Data Potential of Archaeological Deposits at the Chelan Station Site

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DATA POTENTIAL OF ARCHAEOLOGICAL DEPOSITS AT THE CHELAN STATION SITE

(45CH782/783)

A Thesis

Presented to

The Graduate Faculty

Central Washington University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Resource Management

by

Matthew John Breidenthal

May 2017
CENTRAL WASHINGTON UNIVERSITY

Graduate Studies

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DATA POTENTIAL OF ARCHAEOLOGICAL DEPOSITS AT THE CHELAN STATION SITE (45CH782/783)

by

Matthew John Breidenthal

May 2017

The Chelan Station Site (45CH782/783), located along the Rocky Reach of the Columbia River, includes lithic and faunal artifacts buried beneath volcanic tephra from Mt. Mazama (6,830 BP). Artifacts were inadvertently discovered in buried soils within a secondary alluvial terrace during construction of a pipeline to supply water to the Beebe Springs Fish Hatchery. This thesis stems from participation in original field work and includes the author’s own models of early land forms and site formation. The study reviews the construction monitoring and archaeological testing of both sites, and documents the archaeological data potential early occupations of the vicinity. The stratigraphy of artifacts, tephra, alluvial sediment, and buried soils is summarized for a 1,212 m-long transect. People bearing tools related to the Old Cordilleran Tradition (cobble tools and leaf shaped points) colonized the region and fished for salmon and hunted large game in the vicinity between 9,190 ± 50 BP and 8,480 ± 40 BP. Stratigraphic models are created and schematic diagrams are used to summarize early site formation across five landforms on the terrace. Two buried soils include evidence of burning that probably represent human activity. Magnetic susceptibility measurements confirm the presence of buried organic layers and the influence of fire. All strata are
best preserved in a deeper back-channel of the Columbia River. Artifacts are best represented at the bottom of profiles with less distinct strata on higher ground of the terrace scarp. Deeper strata in the back-channel, at first interpreted to represent tephra from Glacier Peak or Mt St. Helen’s, do not contain tephra. Results from Washington State University Geoanalytic Laboratory reveal feldspar and quartzite associated with alluvial layers from Columbia River floods bearing a unique sediment load. The site stratigraphy and models of site formation are compared with three other site investigations where the author has firsthand experience. Recommendations include: 1) nominating sites 45CH782 and 45CH783 to the National Register of Historic Places under significance criterion D, preparing a site specific historic properties treatment plan, and developing a state-wide database to aid management of buried soils as cultural features.
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For my son Fin.

Now we can go fishing.

“We must come to understand our past, our history, in terms of the soil and water and forests and grasses that have made it what it is. We must see the years to come in the frame that makes space and time one. Our philosophies must be rewritten to remove them from the domain of words and “ideas”, and to plant their roots firmly in the earth.”

# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>INTRODUCTION</td>
</tr>
<tr>
<td></td>
<td>Project Background</td>
</tr>
<tr>
<td></td>
<td>Objectives</td>
</tr>
<tr>
<td></td>
<td>Study Outline</td>
</tr>
<tr>
<td>II</td>
<td>STUDY AREA</td>
</tr>
<tr>
<td></td>
<td>Soils</td>
</tr>
<tr>
<td></td>
<td>Climate</td>
</tr>
<tr>
<td></td>
<td>Geology</td>
</tr>
<tr>
<td></td>
<td>Historic Land Use</td>
</tr>
<tr>
<td></td>
<td>Chelan Station Project</td>
</tr>
<tr>
<td></td>
<td>Chelan Station Archaeological Deposit</td>
</tr>
<tr>
<td></td>
<td>Paleoenvironment</td>
</tr>
<tr>
<td></td>
<td>Plant Communities</td>
</tr>
<tr>
<td></td>
<td>Fish and Wildlife</td>
</tr>
<tr>
<td>III</td>
<td>REGIONAL GEOLOGY AND GEOMORPHOLOGY</td>
</tr>
<tr>
<td></td>
<td>Geochronology and Tephrochronology</td>
</tr>
<tr>
<td></td>
<td>Glaciation</td>
</tr>
<tr>
<td></td>
<td>Outburst Floods</td>
</tr>
<tr>
<td></td>
<td>Late Pleistocene Cascade Range Alpine Glacial Advances</td>
</tr>
<tr>
<td></td>
<td>Alluvial Chronology</td>
</tr>
<tr>
<td></td>
<td>PHT Alluvial Terraces</td>
</tr>
<tr>
<td></td>
<td>Middle to Late Holocene Alluvial Terraces</td>
</tr>
<tr>
<td></td>
<td>Seismic Events</td>
</tr>
<tr>
<td></td>
<td>Soils and Regional Pedogenic Environments</td>
</tr>
<tr>
<td>IV</td>
<td>REGIONAL ETHNOGRAPHY AND ARCHAEOLOGY</td>
</tr>
<tr>
<td></td>
<td>Ethnography</td>
</tr>
<tr>
<td></td>
<td>Previous Archaeology</td>
</tr>
<tr>
<td></td>
<td>PHT Archaeology in the West</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS (CONTINUED)

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHT Archaeological Deposits in the Columbia Basin</td>
<td>55</td>
</tr>
<tr>
<td><strong>V METHODS AND RESULTS</strong></td>
<td>60</td>
</tr>
<tr>
<td>Geoarchaeology</td>
<td>60</td>
</tr>
<tr>
<td>Lithostratigraphic Units</td>
<td>62</td>
</tr>
<tr>
<td>Depositional Environment and Soils</td>
<td>65</td>
</tr>
<tr>
<td>Rocky Reach and Wenatchee Reach Soils</td>
<td>74</td>
</tr>
<tr>
<td>Artifact Assemblages</td>
<td>77</td>
</tr>
<tr>
<td><strong>VI CONCLUSIONS AND RECOMMENDATIONS</strong></td>
<td>80</td>
</tr>
<tr>
<td>Archaeological Deposit and Data Potential</td>
<td>80</td>
</tr>
<tr>
<td>Alpine Influences</td>
<td>81</td>
</tr>
<tr>
<td>Archaeology, CRM, and NRHP Nominations</td>
<td>85</td>
</tr>
<tr>
<td>Future Research</td>
<td>88</td>
</tr>
<tr>
<td>Buried Paleosol Data Potential and Management</td>
<td>90</td>
</tr>
<tr>
<td><strong>REFERENCES</strong></td>
<td>92-125</td>
</tr>
<tr>
<td><strong>APPENDIXES</strong></td>
<td>126-129</td>
</tr>
<tr>
<td>Appendix A—Chelan PUD SEPA Checklist Excerpt</td>
<td>126</td>
</tr>
<tr>
<td>Appendix B—Determination of Nonsignificance for Pipeline</td>
<td>128</td>
</tr>
<tr>
<td>Appendix C—WSU Geoanalytic Lab Tephra Report</td>
<td>129</td>
</tr>
</tbody>
</table>
### LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sub-Mazama Pedostratigraphic Units Across the Study Area</td>
</tr>
<tr>
<td>2</td>
<td>Sub-Mazama Pedostratigraphic Units in the Rocky Reach</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Topographic map of the study area and adjacent archaeological sites</td>
</tr>
<tr>
<td>2</td>
<td>Overview of the study area in the Middle Columbia River Valley</td>
</tr>
<tr>
<td>3</td>
<td>Excerpt from the 1887 AD General Land Office map</td>
</tr>
<tr>
<td>4</td>
<td>Chelan Station pipeline project area and test units</td>
</tr>
<tr>
<td>5</td>
<td>LiDAR image of the study area with alluvial terrace landforms</td>
</tr>
<tr>
<td>6</td>
<td>East Bore Pit (EBP) stratigraphic profile</td>
</tr>
<tr>
<td>7</td>
<td>Sub-Mazama geochronology across the Columbia Basin</td>
</tr>
<tr>
<td>8</td>
<td>Schematic landform cross-section of the Rocky Reach</td>
</tr>
<tr>
<td>9</td>
<td>Middle Columbia River terrace classifications</td>
</tr>
<tr>
<td>10</td>
<td>Well-preserved cicada burrows at 45CH782</td>
</tr>
<tr>
<td>11</td>
<td>Wilkes’ 1841 AD map of North Central Washington</td>
</tr>
<tr>
<td>12</td>
<td>East Bore Pit (EBP) composite stratigraphic profile</td>
</tr>
<tr>
<td>13</td>
<td>West Bore Pit (WBP) 2 x 2 m Test Unit profile</td>
</tr>
<tr>
<td>14</td>
<td>Generalized composite transect of soil profiles across the study area</td>
</tr>
<tr>
<td>15</td>
<td>Schematic floodplain model based on lithostratigraphic units</td>
</tr>
<tr>
<td>16</td>
<td>Magnetic susceptibility results</td>
</tr>
<tr>
<td>17</td>
<td>Pangborn Bar buried paleosols and tephras</td>
</tr>
<tr>
<td>18</td>
<td>Landscape reconstruction of Chelan Station in the early Holocene</td>
</tr>
</tbody>
</table>
CHAPTER I

INTRODUCTION

In 2010, working for Cultural Resource Consultants, Inc. on behalf of Chelan County Public Utility District (PUD), I monitored the excavation of an approximately 1200 m-long pipeline. The project pipeline was partially federally-funded and intended to supply water to the Washington Department of Fish and Wildlife (WDFW) Fish Hatchery at Beebe Springs. Soon after the project began, pipeline excavation exposed cultural material.

Subsequent archaeological testing delineated two sites within the pipeline corridor. At both sites, sparsely distributed lithic and faunal remains were recovered from soil buried under Mazama tephra, suggesting the artifacts were at least 6730 ± 40 radiocarbon years old (Bacon 1983). No artifacts were found in the sandy deposits above Mazama tephra. The buried soil has been defined as the Badger Mountain Geosol, an ancient soil buried below Mazama tephra (Huckleberry et al. 2003; Lenz et al. 2007). Strata of the Badger Mountain soil in archaeological sites often includes cultural material (Lenz 2010).

Lithic artifacts include flaked cobble tools, a bifacial lanceolate projectile point or knife, utilized flakes, multi-directional cores, and late-stage reduction or retouchdebitage. The high percentage of interior flakes interpreted as tool retouch suggests that early-stage lithic reduction was not a common activity. The functions of flaked cobble artifacts are interpreted as possible wood working, food processing, or excavation tools. The flaked cobble found in an archaeological test unit at 45CH782
below the fluvial sands (Unit 4) represents an additional sub-Mazama cultural stratum (Schumacher 2010). Lithic debitage resembling Paleoindian-phase “overshot” biface thinning flakes (Frison 1991) associated with large mammal bone was observed in archaeological test units at 45CH783 overlying river cobbles (Figure 1).

Figure 1. Topographic map of the study area depicting neighboring archaeological sites in the Chelan Falls and Beebe Springs area. Adapted from McKenney and Gough (2012, 2014).
Unfortunately, pipeline construction continued even though most of the project area had not been tested for additional cultural material. Because compliance-driven monitoring discoveries provide only limited information, I decided to develop this thesis project. I argue that further research is warranted at the study sites and on similar landforms along the Middle Columbia River.

On the Columbia River floodplain, several factors restrict the visibility of the early Holocene environmental and archaeological record including depth and impenetrable surfaces. Therefore, archaeological testing methods often fail to locate artifact deposits associated with deeply buried soils. As a result, ground-disturbing developments, as in the case of Chelan Station, proceed without adequate archaeological testing (Rousseau 1993) or evaluation for the National Register of Historic Places (NRHP).

Objectives

Many cultural resource projects landforms and lower terraces. Geoarchaeological investigations at nearby projects, including Wells (Chatters and Hoover 1992), Rocky Reach (Schalk and Mierendorf 1983), and Rock Island (Galm and Matsen 1985) reservoirs, indicate that secondary terrace developed between 7,900 and 11,000 BP. Secondary terraces located farther from the historic river channel, such as are found at Chelan Station, are not well studied (Schalk and Mierendorf 1983).

My main objective is to document the stratigraphy of artifacts, tephra, alluvial sediment, and buried soils is summarized for a 1,212 m/4,000 ft.-long transect covering
the first terrace of the Columbia River at Chelan Station. Utilizing geoarchaeological frameworks based on lithostratigraphic and pedostratigraphic units (Davis and Schweger 2004; Huckleberry et al. 2003; Waters 1992), I create a composite stratigraphic model using field observations of sediment texture, structure, color, vertical position, and attributes of soil formation along a 1,212 m/4,000 ft.-long transect across a Columbia River alluvial terrace (Fecht and Marceau 2006). Composite photographs help profile the pipeline trench. I present Litho- and pedo- stratigraphic models in tables and use schematic diagrams to summarize early site formation across five landforms on the terrace.

One of my special interests has been to solve questions about the possible presence of very early Glacier Peak and/or Mt St Helens tephra. Samples of two possible tephra (n=2) layers collected by Gentry in 2010 were submitted, with his permission, to Washington State University (WSU) Geoanalytic Laboratory for identification. The samples do not contain tephra and this outcome raises more questions about the nature, origin and date of the strata in question.

Below the feldspar-quartz alluvium two buried soils are documented and confirmed with magnetic susceptibility measurement. The two buried soils include evidence of burning that may represent human activity.

For comparative purposes, I examine several buried paleosol exposures from CRM-driven excavations near the study area including Rocky Reach Dam/Douglas Switchyard, Badger Mountain (Rainey Spring and Veedol Substation), and Wenatchee Confluence. I draw in relevant information from outlying locations such as Centralia
(Mellen Site) and Granite Falls (45SN303 and 45SN417). Even a nominal understanding of these types of sites and landforms, along with climate change, fluvial events, and volcanic activity, is significant to contemporary researchers and policy makers.

My general recommendation is that we use lessons, such as from Chelan Station project to better protect archaeological sites and improve our success using strategies developed using risk management (Stapp and Longenecker 2009). Unanticipated archaeological discoveries, have contributed to increased construction and administrative costs. Developing appropriate project schedules and employing adequate testing methods are especially critical where ground-disturbing projects affect landforms that are expected to yield deeply buried archaeological sites. Understanding the spatial distribution of these landforms, buried soils, and temporally-diagnostic sediments enables cultural resource managers to focus subsurface testing efforts in appropriate areas. These precautions may reduce the frequency of unanticipated discoveries, as well as the associated costs and data loss.

My management recommendation is to nominate sites 45CH782 and 45CH783 to the National Register of Historic Places (NRHP). It is also advisable to develop an historic properties treatment plan for the site area, in combination with the Beebe Spring Traditional Cultural Property (TCP) (Marchand 2007). Chelan Station archaeological sites (45CH782 and 45CH783) are scientifically significant (NRHP criterion D) because the sites provide a well preserved geological (floodplain) context for studying the earliest known human occupation along the Rocky Reach of the Columbia River. Several sections of background information needed for a NRHP nomination form
are included in this thesis: geologic, ethnographic, historical, and archaeological records. Thesis results also provide other evidence which supports NRHP documentation: early artifacts and salmonid remains, 2) temporally-diagnostic sediments; 3) the depositional history of landforms; 4) the evidence of environmental change and cultural influence in buried soils; and 5) cultural resource management methods and directions for future research.

I also recommend that human-influenced buried soils should be managed as cultural features by utilizing the existing DAHP WISAARD database. Identified buried paleosols could be added to WISAARD as point, line, or polygon data. These data will be useful for archaeological research targeting deeply buried sedimentary contexts, as well as promoting the conservation of potentially undervalued paleoenvironmental data.

Study Outline

Following a description of the study area and project (Chapter II), I outline background for regional geology and geomorphology (Chapter III) and summarize ethnography and previous archaeology (Chapter IV). This summary focuses on Pleistocene-Holocene Transitions (PHT) and two early archaeological traditions, the Western Stemmed Tradition (WST) and the Old Cordilleran Tradition (OCT). I present methods and results in one chapter (Chapter V) where I share litho-stratigraphic and pedo-stratigraphic models of site formation along five landforms across the pipe-line transects. I compare these models with observations from three other early sites. My conclusions and recommendations (Chapter VI) return to the lessons learned from the
Chelan Station project, my proposal to develop a nomination and historic properties management plan, and suggestions for future research.
CHAPTER II

STUDY AREA and PROJECT

The project area is located in North Central Washington along the Rocky Reach of the Columbia River, between Lake Chelan and the Beebe Bridge at approximately 740-760 feet elevation. Chelan Station (45CH782/783) occupies a glaciated valley and is situated between the Great Terrace and the Columbia River right bank (Figure 2).

Figure 2. Overview north-northeast of the study area in and the Middle Columbia River Valley. Sites include: a) Chelan Station, b) Entiat (Steinkraus and Breidenthal 2013), c) Orondo (Gough 1995), d) Tenas George Bar (Waitt 1977), e) Douglas Switchyard, f) Rainey Spring, g) Wenatchee Confluence (Watrous) and Avey’s Orchard (Galm and Matsen 1985), and i) Veedol Substation.

Soils

Alluvial terrace sediments in the study area generally consist of Quaternary gravel, silt, and sandy alluvium mantled by eolian sands (Gulick and Korosec 1990).
Recognized soil types include Chelan gravelly sandy loam and Pogue gravelly fine sandy loam soils (Beieler 1975). Chelan sandy loam developed in cumulative tephra and loess deposits overlying glacial outwash terraces with tread slopes of less than 3%. Pogue sandy loam is distinguished by quartz-rich parent material, and limited depth of approximately 30” to underlying outwash sands and gravel (Beieler 1975).

Climate

The study area climate is characterized as an erratic moisture regime and a mesic temperature regime. Descriptions vary from MAP 8.8-10 inches, and MAT varies considerably from 48-63°F, affording approximately 145-190 days frost free days (Beieler 1975). Most precipitation occurs from November to January, the least occurs from July to September. The warmest temperatures occur from June to August, the coolest from December to January (NRCS 1981). Prevailing winds out of the south-southwest and are typically strongest during the spring snow melt phase.

Geology

Chelan Station is situated on the western margin of the Columbia Basin (Meinig 1968). Roughly 14 million years ago the weight of Miocene basalt flows depressed the ground surface (Hopson and Mattinson 1971; Reidel 1984), and influenced the landscape in terms of geomorphology, soil formation, and hydrology (Bentley and Lenz 1996). Subsequent compressional tectonic forces created the Yakima Fold Belt topography which limited channel migration of the Lower Columbia, Snake, and Yakima
Rivers (Baker et al. 1987). The fault-bounded Chelan Mountain terrane surrounding the study area includes complex metamorphic formations of migmatite, gneiss, and Late Cretaceous igneous intrusions of tonalite (Hopson 1955; Hopson and Mattinson 1971; Waters 1933).

One of the defining natural features of the vicinity is Beebe Springs. Springs, defined as a surface discharge of ground water, are governed by local hydrology, climate, and geologic structures (Alfaro and Wallace 1994). Springs adjacent to the floodplain would provide stable riparian habitat that can be lacking within the Columbia River sections of canyons (Alfaro and Wallace 1994). Flora and fauna near large springs should persist. During the arid middle Holocene, many marginal springs went dry in the Columbia Basin (Chatters 1998). In arid environments, spring deposits often function as eolian and alluvial sediment traps (Waters 1992). Stable soil moisture regimes support productive vegetation and associated fauna. Spring depositional environments typically favor preservation of bone, diatoms, plant phytoliths, and pollen assemblages (Haynes 1985).

Historic land use records derived from General Land Office (GLO) 1887 AD survey data and Douglas County court documents (Hackenmiller 1995; Marchand 2007) support the interpretation of a productive pedogenic environment at Chelan Station and Beebe Springs. In addition to orchards, Chelan Bob and Cultus Jim’s allotments annually produced at least 40 tons of hay on less than 75 acres (Hackenmiller 1995; Marchand 2007). Assuming the roughly 1/8th-mile square straddling the western boundary of Cultus Jim’s allotment (Lot 4) on the GLO map depicts a ten-acre hay field (Figure 3),
then yields as high as four tons per acre may have been achieved. In comparison, modern mechanized hay production in the region varies from two to seven tons per acre (OSU electronic document).

Figure 3. Modified excerpt adapted from Marchand (2007) of the 1887 AD GLO map depicting the Camp Chelan military road and cable ferry, Beebe Springs/Creeks, and Chelan Indian homesteads.

The western portion of the field may have been intentionally located slightly outside of Cultus Jim’s allotment boundary to take advantage of the nutrient-rich, buried mollisols encountered in the distal portion of the floodplain. Chelan Bob and Cultus Jim’s combined estimated annual hay yields of four tons per acre using horse-drawn implements and non-intensive farming practices suggests that soils in the study area were uniquely productive.

Chelan Station Project

As a case study in contract CRM practices, the circumstances of the inadvertent discovery of the Chelan Station site illustrates systemic problems in policy, consultation,
survey methodologies, and sampling techniques associated with ground disturbing activities in deeply buried contexts. The varied nature of cultural resource types makes the establishment of an overall, congruent management policy difficult to achieve (King 1998). Debate about policy reform solutions has been hampered by differences between CRM specialists, resource types, varied regional contexts, and dogma (King 1980). After 50 years of development, the established NEPA and NHPA regulatory framework has arguably not succeeded in effectively and efficiently managing cultural resources, particularly non-salient archaeological resources. Incongruity between consulting parties within the NHPA framework, combined with the perverse incentives of CRM contractors to cater to their clients’ interest has led to persistent management inefficiencies, reactionary policies, and even violent intergovernmental confrontations (King 1980).

Miscommunication between project engineers, agency regulators, construction contractors, and CRM consultants often leads to adverse impacts, archaeological data loss, and unanticipated costs (Stapp and Longenecker 2009). For example, the actual extent of ground disturbing effects (APE) in the study area were significantly underrepresented on the SEPA application (Chelan County PUD 2009) by the project proponents as a trench measuring eight feet wide and six feet deep, resulting in an estimated displacement of 7,111 cubic yards (5,437 cubic meters). These proposed trench dimensions are roughly half of the observed volume. Actual ground disturbance is estimated at 14,000 cubic yards (10,704 cubic meters) of sediment (Figure 4).
Figure 4. Chelan Station Project Area: Pipeline route and single shovel probe (left), and 45CH782 sampling units (right) adapted from Schumacher (2009, 2010). The dashed red polygons depict locations where reconnaissance-level shovel probing would have likely recovered cultural material within 1.2 m below surface.

No cultural resource assessment was included until Washington State Department of Transportation personnel reviewed the proponents’ application to cross the highway right-of-way and inquired about the absence of a cultural resource assessment (Chelan County PUD 2009). It is unlikely that the project proponents were unaware of recorded cultural resources in the vicinity because a considerable amount of archaeological fieldwork had recently taken place on or near the Beebe Springs Site complex (45CH216) (Groethe et al. 2007; Hodges and Ray 2005; Wilson and Komen 2008). Additionally, the Beebe Springs TCP nomination (Marchand 2007) clearly delineated property boundaries and known cemeteries within the project area, and should have triggered a cultural resource assessment earlier in the project planning process. Because the project objective was to improve fish hatchery productivity, and
satisfy federal compliance requirements, the benefits of fish production may have disproportionately outweighed cultural resource concerns.

At the Chelan Station site, deep geotechnical pits were mechanically excavated before the CRM consultation process was initiated. According to the on-site inspector, these geotechnical pits revealed the presence of extensive buried paleosols beneath paved portions of the study area (Gordon Boon, personal communication 2010). Pre-construction geotechnical excavations should include qualified archaeologists to facilitate the identification of buried soils and cultural deposits early in the project planning process, and allow for avoidance or mitigation of adverse impacts beforehand.

Methodological problems associated with identifying deeply buried and low-density archaeological sites (Lenz 2010; Rousseau 1993) are compounded by a tendency for over-reliance on construction monitoring instead of adequate reconnaissance methods. CRM contractors have deliberately avoided employing adequate subsurface survey techniques in archaeologically-sensitive landscapes. Even when appropriate sampling techniques developed for accretionary sedimentary contexts are employed, the data potential of buried paleosols may not be recognized or correctly interpreted (Robert Mierendorf, personal communication 2017).

The unintended discovery of archaeological sites 45CH782 and 45CH783 was mostly the result of chance. If one flaked cobble artifact had not been exposed by an errant bulldozer, it is unlikely that the monitoring archaeologist would have identified smaller artifacts (i.e., retouch flakes and fish vertebrae) with trench excavation proceeding at an estimated rate of 10-14 cubic yards per minute. Site 45CH783 was only
identified because of unusually heavy rains that exposed a large, lanceolate point on the surface of a spoil pile.

Post recovery studies add significant information about the site deposits and raise more questions about site formation and occupation. Schumacher (2011) reports results for soil flotation analysis (5 kg of soil from the WBP paleosol stratum), Mazama tephra identification, obsidian analysis using energy-dispersive X-ray fluorescence characterization, faunal analysis, and radiometric assay of bulk paleosols sampled from the EBP.

Chelan Station Archaeological Deposit

The northern boundary of the archaeological deposit is the WDFW Hatchery complex. Hatchery construction, in addition to the historic development of Beebe Springs for irrigation purposes, extensively disturbed the deposits north of the study area. The Chelan River fan forms the southern boundary of the secondary alluvial terrace landform. At Beebe Springs artifacts are buried within the toe of a gently sloping alluvial fan composed of fluvial and eolian sediments. At Chelan Station, cultural material occurs in generally well-stratified alluvium on a secondary terrace (Figure 5), which is characterized as a sequence of early Holocene alluvial and middle Holocene eolian deposits (Chatters and Hoover 1992).
Figure 5. LiDAR image of the study area with interpreted alluvial terrace landforms (T1-3). Red line approximates the study area and pipeline trench transect between 45CH782 (A) and 45CH783 (B).
The combination of resistant bedrock (Hopson 1955) and Chelan River fan accretion may have contributed to a bottleneck-effect on the Columbia River channel, possibly slowing down stream flow and improving alluvial deposition upstream (Schalk et al. 2005). A possible abandoned channel, or scour trench (Baker and Nummedal 1978), exposed at the ‘East Bore Pit’ location (45CH782) retains the most well-preserved alluvial stratigraphy in the study area. Deposits preserved under Chelan Station are best represented in the East Bore Pit (Figure 6).

Radiometric assay of bulk carbon collected from paleosols I-IV sampled from the EBP returned Accelerator Mass Spectrometry AMS dates vary from 7,750 ± 40 BP in the uppermost paleosol (Ab), 8,480 ± 40 BP in the paleosol (2Ab) associated with the flaked cobble, to 9,190 ± 50 BP in the third lowest paleosol (3Ab), and 9,160 ± 50 BP in the lowest identified paleosol (4Ab) (Schumacher 2011).

All the recorded post-Mazama archaeological sites occur to the east of Beebe Springs, close to the historic river channel (Hodges and Ray 2005; Mierendorf 1983; Wilson and Komen 2008). Initial testing suggested that after Mazama tephra deposition at 6,730 BP (Bacon 1983) the Beebe Springs fan changed from a stable environment conducive to soil formation, to a relatively sterile, arid environment subject to occasional gravelly debris flows. This depositional change may reflect variation in spring input factors such as local tectonic movement, and reduced water levels in the Lake Chelan basin. This apparent land use pattern change may be attributable to increasingly arid, early Holocene conditions characterized regionally by less predictable precipitation patterns (Graf 2007) and bark beetle epidemics (Brunelle et al. 2008).
Figure 6. East Bore Pit stratigraphic profile with soil horizon designations, bulk soil AMS radiocarbon dates, sediment sample locations, and lithostratigraphic units. Red text indicates artifact presence within a stratigraphic unit. Photograph provided by Gentry (2010).

Paleoenvironment

Prevailing easterly winds of the Last Glacial Maximum, combined with cold and arid conditions, produced ecosystems with no modern analog (Blinnikov et al. 2002). Sparse pollen records from the LGM provide limited information on local vegetation
changes. The regional late Pleistocene climate was characterized by more continental, easterly air flow (Chatters et al. 2012).

As terminal Pleistocene glaciers retreated, Western North America generally experienced a reduction of ecological diversity as species adapted to less predictable climatic conditions, increased seasonality and human environmental manipulation (Harkins 1978; Hughes and Diaz 2008). The Great Plains organized into north-south trending zones of short, mixed, and tall grassland systems (Meltzer et al. 2002; Nordt et al. 2002). Savanna-adapted species such as oak, appear to have spread north from the Willamette Valley into the lower Columbia Valley and Puget Lowland around 10,500 BP (Barnosky et al. 1987), or 10,800 BP (Walsh et al. 2008).

Regional records of cicada burrows (O'Geen et al. 2002), soil micromorphology (Tate 1998), carbon and oxygen stable isotopes from pedogenic carbonates (Stevenson 1997) demonstrate the early Holocene (defined as 11,000-7,000 BP) was a warm and dry interval. High summer insolation and a strong subtropical high-pressure zone are thought to have induced the Altithermal from roughly 9,000-6,000 BP (Blinnikov et al. 2002). Seasonal temperature extremes are represented by higher timber lines indicating hotter summers, and higher rockfall frequencies suggesting colder winters. Synthesized pollen records indicate that intermountain Plateau grasslands persist from 12,000 BP to 9,000 BP; supporting large herbivores such as elk and bison. Sometime around 9,000 BP an increasingly maritime climatic pattern brought mesic conditions to previously xeric coastal areas (Chatters et al. 2012). Conversely, the interior Plateau became increasingly
arid during the early Holocene. Herbivore populations may have declined as grasslands were replaced by sagebrush steppe (Chatters et al. 2012; Rousseau 1993).

Soil organic carbon analysis suggests an increase in the relative proportion of warm-season C4 vegetation (i.e., graminoid grasses) at the expense of the previously cool-season, C3-rich grasslands (Cerling 1984; Nordt et al. 2002). Altithermal conditions promoted the highest proportions of C4 grasslands, particularly in the drier southern plains (Nordt et al. 2002). A single drought event at 8,200 BP may have selected for C4-dominance for the remainder of the Holocene (Clark et al. 2002). However, not all regions experienced measurable vegetation changes during the PHT. In certain microenvironments such as the ancient Palouse grasslands (pre-dating Cascade Range orogenisis) persisted throughout the Holocene (Blinnikov et al. 2002), and reflect long term stability.

Plant Communities

Dry, well-drained slopes common to the Columbia Basin physiographic province are typically characterized by sagebrush (*Artemesia spp.*), antelope brush (*Purshia tridentada*), rabbit brush (*Chrysothamnus nauseosus*), wild onion (*Allium sp.*), Ponderosa pine (*Pinus ponderosa*), and Douglas fir (*Pseudotsuga menzeisii*), wild buckwheat (*Eriogonum sp.*), and bunchgrasses contrast with nearby riparian plant communities (Franklin and Dyrness 1988). Even a slight increase in effective moisture can provide the advantage some species need to persist in arid shrub steppe environments of (Turner et al. 1947). Spring and floodplain ecosystems with reliable soil moisture are productive, dynamic, and important conduits of biodiversity (Whited et al. 2007).
Seeps and springs often sustain shrubs and trees with relatively flexible branches. Young branches of willow (*Salix scouleriana* and *S. spp.*) were used in making hide-stretchers, fish traps, basket hoops, in canoe frames (Elmendorf 1935; Lerman 1952; Ray 1932). Oceanspray (*Holodiscus discolor*) wood is extremely hard, especially when heat-treated, and used to make digging sticks, arrows, spears, pins, and cradle covers (Ray 1932; Turner et al. 1947). Maple (*Acer glabrum*) produces a tough, pliable wood and was used for drying racks, hoop structures, snowshoes, spears, and tongs for removing food from boiling water (Ray 1932; Turner et al. 1947). Mock orange (*Philadelphus lewisii*) is used in a similar way to willow and maple in that the leaves and flowers were bruised and rubbed into a lather for soap (Parish et al. 1996). The hollow stems of elderberry (*Sambucus cerulean*) were used as inflators for animal intestines, and food containers (Elmendorf 1935). Indian hemp (*Apocynum cannabinum*) was a very significant source of fiber and cordage (Parish et al. 1996), and may have been a valuable trade export from the Okanogan River area in the protohistoric period (Ross 1855).

Berries have a long history of use as food and medicine. Shrubs such as Oregon grape (*Mahonia aquifolium*) were used for both the bright yellow pigment of the inner bark and for the tart berries (Parish et al. 1996). Serviceberry (*Amelanchier alnifolia*), were the most popular and widely used very for native interior people, if you recognize up to eight different varieties (Parish et al. 1996). Choke cherry (*Prunus virginiana*) is another abundant shrub with many useful varieties. Cultural significantant rose species such as *Rosa nutkana* and *R. woodsii* are common in the study area (Elmendorf 1935).
Spring-adapted herbaceous plants widely utilized as food and medicine include mint (\textit{Mentha arvensis}, \textit{M. canadensis}), burdock (\textit{Arctium lappa}), plantain (\textit{Plantago major}), and stinging nettle (\textit{Urtica dioica}).

Previous botanical surveys may not have observed dormant plant species. A rare species of orchid “Ute ladies’ tresses” (\textit{Spiranthes diluvialis Sheviak}) found at Beebe Springs can remain dormant for years (Sheviak 1984). Ute ladies’ tresses are restricted to floodplain and wetland habitats with both reliable soil moisture and low vegetation cover and are managed as a federally threatened species and a state endangered species (Sheviak 1984). The persistence of Ute ladies’ tresses in the study area is indicator of spring-moderated, environmental stability over time despite extensive modern and historic ground disturbance, that have introduced exotic forbs, grasses, vines, shrubs, and prolific blackberry thickets.

Phytolith, macrofloral, and organic residue (FTIR) analysis of post-Mazama archaeological soils at Beebe Springs (45CH216) northeast of the study area, suggests a grass-dominated vegetation community with a mix of \textit{Poa} and \textit{Festuca} (Yost et al. 2009). High densities of grass seed hulls may reflect intensive human utilization of grasses during the middle to late Holocene. Willow, sagebrush, and an unknown type of hardwood, occurring locally or as recovered driftwood, were likely used as fuel (Yost et al. 2009). Carbonized \textit{Chenopodium} (also known as goosefoot or lambsquarters) seeds were recovered from 45CH216 in a buried anthropogenic soil (43-75 cmbs) developed in quartz, feldspar, and mica-rich sands (Mierendorf et al. 1977).
Fish and Wildlife

Anadromous fish are a critical resource in the Columbia River Basin as a subsistence and trade good (Schalk 1986), as well as a significant source of marine-derived nutrients in riparian soils (D’Amore et al. 2011). The impact of anadromous fish populations on the archaeological and pedogenic record is typically underrepresented in recovered faunal remains (Huber et al. 2011). The dynamic nature of Columbia River periglacial riparian habitats influenced diverse fish populations (Waples et al. 2008). Some anadromous lineages such as inland steelhead (*Oncorhynchus mykiss*), have persisted throughout the Pleistocene and Holocene despite glacial outburst flooding, intensive commercial fishing (Schalk 1986), and hydropower production (Waples et al. 2008). Odd- and even-year pink salmon, for example, may reflect population adaptations to past geologic impacts such as landslides, glacial outburst floods, and alluvial degradation (Reisenbichler et al. 2003; Waples et al. 2008). The Bonneville Landslide (approximately 1450 AD) temporarily obstructing the, resulted in a temporary dam 60–90 m high in the Columbia River Gorge (O’Connor 2004). Similar landslides on a lesser scale occurred in the Rocky Reach (Hackenmiller 1995).

In the Rocky and Wenatchee Reaches, historically-important anadromous species include spring, summer, and fall Chinook Salmon, coho salmon (*O. Kisutch*), sockeye salmon (*O. Nerka*), and steelhead trout (*O. mykiss*) (Ray 1936). Fish were available year-round at prime locations such as the mouth of Rock Island Creek (Ray 1936). However, the procurement and processing of anadromous fish was of secondary importance, and large terrestrial game was the primary faunal resource in the Rocky
Reach (Schalk and Mierendorf 1983; Ray 1936). Lamprey eels (*Lampetra*) were reportedly harvested from exposed rock surfaces in Chelan Falls by Chelan Bob’s children suspended from ropes (Hackenmiller 1995). The Chelan River Gorge was likely a barrier to fish migration throughout the Holocene (Hillman et al. 2000).

Salmonids apparently did not occupy the Lake Chelan Basin (Evermann 1899) until the introduction of Kokanee in the early 1900s (Hillman et al. 2000), although a species of landlocked salmon was reported by Ray (1975). However, a variety of potential resource species were present in Lake Chelan historically including species such as largescale sucker (*Catostomus macrocheilus*), longnose sucker (*C. catostomus*), northern pike minnow (*Ptychocheilus oregonensis*), peamouth (*Mylocheilus caurinus*), redside shiner (*Richardsonius balteatus*), mountain whitefish (*Prosopium williamsoni*), bull trout (*Salvelinus confluentus*), cutthroat trout (*O. clarki*), and burbot (*Lota lota*), sculpin (*Cottus spp.*), three-spine stickleback (*Gasterostius aculeatus*), and dace (*Rhinichthys spp.*), bridge lip sucker (*C. columbiaius*), and westslope cutthroat trout (*O. clarki lewisi*). In the late 1800s, Lake Chelan supported trout weighing up to nine pounds, and sustained a significant commercial fishery (Hillman et al. 2000).

Culturally-utilized shellfish in the Columbia River Basin consist of freshwater mussels such as *Margaritifera* and *Gonidea* (Teit 1928). Shellfish are a ubiquitous component of archaeological deposits, and may provide fluvial environmental data (Chatters and Hoover 1992). Shellfish remains dated to 10,070 +/- 80 BP from the fluvial gravel and sand facies contact at the Avey’s Orchard Site, opposite the Wenatchee
confluence, (Galm and Matsen 1985) indicates shellfish were established in the Columbia River relatively soon after late Pleistocene glacial outburst floods.

Increasing C4-composition across grasslands during the PHT favored ruminants over monogastric species, (i.e., camels, horses, and elephants) less well adapted to lower quality forage (Lyman 2004). While the factors responsible for the reduced abundance of monogastric species are complex, the adaptability and higher reproductive rate of bison may have been significant factor in their competitive release (Meltzer et al. 2002). In the central Columbia Basin, grasslands supporting large herbivores persisted from approximately 12,000 BP to 9,000 BP. Accordingly, large forms of elk and bison are well-represented within numerous PHT archaeological fauna assemblages (Chatters et al. 2012). In the historic-era, xeric mollisols in the Columbia Basin were generally incapable of supporting large herbivore populations without supplemental feed (Lyman 2004). The high visibility of bison and elk in the Columbia Basin zooarchaeological record reflects biological and environmental dynamics during the PHT (Lyman 2004).

As bison became the dominate grassland herbivore, intra-specific competition for forage increased, and may have selected against “dispersal” phenotypes, in favor of more conservative “maintenance” phenotypes (Hill and Widga 2008). Within high density populations, and especially during episodes of forage or water scarcity, smaller bodied “maintenance” phenotypes tend to outcompete larger forms (Hill and Widga 2008). Intensified intra-specific competition for resources during the Altithermal likely contributed to bison “dwarfing” through the Holocene. Analysis of isotopic variation in
bison bone collagen and apatite has been used to correlate forage quality with body size (Hill and Widga 2008).

Various non-mutually-exclusive factors have been proposed to explain bison dwarfing on the Great Plains, including climate change, human exploitation, predation pressure, resource limitations and intra- and inter-specific competition (Hill and Widga 2008; Wilson 1974). The northern plains, for example, with more effective moisture than the southern plains, retained a C3 grass majority throughout the Holocene. This has been viewed as an explanation of the historically-observed discrepancy between the larger-sized northern plains bison and smaller-bodied southern plains bison (Hill and Widga 2008). Synthesized mortality-age data suggests that Holocene dwarfing was due more to environmental factors than human overexploitation (Hill and Widga 2008).

Furthermore, the human colonization of Western North America apparently pre-dates the onset of bison dwarfing during the PHT (Hill and Widga 2008; Meltzer et al. 2002).

The persistence of *Bison antiquus* like forms into the Holocene implies that microhabitats better suited to supporting populations of larger-bodied forms may have persisted in upland and mountain environments. Zooarchaeological *B. antiquus* examples occur as late as 4,300 BP, although many authors limit the species’ duration to the early Holocene. Even historic photos of bison skull stacks depict apparent *B. antiquus* like arched-frontals and down swept horn-cores (Wilson et al. 2008). Additionally, historic accounts of “Mountain Buffalo” indicate morphological and behavioral differences from Plains bison (Wilson et al. 2008).
Pathological features diagnostic of Valley Fever (C. posadasii) were present on bison remains from Nebraska exhibiting an enlarged bony mass on the mandibular ramus (Morrow 2006). While fungal diseases are currently limited to certain arid regions of the southwestern US and South America, climatic changes during the PHT (Hughes and Diaz 2008; Kennet et al. 2007) affected precipitation and pedogenic regimes and may have been conducive to the spread of disease by vectors such as migrating bison, people, and dogs (Morrow 2006). Infection risk is enhanced by windborne dust and proximity to disturbed soils such as bison wallows, active floodplains, and human habitation sites (Morrow 2006).

Mountain goats, an important regional economic resource, wintered near the study area on Chelan Butte until the population was decimated by an unknown livestock-born disease and over-hunting in 1918 AD (Marchand 2007). Faunal remains observed, but not collected, at Chelan Station (45CH783) indicate that bison, goats, or sheep were also utilized in the early Holocene.
CHAPTER III
REGIONAL GEOLOGY AND GEOMORPHOLOGY

Geochronology and Tephrochronology

The relative ages of Quaternary landforms in the Columbia Basin are known primarily from preserved volcanic ash (tephra) deposits (Mullineaux 1986). Well-dated tephra horizons have been used to establish the relative ages of terminal Pleistocene outburst flooding, early Holocene floodplain aggradation, and human occupation (Huckleberry et al. 2003) (Figure 7).

Figure 7. Sub-Mazama geochronology across the Columbia Basin (Lenz et al. 2007).
These chronodiagnostic tephra include Mt. St. Helens Set S at 12,800 BP, Mt. St. Helens Set J roughly 12,000 BP, Glacier Peak layers G/B around 11,600 BP, and Mazama O at 6,850 BP (Mullineaux 1986). Primary deposits of Glacier Peak G/B have not been found at a similar elevation as the study area, but occur on the Great Terrace (Waters 1933) as well as lesser valley margin benches (Gough 1995). Unidentified “tawny ash” from Williams Lake Fen (near Cheney, WA), dating to 10,600 BP, and stratigraphically post-dating the Glacier Peak/MSH J tephra couplet, may represent a second MSH J layer (Mehringer 1996).

Glaciation

The Cordilleran Ice Sheet (Mitchell and Montgomery 2006; Page 1939; Waitt and Thorson 1983) overran the Puget Trough, North Cascades, Waterville Plateau, and Okanogan Highlands during the Fraser Glaciation (Clague 1981). The study area was affected, directly and indirectly, by several lobes of the Cordilleran Ice Sheet including the Skagit, Methow, Okanogan, and Columbia lobes (Riedel et al. 2012). As the Skagit lobe of the Cordilleran Ice Sheet coalesced with alpine glaciers in the Stehekin trough, the 1500 m-thick flow eroded weak bedrock in the valley floor to a depth of approximately 600 m below sea level (Riedel et al. 2012).

Because the Skagit lobe occupied the Cascade Crest, glacial development likely benefitted from exposure to marine-derived and orographic precipitation. This advantage may account for the Skagit lobe’s overdevelopment in the Chelan Basin relative to the Methow and Okanogan lobes, confined by the Sawtooth Range.
Additionally, the Skagit lobe may have introduced erratic rock types originating from the margins of the Puget trough into the Chelan and Columbia River valleys.

The Okanogan lobe, composed of an amalgamation of the Skagit, Methow, and Okanogan lobes (Riedel et al. 2012), terminated just south of Chelan Falls, based on the merger of moraine and outwash terrace landforms (Waters 1933). This last Okanogan Lobe glacial maximum occurred at approximately 14,800 ± 375 BP (Atwater 1986). Boulders mantling an Okanogan lobe lateral moraine north of Chelan suggest glacial recession began sometime between 14,100 ± 1,200 to 14,900 ± 1,200 Be10 BP (Balbas et al. 2017), retreating north of the Columbia River by 13,050 ± 650 BP (Atwater 1986). The highest glacial outwash feature attributed to the Okanogan lobe in the Rocky Reach is the Great Terrace at roughly 1000 ft. elevation, southwest of Chelan Butte (Waters 1933). The Great Terrace maintains a similar down-valley gradient as the modern Columbia River (Chappell 1936). Interpretations of an earlier, pre-LGM glaciation down the Rocky Reach, based on the abrasion of Swakane Gneiss bedrock outcrops in East Wenatchee (Chappell 1936), are not currently supported.

Outburst Floods

Pleistocene glacial outburst floods scoured the Columbia Basin (Bretz 1923), repeatedly throughout the last glacial maximum (Waitt 2016). These well-documented catastrophic floods occasionally became congested at Wallula Gap, causing a large backup known as Lake Lewis (Baker et al. 1987). The Moses Coulee delta may have also
resulted in lacustrine deposition as far upstream as the lower Wenatchee Valley by restricting the drainage of the Columbia River (Tabor et al. 1980). Bedded silt and clay deposits from these temporary lakes, known as Touchet Beds (Baker et al. 1987), are not known to be present in the study area. However, similar impoundments (i.e., Lake Brewster) may have occurred on a smaller scale in the topographically-restricted Rocky Reach canyon (Mierendorf 1983).

LGM megafloods derived from Lake Missoula scoured the Rocky Reach prior to the advance of the Okanogan Lobe (Waitt 2016). After the retreat of the Okanogan Lobe north of the mainstream Columbia River at 13,050 ± 650 BP (Atwater 1986), the Rocky Reach was again exposed to multiple outburst floods from Glacial Lake Columbia and the upper Columbia River (Waitt 2016) lasting until approximately 11,050 ± 180 BP (Fulton 1971).

Following the LGM outburst floods from Lake Missoula and Lake Columbia, and the deposition of MSH S tephra at approximately 12,800 BP (Lenz 2010), at least one outburst flood affected the Columbia River valley after the fall of Glacier Peak B/G tephra (Gough 1995; Fecht and Marceau 2006). Outburst floods sufficient to overtop the tread of Great Terrace (T3) near Chelan, displaced boulders at roughly 10,800 ± 500 \(^{10}^\text{Be}\) BP (Brooks and Crider 2007). Possible sources of the late outburst flood include glacial lakes Brewster, Elk (Rocky Mountain Trench), Penticton, and Kootenay (Gough 1995; Brooks and Crider 2007; Waitt 2016). Although sourcing of some late Pleistocene outburst floods has been accomplished by trace mineral composition (Hanson et al.}
2015), no hypothesized sources of the post-Glacier Peak outburst floods are known to have been tested.

Evidence of an outburst flood flowing upstream through the Rocky Reach includes the Tenas George Bar (Waitt 1977), and paleocurrent reconstruction of 5-m thick sand deposits along the valley margin at Orondo (Gough 1995). Additionally, the Great Terrace has been undermined by younger flood deposits below, but not above Entiat (Tabor et al. 1980). Bolton Bar, opposite the Wenatchee Confluence Site, was partially eroded at approximately 11,000 BP (Galm and Matsen 1985). Possible sources of a late Pleistocene outburst flood deposits in the Rocky Reach include Kootenay (Gough 1995; Brooks and Crider 2007; Waitt 2016), the Wenatchee (Galm and Matsen 1985), Entiat, Chelan, Methow, or Okanogan Rivers (Gough 1995) (Figure 8).

Determining the source and characteristics of the post-Glacier Peak outburst flood is significant to archaeological interpretations of Columbia River floodplain land use in the PHT. Unlike Lake Missoula and Columbia discharges, some underlying soils were preserved in favorable depositional environments on the valley margins (Gough 1995).
Figure 8. Schematic cross-section of Columbia River glacio-fluvial features and alluvial terraces along the Rocky Reach Dam and Rock Island Dam reservoirs (Waitt 2016), with relevant study sites added by the author: a) Chelan Station, b) Entiat (Steinkraus and Breidenthal 2013), c) Orondo (Gough 1995), d) Tenas George Bar (Waitt 1977), e) Douglas Switchyard, f) Rainey Spring, g) Wenatchee Confluence (Watrous and Breidenthal) and Avey’s Orchard (Galm and Matsen 1985), h) ‘Lake Chiwaukum’ approximate elevation (Breidenthal and Miller 2015), i) Veedol. Dashed line depicts possible Wenatchee River-sourced outburst flood(s).
Late Pleistocene Cascade Range Alpine Glacial Advances

Late Pleistocene Cascade Range alpine glacial advances, correlated with the Hyak and Rat Creek moraines, culminated approximately 12,000 BP (Porter and Swanson 2008). The distribution of airfall Glacier Peak B/G tephra nearly to the headwaters of several Cascade Mountain valleys indicates that major alpine glaciers had nearly receded by 11,600 BP (Porter and Swanson 2008). Alpine glaciers descended Icicle and Chiwaukum Creeks (Long 1989; Waitt 1977) during the LGM, and readvanced sometime before Glacier Peak B/G tephra at 11,600 BP (Porter 1978; Beget 1984), and to a lesser extent during the Younger Dryas phase (>11,250 BP), Carne Mountain/Hyak advance to Leavenworth and Tumwater Campground, respectively (Waitt 1977). Reliable dating of these moraine sequences has proven difficult (Crider et al. 2015; Long 1989).

Although terminal moraines at the confluences of Icicle and Chiwaukum Creeks are not well defined, both glaciers were likely capable of damming, or partially obstructing, the Wenatchee River in Tumwater Canyon (Waitt 1977). At the upstream entrance to Tumwater Canyon, the Wenatchee River is confined by resistant bedrock of the Stuart Batholith, characterized by extremely steep topography and structural geologic features associated with the Chiwaukum Graben (Willis 1953). The Wenatchee River is a unique, middle Columbia River tributary because late Pleistocene glacial advances terminated only 18 miles from its’ confluence with the Columbia River, and maintains a steep stream gradient resulting from an elevation loss of 152 m/500 ft. between Leavenworth and the Wenatchee confluence (Waitt 1977).
If either the Icicle or Chiwaukum Creek (RM 36) glaciers dammed the Wenatchee River during the Younger Dryas, then major tributaries such as Nason Creek, Little Wenatchee River, White River, and Chiwawa River would have likely been impounded in the upper Wenatchee River basin. Evidence of possible late Pleistocene impoundment consists of lacustrine varve sediments north of Lake Wenatchee at an elevation of 582 m/1920 ft., some 16 m/53 ft. above the current Lake Wenatchee level of 566 m/1868 ft. (Breidenthal and Miller 2015). At a minimum elevation of 582 m/1920 ft., this possible PHT-period lake, termed Lake Chiwaukum, may have achieved a substantial water storage capacity by capturing Fish Lake, the lower Chiwawa River, Beaver Valley (Plain), and several miles up both the Little Wenatchee and White River valleys. Due to the topographic structure of the Chiwaukum Graben (Willis 1953), overflow down Chumstick Creek would only be possible if lake levels exceeded roughly 697 m/2300 ft. in elevation.

Evidence for outburst flooding affecting the lower Wenatchee River valley includes erratic boulders derived from the Stuart Batholith, and the heavily eroded character of the Icicle Creek terminal moraine in Leavenworth contrary to the relatively well-preserved lateral moraine on Boundary Butte (Porter and Swanson 2008). Preserved outburst flood landforms may include ripple topography on outwash terraces near Peshashtin, the Wenatchee high terrace gravels (Tabor et al. 1980), the broad alluvial fan positioned well above the modern confluence with the Columbia River, and partial erosion of Bolton Bar dating to 10,070 ± 80 BP (Galm and Matsen 1985).
Lacustrine beds derived from Moses Coulee backflooding into the Wenatchee River valley (Wait 2016), appear to be well-preserved only along protected margins of the lower Wenatchee River valley, particularly on the downstream side of bedrock spurs (i.e., Monitor and lower Horse Lake Road). If Stuart Batholith erratics were transported to the lower Wenatchee River valley by a Columbia River-derived megaflood (Waitt 1977), then the preservation of Touchet Beds on the eastern sides of bedrock outcrops seems less likely given the erosion potential of fine-grained lacustrine sediment exposed to Glacial Lake Columbia outburst floods (Waitt 2016). The Wenatchee River Basin should be studied further as a potential contributor to PHT-aged landforms and sediments along the Middle Columbia River and the Rocky Reach. It may even be possible that these events explain the origin of the feldspar and quartz-rich alluvium (Unit 4) observed in the study area and discuss below.

Alluvial Chronology

Alluvial processes reflect environmental conditions. Riparian vegetation, and eddies induced by salient tributary fans, tend to encourage alluvial deposition. Paleoenvironmental proxy indicators suggest that river degradational episodes correspond with climatic transitions such as the high frequencies of rain-on-snow events predicted by global warming models (Chatters and Hoover 1992). The Wolman and Leopold (1957) model suggests alluviation frequency should decline exponentially over time.

Columbia River terrace landforms have been included in CRM investigations along the reservoir-margins of dams near the study area such as Wells (Chatters and
Hoover 1992), Rocky Reach (Schalk and Mierendorf 1983), and Rock Island (Galm and Matsen 1985). These alluvial terrace sequences have varied geochronological interpretations and nomenclature. However, in general, these relict floodplains and bedforms can be characterized as historic floodplain (T0), primary Holocene floodplain (T1), secondary PHT floodplain (T2), tertiary glaciofluvial (T3) terrace units.

**PHT Alluvial Terraces**

Although late Pleistocene floodplain archaeological sites occur on the Lower Salmon River at Cooper’s Ferry (Davis and Schweger 2004), and along the Lower Snake River at Marmes (Fryxell and Keel 1969), there are no recorded late Pleistocene sites on the mainstream Columbia River floodplain. Late Pleistocene age archaeological sites such as the East Wenatchee “Clovis Cache” occur stratigraphically above Glacier Peak B/G tephra on the T3 landform sequence (Mehringer 1990) (Figure 9).

The supply of remaining glacial outwash gravels was greater than the underfit Columbia River was able to flush out (Fecht and Marceau 2006). This glut of coarse sediment likely contributed to the establishment of braided stream channel morphology (Galm and Matsen 1985). Braided streams, exhibiting multiple channels diverging and converging across the floodplain, form in sand or gravel-dominant, high energy fluvial systems (Wooster 2002). Braided stream morphology depends significantly on flow competence and sediment mobility (Wooster 2002). Relative to the entrenched middle Holocene Columbia River, braided stream morphology during the PHT may have been conducive to the delivery of effective soil moisture and riparian nutrients (D’Amore et al. 2011) across a more extensive portion of the floodplain.
The Early Holocene Terrace (T2) formation began around 10,600 BP (Schalk and Mierendorf 1983; Chatters and Hoover 1992). The late Pleistocene to early Holocene transition (PHT) is underrepresented in the regional archaeological record (Rousseau 1993). The Badger Mountain paleosol is present on T2 along much of the Columbia River (Huckleberry et al. 2003). In the project area, the early Holocene terrace has been isolated from the Columbia River since about 9,000 BP when increasingly arid conditions caused extensive channel incision and entrenchment (Schalk and Mierendorf 1983;
Chatters and Hoover 1992). Similar alluvial terraces along the Snake River are more than 20 meters above the modern Snake River flood plain (Davis and Schweger 2004).

Mierendorf’s (1983) Rocky Reach alluvial chronology is particularly important to address geoarchaeological questions and testing methodologies. This framework views fluvial processes as a predictable function of environmental conditions. Traditional braided and meandering stream typologies are poorly suited to channel-restrictive canyons like Rocky Reach, which limit lateral accretion and the temporal availability of landform surfaces. Alternating fluvial and eolian processes tend to have a homogenizing effect on lower channel-margin landforms and sediments. Upper channel-marginal bars and Pleistocene terraces are poorly understood because they are not included in most reservoir survey and management plans, and often require deep sampling. Mierendorf (1983) proposes an early Holocene alluviation period beginning sometime before 8,200 BP (based on shell dated from 45CH58).

Middle to Late Holocene Alluvial Terraces

Small-scale floods, with discharges similar to the historic 1948 AD flood, incised and reworked early Holocene floodplain sediments and formed a sequence of inset terraces along the Middle Columbia River (Fecht and Marceau 2006). Archaeological sites on and within the middle to late Holocene Terrace (T1) sequence are typically at least 4,500-2,500 years old. Chatters and Hoover (1992), place the timing of T1 formation between 5,500-2,400 years ago. The Columbia’s Historic Floodplain (T0) is better understood because of oral tradition, written accounts, maps, and air photos. T0
associated cultural material is typically less than 1,200 years old. Except during
drawdowns, this landform is submerged by the Rocky Reach Dam pool.

Seismic Events

The 1872 AD earthquake-triggered landslide along Ribbon Cliffs (Russell 1900),
just downriver from the study area, temporarily blocked the Columbia and subsequently
released a significant discharge downstream (Bountry 2009). The 1872 earthquake, or
similar prior events, may have affected deposits in the study area, although the extent
of landslides and outburst floods is unknown. Evidence of landslide deposit topography
below the surface of Lake Chelan (Whetten 1967) and large, incipient blockslides above
Lake Chelan may have previously generated high energy waves (Tabor et al. 1980).
These displacements were likely capable of overtopping the Great Terrace and affecting
the study area. According to Sylvester and Peter Wapato’s account of the 1872 AD
earthquake:

At what is now Chelan Station a great hole opened in the earth and a
geyser was blown into the air 20 or 30 feet high. Continuing at irregular
intervals for forty-two days.... a crack in the surface of the earth... open
for about one hundred and fifty yards in length... two to three feet wide
at the top, and is from two to six feet deep.... Indians came to see it for
months but as time went on the water decreased in height until
eventually just the springs were left and continued to flow at this point...
now used to irrigate Beebe orchard [Wenatchee Daily World 1932].
Soils and Regional Pedogenic Environments

Paleosols, defined as ancient ground surfaces with sufficient stability to preserve evidence of weathering, retain features which are indicators of past climatic and biotic relationships (Birkeland 1999). Buried paleosols, largely isolated from contemporary pedogenic processes and bioturbation (Schaetzl and Sorenson 1987), are significant potential repositories of archaeological and paleoenvironmental data. Relationships between geological, biological, and pedological systems are complex because slight shifts in climate often cause changes in weathering and depositional processes (Huckleberry and Fadem 2007).

Buried A horizons are often heavily modified by overprinting from younger soils, and easily eroded in dynamic arid environments (Morrison 1964). B horizons retain diagnostic pedogenic attributes such as color, texture, structure, clay dispersion, measured hydrogen ion concentrations (pH), and pedogenic carbonate development (Birkeland 1999). Resistant B horizons are less likely to be affected by subsequent bioturbation and erosion.

The Badger Mountain paleosol (Huckleberry et al. 2003), or American Bar paleosol (Davis and Schweger 2004), is a regionally-recognized paleosol developed during the PHT following the Younger Dryas. The Badger Mountain paleosol is bracketed between lithostratigraphic units of ubiquitous Mazama O tephra, and Glacier Peak B/G tephra. The earliest known date on the Badger Mountain paleosol organic material is 10,940 ± 70 BP (Galm et al. 2000). Even in the absence of diagnostic tephra, buried the Badger Mountain paleosol is typically characterized by well-developed cambic (Bwb),
argillic (Btb), and carbonate filament (Btkb) horizons (Lenz 2010). Pedogenic calcium carbonate horizons indicate a MAP of < 760 mm (Birkeland 1999). Clay dispersion, preserved on peds as clay skeletans underlying buried A horizons, is often more pronounced on slopes and basin depositional environments (Lenz 2010). At Columbia Park in Kennewick, Washington (Chatters 1999), buried Badger Mountain paleosol underlies Mazama ash and forms a resistant ledge that is visible along cut-bank exposures (Huckleberry et al. 2003).

Well-preserved cicada burrows at Chelan Station provide a record of pedogenesis, and are proxy indicators of environmental stability and biodiversity (O’Geen et al. 2002; Smith and Hasiotis 2008) (Figure 10). Cicada nymphs burrow vertically and horizontally as they feed on the xylem sap of plant roots for 2-6 years before forming an emergence burrow near the surface. Emergence burrows consist of a feeding cell, burrow, and surface turret. These structures tend to remain open after emergence, and become filled passively. Burrowing depth varies from 10-120 cmbs and is influenced by species type, depth of food-roots, substrate moisture content, chemical composition, and frost depth. Cicada traces tend to be better preserved well below active A/B soil horizons. The better-known periodic cicadas emerge at 13 or 17-year intervals. If burrow morphology can be attributed to a specific periodic species, emergence burrows can potentially be used as geochronometric indicators in alluvial and eolian depositional environments. This requires a sufficient sedimentation rate of at least 21 mm/year to prevent overlap of the subsequent generation’s emergence (Smith and Hasiotis 2008).
Figure 10. Well-preserved cicada burrows near the EBP at 45CH782, exposed on a test unit floor at the contact between lithostratigraphic Units 4 and 3.

Comparison of pedogenic environments in the Columbia Basin and Puget Sound during the PHT are useful for framing interpretations of buried paleosols in the study area. To supplement the limited subsurface investigation in the study area, I examined several buried paleosol exposures from selected CRM-driven excavations near the study area including Rocky Reach Dam/Douglas Switchyard, Badger Mountain (Rainey Spring and Veedol Substation), and Wenatchee Confluence. Outlying locations including Centralia (Mellen Site). All the comparative paleosol exposures occur within alluvial and eolian parent material in glaciated or periglacial landscapes. However, differences in
factors such as climate, elevation, groundwater, grain size, vegetation, and land use (Jenny 1962) are reflected in pedogenic variation preserved across the region.

The Chehalis River drains a basin primarily composed of ancient sedimentary bedrock, pro-glacial lacustrine clays and silt. Because heavy, marine-influenced precipitation tends to move laterally as surface runoff on the floodplain, the modern Chehalis River exhibits a propensity for out-of-bank flow, and maintains a dynamic meander pattern (Reichmuth 1998). During the early Holocene however, the Chehalis River floodplain was a broad, braided stream surrounded by oak savanna (Reichmuth 1998; Schalk et al. 2005). At the Mellen Site in Centralia, Washington, the change from cumulic to non-cumulative pedogenic environment occurred approximately 6,240 BP, after Mazama tephra deposition on an overthickened, buried paleosol (Schalk et al. 2005).

The Mellen Site paleoenvironment differs from the study area considerably in terms of precipitation and parent material. However, commonalities include similar alluvial landforms, and low-energy deposition of fine-grained alluvium. In both locations, the bottleneck-effect of downstream, tributary alluvial fans may have contributed favorably to the preservation of buried soils and their associated archaeological deposits by reducing the velocity, and likely the erosion potential, of overbank flows (Schalk et al. 2005). As a result, fluvial disturbance is limited to the buoyant organic debris, and less cohesive upper A horizon materials (Birkeland 1999). Sub-turbulent sediments and pedogenic features may remain largely unaffected by flooding (Jenny 1962; Waters 1992). Weakly developed A horizons or accumulations of
floodplain organic matter, classified as fluvents, are often characterized by high nitrogen and phosphorus content (Birkeland 1999).

**Rocky Reach and Wenatchee Reach Soils**

Comparative analysis of buried paleosol exposures in the region supplemented the limited data collected in the study area (see Figures 2 and 8). Pedogenic and lithological similarities between the Chelan Station site and the Douglas Switchyard location reflect similar paleoenvironmental processes in distant Rocky Reach floodplain deposits. These early Holocene floodplain soils likely became isolated from alluvial sedimentation between approximately 9,000 to 8,000 BP. This interpretation conforms to expectations of paleoenvironmental change based on previous research (Chatters and Hoover 1992; Huckleberry et al. 2003; Schalk and Mierendorf 1983). Upland soil exposures at Rainey Spring have little in common with Rocky Reach floodplain soils. However, these upland environments, removed from the effects of LGM glaciation and subsequent outburst flooding, were a likely source of biota available to recolonize the flood-scoured Rocky Reach.

Excavation observed by the author at Veedol Substation (DPUD) at the contact between Badger Mountain landslide colluvium and Pangborn Bar loess-mantled alluvium suggests that the bouldery basalt landslide deposits described by Waitt (2016) overlie Pangborn Bar flood deposits. Landslide-buried Bishop and Badger Mountain paleosols are laterally-traceable to nearby test pits exposures (Lenz et al. 2007). Further research is required to determine the extent and character of the buried contact between Badger Mountain Holocene colluvium and Pangborn Bar LGM flood deposits.
This exposure demonstrates that geomorphological interpretations based on ‘windshield’ assessments of surface lithology are not necessarily representative of underlying deposits. Excavation is required to adequately evaluate deeply buried sedimentary contexts using catena (Gentry 1974; Milne 1935), or transect-oriented methods.

At the Wenatchee Confluence archaeological site, multiple stacked Ab horizons developed on gravels and loamy alluvium, rich in large mammal bone fragments. However, pedogenesis seems to have been reduced considerably prior to Mazama tephra deposition. This may reflect a change from alluvial to eolian depositional regimes. At the loess-dominant Rainy Spring location, Badger Mountain paleosol occurs across in stable, topographically-protected pockets. Wind scour and agricultural plowing have disturbed diagnostic pedogenic features in more exposed areas on the spring margin. The lateral distribution of effective soil moisture appears to govern loess deposition and cumulative pedogenesis.

Depositional environments near abundant sediments sources such as floodplains are more conducive to rapid pedogenesis (Holliday 1988). At the Douglas Switchyard location, on a broad, formerly active floodplain (T2) below Rocky Reach Dam, Badger Mountain paleosol exhibits well-developed carbonate filaments (2Btkb). The poorly-defined upper boundaries of Btkb horizons at both Rainy Spring and Douglas Switchyard sites may be due to similar erosional processes and regional-scale environmental changes. Resistant Btkb horizons can be an important indicator of a buried Paleosol even in the absence of diagnostic tephra (Huckleberry et al. 2003).
Ethnographers (Haines 1938; Hunn 1990; Marsh 2004; Ray 1936, 1974; Relander 1986; Spier 1936; Teit 1928) described Plateau culture as an egalitarian society consisting of autonomous, semi-permanent villages. In the winter, people lived in semi-subterranean earth or mat lodges along the river, primarily in areas protected from strong winds. (Hunn 1990). The Columbia Basin has well-documented cultural traditions of fishing, habitation, trade, and religious practices reflecting influences from the Pacific Coast, Great Basin and Rocky Mountain.

Seasonally cyclic subsistence patterns reinforced social ties between distant groups. Introduction of the horse in the mid-1700s intensified and expanded regional economic and social interaction (Ray 1936). The Wenatchi, Entiat, Chelan, and Okanogan bands were traditionally affiliated in terms of their Interior Salish dialect, as well as general land use practices (Ray 1936; Ross 1855; Splawn 1917;). The Wenatchi, or Pischous, band also shared multiple fisheries and villages with the Sahaptin-speaking Kittitas band (Ray 1936). Some Chelan band members were originally taken as captives during raids into Puget Sound or the Intermountain West (Hackenmiller 1995).

Written accounts of the Columbia Basin ethnographic record begin in 1805 with William Clark’s observation of the Yakima River Delta from an island in the Columbia River (Cleveland and Uebelacker 1980). The subsequent fur trade-era includes the first written ethnographic and geographic records of the study area (Figure 11). In 1811,
David Thompson descended and mapped the Columbia River on behalf of the NorthWest Company (Hunn 1990). Hudson Bay Company (HBC) and the Pacific Fur Company followed soon after, operating from posts associated with traditional exchange centers such as Kettle Falls and Okanogan Falls (Hunn 1990; Luttrell 1994). Fur traders initially characterized the Chelan Station area as the location of the principle village of Chelan people, although less than a decade later Chelan Station was sparsely populated (Luttrell 1994; Schalk and Mierendorf 1983). Potatoes were being cultivated at the Wenatchee confluence as early as 1841 (Wilkes 1845).

Figure 11. An 1841 map of North Central Washington likely depicting the extent of geographic information compiled from roughly 30 years of HBC and US military activities (Wilkes 1845).
Archaeological research within the Columbia Basin has arguably been primarily driven by hydropower production. Dam operation is possibly one of the largest ground disturbing activities undertaken by the US government (Lenihan et al. 1980). Impacts to cultural resources occur not only from pool inundation, but also from associated infrastructure such as power transmission lines, irrigation canals, as well as fish hatcheries and habitat amendments (Gatto and Doe 1987; Germann and Spurling 1985). Federal regulation of these activities shaped cultural resource management practices and influenced the formation and interpretation of the regional archaeological record.

The Columbia River Basin has been the focus of some of the federal government’s largest hydropower projects and corresponding intensive cultural resource management efforts (Graf 1999). The system of Columbia River dams and their associated flow of services are governed by dynamic climatic inputs as well as federal and international policy (National Research Council 1996). For example, the Columbia River Treaty (implemented in 1964) with Canada served to attenuate seasonal flow variations. By holding back spring snowmelt, Canadian reservoirs provide much-needed supply to US hydropower producers during low-input summer flows (Morris and Fan 1998). This agreement is arguably the primary basis for successful Columbia River hydropower production and its associated benefits. Because the terms of the Treaty are due for reconsideration in 2024, future management policies may be affected by changing stream flow regimes (Walker and Pellatt 2008), reduced water storage capacity, endangered species concerns, and power distribution issues.
Early cultural resource surveys funded by the American Museum of Natural History reported that relic collectors were already impacting archeological sites in the Columbia Basin (Smith 1910). Federally-sponsored hydroelectric dam building in the 1930s drove the Smithsonian Institution to survey and test sites within the Columbia Basin under the reservoir salvage program (Schalk et al. 2009). The 1947-1952 Smithsonian River Basin surveys (Combes 1963; Crabtree 1957; Daugherty 1960, 1962; Rice 1972; Sprague and Combes 1966) focused on identification and salvage of prehistoric sites along major rivers that were increasingly affected by dams and intensive subsurface looting. These surveys focused primarily on salient sites along the proposed reservoir margins, and generally used the triage principle to salvage archaeological data ahead of inundation. Also, most surveys and recovery projects were limited to late Holocene age landforms.

Archaeological excavations in the 1960s, such as Lind Coulee and Marmes pushed back the known age of human occupation considerably. However, due to the dominance of the Clovis-first paradigm and the inaccuracies inherent to radiocarbon dating techniques at the time, archaeologists did not recognize WST as a colonizer culture that slightly predates Clovis deposits in the region (Lenz 2010; Waters and Stafford 2007). This geochronological misinterpretation of PHT deposits in Lind Coulee, and the Intermountain West (Cressman et al. 1940), had significant, hemisphere-scale implications for archaeological modeling of the peopling of the Americas.

Data generated by these salvage excavations along the Middle Columbia River and lower Snake River were the basis for forming the regional cultural-historical
typological models (Butler 1965; Daugherty 1962; Leonhardy and Rice 1970; Nelson 1969). Interpretive models were largely concerned with developing cultural-historical sequences, or traditions based on artifact styles. These typological models persist into contemporary CRM literature and are applied throughout the Columbia Basin region. Amateur archaeological excavations such as the Mid-Columbia Archaeological Society (MCAS) collected significant artifact and faunal assemblages, but generated few archaeological publications (Cleveland and Uebelacker 1980).

The cultural resource surveys conducted after 1970s era legislation such as NHPA and ARPA implemented more systematic methodological practices based on “New Archaeology” (Binford 1962; Dunnell 1971). CRM researchers recognized that inter-regional cultural variations did not always conform to earlier typological models (Schalk and Mierendorf 1983).

PHT Archaeology in the Pacific Northwest and Inter-Mountain West

A late Pleistocene pebble tool from Eastern Oregon’s Rimrock Draw Rockshelter (O’Grady et al. 2012) predating Mount St. Helens S tephra, dated to 12,800 ± 60 BP (Lenz 2010; Moody 1978), suggests human occupation of the Inter-Mountain West correlates with the later Lake Missoula outburst floods. Another Eastern Oregon Rockshelter, Paisley Caves includes WST components dating to as early as 12,140 ± 70 BP (Jenkins et al. 2012).

Bison and mastodon remains dating to approximately 12,000 BP with evidence of human modification were found in association with Ayer Pond on Orcas Island, WA
(Kenady et al. 2010), and an abandoned channel of the Dungeness River in Sequim. Like other specimens from the xeric Olympic rain shadow and the well-preserved, carbonate-rich deposits of Vancouver Island; the Ayer Pond bison exhibits a smaller horn core size than the contemporary Great Plains Bison antiquus populations, possibly representing a pattern of island dwarfism induced by peri-glacial sea level change (Kenady et al. 2010).

Some authors suggest that the high number of PHT zooarchaeological bison sites recorded in the High Plains/Rocky Mountains region implies that human groups (i.e., Folsom and Mountaineer) followed bison into protected intermountain basins in the winter (Lyman 2004; Meltzer et al. 2002). Bison are known to endure extreme cold, but high winds can reduce the insulating effectiveness of winter hide and fat reserves. Additionally, bison are poorly adapted to heavy snow packs (greater than 2’) relative to other North American herbivores, and typically favor wind-sheltered landscapes with limited snow accumulation (Meltzer et al. 2002; Telfer and Kelsall 1984).

During the PHT, bison hunters utilized varied entrapment landforms such as arroyo headcuts and parabolic sand dunes that were sometimes supplemented with artificial barriers or corral-like structures (Frison and Wilson 1976; Meltzer et al. 2002). Several authors (Hill and Widga 2008; Meltzer et al. 2002) have interpreted early PHT kill sites as representing non-selective hunting practices, but highly-selective meat transport decisions. Factors such as hunting group size, temperature, precipitation, winds, and scavenger-pressure may have affected meat processing transport decisions, expressed archaeologically as differential element removal (Kelly et al. 2013).
The displacement of Agate Basin-type tool forms from the High Plains to northern Alaska around 10,000 BP (Meltzer et al. 2002), and to the Columbia Basin at 10,200 BP (Huckleberry et al. 2003), has been interpreted to reflect the pursuit of expanding grasslands and bison range into formerly glaciated landscapes (Wilson et al. 2008). The extensive distribution of these stylistic tool forms might reflect on the extensive scale of bison herd migration, as well as the dynamic nature of post-glacial grassland ecosystems.

PHT Archaeological Deposits in the Columbia Basin

Archaeological data from the PHT and Paleoindian periods in the Columbia Basin are limited by post-depositional erosion of alluvial landforms (Lenz 2010). Relict and abandoned channels from late Pleistocene outburst flooding were soon occupied and utilized by people (Fryxell and Keel 1969; Huckleberry et al. 2003; Huckleberry and Fadem 2007; Lenz 2010; Mehringer 1989; Mierendorf 1987). PHT sites in the Columbia Basin with large bison and elk faunal assemblages reflect high grassland productivity, which may have supported larger and more varied ungulate populations (Huckleberry et al. 2003).

Previous cultural resource investigations in the Columbia Basin utilized several varieties of paleoenvironmental data to explore the complex relationships between climate, volcanic activity, fluvial processes, soil formation, flora, fauna, and human behavior (Chatters et al. 2012; Huckleberry et al. 2003). Potential proxy indicators of environmental change include soil micromorphology, cicada burrows, macro faunal and floral remains, pollen and phytolith samples, carbon and oxygen stable isotopes from...
pedogenic carbonates, freshwater mussel shell rhyzolith samples, and plant biomass (Cerling 1984; Chatters and Hoover 1992; Davis 1995; Nordt et al. 2002).

Stratified late Pleistocene sites from upland locations such as East Wenatchee, Bishop Spring, Lind Coulee, Winchester Wasteway, Willow Lake, and BPA Springs (Huckleberry et al. 2003), are underrepresented in the regional archaeological record. Therefore, late Pleistocene to early Holocene transition (PHT) deposits are potentially valuable cultural resources for addressing regional and hemisphere-scale archaeological population questions.

For example, evidence of the replacement of the Western Stemmed Tradition (WST) archaeological population by the Old Cordilleran Tradition (OCT) corresponds with early Holocene climate change (Chatters et al. 2012). A similar pattern is reported from Cooper’s Ferry, where Davis and Schweger’s (2004) stratigraphic framework evaluates human occupation in the context of the Lower Salmon River geomorphic record. However, empirically demonstrating relationships between ancient environments and cultures is difficult given the limited archaeological data available (Booth et al. 2005; Davis 1995; Kennett et al. 2007; Mehringer 1996).

The Okanogan valley is a likely conduit for the spread of Western Stemmed Tradition (WST), and Fluted Point Tradition (FPT). Grabert (1974) proposed a plains-influenced population movement north from the Columbia Plateau, following the retreat of the Okanogan lobe. Fluted Point Tradition assemblages such as Clovis and Folsom, are characterized by prismatic blades and thin, bifacially-flaked projectile points and knives, sometimes exhibiting basal fluting and laterally-extensive, overshot flaking.
The East Wenatchee Clovis Site, 45DO482 (Mierendorf 1987), occupying an abandoned channel, or scour trench of Pangborn Bar (Mehringer 1989; Waitt 2016) is a unique example of in situ Clovis artifact diversity including formed bone objects, stone adzes, and large fluted points. Reports of additional, nearby Clovis tools on Pangborn Bar suggests that the East Wenatchee Clovis Site may not be an isolated cache. (Schumacher 2006). Reports of fluted point finds on Badger Mountain, Lake Chelan, Bridgeport, and Pateros indicates fluted point cultures occupied North Central Washington and the Rocky Reach of the Columbia River Valley (Avey 1991).

Early WST sites represent collector-like residential base camps dating between 13,000-9,000 BP. Assemblages typically include composite technology oriented towards big game hunting (Chatters et al. 2012). Diagnostic tools such as crescents and bolo stones are present in WST assemblages and often associated with wetland paleoenvironments (Jenkins et al. 2012; Murphy 2014).

Lind Coulee (45GR97), dating from approximately 10,250 ± 40 BP (Craven 2004) to 8,500 BP (Irwin and Moody 1978; Huckleberry et al. 2003), is the type-site for stylistically-distinct, stemmed projectile points found in the Southern Plateau. Problematically, a bison scapula buried by Mt. St. Helens J tephra was dated by Moody (1978) at 12,800 BP. Researchers considered this date invalid due to a misunderstanding of MSH J tephrachronology; originally thought to be only about 8,500 BP (Mullineaux 1986; Huckleberry et al. 2003). All cultural material observed at Lind Coulee occurs above Mount St. Helens S tephra, dated to 12,800 ± 60 BP (Craven 2004; Irwin and
Moody 1978). Because some cultural material is present below MSH J (Lenz 2010), Lind Coulee (WST) considerably predates Clovis (FPT) occupation at the East Wenatchee Clovis Site.

Irwin and Moody (1978) characterized the Lind Coulee (45GR97) bison remains as equivalent or slightly larger in size than modern bison (Lyman 2004). Irwin and Moody (1978) interpreted episodic use of the site in the early spring based on the high numbers of full-term-fetal and new born bison. A lack of large mammal caudal vertebrae and the presence of sewing needles suggested an intensive economic focus on hide processing (Irwin and Moody 1978).

Bishop Springs is a significant, well-stratified archaeological site in a scabland depositional environment (Mierendorf 1987; Orvald 2003) associated with other late Pleistocene archaeological (Mierendorf 1983; Murphy 2014) and faunal discoveries on Babcock Bench (Chatters et al. 2004; Lenz 2010). The Bishop springs deposit preserves significant floral and faunal remains, as well as WST and OCT cultural material (Orvald 2003). Lithic analysis demonstrates that use-wear, indicative of functional diversity is present on 27% of the artifacts (Chatters 1982). However, archaeological site formation processes in similar groundwater discharge environments are generally not well understood (Alfaro and Wallace 1994).

The Five Mile Rapids Site (35WS8) indicates that salmonids and birds were intensively utilized on the Columbia River floodplain in the early Holocene (Butler and O’Conner 2004; Cressman 1960). While the anthropogenic interpretation of the
salmonid remains is disputed (Schalk 1986), the presence of considerable numbers of anadromous fish bones in an eolian depositional context dating to 8,090 ± 90 BP or 9,785 ± 220 BP (Cressman 1960) is significant to the Columbia River paleoenvironmental context.

At the Rock Island Overlook Site (45CH204) the deepest cultural materials reported include both WST and OCT lithic assemblages (Valley 1975). These artifacts correspond with forms recovered from the Little's Landing Site, 45CH64 (McCoy 1971), the Rocky Road Site, 45D0174 (Rice and Brauner 1974), and the Okanogan Valley (Grabert 1968). Evidence of trade includes obsidian, quartz, graphite and pumice (Valley 1975). Although the initial age of occupation may have been underestimated, landforms similar to the Rock Island Overlook Site (at approximately 215 m/710 ft. elevation), preserve a record of early floodplain occupation.

Cascade Phase, or Old Cordilleran Tradition (OCT) includes Carlson’s Pebble Tool and Microblade Traditions, Olcott, Cascade, Vantage, and Okanogan Phases. OCT sites suggest a residentially mobile foraging strategy (Hess 1997; Nelson 1969), while lithic assemblages are typically simple, complex food processing technology suggests a primarily riparian-focused resource adaptation (Daugherty 1956). Several pre-Mazama sites in British Columbia such as the Drynoch Slide and Landels sites, represent similar OCT assemblages (Rousseau 1993). The Gore Creek Burial, dated to 8,250 ± 115 BP (Cybulski et al. 1981), shares morphological similarities with “Kennewick Man” (Rousseau 1993).
In the Rocky Reach, excavations at the Plew Site (45DO387), recovered cultural materials above redeposited Mazama tephra (Draper 1986), in a similar context to the house feature identified by Hodges and Ray (2005) at 45CH216. Residential features consist of curvilinear depressions bounded by large cobbles, often associated with shell ovens. Subsistence activities include lithic procurement and reduction, intensive shellfish processing (M. falcata), salmon fishing, and small to medium-sized mammal hunting. Draper (1986) suggests that deposits at 45DO387 represent winter occupation of an increasingly crowded river corridor during the Altithermal. Along with 450K422 and 450K424, the Plew Site may address the impact of Mazama tephra deposition on local populations (Bense 1972; Matz 1987). Early Holocene deposits at 45CH58 (Schalk and Mierendorf 1983) resemble 45CH783 stratigraphy.

Regional exchange of obsidian was established as early as 9,000 BP (Carlson 1994; Minor 2013). However, the distribution of Pacific Northwest obsidian sources is not well known (Galm 1994; Hess 1997; McClure 2015; Mierendorf and Baldwin 2015). The high frequency of Skagit Valley Hozomeen chert and quartz crystal microblade technology at Cascade Pass (45CH221), suggests a pattern of mountain resource exploitation by Skagit valley people as early as 8,600 BP (Mierendorf et al. 2006). Columbia Plateau-derived CCS dominates the Cascade Pass assemblage after 4,000 BP, indicating predominantly west-bound travel via Lake Chelan and Stehekin. Combined with high densities of OCT sites in the Stilliguamish Valley (Kidd 1964; Baldwin and Chambers 2014), the presence of OCT artifacts in the Cascades suggests that post-glacial population densities in Puget Sound may have been higher than previously expected.
Occupation of an interfluvial landform at the Woodhaven Site (45SN417), thermal luminescence-dated (TL) to approximately 8,700 BP and 7,400 BP (Baldwin and Chambers 2014), may reflect utilization of the periglacial Stilliguamish River floodplain (Minard 1985).
CHAPTER V

METHODS and RESULTS

Geoarchaeology

Archaeological research depends on the assessment of archaeological deposits as sedimentary units that are distinguished by observed changes in sediment properties (Stein 2001). Because archaeological deposits occur in sedimentary geologic units, stratigraphic methods have been employed to investigate the modes of archaeological deposition and the post-depositional alteration of sedimentary units. Stratigraphy is the study of the spatial and temporal relationships between sediments and sedimentary units (Waters 1992).

Geoarchaeological methods address contextual research questions such as the distribution of archaeological deposits, landforms, stratigraphy, geochronology, facies identification, micromorphology, and reconstruction of past depositional environments (Fryxell 1970; Waters 1992). Interdisciplinary research techniques are critical to reconstruct past cultural and environmental contexts (Fryxell 1970; Moody 1978), particularly in cases where cultural and environmental contexts have changed over space and time.

I used lithostratigraphic units consisting of sedimentary beds distinguished by observable physical properties (Waters 1992), and pedostratigraphic units defined as laterally-traceable soils that include one or more weathered horizons buried beneath a younger sedimentary unit (Birkeland 1999; Huckleberry et al. 2003).
Review of available LiDAR imagery and aerial photographs (USGS 2014) indicates that analogous abandoned channel bedforms are present on an upriver secondary alluvial terrace along the toe of the Great Terrace scarp. Although these relict abandoned channels currently receive irrigation runoff from above and an artificially high water table from the Rocky Reach Dam pool below, the lush riparian vegetation supported in the relict channels likely serves as an analog for early Holocene pedogenic environment in the EBP portion of the study area.

Field sampling techniques consist of observations of artifacts, soil, and sediment profiles recorded by the author during construction monitoring, as well as excavation of archaeological test units (primarily 2 x 1 m units excavated by arbitrary and natural levels), trench sidewall facings, and shovel probes. Samples of possible tephras, buried paleosols, and artifacts were collected for further analysis (Schumacher 2011).

The monitoring and testing project did not establish a site datum from which to measure elevation between units and profiled sections of the trench. Future research designs should install appropriate elevation control stations in order to better define the spatial relationships of buried soils, sediments, and artifacts. Secondly, attempting to use 1/8-inch dry-screening technique was not productive in the water-saturated, clay-rich beds (i.e., Unit 3). When feasible, future testing should employ a wet-screening station during excavation of loamy soils (Units 2-3).

These dates conform to geochronological expectations based on known Badger Mountain paleosol ages (Lenz 2010), such as the Sentinel Gap Site the uppermost A horizon dated to 8,880 ± 70 BP (Huckleberry et al. 2003). These dates also fall within the
range of Marmes floodplain soils (Stratum III) and rockshelter (Stratum II/I) (Huckleberry and Fadem 2007). The overlapping dates on the lower paleosols may reflect rapid sedimentation and non-cumulic pedogenic environments. The roughly 1,400 radiocarbon year gap between the lower paleosols (2-4Ab) and the well-developed upper paleosol (Ab) indicates a period of relative stability, and addresses the research objective of identifying evidence of depositional environmental change at the EBP location (Figure 12).

Field observations of artifacts, soil, and sediment profiles were conducted along with archaeologist Josh Watrous during pipeline construction monitoring and limited archaeological testing in the late winter and spring of 2010. To provide a context for evaluating the Chelan Station Site’s archaeological data potential, a lithostratigraphic model of the study area was tested against observed deposits. Results demonstrate that lithostratigraphic units are traceable across large portions of the study area despite modern disturbances and discontinuous exposures.

Lithostratigraphic Units

The uppermost deposits consisting of predominantly eolian sands (Unit 5), were extensively disturbed by historic development. Primary Mazama tephra (Unit 5) caps the Badger Mountain paleosol which developed on a thick, possible fluvial sand deposit (Unit 4). These sands may represent a post-11,600 BP outburst flood identified by Gough (1995). The sands discretely buried a dark brown, clay loam Ab horizon. The sand-to-soil contact preserves extensive burrowing cicada traces. This Ab horizon seems
Figure 12. East Bore Pit (EBP) composite stratigraphic profile drawing by Watrous and Gentry depicting soil texture, color, carbonate morphology, and krotovina (adapted from Schumacher 2010). Photograph by the author.
to have developed on brown, ash-like sediment. The possible ash overlies yet another thin, buried Ab horizon. This sequence includes three to five, plastic, carbon-rich beds (Unit 3), interpreted as overbank alluvium representing early Columbia River floodplain accretion and ecosystem development. With depth, the sediments become increasingly rhythmically-bedded, fluvio-lacustrine sand and silt (Unit 2), which mantle poorly-sorted gravels (Unit 1) possibly derived from braided stream bedforms. These general stratigraphic units are further subdivided into 26 lithostratigraphic sub-units based on observations in the EBP exposure of sediment texture, particle size, Munsell color, structure, and carbonate morphology.

At the slope toe exposed in the WBP profile (Figure 13), lenses of cemented gravelly sand (Unit 6) sloping to the southeast, may be a result of intensive groundwater discharges from Beebe Springs. Alternative interpretations include small-scale slope failures from the overlying Great Terrace (T3) scarp, as well as possible catastrophic landslide displacements into Lake Chelan (Whetten 1967) that may have generated waves capable of overtopping the Great Terrace (T3), and depositing gravels in the study area.

Unit 6 includes a mottled white silt horizon interpreted as a secondary deposit of Mazama tephra. However, this possible tephra might derive from middle Holocene MSH Y, dating to 3,500 cal BP (Mullineaux 1996), or the Glacier Peak “Dusty Creek” tephra dating to 5,800 cal BP (Foit et al. 2004), or the Mount Baker BA tephra dating to roughly 6,600 BP (Hildreth et al. 2003).
Depositional Environments and Soils

Sub-Mazama pedostratigraphic units (Table 1, Figure 14) are traceable across much of the study area, and reflect pedogenic differences based on varied parent materials, landform position, slope, effective moisture, bioturbation, and land use. At the northern end of the study area, mottled Mazama tephra overlies a weakly-expressed buried soil (Bwb) developed in gravelly sands (C). Deposition on this gentle, wind-protected slope includes gravelly colluvium (Unit 6) from the Great Terrace (T3) above, interbedded with eolian silt and sands. Limited horizonation may be due to bioturbation from vegetation or human land use. A lack of visible Ab horizon formation
suggests reduced effective moisture and erosional conditions prior to Mazama tephra deposition.

Table 1. Sub-Mazama Pedostratigraphic Units Across the Study Area (N-S).

<table>
<thead>
<tr>
<th>Age</th>
<th>LU</th>
<th>SPRING</th>
<th>SLOPE TOE</th>
<th>CHANNEL</th>
<th>DISTAL FP</th>
<th>BAR</th>
<th>SCARP</th>
<th>PROX. FP</th>
</tr>
</thead>
<tbody>
<tr>
<td>6,800-8,480 ± 40 BP</td>
<td>4</td>
<td>Bwb Cb</td>
<td>Ab Bb Ckb Cb</td>
<td>Ab Btb</td>
<td>Ab Btb</td>
<td>Abp Bwb</td>
<td>Abp Bwb</td>
<td></td>
</tr>
<tr>
<td>8,480 ± 40-9,160 ± 50 BP</td>
<td>3</td>
<td>2Ab 2Btkb 2Ckb 3Akkb 3Ckb 4Akkb 4Ckb</td>
<td>2Ab Btkkb 2Ckb 3Akkb 3Ckb 4Akkb 4Ckb</td>
<td>2ABb 2Cb</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;9,160 ± 50 BP &lt;11,600 BP</td>
<td>2</td>
<td>5Cb</td>
<td>5Cb 5Bwb 5Bwb 5Bwb</td>
<td>5Bwb 5Bwb 5Bwb</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>6Cb</td>
<td>6Cb</td>
<td>6Cb</td>
<td>6Cb</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the WBP test units Mazama tephra (Unit 5) overlies an organically-rich buried soil (Ab) supported by a resistant Bhb horizon (Birkeland 1999) printing into deep, well-drained, predominantly eolian sands that likely represent reworked fluvial sands (Unit 4). The buried soil surface preserves traces of charcoal interpreted as burned shrubs such as big sage, rabbitbrush, or bitterbrush. Because the WBP buried Paleosol I lacked access to underlying moisture-retaining clays and colloidal material, the pedogenic environment was less effective at supporting riparian vegetation and accumulating eolian and biogenic sediments.

Until Mazama tephra deposition, soils in the WBP probably benefitted from surface water runoff from Beebe Springs. Indications of effective surface moisture
include a Bhb horizon with sufficient accumulations of illuvial organic matter-sesquioxide complexes to form a well-cemented structure (Birkeland 1999), in otherwise sandy parent material. Coniferous pine trees were present in this area and may have contributed to an acidic microenvironment and Bhb horizon formation.

Gravels and overlying sands (Units 1 and 2), interpreted as Younger Dryas phase braided stream channel bedforms and overbank alluvium, established the topographic basis for subsequent sediment deposition, pedogenesis, and erosion in the alluvial portion of the study area (Figures 14 and 15). The depression observed in the EBP, interpreted as an abandoned channel or scour trench, represents a depositional environment that has not been previously identified in subsurface investigations in the area.

In the depositional basin exposed in the EBP profile, interpreted as an abandoned channel or scour trench, observed soils consist of a cumulic Ab horizon, correlating to the sand-dominant WBP profile, overlying a Btb with clay lamellae (Unit 4). This soil has overprinted into well-stratified, greasy-textured, fine-grained clay loam fluvents. Stage I+ carbonate filaments (Birkeland 1999) are present in the 2Ab (Paleosol II) and 3Ab (Paleosol III). Below fluvent 4Ab (Paleosol IV), organic sediment staining is gradually reduced with depth. This stratigraphic pattern is maintained across a significant portion of the study area, and well-preserved below former fruit packing shed foundations. These deposits are interpreted as overbank alluvium accreting on the distal portion of the floodplain.
Figure 14. Generalized composite transect of soil profiles across the study area from north (45CH782) to south (45CH783), with interpreted depositional environments.
Figure 15. Composite, schematic floodplain vertical accretion model based on lithostratigraphic units (1-6) and cultural components (OCT: Old Cordilleran Tradition). Upper frame (Time 1-3) depicts the early Holocene floodplain. Middle frame (Time 4-5) depicts Mazama tephra deposition (orange line) and dramatic river incision. Lower frame (Time 5-6) depicts middle-late Holocene eolian conditions. Dashed blue line indicates the approximate Columbia River water level elevation.

The greasy-textured clay and silt loam beds (Unit 3), interpreted as fluvents formed in Columbia River overbank alluvium, provided a productive pedogenic environment because of high amounts of organic matter and colloidal material. Violently-effervescent Stage I+ carbonate filaments associated with the earliest artifact...
and Paleosol II (2Ab) implies a high cation-exchange capacity (Birkeland 1999), and may have been enhanced by human activity and organic additions (Huckleberry et al. 2003). These fluvents, formed within Unit 3, were a source of moisture and nutrients for subsequent soil development in the overlying fluvial sands (Unit 4). Vertical transfers of clays by tree roots, burrowing cicadas or small rodents may have contributed to development of a distinct argillic horizon (Btb) characterized by clay lamellae (Birkeland 1999). Moisture retained in these argillic structures (Unit 4) and underlying beds (Unit 3) likely supported favorable pedogenic conditions in the abandoned channel, even as the climate became increasingly arid in the early Holocene (Huckleberry and Fadem 2007; Davis and Schweger 2004). This interpretation is based on the relatively overthickened Ab horizon (Paleosol I) in the EBP, in contrast to the thinner Ab in the nearby WBP exposure.

At the southern end of the study area transect, sub-Mazama soils (Apb) are heavily mottled and homogenized, possibly due to exposure to fluvial erosion, riparian vegetation, intensive human land use, or poor drainage. Because of the higher elevation, late Holocene sediments mantling this section are heavily disturbed by historic land use.

A gravel berm feature, interpreted as a relict longitudinal bar, levee, or relict interfluve, protected subsequent fine-grained accretionary deposits in the abandoned channel and distal floodplain area from fluvial mixing that may have affected channel-proximal deposits at 45CH783. An east-sloping unconformity interpreted as a secondary terrace scarp suggests that fine-grained accretionary sands and clays (Units 2-3) were
only eroded east of the bar. This unconformity may be a result of erosion from high-energy stream flow associated with the final deposition of fluvial sands (Unit 4) that occurred between 8,480 ± 40 and 7,750 ± 40 BP.

Evidence of erosion on the channel-ward, eastern side of the bar includes an abrupt decrease in the elevation of the supporting gravels interpreted as a scarp resulting from lateral channel migration in the early Holocene. Below the scarp cut, just north of the existing 45CH783 boundary, no intact Mazama tephra was observed. This area is interpreted as a proximal floodplain environment exposed to middle and perhaps late Holocene Columbia River flows. Post-depositional bioturbation of soils and sediments is most pronounced in this section.

East of the secondary terrace scarp the soils and strata become increasingly mottled and difficult to trace through 45CH783. However, based on soil texture and color correlation with the EBP exposure, the fine-grained deposits overlying the gravels (Unit 1) are assigned to Unit 2 (Stratum 23). If Paleoindian-aged cultural material is present at 45CH783, then it probably derives from within or below Unit 2.

Laboratory analysis of the possible tephra samples collected from the EBP by Gentry in 2010, and submitted to the Washington State University Geoanalytic Laboratory did not identify any volcanic glass despite multiple inspections (Owen Neill, personal communication 2017). These sediment samples were found to consist of quartz and feldspar-rich alluvium. Therefore, these sediments do not represent chronostratigraphic tephra deposits as expected. These data do not address the research objective of determining the origin and extent of temporally-diagnostic
sediments. Further research will be required to identify additional temporally-diagnostic sediments in the study area, if present.

The initial appearance of a lithic artifact raises the question of how heavily and intensively the surface was occupied (Figure 16). Are the buried soils (2-4Ab) the result of habitation and soil enrichment, and/or site clearing by burning? The tawny “ash” which is not volcanic in origin, probably represents wood ash distributed over a considerable portion of the distal floodplain area. Fuller geochemical characterization and testing for animal and plant residues and genetic material might produce useful evidence. For example, at the Sentinel Gap Site (45KT1362) human activity is interpreted to have increased carbonate precipitation on the 10,200 BP occupation surface (Huckleberry et al. 2003). The input of large animal waste-tissues may have also contributed to an accretionary pedogenic environment. Fire tends to reduce the density of forbs and woody species, as well as promote rapid, nutrient-rich grass growth. While it is difficult to distinguish between natural and anthropogenic fire regimes in buried contexts, intensive fire-management may be expressed in relict soil attributes (Dormaar and Beaudoin 1991).
Figure 16. Magnetic susceptibility results. Note higher frequency-dependent values are correlated with buried soils and the highest frequency-dependent variables are associated with the first cultural stratum.
Rocky Reach and Wenatchee Reach Soils

Comparative analysis of buried paleosol exposures in the region supplemented the limited data collected in the study area (see Figures 2 and 8). Pedogenic and lithological similarities between the Chelan Station site and the Douglas Switchyard location reflect similar paleoenvironmental processes in distant Rocky Reach floodplain deposits. These early Holocene floodplain soils likely became isolated from alluvial sedimentation between approximately 9,000 to 8,000 BP. This interpretation conforms to expectations of paleoenvironmental change based on previous research (Chatters and Hoover 1992; Huckleberry et al. 2003; Schalk and Mierendorf 1983).

Upland soil exposures at Rainey Spring and Veedol Substation were found to have little in common with the Rocky Reach floodplain soils and were not included in the stratigraphic comparison. However, these upland environments, removed from the effects of LGM glaciation and subsequent outburst flooding, were a likely source of biota available to recolonize the flood-scoured Rocky Reach. At the loess-dominant Rainy Spring location, Badger Mountain paleosol occurs across in stable, topographically-protected pockets. Wind scour and agricultural plowing have disturbed diagnostic pedogenic features in more exposed areas on the spring margin. The lateral distribution of effective soil moisture appears to govern loess deposition and cumulative pedogenesis.

Observed excavation at the Veedol Substation (DPUD) at the contact between Badger Mountain landslide colluvium and Pangborn Bar loess-mantled alluvium suggests that the bouldery basalt landslide deposits described by Waitt (2016) overlie Pangborn
Bar flood deposits (Figure 17). Landslide-buried Bishop and Badger Mountain paleosols are laterally-traceable to nearby test pits exposures (Lenz et al. 2007). Further research is required to determine the extent and character of the buried contact between Badger Mountain Holocene colluvium and Pangborn Bar LGM flood deposits. This exposure demonstrates that landform and soils interpretations based on ‘windshield’ assessments of surface lithology are not necessarily representative of underlying deposits. Excavation is required to adequately evaluate deeply buried sedimentary contexts using catena (Gentry 1974; Milne 1935), or transect-oriented methods.

Figure 17. Pangborn Bar buried paleosols and tephras deposited on Missoula flood loess (Waitt 2016). Correlative exposures (left) beneath Badger Mountain colluvium (Breidenthal 2016), and (right) in the adjacent scour trench or fosse (Lenz et al. 2007).

At the Wenatchee Confluence archaeological site, multiple stacked Ab horizons developed on gravels and loamy alluvium, rich in large mammal bone fragments. However, pedogenesis seems to have been reduced considerably prior to Mazama tephra deposition. This may reflect a change from alluvial to eolian depositional regimes observed elsewhere in the Columbia Basin (Lenz 2010).
Subsurface exposures at the former Entiat town site (Steinkraus and Breidenthal 2013), which was burned and then bulldozed, reveal similarities in parent material (Unit 4) with the proximal floodplain and spring environments in the study area. Despite extensive, modern removal of most of the solum at Entiat, traces of cambic (Bw) horizon formation into massive sands, interpreted as Unit 4, suggests that sand-dominant parent material is unlikely to generate argillic (Bt) soil horizons without access to underlying or overlying clays. The relative thickness of Unit 4 fluvial sands at Entiat compared with the study area suggests it lies closer to the source of the flood (Table 3).

Table 2. Sub-Mazama Pedostratigraphic Units (N-S Rocky Reach Transect).

<table>
<thead>
<tr>
<th>Age</th>
<th>LU</th>
<th>SPRING</th>
<th>SLOPE TOE</th>
<th>DISTAL FP</th>
<th>PROX. FP</th>
</tr>
</thead>
<tbody>
<tr>
<td>6,800-8,480 ± 40 BP</td>
<td>4</td>
<td>Bwb Cb</td>
<td>Ab Bhb Ckb Ckb</td>
<td>Ab Bwb</td>
<td>Abp Bwb</td>
</tr>
<tr>
<td>8,480 ± 40-9,160 ± 50 BP</td>
<td>3</td>
<td>2Ab 2Btkb 2Ckb 3Akbb 3Ckb 4Akbb 4Ckb</td>
<td>6Cb 5Cb</td>
<td>5Bwb 6Cb</td>
<td></td>
</tr>
<tr>
<td>&lt;11,600 BP</td>
<td>1</td>
<td>2Cb</td>
<td>3AAb</td>
<td>3Cb</td>
<td></td>
</tr>
</tbody>
</table>

Depositional environments near abundant sediments sources such as floodplains are more conducive to rapid pedogenesis (Holliday 1988). At the Douglas Switchyard location on a broad, formerly active floodplain (T2) below Rocky Reach Dam, Badger Mountain paleosol exhibits well-developed carbonate filaments (2Btkb). The poorly-defined upper boundaries of Btkb horizons at both Rainy Spring and Douglas Switchyard
sites may be due to similar erosional processes and regional-scale environmental changes. Resistant Btkb horizons can be an important indicator of a buried Paleosol even in the absence of diagnostic tephra (Birkeland 1999; Huckleberry et al. 2003).

Artifact Assemblages

Lithic and faunal artifacts were observed across most of the study area. Apart from a historic root cellar dating to approximately 1919 AD found north of 45CH783, all recovered artifacts were found stratigraphically below Mazama tephra. Although the lithic assemblage collected from the Chelan Station site (45CH782/783) is not large enough to draw statistically-significant conclusions, these materials are most likely associated with the Old Cordilleran Tradition eastern variant (Butler 1961; Chatters 2017).

The lithic assemblage from Chelan Station may be useful for comparison with temporally-similar collections from the Cascade Pass Site (Mierendorf 1986), the Woodhaven Site (45SN417) near Granite Falls (Baldwin and Chambers 2014), the Plew Site (Draper 1986), and the Rock Island Overlook Site (Valley 1975) for addressing regional-scale research questions pertaining to trade, land use, population responses to PHT environmental change.

Lithic artifacts include flaked cobble tools, a bifacial lanceolate projectile point or knife, utilized flakes, multi-directional cores, and late-stage reduction or retouch debitage. The high percentage of interior flakes interpreted as tool retouch suggests that early-stage lithic reduction was not a common activity. The functions of flaked
cobble artifacts are interpreted as possible wood working, food processing, or excavation tools.

Material types include jasper, petrified wood, basalt, quartzite, and Chelan Butte obsidian. All lithic materials appear to derive from local or nearby gravels ubiquitous in the Columbia Basin. Previous investigations were unable to locate bedrock or gravel sources of Chelan Butte obsidian (Kassa and McCutcheon 2016). Chelan Butte was heavily modified by mining explorations, homesteading, and moonshining operations in the early 20th century that may have obscured potential obsidian sources. Early Holocene peoples utilizing obsidian in the study area were probably sufficiently familiar with the natural distribution of obsidian to locate the material sources more easily than contemporary investigations. Therefore, early Holocene peoples were likely not just passing through the study area, but were instead regularly occupying the area on a seasonal or permanent basis as “tethered” foragers (Willig and Aikens 1988).

In comparison to lithic assemblages from the nearby 45CH216 site complex (Wilson and Komen 2008), the Chelan Station Site (45CH782/783) assemblage is remarkably similar in terms of material types and flaked cobble/core morphology. Potentially significant differences include the presence of microblades at 45CH216 which are absent in the study area. At least one utilized CCS flake measuring approximately three centimeters in length was recovered in the WBP in association with fish vertebrae. However, this blade-shaped, utilized flake lacks prismatic morphology characteristic of microblade technology.
Considering the combination of the possible overshot flakes observed at 45CH783, bifaces with overshot flake scars at Bishop Spring (Lenz 2006), and reports of fluted point surface finds in the vicinity (Avey 1991), suggests that a Paleoindian-phase component (Frison 1991) may be present in the study area in an erosional, alluvial context. Because the possible overshot flakes remain angular, they were probably not transported far, if at all, from their primary depositional context. Intact or minimally-disturbed archaeological deposits may be preserved along braided stream channels and interfluvial features if protected from direct, high-energy stream flows (Waters 1992).

Faunal bone collected from trench facing excavations at 45CH783 by the monitoring archaeologists was not included in the archaeological investigation and was unavailable for analysis. However, these faunal remains generally consisted of fragmentary, varied elements of large mammals (i.e., bison, elk, mountain goats). These results were consistent with my observations of robust faunal bone at the Wenatchee Confluence Site, and support previous researchers’ interpretation of high productivity grasslands in the early Holocene. Mussel shell present in these sediments may provide archaeological and proxy stream flow data (Chatters and Hoover 1992). Further research is required to provide sufficient analysis of faunal remains.
CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Although much of the study area has been disturbed by historic and modern development, significant volumes of early Holocene soils and associated artifacts remain intact. The extent and character of the remaining archaeological deposits is inferred from field observations and previous excavations on the landform (Hodges and Ray 2007; Schalk and Mierendorf 1983). In the EBP area, buried paleosols remain protected by substantial Mazama tephra deposits and historic fruit industry building foundations. These data may be used in planning future ground disturbing activities and associated CRM data recovery excavations near the study area. The sites should be nominated for the NRHP and future research should follow a research design outlined in an historic properties treatment plan.

Archaeological Deposits and Data Potential

The recovered cultural material was sparsely distributed along the pipeline transect (Schumacher 2010), and not large enough to draw statistically-significant conclusions. However, the artifact assemblages retain significant information on early Holocene land use in the study area, as well as along the cross-mountain travel routes associated with the Stehekin, Skagit, Stillaguamish, and Columbia River valleys. The Chelan Station lithic assemblage may reflect similar patterns as the sub-Mazama component at the Cascade Pass Site, indicating early Holocene population dispersal east from Puget Sound via the Stilliguamish and Skagit River Valleys (Mierendorf et al. 2006).
The lack of microblade technology below Mazama tephra is consistent with the conclusions of previous investigations in the Columbia Basin (Draper 1986; Galm et al. 1981; Wilson and Komen 2008). Despite Mazama tephra deposition, populations added microblade technology to the established Old Cordilleran Tradition cobble tool industries (Draper 1986).

The depositional chronology of the Chelan Station site suggests the study area was occupied by humans while the Columbia River floodplain was considerably more active than during the historic period (Fecht and Marceau 2006). People utilizing flaked cobble tools were present in the study area before 8,480 ± 40 BP when at least one Columbia River flood deposited over 60 cm of sand across most of the study area.

Alpine Influences

Based on AMS dating of underlying buried paleosol (2Ab) at 8,480 ± 40 BP (Schumacher 2011), this flood deposit (Unit 4) may correlate with an early Holocene cold climatic episode (Nickmann and Leopold 1985), and the Brisingame and White Chuck alpine glacial advances from approximately 8,400 to 8,200 BP (Clark et al. 2002; Waitt et al. 1982). Alluvial landforms at similar elevations (224 m/742-778 ft.) in the Rocky Reach may have been influenced by increased streamflow and sediment delivered from proximal Cascade Range alpine glacial advances (Gough 1995; Mierendorf 1983; Waitt 1977).

The influence of Younger Dryas phase alpine glaciations (Long 1989; Porter and Swanson 2008; Reasoner et al. 1994; Waitt 1977) on fluvial landforms in the study area
may have been significant. Basal deposits in the study area consisting of bedload gravels (Unit 1) overlain by upwardly-fining white sand and silt (Unit 2) may represent a Younger Dryas phase periglacial floodplain environment dominated by high energy stream flows. Alpine glacial advances in tributary valleys such as the Okanogan, Methow, Stehekin, Entiat, and Wenatchee may have generally increased stream flow and sediment deposition along the Rocky Reach.

High Lake Chelan levels in the early Holocene may have been a significant influence on Beebe Springs’ hydrology and the associated pedogenic environment at the Chelan Station site. Based on the lack of recognizable middle Holocene soil development in the WBP portion of the study area, reduced groundwater discharge changed the depositional environment. This inferred change may have resulted from reduced, sub-historic water levels in the Lake Chelan Basin during the arid middle Holocene. Based on varve count estimates, Lake Wenatchee was also possibly reduced to historic or sub-historic water levels as early as 150 years after Mazama tephra deposition (Breidenthal and Miller 2015).

Additionally, Beebe Springs hydrology has been influenced by tectonic activity, as demonstrated by ethnographic accounts of the 1872 AD earthquake (Hackenmiller 1995). Similar seismic displacements may have affected local fault mechanics and groundwater discharge at Beebe Springs throughout the Holocene. Cemented gravelly sand lenses (Unit 6) overlying Mazama tephra (Unit 5) in the WBP, interpreted as high-energy spring discharge alluvium, may indicate a cyclic pattern of fault-controlled spring
hydrology (Alfaro and Wallace 1994). Further research into sediment lithology and trace minerals preserved near the WBP may address these broader geologic questions.

Radiometric assay results of bulk carbon from buried paleosols in the EBP conform with expectations based on previous research (Schumacher 2011). However, the presence of overshot flakes at 45CH783, indicative of late Paleoindian lithic traditions (Frison 1991), on a cobble surface in association with faunal remains suggests that further research is required to determine whether intact Paleoindian sites may be preserved on the Columbia River floodplain in the Rocky Reach (Gough 1995).

Salmon and shellfish were present in formerly glaciated portions of the Columbia River Valley as early as 9,500 calendar-years ago; roughly less than 700-2,300 years after lesser outburst floods impacted the Wenatchee and Rocky Reaches (Brooks and Crider 2007; Galm and Matsen 1985). Although the sample of possible salmonid vertebrae (n=9) is statistically insignificant, and not directly dated, the presence of salmonids associated with stone cutting tools (Schumacher 2011) supports an interpretation of productive salmon habitats in formerly glaciated portions of the Columbia River Valley as early as 9,500 cal BP. This is less than 3,500 years after terminal Pleistocene megaflooding (Balbas et al. 2017; Brooks and Crider 2007; Gough 1995; Waitt 2016), and approximately 700-2,300 years after lesser outburst floods impacted the Wenatchee and Rocky Reaches (Brooks and Crider 2007; Galm and Matsen 1985). Future genetic analyses may identify more specific fish genetic information from this assemblage, useful for addressing evolutionary research questions in the Columbia River Basin during the PHT (Waples et al. 2008).
Pedogenic evidence of human activity includes the increase in bulk soil organic matter inferred from color changes observed in the EBP fluvents (Unit 3), and the well-developed carbonate filaments associated with the lower flaked cobble artifact. Human activity may have increased carbonate precipitation (Huckleberry et al. 2003) as well as additions of organic material to these buried paleosols. Anthropogenic additions likely include salmon-derived nutrients (D'Amore et al. 2011; Gende et al. 2007), grasses utilized for food or structures (Yost et al. 2009), and possibly woodworking debris.

Charcoal features interpreted as burned shrubs (i.e., big sage) preserved on the Badger Mountain paleosol surface (Lenz 2010), just below Mazama tephra, may represent the intentional burning of brush as a mollisol conservation strategy. Burning to improve growing conditions for edible grasses and herbs, such as lambsquarters (Mierendorf et al. 1977), may have also been an attempt to encourage ungulate productivity (Dormaar and Beaudoin 1991), or enhance group security.

Mazama tephra deposition effectively ended recognizable soil horizon formation in most of the study area. If later Holocene soils developed, then they were disturbed or removed in the 20th century. Although approximately 12 cubic meters of post-Mazama sediment (Unit 6) in the WBP area was sampled, no cultural material was observed. The absence of cultural material correlating with a pedogenic hiatus in the middle Holocene suggests that Beebe Springs became less productive in terms of effective moisture. Alternatively, human populations may not have been large enough to produce an effective archaeological signature. Cultural hiatus associated with the Mt. Baker BA tephra and Glacier Peak “Dusty Creek” tephras at Cascade Pass (Mierendorf et al. 2006),
may be a result of catastrophic lahar flows (Hildreth et al. 2003) significantly reducing adjacent riverine populations. In any case, evaluating possible factors contributing to the interpreted early-middle Holocene land use change at Chelan Station will require extensive further research.

Archaeology, CRM and NRHP Nominations

Archaeological research is primarily concerned with the form and distribution of cultural material over time. Hypothesized relationships between these variables drive archaeological research questions (Spaulding 1960). Because the CRM regulatory framework requires the evaluation of archaeological deposits as finite properties, or sites (Dunnell 1971), assessments of archaeological significance under NRHP criterion D are primarily concerned with the integrity of archaeological deposits and the availability of information for addressing existing research questions and data gaps in the archaeological record (King 1998).

Compliance-driven CRM investigations identify and define archaeological deposits based on the extent of observed artifacts within a limited project area. Sampling methods are directed at determining the extent, integrity, character, and ultimately the significance of archaeological deposits. Given the sparse and generally uneven distribution of the PHT archaeological record, significant data gaps can be filled with minimal data collection effort.

The significance and character of an archaeological site is difficult to objectively evaluate. Under NHPA, informational value is a criterion for significance and inclusion on the National Register of Historic Properties. Significance is evaluated, sometimes
subjectively, based on context, depositional integrity, or potential to contribute new information. A determination of register eligibility (or potential-eligibility) increases the protective protocols afforded to cultural deposits, as well as increased potential management costs. Significance of surface cultural deposits is difficult to evaluate because these deposits are typically disturbed by natural (i.e., wind blowout) or anthropogenic processes (i.e., plowing, road building). Because many surface sites lack integrity, CRM evaluation mechanisms often determine them to be less significant than well-stratified, buried sites. Non-cumulic pedogenic environments, in general, retain greater archaeological data potential by providing finer chronostratigraphic resolution and reducing peri-depositional artifact mixing.

The buried archaeological deposits preserved at the Chelan Station Site (45CH782/783) retain significant archaeological data potential addressing regional-scale research questions, and should be nominated to the National Register of Historic Places under criterion D. Based on the observed similarities in cultural material, soils, and landform age, archaeological sites 45CH782 and 45CH783 should be managed congruently. Because the existing site boundaries do not accurately reflect the extent of observed artifacts, it is likely that any future subsurface investigations would result in the site boundary expansions.

The archaeological site boundary of 45CH783 should be updated to better represent the extent of observed artifacts, including the historic root cellar that was not recorded by the principle investigator. Based on the 1919 AD-dated glass jars found within the feature, the root cellar may be associated with the regional introduction of
rail service and mechanized agriculture (Mitchell 1968). The cellar feature may also be associated with Indian allotment property, and could potentially provide empirical archaeological information on nationally-significant historical figures such as Chelan Bob, Cultus Jim, Long Jim, and A.W. LaChappelle (Marchand 2007). This nomination may supplement the existing Beebe Springs Traditional Cultural Property (TCP) eligible under criteria A, B, and D (Marchand 2007; Stevens 2008).

Local production of trade goods derived from resources such as mountain goats, bison, grasses, and Indian hemp likely occurred in the study area during the early Holocene. Demand for these products in densely-populated Puget Sound may have increased the intensity of land use in the study area. Trading parties travelling between Puget Sound and interior exchange centers such as Okanogan Falls, Kettle Falls, Wenatchee, and Kittitas may have utilized Chelan Station as a minor exchange center, portage camp, rendezvous, or religious site (Marchand 2007). Chelan Station archaeological deposits likely retain evidence of intensive trade good production reflected in lithic and faunal remains, ochre concentrations, and organic residues. The well-stratified deposit at Chelan Station preserves a record of environmental and cultural change, and provides an opportunity to test regional archaeological research questions (Figure 18).
Figure 18. Landscape reconstruction of the Columbia River Valley at Chelan Station in the early Holocene. The overview looks south from a vantage point on the Great Terrace (Waters 1933) down towards the Chelan River delta in the distance. A hypothesized trail approximating the Chelan Military Road (Marchand 2007) ascends from Beebe Springs up the Great Terrace scarp in the right foreground. 45CH782 is located near the two pines in the center. 45CH783 lies beyond and to the left of the abandoned channel. Illustration by Lindsay Breidenthal.

Future Research

Because the study area is limited by impenetrable surfaces, disturbed areas, and access to private property, future test excavation should focus on intact, well-stratified deposits that were not adequately tested in 2010. Future supplemental testing should utilize one-by-two meter units, excavated by natural and arbitrary 10-cm levels, to recover samples adjacent to the pipeline route. To determine the extent of remaining
chronostratigraphic deposits on the Beebe Springs alluvial fan and Columbia River secondary terrace landforms, the proposed research design should utilize 10 cm-diameter auger probes arrayed on a 10-meter grid. Auger probing is an expedient and minimally destructive technique that should provide adequate resolution to reconstruct pertinent paleotopographic features which may have created favorable environments for subsequent alluvial, eolian, and anthropogenic deposition.

Additional test excavation should focus on obtaining adequate representative sediment samples, which would provide more specific environmental reconstruction. Changes in plant biomass overtime could be quantified from sediment samples (Cerling 1984; Nordt et al. 2002). Opal phytolith analysis would be used to identify taxonomic groups of grasses, sedges, conifers, herbs, and shrubs present in the study area (Blinkov et al. 2002; Norgren 1973). These data could then be integrated into a regional paleoenvironmental model.

Additional sampling of alluvial sediments (units 1-4, 6) may provide flood sourcing data using trace mineral composition analyses (Hanson et al. 2015), and contribute to the development of the regional alluvial chronology. Remaining possible tephra samples include a thin, white bed at the Unit 4/3 contact just east of the EBP. Also, Unit 2 may represent a secondary deposit of possible Glacier Peak B/G tephra. Future sampling of these possible tephras may answer geochronological questions that the limited sample available in this study were unable to address.
Future test excavation would likely expand the sparse lithic assemblage, which is predominantly composed of debitage and tools such as bifaces, utilized flakes, and flaked cobbles. Diagnostic tool recovery would enhance the existing geochronological data. Future research design should investigate the sources of lithic material-types present in the study area such as jasper, petrified wood, basalt, quartzite, and Chelan Butte obsidian. If Skagit Valley-sourced material such as Hozomeen Chert (Mierendorf et al. 2006) can be identified at Chelan Station, it would likely provide valuable lithic reduction trajectory data. The assemblage should be characterized with a technological paradigmatic classification (McCutcheon 1997), allowing inter-site comparisons and modeling of land use change over time in the Rocky Reach (Kassa and McCutcheon 2016).

Buried Paleosol Data Potential and Management

Cultural resources, as well as their landscape context, have potential value under aesthetic, informational, economic, utilitarian, and associative/symbolic criterion, which are dependent on the subjective theoretical framework of the valuator (Lipe 1974). Accordingly, the informational value of a cultural deposit is difficult to quantify, although some activities that affect cultural deposits have economic components that can be used for comparison (Lipe 1974).

As demonstrated in the study area, buried soils may provide useful data to build landscape context even in the absence, or scarcity, of observable cultural material. Because paleosols reflect the interactions of biota subject to selective pressures, pedogenic features are a function of the extended composite phenotypes of associated
organisms (Phillips 2009). Where ancient human land use is a pedogenic factor, paleosols represent the cumulative effects of human extended phenotypes. Therefore, buried paleosols associated with human land use, and stratigraphically isolated from significant post-depositional bioturbation, should be considered cultural features.

Human-influenced buried soil should be managed as cultural features by utilizing the existing DAHP WISAARD database. Identified buried paleosols could be added to WISAARD as point, line, or polygon data. These data will be useful for archaeological research targeting deeply buried sedimentary contexts, as well as promoting the conservation of potentially undervalued paleoenvironmental data. Future improvements to genetic and organic residue sampling technologies (i.e., FTIR, sedaDNA) may enhance the data recovery potential from buried paleosols in unanticipated ways. Standardizing soils data collection methods between CRM consultants and government agencies (i.e., USDA and NRCS) may maximize data recovery benefits by sharing subsurface sampling results cooperatively.

Understanding the spatial distribution of alluvial landforms, buried soils, and temporally-diagnostic sediments (Lenz 2010) enables cultural resource managers to focus subsurface reconnaissance efforts in appropriate areas. Development of a valuation framework for archaeological and associated paleoenvironmental deposits may allow for more cost-effective assessment of data recovery potential. Providing cultural and natural resource managers with quantitative volumetric data may help improve management practices.
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APPENDIXES

Appendix A—SEPA Chelan PUD Hatchery Well Field Pipeline

11. Give brief, complete description of your proposal, including the proposed uses and the size of the project and site. There are several questions later in this checklist that ask you to describe certain aspects of your proposal. You do not need to repeat those answers on this page. (Lead agencies may modify this form to include additional specific information on project description.)

In order to meet commitments identified in the District’s HCP, additional instantaneous water flow is required at Chelan Hatchery by June 2010. In recognition of this requirement, the District is engaged in an on-going effort to secure a sustainable water supply from the hatchery’s primary water supply, the Chelan Hatchery Wellfield. Recent performance testing indicates the wellfield can supply the required peak instantaneous flow of 7,200 gpm for short durations and additional wells are planned to bring the wellfield into full sustainability during 2009. However, the existing water transmission main running from the wellfield to the hatchery has a limited capacity of approximately 5,800 gpm.

The condition of the existing water transmission main, constructed in 1964, is considered poor due to the number of leak repairs made over the years. Based on the result of recent thickness testing of the pipe, it is believed the pipe was not bedded (with sand and pea gravel) and appears to have moderate amounts of corrosion on the exterior, particularly the underside. The poor condition of the pipe has raised concern over whether the pipeline can accommodate an increase in pressure associated with an increase in flow.

At this time, it is impossible to ascertain the pressure capacity of the existing main without putting the pipe at a high risk for failure; a major leak or combination of several small leaks resulting from the pressure increase at 7,200 gpm would place the hatchery water supply at great risk during a time period of greatest need.

Based on a feasibility analysis recently conducted to evaluate alternatives for delivering the full 7,200 gpm flow required, the District has determined the construction of a new transmission pipeline is necessary. The existing pipeline will be left in place for emergency use. The proposal involves the installation of a new 28-inch DR 17 High Density Polyethylene (HDPE) transmission pipeline. The new pipeline will begin at the existing wellfield and terminate at the hatchery aeration towers, with a length of approximately 4,000’.

Construction of the new pipeline will require trenching and placement of bedding material prior to installation of the new line. The trench will measure approximately 4,000’ long x 8’ wide x 6’ deep, for a total of 7,111 cy. A portion of the material removed
during the trenching process will be used to backfill the trench following placement of the pipeline. That portion not used to backfill will be disposed of off-site. After trenching, but prior to placement of the pipeline, approximately 2,919 cy of bedding material (sand and pea gravel) will be placed in the trench. The pipeline will then be laid in place and excavated material will be used to backfill the trench.

13. Historic and cultural preservation

a. Are there any places or objects listed on, or proposed for, national, state, or local preservation registers known to be on or next to the site? If so, generally describe.

No. There are no places or objects included or proposed for inclusion on national, state, or local preservation registers.

b. Generally describe any landmarks or evidence of historic, archaeological, scientific, or cultural importance known to be on or next to the site.

There are no known landmarks or evidence of historic, archaeological, scientific, or cultural importance on or next to the site.

c. Proposed measures to reduce or control impacts, if any: N/A

Update: July 13, 2009. DOT inquired about cultural resources and it was determined that a project specific survey is required for this project. Will add the report by CRC to the file when complete.
Appendix B—Determination of Nonsignificance for Chelan PUD Pipeline

**Determination of Nonsignificance**

**Description of Proposal:** *Chelan Hatchery Well Field Transmission Pipeline.* Because the existing pipeline does not have the capacity nor integrity to transmit the full amount of water needed at the Chelan Hatchery, Public Utility District No. 1 of Chelan County proposes the construction of a new water transmission pipeline to convey hatchery supply water from the existing Chelan wellfield to the hatchery.

**Proponent** *Public Utility District No. 1 of Chelan County.*

**Location of proposal, including street address, if any:** The site is located in the western 1/2 of Sections 20 and 29 Township 27, Range 23. The pipeline will begin just southwest of the Highway 97 Beebe Bridge and run north, terminating at the hatchery to the northwest of the bridge.

**Lead Agency:** *Public Utility District No. 1 of Chelan County*

The Lead Agency for this proposal has determined that it does not have a probable significant adverse impact on the environment. An environmental impact statement (EIS) is not required under RCW 43.21C.030(2)(c). This decision was made after review of a completed environmental checklist and other information on file with the lead agency. This information is available to the public on request.

This DNS is issued under RCW 197-11-340(2). Comments must be submitted by **April 28, 2009.**

**Responsible Official:** Jennifer Burns

**Address:** *P.O. Box 1231 Wenatchee, Washington 98807*
Appendix C—WSU Geoanalytic Lab Tephra Report

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Make checks payable and remit to:  
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University Revenues Cashier  
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Pullman, WA 99164-1099

The total amount is due upon receipt of this invoice.

Checks should include:  
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• Invoice Number  
• Item Types (subcodes) if payment is not in full

*Your social security number is requested for purposes relating to the extension of credit to you. Disclosure is not required by law. If you choose not to disclose your number, you will be required to pay in full at the time service is provided.*