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Frederick C. Anderson for the degree of

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Signature redacted for privacy.

Loren G. Davis

The continuation of geoarchaeological investigations at Tseriadun (35CU7) contributes to the understanding of the site's depositional history and the associated environments, thereby identifying the long term geomorphic change in the area and providing the environmental context for local human activity as it is reflected in the archaeological record. Meeting this goal involved collecting a sufficient number of geoarchaeological samples within the area of potential effect of a proposed culvert system and in adjacent site areas. A result of this research was the revision of the model of landscape change at Tseriadun that serves as a platform for exploring how environmental conditions may have affected human activity at the site. The location of a paleochannel in the eastern site area led to assigning a relative period of time to alluvial deposits in this area of the site due to the middle Holocene formation of

Garrison Lake's southern bay. Conclusions are that site use was dependent upon the degree of surficial stability within an area and that activities within all site areas shifted in response to changes in environmental conditions, which were largely determined by early Holocene marine transgression.

GEOARCHAEOLOGY AT TSERIADUN (35CU7), CURRY COUNTY, OREGON

by

Frederick C. Anderson

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APPROVED:

Signature redacted for privacy.

Major Professor, representing Applied Anthropology

Signature redacted for privacy.

Chair of the Department of Anthropology

Signature redacted for privacy.

Dean of the Graduate School

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Frederick C. Anderson, Author

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF TABLES

List of Appendix Tables

CHAPTER 1

TSERIADUN: INTRODUCTION AND RESEARCH OBJECTIVES

Introduction

Archaeologists can only say so much about how and why people behaved in the past, particularly when their research centers on material remains within the archaeological record, and that these culture materials may have undergone significant alterations since the time of their burial. Schiffer (1972) and others (Binford 1983; Gibbon 1984; Shafer 1997) have written about the various cultural and natural transformations that can occur after an artifact has left the system of which it was once part. In instances where only a moderate amount of time has passed, the context of how artifacts were used, their associated behaviors and cultural significance may predate the use of modern ethnographic comparison. A precise and detailed understanding of past human behavior may never be obtained, but a greater portion may be understood from use of the earth sciences to provide context for archaeological sites and the proximate landscape. With the employ of methods associated with geology, soil science, and sedimentology, archaeologists may be able to determine the site formation processes that have shaped a site, and reconstruct the environment in which humans once interacted. This presents the opportunity to move analysis of a site beyond the artifact.

A geoarchaeological approach is particularly useful in coastal settings due to the dynamic nature of coastal environments where changes in sediment deposition can alter how a site was used. For example, at Oregon's Tahkenitch Landing site, the answer to why faunal materials at this fresh water coastal lake reflected an estuarine setting when the site is approximately a kilometer east of the modern ocean was provided by a geoarchaeological investigation in the area. It was determined that there had once been a river-fed estuary that was closed off by the accumulation of dune sand as a result of the middle Holocene return of sea levels (McDowell 1986). The Tseriadun site (35CU7) in Port Orford is another archaeological site on the southern Oregon coast whose history is intricately linked to the geology of the area. One research question raised regarding this site, is why the archaeological record on the western border of the site dates to ca. 7500 BP, while 140 m to the east, cultural material dates to the late Holocene. The answer lies in the site's unique and varied stratigraphic record. Consequently, further research into the timing and nature of Tseriadun's geomorphic and depositional history is the focus of this thesis.

Project Background

The research presented here is a continuation of geoarchaeological and archaeological investigations conducted at the Tseriadun site from 2003 through 2005 (Byram 2005; Davis 2005). Archaeological survey and excavations began in 2003 as part of the city of Port Orford's Ocean Outfall Effluence project. This project involved Section 106 archaeological compliance[1] in conjunction with the placement of a water treatment pipeline through the site by the City of Port Orford (Byram 2005). Two additional projects that followed the 2003 excavations were conducted by the Coquille

[1] Section 106 is part of the National Historic Preservation Act that requires all federal agencies to identify and measure the impact of its actions upon historic resources with the goal of avoiding, minimizing or mitigating adverse effects on historic properties. Furthermore it states that Federal agencies must consult with Indian tribes who may place religious or cultural significance to properties within the area of potential effect (www.achp.gov).

Indian Tribe (CIT) for the Oregon Parks and Recreation Department (OPRD) and the State Historic Preservation Office (SHPO) in order to: 1) understand the nature and extent of the site that was on property recently acquired by the OPRD in June 2003, and 2) salvage archaeological material eroding out of the site's western edge due to breaches of Agate Beach in order to regulate seasonally fluctuating lake levels. In September of 2003, archaeologists established site boundaries and discovered two clay-lined house features and several midden lenses along the western terrace (Byram 2005; Davis et al. 2003). The last project in 2003 is known as the Garrison Lake Outlet Modification Project. This project focused on the excavation of clay-lined house features and an adjacent shell midden to recover data due to its imminent loss by bank erosion.

Physical Setting

The Tseriadun site is located on Oregon's southern coast, in the town of Port Orford, on the south side of Garrison Lake. Cape Blanco lies about 16 kilometers to the north and the Port Orford Heads is directly south (Figure 1). The Port Orford Heads is a geographical feature that factors prominently in the traditional name of the site: "Tseriadun" is interpreted by the Siletz Tribe to mean "the village at the large rocky headland" (Byram 2004a personal communication).

The total site area for Tseriadun is approximately 88,800 square meters (Byram 2006). The site's western boundary is Agate Beach, and an historic lake outlet that extends between the peninsula and the beach (Figure 2). The eastern

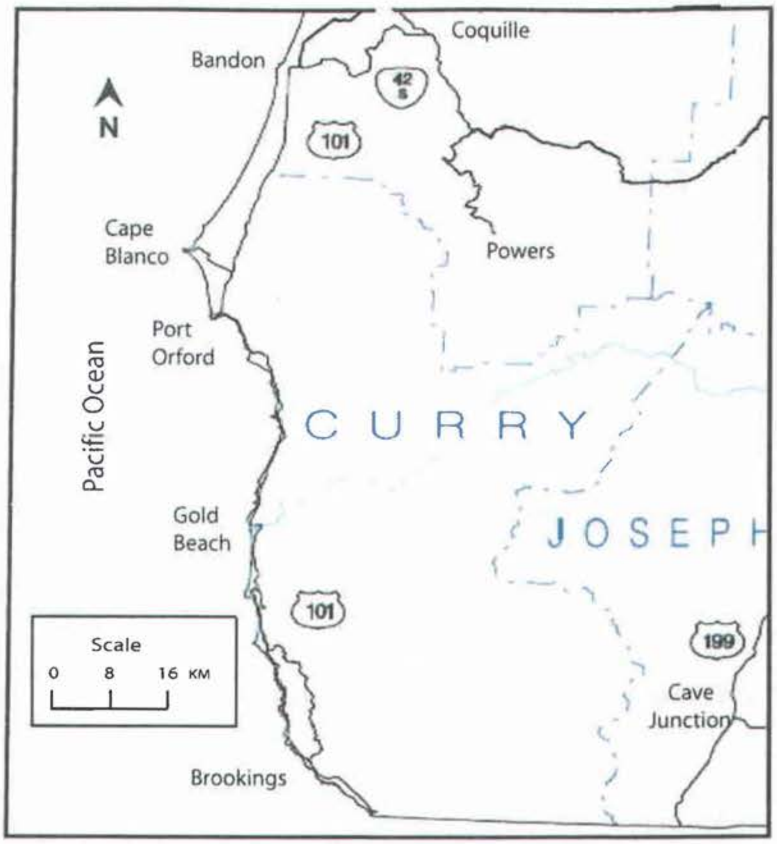


Figure 1. Southern Oregon coast, modifed from State of Oregon map. Close -up of the shaded area shown in Figure 2 below.

Figure 2. Port Orford, Oregon, with 35CU7 outlined. Extent from USGS Sixes, Port Orford, OR., and Cape Blanco, OR. 7.5 Minutes Series maps. A possible location of Heusser's (1960) lake floor coring is marked.

boundary is approximately 90 meters west of California Street (Figure 3); the northern boundary is marked by Garrison Lake's southern-most bay. To the south, the site extends beyond a wetland, also known as Little Round Lake (Figure 4).

Site Areas, Stratigraphy, and Site Formation Model

Site Areas

Byram subdivided the Tseriadun site into six areas, based on differences in local physiography (Figure 5). These areas are as follows: Site Area 1, located in the southwestern edge of the site, along the western terrace; Site Area 2, located in the center of the site, in a forested wetland terrace; Site Area 3, located in the central-eastern portion of the site, near the former location of a residential trailer park; and Site Area 4 located in the northern section of the site, on a peninsula west of Garrison Lake's southern finger. Site Area 5 is south of Site Area 2 and remains untested, while Site Area 6 was defined during the 2005 culvert route testing to which this investigation is linked.

Excavations in 2003 produced over 206 diagnostic artifacts, 10,000 pieces of lithic debitage, and 2000 diagnostic faunal remains. From this material, Byram (2005) identified four discrete archaeological components that are distributed differently across the site areas. Two of these components date to the early to middle Holocene period (ca. 7,000 to 5,000 BP) and are named the Pre-Dune Component and the Initial-Dune Component based on their contextual association with aeolian sediments in the western portion of the site (Figure 6). According to the stratigraphic record (Davis 2005), this first period of aeolian deposition

Figure 3. Close up of the Tseriadun site with site boundaries. The approximate location of geotechinal drilling for the Port Orford Wastewater Treament Plant, a source of comparative data, is marked.

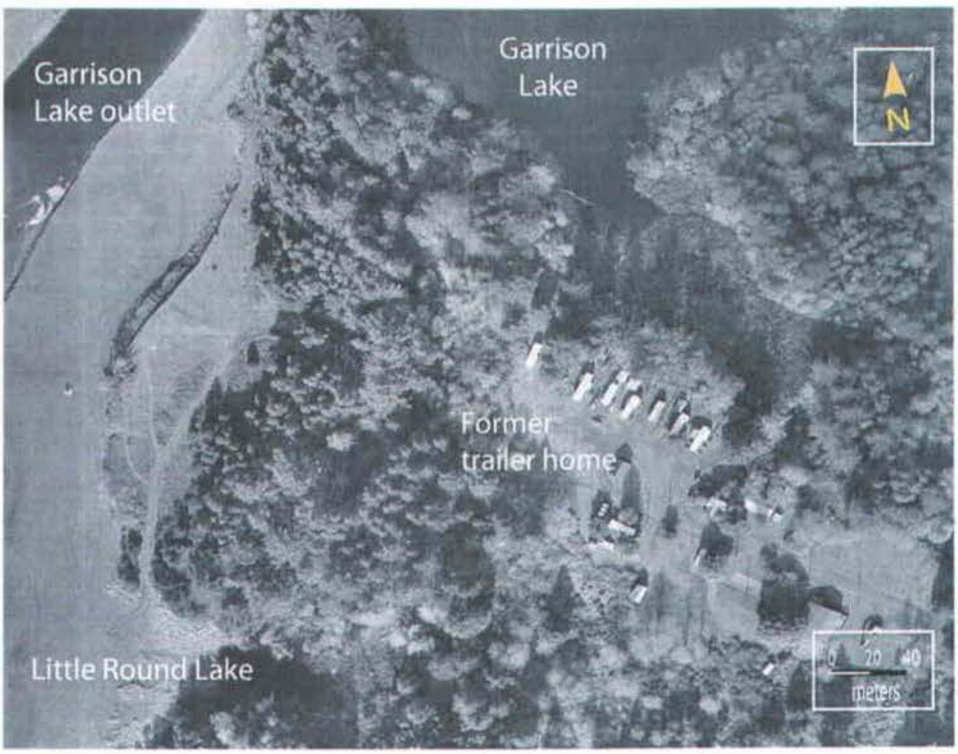


Figure 4. Aerial photograph of 35CU7.

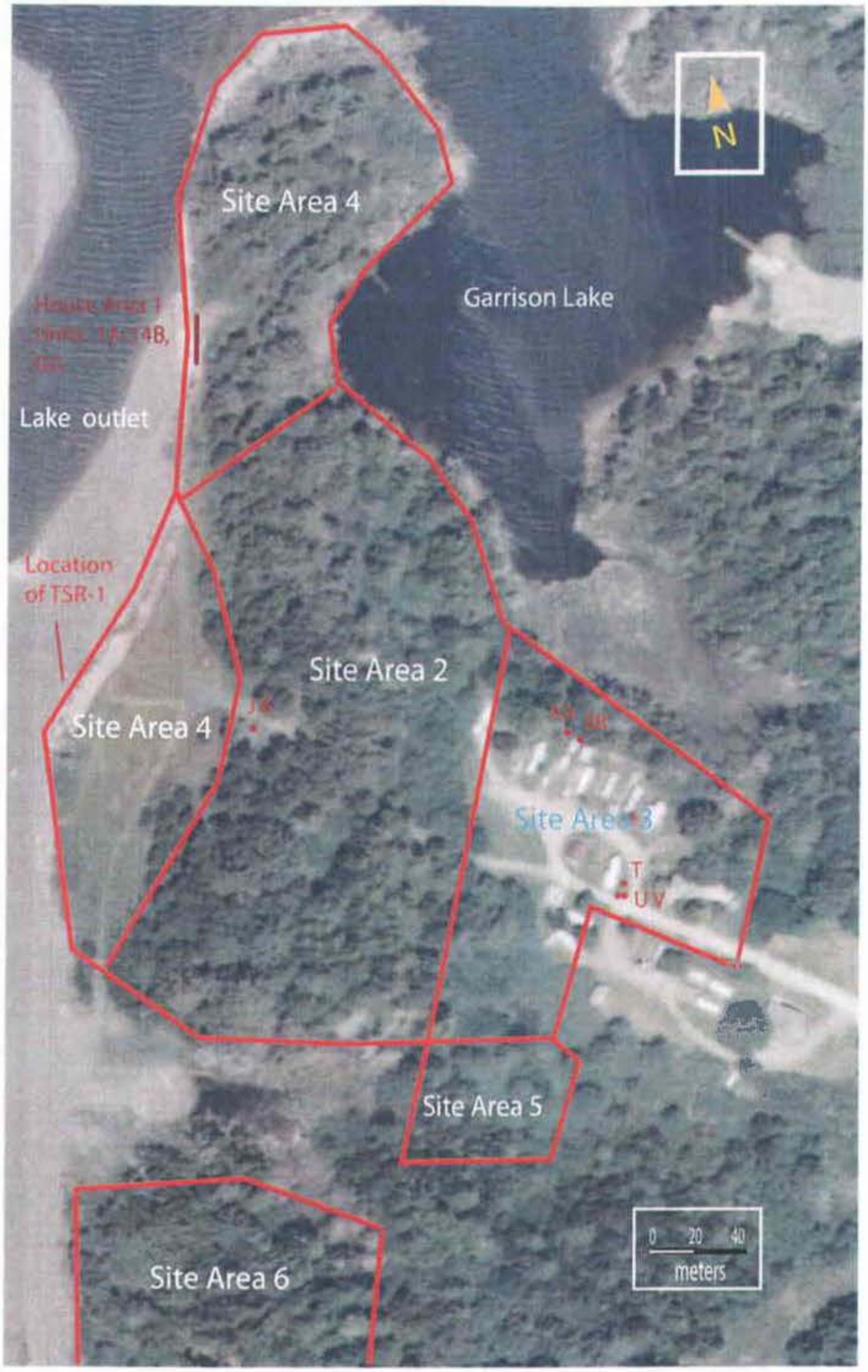


Figure 5. Map of site areas designated at the Tseriadun site (35CU7). Site Areas 1 through 4 were established in 2003, Site Areas 5 and 6 are a product of 2005 investigations. Site Area 6 extends about 100 meters further south than shown here. Units that Davis (2005) used to describe stratigraphic units are marked in dark red.

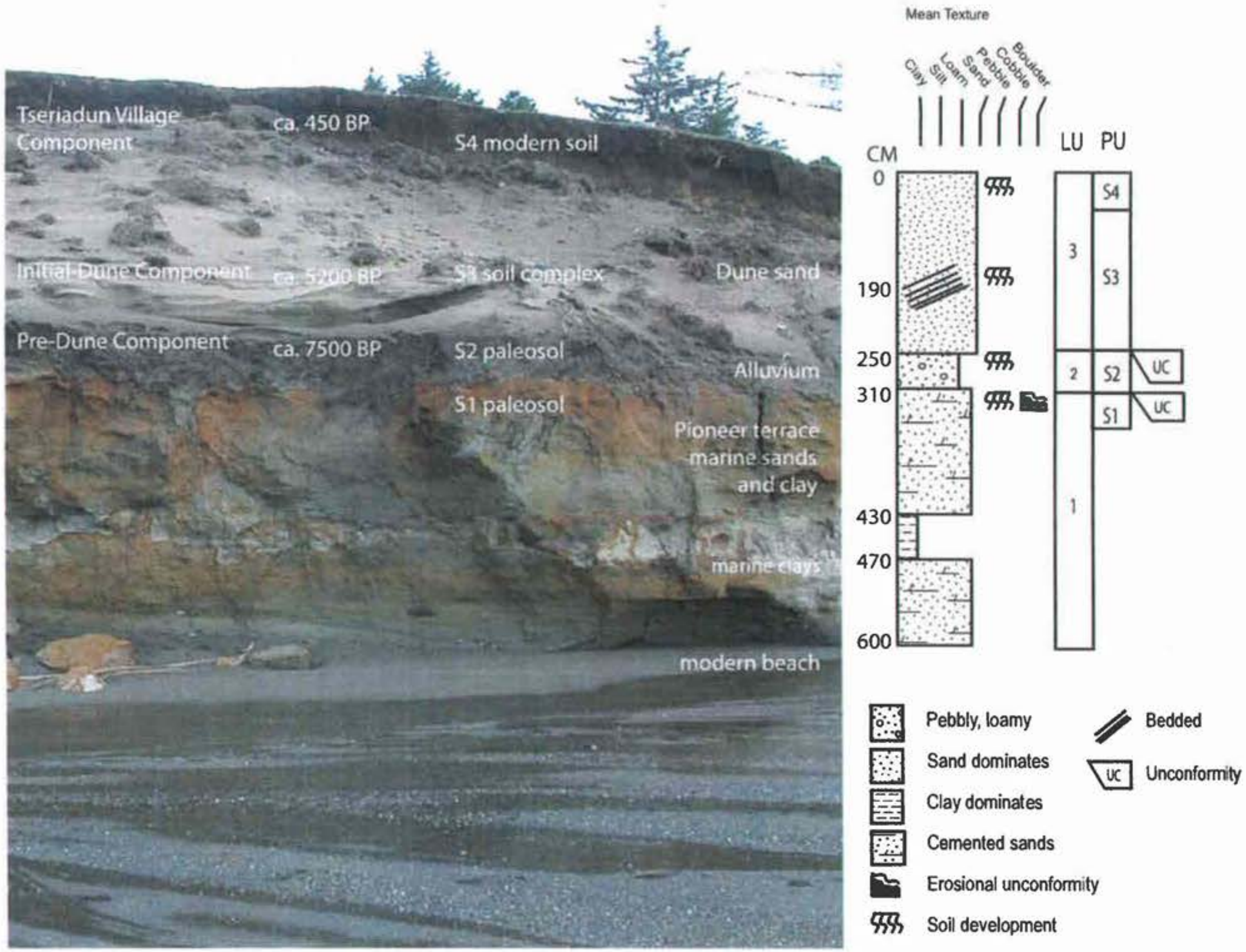


Figure 6. Profile of Site Area 1 illustrating the relative positions of cultural components and the stratigraphic units in which they were identified. The Wetland Component was not identified in this site area, and is not noted here. Stratigraphic units were defined by Davis (2005).

occurred after 7,500 BP and was followed by a second phase after 5,200 BP. The other two components are middle to late Holocene in age and are called the Wetland and Tseriadun Village Component. The former component was found across much of the site but had the greatest concentration of artifacts in Site Areas 2 and 3. The Tseriadun Village Component is described by Byram (2005:8) as:

> the most extensive at the site, represented by shell midden and house pits remains in the western and eastern portions of the site. Radiocarbon samples from House 1, the adjacent midden, House 2, and midden in Areas 3 and southern Area 1 all date to the last millennium. Arrow-size projectile points dominate the Tseriadun Village Component, but there is some degree of intermixing of the Wetland Component materials outside discrete features, including dart points and obsidian flakes.

The cultural components, the site areas where they were observed, associated dates, dating methods, and cultural activity inferred by Byram (2005) from the archaeological record, are summarized in Table 1.

Site Stratigraphy

Davis (2005) provided an initial study of site stratigraphy using guidelines outlined by the Soil Survey Division Staff (1993), the North American Stratigraphic Code (NACOSN 1983) and by employing the concepts and methods written about by Butzer (1982) and Birkeland (1984). Using nomenclature of the North American Stratigraphic Code, stratigraphic units were described on the basis of their

Cultural Component	Site Areas Observed	Age	Dating method	Materials	Inferred activity
Tseriadun Village	1	450 BP to present	Radiocarbon(shell), and correlation to Site Area 4	Clay floors in house pits, marine fauna	Habitation, processing of marine resources
	2	450 BP to present	Radiocarbon(shell), and correlation to Site Area 4	Projectile points, debitage	Hunting (possible)
	3	ca.850 BP to 730 BP (shell)	Radiocarbon, Obsidian Hydration	Shell midden, arrow-sized projectile points, debitage	Food processing, hunting
	4	ca.510 to 380 BP (shell)	Radiocarbon (shell)	Whale bone, shell, clay floors lithic material	Habitation, processing of marine resources
Wetland	1	ca. 4,100 BP to 3,300 BP (obsidian)	Obsidian hydration, Comparative lithic tech.	Projectile points, debitage	Lithic tool manufacture
	2	4,200 BP (shell)	Radiocarbon (shell), Obsidian hydration, Comparative lithic tech.	Projectile points, debitage	Hunting, lithic tool manufacture
	3	ca. 2,500 BP to 1,100 BP (obsidian)	Radiocarbon (shell), Obsidian hydration, Comparative lithic tech.	Projectile points, debitage	Food processing, lithic tool manufacture
	4	ca. 1,500 BP (obsidian)	Obsidian hydration, Comparative lithic tech.	Projectile points, debitage	Lithic tool manufacture
Initial-Dune	1	7,500 BP to 5,300 BP	Radiocarbon (shell), Obsidian hydration,	Shell midden, charcoal, marine resources	Processing marine of resources, habitation
Pre-Dune	1	ca. 7,500 BP	Radiocarbon (charcoal)	CCS flakes, Fire-cracked rock	Unclear

Table 1. Tseriadun's cultural components and their associated inferred cultural activity. Obsidan hydration involves the measure of the hydration rind on an obsidian artifact. The absorbtion of moisture in osidian is measurable. Radiocarbon dating measures the percentage of Carbon 14 that decays at a fixed rate in organic materials after their death.

lithostratigraphic, pedostratigraphic, allostratigraphic, and chronostratigraphic qualities. These units are: 1) lithostratigraphic, a measurement of sediment qualities; 2) pedostratigraphic, a measurement of soil development; 3) allostratigraphic, a description of the boundaries between stratigraphic units; and 4) chronostratigraphic, a measurement that uses dated stratigraphic layers as representative blocks of geologic time (NACOSN 1983; Waters 1992).

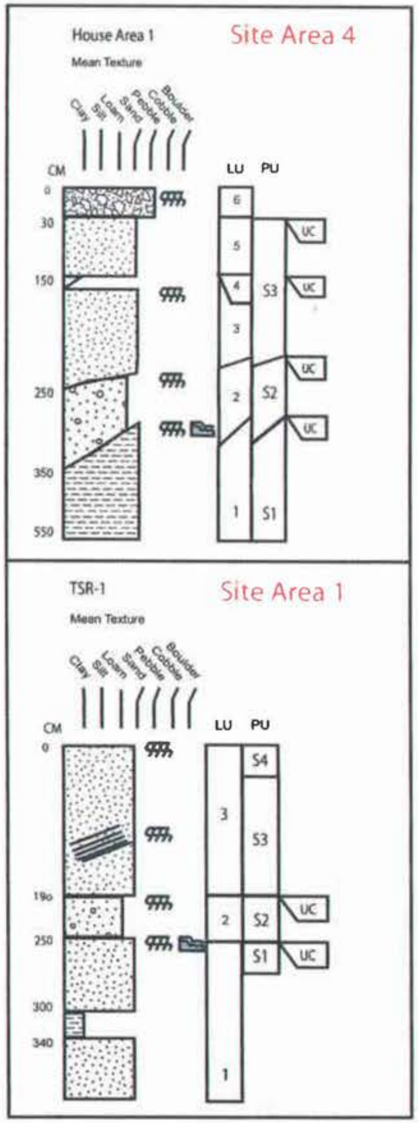
The following is a summary of stratigraphic units described by Davis (2005) from profiles studied in Site Areas 1-4 and the analysis of sediment samples taken from 2003 test units and exposures. These units (Figure 5) are listed in Table 2 according to site area, section, and the interpreted depositional environment. Figure 7 graphically represents the test unit profiles from which the lithostratigraphic units are derived.

The basal stratigraphic unit at 35CU7 is comprised of Pioneer terrace sediments that date between 105,000 BP and 80,000 BP (Bockheim et al. 1990; Kelsey 1990; Muhs et al. 1992). This lithostratigraphic unit (LU1) is composed of iron-cemented, bedded sands and was encountered in most of the site's test units within 120 centimeters below surface. Within this unit is a paleosol (S1) that is also observed across the site. Whereas marine sediments generally form a consistent basal deposit across the site, the lithostratigraphic sequence that overlies LU1 varies widely. However, there are greater similarities between the stratigraphy of Site Areas 1 and 4 and between Site Areas 2 and 3 (Davis 2005).

In Site Areas 1 and 4, two buried soils (S2 and S3) exposed in profiles along the western boundary are distinct in their pedogenic expression and are specific to the

Site Area	Section	LU	PU	AU	CU	Lithofacies
1	TSR-1	1	1	UC	80,000 BP	Marine sand and clay
		2	2	UC	ca. 7,500 BP	Alluvium
		3	3	UC	7,500 BP to 450 BP	Aeolian sand
		4	4		450 BP to present	Aeolian with alluvial input
2	Units J and K	1	1	UC	80,000 BP	Marine sand and clay
		2	2		3,500 BP to present	Aeolian with alluvial input
3	Unit AA	1	1	UC	80,000 BP	Marine sand and clay
		2	2		4,200 BP to present	Alluvium
3	Unit T	1	1	UC	80,000 BP	Marine sand and clay
		2	2	UC	4,200 BP to 1,300 BP	Alluvium
		3	2	UC	740BP to 450 BP	Thick shell midden
		4	2		450 BP to present	Alluvium
4	House Area 1	1	1	UC	80,000 BP	Marine sand and clay
		2	2	UC	ca. 7,500 BP	Alluvium
		3	3	UC	7,500 to 450 BP	Aeolian sand
		4	3	UC	ca.1,000 BP (from overlying shell)	Anomolous clay lens
		5	3	UC	1,000 BP to present	Aeolian sand
		6			Modern	Gravel roadbed

Table 2. Site stratigraphy by site area, section and depositional environment. Section refers to the test unit or sample location. LU, PU, AU, and CU stand for lithostratigraphic unit, pedostratigraphic unit, allostratigraphic unit, and chronostratigraphic unit, respectively. UC is an abbreviation for "unconformity," an allostratigraphic boundary formed by erosion or a haitus in deposition. Lithofacies are the physical properties of sediments that allow inferences to be made about the environment of a sediment's deposition, for example, alluvium is deposited by water.



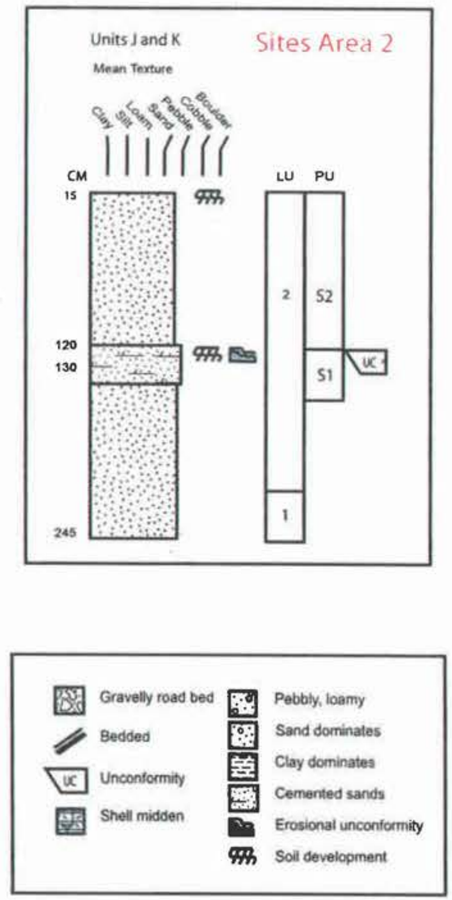
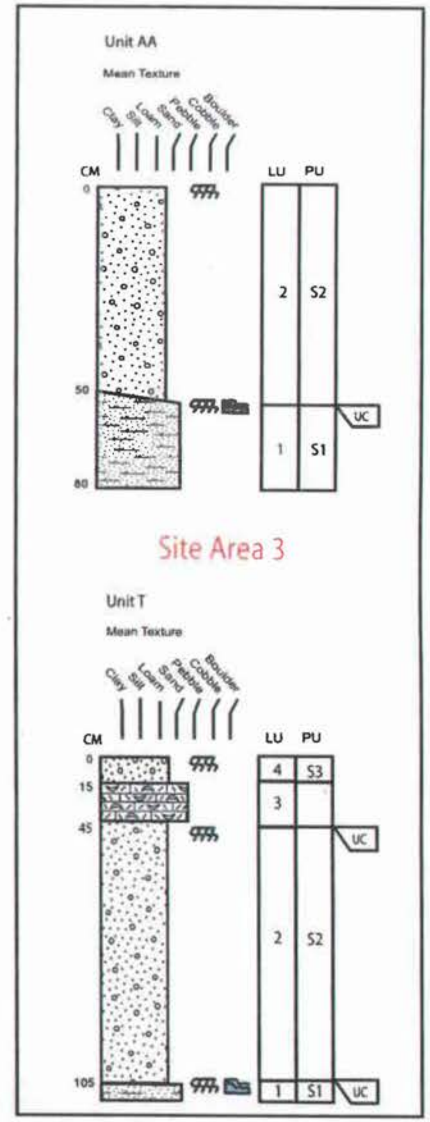


Figure 7. Test unit profiles with the stratigraphic units used by Davis (2005) to characterize the site stratigraphy.



depositional history of this location (Figure 6). These pedostratigraphic units disappear toward the east (Site Area 2) and to the south, before reaching Little Round Lake. A third lithostratigraphic (LU3) and pedostratigraphic unit (S3) overlies S1 and S2. This third soil unit is represented by the modern soil horizon.

In Site Area 2, the marine sands of LU1 are truncated and are overlain by a moderately well sorted sandy loam to loamy sand. In Site Area 3, the stratigraphic units are characterized according to the sediments found within excavation Units T and AA. In this location, LU1 is overlain by a unit of pebbly, loamy sand to sandy loam that contains a relatively high organic content (8-18 %). Davis (2005) interprets the moderately poor sorting as signaling alluvial deposition and argues that the sediments in this location were once part of an alluvial floodplain and paleochannel. This view is further supported by the presence of pedogenetically-altered marine sand clasts entrained in the matrix overlying LU1 in the bottom of Unit AA (Davis 2005) and by the presence of pebble-sized clasts in Unit T.

Site Formation Model

Davis' (2005) site formation model reveals different geomorphological patterns for the western and eastern portions of the site. A summary of this model is described as follows:

Along the western terrace in Site Area 1, marine sediments of the Pioneer terrace were eroded by an alluvial channel that was subsequently infilled by alluvial floodplain activity in the early Holocene (Figure 8). The sediments from this fluvial source covered Site Area 1 and 4, and then became the parent material for the second

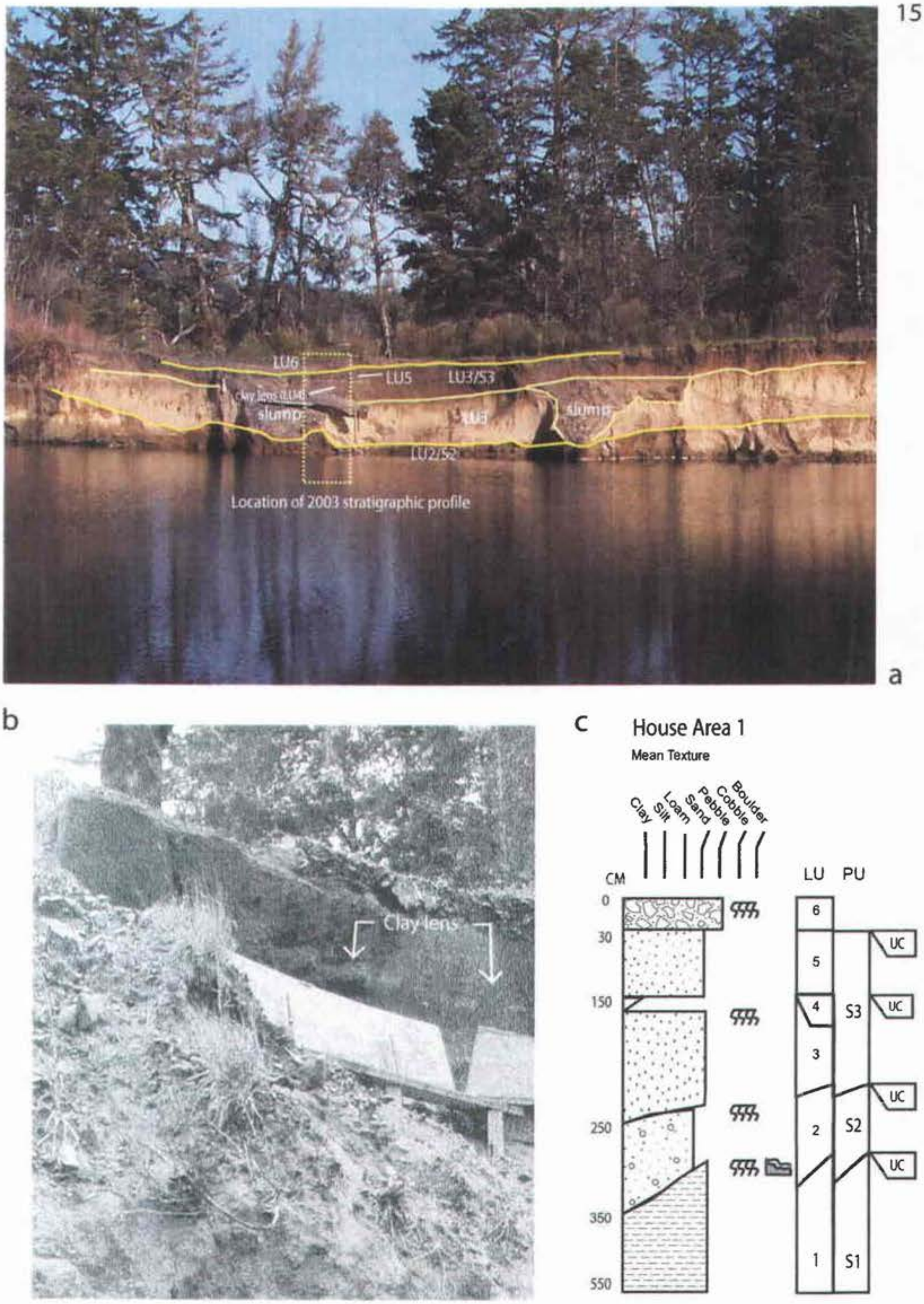


Figure 8. a) Eastern exposure of House Area 1 in Site Area 4 in March 2004. The Garrison Lake outlet obscures the visibility of LU1. Shoring from 2005 excavations is observable in the foreground. b) Excavations in 2003. Note the clay lens (LU4) in the sidewall. c) Profile of House Area 1 stratigraphic units.

pedostratigraphic unit (S2) in Site Areas 1 and 4. After a period of stability associated with the development of S2, two periods of dune building occurred. The first period occurred at the end of the early Holocene; the second in the middle Holocene. A third paleosol (S3) developed during a middle Holocene depositional hiatus, and the modern soil (S4) developed when aeolian deposition slowed in the late Holocene.

In the eastern portion of the site, alluvial floodplain activity seems to have eroded S1 some time in the early Holocene. The channel that crossed Site Area 4 from the northeast may have shifted to flow across Site Area 3 for an undetermined amount of time in the middle Holocene. This area gradually filled in with alluvium, which became the parent material for a second pedostratigraphic unit (S2) for much of the area.

Excavations in 2005

My geoarchaeological investigation of Tseriadun was intricately linked to an archaeological investigation conducted in October and November of 2005 by Scott Byram and the Coquille Indian Tribe (CIT). The focus of this archaeological investigation was to conduct subsurface testing along the proposed pathway of a culvert system that will serve as a permanent outlet for Garrison Lake (Figure 9). An initial examination of the site stratigraphy occurred in 2003 while serving as one of the CIT crew, followed by small scale surveys in 2004 and 2005. Additional knowledge of the Tseriadun site's depositional history was gained by processing sediment samples from 2003 test units in the geoarchaeology

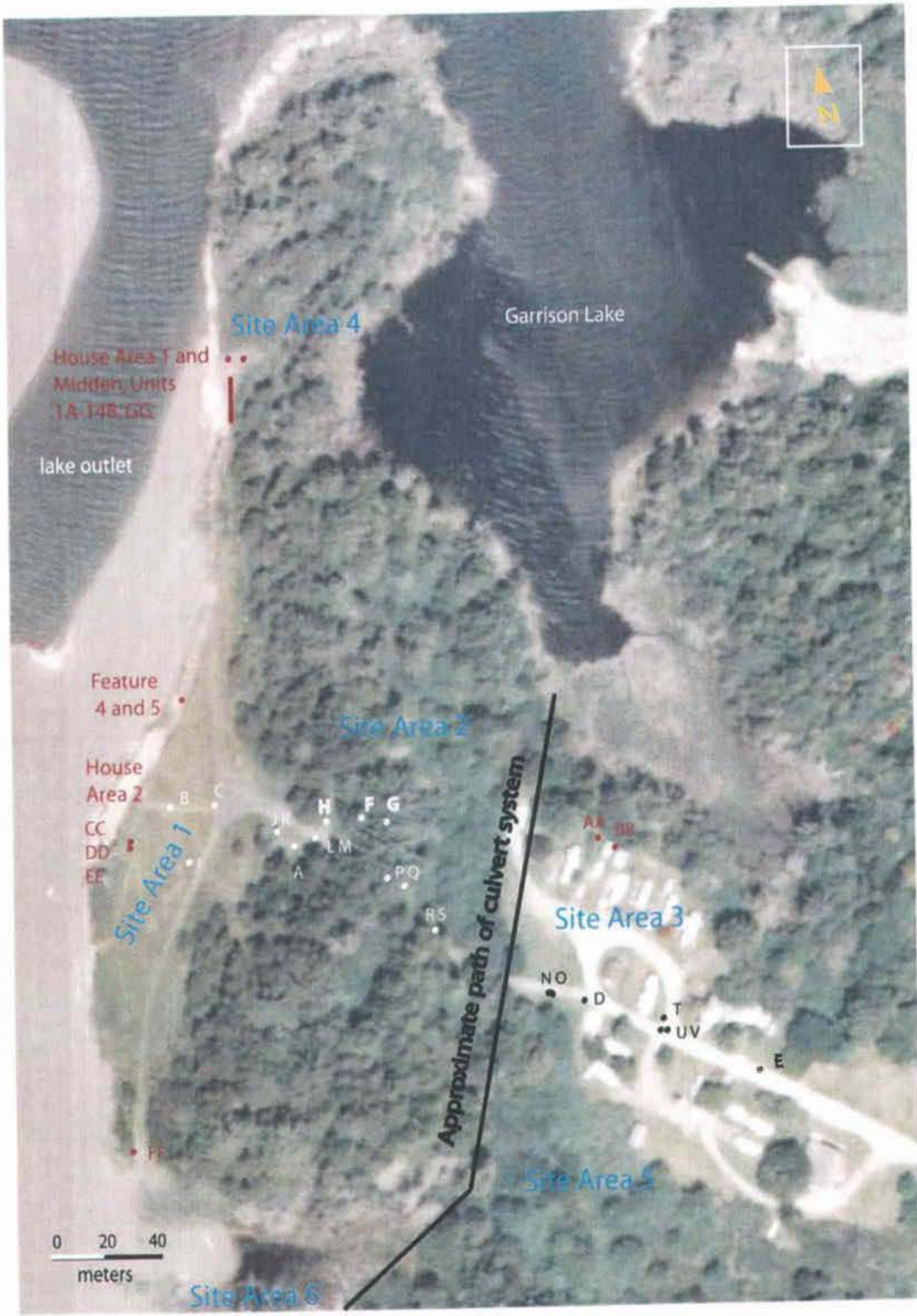


Figure 9. Aerial photo showing the 2005 proposed culvert route with 2003 test units. The 2003 test units have three colors. The red units were part of the Oregon Parks and Rec. Dept./Coquille Indian Tribe projects, the black and white units were part of the Ocean Outfall project (see Byram 2005). Adapted from S. Byram 2005.

laboratory at Oregon State University. To clarify my contribution, a timeline and summary have been created in Table 3 that refers to the various activities related to investigations at the Tseriadun site, subsequent reports, and their relevant outcomes.

Year	Activity	Reports/Publications	Result
2003 June	R. Scott Byram, Don Ivy and CIT conduct archaeological survey, testing, mitigation known as the Ocean Outfall Project.	2003a - Byram, R. Scott, *Archaeological Evaluation of Site 35-CU-7, for the City of Port Orford* 2003b - Byram, R. Scott, *Archaeological Survey for the City of Port Orford Effluent Disposal Project, Curry County, Oregon*.	Site Areas 1-4 established. Test units A -V excavated. Identification of clay features. House Areas One and Two are established. Photos taken. Soil samples from Test units C, K, J, T, and P are taken.
2003 Sept.and Dec.	R. Scott Byram, Don Ivy and CIT document and salvage clay features in House Areas One and Two, plus two other locations.	2003c - Byram, R. Scott, *Preliminary Findings of Archaeological Mitigation at 35CU7, the Tseriadun site in advance of Sea Wall Breaching at Garrison Lake.*	Test units AA - GG excavated. 1A-14B excavated. House Area One midden excavated. Features 4 and 5 identified. Soil samples from AA, BB, FF, GG, Features 1 and 2 are taken. Documentation of sea-wall breach.
2003 Sept.and Dec.	Loren Davis begins geoarchaeological analysis of the site	2003 - Davis, Loren G., and Craig E. Skinner, *Preliminary Evaluation of Tseriadun Site (35CU7) Stratigraphy and Clay Features.*	Descriptive data collected from site. Photographs taken of western terrace stratigraphy.
2003 Dec.	Fred Anderson joins CIT crew, and begins to collect geoarchaeological data from House Area One.		Photographs taken of Site Areas 4 and 2. Some descriptive data collected from House area 1 midden.
2004 March	Papers presented at Northwest Archaeological Convention Anderson assists Davis in processing sediment samples.	2004 - Davis, Loren G., R. Scott Byram, Frederick C. Anderson, and Craig E. Skinner, *Establishing an Origin for Clay Features at the Tseriadun Site (35CU7), Southern Oregon Coast*. 2004 - Byram, R. Scott, *Unknown title*.	
2005 May	Davis submits to Byram, *Geoarchaeological context of the Tseriadun Site, a chapter within the Outlet Modification report.*	2005 - Byram, R. Scott, *Archaeological Excavations at Tseriadun, 35CU7 for Garrison Lake Outlet Modification, Port Orford, Oregon*.	
2005 Oct./ Nov.	Byram and CIT begin testing for the proposed culvert route. Anderson performs geoarchaeological investigations.	2006 - Bryam, R. Scott, *Archaeological Excavations at Tseriadun, 35CU7 for Garrison Lake Outlet Modification, Port Orford, Oregon.*	Excavation of Test Units 5-1 through 5-17 in Site Areas 3 and 6. Augers 1 through 8 excavated in Site Area 3. Profiles cleared in Site Areas 2 and 6.

Table 3. Previous activity relevant to 2005 thesis research at the Tseriadun site.

CHAPTER 2

RESEARCH DESIGN

Research Problem and Questions

Geoarchaeological research at 35CU7 in 2005 was aimed at providing the stratigraphic context for the culvert project while collecting sufficient data to address both basic questions about the site's geologic and depositional history, and questions that were specific to this thesis. With the reconstruction of paleoenvironmental data it is possible to identify long term geomorphic change and to better understand the environmental context of local human activity as it is reflected in the archaeological record at 35CU7. Questions that directed this research include: 1) how do stratigraphic records from the areas that were untested during 2003 excavations contribute to our understanding of the site's depositional history?; 2) what does the data from these and previously excavated units tell us about the environmental history of the southern Garrison Lake basin?; and 3) how were environmental and geological conditions observed at 35CU7 likely to have influenced site use?

Research Objectives

My research objectives for this thesis were two-fold. The first objective was to evaluate and expand upon previously made determinations about the depositional history of the site and the Garrison Lake basin. Meeting this goal involved collecting geoarchaeological samples within the culvert project's area of potential effect and in

Oregon State Parks property adjacent to the eastern border of the site. A second objective was to expand upon Davis' (2005) model of landscape change at Tseriadun. The analysis of original data generated as part of this thesis research contributed to the development of a revised model that served as a platform for exploring how environmental conditions may have affected human activity at the site.

Theoretical Basis

Johnson (1999) writes that theory and method are often confused in archaeology. He believes that theory addresses the question of why an archaeological investigation should be undertaken while method speaks to how it will be done. He also states that no proposition is atheoretical and that in the effort to justify what archaeologists do, it is necessary to be as open as possible about the reasons and biases within one's approaches. It is in this scientific vein that I outline the theoretical perspectives that guided my approach to the question of how changes in the landscape and the environment may have influenced human behavior at Tseriadun.

The idea of the environment factoring prominently in shaping human behavior has roots in theoretical deliberations posed by archaeologists and cultural anthropologists beginning in the mid-1900s (Gibbon 1984; Shafer 1997; Steward 1955; White 1949). These philosophical discussions grew out of academic discourse over the ramifications of Darwin's Theory of Evolution, and a definition of culture that could account for the tremendous variety in how it is expressed by humans around the world. During the first fifty years of American archaeology and anthropology, the respective practitioners of these field classified and defined cultures, "based on similarities and differences in their material traits" (Shafer 1997). This approach was founded on the belief that cultural development occurred along an evolutionary continuum in accordance to certain universal laws yet to be defined. The introduction of Leslie White and Julian Steward's environment-focused approach signaled a major shift in how culture might be interpreted (Gibbon 1984).

White (1949) proposed that cultural adaptations are a product of humans' attempt to harvest the maximum amount of energy from the environment and that their tools are the product of that adaptation. Steward (1955) has a similar belief, but he took the relationship with nature further in suggesting that humans are part of the "total web of life" and that to understand a culture one has to consider all the "plant and animals in a particular unit of territory" since cultural features are closely related to a group's subsistence activities.

Marvin Harris (Gibbon 1984), the founder of an anthropological approach called Cultural Materialism, drew from Steward and White's theories and provided a practical method for anthropologists and archaeologists to become more scientific in their investigations (Shafer 1997; Johnson 1999). According to Harris' view, the environment is one of four interconnected pressures[1] that societies respond and adapt to in their evolution. Lewis Binford took this view further, stressing the importance between the environment and technology in shaping sociocultural systems (Shafer 1997). Binford's emphasis on the scientific method allowed archaeologists to move

[1] These pressures are population (numbers of people within a group), the economy, technology, and the environment.

toward asking "why, and how?" about cultural processes rather than only "when?" as was the focus of an earlier cultural-historical era (Johnson 1997).

Stimulated by this scientific and systemic approach to understanding past cultures, archaeologists found the need to synthesize these high level theories while continuing to work with the material archaeological record (Shafer 1997). As a result, several subfields were developed that contributed to a body of knowledge known as middle-range theory (Shafer 1997). One of these subfields called behavior archaeology was developed by Michael Schiffer. Schiffer aimed to address how human behaviors may affect the patterning of artifacts and features once they had left their systemic context (Martin, 1997; Schiffer, 1972). He referred to these behaviors as 'C-transforms' which are the culture-based processes in which artifacts are discarded, recycled, trampled, buried for storage, or reclaimed (Schiffer 1975). Schiffer also proposed there are natural processes or 'N-Transforms' that must be understood when interpreting past behavior, such as the ability for flora and fauna to reposition artifacts after their burial (Schiffer 1975). The focus of geoarchaeology mirrors this concern with addressing the environmental forces that shape the archaeological record (Butzer 1982; Shafer 1997; Rapp and Gifford 1985; Waters 1992).

According to Waters (1992), archaeologists refined their questions about the archaeological record and made more "sophisticated interpretations" about what the various materials represented. Archaeologists began to employ methods used by various scientific disciplines in their attempt to comment upon the human ecosystem; a system in which cultural groups dynamically interact with the climate, landscape, flora, fauna, and other cultures (Waters 1992). From this perspective, significant perturbations affecting one of these components within a region may result in a behavior response that is observable or may be inferred from the archaeological record (Butzer 1982; Waters 1992:6). Some contemporary archaeologists are applying elements of Darwinian theory in their discussion of how artifacts represent behavioral responses to the ecosystem. Employing evolutionary concepts such as natural selection, heritability, and drift, evolutionary archaeologists argue that objects in the archaeological record were acted upon by the same evolutionary processes that acted upon their manufacturers (O'Brien 2005).

Butzer wrote that geoarchaeologists and other archaeological subfields with a context-providing focus, such as zooarchaeology and paleobotany, are less concerned with the artifacts of a site than they are with "the expression of human decision making within the environment" (Butzer 1982: 12), despite the critical role that artifacts play in gaining knowledge about the human and physical environment that produced them. Contextual archaeology, which is indirectly described here, proposes that all aspects of an archaeological culture must be explored in order to understand the "functional" and "structural interrelationships" (Shafer 1997) that defined the culture. Butzer's contextual archaeology focuses on methods that might be used to characterize the functional interrelationship between humans and the physical environment (Butzer 1982; Shafer 1997). One of the themes at the core of his approach concerns issues of scale. On this, Butzer (1982: 17) writes:

> ...scale is a metrical concept, distinct from dimension, that has both magnitude and direction, with respect to two or more

> coordinates, and conveys a sense of scope or perspective.[...] It also includes several dimensions, namely spatial (the site subsystem), hierarchical (the environmental subsystem), and ecological (the interactive process).

The role of scale in this geoarchaeological investigation is a prominent one that is defined by the goals of the discipline but also by the research objectives that are specific to the research site and its location along the Oregon coast. Interpreting the various site formation processes that may have shaped the Tseriadun site requires understanding the scale at which seasonal overland flow of precipitation gradually transports sediments down slope as well as the thousands of years required for marine terraces to be tectonically uplifted and pedogenically altered.

Lastly, according to Waters (1992:7), the primary goal of geoarchaeology is to place archaeological sites and all their parts in "relative and absolute temporal context" through the use of "stratigraphic principles and absolute dating techniques." The methodologies and techniques employed by the earth sciences that provide empirical information, such as pedology, sedimentology, and geomorphology are considered critical components to meeting this main objective (Butzer 1982) and the secondary goal of discerning the natural processes from the cultural processes involved in site formation and landscape evolution (Waters 1992).

Materials and Methods

The research design for this investigation is derived, in part, from the results of geoarchaeological investigations conducted by Davis (2005), archaeological investigations conducted by Byram (2005), and the fieldwork requirements for the 2005 proposed culvert system. The latter required some flexibility since a significant portion of the data used for this thesis was linked to the research design of project archaeologist, Scott Byram, for the culvert project. As mentioned in Chapter One, the primary goal of the 2005 archaeological investigations was to conduct subsurface testing along the proposed culvert route to determine the nature and extent of cultural materials that may be present in the area of potential effect. Written into the permit was a brief explanation of the geoarchaeological sampling methods to be used to provide the stratigraphic context for the culvert project, and to address the research questions specific to this thesis. Figures 10 and 11 show the locations of archaeological test units studied in 2005, with several of the 2003 test units relevant to analysis in the following chapters.

The route proposed for the culvert system contained a northern and southern segment. The first segment extended south from Garrison Lake between Site Areas 2 and 3, through a wetland depression abutting Little Round Lake. The southern segment moves southwestward from the wetland depression, through Site Area 6, and out to the ocean (Figure 9).

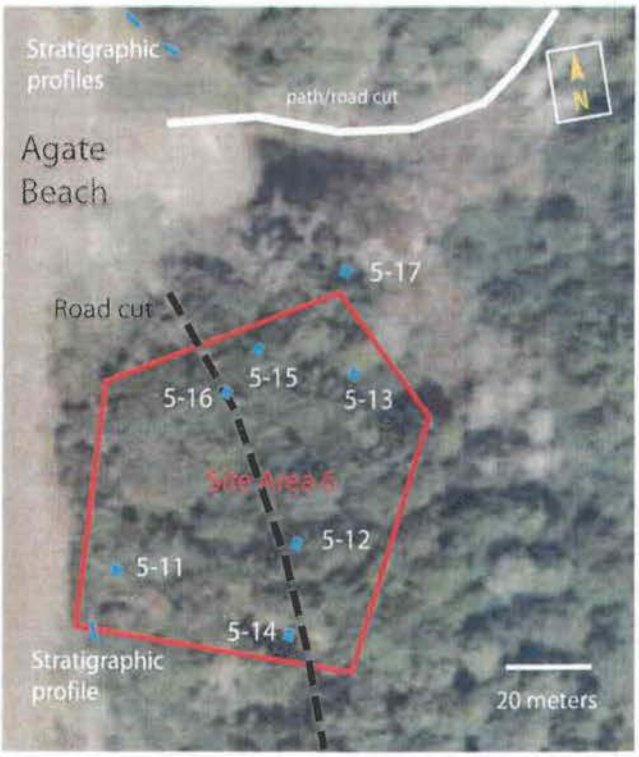


Figure 10 The 2005 excavations in Site Area 1-5 (white) with several of the 2003 test units (red). Map adapted from Byram 2006.

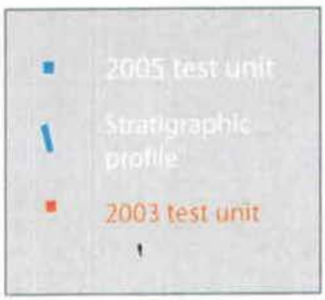


Figure 11. Site Area 6 with the 2005 test units and stratigraphic profiles. Map adapted from Byram 2006.

In the field, representative samples were collected from the stratigraphic profiles exposed in the analyzed test units opened under Byram's direction for the culvert testing, as well as from stratigraphic profiles that were created to collect geologic data. These methods included subsurface sampling with a 10 cm diameter hand auger and cleaning of stratigraphic profiles in existing bank exposures. Seven auger probes were excavated from locations within and to the east of Site Area 3. Three stratigraphic sections were cleared in cut banks during the project; each measured approximately 1 m across, 2 m tall and ca. 1 m in depth.

Archaeologists used a combination of shovel test pits measuring 50 cm square and 1x1 m test units dug in arbitrary 10 cm levels. Ten test units and one auger hole were excavated along the northern section of the culvert route; seven test units and three auger holes were excavated in the southern segment.

Two bank exposures were cleared and profiled along the south side of Site Area 2 where the landform opens to Little Round Lake, for the purpose of determining the lateral extent of stratigraphic units across the site. A third cut bank exposure was cleared near Test Units 5-11 in Site Area 6 (see Figure 13).

The primary method of data collection used in the field portion of my thesis research involved sampling sediments at 10 centimeter intervals of depth from nine of the seventeen archaeological test units and one of the three cut bank exposures. Over-sampling of the same stratigraphic units was minimized by only collecting representative sample within test units that had similar stratigraphy. Sediments cleared from natural exposure were sifted through 1/8" hardware mesh screen to determine the presence of artifacts. No artifacts were found in these locations.

Subsurface sampling of geologic units was also accomplished by use of a hand auger. Samples were collected in arbitrary 10 cm depth intervals from which a representative bulk sample was collected and labeled for laboratory analysis.

Descriptive data were collected from stratigraphic profiles and auger samples according to guidelines set out by the Soil Survey Division Staff (1993) for describing soils, and the North American Stratigraphic Code (NACOSN 1983) for describing sediments and stratigraphic units. Sediment colors were recorded using a Munsell soil color chart.

Laboratory analysis of sediments involved a number of methods chosen with the purpose of clarifying pedological and sedimentological aspects of stratigraphic units. It included their sedimentary content, their boundaries and elucidation of the depositional environment associated with these sediments. Particle size was determined by two means, the first method involved passing a 50 g sample through a 1000 ml column of water and calculating the percentages of sand, silt, and clay based on their rate of settling (Gee and Bauder 1986). These samples were pretreated with sodium hexametaphosphate (SHMP), a deflocculating agent that breaks down the chemical bond between clays (Gee and Bauder 1986). The second method involved passing a dry 100 g sample through a series of wire-mesh sieves while manipulated by a Ro-Tap machine. Each sieve represents a grain size interval on the Wentworth scale (Wentworth 1922). The sediment weight of each sieve was recorded, graphed, and compared to distributions representing various depositional environments (Gee and Bauder 1986; Beverwijk 1967). All samples were pre-treated with SHMP and oven-dried before they were sieved. To further assist in the sorting process, the sediments in each sieve were gently stirred by hand for several minutes. Several sediment samples with a high percentage of organic matter were pretreated with a heated solution of 30% hydrogen peroxide to digest organics (Gee and Bauder 1986).

The original organic and carbon content of each sediment sample was determined by loss on ignition; a method that involves heating an untreated oven-dried 10 g sample for two hours at 550° C, measuring the difference in weight, then heating the sample at 1000°C for four hours and weighing the sample again (Dean 1974; Heiri et al. 2001; Rible and Quick 1960). The loss in weight from the former sample represents the sample's organic matter; the latter represents the percentage of calcium carbonate in the sample.

For some samples the surface properties of sediment particles were studied under a microscope in order to relate their surface texture and shape to a specific depositional environment. The degree of roundness and sphericity of sand size particles may be used to confirm the environment of their deposition. The shape or roundness of a particle has been shown to affect its behavior during transport and whether the particle will be selected for transport (Friedman 1967 and 1978). Boggs (1995: 100) cites a study that suggests that transport by wind is 100 to 1000 times more effective in rounding sand-size quartz grains than water. The surface texture of a particle may also indicate a mode of transportation; for example the polished, pitted, and etched surface of sand grains transported by wind are generally not observed in fluvial environments (Boggs 1995; Friedman 1978).

Next, several analytical methods were used to organize laboratory data. A primary method of analysis was to plot sediment data within a computer program to observe the normal and cumulative frequencies of the grain-size distributions. This data was compared to the distributions of modern beach and dune sand from Tseriadun, and descriptions of other known depositional environments. The particle size data was used to refine the boundaries between lithostratigraphic units, and served as a principle means of determining sediments' depositional environment. The vertical relationships of sediments, or facies, were also noted and compared to the horizontal sequences of sediments of specific environments, for example, the fining upward sequence observed within sediments of an aggrading channel that is changing to a lower flow regime (Boggs 2001).

A second analytical method involved graphing the relative depths and elevations of test units within a computer program in order to observe the lateral behavior of lithostratigraphic units. The resultant figures that assisted in constructing the revised model for landscape evolution are discussed in Chapter 5.

CHAPTER 3

GEOLOGY AND GEOMORPHOLOGY

A majority of the background research relating to this investigation concerns the geology within the area, soils and tectonic activity of the Oregon coast. There are several challenges involved in the process of determining which forces have worked to form the Tseriadun site over time. These challenges stem from the fact that geomorphic agents affecting the landscape of the region operate at varying time scales, and that previous studies only indirectly address how these agents may affect the research area. The following sections will briefly discuss how these agents are relevant to this investigation.

Regional Geology

Geographically, this area of the southern Oregon coast is comprised of an active beach margin backed to the east by five tectonically uplifted marine terraces of varying age and elevation. These include: Cape Blanco (ca. 80,000 yr), Pioneer (ca. 105,000 yr), Silver Butte (ca. 125,000 yr), Indian Creek (ca. 240,00 yr), and Poverty Ridge (ca. 500,000 yr). At Cape Blanco, the Poverty Ridge terrace reaches an elevation of about 260 meters above sea level (masl), and eight kilometers inland, the other elevations follow: Indian Creek (110 to 195 masl), Silver Butte (67 masl), Pioneer (51-61 masl) and Cape Blanco (61 masl) (Langley-Turnbaugh and Kelsey 1997). The Whiskey Run terrace, which is synonymous with the Cape Blanco terrace, has been dated by uranium series to 80,000 BP (Muhs et al. 1992). At Tseriadun, late Quaternary terrestrial age sediments rest on top of the Pioneer terrace and contain a stratified archaeological sequence (Davis 2005; Kelsey 1990).

Several other factors influencing the site's geomorphology include its proximity to the Cascadia Subduction Zone (CSZ), the climate of the area, and the closeness of the Pacific Ocean. The CSZ is a region off of the west coast of North America that marks the location of tectonic activity associated with the subduction of the oceanic crust, comprised of the Juan de Fuca and Gorda plates (Figure 12), beneath the North America plate (Muhs et al. 1992). The long sloping fault parallels the coastline from British Columbia, Canada to Northern California. Seismic activity along the fault zone has both long-term and short-term effects on the area's geomorphology as the North America Plate responds to pressures created by the subduction of the Pacific Plate (Atwater 1989; Atwater 1992; Brandon 2004; Clarke and Carver 1992; Darienzo and Peterson 1990; Jacoby et al. 1997; Kelsey 1990; Muhs et al. 1992; West and McCrumb 1988; Witter et al. 2004). Tsunamis are formed by the sudden displacement of the seafloor associated with great thrust earthquakes of a magnitude 8.8 or higher (Atwater 1992; Darienzo and Peterson 1990; Jacoby et al. 1997; Kelsey 2006). A record of tsunami run-up deposits on the Oregon coast was discovered about 40 km north of Garrison Lake in Bradley Lake (Kelsey et al. 2006).

The climate of the Oregon coast is characterized by moist winters and a fairly narrow temperature range (between the averages of 46.8 F and 60.4 F) that create a

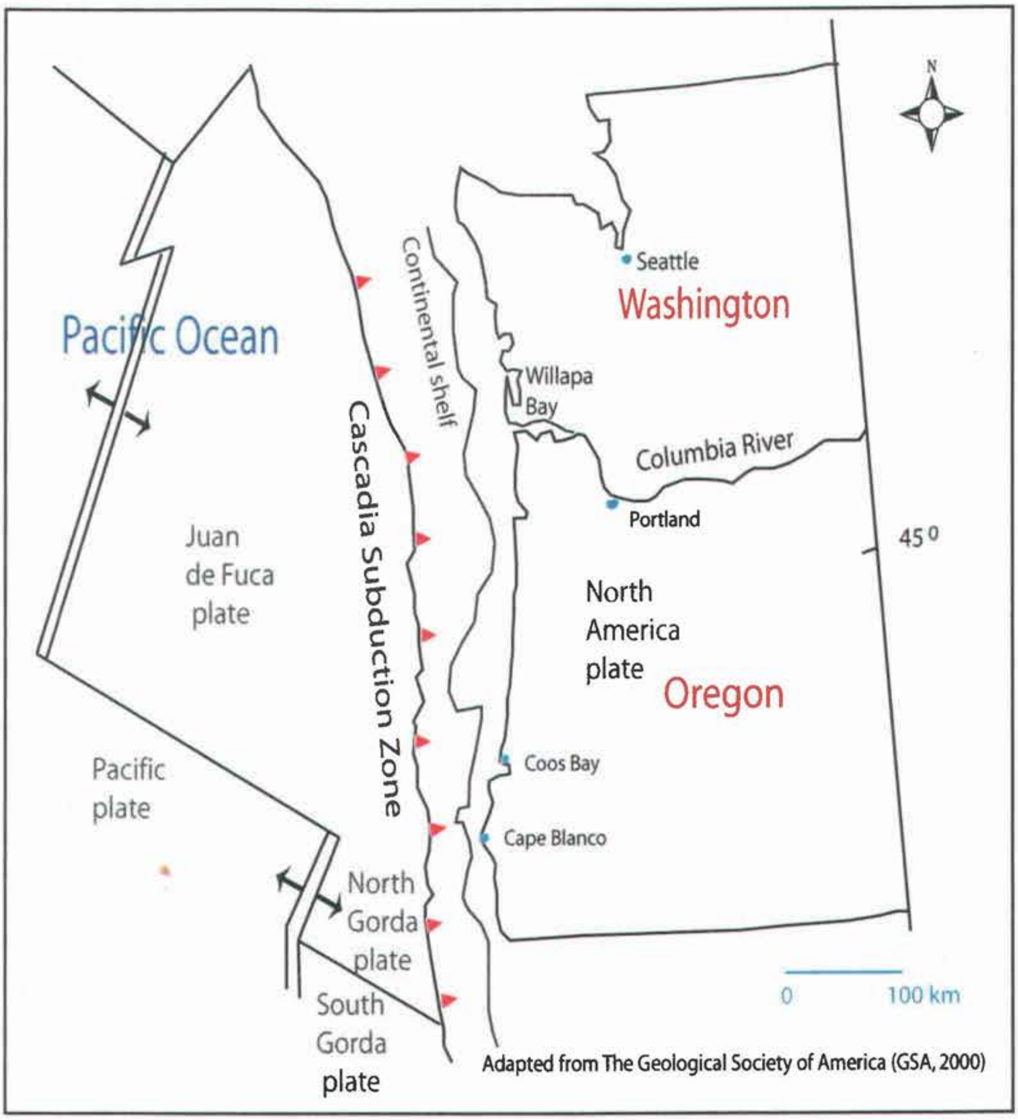


Figure 12. The Cascadia Subduction Zone in relationship to the Pacific Northwest.

udic moisture regime[1] (Soil Survey Staff 1999b). The annual variation in soil temperature regime is low or isomesic in the Cape Blanco area, and most soils here have been determined to be Spodisols[2] except for the occurrence of Inceptisols and Ultisols[3] on the youngest and oldest marine terraces, respectively (Bockheim et al. 1996).

Due to the presence of accelerated uplift at Cape Blanco, terrain in the vicinity of and to the north of Port Orford generally tilts to the southwest (Kelsey 1990). This structural system forms the context of the hydraulic basin that feeds into modern-day Garrison Lake. To the south and east, the high relief of the Port Orford Heads and the ridge of uplifted marine terraces further bind the Garrison Lake catchment, respectively.

Garrison Lake is an uncommon feature on the Oregon coast as it is separated from the Pacific Ocean by a narrow strip of beach sand (Figure 2). Because of this position, the potential for shoreline change is high, and the lake can be affected by Pacific storm surges that can introduce saltwater into Garrison Lake. Such was the case in 1997-1998 when a La Niña storm struck the Oregon coast and large portions of the Agate Beach and Garrison Lake shorelines were eroded. This single event resulted

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[1] This means that soil of a specific depth remains moist for 180 days of the year.

[2] Spodisols are most common in cool, humid climates. They are mineral soils that have a spodic horizon which is an illuvial layer with more than 85 percent spodic material. These are translocated organic material and aluminum, with or without iron from an overlying soil horizon, with colors that are similar to the parent material (Soil Survey Staff 1999a: 695).

[3] Inceptisols are characterized by their minimal soil development and they have a variety of horizons that fail to meet the criteria of other soil orders (Soil Survey Staff 1999a: 489). The most common soil sequence is an ochric epipedon (often very thin) overlying a cambic horizon (a subhorizon characterized by physical or chemical alterations) with or without a duripan (a silica-cemented horizon) or fragipan (a hard but brittle subsurface, often with chemical alteration). Ultisols are soils that are characterized by argillic (high in illuviated clay) or kandic (underlying a coarser textured surface) horizons, with a low base saturation that is less than 35 percent (Soil Survey Staff 1999a and 1999b).

in a 36 m shift of the shoreline landward, the loss of Port Orford's sewage treatment drainage system station, and an increase in the salinity of Garrison Lake (Allan et al. 2003: 101).

The bedrock underlying Garrison Lake and the section of the coast extending south from Cape Blanco is identified as the Jurassic Otter Point Complex; a combination of black mudstone, thin-bedded, fine grained sandstone, conglomerate and volcanic rock (Bourgeous and Dott 1985: 3).

Tectonics

Coastal Oregon's proximity to the Cascadia Subduction Zone (CSZ) ensures that tectonic activity is a significant agent of geomorphologic change. A large number of reports on the subject of tectonics discuss the results of the Juan de Fuca and Gorda plate subduction below the North American plate. In general, this subduction imposes stress on the continental plate causing it to fold, warp, and move along fault lines (Atwater 1987; Clarke and Carver 1992; Darienzo 1990; Kelsey 1990; Kelsey et al. 1996; Verdonck 2006; West and McCrumb 1988). The long-term effects of the CSZ on the coastal margin of Oregon are particularly evident along its southern central coast where uplifted marine terraces are well preserved (Kelsey 1990; West and McCrumb 1988).

Several studies have documented tectonic uplift in the Cape Blanco area (Kelsey 1990; Kelsey et al. 1996; Muhs et al. 1992; West and McCrumb 1988) and the folding caused by the east-west oriented Cape Blanco anticline (Kelsey 1990). While the rate of uplift at Cape Blanco has been calculated to be 1.08 m/ka at Cape Blanco (Kelsey, 1990; Muhs, 1992), synclinal activity (downward warping) between Cape Blanco and Garrison Lake appears to have offset the upper-plate deformation of the Pioneer terrace locally, in a similar manner as that seen north of the Cape Blanco anticline (Kelsey 1990; Punke and Davis 2006). As a result, the Garrison Lake basin may have experienced an uplift rate averaging 0.4 m/ka, which is more typical of other regions along the Oregon coast (West and McCrumb 1988).

Support of these interpretations is found within the two fault zones that intersect marine terraces in the vicinity of Port Orford (Figure 13). The Battle Rock fault zone occurs along a north trending strike-slip fault where the movement of geologic blocks occurs laterally, and the Beaver Creek fault zone, which is a northeast trending fault zone comprised minimally of six closely spaced normal faults (Kelsey 1990: 1002) where movement occurs vertically. Based on the stratigraphic integrity of Pioneer terrace, compared to the degree of displacement observed within the older marine terraces it appears that the latest movement along either fault zone occurred prior to the formation of the Pioneer terrace (Kelsey 1990).

One consequence of this geologic structure is that the sum of tectonic uplift and coseismic subduction in the area appears to be the "positive vertical displacement" of the Garrison Lake basin that Punke and Davis (2006: 336) suggest is possible in certain locations along the Oregon coast. Another consequence is the preservation of late Pleistocene and early Holocene sediments overlying the Pioneer terrace and the significant cultural material located within these deposits at the Tseriadun site.

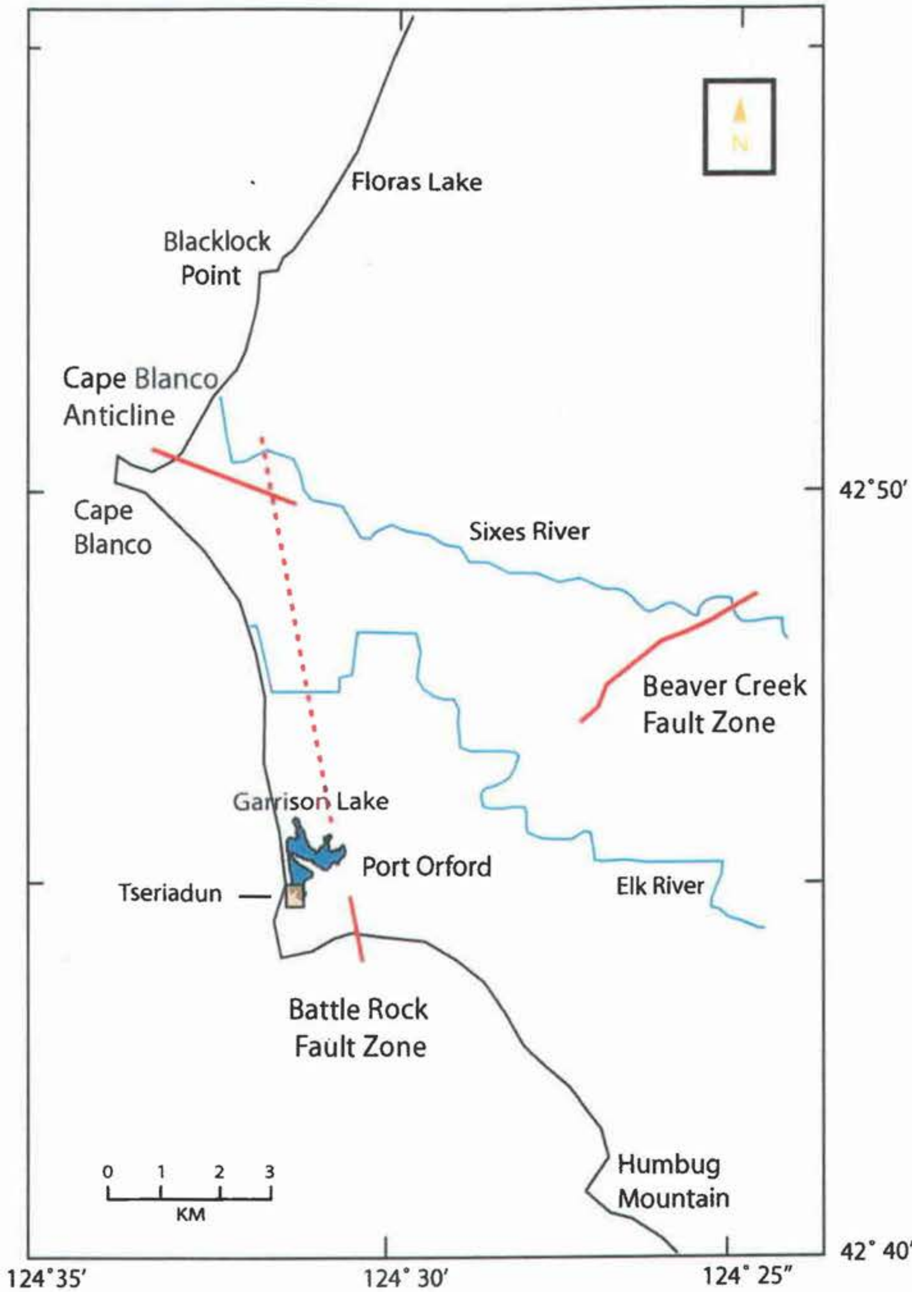


Figure 13. Geologic map indicating the locations of the Battle Rock and Beaver Creek fault zones. The location of the Cape Blanco anticline is also noted, just north of Cape Blanco. Kelsey's (1996) use of a dashed line to indicate the approximate location of the Battle Rock fault is borrowed here.

While Punke and Davis (2006) identify two locations within the Coquille River area where upper-plate tectonic structures also preserve late Pleistocene sediments, these situations are unique. In other fluvial environments along the coast where pre-historic people congregated, the post-glacial rise in sea level drowned landforms bearing late Pleistocene and early Holocene sediments, except where these sediments were situated above the middle Holocene eustacy (Punke and Davis 2006).

Eustacy

The post glacial rise in sea level plays a large role in the landscape change modeled by Davis (2005) and in this thesis. During the late Pleistocene, global sea levels may have dropped as much as 130 m in association with the last glacial maximum at 21,000 BP (Waters 1992). Global sea level rose to modern levels by the middle Holocene at about 6,000 BP (Waters 1992), which is well after humans are recorded to have entered North America (Dixon 1999). Kelsey's (2005) investigation of Bradley Lake, located 45 miles north of Garrison Lake, suggests that at approximately 7,000 BP dune growth blocked the outlet for the China Creek drainage basin which led to its formation. Similarly, Heusser's (1960) study reveals that Garrison Lake began to form around 6720 +/- 250 BP, based on sediment cores taken from the northwest arm of the lake (Figure 2). In the latter investigation, radiocarbon dates were provided from basal limnic-lignous peat and the core was also studied for its pollen records. In his study of the Garrison Lake pollen record, Heusser found flora (*Ruppia*, or ditch grass) indicating strongly brackish conditions. Heusser (1960: 98) interpreted this to signal the effects of eustatic transgression, and assigned this section of the core a relative date of ca. 5,000 BP, corresponding to the arrival of modern sea level.

Paleoenvironmental Data

Since the late Pleistocene, the Pacific Northwest climate has changed from cool and dry before 12 ka, to warm and dry conditions during the period from ca. 12 ka to 6 ka. Since 6,000 years ago, Oregon coastal climates have been warm and wet (Eddleman et al. 1994; Swanson 2006).

Modern regional vegetation of southern Oregon is characterized by an abundance of Douglas fir and Port Orford cedar in the Pacific Coastal Range; White fir and Sitka spruce populate the lowlands; small trees, shrubs and salal grow behind the coastal beaches; and grass, sedges and rushes commonly established themselves between the forest and coastal lakes (Heusser 1960: 68-72). Paleoenvironmental data for the area was obtained by Heusser (1960) from the pollen and peat records preserved with sediment cores extracted from the floor of Garrison Lake (Figure 2). Hessuer's (1960: 130-131, 171) pollen analysis shows there is an abundance of Alder ca. 7,000 BP, which he believes to be a result of fire eliminating more dominant tree species, such as Lodgepole pine. Successive species in the pollen record include Sitka spruce followed by White pine, Douglas fir, mountain hemlock-fir, Western hemlock, Port Orford pine.

Tsunamis

The Pacific Coast has become one of the leading locations to study tsunamis and the effects of coseismic subsidence of the coastal landscape associated with great subduction zone earthquakes. The evidence for such events in the Pacific Northwest exists as buried soils and drowned forests (Atwater 1992; Jacoby et al. 1997; West and Crumb 1988), as well as the sub-aqueous rip-up clasts, marine sand intrusions, debris-rich mud facies, and brackish diatom incursions into freshwater systems (Kelsey 2006). Kelsey's (2006) study of Bradley Lake sediments documents 13 marine incursions into the lake of which three occurred between 4,600 BP and 4,250 BP (Kelsey: 21). The first of these three events dates closely to Heusser's relative date of 5,000 BP for an influx of saltwater into Garrison Lake. Considering the proximity of the two lakes there is a strong possibility that the brackish conditions observed in Garrison Lake are the result of a middle Holocene tsunami event.

CHAPTER 4

RESULTS OF GEOARCHAEOLOGICAL INVESTIGATIONS

The results of this investigation are organized by stratigraphic unit and site area. Due to the variety in how these units map horizontally, Site Area 3 was divided into three sub areas: the western, middle to eastern border, and southwest sections. Following a brief summary of the data collected from each site area and sub-section, results will be discussed according to the various stratigraphic units observed in those locations. The stratigraphic framework established by Davis (2005) from the 2003 excavations (Figure 7) served as a reference point for assigning lithostratigraphic units to sedimentary data collected during 2005 fieldwork.

Introduction of Site Areas

Site Area 3: Western Section

Geologic data from four 50 x 50 cm Test Units 5-3, 5-4, 5-5, and 5-7, and Auger 1, were used to characterize the stratigraphy in this location. The single auger probe was excavated from the bottom of test unit 5-1

Site Area 3: Middle to the Eastern Border

Analysis of this section relies solely upon sediment samples retrieved by auger. Eight auger holes were hand-drilled within Site Area 3 to observe the stratigraphy and to infer the area's geomorphological history. Seven of these auger holes were located between the middle and eastern border of the site area. Due to time constraints and the limitations of this excavation method, only five of the augered samples were processed in the lab, and not all sediment samples from these test units were subjected to all forms of lab analysis. Table 4 lists the laboratory analyses conducted on samples from each test unit.

Site Area 3: Southwest Section

The proposed culvert route extends south from the relatively flat surface of the former mobile home park into a southward trending depression that terminates several meters north of the wetlands associated with Little Round Lake. Deposits from this area are represented by sediment samples obtained from two of the four archaeological test units excavated along this route: Unit 5-7 and Unit 5-10. Test Unit 5-7 was located at the top of the erosional depression that separates Site Areas 2, 3 and 5. Test Unit 5-10 was positioned near the base of the feature just north of Little Round Lake. Unit 5-7 was only partially sampled (70 to 100 cmbs) due to similarities to nearby units, while the entire profile of 5-10 was sampled to 80 centimeters below surface (cmbs).

Site Area 6

Profiles revealed in four of the seven test units excavated in Site Area 6 were used to characterize the stratigraphy in this portion of the Tseriadun site. Test Units 5-14 and 5-16 were fully sampled and Test Units 5-12 and 5-13 were only partially sampled.

	Test unit						
Data source	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**
Dry Sieve	20-220 cmbs	10-200 cmbs	10-130 cmbs	NA	NA	NA	10-260, 330-340 cmbs
Hydrometer	NA	10-90 cmbs	10-130 cmbs	NA	NA	NA	30-60 cmbs
Loss on Ignition							
Organic Matter% and Cca%	NA	10-90 cmbs	10-130 cmbs	NA	NA	NA	10-90 cmbs
pH	NA	10-90 cmbs	10-130 cmbs	NA	NA	NA	10-120 cmbs
Field Notes		X	X	X	X	X	X
	X = available NA = Not available						

Table 4. Table showing the various sources of data obtained from Site Area 3 auger probes. Field notes included descriptive data and observations about sediment composition.

Lithostratigraphy

Lithostratigraphic units (LU) are based on the observable characteristics of a sediment body. These characteristics include texture, composition or structure (Waters 1992). Table 5 summarizes the stratigraphic units identified from stratigraphic profiles and sediment data obtained from test units excavated in 2005.

Site Area 3: Western Section

Three lithostratigraphic units were identified along the eastern border of Site Area 2 and the western border of Site Area 3. The 2005 excavations verified the presence of LU1 identified by Davis. This unit is characterized by iron-stained, ferric-cemented sands and clay (Davis 2005). In test units 5-3, 5-5, and 5-6, a light gray (10YR 7/2) sandy clay is the upper-most expression of this lithostratigraphic unit, while in Test Unit 5-4 it is the iron-oxidized sands of the S1 paleosol (Figure 14).

The second lithostratigraphic unit (LU2) in the area varies by location and composition as it unconformably overlies LU1. Approximately 30 m east of Test Unit 5-5, LU2 is a discontinuous lens of sand that is observed only within Test Units 5-1 and 5-3 (Figure 15) and in Augers 2 and 3 in the middle of Site Area 3. In Test Unit 5-1 these sediments are approximately 150 cm thick; in Test Unit 5-3, the sand appears at ca. 85 cm below surface (cmbs) in the southern half of the test unit and was not excavated further due to the presence of a single piece of fire-cracked rock. The layer of sand, estimated to be about 40 cm thick, angles down sharply to the north within the unit where it becomes into contact with S1 clay at 105 cmbs (Figure 16).

Site Area 3: Western Section

Site Area	Section		LU	PU	AU	CU	LF
3	5-1	1	Iron-stained ferric cemented sands and clay	1	Disconformity (alluvial) with an abrupt contact	Late Pleistocene	Qpi
		2	Brownish yellow (10YR 6/6) sand	2	Unconformable contact with abrupt, smooth contact	> 7,000 BP	Hal1
		3	Dark brown (7.5YR 3/3) pebbly loamy sand	2	NA	Middle to late Holocene	Hal2
3	5-3	1	Iron-stained ferric cemented sands and clay	1	Disconformity (alluvial) with an abrupt contact	Late Pleistocene	Qpi
		2	Brownish yellow (10YR 6/6) sand	2	Unconformable contact with clear, wavy boundary	> 7,000 BP	Hal1
		3	Dark brown (7.5YR 3/3) pebbly loamy sand	2	NA	< 1405-2195 BP	Hal2
3	5-4	1	Iron-stained ferric cemented sands and clay	1	Disconformity (alluvial) with an abrupt contact	Late Pleistocene	Qpi
		2	Dark brown (7.5YR 3/3) pebbly sandy loam	2	NA	< 1405-2195 BP	Hal2
3	5-5	1	Iron-stained ferric cemented sands and clay	1	Disconformity (alluvial) with an abrupt contact	Late Pleistocene	Qpi
		2	Dark brown (10YR 2/2) sandy loam	2	NA	< 1405-2195 BP	Hal2

Site Area 3: Middle to Eastern Border

Site Area	Section		LU	PU	AU	CU	LF
3	Auger 2	1	Iron-stained ferric cemented sands and clay	1	Disconformity (alluvial) with an abrupt contact	Late Pleistocene	Qpi
		2	Silty yellow brown (10 YR 6/6) and very dark grayish brown (10YR 3/2) sand	2	NA	> 7,000 BP	Hal1
		3	dark brown (7.5 YR 4/2) pebbly sandy loam grades to dark reddish brown (5YR 3/2) pebbly sandy loam	2	NA	Middle to late Holocene	Hal3
3	Auger 3	1	Iron-stained ferric cemented sands and clay	1	Disconformity (alluvial) with an abrupt contact	Late Pleistocene	Qpi
		2	Very dark bluish gray (Gley 2 3/10b) to brown (7.5YR 4/2) sand	2	NA	> 7,000 BP	Hal1
		3	dark brown (7.5YR 3/3) to very dark brown (7.5YR 2.5/2) pebbly loamy sand	2	NA	Middle to late Holocene	Hal2
3	Auger 4	1	Iron-stained ferric cemented sands and clay	1	Disconformity (alluvial) with an abrupt contact	Late Pleistocene	Qpi
		2	brownish yellow (10YR 6/6) to pale brown (10YR 6/3) sandy loam	2	NA	Middle to late Holocene	Hal4
		3	Dark reddish brown (5YR 3/2) loam	2	NA	Middle to late Holocene	Hal3

Table 5. Lithostratigraphic units of Site Areas 3 and 6 from 2005 excavations. Abbreviations for lithostratigraphic, pedostratigraphic, allostratigraphic, and chronostratigraphic unit are LU, PU, AU, CU, repectively. LF stands for lithofacies, which are described in Table 7. NA means not applicable. A disconformity is an erosional unconformity.

Site Area 3: Middle to Eastern Border (Continued)

Site Area	Section		LU	PU	AU	CU	LF
3	Auger 7	1	Iron-stained ferric cemented sands and clay	1	Disconformity (alluvial) with an abrupt contact	late Pleistocene	Qpi
		2	Yellowish brown (10YR 6/4) to dark yellowish brown (10YR 4/4) sandy clay loam	2	NA	Holocene	Hal4
		3	Dark brown (7.5YR 3/3) to dark reddish brown (5YR 3/3) sandy loam	2	NA	Holocene	Hal3
3	Auger 8	1-7	Beds of well sorted coarse, medium and fine sand	NA	Several abrupt contacts	Late Pleaistocene to early Holocene	Hals1-Hals7
		8	Dark reddish brown (5YR 3/3) loamy sand	1	NA	Holocene	Hal3
		9	Dark brown (7.5YR 3/3) to dark reddish brown (5YR 3/3) sandy loam	1	NA	Holocene	Hal2/Hal3

Site Area 3: Southwest Section

Site Area	Section		LU	PU	AU	CU	LF
3	5-7	1	Iron-stained ferric cemented sands and clay	1	Disconformity (alluvial) with an abrupt contact	Late Pleistocene	Qpi
		2	dark gray brown (7.5YR 3/2) to brown (7.5YR 5/3) sandy loam	2	NA	Middle Holocene	Hal2
3	5-10	1	Iron-stained ferric cemented sands and clay	1	Disconformity (alluvial) with an abrupt contact	Late Pleistocene	Qpi
		2	Yellowish red (5YR 5/6) sand	2	Unconformable contact	Middle to late Holocene	Hael
		3	Reddish brown (5YR 5/4) to dark reddish gray (2.5YR 3/1) loamy sand	2	NA	Middle to late Holocene	Hal5

Site Area 6

Site Area	Section		LU	PU	AU	CU	LF
6	5-14	1	Iron-stained ferric cemented sands and clay	1	Disconformity (alluvial) with an abrupt contact	Late Pleistocene	Qpi
		2	Dark gray brown (10YR 4/1) to brown (10YR 5/3) pebbly sandy loam	2	NA	Middle to late Holocene	Hal6
6	5-16	1	Iron-stained ferric cemented sands and clay	1	Disconformity (alluvial) with an abrupt contact	Late Pleistocene	Qpi
		2	Dark gray brown (10YR 4/1) to brown (10YR 5/3) pebbly sandy loam	2	NA	Middle to late Holocene	Hal6

Table 5. (Continued) Lithostratigraphic units of Site Areas 3 and 6 from 2005 excavations.

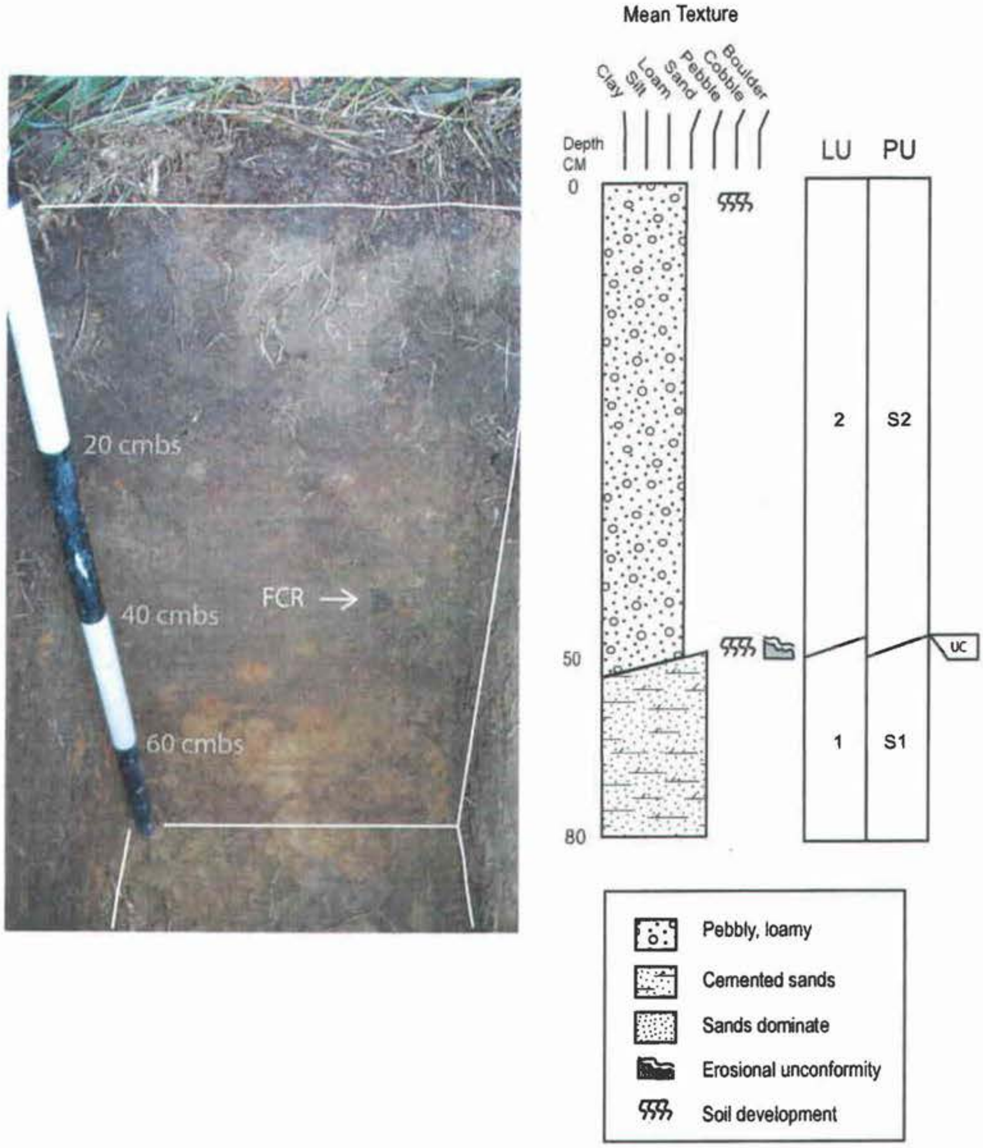


Figure 14. Southern wall of Test Unit 5-4. Within most illustrations of stratigraphic profile, the width of each lithostratigraphic unit represents an average textural mean of a lithostratigraphic unit. The white lines in the photo mark the edges of the test unit. LU and PU are abbreviations for lithostratigraphic unit and pedostratigraphic unit, respectively. UC represents an unconformable contact.

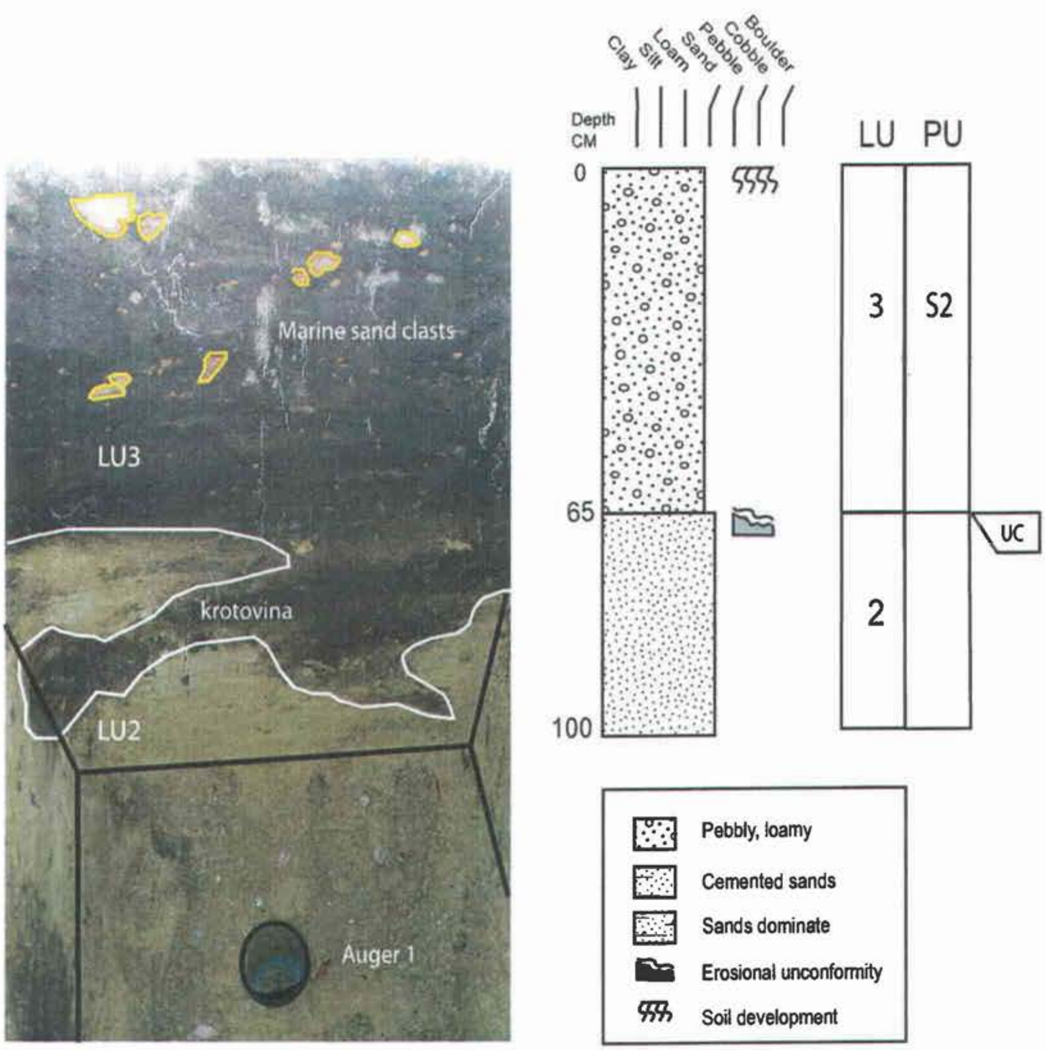


Figure 15. Northern exposure of Test Unit 5-1. Clasts near surface may be bioturbated. LU2 here is a 60 cm lens of sand that extends to an approximate depth of 120 centimeters below surface (cmbs) where LU1 was encountered. The illustration above does not include LU1 and S1 for this reason. The black lines represent test unit boundaries.

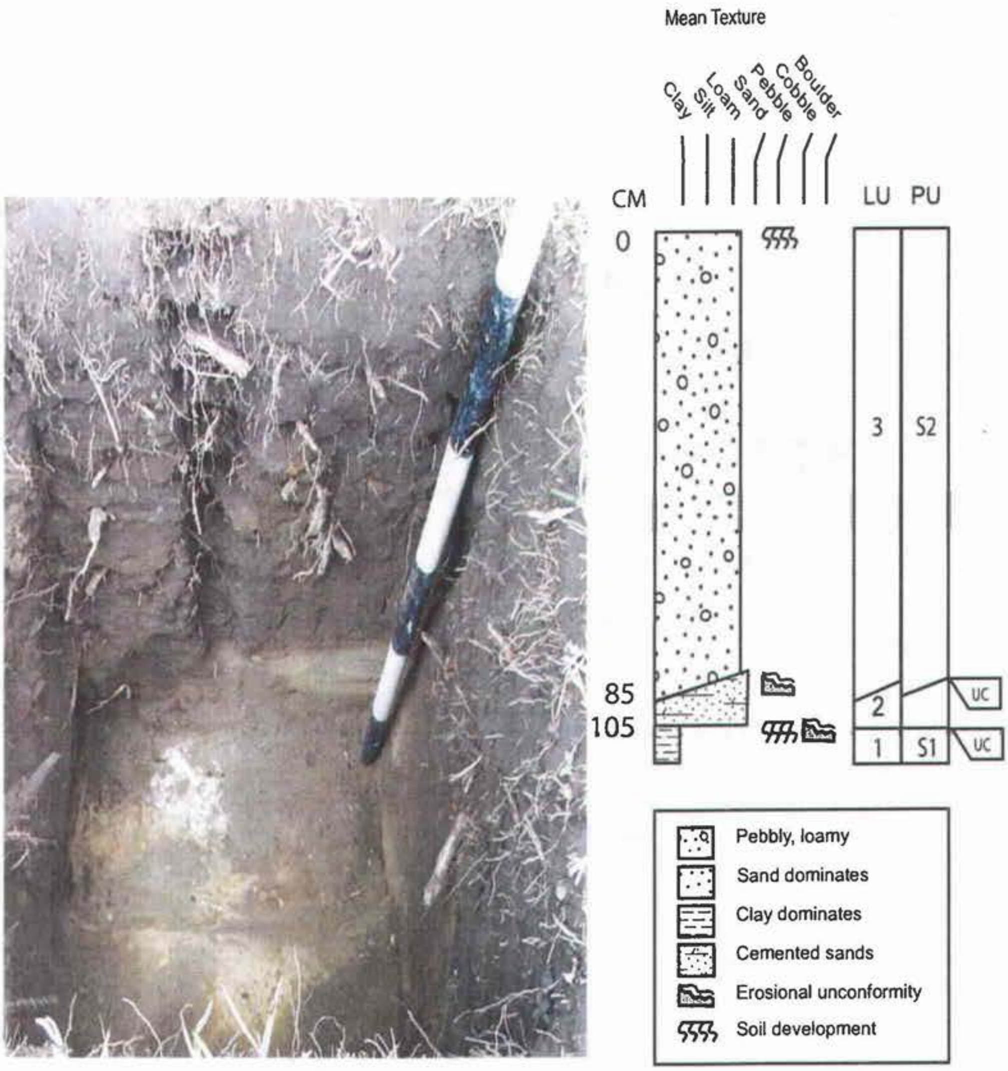


Figure 16. North wall of Test Unit 5-3 after a column sample was taken. Note the sand (LU2) in the southern half of the test unit rests on top of the exposed LU1 clay of S1 in the northern half, and is not present in the north wall. The stratigraphic profile to the right is fitted to this photo but representative of units as they appear in the east wall.

Unfortunately, the sediments in Test Unit 5-1 were not sampled, and the column sample taken from Test Unit 5-3 did not capture this layer. For this reason the evidence of this lithologic unit is observed only in photographs and field notes rather than the laboratory data (Appendix A). The same may be said of Test Unit U (Figure 17) that was not sampled for 2003 laboratory analysis.

Site Area 3: Middle to Eastern Border

The iron-cemented S1 paleosol (LU1) observed across the site was identified in all auger probes but Auger 8, which was hand-drilled to a depth of 340 cmbs. A minimum of nine lithostratigraphic units have been identified in Auger 8 according to changes in sediment texture and color. A description of these lithostratigraphic units was prohibited by both an incomplete sequence in sample collection, and full range of laboratory analyses. Table 6 reproduces the laboratory data for this auger with highlights that mark the presumed boundaries of these units. Despite differences in mineral composition, the sand lens from the western section of Site Area 3 seems to extend east into the middle of the site area. This sedimentary unit (LU2) is observed in Augers 2 and 3. A similarity between the LU2 of Augers 4 and 7, a lens of loamy sand, suggests a different origin for this lithostratigraphic unit. Also of note is the vertical and lateral variation in third lithostratigraphic unit (LU3) in this location that begins as a dark brown (7.5YR 4/2) pebbly sandy loam in Auger 2, grading into a dark reddish brown (5YR3/3) sandy loam further east by Auger 4. Figure 18 provides the stratigraphic profiles of augers in this section of Site Area 3.

Figure 17. Western exposure of Test Unit U excavated in 2003. The bioturbated sand at the base of the unit may correlate to sand units observed in 2005 Test Units 5-1 and 5-3. The trowel at the center of the unit was used for scale. Yellow lines mark test unit boundaries.

		Dry sieve analysis (grams)							Hydrometer analysis			Loss On Ignition		
Lith. Unit	Sample	Granule	V.C.Sand	C.Sand	M.Sand	F.Sand	V.F.Sand	Silt+Clay	Sand	Silt	Clay	OM%	Cca%	pH
9	10-20 cmbs	8.6	4.8	12.9	34.3	36.2	7.5	3.8				29	0	5.44
	20-30 cmbs	1.9**	2.5	7.2	17.1	40.3	8.1	12.6				14	0	6.09
	30-40 cmbs	4.6	2	5.6	20.1	48.9	8.3	12.3	72	20	8	10	0	5.85
	40-50 cmbs	6.5	3.7	5.4	20	47.1	6.6	11.8	76	20	4	9	1	5.61
	50-60 cmbs	6.5	3.9	4.3	19.2	49.4	5.6	12.1	82	14	4	12	1	5.47
8	60-70 cmbs	4.3	2.5	4.1	26.8	53.5	4.3	3.5				13	0	5.62
	70-80 cmbs	3.2	0.9	2.4	22.4	67.9	1.9	2.3				10	1	5.65
7	80-90 cmbs	2.5	0.8 **	1.9	18.2	73.5	1.2	1.2				10	1	5.65
	90-100 cmbs	1.3	0.4	1.6	18.2	76.3	0.7	1.4						5.97
	100-110 cmbs	0.4	0.2	1.9	18.8	77.7	0.2	0.2						6
	110-120 cmbs	0.4	0	0.5	11.2	87.4	0.7	0.4						
6	120-130-cmbs	0	1.4	10.9	40	47.8	0.2	0.2						
	130-140 cmbs	1.1	0.7	9.5	30.8	56.5	0.8	1.1						
	140-150 cmbs	0.6	0.6	17.4	22.5	59.4	0.8	0.9						
5	150-160 cmbs	0	0.6	5.3	18.9	74.7	0.2	0.2						
	160-170 cmbs	0	0.1	1	15.4	84.2	0.3	0.1						
4	170-180 cmbs	0.6	1.5	15.1	14.9	66.7	0.4	0.4						
3	180-190 cmbs	> 0.1	0.1	1.7	11.8	86.4	0.5	0.2						
	190-200 cmbs	0	0.1	0.5	6.5	92	0.5	0.1						
	200-210 cmbs	0	0	0.3	8	92	0.4	>0.1						
	210-220 cmbs	0.2	0.1	0.7	8.9	89.2	0.3	>0.1						
	220-230 cmbs	> 0.1	> 0.1	0.4	6.6	91.9	0.5	0.1						
	230-240 cmbs	> 0.1	0.1	0.8	9.4	91.3	0.6	0.1						
2	240-250 cmbs	> 0.1	> 0.1	1.2	40.1	56.7	0.2	> 0.1						
	250-260 cmbs	0	0	0.1	33.2	67.2	> 0.1	> 0.1						
1	330-340 cmbs	>0.1	>0.1	5.3	60.4	32.6	0.1	0.1						

^ Debitage present ** Charcoal present

Table 6. Table of laboratory data available for sediments obtained from Auger 8.

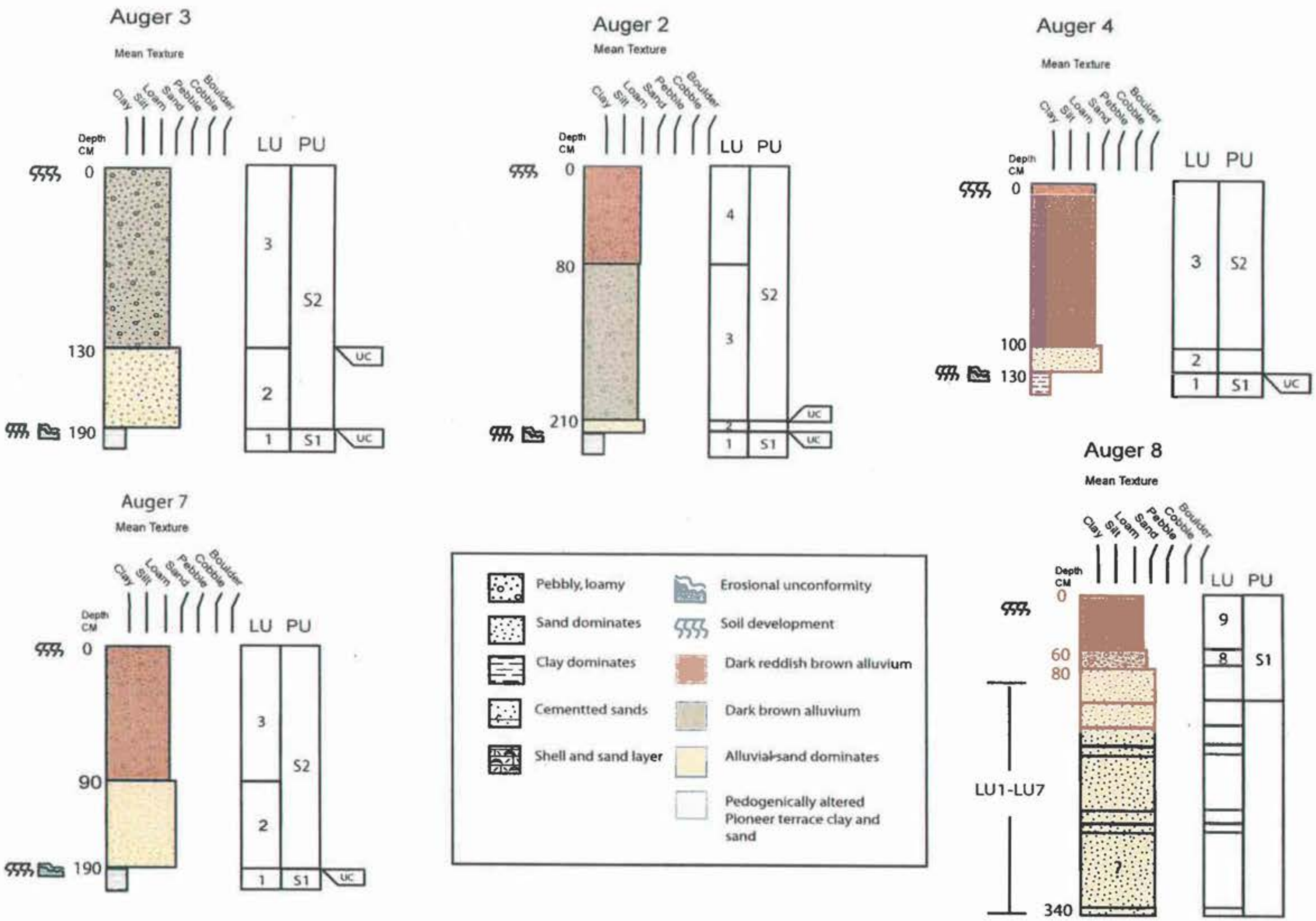


Figure 18. Sratigraphic profiles in the middle to eastern border of Site Area 3 from 2005 excavations.

Site Area 3: Southwest Section

Two lithostratigraphic units were observed in Test Unit 5-7 and three lithostratigraphic units were observed in Test Unit 5-10 (Figures 19 and 20). Of note in Test Unit 5-10 is the thin layer of yellowish red sand (LU2) that is 82.8% fine sand. This lithostratigraphic unit, found between 60 and 70 cmbs, was not found in other locations.

Site Area 6

In this site area, two lithostratigraphic units were observed. LU1 was the iron-cemented sands observed in other site areas, while the second lithostratigraphic unit (LU2) is similar to the sandy loam of Site Area 3. One noted differenced is the presence of cemented sand clasts that appear to be fragments of LU1 that have been eroded and re-deposited as part of LU2.

Pedostratigraphy

Pedostratigraphic units are identified from observable soil properties within a stratigraphic profile that can be verified by various laboratory analyses (Waters 1992). The vertical movement and accumulation of materials such as iron, calcium carbonate, and secondary clay minerals are examples of properties that can indicate diagnostic pedogenic aspects and can be used to distinguish soils from unaltered sediments (Mandel and Bettis 2001). Table 7 summarizes the pedostratigraphic units identified in Site Areas 3 and 6.

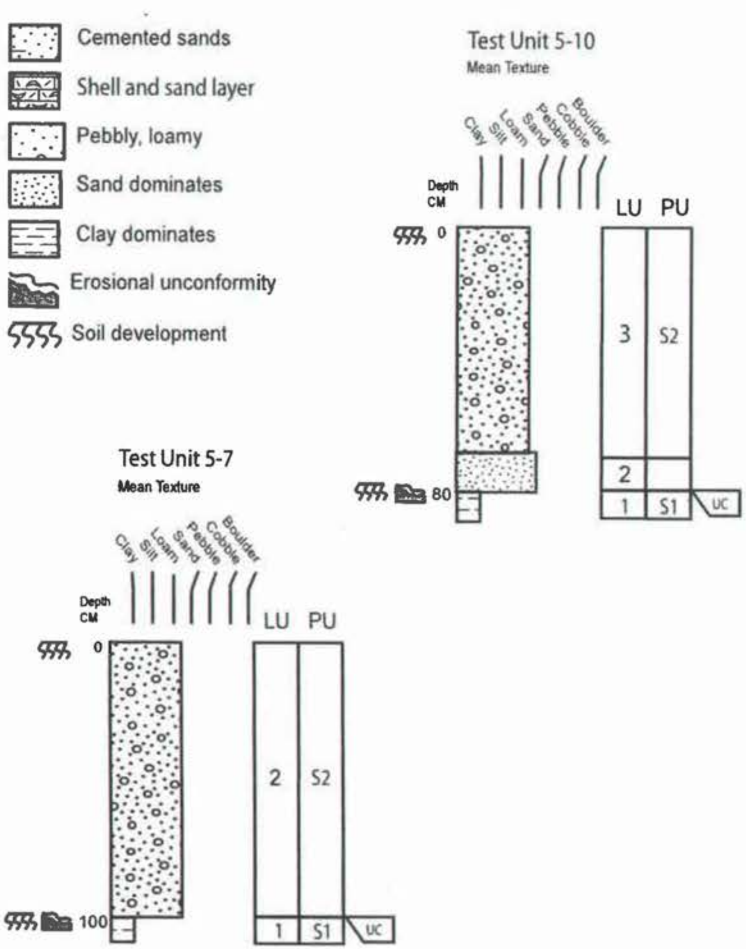


Figure 19. Sediment profiles for Test Units 5-10 and 5-7.

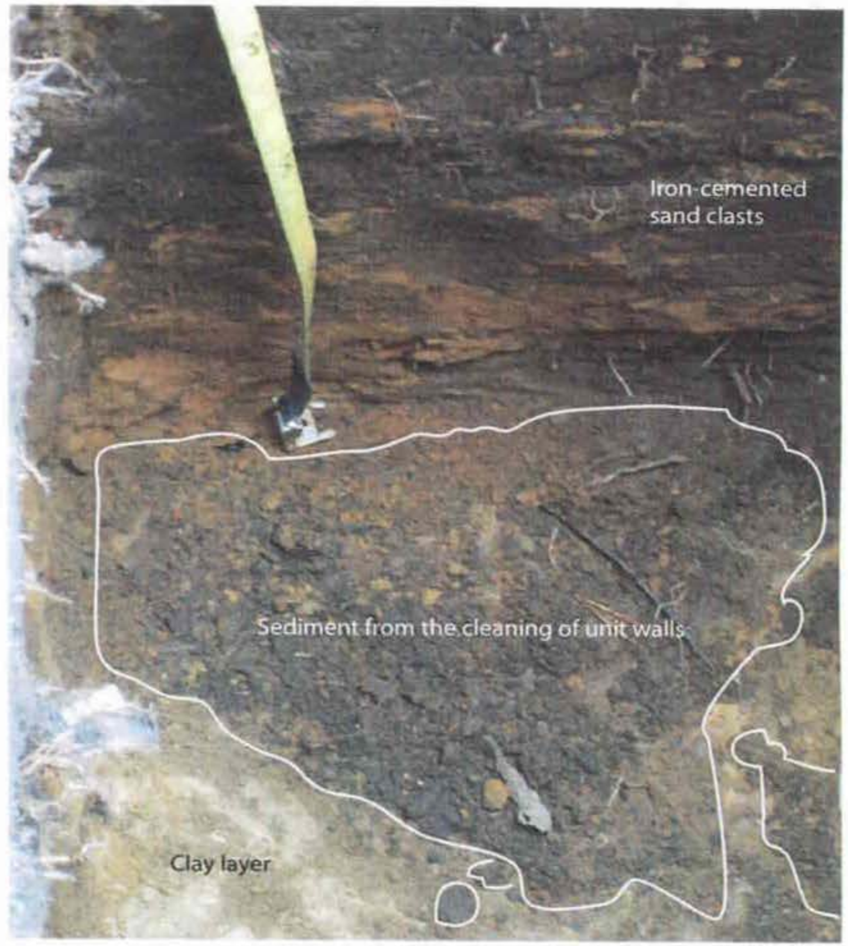


Figure 20. The floor and east wall of Test Unit 5-10. Clasts of LU1 iron-cemented sand are observed in the matrix above the unit floor. The depth of this unit is ca. 80 cmbs.

Site Area 3: Western Section

Site Area	Section	PU	Structure
3	5-1	1	NA
		2	NA
3	5-3	1	Medium to coarse, strong, subangular blocky peds in sand surrounding platy clays
		2	Medium to coarse, weak to moderate subangular blocky
3	5-4	1	Medium to coarse, strong, subangular blocky peds
		2	Medium to coarse, weak, subangular blocky pebbly loam
3	5-5	1	Platy clay
		2	Medium to coarse, weak, subangular blocky silt loam

Site Area 3: Middle to Eastern Border

Site Area	Section	PU	Structure
3	Auger 2	1	Iron oxide cemented sands, with a moist, very sticky, very plastic layer of clay.
		2	NA
3	Auger 3	1	Platy clay
		2	NA
3	Auger 4	1	Moist, plastic layer of clay.
		2	NA
3	Auger 7	1	Platy clay
		2	
3	Auger 8	1	Structureless sand
		2	NA

Site Area 3: Southwest Section

Site Area	Section	PU	Structure
3	5-7	1	Medium to coarse, moderate, subangular blocky; moist, firm consistence
		2	Weak, subangular blocky
3	5-10	1	Medium to coarse, weak, subangular blocky
		2	Weak to structureless subangular blocky loamy sand

Site Area 6

Site Area	Section	PU	Structure
6	5-14	1	Medium to coarse, strong to moderate, subangular blocky; strongly cemented sand
		2	Moderate to weak, subangular blocky
6	5-16	1	Medium to coarse, strong to moderate, subangular blocky; strongly cemented sand
		2	Moderate to weak, subangular blocky

Table 7. Pedostratigraphic units of Site Area 3 and 6 from 2005 excavations.

As identified in Tables 4 and 5, the S1 paleosol that developed within Pioneer terrace is the first pedostratigraphic unit (S1) identified throughout the site, except in Auger 8 of Site Area 3. This unit retains a distinctive accumulation of iron oxide, is moderately cemented and exhibits varying degrees of bioturbation. The iron oxide content helped form S1's high chroma red (10R) and yellowish brown (10YR) colors. In several locations, the clays associated with LU1 show signs of root activity (Figure 21), further indicating soil development within LU1.

Site Area 3: Western Section

In this location pedostratigraphic Unit 2 (S2) is variously expressed in this area. In general, S2 has a weak, subangular blocky structure (Test Unit 5-5), and relatively high percentage of organic matter (between 7 and 13 percent). When this detail is added to there being a lack of an observable B horizon, and the relatively small span of time represented by the cultural material that Byram (2005) identified throughout this stratigraphic layer, there is strong indicate that the soil is continually receiving sedimentary input as it develops. Therefore, S2 may be described as over thickened, and assigned to all LU2 sediments.

Site Area 3: Middle to Eastern Border

The lack of descriptive data for soil units prevents the accurate determination of the depth at which the second pedostratigraphic unit (S2) begins in this site area.

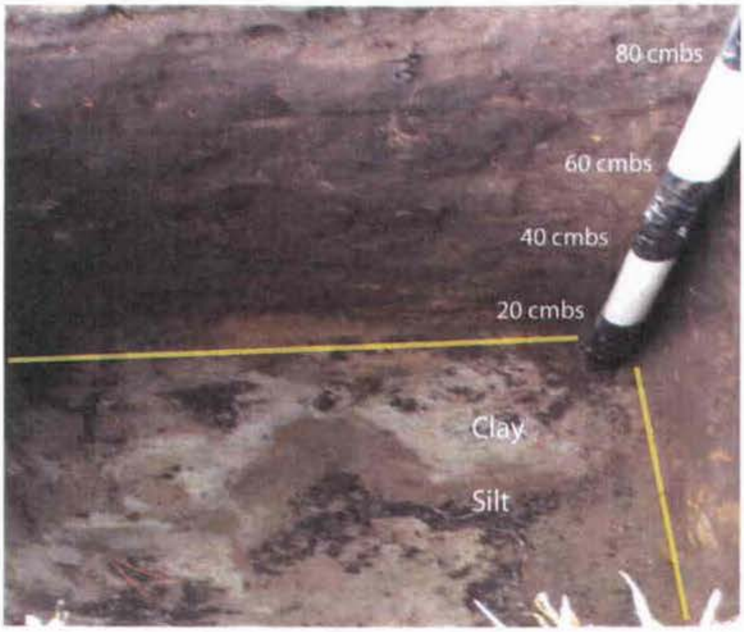


Figure 21. Test Unit 5-6 profile showing clay mixed with brown silt in contact with iron-cemented sands. Orange-brown sand (the S1 paleosol) are observed above and below the yellow line marking the test unit floor.

Based on criteria such as the change of color in sediments overlying S1 from a light yellowish brown (10YR 6/6) to a brown (7.5YR 4/4) to a dark reddish brown (5YR 3/2) at 85 cmbs or deeper, the degree of root activity, accumulation of organic matter, and slightly acid pH of sediments overlying S1, LU2 may also be interpreted to contain incipient soil horizons similar to those observed in the western portion of the site area. Without more conclusive data, a second soil unit (S2) was assigned to the upper portion of the various lithostratigraphic units here.

Site Area 3: Southwest Section

The two pedostratigraphic units (S1 and S2) were observed in profiles from this section of Site Area 3, and appear to be the same two observed in neighboring sections of Site Areas 2 and 3. Because of differences in relief and parent material, the S1 and S2 paleosols of southwest Site Area 3 have a slightly different expression than elsewhere at the site. In Unit 5-10, the cementation of the S1 paleosol is more moderate, which may be due its position near the base of a slope where saturation will occur. The yellowish red (5YR 5/6) sand found here is interpreted to be pedogenically altered Pioneer terrace sands (Figure 20).

The second soil unit shows some signs of pedogenic development in its change of color from a reddish brown (5YR 5/4) sand to a dark reddish gray (2.5YR 3/1) sand and the modest increase in clay (from 4% to 9%) within the solum. In comparison, the S1 paleosol within Unit 5-7 is better drained, contains more silt and clay (ca.14%), and has a subangular blocky structure.

Site Area 6

There is no significant variation evident in the two pedostratigraphic units observed in Site Area 6, despite the differences in topographic relief and its position south of Site Area 1 that experienced alluvial and aeolian activity very different from the rest of the site. The first unit (S1) has the same subangular blocky structure as the S1 paleosol observed in other site area. Similarly, the second soil (S2) in this site area has a weakly expressed subangular structure as observed in the LU2 sandy loam of Site Area 3.

Allostratigraphy

Allostratigraphic units are intervals of sediment or rock that represent a significant change in deposition, or a period of erosional activity that are defined by bounding discontinuities (Ferring 2001; NASCON 1983). A boundary is considered conformable if the break represents a relatively brief period of time and is termed unconformable if the hiatus represents a significant or intermediate break in time, including erosional events that have altered the landscape or periods of soil development (Waters 1992). Waters (1992) also notes that an alluvial erosional unconformity is often referred to as a disconformity, which is a term used to describe the allostratigraphic boundary between the S1 paleosol and the second lithostratigraphic unit in most test unit locations (Table 5). Due to the nature of this stratigraphic unit, a boundary is not described for the lithostratigraphic units that serve as the modern surface. Within the two site areas only three test units within Site Area

3 have a second allostratigraphic boundary: Test Units 5-1 and 5-3 in the western section, and Test Unit 5-10 in the southwestern section. Therefore, this section will discuss the results according to data obtained from these locations.

Regarding Test Units 5-1 and 5-3 in the western section, and Test Unit 5-10 in the southwestern section, there is an unconformable contact between the LU2 lens of sand in both site sections, and the LU3 of overlying units. There is evidence of alluvial erosion of the S1 paleosol in most test units of Site Areas 3 and 6, such as the presence of small clay clasts, and iron-cemented sand clasts in the sediments directly overlying LU1 in Test Units 5-4, 5-10, 5-14, and Augers 2 and 3. In Test Unit 5-10, evidence of alluvial erosion also resides in the southerly down-slope angle of the S1 paleosol contact, and the relatively shallow depths at which LU1 is observed suggests that fluvial processes have been acting with some regularity in this location.

The variability in how the S1 paleosol was eroded can be observed in the different depths at which this lithostratigraphic unit was observed in the eastern border of Site Area 2 (Figure 22). Auger 8 was excavated to a depth of 7.80 meters above sea level (masl) without contacting the S1 paleosol where approximately 10 m to the southeast in Auger 4, the S1 paleosol was identified at an elevation of 13 masl.

Since soil development represents a period of surficial stability it is of note that western Site Area 3 is missing soil units that correspond to S2 and S3, as seen in Site Areas 1 and 4. In this regard, the unconformable contact between the erosion of S1

Figure 22. Depths as which the S1 paleosol were encountered in auger probes from eastern Site Area 3. Not shown is Auger 8 where the S1 paleosol was not encountered at a depth of 340 cmbs. The elevation of Auger 8 is 10.55 masl, which is about 3 meters lower than neighboring test units.

and the deposition of LU2 in Site Area 3 may represent the loss of a sizeable segment of time since dates from LU2 sediments are limited to the early Holocene.

Lithofacies

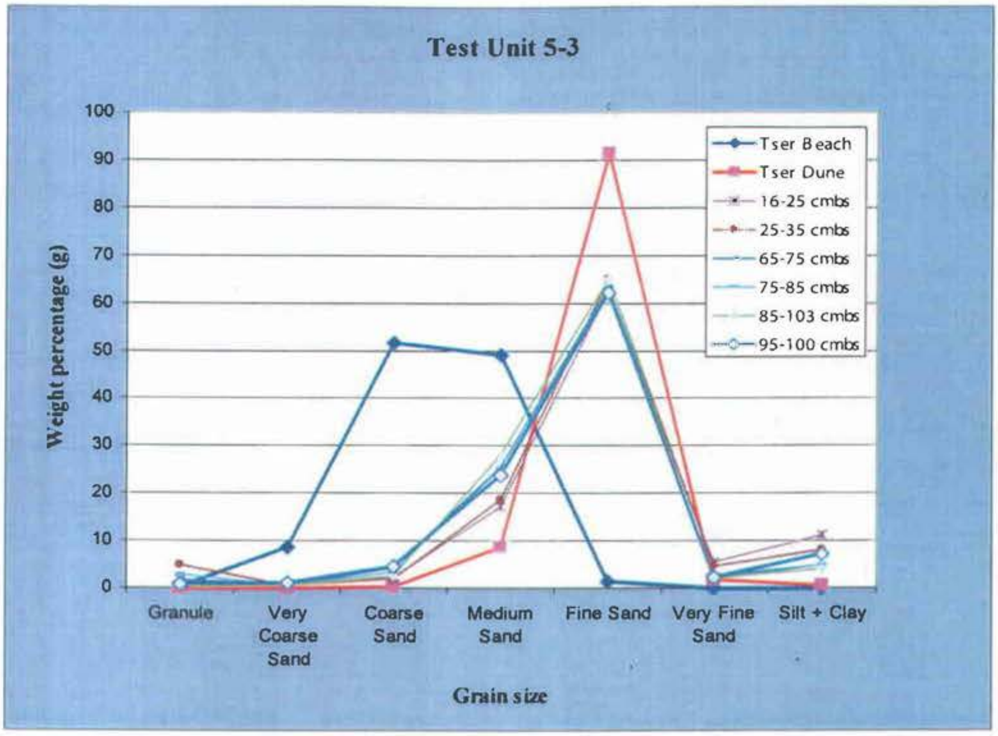
Lithofacies are the physical properties of sediments specific to certain depositional environments as defined by color, texture, sedimentary structure, and lithology (Boggs 2001). Grain-size analysis is one of the primary laboratory methods for interpreting depositional history. Interpretations of grain-size data are supported by noting the soil pH, and percentages of organic matter and calcium carbonate. A summary of the lithofacies identified in Site Areas 3 and 6 are listed in Table 8. These will be referenced in following sections and chapters.

Site Area 3: Western Section

Following Davis' (2005) example, the grain size distribution data from modern beach and dune environments were plotted alongside sample data from test units 5-3, 5-4, and 5-5 for comparison (Figures 23 and 24). According to their granulometric distribution, LU2 and LU3 graph more similar to modern Tseriadun dune sand than modern Tseriadun beach sand. Considering that alluvial environments or environments with a significant alluvial input are also capable of creating well sorted distributions of medium and fine sand (Boggs 2001; Friedman 1978; Waters 1992), LU2 and LU3 were interpreted to have an alluvial deposition. A second source of

Lithofacies	Description	Age	Section Examples
Hal1	Moderately sorted sand with brownish yellow, brown, and very dark grayish colors	Late Pleistocene to early Holocene	5-1, 5-3, Auger 2, Auger 3
Hal2	Dark brown to very dark brown pebbly loamy sand	Middle to late Holocene	5-1, 5-3, 5-4, 5-5, Auger 2, Auger 8
Hal3	Pebbly sandy loam with dark brown to dark reddish brown color	Middle to late Holocene	Auger 2, Auger 4, Auger 7, Auger 8
Hal4	Brownish yellow to pale brown sandy loam	Middle to late Holocene	Auger 4, Auger 7
Hal5	Well sorted loamy sand, reddish brown to dark reddish gray in color	Middle to late Holocene	5-10
Hal6	Moderately sorted pebbly sandy loam, dark gray brown to brown in color	Middle to late Holocene	5-14, 5-16
Hael1	Well sorted yellowish red sand	Middle to late Holocene	5-10
Hals1-Hals7	Beds of well sorted coarse, medium and fine sand	Late Pleistocene to early Holocene	Auger 8
Qpi	Iron stained, ferric-cemented marine sands and clays	ca. 80,000 BP	5-1 through 5-16, Augers 1 through 7
Lithofacies derived from Davis' (2005) analysis of sediments in Site Areas 1, 2, and 4. wt = western terrace			
Hal1wt	Poorly sorted sandy clay loam	Late Pleistocene to early Holocene	LU2 in TSR-1 (Site Area 1) and in House Area 1 test units (Site Area 4)
Hal2wt	Well sorted sandy loam to loamy sand	Middle to late Holocene	LU2 in Units J and K (Site Area 2)
Hae1wt	Well sorted sand	Middle to late Holocene	LU3 in TSR-1 (Site Area 1), and House Area 1 units (Site Area 4)

Table 8. Lithofacies of Site Areas 3 and 6 from 2005 excavations. Lithofacies for the western terrace were created from 2003 excavation data for the sake of discussing the evolution of the landscape in chapter 5.



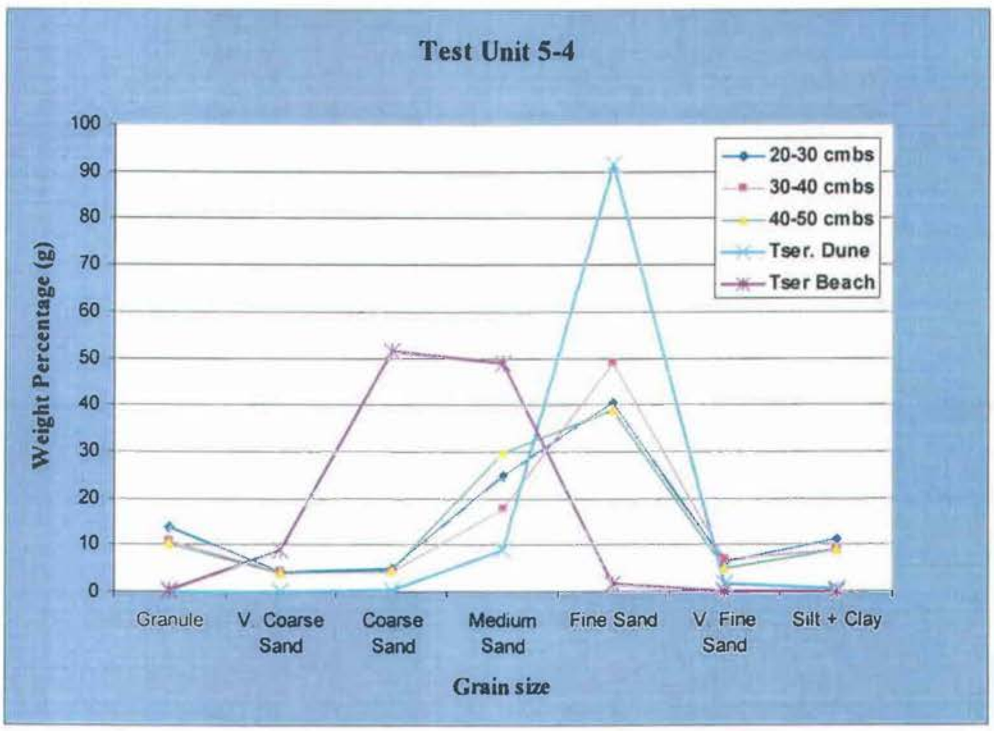


Figure 23. Grain size distribution of samples from Test Units 5-3, 5-4, modern beach sand, and dune sand.

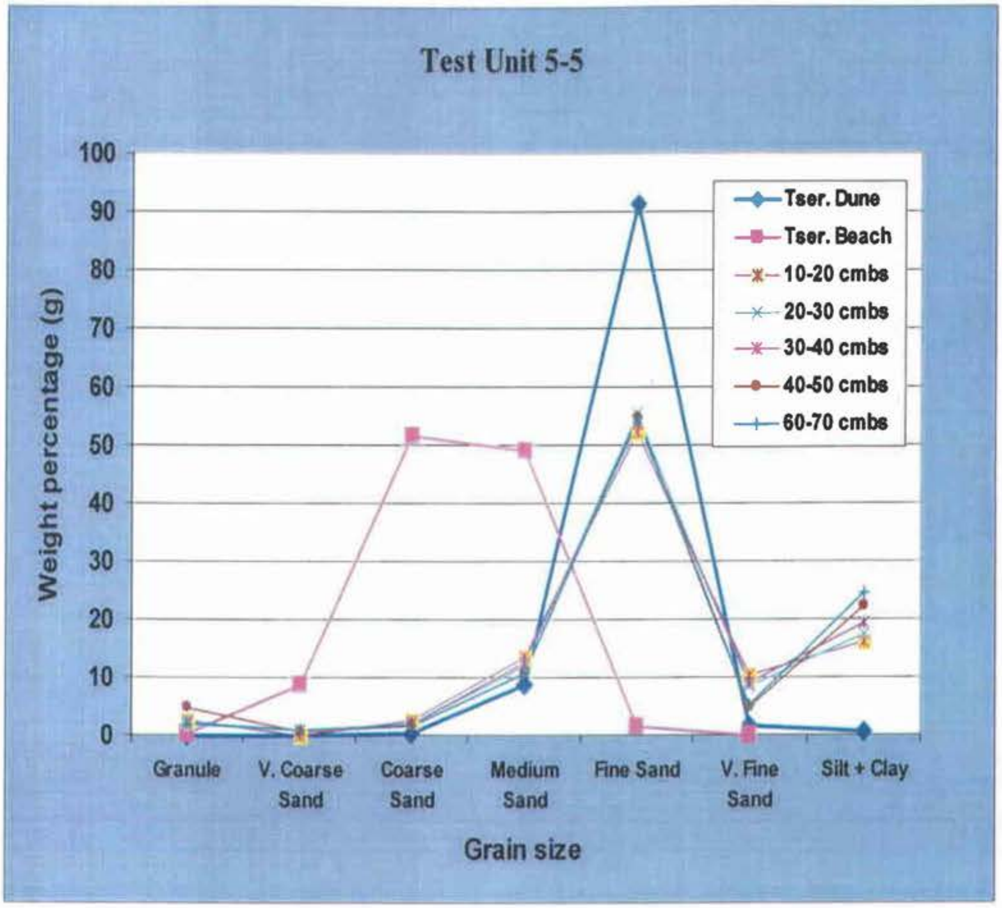


Figure 24. Grain size distribution of samples fromTest Units 5-5, modern beach sand, and dune sand.

comparison is found in the LU2 sediments from TSR-1 and Test Unit AA that Davis (2005) interpreted as being alluvial in nature. The cumulative frequency distribution of LU2 sediments from these 2003 test units, and LU2 sediments of Test Units 5-3, 5-4, and 5-5 have a similar pattern (Figure 25 and Appendix B). Descriptions of the lithofacies assigned to test units from the western section of Site Are 3 are listed in Table 6.

Site Area 3: Middle to Eastern Border

Evidence that Site Area 3 was once part of an alluvial floodplain as claimed by Davis (2005) appears in the sediment data of several test units in this area. In Auger 2, the abrupt transition between the S1 paleosol, the moderately poor sorting of LU3, and the composition of LU3 that measures between 20 and 30% fine grain material all indicate that they had an alluvial deposition (Figure 26).

The various shifts in grain size within Auger 8 move from well sorted coarse sand to a predominantly fine sand, and finally, to a poorly sorted loamy sand. This fining upward sequence is not linear and progressive; instead there are several abrupt changes in grain size which may represent cut and fill sequences or adjustments in stream flow within the channel. Topographic and elevational data support the interpretation that Auger 8 is positioned over a paleochannel. The two upper most deposits in Auger 8 are similar to those of other augers in the area which have large percentages of medium and fine sand, relatively high percentages of silt, and are moderately to poorly sorted (Figure 27). The normal distribution of grain sizes in

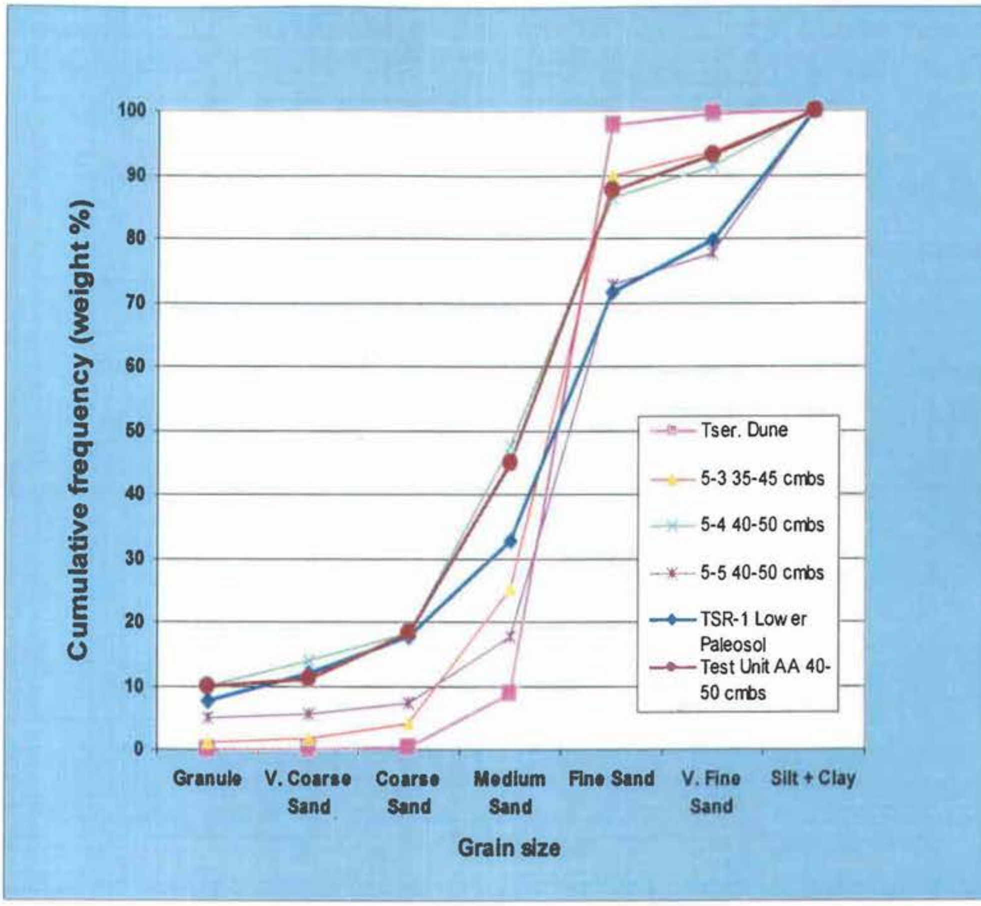
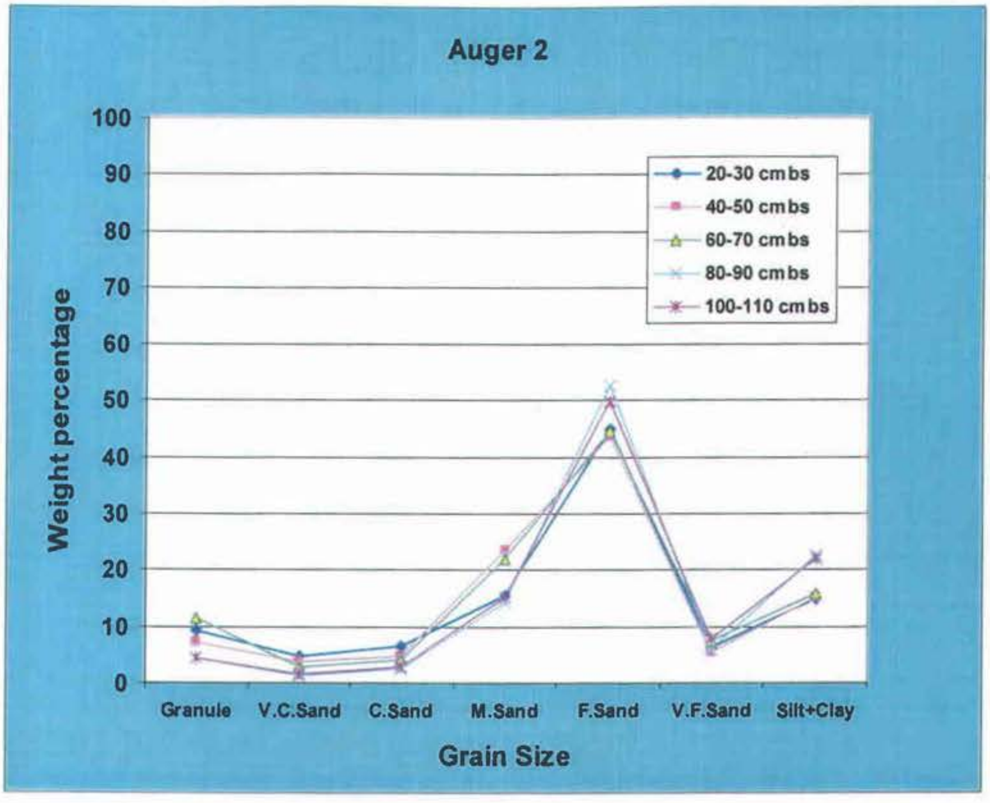


Figure 25. Cumulative frequency distribution of samples from 2005 Test Units 5-3 through 5-5, and 2003 Test Unit AA and section TSR-1. Modern dune sand is plotted for comparison.



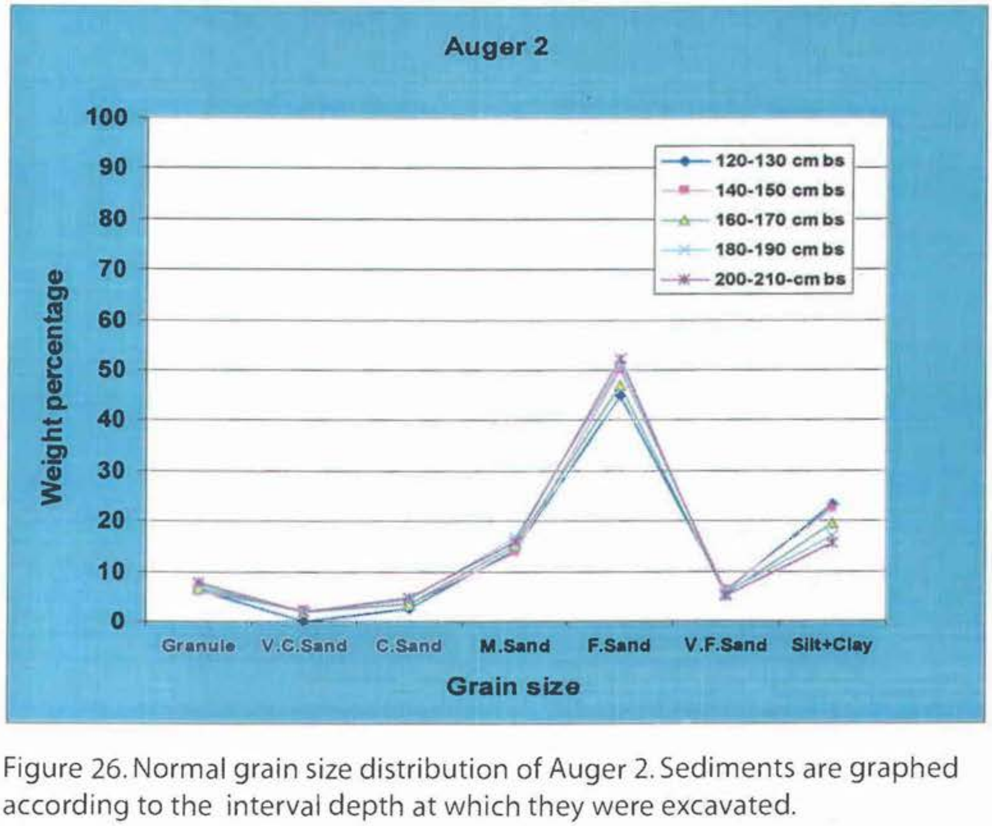


Figure 26. Normal grain size distribution of Auger 2. Sediments are graphed according to the interval depth at which they were excavated.

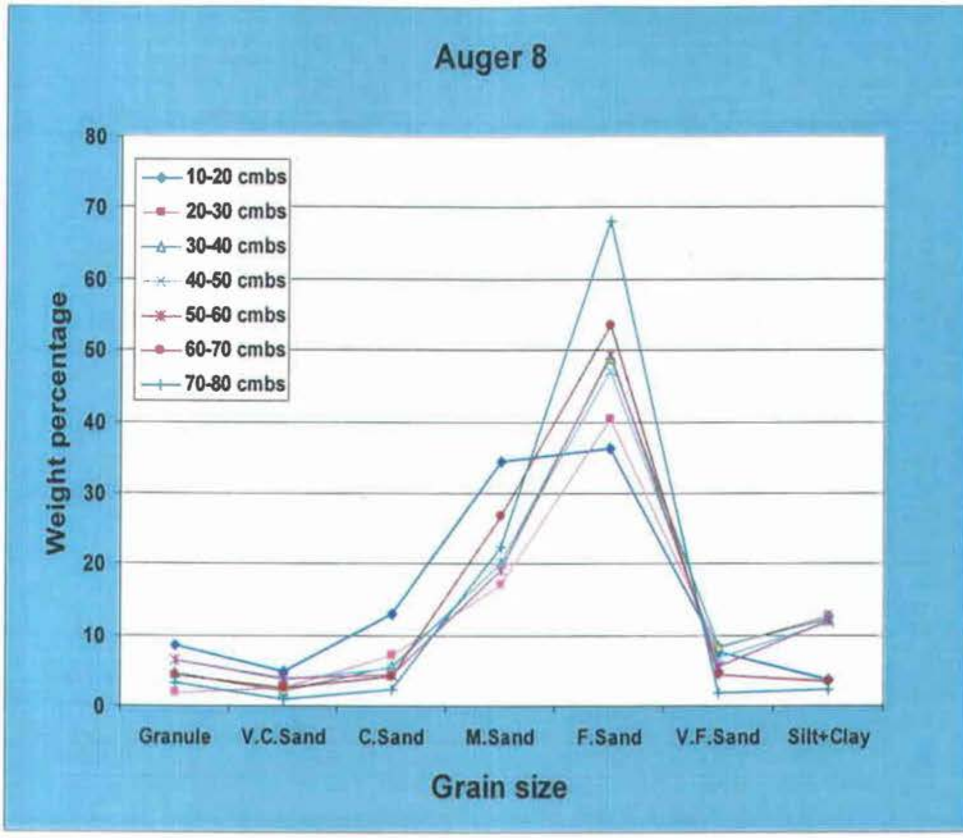


Figure 27. The normal grain size distribution of the two upper most stratigraphic units (LU8 and LU9) in Auger 8.

these lithostratigraphic units (LU8 and LU9) indicates that they were deposited in a low energy alluvial environment.

Site Area 3: Southwest Section

In Test Unit 5-10, the granulometry of LU2 graphs very much like modern Tseriadun dune sand, suggesting an aeolian mode of deposition (Figure 28). The transition from the very well sorted distribution of LU2 sediments to the moderately poor sorting of LU3 sediments indicates a shift to alluvial sedimentation. Of note is that the sediments in LU3 have a twofold increase in the coarser sand fractions.

Of all Tseriadun's site areas the location where one might expect to find evidence of large storm surge or tsunami deposits is in sediments at lower elevations in proximity to the western edge of the site. Sediments within Test Unit 5-10 are neither comprised of the coarse sand that is associated with such events nor was there evidence of rip-up clasts, parallel bedding, or a fining upward sequence all of which are characteristics of such sediments (Atwater 1987; Peters et al. 2003; USGS 2001).

Site Area 6

The LU2 sediments in this site area are moderately to poorly sorted. In the lowest reaches of LU2, medium and fine sands were nearly equal in their weight percentage. On average, medium sand content measured 20.2%, fine sand measured 42.6%, and silt averaged 24% (Appendix A). The majority of sediments found within the coarsest sieves were comprised of iron-cemented clasts, some measuring 4 mm

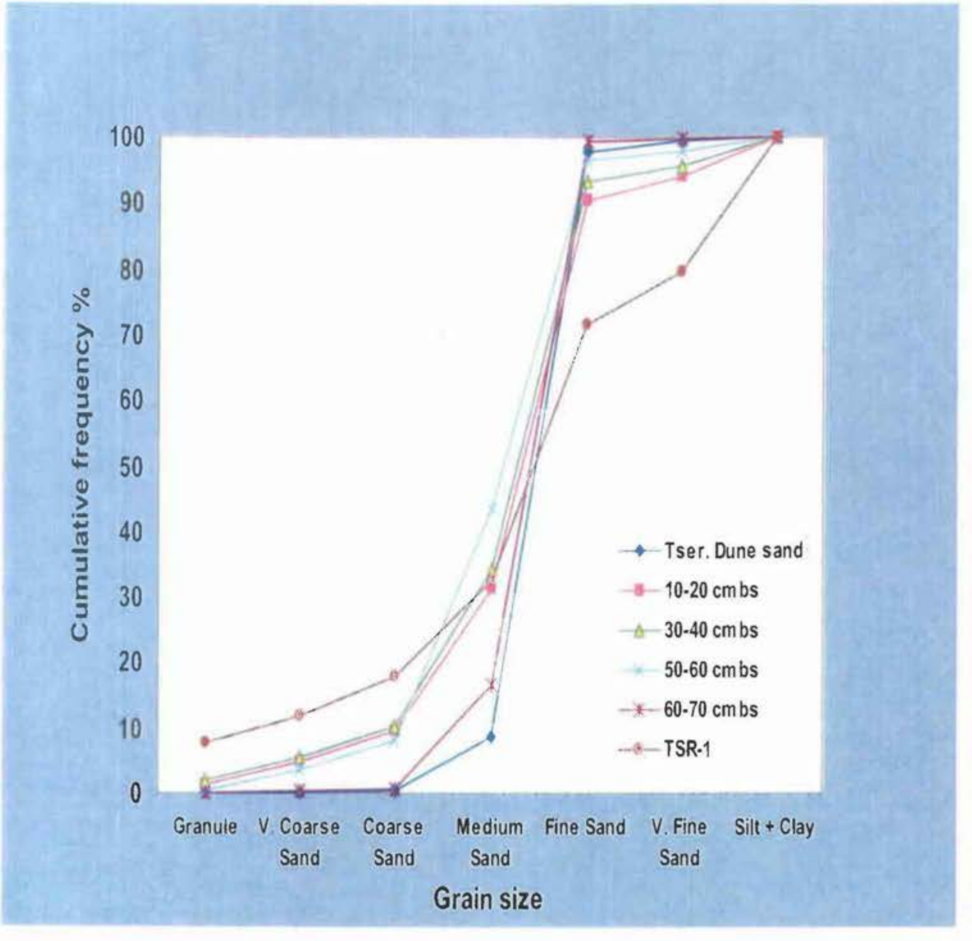


Figure 28. Cumulative frequency of sediments from Test Unit 5-10, modern dune sand, and section TSR-1, the lower S2 paleosol. TSR-1 is a section analyzed by Davis in 2005 excavations.

and larger. Examination of sedimentary clasts under low power magnification (e.g. 4X) revealed sub-rounded to rounded quartz and plagioclase grains in the 1/4 mm and 1/125 mm size range. While a small percentage (10%) of these quartz grains showed signs of frosting, indicating they were transported by wind, these data collectively point toward an alluvial deposition of LU2 sediments. This suggests that there was an alluvial reworking of sand with an aeolian origin.

When compared to the LU2 alluvium in Site Area 1, and the LU2 sediments in Auger 3 of Site Area 3, the LU2 sediments of Site Area 6 more closely resemble the alluvium of Site Area 3 where the depositional environment appears to have been a lower energy floodplain.

Chronostratigraphy

The dating of stratigraphic layers allows the formation of chronostratigraphic units that can be used to represent blocks of geologic time, such as the 80,000 BP date associated with Pioneer terrace.

Temporal control of sediments in Site Area 3 is determined primarily by their relationship to Unit T, which is about 60 m southeast of Test Unit 5-3 (Figure 10). Despite the potential of surface mixing due to the former presence of a mobile home park, Byram (2005) notes that that the sediments within Unit T appear to be intact, and it is a unit from which a radiocarbon date of 850-730 cal BP was received on shell (Figure 29). Other dates were obtained by obsidian hydration from four different samples from within Unit T ranging from approximately 1500 and 3300 BP; all of

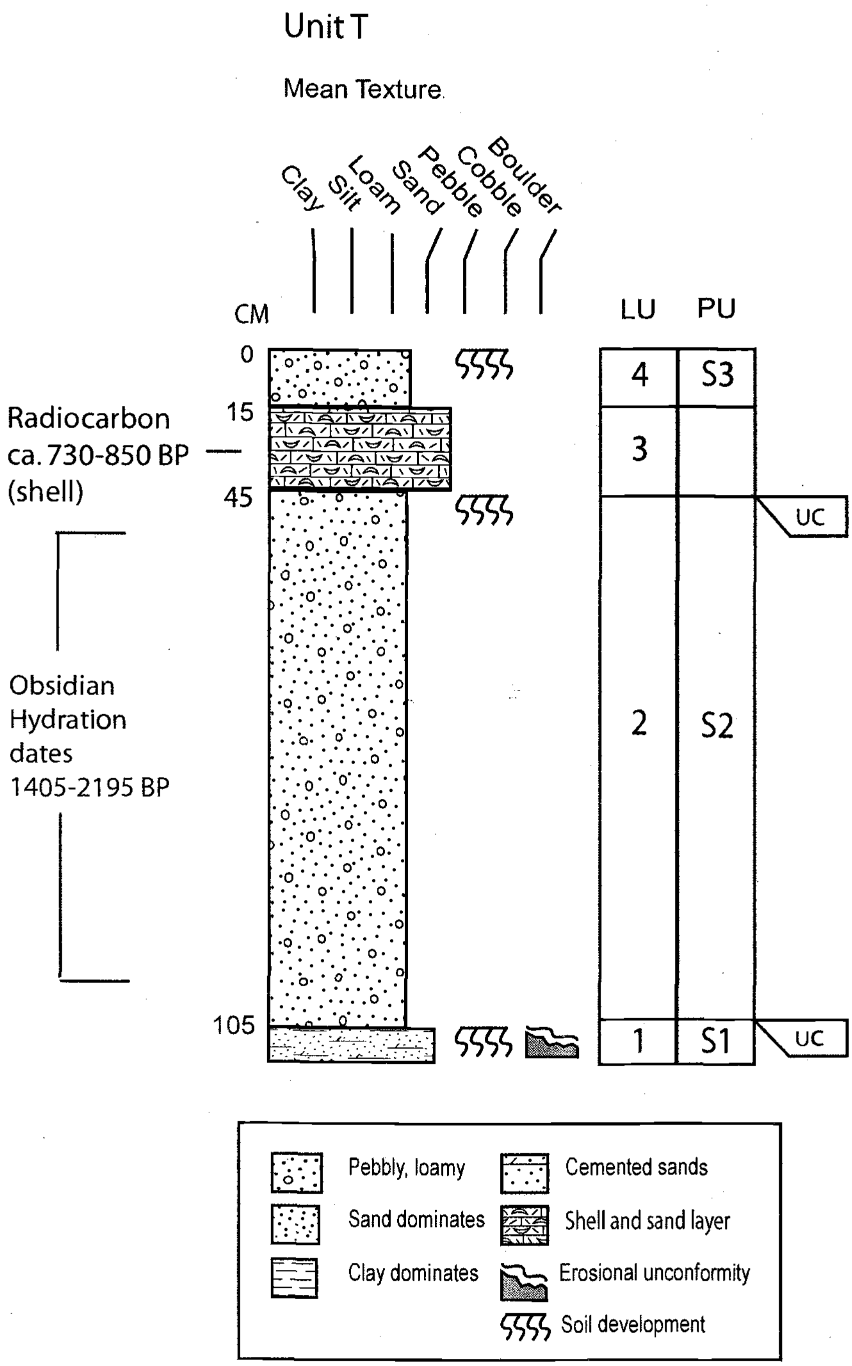


Figure 29. Chronostratigraphy of Test Unit T from 2003 excavations (Byram 2005).

which came from positions throughout stratigraphic units above LU1 in Unit T (Byram 2005; Davis 2005). The dating of these sediments near the middle of Site Area 3 provides a relative date assessment for LU2 and LU3 sediments in other site sections that appear to be contemporaneous. This middle to late Holocene age is relatively young in comparison to the early to middle Holocene sediments found along the western terrace. The fact that this period of time is represented vertically within a meter of sediments indicates that this portion of Site Area 3 experienced a relatively low rate of deposition, when compared to the rapid aeolian deposition seen in Site Area 1.

Sediments from the southwest section of Site Area 3 have not yet been dated. If the well sorted sediments of LU2 in Test Unit 5-10 are indeed of aeolian deposition, then they may date to one of two periods of dune development observed in Site Area 1. The first of these occurred after 7570-7760 BP and the other after 5500 BP (Byram 2004 personal communication; Davis 2005).

There are also no radiometric or obsidian hydration dates available from Site Area 6. However, Byram (2006) indicates a middle to late Holocene age for the artifact types associated with LU2 sediments in this site area, providing a relative age assessment for the timing of LU2 deposition.

Additional Evidence

Two geotechnical boreholes were excavated 140 m northeast of the Tseriadun site's eastern border at the Port Orford Wastewater Treatment Plant in January, 2004 in order to evaluate the composition of subsurface deposits. These boreholes were drilled to depths of 10.05 and 9.53 masl (33 feet and 31.3 feet, respectively).The results of this testing are as follows (SHN 2004: 2):

> The upper 6 to 8 feet near the ground surface consists of poorly graded sand that is loose to medium dense, and fine to medium grained. Underlying the sand is a peat layer with a thickness of about 10 to 12 feet. The peat is very soft and fibrous, with occasional inter-bedded sand layers, and grades to a silty sand at the base of the peat. The silty sand layer is 2 to 3 feet thick, and is loose and fine grained. Below the silty sand are stratified layers of dense gravel and sand. The thickness of the dense granular materials is about 8 to 11 feet, and overlies the Otter Point Formation bedrock material.

Using USGS topographic maps, the surface elevation of the bore holes can be estimated to be about 12.19 masl or 13.10 masl when converted to the NGVD 88 datum used at the Tseriadun site. The depth at which peat was observed in bore hole WW-2 is approximately 11 masl, gravely sand at 6 masl, and the very dense fine grained brown sand (interpreted here to be Pioneer terrace) at 5.61 masl. Compared to Auger 4 where the S1 paleosol developed on Pioneer terrace sediments was identified at 12.75 masl (a difference of 7.4 m), there is fairly clear evidence that erosion, probably alluvial, removed portions of the underlying marine terrace in the area of the Port Orford Wastewater Treatment Plant. Furthermore, the 4 m of peat suggests that this erosional channel later became part of a wetland probably abutting an early version of Garrison Lake. Support of this interpretation is found in Heusser's pollen cores which were collected cores from a location on Garrison Lake's floor that is ca. 200 m northwest of the plant (Figure 2).

CHAPTER 5

DISCUSSION

Expanding the stratigraphic framework of the Tseriadun site has established a means for generating new insights into its site formation history. Moreover, this research provides a platform from which we may consider the form of the local paleolandscape, its change through time, and outline its associated environmental conditions. As Butzer (1982) upholds, geomorphic change in a landscape context occurs at "small, medium and large scales." The value of this concept was very apparent while conducting geoarchaeological research at the Tseriadun site where the characterization of lithofacies required thinking at one scale, and identifying local erosional patterns required another.

Synthesis of the results from field and laboratory analysis has allowed the formation of a new model of Tseriadun's geomorphic history which is presented in this chapter from both diachronic and synchronic viewpoints. A discussion of the implications that these findings have for understanding the context in which prehistoric humans occupied the site through time, and for how the sequence of geologic events served to shape the archaeological record will follow. This interpretive framework will be compared to Davis' (2005) model in the process of presenting new geoarchaeological interpretations.

The sequence of geomorphic change at the Tseriadun site was deduced from stratigraphic cross sections which follow transects marked in Figure 30. Transect A-

Figure 30. Map showing transects A - A', B - B', and C - C'.

A' projects relationships between the 2005 test units and augers in Site Area 3 along a northwest-southeast line (Figure 31). Test Units 5-10, Auger 7 and Auger 2 are correlated in transect B-B' (Figure 32). Transect C-C' correlates test units in the western portion of Site Area 3 to Test Unit 14 in Site Area 6 (Figure 33). In general, these cross sections show that there is variety in how sedimentary units are expressed within each site areas as well as between them. In Site Area 3, LU2 changes laterally across the site from a pebbly, loamy alluvium to a layer of sand that thins as it moves to the east, whereas by Auger 4, LU2 has transitioned again into a pebbly, sandy loam. Transect B-B' shows that the LU2 alluvial sand of Auger 2 disappears by Auger 7, becoming a loamy sand, and a very well sorted fine sand in Test Unit 5-10. The differences between the Site Area 3 and Site Area 6 lithostratigraphic units is observed in Transect C-C' primarily in the LU2 sediments of Test Unit 5-10; while LU2 further north and south of Test Unit 5-10 are a pebbly, sandy loam with similar grain size mean. Of note are the elevations at which S1 was encountered in all site areas which assist in observing the subsurface topography; a perspective aided by the contour map shown in Figure 34.

Model of Landscape Change at Tseriadun

The following is a revised model of Tseriadun's geomorphic history. Inserted within the pages that describe the model are figures that serve as visual representations of the sequences outlined in the model. The described series of evolutionary events are labeled Time one through Time nine.

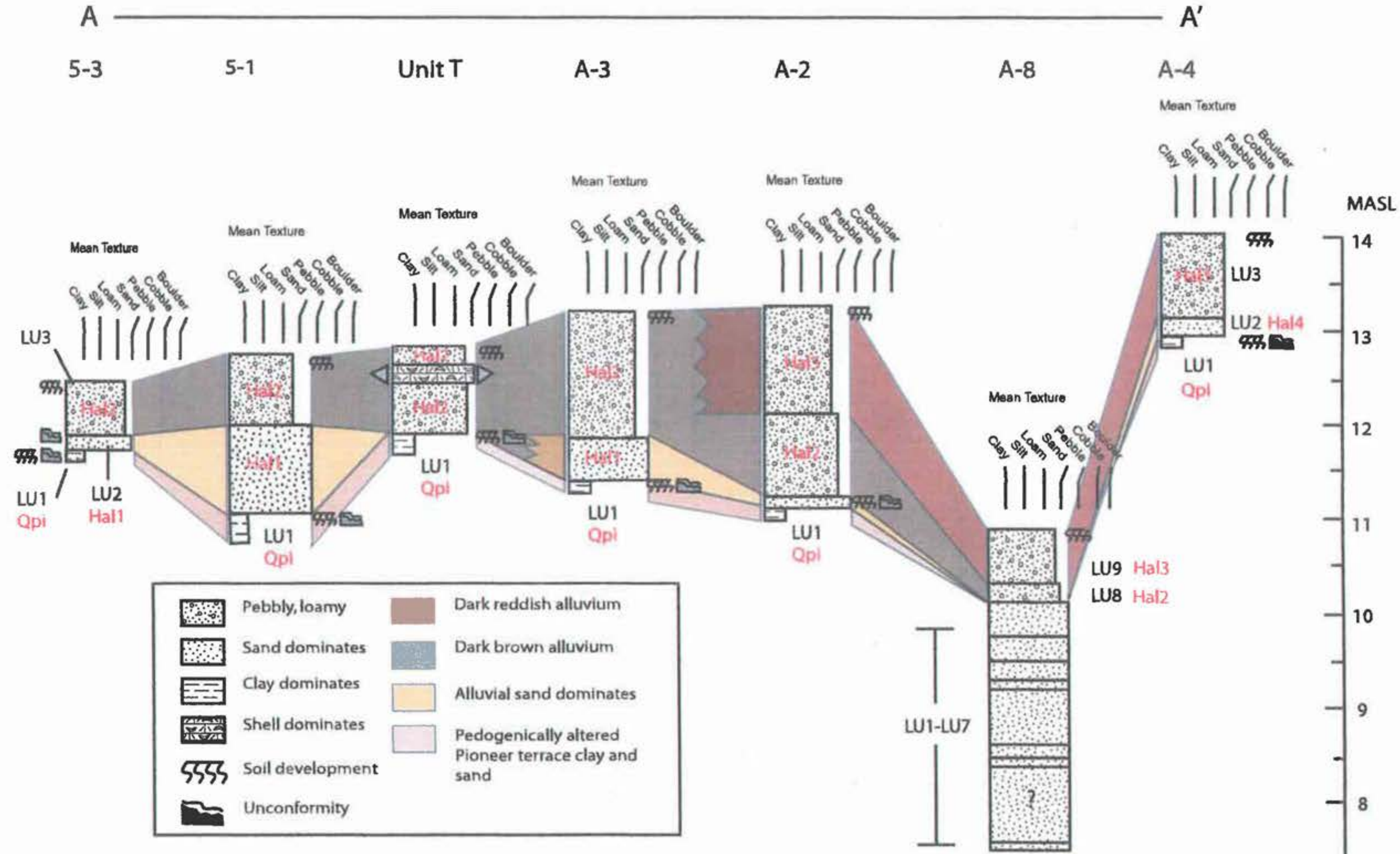


Figure 31. Transect A-A' showing the west to east correlation between Site Area 3 test units and augers. Unit T was part of 2003 investigrations. Despite differences in sampling and analytical foci, granulometric similarities indicate it is reasonable to suggest that LU2 in Unit T is Hal2 and has been drawn so.

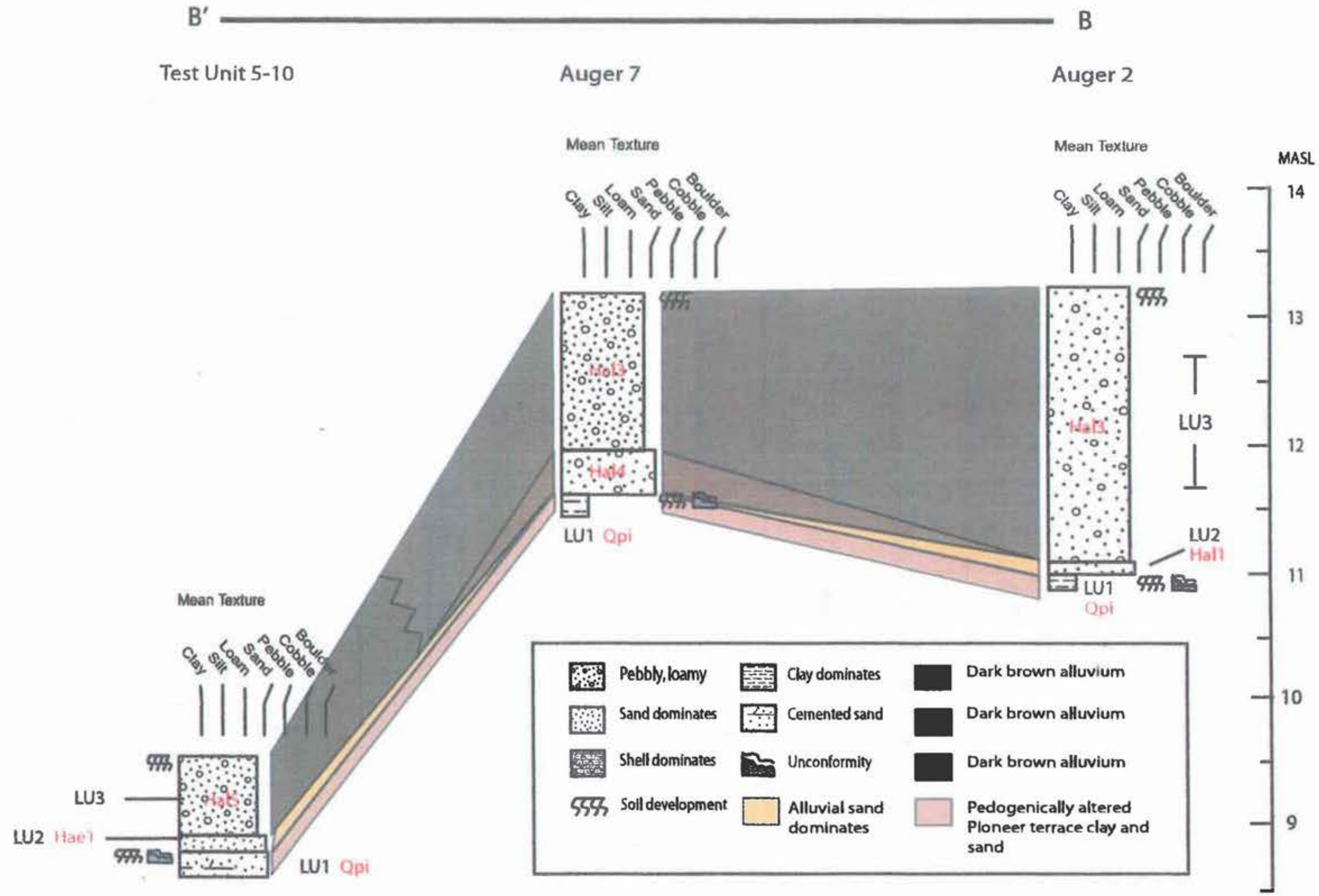


Figure 32. Transect B-B' showing Augers 2, 7 and Test Unit 5-10. A unknown facies transition is marked by a broken line.

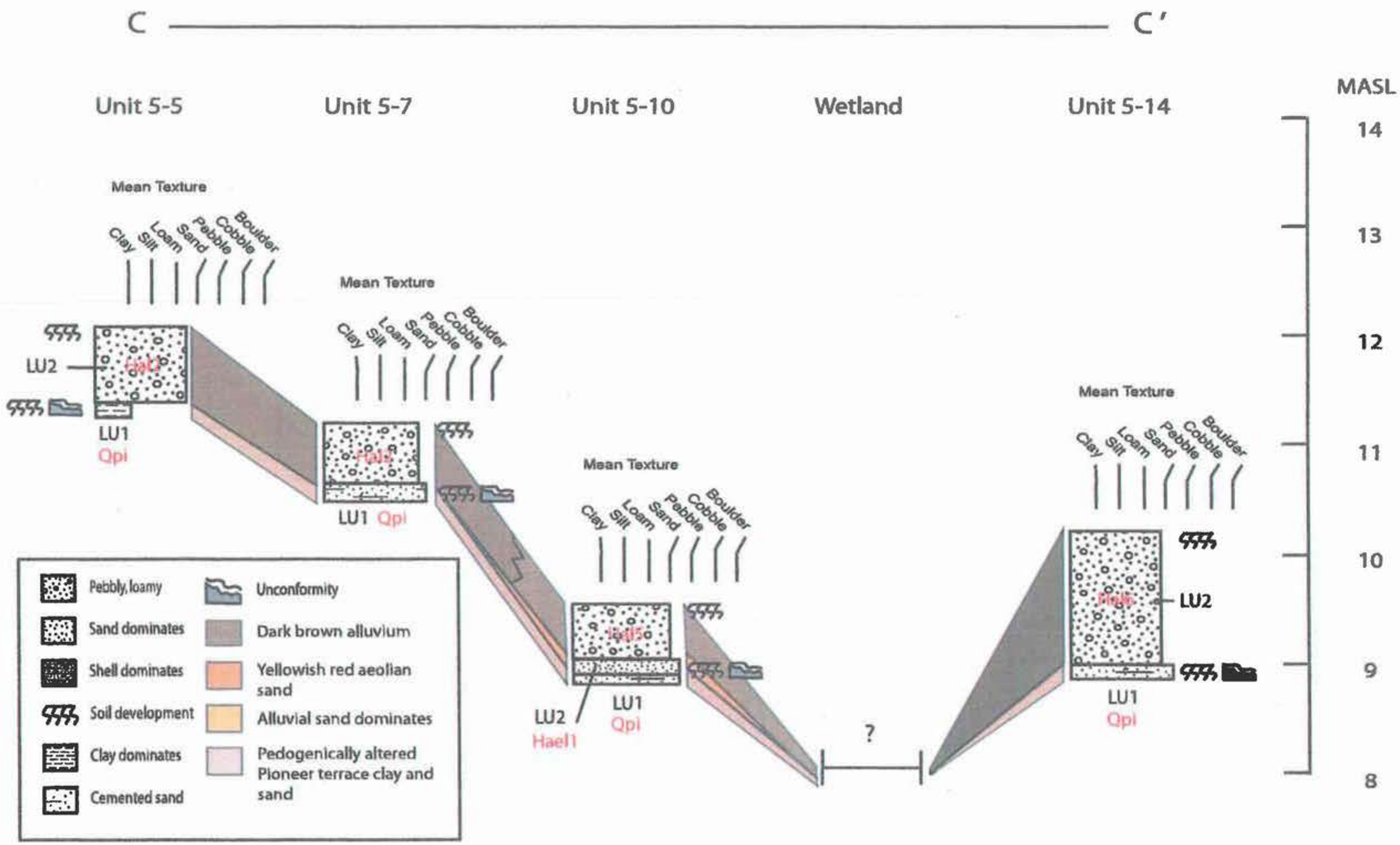


Figure 33. Transect C-C′. North to south correlation of stratigraphy in Test Units 5-5, 5-7, 5-10, and 5-14.

Figure 34. Contour map of Site Area 3. Topographic lines used here are derived from test unit data, and topographic data obtained from an engineering map created in 2005 for the culvert project. Elevations of 2005 test units were measured in meters above sea level (masl) using the NAVD 88 datum. Dashed lines are suggested locations for contour lines.

Time one: The marine sands of the Pioneer terrace (Qpi) were exposed sometime between 125,000 and 80,000 BP. Following uplift of the terrace, fluvial systems established drainageways and floodplains on its surface. During this time, an alluvial channel may have flowed across Site Area 3 and cut through the Pioneer terrace in the southwest section, forming the basin for what would later become Little Round Lake. This channel shifted to the northeast section of the site where it eroded through the Pioneer terrace sediments where the southern bay of Garrison Lake now resides. Also during this period of channel activity, Hal1 sand is deposited in western Site Area 3. This channel may have shifted to the north or another channel formed to incise marine terrace sediments east and north of the site as reflected in the depth at which geotechnical drilling encountered consolidated sandy sediments.

Time two: This is a period of relative surficial stability during the late Pleistocene. Apart from those alluvial features seen during Time one, there are no new channels formed during this time. Pedogenic development alters Pioneer terrace marine sediments (Qpi) in some places after 125,000-80,000 BP, forming the S1 paleosol.

Time three: According to Davis (2005), alluvial activity occurs along the western terrace in Site Areas 4 and 1, eroding the S1 paleosol sometime between the late Pleistocene and early Holocene. The erosion of the S1 paleosol within Site Area 2 is observed in Test Units J and K, a location that was likely within the floodplain of this southwest flowing alluvial body. Davis also suggests that within this same period of time the alluvial channel progrades to the north and cuts through the S1 paleosol and Pioneer terrace (Qpi) in the area of House Area 1. This is clearly observed in profile, showing how the depth of the channel's incision and direction of flow (Figure 8).

Time four: According to Davis (2005), the channel in Site Area 4 aggrades and fills with alluvium (Hal1wt), most likely during the late Pleistocene to early Holocene. Along the western terrace, 40 to 60 cm of Hal1wt is deposited.

Time five: During the early to middle Holocene, the channel that once flowed across the western terrace probably shifted to the north (Figure 35). Davis (2005) suggested that this channel may have temporarily shifted to the south across Site Area 3 producing what may be Hal2. Evidence from 2005 test units suggests that sources of alluvial activity in Site Area 3 were likely to have continued to come from the southeast in the middle to late Holocene. It is also likely that Hal2 has a southern, upslope source.

Time six: According to Davis (2005) a paleosol (S2) develops in Hal1wt along the western terrace during the early Holocene, signifying a period of surficial stability. As sea level continues to rise, channels become less capable of moving sediment out to sea, causing sediments to accumulate. A likely result is the formation of a

Figure 35. Active geomorphic systems during Time one through Time five from the model of landscape change. Arrows represent the inferred paths for various fluvial bodies and are marked with the order in which they occur in the timeline and the period of time during which they are believed to have been present.

freshwater lake in the southern bay of what would become the Garrison Lake basin according to radiocarbon dates of 6720 +/-250 BP obtained by Heusser's (1960) peat samples (Figure 36).

Time seven: A period of surficial instability begins during the early Holocene as rising sea level rework and redistribute sediments that accumulated on the coastal plain during the late Pleistocene to early Holocene (Davis 2005). Extensive aeolian deposits (Hae1wt) cover the S2 paleosol along the western terrace, with slightly higher rates of deposition in Site Area 1. Radiocarbon dates on wood charcoal recovered from within the upper limits of the S2 paleosol in Site Area 1 provides a lower limiting date of 7570-7760 BP for this aeolian deposit.

Time eight: Davis (2005) notes that a third pedostratigraphic unit (S3) develops in dunes along the western terrace during a middle Holocene hiatus in deposition, which is most clearly observed in Site Area 1. In Site Area 2, where aeolian deposition occurred to a much less degree, the grain size distribution of sediments within Units J and K (Hal2wt) are interpreted by Davis (2005) to represent a lee-side dune environment, with a possible seasonal influx of alluvium. In the northeast section of Site Area 3, channel activity has continued, shifting in the early to middle Holocene to a lower energy state that gradually infills with silty alluvium (Hal2), as reflected in Auger 8. The center of Site Area 3 continues to be a floodplain that receives alluvium (Hal2, Hal3, Hal4), probably from an upslope source

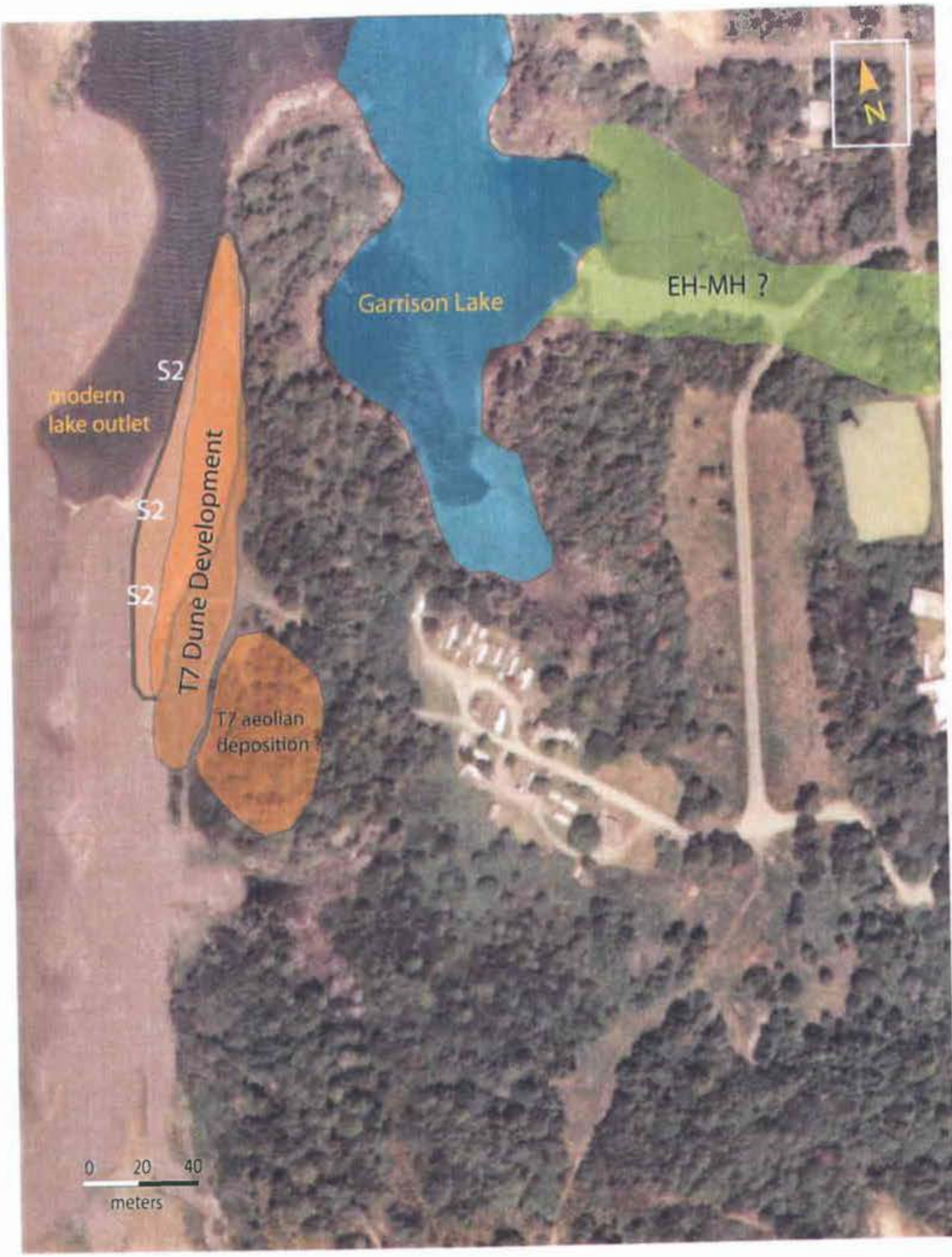


Figure 36. Time six through Time seven. The lateral extent of alluvium in which the S2 paleosol formed along the western terrace is unknown. The border drawn here is for the purpose of illustrating its position along the terrace, beneath the dunes that developed during the middle Holocene.

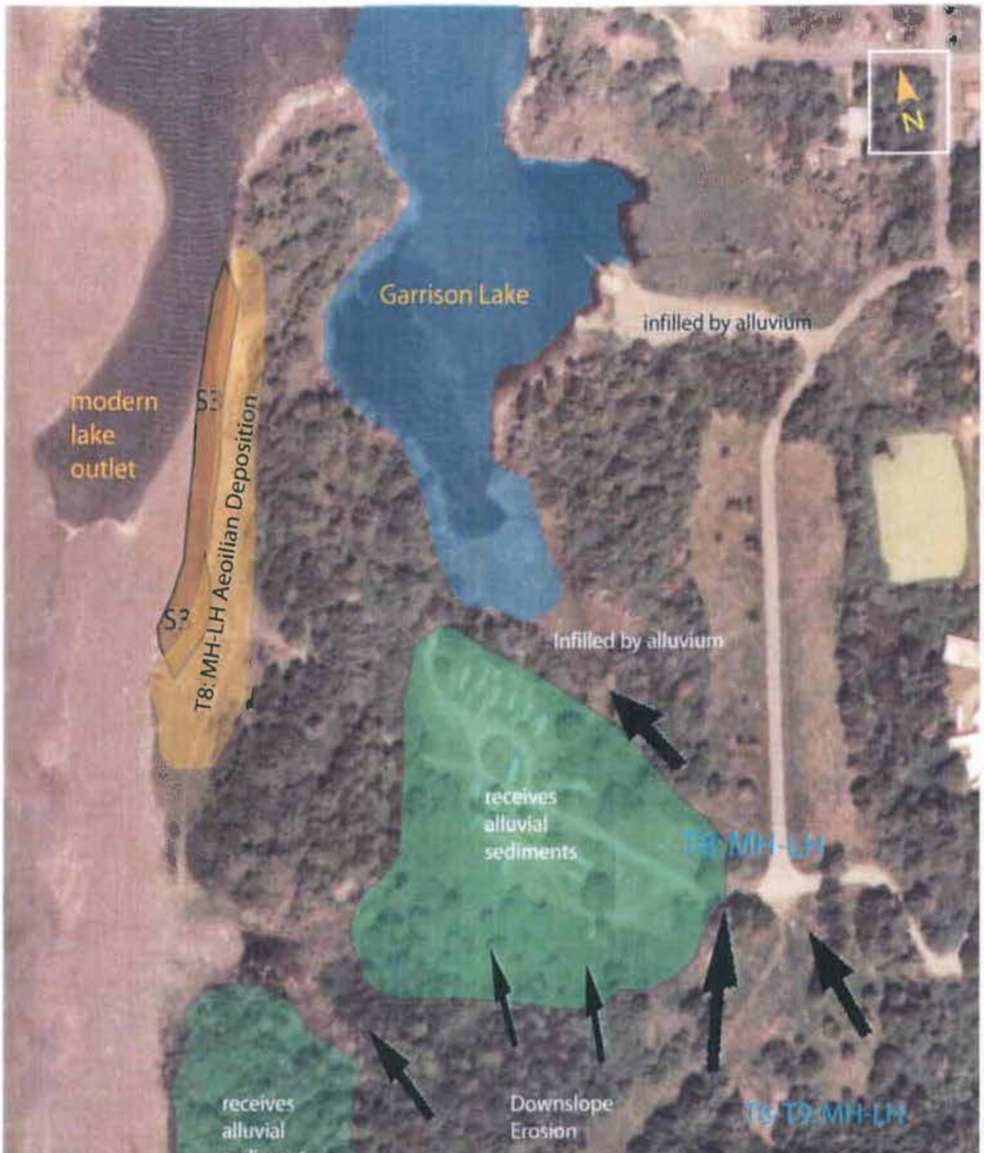


Figure 37. Time eight through Time nine. The boundaries of the S3 paleosol that developed within middle Holocene aeolian deposits along the western terrace is erratic. These boundaries are merely approximated here.

south and southeast of the site, as evidenced by the thicker deposits in the eastern site area (Figure 22). In Site Area 6, down slope erosion continues to contribute alluvium (Hal6) in the location of Test Units 5-12 and 5-14. Aeolian deposition (Hae1) associated with Site Area 1 may have reached the border of Site Area 5 depositing dune sand in the location of Test Unit 5-10 before its late Holocene burial by alluvium (Hal5).

Time nine: Lastly, during the late Holocene, aeolian deposition (Hae1wt) slowed greatly along the western terrace and across the site in general, and the current period of surficial stability began with development of the modern soil across the site. The relatively warm and wet climate of the late Holocene increased precipitation along the coast probably causing intermittent pulses of alluvial erosion, as reflected by pebbles and iron-cemented sand clasts entrained within alluvium (Hal3, Hal4, and Hal6) deposited in test units from Site Areas 3 and 6.

Interpretation of Paleoenvironmental Context

The analysis of the 2005 data allows us to expand our understanding of the various stratigraphic units within the eastern and southern areas of the site, and to add this information to previous interpretations of geomorphic change that has occurred at Tseriadun over time. Figures 38, 39, and 40 provide a graphic means for visualizing the synthesis of these interpretations of the geomorphic changes mentioned in the landscape model from a diachronic and synchronic perspective.

Except for Site Area 5, the stratigraphic record for each of the site areas has been assembled into a chart that synthesizes the various data obtained at Tseriadun. Site Area 5 is omitted since it remains largely untested and was not part of this study's analysis. Explanations of the graphs follow, beginning with Site Areas 1 and 4.

Site Areas 1 and 4

These two site areas are grouped together due to their similar depositional and cultural histories. Site Areas 1 and 4 contain well stratified deposits and thus provide the greatest geological and archaeological resolution as well as the ability to provide views on the environmental context for the site's past human occupants.

While the history of the two site areas begin with the exposure of Pioneer terrace and the formation of the S1 paleosol, these events are not represented in the synthesis chart because they took place well before humans were present in the Pacific Northwest and have little consequence for the site's archaeological context (Figure 38).

Evidence of human activity at the site appears before the early Holocene seen as lithic debitage contained in the S2 paleosol in Site Area 1, which has been dated to 7570 to 7760 cal BP. The first of Byram's (2006) four cultural assemblages, the Pre-Dune Component, was found in Site Area 1. It consists of fewer than 20 flakes of cryptocrystalline silica (CCS) and three pieces of fire cracked rock (FCR).

From a geological perspective, Site Area 1 and 4 were part of an active floodplain with a channel crossing it from the north beginning at some point in time

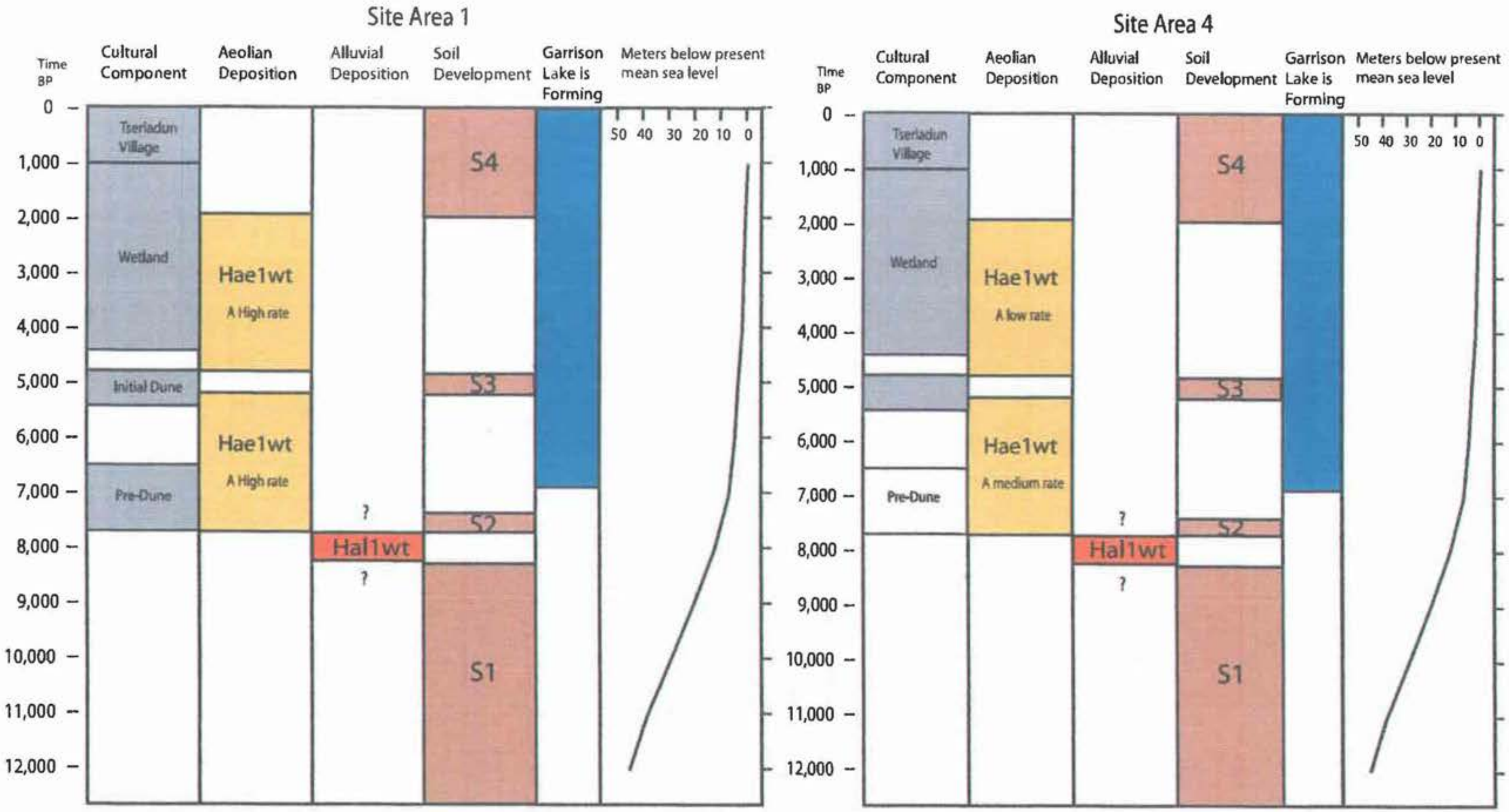


Figure 38. Synthesis chart for Site Areas 1 and 4. The y-axis has thousand year intervals representing the last 12,000 years. A shaded box marks the span of time in which each cultural component, sedimentary, pedological, or geologic agent is inferred from the archaeological record to have been present or been a factor in the site formation process. Ancillary information may be included inside these boxes. The column on the far right marks the relative position of sea level, averaged from rates graphed by Waters (1992: 350). The formation of Garrison Lake is noted by the blue column. Lithofacies are noted within depositional environment. See Table 8 for lithofacies descriptions.

between the late Pleistocene to early Holocene. Aside from the Alder, White pine, Douglas fir, mountain hemlock-fir, Western hemlock, and Port Orford pine that Heusser (1960) indicates were in the area, other species that would also be found near the site at this time between the beach and forest, such as grasses, small trees, salal, and various types of brush.

The early to middle Holocene was an active period of time for fluvial systems at the site. The channel crossing the western terrace cut through the S1 paleosol (Qpi) in the location of House Area 1 (Figure 8) and later it aggraded its channel, probably in response to rising sea level. It then shifted to the north by ca. 7,000 BP when Heusser's peat and pollen records indicate Garrison Lake begins, as referenced in Chapter 3. While prehistoric peoples probably made use of the area during the early Holocene to middle Holocene, the surficial stability next to an active channel is low and is unlikely to preserve cultural deposits in this context.

The stratigraphic record indicates that the accumulation of dunes also began in earnest during the early Holocene. While the introduction of a stable source of fresh water and an associated wetland environment would have provided some opportunities for prehistoric people in the area, it is likely that dune activity forced people to establish their habitation sites further inland or south of Site Area 6, perhaps further up the slope toward the Port Orford Heads near the location of 35CU8 (Byram 2006).

Despite the presence of midden deposits within the first several meters of dune deposits (Hae1wt), the next clear evidence of human activity in the site comes from a midden associated with the thin, mid-dune paleosol (S3) found in Site Area 1 that developed during a brief middle Holocene period of stability (Davis 2005). Together, these two layers of cultural deposits are identified as the Initial Dune Component which Byram (2005: 6-8) describes as several lenses of "dense cultural material including shell midden [...] and a possible occupation surface." This cultural material is the first indication that the western portion of the site was occupied since the early Holocene. The presence of shell and other marine fauna in this component provides information about subsistence activities and reflects the nearness of sea level, which probably stood close to modern levels.

Between the middle to late Holocene, aeolian deposition (Hae1wt) in Site Areas 1 and 4 continued, but slowed markedly over the past thousand years, as reflected by the depth at which the most recent cultural materials of the Tseriadun Village Component were recovered. While a small amount of cultural material representing the Wetland Component was identified in Site Areas 1 and 4, the most significant development along the western terrace is its re-establishment as a habitation site, which reflects the relative surficial stability of the landform here.

According to Byram (2006), the late Holocene-age Tseriadun Village Component is the most extensive cultural component at the site. It is characterized by near surface shell midden, faunal remains, house pits with clay lined floors, and a significant number of lithic tools and waste flakes that demonstrates a wide range of activities. Situated between a freshwater lake and littoral zone, Site Area 1 and 4 would have been a superior location for habitation during the late Holocene, enabling people to take advantage of a wide range of resources.

Site Area 2

The stratigraphic record indicates that some time after the uplift of the Pioneer terrace and the development of the S1 paleosol, alluvial activity with a high flow velocity crossed the site area, as indicated by the rip-up clasts observed by Davis (2005) in Test Units J and K. In the late Pleistocene to middle Holocene, the relative stability of this site seems to have been high, particularly in Test Units J and K where the 120 cm of sediments (Hal2wt) overlying the S1 paleosol show uniform particle size distribution (see Appendix B). In other locations, it may be that aeolian deposition reached into southern Site Area 2, possibly as far as Test Unit 5-10, indicating that the degree of surficial stability this site area location was lower.

The cultural component observed within Site Area 2 is almost exclusively associated with the Coquille series projectile points and side-notched and stemmed point forms, which characterize the Wetland Component at Tseriadun (Figure 39). According to Byram (2005: 8), the absence of midden and faunal material further suggests a hunting-camp focus for the site area. The restricted use of the site may be related to one of Jenny's soil forming factors. As Jenny (1941: 15) writes:

> Parent material, climate and organisms are commonly designated as soil formers or soil-forming factors. Since soils change with time and undergo a process of evolution, the factor time also is frequently given the status of a soil-forming factor. Topography, which modifies the water relationships in soils and to considerable extent influences soil erosion, also is usually treated as a soil former.

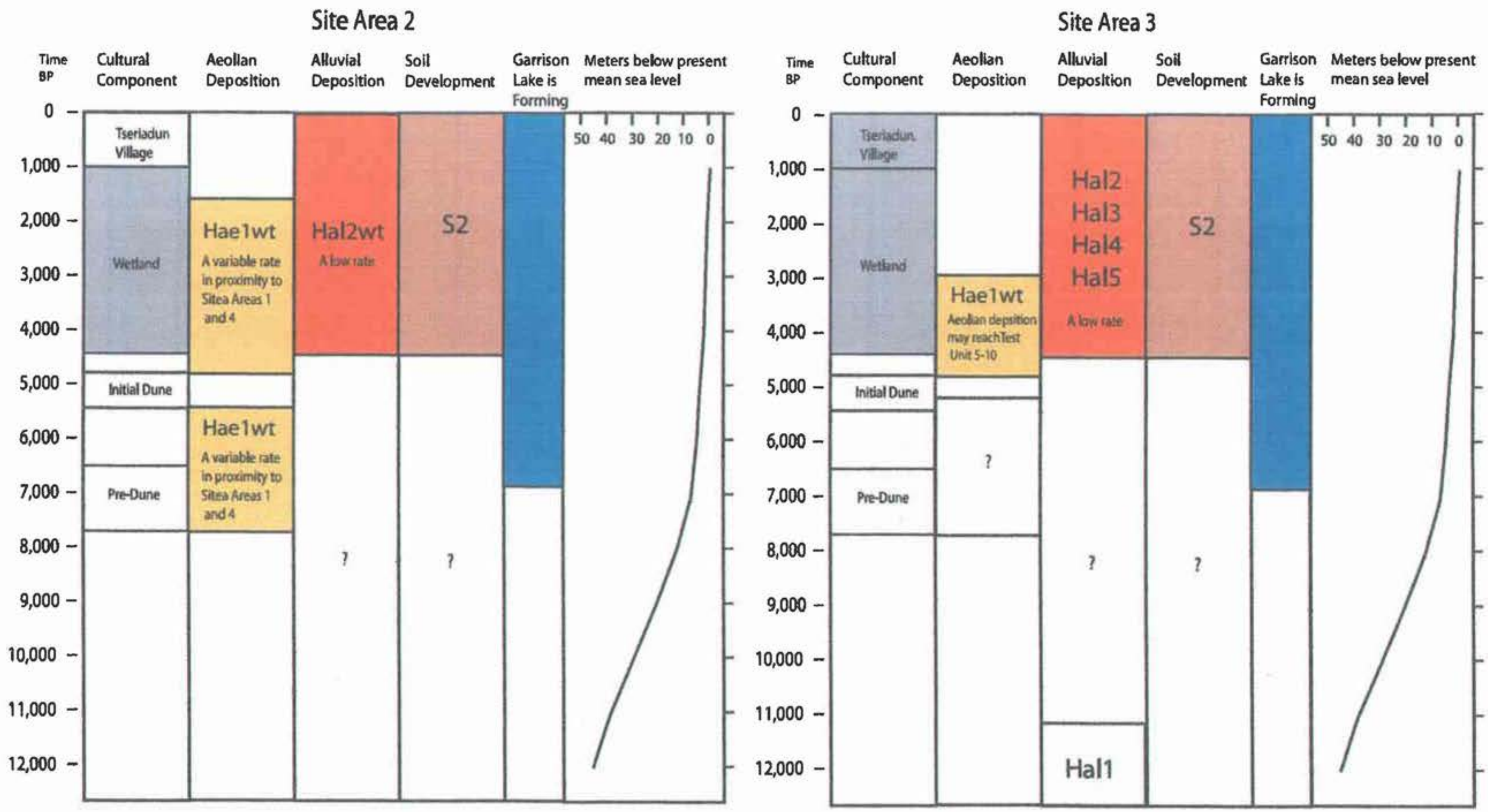


Figure 39. Synthesis chart for Site Areas 2 and 3. While the exact timing of deposition for Hal1 is unknown, the unit is noted within the alluvial column of Site Area 3. See Figure 38 for additional explanation of the graph's format.

Observations about the poorly drained nature of the soils overlying Pioneer terrace sediments have been made by several authors (Bockheim et al. 1992; Kelsey 1990; Langley-Turnbaugh 1997). Indication of why the Pioneer terrace soils are poorly drained can be observed in the Ortstein layer that runs along the entire western terrace. This partially cemented soil horizon is comprised of illuviated iron and aluminum (Soil Survey Staff 1999) that can perch water and reduce a soil's productivity for organisms that are necessary for soil development (Sands 2001). The permeability of the Pioneer terrace is further restricted by its inclusion of thick clay layers, such as that found near the surface of Qpi in eastern Site Area 2, and western Site Area 3 (Figure 6). Even after prehistoric people reestablished the western terrace as a habitation site, the absence of the Tseriadun Village Component from the archaeological record of that Site Area 2 indicates that this part of the site was undesirable for occupation, probably due to its dampness.

Site Area 3

The current chronometric control over the stratigraphic record and the age of sediments overlying the S1 paleosol forms a barrier to our understanding the full history of geomorphic change within this site area. Nonetheless the data obtained from within and outside of the site area is significant to the landscape model. From a geological point of view, the history of landscape evolution begins in Site Area 3 with the large scale channel activity observed in its eastern and northern borders. Evidence that this channelization of the Pioneer terrace occurred well before the Holocene is seen in the depth at which the S1 paleosol is encountered in site area test units (Figure 22), the geotechnical bore holes, and the pedogenic development observed in these locations.

Following a period of alluvial erosion during the late Pleistocene, alluvial activity within the channel north of Site Area 3 continued at an unknown rate. The lithofacies observed within Auger 8 suggest various episodes of alluvial cutting and filling, while the lack of a well developed soil within Hal2 and Hal3 suggest alluvial deposition continued throughout the middle to late Holocene. The formation of Garrison Lake at ca. 7,000 BP assures that major alluvial channel activity occurred before this and subsequently slowed as lake levels rose.

The site area continued to receive floodplain sediments from the channel that cut through the Pioneer terrace, and possibly another channel in the middle to late Holocene, most likely an intermittent stream that originated south or southwest of the site from an upslope location along the Port Orford Heads. This interpretation is supported by several lines of evidence. First, there is the presence of laterally discontinuous alluvial sand (Hal1) in the western portion of Site Area 3. The composition and horizontal behavior of Hal1 indicates that deposition of sediments originated from the paleochannel formed by the late Pleistocene channel. Considering that this layer of sand overlies the pedogenically altered Qpi and that the energy required to transport alluvial sand of this size is not likely to have occurred after the formation of Garrison Lake, this alluvium must predate the early Holocene. The sediments overlying Hal1 are thus younger. With the presence of cultural material in direct contact with Hal1 (a piece of fire cracked rock at a depth of 85 cmbs in Test Unit 5-3) there is reason to believe that a period of surficial stability followed the deposition of Hal1 as the fluvial environment changed. While the timing of this change in depositional environment is unclear, the notion that a large segment of time passed is supported by the dating of cultural material in Test Unit T and the conclusion that alluvium (Hal2) overlying Hal1 has a middle to late Holocene age (Davis 2005; Byram 2005).

Second, when the depths at which the S1 paleosol and the thickness of lithostratigraphic units within Site Area 3 are compared (Transect A-A' in Figure 31), there is reason to believe that Hal1 and the alluvium covering Qpi in Auger 7 (Hal4) have a different source, as appears to be the case for Hal2 and Hal3 alluvium. The relative depths at which Qpi was encountered in eastern Site Area 3 augers suggest that the late Pleistocene alluvial erosion of the Pioneer terrace did not occur south of Auger 4. In order for middle to late Holocene alluvium (Hal3) to have reached the positions of Augers 2, 4, 7 and 8, whose sediments share a similar composition, the late Pleistocene paleochannel would have needed to be infilled. Furthermore, the relative positions of Hal4 and Hal3 alluvium in Auger 7 (Transect B-B' in Figure 32) indicate that Hal4 was deposited before Hal2 and Hal3. While there is not a date associated with these sediments, their position suggests they would have to have been deposited either in the late Pleistocene, such as Hal1, or afterward from a more southern source. The position of lithostratigraphic units in Site Area 3 as graphed in Transects A-A' and B-B' seem to impart a west to northwesterly direction of flow for middle Holocene alluvium that could not have been transported by the late Pleistocene channel, which is supported further by the absence of a well developed soil in these sediments.

The implications of this geomorphic change for early prehistoric people is unclear, except that the preservation of archaeological sites may have been affected by the geomorphic behavior of late Pleistocene channel, which could have disturbed archaeological materials. As reflected in the archaeological record, and associated radiocarbon and obsidian hydration dates, a significant portion of the alluvium overlying the S1 paleosol in the western section of Site Area 3 seems to have been deposited in the early Holocene. The low rate of deposition in the western portion of the site is further evidenced by the fact that these dates are obtained within a meter of sediment (Byram 2006; Davis 2005), and that there is a modest volume of sediment that separates the cultural material from the Wetland and Tseriadun Components in the area.

The difference in alluvium thickness between the western, middle, and eastern site areas indicates that while the degree of surficial stability within Site Area 3 has varied, the environmental conditions within the middle Holocene led to surficial instability in this site area. It is likely that the poorly drained nature of the Pioneer terrace and the higher relief of the terrain south of Site Area 3 created conditions that affected prehistoric people's use of the site area.

Evidence of how the area was used is found in the cultural material identified, which includes the lithic debitage and projectile points associated with both the

Wetland and Tseriadun Village assemblages. According to Byram (2005) the Tseriadun Village Component projectile points are smaller, and arrow-sized. While both cultural assemblages reflect a hunting focus, a lack of faunal remains cannot confirm this (Byram 2005). The thick shell midden (LU3) found within Test Unit T indicates a minor change in site use, which may be due to its proximity to Site Areas 1 and 4 which are being used as a habitation site during the same time period.

Site Area 6

The proximity of Site Area 6 to the Port Orford Heads ensures that the topography of the landform played a significant role in the formation history of this site area, as did the rise in sea level during the late Holocene. The stratigraphic record indicates that the erosion that formed the wetland depression to the north probably occurred prior to the formation of the S1 paleosol, and the likely source is the late Pleistocene channel that incised the Pioneer terrace north of Site Area 3. The geomorphology of this area was probably shaped during the Holocene by several fluvial processes, particularly in the late Holocene when rates of precipitation increased. While there is less evidence to characterize the alluvial activity here than in Site Area 3, the proximity of Site Area 6 to the Port Orford Heads and clastic material throughout the matrix of LU2 alluvium (Hal6) overlying the S1 paleosol suggest that fluvial systems capable of eroding the Pioneer terrace has been active in this location somewhat regularly.

The uniformity of sediments within Site Area 6, and the absence of aeolian deposits associated with Site Area 1, only 100 m to the north, is notable. Three possible explanations for these aspects include: 1) the relief of the site area was too great for dunes to develop upon; 2) the paleochannel between the two site areas formed an obstruction that was too great for the movement of aeolian sand to overcome; and 3) there was some other geographical obstruction west of the site that is no longer evident. Carter (1990: 2) notes that the deposition of dune sand is largely controlled by topography and that dunes form most easily in low angle shorelines. Compared to Site Area 3, the rate of deposition in Site Area 6 is greater (test units average 100 to 120 cmbs before reaching the S1 paleosol), yet similarly, sediments here are not well stratified and have a limited pedogenic development.

The surficial stability of this site area has surely changed as sea levels rose. In the late Pleistocene to middle Holocene, vegetation on the coastal plain probably protected the site from wind and wave activity that has actively changed the geomorphology of the site since the middle Holocene. If this location of the coast experienced the tsunami recorded by Kelsey (2005) in Bradley Lake, Little Round Lake and its adjacent site areas seem to be a likely location for observing such events. Despite this, the evidence for dramatic ocean events is unrecognized in the stratigraphic record.

The higher topographic relief, cumulative effects of surface runoff, and poorly drained marine sands and clays of Pioneer terrace probably made Site Area 6 an undesirable habitation site in comparison to Site Areas 1 and 4. This situation is reflected in the archaeological record of Site Area 6. Artifacts and ecofacts were found throughout the 120 cm of alluvium overlying the S1 paleosol, artifacts included charcoal, fire cracked rock, several lithic tools, and high concentrations of lithic debitage. The dating of this cultural material was restricted to relative methods, such as projectile point typologies and obsidian hydration. Byram (2006) notes that only one projectile point was discovered in this site area: a square-based lanceolate point, which is associated with the Wetland Component (Figure 40). The results of obsidian hydration analysis also suggest that a large portion of the cultural material within the site area may be linked to the middle to late Holocene-age Wetland Component. The Tseriadun Village Component was represented by only a small amount of shell discovered within the upper portions of a few test units.

Combining the archaeological and geologic record from all sites areas allows us to observe how prehistoric peoples have negotiated the opportunities and restrictions posed by both the landscape and the environment in their determining where to conduct certain activities within the Tseriadun site.

Summary of Interpretations

One way to view how geologic events at the Tseriadun site have served to shape the archaeological record is from the perspective of a pre- and post-return of modern sea level. The late Pleistocene to early Holocene is largely characterized by soil development on stable surfaces and alluvial activity that is adjusted to a lower position of sea level. Site landforms are relatively stable and the rate of deposition

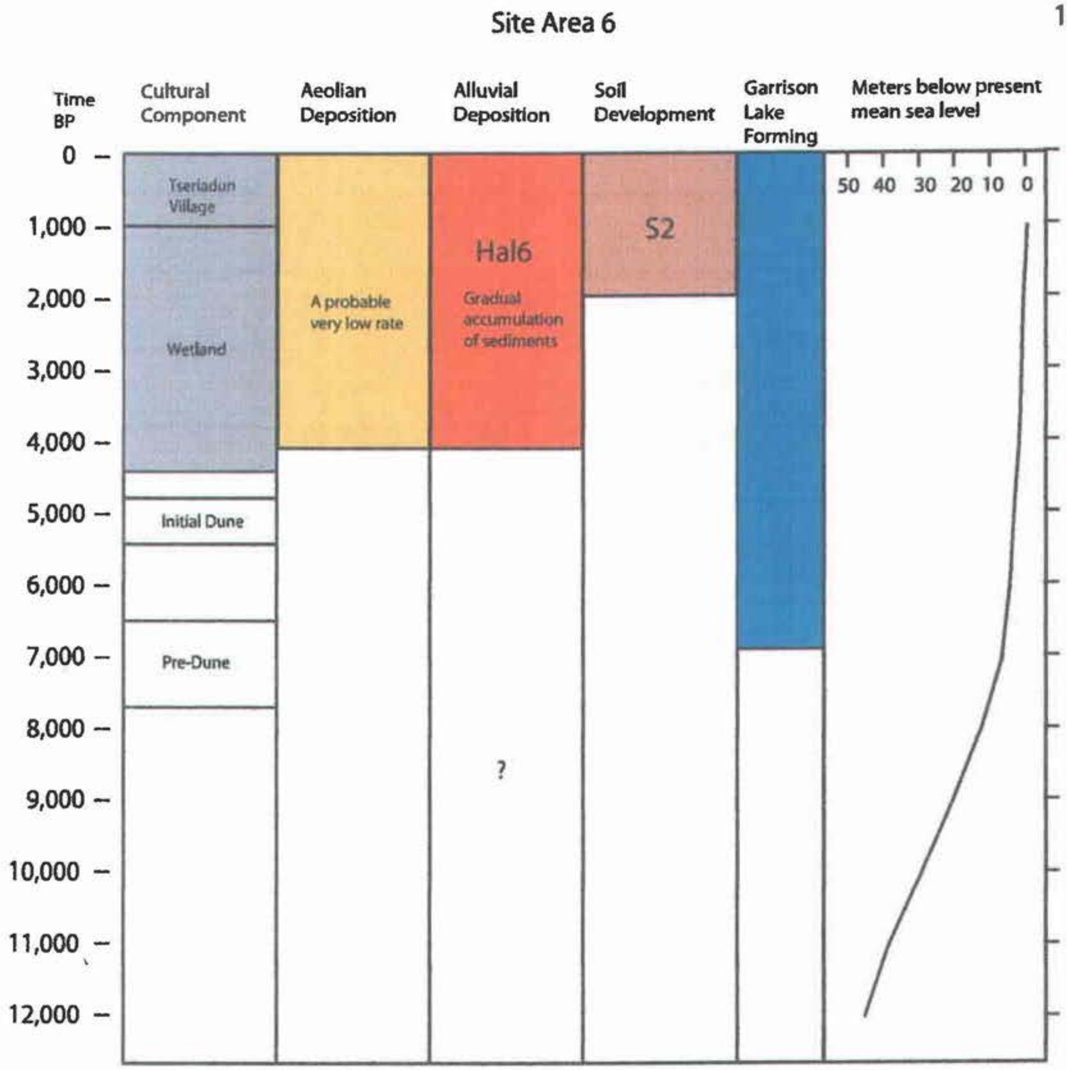


Figure 40. Synthesis chart for Site Area 6. Lithofacies and pedostratigraphic units determined from 2005 excavations are marked. See Figure 38 for additional explanation of the graph's format.

within the site is low, which means that the stratigraphic resolution of archaeological deposits is also low. As a result, it is more difficult to distinguish clearly between cultural assemblages from the early period.

The middle Holocene to late Holocene is also distinguished by alluvial activity, but in this time period fluvial systems were aggrading and prograding as the gradient within their channels changed in response to the rapid rise of sea level. As the beach zone approached the modern shoreline, some parts of the site received a significant amount of aeolian deposition, while others experienced very little dune sand. Overall, a major shift to very high rates of deposition occurred in the middle Holocene to late Holocene period, causing greater vertical separation between archaeological components and improving the degree of stratigraphic resolution.

Deposition rates were reduced in other parts of the site at this time. For example, in the western section of Site Area 3 low rates of deposition during the middle Holocene to late Holocene present a challenge for archaeologists who have difficulty separating the two cultural components observed there. Comparatively, in this location the upper 50 cm of sediment (e.g., LU4 of Test Unit T) represents ca. 4100 years whereas the upper 40 cm in Site Area 1 includes distinct lithostratigraphic and pedostratigraphic units that only span the last 450 years.

CHAPTER 6

CONCLUSION

One of the challenges inherent to building a model of landscape change at Tseriadun lies in the fact that much of the late Pleistocene and early Holocene environment has been eroded or obscured by the post-glacial marine transgression. A second challenge presented to this research stems from a lack of chronometric dates that would provide the age and sequencing of undated stratigraphic units within Site Areas 3, 5 and 6. Obtaining a date from sediments in the paleochannel intersected by Auger 8's location would greatly assist in more precisely determining the age of the channel's infilling during the middle to late Holocene. Lastly, being able to definitely correlate the aeolian sands overlying the S1 paleosol in Test Unit 5-10 to aeolian deposits observed along the western terrace would help clarify the landscape history of this site area. Regardless, a great deal of information has been revealed about the evolution of the landscape context at the Tseriadun site through this study.

New information was gathered about the stratigraphy of the Site Area 3 and the previously untested Site Area 6. In the process, we were able to determine more about the depositional history of those locations, which contributed details about the nature and timing of landscape evolution in the southern part of the Garrison Lake basin. The analysis of stratigraphic units in Site Area 3 identified several alluvial deposits and the position of a paleochannel. Due to the position of this channel relative to Garrison

Lake's southern bay and the early to middle Holocene date of its formation, its discovery allowed for assigning a relative period of time to the deposition of sediments within the paleochannel. Furthermore, the 2005 testing presented a chance to evaluate the existence of the middle Holocene-age paleochannel that Davis (2005) suggested may have crossed Site Area 3. New evidence regarding the early to middle Holocene development of Garrison Lake and the northeast position of the late Pleistocene paleochannel in relationship to Site Area 3 eastern test units strongly suggests that middle Holocene alluvial deposits had a southern to southeastern source.

In Site Area 6, analysis of stratigraphic units allowed this location to be linked to the rest of the site and the geomorphic processes that shaped the southern part of the Garrison Lake basin. The formation of Garrison Lake had less of an influence upon the geomorphology of this site area than its position along the coast behind the western terrace and directly down slope from the Port Orford Heads, allowing it to receive alluvium from a number of directions.

By expanding upon Davis' (2005) model of landscape change at Tseriadun and developing an understanding of the environmental history of these site areas, we may consider how this sequence of events may have influenced prehistoric people's use of the area. At a broad scale, the lower rates of tectonic uplift of marine terraces in the Garrison Lake basin created a topographic depression with a southwestern trending orientation (Kelsey 1990; Muhs et al. 1992). This probably caused late Pleistocene alluvial activity to be directed toward Port Orford, and the southwestern position of Tseriadun. At the time that prehistoric coastal people began to occupy the coastal plain exposed during the late Pleistocene, the most significant determinates of site use were the relative position of sea level, the availability of key resources, and smaller scale influences such as topographic relief, and the character of subsurface geology. This is notable along the western terrace where the deposition of aeolian sand over sediments with relatively low topographic relief significantly improved the drainage of underlying Qpi sediments, creating a more favorable environment for habitation. In comparison, the low rates of deposition, coupled with the presence of poorly-drained marine terrace deposits found in Site Area 2, 60 m to the east, produced a wetland context that was largely unsuitable for occupation.

Modeling landscape evolution at the Tseriadun site allows inferences to be made about how changes in sea level influenced geomorphic processes and features to influence site use. The general picture obtained from the geoarchaeological record is that site use was dependent upon a site area's degree of drainage and surficial stability and that activities within all site areas shifted when the environmental conditions changed, such as the location of an alluvial channel or the shoreward accumulation of dune sands. This observation is based largely on the stratigraphic and archaeological record of the western terrace where the record of human activity is the most extensive and covers the greatest length of time.

As observed in Site Areas 1 and 4, prehistoric peoples were processing marine resources by early to middle Holocene (Byram 2005). This activity appears to have continued in this location after the rise in sea levels caused aeolian sands to accumulate. The first indication that Site Area 1 was used as a habitation site appears during the middle Holocene corresponding break in aeolian deposition. Based on the archaeological evidence from Site Areas 2, 3 and 6, prehistoric peoples must have moved to Tseriadun from a location outside the site, which might also be a location they returned to once middle Holocene aeolian deposition resumed. In the late Holocene, coastal people appear to reoccupy the western terrace and use it for the full range of habitation and subsistence activities observed in the archaeological record.

The depth, frequency, and relative age of archaeological material found in Site Areas 2, 3, and 6 indicate that use of the entire site increased during this time period (ca. 5200 to 1100 BP), especially in the late Holocene. While the diagnostic lithic tools from Site Areas 2, 3 and 6 reflect land-based subsistence activities, faunal remains from these assemblages indicate that a marine focus remained high. This suggests that the acquisition of marine resources was also occurring outside the Tseriadun site during this period of time. Byram (2004) mentions two archaeological sites (35CU8 and 35CU20), that are approximately 80 m northeast of the Tseriadun site, along the eastern border of Garrison Lake's southern bay. These locations might actually be an extension of Tseriadun, and may ultimately have archaeological evidence that adds to this discussion.

In conclusion, geoarchaeological investigations at Tseriadun have helped clarify the stratigraphic and environmental context for a unique archaeological site along the southern Oregon coast. The location of this site in an environment where the preservation of early components in well-stratified archaeological sites were formerly assumed not to exist speaks to the potential to finding additional archaeological sites in locations with similar geologic and sedimentary contexts. This geoarchaeological investigation at the Tseriadun site also provides a case study example of the site-level environmental change associated with post-glacial marine transgression on the southern Oregon coast, and highlights the role that sea level change may have in interpreting archaeological sites with a coastal setting.

Recommendations for future research at Tseriadun are to gain greater chronometric control over Site Areas 3 and 6, and to verify the extent of aeolian deposition by testing the southern portion of Site Area 2. Extending subsurface investigations into the area northeast of Augers 5 and 6 in Site Area 3 (35CU220) may also provide insight into the alluvial history of the area, as well as how Tseriadun's prehistoric residents may have used the eastern border of Garrison Lake's southern bay.

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Appendices

		Dry sieve analysis (grams)						Hydrometer analysis				Loss On Ignition		
Section	Sample	Granule	V.C.Sand	C.Sand	M.Sand	F.Sand	V.F.Sand	Silt+Clay	Sand	Silt	Clay	OM%	Cca%	pH
Unit 5-3	3-10 cmbs	1.8	2	4.1	17.5	61.5	8	6	78	20	2	11	0	5.89
	10-16 cmbs	1.4	1.2	3.5	17.7	60.8	6.3	10.5	84	14	2	11	0	5.96
	16-25 cmbs	1.6	0.8	2.3	17.1	62.5	5.5	11.2	83	13	4	11	0	6.24
	25-35 cmbs	4.9	0.6	2.1	18.7	65	4.5	8	87	9	4	11	0	6.29
	35-45 cmbs	1.3	0.3	2.5	21.2	64.6	3.6	6.5	87	9	4	12	1	6.4
	45-55 cmbs	3	0.5	3.6	24.6	62.8	3.3	5.3	88	9	3	10	0	6.44
	55-65 cmbs	1.4	0.3	3	24.3	65.1	2.7	5.3	86	9	5	8	0	6.57
	65-75 cmbs	1.6	0.7	4.3	25.5	63.4	2.7	4.8	90	6	4	7	0	6.53
	75-65 cmbs	3	0.5	3.3	25.2	63	2.1	5	88	11	1	5	0	6.56
	85-105 cmbs	0.3 ^ **	0.5	2.5	28.1	65.1	1.9	4	90	8	2	6	0	6.74
	95-100 cmbs	1	1.2	4.6	23.7	62.2	2.3	7.2	87	12	1	6	0	6.78
Unit 5-4	20-30 cmbs	13.3	4.1	4.8	24.9	40.4	6.1	11.1	74	23	3	12	1	5.67
	30-40 cmbs	10.8 **	3.8	4.2	17.7	48.8	6.9	3.9	74	20	6	11	0	5.91
	40-50 cmbs	10 **	3.8	4.4	29.5	38.8	4.9	8.7	75.2	19.8	5	7	0	5.8
Unit 5-5	0-10 cmbs	6.9	4.2	10.4	13.5	44.2	9.2	10.5						
	10-20 cmbs	2.5 **	< 0.1**	2.6 **	13.6	52.3	10.2	16				13	1	5.71
	20-30 cmbs	2.1 **	1 **	1.9 **	11.9	55.4	8.4	17.4				10	1	5.51
	30-40 cmbs	1.9	1	1.9	12.7	53.8	9.1	19.4				10	0	5.58
	40-50 cmbs	4.8	0.8 ^	1.5	10.6	54.7	5	22.1				9	0	5.56
	50-60 cmbs	7.4	1 **	1.6	10.3	50.1	5.3	19.7				7	1	5.74
	60-70 cmbs	1.8	0.9	1.5	10.6	55	5.3	24.4						
Unit 5-7	70-80 cmbs	3.8	1.4	4.2	18.6	55.2	5.8	14.2	82	15	3	11	1	5.9
	80-90 cmbs	1.5	1.6	4.7	16.4	58	5.8	14.8	82	14	4	10	0	5.79
	90-100 cmbs	1.6	1.1	3.1	19.5	65.7	4.3	7.9	86	10	4	10	0	5.86

^ Debitage present ** Charcoal present

Appendix Table 1. 2005 Laboratory data. Grain size data are granule, very coarse sand, coarse sand, medium sand, fine sand, very fine sand, sand and clay. Loss On Ignition abbreviations are OM for the percentage of organic matter, and Cca for the percentage of calcium carbonate. The weight of a sample that is less than 0.1 percent of a sample is indicated as < 0.1.

		Dry sieve analysis (grams)						Hydrometer analysis			Loss On Ignition			
Section	Sample	Granule	V.C.Sand	C.Sand	M.Sand	F.Sand	V.F.Sand	Silt+Clay	Sand	Silt	Clay	OM%	Cca%	pH
Unit 5-10	10-20 cmbs	1.2 **	3.8	4.8	22	60.4	3.5	6.2	88	9	3	8	0	5.46
	20-30 cmbs	0.4	3.4	4.8	23.8	60.7	3.7	6.1	88	9	3	14	0	5.5
	30-40 cmbs	2	3.7	5	24.6	61	2.5	4.5	89	9	2	13	0	5.6
	40-50 cmbs	1.1	3.5	5	33	54.9	1.3	2.5	90	7	3	14	1	6.26
	50-60 cmbs	0.3	3.4	4.6	36.4	54.8	1.2	2.4	94	4	2	14	1	6.37
	60-70 cmbs	0	0.2	0.6	16	82.8	0.3	0.4	96	1	3			6.19
Unit 5-12	30-40 cmbs	1.8	2.8	5.9	20.8	46.5	8.7	14.8	70	22	8			
	75-90 cmbs	2.9	1.8	4.3	22.7	43.5	7.4	18.7	66	21	13			
Unit 5-13	90-120 cmbs	8.3	3.1	5.4	17.8	40.5	5.7	21.9						
Unit 5-14	25-35 cmbs	3.7	1.5	3.9	17	48	8.7	14.4	71	23	6			
	35-45 cmbs	0.6	2.5	6.7	22.9	44.1	9.9	13.8	70	24	6			
	45-55 cmbs	1.5 ^	2.6	7.7	22	39.8	7.9	18.9	70	24	6			
	55-65 cmbs	1.8	2.5	5.5	24	40.4	8.2	17.8	70	23	7			
	65-75 cmbs	3.2 ^	1.4	4.5	16.5	43.6	9.7	22.4	70	23	7			
	75-85 cmbs	5.3	1.9	4	15.2	42.9	7	22.4	67	25	8			
	100-115 cmbs	3	0.8	5.3	26.1	39.9	6.7	18.7	70	8	22			
Unit 5-16	10-20 cmbd	8.7	2.1	3.9	19	44.3	5.5	18.9	74	17	9	8	0	5.45
	20-30 cmbd	4.2	2.5	5.1	23.2	45.3	6.5	16.8	74	17	9	8	0	5.67
	30-40 cmbs	5.2 **	3.3 **	4.8	19.6	45.8	7	14.9						
	40-50 cmbd	0.7 ^	1.2	5.2	28.2	46.5	5.4	14.9	75	17	8	7	0	5.26
	50-60 cmbd	3.5	1.7	5.5	26	46.8	6.6	9.9	73	17	10	5	1	5.47
	60-70 cmbd	0.6	1.4	6.3	29.9	47.2	4.9	10.1	81	9	10	4	0	5.57
Center of Unit	60-70 cmbd	1.9	2.2	4.8	24.8	47.2	6.4	15.4	76	12	12	7	0	5.56

^ Debitage present ** Charcoal present

Appendix Table 1 (Continued). 2005 Laboratory data. Grain size data are granule, very coarse sand, coarse sand, medium sand, fine sand, very fine sand, sand and clay. Loss On Ignition abbreviations are OM for the percentage of organic matter, and Cca for the percentage of calcium carbonate.

		Dry sieve analysis (grams)						Hydrometer analysis			Loss On Ignition			
Section	Sample	Granule	V.C.Sand	C.Sand	M.Sand	F.Sand	V.F.Sand	Silt+Clay	Sand	Silt	Clay	OM%	Cca%	pH
Auger 2	20-30 cmbs	9.2	4.5	6.4	15.6	44.9	6.1	15						
	30-40 cmbs	5.3	2.1	4.2	14.8	51.6	8.6	17.4						
	40-50 cmbs	7	3.6	4.6	23.4	43.5	5.3	15.3						
	50-60 cmbs	4 **	2.1 **	4.1	17.5	51.1	7.5	18.5						
	60-70 cmbs	11.6 **	2.7 **	3.9	22.1	44.7	7.5	15.9						
	70-80 cmbs	4.4 **	2.5 **	4.1	25.4	45.7	8	14.3						
	80-90 cmbs	4.3	1.2 **	2.6	14.3	52.5	5.9	22.7						
	90-100 cmbs	2.1	1.3	3.1	16	53.3	8.6	19.5						
	100-110 cmbs	4.3	1.6	2.7	15.1	50	7.7	22						
	110-120 cmbs	2.3	1.5 **	2.7	15.5	49.9	9.3	20.9						
	120-130 cmbs	6.1	1.4 **	2.5	14.2	44.7	5.9	23						
	130-140 cmbs	7	2.1	3.3	13.8	48.8	7.2	23						
	140-150 cmbs	6	2.1	3.3	13.6	49.9	6.2	22.3						
	150-160 cmbs	5	1.8	2.7	13.1	50.5	7.2	22.2						
	160-170 cmbs	6.6	2	3.3	15.1	46.8	5.2	19.5						
	170-180 cmbs	4.8	1.7	4	15	51	8.1	18.3						
	180-190 cmbs	7.1 **	1.7 **	4.2	16.8	50.5	5.5	17.1						
	190-200 cmbs	5.6 **	2.2 **	3.9	17.6	49.7	5.2	17.8						
	200-210 cmbs	7.8	1.7	4.7	15.7	52.3	5	15.5						
	210-220 cmbs	0.7	1.1	4.5	18.1	70.8	1.8	4.8						
Auger 3	10-20 cmbs	3.5	1.7	4.1	25	50.7	7	6.9	80	16	4	9	0	5.8
	20-30 cmbs	1.9	1.1	3.4	28.6	53.7	6.2	6.1	84	12	4	7	0	5.87
	30-40 cmbs	1.2	0.8	3.1	28.8	52.9	5.2	6.5	87	9	4	7	0	6.16

^ Debitage present ** Charcoal present

Appendix Table 1 (Continued). 2005 Laboratory data. Grain size data are granule, very coarse sand, coarse sand, medium sand, fine sand, very fine sand, sand and clay. Loss On Ignition abbreviations are OM for the percentage of organic matter, and Cca for the percentage of calcium carbonate.

		Dry sieve analysis (grams)						Hydrometer analysis			Loss On Ignition			
Section	Sample	Granule	V.C.Sand	C.Sand	M.Sand	F.Sand	V.F.Sand	Silt+Clay	Sand	Silt	Clay	OM%	Cca%	pH
Auger 3	40-50 cmbs	1.8	0.5	2.5	30.3	55.8	3.9	4.9	90	7	3	7	0	6.15
	50-60 cmbs	0.5	0.2	1.6	29.2	60.4	2.4	4.8	90	7	3	6	1	6.15
	60-70 cmbs	2.6	0.4	1.8	28.5	60	2.4	3.9	92	5	3	15	1	6.08
	70-80 cmbs	0.8	0.3	1.9	27.4	61	2.4	4.1	92	6	2	5	1	6.03
	80-90 cmbs	1.2	0.1	1.5	26.4	64.5	2.1	3.7	92	5	3	4	0	6.13
	90-100 cmbs	0.3 **	0.1 **	1.0 **	22.9	69.6	1.4	2.6	93	4	3	5	0	6.14
	100-110 cmbs	0.4	0.1	0.8	23.8	69.7	1.2	2						
	110-120 cmbs	0.3	< 0.1	0.7	23.3	71.8	1.6	1.8						
	120-130 cmbs	0.2	< 0.1	0.2	14	80.2	1.8	1.8						
	130-140 cmbs	0.1	0.1	3.4	34.3	60.1	0.9	0.8						
	140-150 cmbs	< 0.1	< 0.1	6.6	39.7	51.1	0.6	0.4						
	150-160 cmbs	< 0.1	< 0.1	6.2	45.6	46.9	0.7	0.3						
	160-170 cmbs	0	< 0.1	5.8	39.3	52.1	0.9	0.4						
	170-180 cmbs	< 0.1	0.2	15	43	39.7	1.4	0.7						
	180-190 cmbs	< 0.1	0.3	13.5	39.1	44.9	0.6	0.4						
	190-200 cmbs	0.4	1.3 **	3.3	19.6	47.8	7	15.2						
Auger 4	10-20 cmbs	4.8 **	3.8 **	7.5	12.7	34.3	9.1	26.6	56	37	7	14	0	6.07
	20-30 cmbs	3.1 **	3 **	6.4	11.6	30.5	9	33.9	58	34	8	15	0	6.14
	30-40 cmbs	3.5 **	2.9	3.7	11.8	28.9	10.5	39.3	54	36	10	12	0	6.07
	40-50 cmbs	2.1	3.5 **	4.7	10.7	29.8	7.7	41.3	54	36	10	9	1	6.03
	50-60 cmbs	3.4 **	3.4 **	5.3	10.5	28.6	10	38.5	52	41	7			6.05
	60-70 cmbs	1.9 **	3.8 **	4.5	10.6	31.2	11.5	38.4	48	45	7	12	1	5.94
	70-80 cmbs	3.8 **	3.9	4.2	9.3	39.4	12	30.3	54	40	6	2	0	5.84

^ Debitage present ** Charcoal present

Appendix Table 1 (Continued). 2005 Laboratory data. Grain size data are granule, very coarse sand, coarse sand, medium sand, fine sand, very fine sand, sand and clay. Loss On Ignition abbreviations are OM for the percentage of organic matter, and Cca for the percentage of calcium carbonate. The weight of a sample that is less than 0.1 percent of a sample is indicated as < 0.1.

		Dry sieve analysis (grams)						Hydrometer analysis			Loss On Ignition			
Section	Sample	Granule	V.C.Sand	C.Sand	M.Sand	F.Sand	V.F.Sand	Silt+Clay	Sand	Silt	Clay	OM%	Cca%	pH
Auger 4	80-90 cmbs	6.2 **	5.7 **	5.6	11.9	39.4	9.5	24.4	60	35	5	11	0	5.96
	85-90 cmbs	6.3	3.5	4.4	14.4	46.5	6.1	22.6	68	35	5	9	1	5.65
	90-100 cmbs	1.9	2.2	5.2	12.3	55.1	5.9	18.3	72	23	5	6	1	5.56
	100-110 cmbs	4	2.5	3.7	13.7	54.9	7.1	17.2	75	18	7	4	1	5.45
	110-120 cmbs	3.5	3.7	6.4	15.7	46.5	9.9	16.7	68	24	8	4	1	5.41
	120-130 cmbs	3	2	5.4	17.7	53.4	7.6	12.9	78	16	6	4	0	5.29
Auger 8	10-20 cmbs	8.6	4.8	12.9	34.3	36.2	7.5	3.8				29	0	5.44
	20-30 cmbs	1.9 **	2.5	7.2	17.1	40.3	8.1	12.6				14	0	6.09
	30-40 cmbs	4.6	2	5.6	20.1	48.9	8.3	12.3	72	20	8	10	0	5.85
	40-50 cmbs	6.5	3.7	5.4	20	47.1	6.6	11.8	76	20	4	9	1	5.61
	50-60 cmbs	6.5	3.9	4.3	19.2	49.4	5.6	12.1	82	14	4	12	1	5.47
	60-70 cmbs	4.3	2.5	4.1	26.8	53.5	4.3	3.5				13	0	5.62
	70-80 cmbs	3.2	0.9	2.4	22.4	67.9	1.9	2.3				10	1	5.65
	80-90 cmbs	2.5	0.8 **	1.9	18.2	73.5	1.2	1.2				10	1	5.65
	90-100 cmbs	1.3	0.4	1.6	18.2	76.3	0.7	1.4						5.97
	100-110 cmbs	0.4	0.2	1.9	18.8	77.7	0.2	0.2						6
	110-120 cmbs	0.4	0	0.5	11.2	87.4	0.7	0.4						
	120-130-cmbs	0	1.4	10.9	40	47.8	0.2	0.2						
	130-140 cmbs	1.1	0.7	9.5	30.8	56.5	0.8	1.1						
	140-150 cmbs	0.6	0.6	17.4	22.5	59.4	0.8	0.9						
	150-160 cmbs	0	0.6	5.3	18.9	74.7	0.2	0.2						
	160-170 cmbs	0	0.1	1	15.4	84.2	0.3	0.1						
	170-180 cmbs	0.6	1.5	15.1	14.9	66.7	0.4	0.4						

^ Debitage present ** Charcoal present

Appendix Table 1 (Continued). 2005 Laboratory data. Grain size data are granule, very coarse sand, coarse sand, medium sand, fine sand, very fine sand, sand and clay. Loss On Ignition abbreviations are OM for the percentage of organic matter, and Cca for the percentage of calcium carbonate.

		Dry sieve analysis (grams)						Hydrometer analysis			Loss On Ignition			
Section	Sample	Granule	V.C.Sand	C.Sand	M.Sand	F.Sand	V.F.Sand	Silt+Clay	Sand	Silt	Clay	OM%	Cca%	pH
Auger 8	180-190 cmbs	< 0.1	0.1	1.7	11.8	86.4	0.5	0.2						
	190-200 cmbs	0	0.1	0.5	6.5	92	0.5	0.1						
	200-210 cmbs	0	0	0.3	8	92	0.4	< 0.1						
	210-220 cmbs	0.2	0.1	0.7	8.9	89.2	0.3	< 0.1						
	220-230 cmbs	< 0.1	< 0.1	0.4	6.6	91.9	0.5	0.1						
	230-240 cmbs	< 0.1	0.1	0.8	9.4	91.3	0.6	0.1						
	240-250 cmbs	< 0.1	< 0.1	1.2	40.1	56.7	0.2	< 0.1						
	250-260 cmbs	0	0	0.1	33.2	67.2	< 0.1	< 0.1						
	330-340 cmbs	< 0.1	< 0.1	5.3	60.4	32.6	0.1	0.1						
Modern sand	surface	0.3	8.7	51.6	49	1.5	0.05	0.05						
Dune sand	surface	0	0.09	0.2	8.7	91.4	1.7	0.6						

^ Debitage present ** Charcoal present

Appendix Table 1 (Continued). 2005 Laboratory data. Grain size data are granule, very coarse sand, coarse sand, medium sand, fine sand, very fine sand, sand and clay. Loss On Ignition abbreviations are OM for the percentage of organic matter, and Cca for the percentage of calcium carbonate. The weight of a sample that is less than 0.1 percent of a sample is indicated as < 0.1.

Section	Sample	Dry sieve analysis (grams)						Hydrometer analysis			Loss On Ignition		
		Granule	V.C.Sand	C.Sand	M.Sand	F.Sand	V.F.Sand	Silt+Clay	Sand	Silt	Clay	OM%	Cca%
Feature 1, CS3	20-30 cmbd	0.4	0.4	0.8	8.2	84.2	2.3	2.6	90	4	6	6	0
	30-40 cmbd	0.3	0.3	0.7	7.9	86.7	2.1	2	92	2	6	3	0
	40-50 cmbd	0.2	0.4	0.7	8.2	85.7	2	2.1	93	1	6	3	0
	50-60 cmbd	8.2****	1.9****	1.7****	8.4	73.7	2.5	2.8	92	2	6	5	0
	60-70 cmbd	2****	0.8****	1.1****	8.9	82.7	2	1.9	92	2	6	4	1
	70-80 cmbd	0.3****	0.3	0.5	7.8	86.9	1.9	1.4	92	0	8	4	0
	80-90 cmbd	1.9***	0.1	0.5	7.6	85.8	1.9	1.3	93	3	4	4	0
	90-100 cmbd	0.1*	0.2	0.6	8.1	87.5	1.7	1.1	93	3	4	4	0
	100-110 cmbd	0.1	0.1	0.4	7	89	1.6	0.9	89	5	6	3	0
	110-120 cmbd	0.2	0.1	0.2	6.4	90.2	1.5	0.4	93	1	6		
	120-130 cmbd	0	0.1	0.2	7	90.6	1.3	0.3	91	1	8		
	130-140 cmbd	0.1	0.1	0.2	6.4	91.6	1.4	0.3	92	0	8		
	140-150 cmbd	0.1	0.1	0.1	6.5	91	1.4	0.2	92	0	8		
	150-160 cmbd	0.5	0.1	0.1	6.7	90.9	1.3	0.2	92	0	8		
	160-170 cmbd	0.5	0.1	0.1	8.4	88.4	1.2	0.4	92	0	8		
TSR-1	S2 paleosol lower	7.6	4.2	6	15	38.9	8.1	20.4					
	S2 paleosol upper								57.5	16	26.5		
Unit J	20 cmbd	1	1	3	27	55	6	7	77	12	11		
	40 cmbd	2	2	3	26	52	7	8	82	11	7		
	60 cmbd	5	1	1	21	54	7	11	76	12	12		
	80 cmbd	6	1	2	18	53	7	14	73	17	10		
	100 cmbd	6	2	2	16	52	7	15	72	18	10		
	120 cmbd	6	2	2	15	51	7	18	70	19	11		
Unit T	15-25 cm	6.7*	3.2*	5.7*	19.7	40	7.3	12.4	83	5	12	18	2
	25-35 cm	15.9*	5.6*	4.7*	16.7*	34.1	6.4	12.9	81	1	18	14	11

* significant shell component
** significant cemented sand component
*** lithic artifacts(s) present
**** clay floor fragments present

Borrowed from Davis 2005.

Appendix Table 2. 2003 Laboratory data. Grain size data are granule, very coarse sand, coarse sand, medium sand, fine sand, very fine sand, sand and clay. Loss On Ignition abbreviations are OM for the percentage of organic matter, and Cca for the percentage of calcium carbonate. Table data borrowed from Davis (2005).

		Dry sieve analysis (grams)						Hydrometer analysis			Loss On Ignition		
Section	Sample	F.Pebble	Granule	C.Sand	M.Sand	F.Sand	V.F.Sand	Silt+Clay	Sand	Silt	Clay	OM%	Cca%
Unit T	35-45 cm	8.1*	4.1*	6.3*	24.2*	41.4	5.3	8	86	5	9	12	4
	45-55 cm	2*	1.2*	6	31.1	44.8	4.7	7.3	80	1	19	14	0
	55-65 cm	0.6	1	5.4	33.9	44	5.5	6.6	80	1	19	14	0
	65-75 cm	1.2	0.7	5.6	35.3	43.5	4.3	6.2	86	2	12	13	1
	75-85 cm	0.7	0.2	5.3	32.6	48.9	3.4	6.2	80	4	16	10	0
	85-95 cm	7**	0.7	4.6	32.3	46.9	2	4.5	86	7	7	7	1
	95-105 cm	5.9**	0.4	4.7	31.3	50.6	1.7	3.5	83	0	17	6	0
Unit AA	0-10 cmbd	5.8	2.7	10.3	24.6	43.7	5.5	6.3	75	7	18	13	0
	10-20 cmbd	2.2	2.5	10.4	24.7	47.2	5.7	6.7	76	7	17	11	0
	20-30 cmbd	5.8	2.7	10.3	24.6	43.7	5.5	6.3	96	4	0	8	0
	30-40 cmbd	2.7	1.9	4.3	21	52.2	6	10.5	96	4	0	11	0
	40-50 cmbd	9.6***	1.2	7	26.3	41.7	5.5	6.8	93	7	0	8	0
	50-60 cmbd	5.4**	1.9	5.6	23.9	45.4	6.2	10.4	92	8	0	6	0
	60-70 cmbd	4.7**	3	6.8	22.9	44.8	5.9	10.7	92	8	0	8	0
	70-80 cmbd	10.1**	1.9	4.2	20.8	45	5.8	11.1	92	8	0	8	0

* significant shell component

** significant cemented sand component

*** lithic artifacts(s) present

**** clay floor fragments present

Appendix Table 2 (Continued). 2003 Laboratory data. Grain size data are granule, very coarse sand, coarse sand, medium sand, fine sand, very fine sand, sand and clay. Loss On Ignition abbreviations are OM for the percentage of organic matter, and Cca for the percentage of calcium carbonate. Table borrowed from Davis (2005).