*)	Walnut (*Juglans*)	Mesquite (*Prosopis*)	Creosotebush (*Larrea*)	Jojoba (*Simmondsia*)
320	1364	SL20a	25.3	6	200	–	–	–	–
320	1365	SL20b	27.2	8	200	–	–	–	–
320	1370	SL20c	30.6	10	200	–	–	–	–
320	1366	SL20d	30.6	15	200	–	–	–	–
320	1367	SL21a	28.1	2	200	–	–	–	–
320	1368	SL21b	27.8	7	200	–	–	–	–
320	1371	SL21c	25.5	8	200	–	–	–	–
320	1369	SL21d	29.6	4	200	–	–	–	–
320	1372	SL22a	26.1	2	200	–	–	–	–
320	1373	SL22b	24.1	7	200	–	–	–	–
320	1374	SL22c	29.2	14	200	–	–	–	–
320	1375	SL1	29.1	9	200	–	–	–	–
320	1378	SL4	29.0	8	200	–	–	–	–
320	1379	SL5	29.5	19	200	–	–	–	–
320	1380	SL6	33.8	4	200	–	–	1	–
320	1381	SL7	30.1	5	200	–	–	–	–
320	1382	SL8	31.5	17	200	LFS	–	–	–
320	1383	SL9	30.5	32	200	–	–	–	–
0	1384	SL10	29.4	36	200	–	–	–	–
0	1385	SL11	32.5	17	200	–	–	–	–
0	1386	SL12	32.5	20	200	–	–	–	–
320	1388	SL30b	31.1	5	200	–	–	–	–
320	1391	SL31b	31.6	7	200	–	–	–	–
320	1393	SL32a	31.0	5	200	–	–	–	–
320	1394	SL32b	29.0	5	200	–	–	–	–
320	1395	SL32c	25.3	2	200	–	–	–	–
320	1397	SL33b	27.6	9	200	–	–	–	–
320	1399	SL34a	32.9	7	200	–	–	–	–
320	1400	SL34b	26.2	4	200	–	–	–	–
320	1401	SL34c	29.7	7	200	–	–	–	–
57	1164	SL1a	26.2	2	200	–	X	–	–
57	1168	SL1b	23.0	9	200	–	–	–	–
57	1159	SL2b	24.8	13	200	–	–	–	–
57	1163	SL3a	22.1	7	200	–	1	–	–
57	1125	SL3b	26.6	2	200	–	1	–	1
57	1162	SL4a	26.0	4	200	–	–	–	–
57	1160	SL4b	26.6	9	200	–	–	–	–
57	1120	SL5a	19.1	20	200	–	–	–	–
57	1124	SL6a	24.9	9	200	–	–	–	–
57	1169	SL6b	22.6	6	200	–	–	–	–
7	164	2	25.5	7	200	–	–	–	–
7	165	3	26.0	29	211	–	–	–	–
7	166	4	33.6	5	200	–	–	–	–
7	167	5	30.9	9	200	–	–	–	–
7	168	6	26.2	14	200	–	–	–	–
7	169	7	26.0	86	309	–	–	–	–
300	613	–	29.6	29	200	–	–	–	–
301	743	–	32.8	39	200	–	–	–	–
302	715	–	28.2	24	200	–	–	–	–
307	698	–	28.8	5	200	–	–	–	–
312	828	–	31.6	12	200	–	–	–	–

Table D.2. Summary pollen concentration measures[a], scan identifications[b] (X and LFS), and raw counts, PHX Sky Train project.

Feature	Field Number (FN)	Field Sample	Sample Weight (gm)	Tracers	Pollen Sum	Pollen Concentration (grains per cc)	Pollen Concentration (grains per gm)	Deteriorated	Unknown	Maize (*Zea*)	Squash (*Cucurbita*)	Cotton (*Gossypium*)	Cholla (*Cylindropuntia*)	Cactus Family (Cactaceae)	Prickly Pear (*Platyopuntia*)	Cattail (*Typha* monad)	Alder (*Alnus*)	Walnut (*Juglans*)	Mesquite (*Prosopis*)	Creosotebush (*Larrea*)	Jojoba (*Simmondsia*)
320	1364	SL20a	25.3	6	200	61,946.7	48,969.7	1	1	LFS	LFS	LFS	X	–	LFS	–	–	–	–	–	–
320	1365	SL20b	27.2	8	200	46,460.0	34,161.8	1	–	X	LFS	X	X	LFS	LFS	–	–	–	–	–	–
320	1370	SL20c	30.6	10	200	37,168.0	24,292.8	2	–	X	–	LFS	X	–	LFS	–	–	–	–	–	–
320	1366	SL20d	30.6	15	200	24,778.7	16,195.2	1	–	X	LFS	–	1	–	LFS	–	–	–	–	–	–
320	1367	SL21a	28.1	2	200	185,840.0	132,270.5	3	1	LFS	–	–	X	–	LFS	–	–	–	–	–	–
320	1368	SL21b	27.8	7	200	53,097.1	38,199.4	4	–	1	–	–	X	–	–	–	–	–	–	–	–
320	1371	SL21c	25.5	8	200	46,460.0	36,439.2	4	–	LFS	LFS	–	X	–	LFS	–	–	–	–	–	–
320	1369	SL21d	29.6	4	200	92,920.0	62,783.3	3	1		–	1	2	–	–	–	–	–	–	–	–
320	1372	SL22a	26.1	2	200	185,840.0	142,406.1	2	–	LFS	–	–	2	–	–	–	–	–	–	–	–
320	1373	SL22b	24.1	7	200	53,097.1	44,064.0	2	–	1	–	LFS	2	–	LFS	–	–	–	–	–	–
320	1374	SL22c	29.2	14	200	26,548.6	18,184.0	3	1	LFS	–	–	2	LFS	–	–	–	–	–	–	–
320	1375	SL1	29.1	9	200	41,297.8	28,383.3	1	–	LFS	–	LFS	X	–	–	–	–	–	–	–	–
320	1378	SL4	29.0	8	200	46,460.0	32,041.4	2	–	–	–	–	–	–	–	–	–	–	–	–	–
320	1379	SL5	29.5	19	200	19,562.1	13,262.4	2	–	–	–	–	LFS	–	–	–	–	–	–	–	–
320	1380	SL6	33.8	4	200	92,920.0	54,982.2	1	1	–	–	–	1	–	–	–	–	–	–	1	–
320	1381	SL7	30.1	5	200	74,336.0	49,392.7	1	–	–	–	–	X	1	1	–	–	–	–	–	–
320	1382	SL8	31.5	17	200	21,863.5	13,881.6	1	–	LFS	–	LFS	X	–	–	–	–	LFS	–	–	–
320	1383	SL9	30.5	32	200	11,615.0	7,616.4	1	1	X	–	–	X	–	–	–	–	–	–	–	–
0	1384	SL10	29.4	36	200	10,324.4	7,095.8	1	–	X	–	LFS	X	–	–	–	–	–	–	–	–
0	1385	SL11	32.5	17	200	21,863.5	13,454.5	1	–	LFS	–	–	X	–	–	–	–	–	–	–	–
0	1386	SL12	32.5	20	200	18,584.0	11,435.3	1	–	–	–	–	1	–	–	–	–	–	–	–	–
320	1388	SL30b	31.1	5	200	74,336.0	47,804.5	4	–	1	–	LFS	X	–	LFS	–	–	–	–	–	–
320	1391	SL31b	31.6	7	200	53,097.1	33,605.8	1	–	X	–	–	1	–	LFS	–	–	–	–	–	–
320	1393	SL32a	31.0	5	200	74,336.0	47,958.7	3	–	LFS	LFS	LFS	1	–	–	–	–	–	–	–	–
320	1394	SL32b	29.0	5	200	74,336.0	51,266.2	1	–	LFS	–	LFS	1	–	–	–	–	–	–	–	–
320	1395	SL32c	25.3	2	200	185,840.0	146,909.1	3	–	X	–	–	X	–	–	–	–	–	–	–	–
320	1397	SL33b	27.6	9	200	41,297.8	29,925.9	1	–	X	–	LFS	1	–	LFS	–	–	–	–	–	–
320	1399	SL34a	32.9	7	200	53,097.1	32,277.9	2	–	LFS	–	LFS	X	X	X	–	–	–	–	–	–
320	1400	SL34b	26.2	4	200	92,920.0	70,931.3	1	1	X	–	LFS	X	–	–	–	–	–	–	–	–
320	1401	SL34c	29.7	7	200	53,097.1	35,755.6	1	–	X	–	LFS	1	–	–	–	–	–	–	–	–
57	1164	SL1a	26.2	2	200	185,840.0	141,862.6	3	–	–	–	–	–	–	–	–	–	–	X	–	–
57	1168	SL1b	23.0	9	200	41,297.8	35,911.1	2	–	1	–	–	1	–	–	–	–	–	–	–	–
57	1159	SL2b	24.8	13	200	28,590.8	23,057.1	3	–	X	–	–	–	–	–	–	–	–	–	–	–
57	1163	SL3a	22.1	7	200	53,097.1	48,051.7	2	–	–	–	–	–	–	–	–	1	–	1	–	–
57	1125	SL3b	26.6	2	200	185,840.0	139,729.3	1	–	–	–	–	–	–	–	–	–	–	1	–	1
57	1162	SL4a	26.0	4	200	92,920.0	71,476.9	3	1	X	–	–	1	–	–	–	1	–	–	–	–
57	1160	SL4b	26.6	9	200	41,297.8	31,051.0	3	–	X	–	–	–	–	–	–	–	–	–	–	–
57	1120	SL5a	19.1	20	200	18,584.0	19,459.7	2	–	–	–	–	1	–	–	–	–	–	–	–	–
57	1124	SL6a	24.9	9	200	41,297.8	33,170.9	2	–	–	–	–	X	–	–	–	1	–	–	–	–
57	1169	SL6b	22.6	6	200	61,946.7	54,820.1	2	2	–	–	–	1	–	–	–	–	–	–	–	–
7	164	2	25.5	7	200	53,097.1	41,644.8	1	2	–	–	–	–	–	–	–	–	–	–	–	–
7	165	3	26.0	29	211	13,521.5	10,401.1	26	3	X	–	–	X	–	–	–	–	–	–	–	–
7	166	4	33.6	5	200	74,336.0	44,247.6	6	–	–	–	–	X	–	–	–	–	–	–	–	–
7	167	5	30.9	9	200	41,297.8	26,730.0	4	1	–	–	–	2	–	–	–	–	–	–	–	–
7	168	6	26.2	14	200	26,548.6	20,266.1	5	–	–	–	–	X	–	–	–	–	–	–	–	–
7	169	7	26.0	86	309	6,677.3	5,136.4	54	1	X	X	X	X	X	X	–	–	–	–	–	–
300	613	–	29.6	29	200	12,816.6	8,659.8	2	–	X	–	–	1	–	–	–	–	–	–	–	–
301	743	–	32.8	39	200	9,530.2	5,811.1	3	1	7	–	–	X	–	–	–	–	–	–	–	–
302	715	–	28.2	24	200	15,486.7	10,983.4	3	1	X	–	–	1	–	–	–	–	–	–	–	–
307	698	–	28.8	5	200	74,336.0	51,622.2	1	1	1	–		3	–	–	–	–	–	–	–	–
312	828	–	31.6	12	200	30,973.3	11,762.0	1	–	X	–	X	X	–	–	–	–	–	–	–	–

Table D.2. Continued.

Feature	Field Number (FN)	Field Sample	Sample Weight (gm)	Tracers	Pollen Sum	Pollen Concentration (grains per cc)	Pollen Concentration (grains per gm)	Deteriorated	Unknown	Maize (*Zea*)	Squash (*Cucurbita*)	Cotton (*Gossypium*)	Cholla (*Cylindropuntia*)	Cactus Family (Cactaceae)	Prickly Pear (*Platyopuntia*)	Cattail (*Typha* monad)	Alder (*Alnus*)	Walnut (*Juglans*)	Mesquite (*Prosopis*)	Creosotebush (*Larrea*)	Jojoba (*Simmondsia*)
313	836	–	27.5	42	200	8,849.5	6,436.0	3	–	1	–	–	2	–	–	–	–	–	–	–	–
314	844	–	31.9	58	200	6,408.3	4,017.7	4	1	6	–	–	X	–	–	–	–	–	–	–	–
316	855	–	30.5	17	200	21,863.5	14,336.7	4	1	X	–	–	3	–	–	–	–	–	–	–	–
306	779	–	31.0	11	200	33,789.1	21,799.4	4	1	1	–	–	1	–	–	–	–	–	–	–	–
310	789	–	31.0	40	200	9,292.0	5,994.8	5	2	2	–	–	1	–	–	–	–	–	–	–	–
318	882	–	30.8	3	200	123,893.3	80,450.2	4	1	X	–	–	2	–	–	–	–	–	–	–	–
326	1344	–	28.0	14	200	26,548.6	18,963.3	1	–	2	–	–	4	–	–	–	–	–	–	–	–
329	1293	–	30.4	23	200	16,160.0	10,631.6	3	1	1	–	X	9	–	–	1	–	–	–	–	–
334	1313	–	29.0	134	200	2,773.7	1,912.9	2	–	–	–	–	–	–	–	–	–	–	–	–	–

[a]Pollen concentrations are calculated two ways: grains per cc of sample sediment and grains per gram of sample sediment. The parameters necessary to calculate concentrations include sample volume, which was 20 cc for all samples, or sample weights, documented in the fourth column of this table, and the initial tracer concentration of 37,168 spores of *Lycopodium*.

[b]X and LFS note taxon identifications resulting from two levels of scanning implemented after the conventional 200 grain counts were obtained. X is the symbol used for taxa observed during 100x scans of single microscope slides, and LFS is the abbreviation for large fraction scanning. LFS was used only on Feature 320 field samples. For LFS, the pollen extractions were split and one fraction was sieved through screens to separate larger pollen grains.

[c]Pine fragments is a category used to document broken pine pollen grains, which can reflect turbulent water or other poor preservation environments.

[d]Algal polyad is a special category of palynomorph that may reflect hydrologic environments. The polyads are not included in the pollen sum.

Table D.2. Continued.

Feature	Field Number (FN)	Yucca (*Yucca*)	Cheno am (Cheno-am)	Bursage type, *Ambrosia* type	Sunflower type (*Helianthus* type)	Grass (Poaceae)	Tidestromia type (*Tidestromia* type)	Wild-lettuce type (*Liguliflorae*)	Buckwheat (*Eriogonum*)	Globemallow (*Sphaeralcea*)	Four-o'clock (*Mirabilis*)	Spiderling (*Boerhaavia*)	Summer Poppy (*Kallstroemia*)	Spurge Family (Euphorbiaceae)	Rock Purslane (*Calandrinia*)	Pink Family (Caryophyllaceae)	Mustard Family (Brassicaceae)	Spectacle-pod type (*Dithyrea* type)	Papilionoideae (Papilionoideae)	Evening Primrose type (*Oenothera* type)
320	1364	–	170	9	3	5	2	–	–	4	–	1	1	1	–	–	–	–	–	–
320	1365	–	179	7	7	1	2	–	1	X	–	1	1	–	–	–	–	–	–	–
320	1370	–	167	13	8	1	LFS	–	–	3	–	3	1	–	–	–	1	–	–	LFS
320	1366	–	178	3	3	1	1	–	–	2	–	3	3	1	–	–	–	–	–	–
320	1367	–	167	15	1	4	1	–	–	4	–	1	1	1	–	–	–	–	–	–
320	1368	–	163	9	7	3	LFS	–	X	4	–	2	2	–	–	–	–	–	–	–
320	1371	–	156	19	9	4	1	–	–	1	–	2	3	–	–	–	–	–	–	–
320	1369	–	142	20	5	3	11	–	–	3	–	7	X	2	–	–	–	–	–	–
320	1372	–	171	4	6	2	–	1	–	6	–	2	LFS	–	–	–	–	–	–	–
320	1373	–	156	16	5	6	1	–	–	2	–	1	1	X	–	–	–	–	–	–
320	1374	–	158	8	5	3	4	–	–	8	–	2	1	2	–	–	1	1	–	–
320	1375	–	162	14	12	5	LFS	X	X	3	–	X	X	2	–	–	–	–	–	LFS
320	1378	–	150	22	12	3	–	X	–	1	–	1	–	4	–	–	–	–	–	–
320	1379	–	172	16	6	–	1	X	X	X	–	1	LFS	1	–	–	–	–	–	–
320	1380	–	169	11	5	1		1	1	–	–	3	X	2	–	–	–	–	–	–
320	1381	–	167	12	10	3	1	–	X	1	–	X	X	2	–	–	–	–	–	–
320	1382	–	167	19	5	1	–	–	LFS	2	–	2	X	–	–	–	–	–	–	–
320	1383	–	176	8	6	3	1	–	–	1	–	2	X	1	LFS	–	–	–	–	–
0	1384	–	163	23	4	1	1	1	1	4	–	X	X	1	X	–	–	–	–	–
0	1385	–	157	23	4	2	X	–	–	3	–	2	1	2	–	–	1	–	–	–
0	1386	–	163	23	5	–	1	–	–	2	–	1	1	2	–	–	–	–	–	–
320	1388	–	165	13	2	LFS	5	–	–	2	–	1	X	1	–	–	1	1	–	–
320	1391	–	185	3	LFS	LFS	3	–	–	2	LFS	3	X	–	–	–	1	–	–	–
320	1393	–	163	15	5	5	LFS	X	–	X	–	1	1	–	–	–	–	–	–	–
320	1394	–	176	6	3	3	LFS	–	–	5	–	2	LFS	–	–	–	–	–	–	–
320	1395	–	162	11	4	3	2	–	1	7	–	1	1	–	–	–	1	–	–	–
320	1397	–	176	7	3	1	1	–	–	1	–	8	1	–	–	–	–	–	–	–
320	1399	–	164	16	7	3	1	–	–	1	LFS	3	X	1	LFS	–	–	–	–	–
320	1400	–	165	13	3	3	LFS	–	–	4	LFS	3	4	1	LFS	–	X	–	–	LFS
320	1401	–	177	13	3	1	LFS	–	–	X	–	3	X	–	–	–	–	–	–	–
57	1164	–	91	66	18	10	–	1	1	–	–	X	–	1	–	–	2	–	–	–
57	1168	–	102	55	19	5	–	–	–	–	–	X	–	2	–	–	–	–	–	–
57	1159	–	102	42	17	8	–	–	2	1	–	1	–	3	–	1	1	–	–	–
57	1163	–	51	102	19	6	3	–	2	4	–	–	–	2	–	–	–	–	–	–
57	1125	1	91	57	19	10	1	–	1	1	–	X	1	2	–	–	–	–	–	–
57	1162	–	86	60	22	9	–	1	1	2	–	2	–	1	–	–	–	–	–	–
57	1160	–	57	74	12	20	1	–	X	3	–	1	–	1	–	–	–	–	–	–
57	1120	–	91	68	18	5	2	–	–	1	–	X	–	–	–	–	–	–	–	–
57	1124	–	64	64	29	16	1	–	1	2	–	1	–	2	–	–	4	–	1	–
57	1169	–	71	71	31	4	–	–	1	1	–	X	–	2	–	–	3	–	–	–
7	164	–	136	28	6	13	4	–	–	3	–	2	1	–	–	–	1	–	X	–
7	165	–	67	1	84	10	–	–	–	1	–	X	X	6	–	–	–	–	–	–
7	166	–	134	17	11	18	1	–	1	5	–	1	3	2	–	–	–	–	–	–
7	167	–	119	31	16	3	5	–	–	6	–	4	X	2	–	–	1	2	–	–
7	168	–	138	31	10	3	2	–	–	3	–	3	2	–	–	–	1	–	–	–
7	169	–	150	18	64	–	–	–	2	2	–	2	X	9	–	–	–	–	–	–
300	613	–	163	15	5	3	4	–	2	X	–	2	X	1	–	–	–	–	–	X
301	743	–	125	28	11	6	–	–	1	7	–	3	5	–	–	–	–	–	–	–
302	715	–	142	18	11	3	1	–	2	3	–	9	2	1	–	–	–	–	–	–
307	698	–	164	10	5	3	–	1	–	3	–	3	3	–	–	–	–	–	–	–
312	828	–	150	29	8	3	–	–	–	2	–	4	1	–	–	–	–	–	–	–

Table D.2. Continued.

Feature	Field Number (FN)	Yucca (*Yucca*)	Cheno am (Cheno-am)	Bursage type (*Ambrosia* type)	Sunflower type (*Helianthus* type)	Grass (Poaceae)	Tidestromia type (*Tidestromia* type)	Wild-lettuce type (*Liguliflorae*)	Buckwheat (*Eriogonum*)	Globemallow (*Sphaeralcea*)	Four-o'clock (*Mirabilis*)	Spiderling (*Boerhaavia*)	Summer Poppy (*Kallstroemia*)	Spurge Family (Euphorbiaceae)	Rock Purslane (*Calandrinia*)	Pink Family (Caryophyllaceae)	Mustard Family (Brassicaceae)	Spectacle-pod type (*Dithyrea* type)	Papilionoideae (Papilionoideae)	Evening Primrose type (*Oenothera* type)
313	836	–	159	8	7	–	2	–	–	5	–	8	4	–	–	–	–	–	–	–
314	844	–	152	14	4	–	–	–	1	8	–	8	X	–	–	–	–	–	–	–
316	855	–	141	18	6	2	2	–	–	6	–	13	1	1	–	–	–	–	–	–
306	779	–	123	24	8	7	4	–	6	5	–	12	2	–	–	–	–	–	–	–
310	789	–	158	11	5	4	1	–	1	1	–	5	3	–	–	–	–	–	–	–
318	882	–	157	11	3	10	2	–	1	3	–	5	1	–	–	–	–	–	–	–
326	1344	–	168	3	5	1	–	–	1	–	–	8	2	1	–	–	–	–	–	–
329	1293	–	148	13	10	2	4	–	2	1	–	4	X	–	–	–	–	–	–	X
334	1313	–	166	10	7	1	–	–	–	–	–	10	X	1	–	–	–	–	–	–

Table D.2. Continued.

Feature	Field Number (FN)	Gaura type (*Gaura* type)	Indian Wheat (*Plantago*)	Ground Cherry/Nightshade (*Physalis/Solanum*)	Spruce (*Picea*)	Fir (*Abies*)	Pine Fragments[c] (Pinceae fragments)	Pinon type (*Pinus edulis* type)	Ponderosa type (*Pinus ponderosa* type)	Juniper (*Juniperus*)	Oak (*Quercus*)	Mormon Tea (N type) (*Ephedra nevadensis* type)	Mormon Tea (T type) (*Ephedra torreyana* type)	Sagebrush (*Artemisia*)	Crane's Bill (*Erodium*)	Pecan (*Carya*)	Elm (*Ulmus*)	Oleaster Family (Elaeagnaceae)	Algal Polyads[d]
320	1364	–	–	–	LFS	LFS	–	2	X	–	–	X	–	–	–	–	–	–	–
320	1365	X	–	–	LFS	LFS	–	LFS	X	–	–	–	–	–	–	–	–	–	X
320	1370	LFS	–	1	–	LFS	–	–	LFS	–	–	–	–	–	–	–	–	–	–
320	1366	–	1	–	–	–	–	1	LFS	–	–	–	–	1	–	–	–	–	X
320	1367	–	–	–	–	LFS	–	1	X	–	–	–	–	–	–	–	–	–	X
320	1368	–	1	–	LFS	–	–	2	LFS	1	–	–	–	1	–	–	–	–	–
320	1371	–	–	–	–	–	–	1	LFS	–	–	–	–	–	–	–	–	–	–
320	1369	–	–	–	–	–	–	LFS	LFS	–	–	–	–	–	–	–	–	–	–
320	1372	–	–	–	–	–	1	LFS	LFS	1	–	1	–	1	–	–	–	–	–
320	1373	–	2	–	1	LFS	–	1	2	1	–	X	–	–	–	–	–	–	–
320	1374	–	–	–	LFS	–	–	X	1	–	–	–	–	–	–	–	–	–	–
320	1375	–	1	–	LFS	–	–	X	X	–	–	LFS	–	–	–	LFS	–	–	–
320	1378	–	1	–	–	–	–	2	–	1	–	–	–	1	–	–	–	–	–
320	1379	–	–	–	–	–	–	LFS	–	1	–	LFS	X	–	–	–	–	–	–
320	1380	–	–	–	–	–	–	X	–	1	–	1	X	–	–	–	–	–	–
320	1381	–	–	X	LFS	–	–	X	X	–	–	X	–	1	–	–	–	–	–
320	1382	–	–	–	–	–	–	1	1	–	–	LFS	–	1	–	–	–	–	LFS
320	1383	–	–	–	–	–	–	X	LFS	–	–	–	–	–	–	–	–	–	–
0	1384	–	–	–	–	–	–	X	X	–	–	–	–	–	–	–	–	–	–
0	1385	–	–	–	–	–	–	3	1	–	–	–	–	–	–	–	–	–	–
0	1386	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
320	1388	–	–	–	–	–	–	1	X	1	1	1	–	–	–	–	–	–	LFS
320	1391	–	1	–	LFS	–	–	X	LFS	–	–	–	–	–	–	–	–	–	–
320	1393	–	–	–	LFS	–	–	2	X	4	–	–	–	–	–	–	–	–	–
320	1394	–	–	–	LFS	–	–	1	1	1	–	–	–	–	–	–	–	–	–
320	1395	–	–	–	–	–	–	1	1	2	–	–	–	–	–	–	–	–	–
320	1397	–	–	–	–	–	–	X	X	–	X	–	–	–	–	–	–	–	–
320	1399	–	–	–	LFS	–	–	X	1	–	–	1	LFS	–	–	–	–	–	–
320	1400	–	–	–	–	–	–	1	X	–	1	–	–	–	–	–	–	–	X
320	1401	–	–	–	–	–	–	X	X	1	–	–	–	–	–	–	–	–	X
57	1164	–	1	–	–	–	–	X	1	–	3	1	–	1	–	–	–	–	X
57	1168	–	1	–	–	–	–	1	3	4	1	2	–	1	–	–	–	–	X
57	1159	–	–	–	X	–	1	9	3	3	2	–	–	1	–	–	–	–	X
57	1163	–	–	–	–	–	1	2	1	1	–	–	–	1	–	–	–	1	X
57	1125	–	2	–	–	X	–	2	3	3	1	–	1	1	–	–	–	–	X
57	1162	–	–	–	–	–	–	3	1	1	3	–	–	2	–	–	–	–	–
57	1160	–	1	–	X	–	2	9	6	4	3	1	–	2	–	–	–	–	X
57	1120	–	–	–	–	–	–	2	2	2	4	–	–	2	–	–	–	–	X
57	1124	–	1	–	–	–	–	3	1	2	3	–	–	1	–	1	–	–	X
57	1169	–	–	–	–	–	–	4	–	1	4	–	–	2	–	–	–	–	X
7	164	–	1	–	–	–	1	X	1	–	–	–	–	–	–	–	–	–	–
7	165	–	–	–	–	–	–	3	6	4	–	–	–	–	–	–	–	–	–
7	166	–	1	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	X
7	167	–	1	–	–	–	–	–	–	1	–	–	–	2	–	–	–	–	X
7	168	X	–	–	–	–	–	1	–	–	–	–	1	–	–	–	–	–	–
7	169	–	–	–	–	–	–	–	3	4	–	–	–	–	–	–	–	–	–
300	613	–	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
301	743	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	X
302	715	–	1	–	–	–	–	1	X	–	–	1	–	–	X	–	–	–	–
307	698	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
312	828	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–

Table D.2. Continued.

Feature	Field Number (FN)	Gaura type (*Gaura* type)	Indian Wheat (*Plantago*)	Ground Cherry/Nightshade (*Physalis/Solanum*)	Spruce (*Picea*)	Fir (*Abies*)	Pine Fragments[c] (Pinceae fragments)	Pinon type (*Pinus edulis* type)	Ponderosa type (*Pinus ponderosa* type)	Juniper (*Juniperus*)	Oak (*Quercus*)	Mormon Tea (N type) (*Ephedra nevadensis* type)	Mormon Tea (T type) (*Ephedra torreyana* type)	Sagebrush (*Artemisia*)	Crane's Bill (*Erodium*)	Pecan (*Carya*)	Elm (*Ulmus*)	Oleaster Family (Elaeagnaceae)	Algal Polyads[d]
313	836	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
314	844	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–
316	855	–	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	X
306	779	–	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
310	789	–	1	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–
318	882	–	–	–	–	–	–	X	X	–	–	–	–	–	–	–	–	–	–
326	1344	–	–	–	–	–	–	1	1	–	1	1	–	–	–	–	–	–	–
329	1293	X	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
334	1313	–	–	–	–	–	–	2	1	–	–	–	–	–	–	–	X	–	X

Table D.3. Pollen aggregate information[a] from conventional counts and 100x scans of one microscope slide, PHX Sky Train project.

Feature Number	Field Number (FN)	Field Sample	Total Number of Aggregates	Maize Aggregates	Cholla Aggregates	Pinon type Aggregates	Ponderosa type Aggregates	Mormon Tea (*Ephedra* N) Aggregates	Cheno-am Aggregates	Tidestromia type Aggregates	Bursage type Aggregates	Sunflower type Aggregates	Grass Aggregates	Buckwheat Aggregates	Spiderling Aggregates	Mustard Family Aggregates	Summer Poppy Aggregates	Spurge Family Aggregates	Globemallow Aggregates	Indian Wheat Aggregates
320	1364	SL20a	28+	–	(2a)	–	–	–	5d(250c)	3a	2a	–	–	–	(3b)	–	–	–	–	–
320	1365	SL20b	37+	(8b)	–	–	–	–	80e(400d)	2a(200a)	–	6a	–	–	(3a)	–	–	–	(6a)	–
320	1370	SL20c	30+	–	–	–	–	–	30d(500d)	–	2b	–	–	–	11a(12a)	–	–	–	(3a)	–
320	1366	SL20d	35+	(3a)	–	–	–	–	20e(300d)	–	(14a)	–	–	–	11a	–	(5a)	–	13a	–
320	1367	SL21a	28+	–	(5a)	–	–	–	15e(250c)	–	2a	–	–	–	(4b)	–	–	–	2a	–
320	1368	SL21b	32+	(2a)	–	–	4a	–	80d(220c)	–	–	2a	–	–	(10c)	–	–	–	–	–
320	1371	SL21c	25+	–	–	–	–	–	50e(180c)	2a	–	–	–	–	(9a)	–	–	–	–	–
320	1369	SL21d	32+	–	–	–	–	–	12c(170c)	5c(100b)	2b	–	–	–	3a(4b)	–	–	3a	–	–
320	1372	SL22a	19+	–	–	–	–	–	12c(500c)	–	2a	–	–	–	(3a)	–	–	–	2a	–
320	1373	SL22b	6+	–	–	–	(2a)	–	5b	–	–	–	–	–	–	–	–	–	–	–
320	1374	SL22c	21+	–	–	(4a)	–	–	20d(120b)	5a	–	–	–	–	(9a)	–	–	–	2a	–
320	1375	SL1	12+	–	–	–	–	–	4c(40b)	–	–	–	–	–	–	–	–	–	–	–
320	1378	SL4	6+	–	–	–	–	–	3b(30a)	–	2a	–	–	–	–	–	–	–	–	–
320	1379	SL5	22+	–	–	–	–	–	12e	(2a)	(5a)	–	–	–	(11a)	–	–	–	–	–
320	1380	SL6	17+	–	–	–	–	–	8d	–	(4a)	–	–	–	(4b)	–	–	–	–	–
320	1381	SL7	9+	–	–	–	–	(2a)	4b(17b)	–	–	(20a)	–	–	–	–	–	–	–	–
320	1382	SL8	13+	–	–	–	–	–	5c(60b)	–	–	–	–	–	(8a)	–	–	–	–	–
320	1383	SL9	23+	–	–	–	–	–	20d(170b)	–	3b	3a	–	–	(9c)	–	–	–	–	–
0	1384	SL10	16+	–	–	–	–	–	4c(60b)	2a	3b	–	–	–	(3b)	–	–	–	–	–
0	1385	SL11	15+	–	–	–	–	–	4c(30b)	(70a)	–	–	–	–	(14b)	–	–	–	(3a)	–
0	1386	SL12	26+	–	–	–	–	–	10d(60b)	–	3a	–	–	–	(9b)	–	–	–	2a(12b)	–
320	1388	SL30b	23+	(3a)	–	–	–	–	10c(200c)	–	2a	–	–	–	(16b)	–	–	–	–	–
320	1391	SL31b	43+	–	(9a)	–	–	–	30e(130d)	3a	–	–	–	–	(12b)	–	(4a)	–	–	–
320	1393	SL32a	20+	–	–	–	–	–	20d(200c)	–	–	–	–	–	2a	–	–	–	–	–
320	1394	SL32b	16+	–	–	–	–	–	30d(120a)	–	–	–	–	–	(13b)	–	–	–	(2b)	–
320	1395	SL32c	20+	–	–	–	–	–	4d(180c)	30b	–	–	–	–	2a(4a)	–	–	–	–	–
320	1397	SL33b	43+	(3b)	(7a)	–	–	–	130e(200d)	–	–	–	–	–	2a(21b)	–	–	–	(18b)	–
320	1399	SL34a	31+	–	–	–	–	–	8d(300c)	12a	2a	–	–	–	(17b)	–	–	–	(2a)	–
320	1400	SL34b	57+	–	–	–	–	–	7e(300f)	–	–	2a	–	–	(6b)	–	–	–	–	–
320	1401	SL34c	50+	–	(3a)	–	–	–	30e(500f)	–	(7a)	–	–	–	–	–	–	–	–	–
57	1164	SL1a	7+	–	–	–	–	–	4b(60a)	–	5b	–	–	–	–	–	–	–	–	–
57	1168	SL1b	9+	–	–	–	–	–	6b	–	2b	–	3a	–	–	–	–	–	–	–
57	1159	SL2b	9+	–	–	–	–	–	30c(40a)	2a	–	–	–	–	–	–	–	–	–	–
57	1163	SL3a	7+	–	–	–	–	–	3a	–	4b	–	6a(9b)	–	–	–	–	–	–	–
57	1125	SL3b	4	–	–	–	–	–	12b	–	2b	–	–	–	–	–	–	–	–	–
57	1162	SL4a	6+	–	–	–	–	–	3b(17a)	–	–	–	2a	–	–	–	–	–	–	–
57	1160	SL4b	9+	–	–	–	2b	–	2a	–	3b(7b)	2a	–	–	–	–	–	–	–	–
57	1120	SL5a	10+	–	–	–	–	–	4b	–	2a(14)	2b	–	–	(2a)	–	–	–	–	–
57	1124	SL6a	4	–	–	–	–	–	5b	–	–	–	–	–	–	2a	–	–	–	–
57	1169	SL6b	7+	–	–	–	–	–	3b(12a)	–	6b	–	–	–	–	–	–	–	–	–
7	164	2	12+	–	–	–	–	–	6c	–	4b	–	–	–	–	–	–	–	–	–
7	165	3	1	–	–	–	–	–	1a	–	–	–	–	–	–	–	–	–	–	–
7	166	4	9+	–	–	–	–	–	2b(5a)	–	3a	–	3a	–	(3b)	–	–	–	–	–
7	167	5	15+	–	–	–	–	–	15c	5b	–	3a	(2a)	–	(3b)	–	–	–	–	–
7	168	6	15+	–	–	–	–	–	4c(12b)	–	4b	–	–	–	(3a)	–	(4a)	–	–	–
7	169	7	2	–	–	–	–	–	2a	–	–	–	–	–	–	–	–	–	–	–
300	613	–	23+	(3a)	–	–	–	–	20d(120c)	3a	–	–	–	–	(3a)	–	–	–	–	–
301	743	–	46+	(9e)	–	–	–	–	300c(300d)	–	–	–	–	–	(16b)	–	(2a)	–	(12a)	–
302	715	–	40+	(2a)	–	–	–	–	5d(500b)	(250a)	3a	2a	(6a)	–	2a(28c)	–	(2a)	(9a)	2a(7b)	(11a)

Table D.3. Continued.

Feature Number	Field Number (FN)	Field Sample	Total Number of Aggregates	Maize Aggregates	Cholla Aggregates	Pinon type Aggregates	Ponderosa type Aggregates	Mormon Tea (*Ephedra* N) Aggregates	Cheno-am Aggregates	Tidestromia type Aggregates	Bursage type Aggregates	Sunflower type Aggregates	Grass Aggregates	Buckwheat Aggregates	Spiderling Aggregates	Mustard Family Aggregates	Summer Poppy Aggregates	Spurge Family Aggregates	Globemallow Aggregates	Indian Wheat Aggregates
307	698	-	17+	(4b)	-	-	-	-	19d(26a)	-	-	-	5a	-	2a	-	-	-	-	-
312	828	-	36+	-	(4a)	-	-	-	12d(160e)	-	3b	-	-	-	(2a)	-	-	-	(10b)	-
313	836	-	95+	-	-	-	-	-	100f(800f)	3b	(15a)	6a	-	-	3a(11b)	-	-	-	3b	-
314	844	-	39+	(5c)	-	-	-	-	20e(400c)	-	2a	-	-	-	(5a)	-	-	-	2a(7a)	-
316	855	-	48+	(4a)	-	-	-	-	130e(200e)	3a	4b	-	-	-	5a(30c)	-	-	-	-	-
306	779	-	20+	-	(2a)	-	-	-	8c(190b)	3a	-	-	-	2a	9b	-	-	-	-	-
310	789	-	22+	-	-	-	-	-	90d(200c)	3a	-	-	5a	-	(3a)	-	-	-	-	-
318	882	-	15+	-	-	-	-	-	10c(80b)	-	-	-	-	-	(10b)	-	-	-	-	-
326	1344	-	20+	-	-	-	-	-	20e(140c)	-	-	-	-	-	-	-	-	-	-	-
329	1293	-	49+	-	2a(4b)	-	-	-	350e(400d)	2a	3a	7a	-	(15a)	(8c)	-	-	-	(40a)	-
334	1313	-	38+	-	-	-	-	-	110f(180c)	-	-	-	-	-	(18b)	-	-	-	-	-

[a]Pollen aggregate notation documents aggregate frequency using the following codes: a = 1 aggregate, b = 2-5 aggregates, c = 6-10 aggregates, d = 11-15 aggregates, e = 16-25 aggregates, f = 26-75 aggregates. Aggregate size is recorded directly, but only the largest clump is indicated in the notation. Only small aggregates of about 20 grains or less are specifically counted. Larger aggregates are estimated due to the overlapping masses of the pollen grains.An example of aggregate notation is 15c in the Cheno-am row, which means that up to 10 aggregates were seen during the count, and the largest contained 15 grains of Cheno-am pollen. If the example is (15c) in the Cheno-am row, it means the same observed frequency and size was encountered during 100x magnification scans. Aggregates seen in scanning are relative to the entire slide not just the standard 200 grain count.

Table D.4. Cultigen counts and concentrations based on low magnification (100x) scan of one microscope slide per sample, PHX Sky Train project.

Feature	Sample	Field Sample Number	Sample Weight	Number of Tracers in One Slide Transect	Estimated Number of Tracers per Slide	Total Cultigen Counts from 100x Scans of One Microscope Slide				Calculated Concentrations (gr/gm)		
						Maize	Cotton	Cholla	Squash	Maize	Cotton	Cholla
320	1364	SL20a	25.3	8	328	0	0	4	0	0.0	0.0	17.9
320	1365	SL20b	27.2	21	861	2	1	10	0	3.2	1.6	15.9
320	1370	SL20c	30.6	29	1,189	1	0	9	0	1.0	0.0	9.2
320	1366	SL20d	30.6	14	574	3	0	3	0	6.3	0.0	6.3
320	1367	SL21a	28.1	2	82	0	0	7	0	0.0	0.0	112.9
320	1368	SL21b	27.8	5	205	1	0	7	0	6.5	0.0	45.7
320	1371	SL21c	25.5	7	287	0	0	3	0	0.0	0.0	15.2
320	1369	SL21d	29.6	5	205	0	1	3	0	0.0	6.1	18.4
320	1372	SL22a	26.1	1	41	0	0	3	0	0.0	0.0	104.2
320	1373	SL22b	24.1	11	451	1	0	9	0	3.4	0.0	30.8
320	1374	SL22c	29.2	4	164	0	0	2	0	0.0	0.0	15.5
320	1375	SL1	29.1	7	287	0	0	3	0	0.0	0.0	13.4
320	1378	SL4	29.0	5	205	0	0	0	0	0.0	0.0	0.0
320	1379	SL5	29.5	16	656	0	0	0	0	0.0	0.0	0.0
320	1380	SL6	33.8	2	82	0	0	1	0	0.0	0.0	13.4
320	1381	SL7	30.1	4	164	0	0	1	0	0.0	0.0	7.5
320	1382	SL8	31.5	16	656	0	0	4	0	0.0	0.0	7.2
320	1383	SL9	30.5	25	1,025	1	0	4	0	1.2	0.0	4.8
0	1384	SL10	29.4	28	1,148	2	0	7	0	2.2	0.0	7.7
0	1385	SL11	32.5	11	451	0	0	4	0	0.0	0.0	10.1
0	1386	SL12	32.5	16	656	0	0	3	0	0.0	0.0	5.2
320	1388	SL30b	31.1	6	246	1	0	8	0	4.9	0.0	38.9
320	1391	SL31b	31.6	20	820	1	0	6	0	1.4	0.0	8.6
320	1393	SL32a	31.0	11	451	0	0	10	0	0.0	0.0	26.6
320	1394	SL32b	29.0	2	82	0	0	5	0	0.0	0.0	78.1
320	1395	SL32c	25.3	2	82	2	0	3	0	35.8	0.0	53.7
320	1397	SL33b	27.6	14	574	3	0	15	0	7.0	0.0	35.2
320	1399	SL34a	32.9	20	820	0	0	3	0	0.0	0.0	4.1
320	1400	SL34b	26.2	12	492	1	0	6	0	2.9	0.0	17.3
320	1401	SL34c	29.7	10	410	3	0	3	0	9.2	0.0	9.2
57	1164	SL1a	26.2	1	41	0	0	0	0	0.0	0.0	0.0

Table D.4. Continued.

Feature	Sample	Field Sample Number	Sample Weight	Number of Tracers in One Slide Transect	Estimated Number of Tracers per Slide	Total Cultigen Counts from 100x Scans of One Microscope Slide				Calculated Concentrations (gr/gm)		
						Maize	Cotton	Cholla	Squash	Maize	Cotton	Cholla
57	1168	SL1b	23.0	6	246	1	0	1	0	6.6	0.0	6.6
57	1159	SL2b	24.8	9	369	3	0	0	0	12.2	0.0	0.0
57	1163	SL3a	22.1	1	41	0	0	0	0	0.0	0.0	0.0
57	1125	SL3b	26.6	1	41	0	0	0	0	0.0	0.0	0.0
57	1162	SL4a	26.0	1	41	1	0	1	0	34.9	0.0	34.9
57	1160	SL4b	26.6	3	123	1	0	0	0	11.4	0.0	0.0
57	1120	SL5a	19.1	2	82	0	0	1	0	0.0	0.0	23.7
57	1124	SL6a	24.9	2	82	0	0	1	0	0.0	0.0	18.2
57	1169	SL6b	22.6	2	82	0	0	0	0	0.0	0.0	0.0
7	164	2	25.5	1	41	0	0	0	0	0.0	0.0	0.0
7	165	3	26.0	Pilot sample		X	0	X	0	0.0	0.0	0.0
7	166	4	33.6	1	41	0	0	1	0	0.0	0.0	27.0
7	167	5	30.9	5	205	0	0	2	0	0.0	0.0	11.7
7	168	6	26.2	13	533	0	0	1	0	0.0	0.0	2.7
7	169	7	26.0	Pilot sample		X	X	X	X	0.0	0.0	0.0
300	613	20	29.6	14	574	4	0	4	0	8.8	0.0	8.8
301	743	20	32.8	20	820	80	0	4	0	110.6	0.0	5.5
302	715	20	28.2	23	943	5	0	5	0	7.0	0.0	7.0
307	698	20	28.8	1	41	4	0	2	0	125.9	0.0	63.0
312	828	20	31.6	13	533	3	3	1	0	6.6	6.6	2.2
313	836	20	27.5	22	902	8	0	11	0	12.0	0.0	16.5
314	844	20	31.9	14	574	49	0	1	0	99.5	0.0	2.0
316	855	20	30.5	8	328	1	0	3	0	3.7	0.0	11.1
306	779	20	31.0	5	205	1	0	1	0	5.8	0.0	5.8
310	789	50	31.0	9	369	2	0	1	0	6.5	0.0	3.2
318	882	20	30.8	2	82	2	0	5	0	29.4	0.0	73.6
326	1344	50	28.0	9	369	2	0	13	0	7.2	0.0	46.8
329	1293	20	30.4	12	492	3	2	75	0	7.5	5.0	186.4
334	1313	50	29.0	22	902	0	0	0	0	0.0	0.0	0.0

Table D.5. Cultigen and pollen aggregate counts[a] based on large fraction scan (LFS) of split samples for Feature 320 field samples only, PHX Sky Train project.

				LFS Cultigen Pollen Counts				LFS Pollen Aggregate Data															
Feature Number	Field Number (FN)	Field Sample	Number of Microscope Slides Examined from Large Fraction	Maize	Squash	Cotton	Cholla	Total LFS Aggregates	Maize Aggregates	Squash Aggregates	Cholla Aggregates	Pinon type Aggregates	Ponderosa type Aggregates	Cheno-am Aggregates	Tidestromia type Aggregates	Sagebrush Aggregates	Bursage type Aggregates	Sunflower type Aggregates	Grass Aggregates	Spiderling Aggregates	Summer Poppy Aggregates	Spurge Family Aggregates	Globemallow Aggregates
320	1364	SL20a	2	5	1	1	22	240	9b	–	3c	–	–	800h	250b	–	14a	–	–	20e	11b	–	16c
320	1365	SL20b	2	41	1	2	160	474	6c	–	10d	–	–	1000h	1000f	–	–	–	–	30f	12c	–	50c
320	1370	SL20c	2	28	0	8	93	370	5c	–	4c	–	–	500h	800f	–	–	18b	–	40f	16d	–	8b
320	1366	SL20d	2	6	1	0	34	266	–	–	3b	–	–	800h	–	–	–	–	–	19f	40b	–	2a
320	1367	SL21a	2	9	0	0	36	108	–	–	4a	–	–	300g	200d	–	–	6a	–	8c	–	–	–
320	1368	SL21b	2	1	0	0	17	159	–	–	–	–	–	700g	70a	–	–	–	–	40f	4a	–	6b
320	1371	SL21c	1	1	1	0	14	156	3a	–	–	–	–	300g	100a	–	–	–	–	9d	7b	–	5b
320	1369	SL21d	2	0	0	0	2	114	–	–	–	–	–	500g	70b	–	2a	20a	–	11e	3a	–	3a
320	1372	SL22a	2	1	0	0	18	39	–	–	–	–	–	70f	–	–	6a	–	–	14c	–	–	–
320	1373	SL22b	2	11	0	2	47	90	–	–	2a	–	–	300f	500c	–	–	–	2a	7c	–	–	5a
320	1374	SL22c	2	5	0	0	17	462	4b	–	–	–	–	1000i	200c	–	20a	–	20a	40f	3b	–	12b
320	1375	SL1	2	6	0	2	19	53	2a	–	–	–	–	160f	17a	–	–	7b	–	9c	2a	–	4a
320	1378	SL4	1	0	0	0	0	3	–	–	–	–	–	20b	–	–	–	–	–	–	–	–	–
320	1379	SL5	2	0	0	0	5	19	–	–	–	–	–	50e	–	–	–	–	–	5b	–	–	–
320	1380	SL6	1	0	0	0	5	23	–	–	–	–	–	130e	–	2a	20b	–	–	12b	–	–	–
320	1381	SL7	2	0	0	0	1	16	–	–	–	–	–	70d	–	–	–	–	–	7b	–	6b	–
320	1382	SL8	2	11	0	1	38	167	–	–	–	–	2a	150g	–	–	–	4a	3a	9e	–	–	3b
320	1383	SL9	2	1	0	0	10	29	–	–	–	–	–	80e	–	–	20b	–	–	6b	–	–	5a
0	1384	SL10	1	7	0	4	45	80	2b	–	–	–	–	300f	–	–	–	10a	–	9c	2b	–	6b
0	1385	SL11	1	2	0	0	12	38	–	–	–	–	–	60d	140a	–	100b	11a	–	20e	3a	–	3a
0	1386	SL12	1	0	0	0	14	54	–	–	–	–	–	300f	–	–	20d	–	–	8d	2a	–	5b
320	1388	SL30b	2	13	0	4	83	165	2b	–	4b	–	–	300g	400c	–	–	11a	5a	10d	–	–	17b
320	1391	SL31b	2	10	0	0	72	494	3b	–	3c	–	–	500i	1000f	–	–	24a	–	24f	8b	–	40b
320	1393	SL32a	2	32	3	2	20	175	4b	2a	2a	5a	–	500h	400b	–	–	–	–	12c	2b	–	3a
320	1394	SL32b	2	33	0	2	77	147	2b	–	2b	–	–	300g	200a	–	–	–	–	11c	2a	–	4a
320	1395	SL32c	2	3	0	0	13	48	–	–	–	–	–	250f	–	–	–	–	–	8b	9a	–	–
320	1397	SL33b	2	14	0	3	115	563	3a	–	3b	–	–	400j	200b	–	–	–	–	23e	2b	–	6b
320	1399	SL34a	2	36	0	3	65	287	15c	–	–	3b	2a	700h	200b	–	11a	–	20b	20e	4b	–	60b
320	1400	SL34b	2	13	0	1	47	205	–	–	–	5a	–	1000h	100a	–	–	–	–	11d	8b	–	8b
320	1401	SL34c	2	9	0	4	43	208	2a	–	2b	–	–	400h	100b	–	–	–	–	12e	3b	–	4b

[a]a = 1 aggregate, b = 2-5 aggregates, c = 6-10 aggregates, d = 11-15 aggregates, e = 16-25 aggregates, f = 26-75 aggregates, g = 76-150 aggregates, h = 151-300 aggregates, i = 301-500 aggregates, j = 501-750 aggregates. An example of the designations is 800h in the Cheno-am row, which means that up to 300 aggregates were seen, and the largest contained an estimated 800 grains of Cheno-am pollen.

APPENDIX E

SUPPLEMENTARY GROUND STONE DATA, PHX SKY TRAIN PROJECT

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Table E.1. Attributes for each artifact recovered from Pueblo Grande, AZ U:9:1 (ASM), and AZ U:9:28 (ASM), PHX Sky Train project.

Site	Locus	Area	Period	Phase	Feature	Feature Type	Context	FN	Artifact	Subtype	Count	Condition	Burned	Design	Use	Sequence	Second Type
Pueblo Grande, AZ U:9:1 (ASM)																	
	B7	–	–	–	315	Possible pithouse	Fill	849.01	Raw material	Parent–pigment	1	Whole	No	–	Single	–	–
	B5	–	–	–	–	–	Sheet trash	648.01	Raw material	Temper	1	–	–	–	Unused	–	–
	B3	3A	Colonial	Late Gila Butte-Santa Cruz	306	Pithouse	Floor	777.01	Handstone	Flat	1	Whole	No	Expedient	Single	–	–
	B3	3A	Colonial	Late Gila Butte-Santa Cruz	306	Pithouse	Fill	725.01	Polisher	Handstone	1	Broken	No	–	Redesigned	Sequential	Pecking stone
	B3	3A	Colonial	Late Gila Butte-Santa Cruz	306.01	Hearth	Fill	798.01	Lapstone	Flat	1	Whole	No	Expedient	Multiple	Concomitant	Pestle
	B3	3A	Colonial	Late Gila Butte-Santa Cruz	310	Trivet	Fill	793.01	Netherstone	–	1	Broken	Heat-cracked	Expedient	Multiple	Sequential	Trivet
	B3	3B	Classic	Soho phase	318	Pithouse	Floor fill	870.01	Polisher	Pebble	1	Whole	No	Expedient	Single	–	–
	B3	3B	Classic	Soho phase	326	Posthole	Fill	1340	Handstone	Flat	1	Whole	No	Expedient	Multiple	Concomitant	Handstone
	B3	3B	Classic	Soho phase	326	Posthole	Fill	1339	Lapstone	Flat	1	Broken	No	Expedient	Multiple	Concomitant	Polisher
	B3	3B	Classic	Soho phase	326	Posthole	Fill	1337	Mano	Trough	1	Broken	No	Strategic	Redesigned	Sequential	Chopper
	B3	3B	Classic	Soho phase	326	Posthole	Fill	1336	Mano	Trough	1	Broken	No	Strategic	Multiple	–	Polisher
	B3	3B	Classic	Soho phase	326	Posthole	Fill	1335	Metate	Trough	1	Broken	–	Strategic	–	–	–
	B3	3B	Classic	Soho phase	326	Posthole	Fill	1329	Netherstone	Flat	1	Whole	No	Expedient	Single	–	–
	B3	3B	Classic	Soho phase	326	Posthole	Fill	1333	Netherstone	Flat	1	Whole	No	Expedient	Single	–	–
	B3	3B	Classic	Soho phase	326	Posthole	Fill	1338	Pestle	Shaped	1	Broken	No	Strategic	Multiple	Sequential	Pestle
	B3	3B	Classic	Soho phase	326	Posthole	Fill	1334	Polisher	Faceted	1	Whole	No	Expedient	Single	–	–
	B3	3B	Classic	Soho phase	329	Adobe structure	Floor	1252	Axe	–	1	Broken	No	Strategic	–	Sequential	Scraper
	B3	3B	Classic	Soho phase	329	Adobe structure	Sheet trash	1232	Raw material	Tool	1	Whole	No	–	Unused	–	–
	B3	3B	Classic	Soho phase	329	Adobe structure	Fill	1223	Disk	Flat disk	1	Whole	No	Incomplete	Unused	–	–
	B3	3B	Classic	Soho phase	329	Adobe structure	Fill	1239	Polisher	Handstone	1	Whole	No	Expedient	Multiple	Sequential	Hammerstone
	B3	3B	Classic	Soho phase	329	Adobe structure	Fill	1305	Lapstone	Flat	1	Whole	No	Expedient	Redesigned	Concomitant	Chopper
	B3	3B	Classic	Soho phase	329	Adobe structure	Fill	1274	Mano	Trough	1	Broken	Yes	Strategic	–	–	–
	B3	3B	Classic	Soho phase	329	Adobe structure	Floor fill	1247	Netherstone	Flat	1	Whole	No	Expedient	Single	–	–
	B3	3B	Classic	Soho phase	329	Adobe structure	Fill	1306	Ornament	Pendant	1	Broken	No	Strategic	–	–	–
	B3	3B	Classic	Soho phase	329	Adobe structure	Floor fill	1290	Pigment	Processed	1	Whole	No	Strategic	–	–	–
	B3	3B	Classic	Soho phase	329	Adobe structure	Fill	1271	Polisher	Handstone	1	Broken	No	Expedient	Redesigned	Sequential	Lithic anvil
	B3	3B	Classic	Soho phase	329	Adobe structure	Floor fill	1286	Polisher	Pebble	1	Whole	No	Expedient	Single	–	–
	B3	3B	Classic	Soho phase	329	Adobe structure	Fill	1275	Polisher	Pebble	1	Whole	No	Expedient	Single	–	–
	B3	3B	Classic	Soho phase	329	Adobe structure	Fill	1222	Polisher	Handstone	1	Whole	No	Expedient	Single	–	Handstone
	B3	3B	Classic	Soho phase	329	Adobe structure	Fill	1297	Pottery anvil	Grooved	1	Whole	No	Strategic	Single	–	–
	B3	3B	Classic	Soho phase	329	Adobe structure	Fill	1241	Raw material	Tool	1	Whole	No	–	Unused	–	–
	B3	3B	Classic	Soho phase	329	Adobe structure	Fill	1242	Raw material	Unaltered	1	–	–	–	–	–	–
	B3	3B	Classic	Soho phase	329	Adobe structure	Fill	1242	Raw material	Unaltered	1	–	–	–	–	–	–
	B3	3B	Classic	Soho phase	329	Adobe structure	Floor fill	1248	Raw material	Tool	1	Whole	No	–	Unused	–	–
	B3	3B	Classic	Soho phase	329	Adobe structure	Fill	1276	Raw material	Parent–pigment	1	Whole	No	Expedient	Multiple	Sequential	Polisher
	B3	3B	Classic	Soho phase	329	Adobe structure	Fill	1240	Whorl	Flat disk	1	Broken	No	Strategic	–	–	–
	B3	3B	Classic	Soho phase	332	Small pit	Fill	1319	Abrader	Flat	1	Whole	Yes	Expedient	Single	–	–
	B3	3B	Classic	Soho phase	332	Small pit	Fill	1318	Mano	Flat/Concave	1	Whole	No	Expedient	Single	–	–
	B3	3B	Classic	Soho phase	333	Small pit	Fill	1351	Mano	Flat/Concave	1	Whole	No	Expedient	Single	–	–
	B3	3B	Classic	Soho phase	333	Small pit	Fill	1353	Netherstone	–	1	Broken	No	–	–	–	–
	B3	3B	Classic	Soho phase	333	Small pit	Fill	1352	Polisher	Floor	1	Whole	No	Expedient	Multiple	Concomitant	Polisher
	B3	3B	Classic	Soho phase	334	Small pit	Fill	1310	Tabular tool	Blank	1	Whole	No	Incomplete	Unused	–	–
	–	3B	–	–	–	–	Sheet trash	1326.01	Abrader	Flat	1	Whole	No	Strategic	Single	–	–
	–	3B	–	–	–	–	Sheet trash	1322	Polisher	Floor	1	Whole	No	Strategic	Multiple	Concomitant	Abrader
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	300	Pithouse	Floor	787.01	Mano	Flat/Concave	1	Whole	Heat-cracked	Strategic	Single	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	302	Pithouse	Fill	631.01	Handstone	–	1	Broken	Yes	–	–	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	307	Pithouse	Floor	728.01	Abrader	Flat	1	–	No	–	–	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	307	Pithouse	Floor	697.01	Handstone	Flat	1	Whole	No	Expedient	Multiple	Concomitant	Handstone
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	307	Pithouse	Floor	692.01	Mano	Trough	1	Whole	No	Strategic	Multiple	Both	Lapstone

Table E.1. Continued.

Site	Locus	Area	Period	Phase	Feature	Feature Type	Context	FN	Artifact	Subtype	Count	Condition	Burned	Design	Use	Sequence	Second Type
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	307	Pithouse	Floor	691.01	Netherstone	Basin	1	Broken	No	Strategic	–	–	Cupped stone
	B5	5A	Sedentary-Classic Transition	Late Sacaton-Early Soho	307	Pithouse	Floor	696.01	Polisher	Plaster	1	Whole	Yes	Expedient	–	–	Handstone
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	307	Pithouse	Floor	729.01	Polisher	Plaster	1	Whole	No	Expedient	Single	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	307	Pithouse	Floor fill	687.01	Abrader	–	1	Whole	No	Expedient	Multiple	Concomitant	Polisher
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	307	Pithouse	Floor fill	686.01	Handstone	–	1	Broken	No	–	–	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	307	Pithouse	Fill	659.01	Mano	Trough	1	Broken	Yes	Expedient	–	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	307	Pithouse	Fill	658.01	Metate	Trough	1	Broken	Heat-cracked	Strategic	–	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	307	Pithouse	Fill	681.01	Ornament	–	1	Broken	No	–	–	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	307	Pithouse	Fill	658.02	Unidentified	–	1	Broken	No	–	–	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	307	Pithouse	Fill	679.01	Unidentified	–	1	Broken	Yes	–	–	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	309	Artifact concentration	Fill	757.01	Metate	Trough	1	Broken	No	–	–	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	309	Artifact concentration	Fill	783.01	Raw material	Temper	1	Broken	–	–	Unused	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	309	Artifact concentration	Fill	761.01	Tabular tool	–	1	Broken	No	–	Multiple	Sequential	Lapstone
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	309	Artifact concentration	Fill	761.02	Tablet	–	1	Broken	No	–	–	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	309	Artifact concentration	Fill	757.02	Unidentified	–	1	Broken	–	–	–	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	309	Artifact concentration	Fill	757.03	Unidentified	–	1	Broken	–	–	–	–	–
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	309	Artifact concentration	Sheet trash	792.01	Metate	Open trough	1	Whole	No	Strategic	Multiple	Sequential	Netherstone
	B5	5A	Sedentary-Classic transition	Late Sacaton-Early Soho	309	Artifact concentration	Sheet trash	791.01	Pestle	Blank	1	Whole	Yes	Strategic	Unused	–	–
	–	5A	–	–	–	–	Sheet trash	752.01	Mano	Flat/Concave	1	Whole	Yes	Strategic	Reused	Sequential	Handstone
	–	5A	–	–	–	–	Sheet trash	753.01	Mano	Flat/Concave	1	Whole	No	Strategic	Single	–	–
	–	5A	–	–	–	–	Sheet trash	750.01	Polisher	Handstone	1	Broken	No	Expedient	Redesigned	Sequential	Pecking stone
	B6	6B	Sedentary	Early Sacaton	314	Pithouse	Floor fill	842.01	Polisher	Handstone	1	Broken	No	–	Redesigned	Sequential	Pecking stone
	–	B5	–	–	–	–	Sheet trash	772.01	Metate	–	1	Broken	Heat-cracked	–	Multiple	Sequential	Netherstone
	–	B5	–	–	–	–	Sheet trash	769.01	Netherstone	Flat	1	Whole	No	Expedient	Reused	–	Handstone
	–	B5	–	–	–	–	Sheet trash	770.01	Pestle	Cobble	1	–	No	Expedient	Multiple	Concomitant	Hammerstone
	–	B5	–	–	–	–	Sheet trash	771.01	Unidentified	–	1	Broken	No	–	–	–	–
AZ U:9:28 (ASM)																	
	B7	–	–	–	2	Canal	Canal sediments	1128	Polisher	Handstone	1	Broken	No	Expedient	Redesigned	Sequential	Pecking stone
	B7	–	–	–	2	Canal	Canal sediments	1128	Polisher	Pebble	1	Broken	No	Expedient	Redesigned	Sequential	Pecking stone
	B6	6A	Sedentary	Middle-Late Sacaton	57	Other	Canal sediments	1192	Mano	Trough	1	Broken	Yes	Strategic	–	–	–
	B6	6A	Sedentary	Middle-Late Sacaton	57	Other	Canal sediments	1179	Unidentified	–	1	Broken	No	–	–	–	–
	B6	6A	Sedentary	Middle-Late Sacaton	57	Other	Canal sediments	1183	Unidentified	–	1	Broken	Heat-cracked	–	–	–	–
	B6	6A	Sedentary	Middle-Late Sacaton	57	Extramural feature	Fill	1500	Disk	–	1	Broken	No	–	–	–	–
	B7	7,5,3	Classic	Classic period	3	Canal	Canal sediments	1129	Polisher	Handstone	1	Broken	No	Expedient	Redesigned	Sequential	Hammerstone
	B7	7,5,3	Classic	Classic period	3	Canal	Canal sediments	1129	Polisher	Handstone	1	Broken	No	Expedient	Redesigned	Sequential	Pecking stone
	–	7A	–	–	–	–	Sheet trash	85.02	Chopper	Other	1	Whole	No	Strategic	Single	–	–
	–	7A	–	–	–	–	Sheet trash	86.01	Lapstone	Flat	1	Whole	No	Expedient	Single	–	–
	–	7A	–	–	–	–	Sheet trash	1140	Mano	Trough	1	Broken	No	Strategic	–	–	–
	–	7A	–	–	–	–	Sheet trash	87.02	Mano	–	1	Broken	–	Strategic	–	–	–
	–	7A	–	–	–	–	Sheet trash	90.01	Metate	Trough	1	Broken	No	Strategic	Single	–	–
	–	7A	–	–	–	–	Sheet trash	87.01	Metate	Trough	1	Broken	–	Strategic	–	–	–
	–	7A	–	–	–	–	Sheet trash	89.01	Netherstone	Flat	1	Broken	No	Expedient	Multiple	Concomitant	Pestle
	–	7A	–	–	–	–	Sheet trash	1134	Pecking stone	Core	1	Whole	No	Expedient	Single	–	–
	–	7A	–	–	–	–	Sheet trash	85.01	Polisher	Handstone	1	Broken	No	Expedient	Redesigned	Sequential	Pecking stone
	–	7A	–	–	–	–	Sheet trash	84.01	Tabular tool	–	1	Broken	No	–	–	–	–
	–	7A	–	–	–	–	Sheet trash	87.03	Unidentified	–	1	Broken	No	–	–	–	–

Table E.1. Continued.

Site	Feature	Feature Type	FN	Wear	Text Activity	Designed Activity	Actual Activity	Length (cm)	Width (cm)	Thickness (cm)	Weight (gm)	Residue	Color	Rock Type
Pueblo Grande, AZ U:9:1 (ASM)														
	315	Possible pithouse	849.01	Heavy	Pigment processing	Processing	Pigment processing	4.2	3.7	1.8	36.0	Pigment	10R 5/8	Rhyolite
	–	–	648.01	Unused	Manufacturing	Procurement	Unused	–	–	–	2.0	–	–	Phyllite
	306	Pithouse	777.01	Light	Processing	Processing	Processing	6.8	5.7	2.9	153.0	–	–	Diorite
	306	Pithouse	725.01	Moderate	Manufacturing	Polishing	Multiple	–	–	–	–	–	–	Unknown
	306.01	Hearth	798.01	Light	Manufacturing	Smoothing	Multiple	13.1	11.9	3.7	899.0	–	–	Quartzite
	310	Trivet	793.01	–	Processing	Processing	Multiple	–	–	–	–	–	–	Granodiorite
	318	Pithouse	870.01	Moderate	Manufacturing	Polishing	Manufacture	3.1	3.0	1.9	23.0	–	–	Quartzite
	326	Posthole	1340	Light	Processing	Processing	Multiple	7.6	4.7	2.8	142.0	–	–	Rhyolite
	326	Posthole	1339	Light	Manufacturing	Smoothing	Stone working	–	8.6	3.3	–	–	–	Gneiss
	326	Posthole	1337	Moderate	Food processing	Food processing	Multiple	–	8.6	4.1	–	–	–	Basalt/Andesite,vesicular
	326	Posthole	1336	Moderate	Food processing	Food processing	Multiple	–	9.0	4.4	–	–	–	Basalt/Andesite, vesicular
	326	Posthole	1335	Heavy	Food processing	Food processing	–	–	–	–	–	–	–	Basalt
	326	Posthole	1329	Light	Processing	Processing	Processing	27.1	20.7	9.4	8,455.0	–	–	Granodiorite
	326	Posthole	1333	Moderate	Processing	Processing	Processing	21.2	10.7	2.3	1,033.0	–	–	Phyllite
	326	Posthole	1338	Moderate	Food processing	Food processing	–	–	6.9	5.9	–	–	–	Volcanic, intermediate
	326	Posthole	1334	Heavy	Manufacturing	Polishing	Pottery manufacture	4.9	1.9	1.7	28.0	–	–	Granodiorite
	329	Adobe Structure	1252	–	Manufacturing	Percussion	Manufacture	–	–	–	346.0	–	–	Diabase
	329	Adobe Structure	1232	–	Manufacturing	Procurement	Unused	17.5	14.5	2.7	908.0	–	–	Phyllite
	329	Adobe Structure	1223	Unused	Manufacturing	Paraphernalia	Unused	3.8	3.7	0.4	7.2	–	–	Phyllite
	329	Adobe Structure	1239	Moderate	Pigment processing	Processing	Pigment processing	9.8	7.8	5.1	607.0	Pigment	10R 4/8	Diorite
	329	Adobe Structure	1305	Light	Manufacturing	Smoothing	Multiple	12.5	8.7	3.0	512.0	–	–	Gneiss
	329	Adobe Structure	1274	Heavy	Food processing	Food processing	Food processing	–	9.7	3.3	–	–	–	Rhyolite
	329	Adobe Structure	1247	Light	Manufacturing	Abrading	Manufacture	16.9	10.5	4.1	1,074.0	–	–	Quartzite
	329	Adobe Structure	1306	Unused	–	Paraphernalia	Paraphernalia	–	–	0.2	–	–	–	Phyllite
	329	Adobe Structure	1290	–	Paraphernalia	Ornamentation	Paraphernalia	–	–	–	17.0	Pigment	10R 4/6	Hematite, earthy
	329	Adobe Structure	1271	Moderate	Manufacturing	Polishing	Multiple	–	9.9	4.5	–	–	–	Dacite
	329	Adobe Structure	1286	Heavy	Manufacturing	Polishing	Pottery manufacture	9.2	1.7	2.1	53.0	–	–	Quartzite
	329	Adobe Structure	1275	Heavy	Manufacturing	Polishing	Pottery manufacture	6.3	2.6	1.5	40.0	–	–	Quartzite
	329	Adobe Structure	1222	Heavy	Manufacturing	Polishing	Stone working	9.6	5.8	2.5	223.0	–	–	Diabase
	329	Adobe Structure	1297	Light	Manufacturing	Percussion	Pottery manufacture	13.4	10.3	6.5	1,292.0	–	–	Rhyolite
	329	Adobe Structure	1241	Unused	Manufacturing	Procurement	Unused	14.6	3.9	1.0	–	–	–	Schist
	329	Adobe Structure	1242	–	Manufacturing	Procurement	Unused	–	–	–	–	–	–	Schist
	329	Adobe Structure	1242	–	Manufacturing	Procurement	Unused	–	–	–	–	–	–	Schist
	329	Adobe Structure	1248	–	Manufacturing	Procurement	Unused	16.0	9.2	2.3	502.0	–	–	Phyllite
	329	Adobe Structure	1276	Heavy	Pigment processing	Processing	Multiple	2.5	1.8	1.5	12.0	Pigment	10R 4/6	Hematite, rock
	329	Adobe Structure	1240	–	Manufacturing	Paraphernalia	Manufacture	–	–	0.2	–	–	–	Phyllite
	332	Small pit	1319	Heavy	Manufacturing	Abrading	Manufacture	10.1	6.7	5.2	37.4	–	–	Unknown
	332	Small pit	1318	Light	Food processing	Food processing	Food processing	9.5	9.2	3.7	461.0	–	–	Quartzite
	333	Small pit	1351	Light	Food processing	Food processing	Food processing	13.5	10.1	4.4	863.0	–	–	Quartzite
	333	Small pit	1353	–	Processing	Processing	–	–	–	–	–	–	–	Dacite
	333	Small pit	1352	Heavy	Manufacturing	Smoothing	Multiple	10.7	7.6	4.6	683.0	–	–	Diabase
	334	Small pit	1310	Unused	Manufacturing	Cutting	Unused	17.9	9.9	1.7	386.0	–	–	Phyllite
	-	-	1326.01	Moderate	Manufacturing	Abrading	Manufacture	8.8	6.9	3.2	206.0	–	–	Sandstone
	-	-	1322	Moderate	Pigment processing	Smoothing	Pigment processing	11.5	10.4	5.2	915.0	–	10R 4/8	Quartzite
	300	Pithouse	787.01	Moderate	Food processing	Food processing	Food processing	13.3	8.9	4.5	–	–	–	Quartzite
	302	Pithouse	631.01	–	Processing	Processing	–	–	–	–	–	–	–	Quartzite
	307	Pithouse	728.01	Moderate	Manufacturing	Abrading	–	–	–	–	–	–	–	Quartzite
	307	Pithouse	697.01	Light	Pigment processing	Processing	Pigment processing	9.2	8.4	5.2	549.0	Pigment	10R 4/8	Quartzite
	307	Pithouse	692.01	Moderate	Food processing	Food processing	Multiple	17.6	8.5	3.2	826.0	Pigment	10R 3/6	Rhyolite

Table E.1. Continued.

Site	Feature	Feature Type	FN	Wear	Text Activity	Designed Activity	Actual Activity	Length (cm)	Width (cm)	Thickness (cm)	Weight (gm)	Residue	Color	Rock Type
	307	Pithouse	691.01	-	Pigment processing	Processing	Pigment processing	–	–	–	–	Pigment	10R 4/8	Rhyolite
	307	Pithouse	696.01	Heavy	Manufacturing	Smoothing	Manufacture	8.4	8.7	3.1	353.0	–	–	Quartzite
	307	Pithouse	729.01	Heavy	Manufacturing	Smoothing	Manufacture	9.7	6.4	5.8	594.0	–	–	Quartzite
	307	Pithouse	687.01	Moderate	Manufacturing	Smoothing	Manufacture	7.6	7.7	5.6	520.0	–	–	Granodiorite
	307	Pithouse	686.01	–	Processing	Processing	–	–	–	–	–	–	–	Quartzite
	307	Pithouse	659.01	Light	Food processing	Food processing	Food processing	–	10.5	4.5	–	–	–	Basalt/Andesite, vesicular
	307	Pithouse	658.01	–	Food processing	Food processing	–	–	–	–	–	–	–	Basalt, vesicular
	307	Pithouse	681.01	–	Paraphernalia	Ornamentation	–	1.4	0.6	0.7	–	–	–	Muscovite
	307	Pithouse	658.02	–	–	–	–	–	–	–	–	–	–	Schist
	307	Pithouse	679.01	–	–	–	–	–	–	–	–	–	–	Rhyolite
	309	Artifact concentration	757.01	Heavy	Food processing	Food processing	–	–	–	–	–	–	–	Basalt/Andesite, vesicular
	309	Artifact concentration	783.01	–	Manufacturing	Procurement	Unused	–	–	–	14.0	–	–	Phyllite
	309	Artifact concentration	761.01	Light	Manufacturing	Cutting	Multiple	–	9.9	1.1	–	–	–	Schist
	309	Artifact concentration	761.02	–	Paraphernalia	Paraphernalia	–	–	–	–	–	–	–	Phyllite
	309	Artifact concentration	757.02	–	–	–	–	–	–	–	–	–	–	Basalt/Andesite, vesicular
	309	Artifact concentration	757.03	–	–	–	–	–	–	–	–	–	–	Basalt/Andesite, vesicular
	309	Artifact concentration	792.01	Light	Food processing	Food processing	Multiple	37.0	18.2	10.0	–	Pigment	10R 4/6	Quartzite
	309	Artifact concentration	791.01	Unused	Manufacturing	Percussion	Unused	27.2	8.8	6.2	2,020.0	–	–	Rhyolite
	-	-	752.01	Moderate	Pigment processing	Food processing	Pigment processing	12.4	8.3	5.5	875.0	Pigment	10R 3/6	Quartzite
	-	-	753.01	Moderate	Food processing	Food processing	Food processing	14.8	9.8	7.1	1,495.0	Pigment	–	Quartzite
	-	-	750.01	Moderate	Manufacturing	Polishing	Multiple	–	–	–	–	–	–	Diorite
	314	Pithouse	842.01	Moderate	Manufacturing	Polishing	Multiple	–	–	–	–	–	–	Diorite
	-	-	772.01	Heavy	Food processing	Food processing	Multiple	–	–	–	–	Pigment	10R 4/4	Basalt/Andesite, vesicular
	-	-	769.01	Moderate	Manufacturing	Smoothing	Stone working	9.6	9.8	6.1	1,082.0	–	–	Quartzite
	-	-	770.01	Moderate	–	Percussion	Multiple	–	7.1	5.3	–	–	–	Diabase
	-	-	771.01	–	–	–	–	–	–	–	–	–	–	Felsic volcanic
AZ U:9:28 (ASM)														-
	2	Canal	1128	Moderate	Manufacturing	Polishing	Multiple	–	5.3	5.2	–	–	–	Undifferentiated felsic volcanic
	2	Canal	1128	Light	Manufacturing	Polishing	Multiple	–	9.4	4.5	–	–	–	Basalt/Andesite
	57	Other	1192	Moderate	Food processing	Food processing	Food processing	–	8.3	4.2	–	–	–	Rhyolite
	57	Other	1179	–	–	–	–	–	–	–	–	–	–	Basalt/Andesite, vesicular
	57	Other	1183	Moderate	–	–	–	–	–	–	–	–	–	Dacite
	57	Extramural feature	1500	–	Paraphernalia	Paraphernalia	–	–	–	0.2	–	–	–	Phyllite
	3	Canal	1129	Moderate	Manufacturing	Polishing	Multiple	–	8.5	6.2	–	–	–	Basalt/Andesite
	3	Canal	1129	Moderate	Manufacturing	Polishing	Multiple	–	–	6.2	–	–	–	Diorite
	-	-	85.02	Light	Processing	Percussion	Processing	17.2	11.2	7.6	2,500.0	–	–	Diorite
	-	-	86.01	Light	Manufacturing	Smoothing	Stone working	19.6	7.7	3.5	895.0	–	–	Gneiss
	-	-	1140	Light	Food processing	Food processing	Food processing	–	7.9	3.1	–	–	–	Undifferentiated felsic volcanic
	-	-	87.02	Moderate	Food processing	Food processing	–	–	6.9	3.8	–	–	–	Basalt/Andesite, vesicular
	-	-	90.01	Moderate	Food processing	Food processing	Food processing	–	22.0	13.6	–	–	–	Dacite
	-	-	87.01	-	Food processing	Food processing	–	–	–	–	–	–	–	Undifferentiated felsic volcanic
	-	-	89.01	Light	Manufacturing	Smoothing	Stone working	32.7	11.9	9.4	5,618.0	–	–	Gneiss
	-	-	1134	Moderate	Manufacturing	Percussion	Stone working	8.5	6.7	6.0	450.0	–	–	Diorite
	-	-	85.01	Moderate	Manufacturing	Polishing	Multiple	–	8.1	5.5	–	–	–	Basalt/Andesite
	-	-	84.01	–	–	Cutting	–	–	–	–	–	–	–	Quartzite
	-	-	87.03	–	–	–	–	–	–	–	–	–	–	Quartzite

APPENDIX F

SUPPLEMENTAL PETROGRAPHIC DATA

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Table F.1. Point-count parameters used in the petrographic analysis of the data set, PHX Sky Train project.

Parameter	Description
Monomineralic Grains	
Qtz	All sand-sized quartz grains, except those derived from or contained within coarse-foliated rocks; unstained
Kspar	Alkali feldspars, except those derived from or contained within coarse-foliated rocks.; potassium feldspar stained yellow, unstained plagioclase feldspar, perthite, antiperthite
Sanid	Sanidine (alkali feldspar of volcanic origin)
Micr	Microcline/anorthoclase: alkali feldspar with polysynthetic (cross-hatch) twinning; stained yellow or unstained
Plag	Plagioclase feldspar, stained pink, except grains derived from or contained within coarse-foliated rocks; grains commonly have albite and/or carlsbad twinning; alteration, sericitization affect less than 10 percent of grain
Plagal	Altered plagioclase, except grains derived from or contained within coarse-foliated rocks; alteration affects 10 to 90 percent of the grain; alteration products include sericite, clay minerals, carbonate, epidote
Plaggn	Considerably altered plagioclase, except grains derived from or contained within coarse-foliated rocks; alteration affects more than 90 percent of grain
Px	Undifferentiated members of the pyroxene group
Amph	Undifferentiated members of the amphibole group
Opaq	Undifferentiated opaque minerals, such as magnetite/ilmenite, rutile, and iron oxides
Biot	Biotite mica
Musc	Muscovite mica
Chlor	Chlorite group minerals
Oliv	Undifferentiated members of the olivine group
Epid	Undifferentiated members of the epidote family (epidote, zoisite, clinozoisite)
Sphene	Sphene
Gar	Undifferentiated members of the garnet group
Caco	Calcium carbonate minerals
Metamorphic Lithic Fragments	
Lmm	Microgranular quartz aggregate: non-oriented polygonal aggregates of newly grown strain-free quartz with sutured, planar, or curved grain boundaries
Lmf	Foliated quartz aggregate: planar-oriented fabric developed in mostly strained quartz crystals with sutured crystallite boundaries; quartzite
Lma	Quartz-feldspar (mica) aggregate: quartz, feldspars, mica, and opaque oxides in aggregates with highly sutured grain boundaries but no planar-oriented fabric; some represent schists or gneisses viewed on edge, some are metasediments or metavolcanics
Lmt	Quartz-feldspar-mica tectonite (schists or gneisses): quartz, feldspars, micas, and opaque oxides, with strong planar oriented fabric; often display mineral segregation with alternating quartz-felsic and mica ribbons; grains are often extremely sutured and/or elongated
Lmtp	Phyllite: like Lmt, but the grains are silt sized or smaller, with little or no mineral segregation; also argillaceous grains, which exhibit growth of planar-oriented micas, silt sized or smaller
Lmvf	Metamorphosed volcanic rock such as rhyolite; massive-to-foliated aggregates of quartz and feldspar grains with relict phenocrysts of feldspar
Lmss	Metamorphosed sedimentary rock, such as a meta-siltstone; massive fine-grained aggregates of quartz and feldspar, with or without relict sedimentary texture
Lmamph	Amphibolite: a high-grade metamorphic rock, composed largely of amphibole
Volcanic Lithic Fragments	
Lvfb	Biotite-bearing felsic volcanic: microgranular nonfelted mosaics of submicroscopic quartz and feldspars, often with microphenocrysts of feldspar, quartz, always with phenocrysts of biotite; groundmass is fine to glassy, always has well-developed potassium feldspar (yellow) stain
Lvf	Felsic volcanic such as rhyolite: microgranular nonfelted mosaics of submicroscopic quartz and feldspars, often with microphenocrysts of feldspar, quartz, or rarely, ferromagnesian minerals; groundmass is fine to glassy, always has well-developed potassium feldspar (yellow) stain, may also have plagioclase (pink) stain.

Table F.1. Continued.

Parameter	Description
Lvi	Intermediate volcanic rock such as rhyodacite, dacite, latite, and andesite
Lvm	Mafic volcanic: visible microlites or laths of feldspar crystals in random to parallel fabric, usually with glassy, devitrified, or otherwise altered dark groundmass; often with phenocrysts of opaque oxides, occasional quartz, pyroxene, or olivine; rarely yellow-stained, usually has well-developed pink stain, representing intermediate to basic lavas such as latite, andesite, quartz-andesite, basalt, or trachyte
Lvv	Glassy volcanics: vitrophyric grains showing relict shards, pumiceous fabric, welding or perlitic structure, sometimes with microphenocrysts, representing pyroclastic or glassy volcanic rocks
Lvh	Hypabyssal volcanics (shallow igneous intrusive rocks): equigranular anhedral-to-subhedral feldspar-rich rocks, with no glassy or devitrified groundmass, coarser-grained than Lvf, most have yellow and pink stain
Sedimentary Lithic Fragments	
Lss	Siltstones: granular aggregates of equant subangular-to-rounded silt-sized grains, with or without interstitial cement; may be well-to-poorly sorted, with or without sand-sized grains; composition varies from quartzose to lithic-arkosic, with some mafic-rich varieties
Lsch	Chert: microcrystalline aggregates of pure silica
Lsca	Carbonate: mosaics of very fine calcite crystals, with or without interstitial clay- to sand-sized grains; most appear to be fragments of soil carbonate (caliche) and are subround to very round
Monomineralic Grains in Coarse Foliated Rocks	
Sqtz	All quartz derived from or contained within coarse foliated rocks
Skspar	Alkali feldspar (sodic or potassic) derived from or contained within coarse foliated rocks
Splag	Plagioclase feldspar (sodic or calcic, altered or fresh) derived from or contained within coarse foliated rocks
Sbiot	Biotite mica derived from or contained within coarse foliated rocks
Smusc	Muscovite mica derived from or contained within coarse foliated rocks
Schlor	Undifferentiated chlorite group minerals derived from or contained within coarse foliated rocks
Sopaq	Undifferentiated opaque minerals derived from or contained within coarse foliated rocks
Totals and Paste Parameters	
Total	The total number of point-counted sand-sized grains
Total Sand Temper	If temper type is "Crushed rock," or "Crushed rock + sand," then Total sand temper = Total - Total Foliated Rocks; if temper type is "Sand," or "Sand + muscovite" then Total sand temper = Total. Counts for grog and clay lumps are also removed to create this total
Paste	The total number of points counted in the silt- to clay-sized fraction of the paste
Percent Temper	Total/(Total+Paste) x 100
Grog	Sherd temper: Dark, semiopaque angular to subround grains with discrete margins, including silt to sand size temper grains in a clay, iron oxides, and/or micaceous matrix. The grains differ in color and/or texture from the surrounding matrix of the "host" ceramic
Clay lumps	Discrete sand-sized grains or "lumps," of untempered clay. They comprise clay that lacks silt- to sand-sized grains. The grains are often similar in color to the surrounding paste, but have well-defined, abrupt boundaries. Their internal texture is finer than the paste and has a different orientation. They are interpreted as clay that was insufficiently mixed with the surrounding clay body
Fiber	Voids left in the paste by the use of organic fibrous material. Can be temper or accidental
Unknown and Indeterminate Grains	
Unkn	Grains that cannot be identified, grains that are indeterminate, and grains such as zircon and tourmaline that occur in extremely low percentages
Other	Grains or rock fragments that are typically rare and are not covered by the categories above
Calculated Parameters Used in the Statistical Analyses	
K	Kspar + Skspar + Micr + Sanid
Tplag[a]	Plag + Plagal + Plaggn + Splag
TMusc	Musc + Smusc

Table F.1. Continued.

Parameter	Description
Tbiot	Biot + Sbiot
Tchlor	Chlor + Schlor
Mica[a]	Musc + Smusc + Biot + Sbiot + Chlor + Schlor
Pyr[a]	Px + Amph
Hmin	Pyr + Topaq
Lm	Lmm + Lmf + Lma + Lmamph + Lmss + Lmvf + Lmepid + Lmt + Lmtp
Lv	Lvfb + Lvf + Lvi + Lvm + Lvh + Lvv
Lscaco	Lsca + Caco

[a]Summary parameters indicate the combination of two closely related grain types, i.e., Lvf2 = Lvf + Lvfb. In the case of early point-count data where a distinction was not made, data are simply entered into the summary field.

Table F.2. Qualitative attribute codes applied to the samples during petrographic analysis, PHX Sky Train project.

Qualitative Attributes of the Less-than-sand-sized Fraction			
Matrix Opacity			
0	Opaque	5	Translucent
1	Almost opaque	6	More than translucent
2	Sort of opaque	7	Sort of transparent
3	Sort of translucent	8	Almost transparent
4	Almost translucent	9	Transparent
Matrix Color			
10	Black	25	Reddish-brown
12	Brownish-gray	30	Red
15	Brownish-black	40	Orange
19	Dark brown	41	Brownish-orange
21	Yellowish-brown	42	Yellowish-orange
22	Light brown	50	Yellow
23	Orangish-brown	-9	Indeterminate (i.e. too much stain)
Matrix Heterogeneity			
0	None	5	Mottled
1	Few clay lumps in the paste	6	Zoned and mottled
2	Several clay lumps	7	Zoned, mottled, lumpy, and otherwise highly heterogeneous
3	Many clay lumps		
4	Zoned margin to core		
Composition Information (composition codes are given at the end of this table)			
Silt Dominant: composition of the most abundant grain type in the silt fraction			
Silt Secondary: composition of the second most abundant grain type in the silt fraction			
Clay Dominant: composition of the most abundant grain type in the clay fraction			
Clay Secondary: composition of the second most abundant grain type in the clay fraction			

Qualitative Attributes of the Sand-sized Fraction			
Temper Type			
1	Sand	7.0	Sand + > 25% crushed rock
2	Sand plus grog	7.1	Sand + 7-25% crushed rock
3	Grog	7.2	Sand + 1-7% crushed rock
4	Sand and disaggregated rock	8	Crushed rock
5	Disaggregated rock	-9	Indeterminate
6	Self-tempered clay		
Grain size codes			
Modal Schist Size: size mode of the schist or gneiss temper component			
Modal Sand Size: size mode of the sand temper component			
Finest: size of the finest temper grain			
Coarsest: size of the coarsest temper grain			
Mode: overall size mode of the temper			
The codes are as follows:			
0	does not exist	5	coarse sand (0.5-1.0 mm)
1	silt (< 0.0625 mm)	6	very coarse sand (1.0-2.0 mm)
2	very fine sand (0.0625-0.125 mm)	7	granule (> 2.0 mm)
3	fine sand (0.125-0.250 mm)	9	bimodal
4	medium sand (0.250-0.5 mm)		
Sorting (of the overall temper)			
1	well sorted	4	moderately-poorly sorted
2	moderately-well sorted	5	poorly sorted
3	moderately sorted	9	bimodally sorted

Table F.2. Continued.

Grain composition codes
Only those identified in the analysis are reported here
Dominant: dominant grain in the sand-sized fraction of the temper
Secondary: second most abundant grain type in the sand-sized fraction of the temper
Tertiary: third most abundant grain type in the sand-sized fraction of the temper
The codes are as follows:

1	Quartz, monocrystalline
9	Quartz and/or feldspars
10	Undifferentiated feldspars
11	Potassium feldspar
17	Microcline or perthite type feldspar with stained and unstained
18	Perthite
19	Microcline from granitic rock
20	Plagioclase feldspar, undifferentiated
21	Altered plagioclase feldspar
40	Micas, undifferentiated
41	Muscovite
43	Chlorite
54	Amphibole group minerals, may be altered
272.01	Granite gneiss: medium to coarse grained

Table F.3. Point-count data for Phoenix petrofacies sand samples, PHX Sky Train project. (Parameter definitions are provided in Table F.1.)

A. Inventory data, totals, and other inclusions.

Sample No.	Topographic Map Name	Petrofacies[a]	Sample Type	Observation	Thin Section Use	Total	Other	Unknown
PB-0001	McDowell Peak	P	Sand	2	1	355	0	3
PB-0002	McDowell Peak	P	Sand	2	1	366	3	14
PB-0003	McDowell Peak	P	Sand	2	1	335	0	3
PB-0007	McDowell Peak	P	Sand	2	1	291	2	8
PB-0011	Sawik Mountain	P	Sand	2	1	351	4	1
PB-0012	Sawik Mountain	T	Sand	2	1	379	16	0
PB-0014	Sawik Mountain	T	Sand	2	1	364	2	0
PB-0017	Sawik Mountain	T	Sand	2	1	321	4	0
PB-0019	Sawik Mountain	T	Sand	2	1	322	0	0
PB-0020	Sawik Mountain	T	Sand	2	1	312	0	0
PB-0026	Mesa	F4	Sand	2	1	328	0	5
PB-0027	Mesa	F4	Sand	2	1	364	0	2
PB-0034	Sawik Mountain	F4	Sand	2	1	349	0	0
PB-0037	Granite Reef Dam	F4	Sand	2	1	329	0	1
PB-0039	Granite Reef Dam	F4	Sand	2	1	306	0	2
PB-0041	Granite Reef Dam	F4	Sand	2	1	334	0	0
PB-0042	Sawik Mountain	F4	Sand	2	1	330	0	0
PB-0043	Sawik Mountain	F4	Sand	2	1	334	0	1
PB-0044	Sawik Mountain	T	Sand	2	1	339	0	0
PB-0045	Sawik Mountain	T	Sand	2	1	328	0	2
PB-0048	Sawik Mountain	T	Sand	2	1	313	2	1
PB-0049	Sawik Mountain	T	Sand	2	1	282	0	0
PB-0050	Mesa	T	Sand	2	1	332	0	2
PB-0061	Buckhorn	U	Sand	1	1	421	0	0
PB-0062	Buckhorn	U	Sand	1	1	387	1	0
PB-0063	Buckhorn	U	Sand	1	1	382	4	1
PB-0064	Buckhorn	U	Sand	1	1	409	0	0
PB-0065	Guadalupe	Q	Sand	1	1	407	0	0
PB-0066	Guadalupe	Q	Sand	1	1	388	0	2
PB-0067	Lone Butte	Q	Sand	1	1	400	0	3
PB-0068	Tempe	I	Sand	1	1	370	0	0
PB-0069	Tempe	I	Sand	1	1	404	0	2
PB-0070	Tempe	I	Sand	1	1	404	0	1
PB-0071	Tempe	I	Sand	1	1	367	0	0
PB-0072	Paradise Valley	I	Sand	1	1	405	0	0
PB-0074	Paradise Valley	V	Sand	1	1	396	0	0
PB-0075	Mesa	U	Sand	1	1	330	0	1
PB-0076	Mesa	U	Sand	1	1	384	1	0
PB-0077	Buckhorn	U	Sand	1	1	335	0	1
PB-0078	Buckhorn	U	Sand	1	1	376	1	1
PB-0079	Stewart Mountain	U	Sand	1	1	397	1	0
PB-0080	Stewart Mountain	U	Sand	1	1	358	1	0
PB-0081	Tempe	I	Sand	1	1	365	0	1
PB-0082	Tempe	I	Sand	1	1	413	2	2
PB-0083	Tempe	I	Sand	1	1	398	0	0
PB-0084	Paradise Valley	I	Sand	1	1	370	0	1

Table F.3.A. Continued.

Sample No.	Topographic Map Name	Petrofacies[a]	Sample Type	Observation	Thin Section Use	Total	Other	Unknown
PB-0085	Paradise Valley	V	Sand	1	1	352	1	1
PB-0088	Sunnyslope	V	Sand	1	1	352	0	6
PB-0090	Sunnyslope	V	Sand	1	1	318	0	0
PB-0091	Sunnyslope	V	Sand	1	1	389	0	3
PB-0092	Sunnyslope	V	Sand	1	1	117	0	0
PB-0093	Paradise Valley	V	Sand	1	1	369	1	0
PB-0094	Granite Reef Dam	U	Sand	1	1	312	0	0
PB-0095	Buckhorn	U	Sand	1	1	359	0	1
PB-0096	Sunnyslope	V	Sand	1	1	347	6	2
PB-0098	Sunnyslope	V	Sand	1	1	364	4	1
PB-0099	Paradise Valley	V	Sand	1	1	350	0	5
PB-0100	Union Hills	Y	Sand	1	1	384	3	0
PB-0101	Union Hills	V	Sand	1	1	359	1	6
PB-0104	Paradise Valley	V	Sand	1	1	336	0	3
PB-0106	Sunnyslope	V	Sand	1	1	388	3	0
PB-0107	Guadalupe	Q	Sand	1	1	344	1	0
PB-0108	Tempe	Q	Sand	1	1	538	0	0
PB-0109	Lone Butte	Q	Sand	1	1	349	0	0
PB-0110	Lone Butte	Q	Sand	1	1	395	0	0
PB-0111	Lone Butte	Q	Sand	1	1	402	0	0
PB-0112	Lone Butte	Q	Sand	1	1	375	0	0
PB-0113	Laveen	Q	Sand	1	1	367	2	2
PB-0114	Laveen	Q	Sand	2	1	403	0	0
PB-0115	Laveen	Q	Sand	1	1	342	1	0
PB-0116	Laveen	Q	Sand	1	1	354	3	4
PB-0117	Lone Butte	Q	Sand	1	1	338	0	3
PB-0118	Laveen	Q	Sand	1	1	373	2	2
PB-0119	Lone Butte	Q	Sand	1	1	304	4	4
PB-0120	Sunnyslope	V	Sand	1	1	355	1	0
PB-0121	Sunnyslope	V	Sand	1	1	408	1	1
PB-0122	Sunnyslope	W	Sand	1	1	371	9	0
PB-0123	Sunnyslope	W	Sand	1	1	370	3	0
PB-0124	Sunnyslope	W	Sand	1	1	410	5	2
PB-0125	Sunnyslope	Y	Sand	1	1	379	3	2
PB-0126	Sunnyslope	Y	Sand	1	1	396	2	0
PB-0127	Sunnyslope	Y	Sand	1	1	325	2	2
PB-0128	Sunnyslope	Y	Sand	1	1	347	3	0
PB-0131	Union Hills	Y	Sand	1	1	321	0	1

[a]P = Paradise; T = Taliesin; F4 = Fountain Hills; U = Usery; Q = South Mountain; I = Camelback Buttes; V = Phoenix Mountains; W = North; Y = Lookout.

Table F.3. Continued.

B. Monocrystalline grains (only those present are included).

Sample No.	Qtz	Kspar	Micr	Plag	Plagal	Plaggn	Px	Amph	Opaq	Biot	Musc	Chlor	Oliv	Epid	Sphene	Gar	Caco
PB-0001	48	4	3	2	23	0	0	0	3	1	2	1	0	0	0	0	0
PB-0002	127	11	36	2	26	2	0	0	3	2	10	4	0	3	0	0	0
PB-0003	140	8	43	14	23	4	0	1	1	2	6	0	0	1	1	0	0
PB-0007	206	0	0	4	4	0	1	1	11	0	2	2	0	1	0	0	0
PB-0011	72	4	2	3	11	0	0	0	4	0	11	2	0	1	0	0	0
PB-0012	19	0	1	2	33	5	0	0	3	1	0	0	0	8	0	0	0
PB-0014	45	6	20	13	89	6	0	0	4	2	5	0	0	6	3	0	0
PB-0017	92	1	131	9	57	0	0	0	2	3	0	1	0	1	3	0	0
PB-0019	80	15	82	20	63	5	0	0	9	2	4	1	0	0	0	0	0
PB-0020	92	21	80	16	68	2	0	0	1	2	1	0	0	1	0	0	0
PB-0026	126	15	44	21	31	6	1	1	4	1	3	0	0	1	0	0	1
PB-0027	154	31	64	22	53	9	2	0	2	0	1	1	0	1	1	0	0
PB-0034	153	28	60	11	45	14	1	0	8	1	2	0	0	2	1	0	0
PB-0037	87	34	47	21	50	3	6	1	14	6	0	1	0	1	0	0	0
PB-0039	95	19	56	20	55	5	2	0	5	1	1	1	0	0	0	0	0
PB-0041	120	11	60	11	52	12	3	0	7	2	1	0	0	2	0	0	0
PB-0042	149	16	66	11	39	18	1	0	2	0	3	1	0	1	2	0	0
PB-0043	131	24	64	8	31	15	2	0	3	0	2	2	0	0	0	0	0
PB-0044	115	21	73	13	75	8	0	0	5	0	2	0	0	4	0	0	0
PB-0045	97	15	66	11	67	6	0	4	29	4	3	1	0	3	0	1	0
PB-0048	92	18	92	10	59	1	0	0	2	0	2	0	0	2	0	0	0
PB-0049	100	9	90	12	40	5	0	0	0	1	0	0	0	3	1	0	0
PB-0050	108	18	10	39	18	8	0	1	16	3	1	2	0	3	0	0	0
PB-0061	128	58	43	17	120	1	0	0	10	5	2	3	0	6	2	0	0
PB-0062	139	23	60	23	87	31	0	0	2	5	0	5	0	2	1	0	0
PB-0063	134	13	78	12	111	13	0	0	4	3	0	1	0	2	1	0	0
PB-0064	170	71	42	9	90	3	0	1	3	5	0	1	0	2	0	0	0
PB-0065	53	39	24	110	46	4	0	0	4	1	3	3	0	0	0	0	0
PB-0066	78	72	10	80	41	1	0	0	1	3	0	4	0	0	0	0	0
PB-0067	57	49	1	95	53	4	0	10	3	6	1	5	0	0	0	0	0

Table F.3.B. Continued.

Sample No.	Qtz	Kspar	Micr	Plag	Plagal	Plaggn	Px	Amph	Opaq	Biot	Musc	Chlor	Oliv	Epid	Sphene	Gar	Caco
PB-0068	41	22	10	10	28	2	0	0	3	1	2	1	0	3	0	0	0
PB-0069	91	62	14	18	64	3	0	1	4	5	5	3	0	4	2	0	0
PB-0070	94	69	22	12	45	2	1	0	6	3	4	3	0	5	2	0	1
PB-0071	74	53	21	21	48	9	0	0	4	2	3	4	0	3	0	0	0
PB-0072	101	13	67	68	58	6	1	13	10	5	15	3	0	6	1	0	0
PB-0074	113	21	51	24	76	3	1	2	3	1	6	1	0	4	0	0	0
PB-0075	117	20	43	14	38	7	3	0	15	2	0	1	0	4	3	0	0
PB-0076	148	14	67	14	34	23	3	1	6	0	2	1	0	0	0	0	0
PB-0077	70	8	35	29	68	5	1	0	12	7	3	8	0	8	1	0	0
PB-0078	104	11	81	22	87	7	0	0	8	8	2	4	0	6	1	0	0
PB-0079	122	18	66	29	113	11	0	0	1	14	2	3	0	8	2	0	0
PB-0080	146	13	84	15	55	7	0	0	0	4	2	3	0	3	0	0	0
PB-0081	120	47	61	23	57	3	0	0	2	3	9	4	0	3	2	0	0
PB-0082	94	21	64	39	63	9	2	0	7	6	4	7	0	3	3	0	1
PB-0083	93	26	45	25	31	8	1	2	4	4	6	4	0	2	2	0	1
PB-0084	102	9	78	32	99	5	0	0	3	6	10	4	0	5	5	0	0
PB-0085	131	5	83	16	37	7	1	1	4	1	3	1	0	5	1	0	0
PB-0088	191	4	8	5	6	7	2	1	6	0	38	2	0	1	0	0	0
PB-0090	116	3	6	6	7	0	0	0	10	2	32	3	0	3	1	0	2
PB-0091	205	0	12	9	10	5	1	6	14	0	33	8	0	2	0	1	0
PB-0092	43	8	1	4	10	0	1	2	3	3	13	3	0	1	0	0	0
PB-0093	146	6	67	12	55	5	0	2	11	0	11	2	0	5	1	0	0
PB-0094	93	11	47	16	79	22	0	0	3	2	7	16	0	3	3	0	0
PB-0095	156	8	58	16	51	14	0	1	4	1	2	3	0	8	2	0	0
PB-0096	104	4	11	5	9	1	0	3	22	0	20	9	0	2	0	0	1
PB-0098	144	7	28	14	17	6	0	2	43	0	7	5	0	4	0	0	1
PB-0099	204	1	3	2	3	4	4	6	20	1	16	10	0	1	1	0	0
PB-0100	128	9	37	16	20	23	2	0	3	0	1	2	0	5	1	0	0
PB-0101	193	2	0	7	10	1	10	2	6	1	27	18	5	1	0	0	0
PB-0104	211	0	3	5	9	0	1	2	14	2	18	8	0	1	0	0	0
PB-0106	54	4	26	2	19	10	1	2	24	0	5	7	0	3	0	0	1
PB-0107	62	8	52	94	47	9	0	3	4	4	1	5	0	1	2	0	0

Table F.3.B. Continued.

Sample No.	Qtz	Kspar	Micr	Plag	Plagal	Plaggn	Px	Amph	Opaq	Biot	Musc	Chlor	Oliv	Epid	Sphene	Gar	Caco
PB-0108	206	76	63	1	148	0	0	7	1	3	3	8	0	3	0	0	0
PB-0109	59	8	78	114	32	1	0	1	6	4	1	4	0	0	0	0	0
PB-0110	86	8	84	113	43	3	1	2	9	16	0	3	0	0	0	0	0
PB-0111	82	27	79	92	35	4	0	2	5	3	1	6	0	0	0	0	0
PB-0112	29	11	62	133	28	6	0	1	6	8	5	9	0	1	0	0	0
PB-0113	67	1	0	22	84	18	0	28	8	8	27	48	0	9	0	0	1
PB-0114	160	9	106	26	50	15	0	0	3	6	3	1	0	3	0	0	0
PB-0115	62	1	0	23	90	6	1	19	17	6	16	35	0	20	1	1	0
PB-0116	67	3	5	23	99	12	1	23	5	5	11	34	0	9	3	0	0
PB-0117	99	27	44	29	72	4	0	6	11	3	5	7	0	1	0	0	0
PB-0118	80	6	4	43	75	11	2	19	11	4	12	43	0	18	0	0	0
PB-0119	56	3	5	37	45	3	1	20	13	2	11	34	0	15	0	0	0
PB-0120	80	8	38	7	28	4	0	0	10	1	2	2	1	2	0	0	2
PB-0121	93	5	20	12	38	6	1	4	20	4	13	11	0	4	1	0	1
PB-0122	122	2	5	24	84	20	0	1	1	10	12	17	0	11	0	0	0
PB-0123	84	2	1	33	109	12	0	1	2	9	22	28	0	15	1	1	1
PB-0124	95	0	3	18	77	11	2	2	7	17	17	24	0	13	0	0	2
PB-0125	94	5	39	22	54	7	2	0	10	1	3	2	0	9	1	0	4
PB-0126	113	14	37	36	39	11	7	0	10	0	3	9	0	4	0	0	1
PB-0127	70	1	22	19	37	6	9	0	5	1	13	16	0	7	0	0	0
PB-0128	115	2	50	21	44	6	1	0	3	2	5	4	0	5	1	0	0
PB-0131	49	4	12	31	33	7	16	0	13	3	6	4	0	2	0	0	1

Table F.3. Continued.

C. Lithic grains and monocrystalline grains within course foliated rock fragments (only those present are included).

Sample No.	Lmm	Lmf	Lma	Lmt	Lmtp	Lmvf	Lmss	Lmamph	Lvfb	Lvf	Lvi	Lvm	Lvv	Lvh	Lss	Lsa	Lsch	Lsca	Sqtz	Skspar	Splag	Sbiot	Smusc	Schlor	Sopaq
PB-0001	8	3	104	109	37	1	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0
PB-0002	12	1	71	37	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PB-0003	6	1	40	36	0	0	1	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
PB-0007	24	0	14	8	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
PB-0011	15	1	121	79	1	13	0	3	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
PB-0012	3	0	130	120	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PB-0014	1	0	75	44	0	40	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0
PB-0017	0	0	10	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PB-0019	2	0	24	3	0	3	0	2	0	0	0	0	0	6	0	0	0	0	0	0	1	0	0	0	0
PB-0020	0	0	18	1	0	1	0	0	0	0	1	0	0	7	0	0	0	0	0	0	0	0	0	0	0
PB-0026	0	0	1	5	0	0	0	0	0	7	2	0	3	8	0	2	4	5	0	0	0	0	0	0	0
PB-0027	1	0	3	2	0	0	0	0	0	5	0	0	4	4	1	0	0	0	1	0	0	0	0	0	0
PB-0034	0	0	4	2	1	0	0	0	2	1	5	0	3	4	0	0	0	1	0	0	0	0	0	0	0
PB-0037	0	0	4	0	0	0	0	0	0	11	36	0	0	6	0	0	0	0	0	0	0	0	0	0	0
PB-0039	0	1	1	1	0	0	0	0	0	11	18	0	2	7	0	0	0	2	0	0	1	0	0	0	0
PB-0041	0	0	8	1	0	0	0	0	0	11	21	0	6	5	0	0	0	0	0	0	0	0	0	0	0
PB-0042	1	1	8	5	0	0	0	0	0	0	1	0	2	3	0	0	0	0	0	0	0	0	0	0	0
PB-0043	1	0	7	3	0	4	0	0	0	22	6	0	0	3	0	0	0	2	0	0	0	0	0	0	0
PB-0044	0	0	5	2	0	6	0	0	0	0	0	0	1	7	0	0	0	0	2	0	0	0	0	0	0
PB-0045	0	0	7	5	0	0	0	2	0	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0
PB-0048	0	0	22	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PB-0049	0	0	13	0	0	3	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
PB-0050	0	0	0	0	0	0	0	1	0	8	1	0	12	5	0	0	0	14	0	0	0	0	0	0	0
PB-0061	0	0	2	1	0	0	1	0	0	0	4	0	0	0	0	3	1	5	2	2	5	0	0	0	0
PB-0062	0	0	1	1	0	0	0	0	0	0	0	0	0	2	0	0	0	4	0	0	0	0	0	0	0
PB-0063	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	2	0	0	0	0	0	0	0
PB-0064	0	0	0	1	0	0	0	0	0	1	0	0	1	1	0	2	1	0	3	0	2	0	0	0	0
PB-0065	17	36	14	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	35	7	7	0	0	0	0
PB-0066	4	14	27	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	27	14	4	0	0	0	0
PB-0067	5	3	29	4	6	0	0	8	0	0	0	0	0	0	0	0	0	4	32	9	12	1	0	0	0
PB-0068	0	0	72	78	1	33	0	0	0	0	0	1	0	4	0	18	0	40	0	0	0	0	0	0	0
PB-0069	0	0	42	9	0	0	0	0	0	0	0	0	0	2	0	3	1	61	3	1	4	0	0	0	0
PB-0070	0	0	74	31	0	9	0	0	0	3	0	1	0	7	0	4	0	4	1	0	0	0	0	0	0
PB-0071	0	1	62	37	0	9	0	0	0	3	0	0	0	0	0	1	0	8	2	0	2	0	0	0	0
PB-0072	2	0	23	4	0	0	0	1	0	0	0	1	0	2	0	0	0	2	1	1	0	0	0	0	0
PB-0074	1	2	46	13	0	9	0	0	0	4	1	0	0	0	0	0	0	12	2	0	0	0	0	0	0
PB-0075	0	0	0	0	0	1	0	0	1	35	9	0	5	4	0	0	0	6	0	0	0	0	0	0	0
PB-0076	2	0	4	1	0	0	0	1	0	43	15	0	1	2	0	0	1	0	0	0	0	0	0	0	0
PB-0077	2	0	0	2	0	1	0	0	0	18	0	0	9	8	0	0	0	27	0	0	0	0	0	0	0
PB-0078	0	0	2	0	0	0	0	0	0	1	0	0	1	3	0	0	1	19	0	0	0	4	0	1	0
PB-0079	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0
PB-0080	0	0	1	0	0	0	0	0	2	9	0	0	11	0	0	0	0	0	0	0	1	0	0	0	0
PB-0081	0	0	13	2	0	1	0	0	0	6	0	1	0	2	0	0	0	4	0	0	0	1	0	0	0
PB-0082	0	0	35	0	0	5	2	0	0	5	0	0	0	3	0	0	0	28	0	0	0	0	0	0	0
PB-0083	0	0	4	0	2	1	0	0	0	16	0	0	3	1	0	0	2	98	0	0	1	0	0	0	0
PB-0084	0	0	2	0	0	0	0	0	0	2	0	0	1	1	0	0	0	5	0	0	0	0	0	0	0
PB-0085	0	0	32	2	0	1	0	0	1	4	3	0	0	0	0	0	0	11	0	0	0	0	0	0	0
PB-0088	1	0	24	44	0	0	0	0	0	2	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
PB-0090	1	0	28	47	0	0	0	1	0	3	0	0	0	0	0	0	0	46	1	0	0	0	0	0	0

Table F.3.C. Continued.

Sample No.	Lmm	Lmf	Lma	Lmt	Lmtp	Lmvf	Lmss	Lmamph	Lvfb	Lvf	Lvi	Lvm	Lvv	Lvh	Lss	Lsa	Lsch	Lsca	Sqtz	Skspar	Splag	Sbiot	Smusc	Schlor	Sopaq
PB-0091	0	0	16	6	0	0	0	4	0	7	1	0	1	0	0	0	0	43	1	0	0	0	0	0	0
PB-0092	0	0	5	0	0	0	0	0	0	1	1	0	0	1	0	0	0	16	0	0	0	0	0	0	0
PB-0093	0	0	23	7	0	2	0	0	0	5	0	1	0	0	0	0	0	7	0	0	0	0	0	0	0
PB-0094	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	0	0	0
PB-0095	0	0	4	1	0	0	0	0	0	8	1	0	2	0	0	0	0	17	0	0	0	1	0	0	0
PB-0096	1	0	46	48	4	4	0	1	0	6	3	0	0	0	0	0	0	35	0	0	0	0	0	0	0
PB-0098	1	0	16	15	7	0	0	0	0	10	4	0	0	0	0	0	0	28	0	0	0	0	0	0	0
PB-0099	1	0	23	13	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0	0	0	0
PB-0100	0	0	20	8	2	5	0	1	1	56	19	0	2	2	0	0	0	18	0	0	0	0	0	0	0
PB-0101	0	0	30	23	2	0	0	3	1	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0
PB-0104	1	0	25	18	0	0	0	2	0	0	1	0	0	0	0	0	0	8	4	0	0	0	0	0	0
PB-0106	0	0	46	52	43	6	0	0	1	27	27	3	0	0	0	0	0	20	2	0	0	0	0	0	0
PB-0107	2	5	8	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0	0
PB-0108	1	0	3	0	0	0	1	0	5	4	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0
PB-0109	3	4	5	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	22	0	3	0	0	0	0
PB-0110	2	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0
PB-0111	0	7	6	3	0	1	0	0	0	3	1	0	0	0	0	0	0	1	44	0	0	0	0	0	0
PB-0112	5	6	22	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	1	0	0	0	0
PB-0113	0	0	13	6	5	0	0	6	0	0	0	0	0	0	0	0	0	8	4	0	0	0	0	0	0
PB-0114	0	0	0	0	0	0	0	0	2	4	0	0	13	0	0	0	0	1	1	0	0	0	0	0	0
PB-0115	0	1	23	10	0	0	0	3	0	0	0	0	0	0	0	0	0	3	2	0	1	0	0	0	0
PB-0116	0	0	18	5	0	0	0	9	0	0	0	0	0	0	0	0	0	12	2	0	0	1	0	0	0
PB-0117	0	1	7	0	0	0	0	2	0	3	0	0	0	0	0	0	0	1	9	0	3	0	0	0	1
PB-0118	1	0	18	5	1	0	0	7	0	0	0	0	0	0	0	0	0	1	4	0	3	0	1	0	0
PB-0119	3	0	26	4	0	0	0	6	0	0	0	0	0	0	0	0	0	6	2	0	0	0	1	3	0
PB-0120	0	0	32	53	8	6	1	3	3	16	8	1	0	1	0	0	0	35	0	0	0	0	0	0	2
PB-0121	3	0	45	44	31	1	0	0	7	21	8	0	0	0	0	0	0	12	0	0	1	0	0	0	0
PB-0122	0	0	24	12	1	0	0	1	0	1	0	0	0	0	0	0	0	11	3	0	0	0	0	0	0
PB-0123	0	0	14	11	0	0	0	0	0	0	2	0	0	0	0	0	0	15	2	0	2	0	0	0	0
PB-0124	0	0	27	14	10	0	0	0	1	5	5	0	1	0	0	1	0	46	0	0	0	0	0	0	0
PB-0125	2	0	38	26	3	1	0	0	0	10	17	1	2	1	0	0	1	12	4	0	0	0	0	0	0
PB-0126	0	0	15	2	5	0	0	0	0	28	15	0	9	3	0	0	2	30	0	0	0	0	0	0	0
PB-0127	0	0	42	20	8	0	0	0	0	2	14	4	0	0	0	0	0	21	1	0	0	0	0	0	0
PB-0128	1	0	12	10	5	0	0	3	0	16	9	0	0	1	0	0	1	26	0	0	0	0	0	0	0
PB-0131	0	0	5	8	0	2	0	0	0	13	72	1	0	0	0	0	0	38	0	0	0	0	0	0	0

Table F.4. Point-count data for the analyzed samples, PHX Sky Train project. (Parameter definitions are given in Table F.1.)

A. Inventory data, totals, and other inclusions.

Sample	Temper Type	Temper Source Generic	Petrofacies[a]	Total	Total Sand Temper	Paste	Percent Temper	Voids	Grog	Clay Lumps	Fiber	Other	Unknown
COP10-0025	Sand	Q	Q	386	386	545	41.46	93	0	0	0	0	0
COP10-0026	Sand	Q	Q	413	412	603	40.65	98	0	1	0	0	0
COP10-0027	Sand	Q	Q	293	293	499	36.99	48	0	0	0	0	0
COP10-0028	Sand	Q	Q	600	600	207	74.35	95	0	0	0	0	0
COP10-0029	Sand	Q	Q	375	375	608	38.15	114	0	0	0	0	0
COP10-0030	Sand	Q	Q	245	242	534	31.45	69	2	0	1	0	0
COP10-0031	Sand	Q	Q	299	293	618	32.61	98	6	0	0	0	0
COP10-0032	Sand	Q	Q	306	306	507	37.64	64	0	0	0	0	0
COP10-0033	Sand	Q or R	Q?	408	408	522	43.87	66	0	0	0	0	0
COP10-0034	Sand	Q or R	Q	278	278	645	30.12	138	0	0	0	0	0
COP10-0035	Sand	Q or R	Q	274	273	632	30.24	73	0	1	0	0	0
COP10-0036	Sand	Q or R	Q	441	441	492	47.27	67	0	0	0	0	0
COP10-0037	Low LMT	I or V	I	332	331	622	34.80	105	1	0	0	0	0
COP10-0038	Sand and grog	I or V	R	350	346	598	36.92	145	4	0	0	0	0
COP10-0039	Sand	I or V	Unknown	325	325	542	37.49	97	0	0	0	0	0
COP10-0040	Sand	I or V	Q	367	365	449	44.98	136	1	1	0	0	0
COP10-0041	Low LMT	I or V	Unknown	343	343	485	41.43	63	0	0	0	0	0
COP10-0042	Sand	I or V	Unknown	195	158	615	24.07	78	37	0	0	0	0
COP10-0043	Grog, schist, and sand	I or V	Unknown	221	170	433	33.79	68	50	1	0	0	0
COP10-0044	Low LMT	I or V	I	391	383	593	39.74	68	7	1	0	0	0
COP10-0045	Moderate LMT	I or V	I	428	428	467	47.82	79	0	0	0	0	0
COP10-0046	Moderate LMT	I or V	Unknown	517	515	595	46.49	75	0	2	0	0	0
COP10-0047	Moderate LMT	I or V	V	325	323	530	38.01	47	2	0	0	0	0
COP10-0048	Sand	-9A	R?	209	202	418	33.33	83	7	0	0	0	0
COP10-0049	Sand	-9A	Unknown	269	267	403	40.03	98	0	2	0	0	0
COP10-0050	Sand	-9A	Unknown	391	391	515	43.16	91	0	0	0	0	0
COP10-0051	Sand	-9B	Unknown	418	418	435	49.00	97	0	0	0	0	0
COP10-0052	Sand	-9B	I?	304	304	564	35.02	83	0	0	0	0	0
COP10-0053	Sand	-9B	I?	397	394	501	44.21	87	2	1	0	0	0
COP10-0054	Sand	-9C	Unknown	345	344	518	39.98	63	0	1	0	0	0

Table F.4.A. Continued.

Sample	Temper Type	Temper Source Generic	Petrofacies[a]	Total	Total Sand Temper	Paste	Percent Temper	Voids	Grog	Clay Lumps	Fiber	Other	Unknown
COP10-0055	Sand and grog	Granitic, White (H, J, Q, R)	Q	221	167	315	41.23	54	54	0	0	0	0
COP10-0056	Sand	Granitic, White (H, J, Q, R)	Q	257	218	506	33.68	42	38	1	0	0	1
COP10-0057	Grog, schist, and sand	Granitic (A, C, H, S)	T?	411	350	456	47.40	93	61	0	0	0	0
COP10-0058	Sand	-9C	Q	199	199	498	28.55	85	0	0	0	0	0
COP10-0059	Sand and grog	-9C	Q	245	174	537	31.33	95	70	1	0	0	0
COP10-0060	Sand and grog	-9C	Unknown	282	194	488	36.62	97	88	0	0	0	0

[a]This is the petrofacies assigned during the petrographic analysis: Q = South Mountain; R = Montezuma; I = Camelback Buttes; V = Phoenix Mountains; 9A = Gila River/Santan Mountains; 9B = Gila River/Olberg; 9C = Gila River/Twin Buttes; H = Sacaton Mountains; J = Sacaton West; S = Pima Butte.

Table F.4. Continued.

B. Monocrystalline grains (only those present are included).

Sample No.	Qtz	Kspar	Micr	Plag	Plagal	Plaggn	Px	Amph	Opaq	Biot	Musc	Chlor	Epid	Sphene	Caco
COP10-0025	95	72	2	0	141	0	0	1	11	0	0	6	0	3	1
COP10-0026	125	36	2	5	140	0	0	53	2	3	2	23	2	3	1
COP10-0027	86	25	1	9	95	0	0	27	8	0	0	20	2	5	1
COP10-0028	142	70	1	34	145	0	0	124	15	0	0	30	2	5	2
COP10-0029	98	90	1	15	100	0	0	2	3	0	0	5	0	0	0
COP10-0030	45	22	4	3	65	3	1	60	7	0	2	8	0	0	2
COP10-0031	74	42	5	0	99	1	0	10	4	0	1	11	1	0	0
COP10-0032	57	26	0	9	97	4	1	73	2	1	0	12	0	0	8
COP10-0033	11	5	0	20	198	0	0	115	13	0	0	33	3	2	8
COP10-0034	35	14	0	12	89	0	0	89	10	0	0	10	0	0	14
COP10-0035	0	18	0	44	64	0	0	86	6	36	0	6	0	0	8
COP10-0036	23	3	3	34	165	2	1	174	11	0	0	16	0	1	6
COP10-0037	96	30	14	0	42	2	0	0	13	0	66	7	7	5	5
COP10-0038	88	54	69	0	94	0	0	0	12	0	0	13	7	2	3
COP10-0039	113	65	35	5	65	0	0	0	10	1	1	3	1	1	9
COP10-0040	110	55	25	0	120	3	0	1	10	0	5	14	4	2	9
COP10-0041	148	45	16	0	29	2	0	0	12	0	37	18	1	0	4
COP10-0042	51	28	28	0	28	2	0	0	0	0	8	2	2	4	1
COP10-0043	74	16	4	0	20	0	0	3	10	0	3	11	1	0	6
COP10-0044	153	42	34	0	65	1	0	0	8	0	49	9	1	0	7
COP10-0045	130	51	40	0	98	1	1	0	15	0	35	20	4	5	3
COP10-0046	174	106	72	0	55	2	0	0	21	2	41	7	3	4	17
COP10-0047	118	9	0	1	31	3	0	0	15	3	65	11	0	0	2
COP10-0048	77	45	12	0	35	5	0	0	2	0	10	5	3	4	0
COP10-0049	92	49	28	0	60	2	0	0	6	0	5	6	9	0	5
COP10-0050	133	62	47	0	92	5	0	0	24	0	1	9	3	3	4
COP10-0051	118	60	48	0	142	3	0	0	8	1	2	9	9	9	4
COP10-0052	91	43	26	0	74	0	0	0	5	1	3	4	9	10	25
COP10-0053	124	42	39	0	132	6	0	0	2	1	5	10	13	9	5
COP10-0054	124	48	30	0	90	0	0	1	9	0	5	11	8	4	2
COP10-0055	45	28	2	0	48	2	0	1	5	0	2	4	1	1	3
COP10-0056	52	24	3	0	65	6	0	2	9	0	8	9	0	0	0

Table F.4.B. Continued.

Sample No.	Qtz	Kspar	Micr	Plag	Plagal	Plaggn	Px	Amph	Opaq	Biot	Musc	Chlor	Epid	Sphene	Caco
COP10-0057	147	10	68	2	110	2	0	4	3	0	1	2	1	0	0
COP10-0058	50	12	3	0	36	0	0	1	7	1	2	36	0	0	5
COP10-0059	64	21	1	1	29	1	0	3	6	1	4	14	0	0	4
COP10-0060	71	21	15	2	39	6	0	13	12	0	1	6	5	0	0

Table F.4. Continued.

C. Lithic grains and monocrystalline grains within coarse foliated rock fragments (only those present included).

Sample No.	Lmm	Lmf	Lma	Lmt	Lmtp	Lmvf	Lmss	Lvf	Lvi	Lvv	Lsch	Lsca	Smusc	Schlor
COP10-0025	3	11	20	19	0	0	0	0	0	0	0	1	0	0
COP10-0026	0	0	1	8	0	0	0	0	2	0	0	4	0	0
COP10-0027	0	0	0	7	0	0	0	1	3	0	0	3	0	0
COP10-0028	0	0	12	13	0	0	0	1	3	0	0	1	0	0
COP10-0029	7	13	25	16	0	0	0	0	0	0	0	0	0	0
COP10-0030	2	3	3	4	1	0	2	0	1	2	0	2	0	0
COP10-0031	0	2	21	19	1	0	0	0	2	0	0	0	0	0
COP10-0032	8	5	0	1	0	0	0	0	0	0	0	2	0	0
COP10-0033	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COP10-0034	0	0	0	4	0	0	0	0	0	0	0	1	0	0
COP10-0035	0	0	0	0	0	0	0	0	0	0	0	5	0	0
COP10-0036	0	0	0	0	0	0	1	0	0	0	0	1	0	0
COP10-0037	0	1	29	9	0	1	3	0	1	0	0	0	0	0
COP10-0038	0	0	0	1	0	0	1	0	0	0	0	2	0	0
COP10-0039	0	1	0	4	0	0	0	0	0	0	0	11	0	0
COP10-0040	0	0	3	0	0	0	0	0	0	0	0	4	0	0
COP10-0041	1	4	3	2	0	0	0	0	0	0	0	3	13	5
COP10-0042	0	0	0	2	0	0	0	0	1	0	1	0	0	0
COP10-0043	1	4	2	7	0	0	0	1	0	1	0	0	1	5
COP10-0044	0	1	1	1	0	0	0	0	0	0	0	1	9	1
COP10-0045	4	4	3	6	0	0	0	1	0	1	1	0	2	3
COP10-0046	0	0	3	0	0	0	0	0	3	0	0	1	3	1
COP10-0047	1	2	37	15	5	0	0	1	0	0	0	0	1	3
COP10-0048	0	0	1	1	0	0	0	0	0	0	0	0	1	1
COP10-0049	2	2	0	1	0	0	0	0	0	0	0	1	0	1
COP10-0050	1	1	5	0	0	0	0	0	0	0	0	0	0	1
COP10-0051	0	0	4	0	0	0	0	0	0	0	0	1	0	0
COP10-0052	0	0	9	0	0	0	0	0	0	0	0	4	0	0
COP10-0053	0	0	5	0	0	0	0	0	0	0	0	1	0	0
COP10-0054	0	1	5	0	2	0	0	0	0	0	0	3	0	1
COP10-0055	0	13	10	1	0	0	0	0	1	0	0	0	0	0
COP10-0056	2	5	27	2	1	0	0	0	0	0	0	0	1	1
COP10-0057	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COP10-0058	4	20	22	0	0	0	0	0	0	0	0	0	0	0
COP10-0059	1	10	8	3	1	0	0	0	0	1	0	1	0	0
COP10-0060	0	0	2	0	0	0	0	0	1	0	0	0	0	0

Table F.5. Qualitative observations for analyzed samples, PHX Sky Train project. (Parameter definitions are provided in Table F.2.)

A. Qualitative data for the less-than-sand-sized fraction.

	Matrix Attributes			Silt Fraction		Clay Fraction	
Sample No.	Opacity	Color	Heterogenity	Dominant	Secondary	Dominant	Secondary
COP10-0025	3	25	0	1	20	9	40
COP10-0026	3	19	0	1	20	9	40
COP10-0027	3	41	0	1	43	9	40
COP10-0028	3	25	0	1	20	9	40
COP10-0029	3	25	0	1	20	9	40
COP10-0030	3	12	1	1	10	9	40
COP10-0031	3	20	0	1	20	9	40
COP10-0032	3	41	0	1	20	9	40
COP10-0033	3	42	1	1	20	9	40
COP10-0034	3	41	0	1	20	9	40
COP10-0035	3	41	1	1	20	9	40
COP10-0036	3	41	1	1	20	9	40
COP10-0037	3	41	1	1	40	9	40
COP10-0038	2	19	0	1	20	9	40
COP10-0039	3	19	0	1	11	9	40
COP10-0040	3	40	0	1	11	9	40
COP10-0041	3	23	0	1	41	9	40
COP10-0042	3	42	0	1	41	9	40
COP10-0043	3	25	1	1	40	9	40
COP10-0044	3	40	1	1	41	9	40
COP10-0045	3	25	1	1	41	9	40
COP10-0046	3	23	1	1	41	9	40
COP10-0047	3	41	0	1	20	9	40
COP10-0048	2	41	1	1	11	9	40
COP10-0049	3	25	1	1	11	9	40
COP10-0050	3	20	1	1	11	9	40
COP10-0051	3	23	0	1	11	9	40
COP10-0052	3	40	0	1	11	9	40
COP10-0053	3	40	1	1	20	9	40
COP10-0054	3	20	1	1	11	9	40
COP10-0055	3	23	1	1	11	9	40
COP10-0056	3	41	1	1	11	9	40
COP10-0057	3	40	0	1	11	9	40
COP10-0058	3	20	1	1	43	9	40
COP10-0059	3	50	1	1	11	9	40
COP10-0060	3	40	0	1	10	9	40

Table F.5. Continued.

B. Qualitative data for sand-sized fraction.

Sample No.	Temper Type	Modal Schist Size	Modal Sand Size	Finest	Coarsest	Mode	Sorting	Grain Types: Dominant	Grain Types: Secondary	Grain Types: Tertiary
COP10-0025	1	0	9	1	7	9	5	1	11	21
COP10-0026	1	0	9	1	7	9	5	1	21	11
COP10-0027	1	0	9	1	7	9	5	1	21	11
COP10-0028	1	0	9	1	7	9	5	1	21	54
COP10-0029	1	0	9	1	7	9	5	1	21	11
COP10-0030	2	0	9	1	7	9	5	1	21	11
COP10-0031	2	0	9	1	7	9	5	1	21	11
COP10-0032	1	0	9	1	7	9	5	1	21	54
COP10-0033	1	0	9	1	7	9	5	21	1	54
COP10-0034	1	0	9	1	7	9	5	1	20	54
COP10-0035	1	0	9	1	7	9	5	1	21	54
COP10-0036	1	0	9	1	7	9	5	21	54	1
COP10-0037	1	0	9	1	7	9	5	1	21	40
COP10-0038	2	0	9	1	7	9	5	1	11	21
COP10-0039	1	0	9	1	7	9	5	1	11	21
COP10-0040	1	0	9	1	7	9	5	1	11	21
COP10-0041	1	9	9	1	7	9	5	1	41	11
COP10-0042	2	9	9	1	6	9	4	1	17	41
COP10-0043	2	9	9	1	5	9	9	1	43	21
COP10-0044	2	9	9	1	7	9	5	1	19	41
COP10-0045	1	9	9	1	7	9	5	1	41	11
COP10-0046	1	9	9	1	7	9	5	1	11	41
COP10-0047	1	9	9	1	7	9	5	1	41	21
COP10-0048	2	9	9	1	7	9	5	1	11	41
COP10-0049	1	4	9	1	7	9	5	1	11	21
COP10-0050	1	4	9	1	7	9	5	1	11	21
COP10-0051	1	0	9	1	7	9	5	1	19	11
COP10-0052	1	0	9	1	7	9	5	1	19	11
COP10-0053	1	0	9	1	7	9	5	1	21	18
COP10-0054	1	0	9	1	7	9	5	1	19	11
COP10-0055	2	0	9	1	6	9	5	1	21	11
COP10-0056	2	5	9	1	7	9	5	1	21	11
COP10-0057	2	0	9	1	7	9	5	1	19	21
COP10-0058	1	0	9	1	7	9	5	1	21	43
COP10-0059	2	9	9	1	7	9	5	1	11	21
COP10-0060	2	0	9	1	7	9	5	1	21	11

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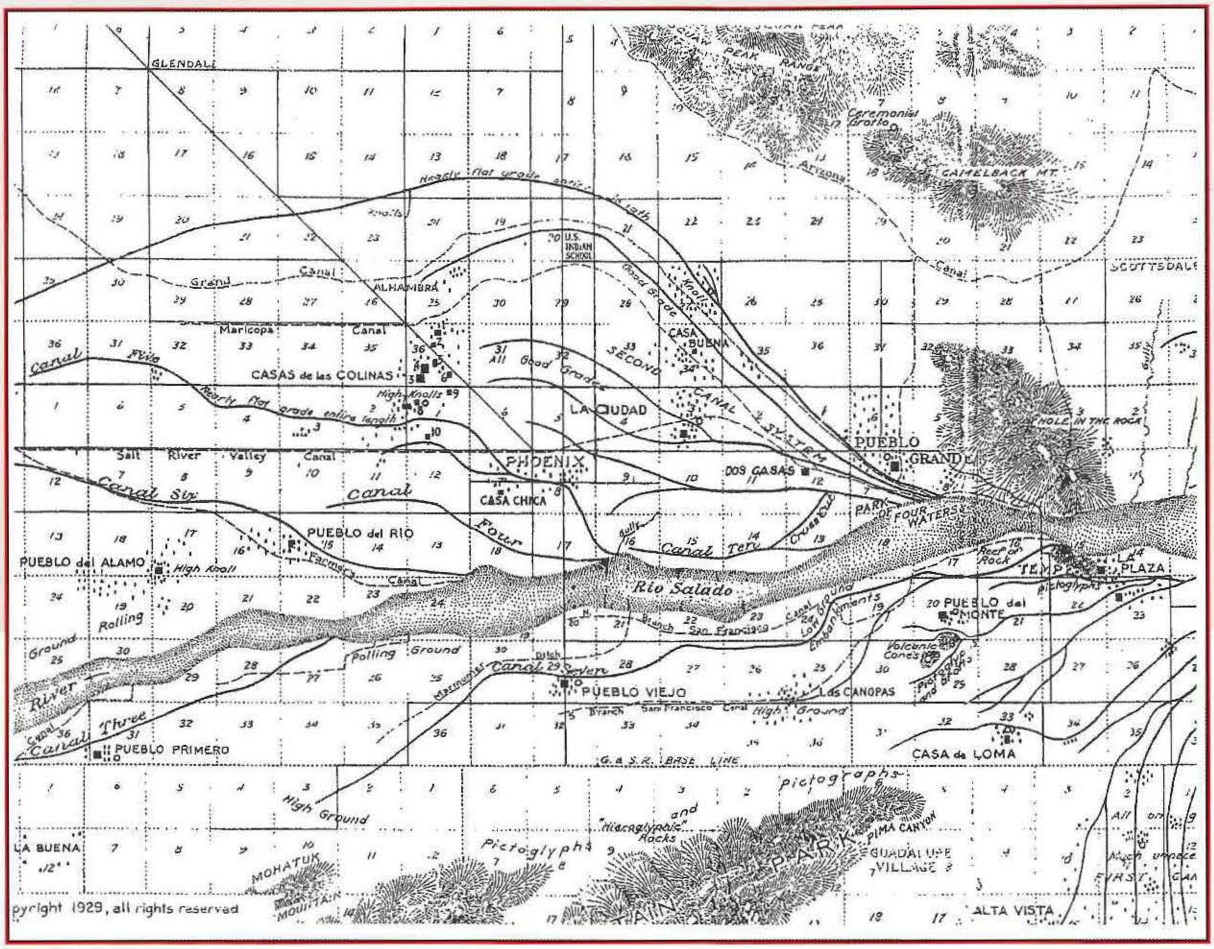

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