MID-HOLOCENE RIVER DEVELOPMENT AND SOUTH-CENTRAL PACIFIC NORTHWEST COAST PREHISTORY: GEOARCHAEOLOGY OF THE FERNDALE SITE (45WH34), NOOKSACK RIVER, WASHINGTON

By

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Accepted in Partial Completion

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In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

By
Richard M. Hutchings
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ABSTRACT

Sediments, soils, mollusks and fish in archaeological context are used to deduce mid-Holocene delta positions and reconstruct the paleoenvironment of a southern Pacific Northwest coastline. Recent investigations on the upper Nooksack River delta in western Whatcom County, northwestern Washington State, provide evidence for a temporal delay in delta construction and a model for applying geological evidence to mid- to late-Holocene site location. Geoarchaeological and paleoecological data derived from the 6 mile (10 km) inland alluvial Ferndale archaeological site-complex, including the shell midden site 45WH34, are used to test two models of Nooksack delta development in an effort to better explicate the complexities associated with human land use patterns in a dynamic coastal plain river valley. One developmental model places the lower Nooksack River in its present watershed by 9000 BP and suggests the delta has prograded seaward (i.e. away) from the site-complex at a steady rate to its modern position. Under this model it is expected that archaeological deposits and associated geological materials at the site-complex would increasingly reflect inland riverine/terrestrial conditions across the mid-Holocene horizon. An alternative model suggests the lower Nooksack River did not occupy its present watershed until late in the Holocene thereby delaying the onset of delta progradation. Under this model it is expected that archaeological deposits and associated geological materials at the site-complex would reflect a small and geologically stable river valley (i.e. not including the Nooksack River) and proximal stable marine paleoshorelines until the late-Holocene avulsion and concomitant delta progradation.

This thesis uses on-site data collected during the original 1972 excavation of 45WH34, including profile descriptions of excavated units and sediment samples, to test the validity of the originally proposed depositional event sequence. The primary objective is to test the original interpretation that 45WH34 represents some 5000 years of continuous cultural activity. Utilizing a geoarchaeological approach I define analytic units and propose a new chronostratigraphic sequence for 45WH34. Results of twelve new radiocarbon assays and sedimentological and pedological data derived from 16 soil pits are subsequently used to refine that chronostratigraphic sequence. Other geoarchaeological considerations include investigations of fish and shellfish remains from the Ferndale site-complex shell midden, geoarchaeological investigations at the upper delta East Ferndale site-complex, and consideration for the effects of post-depositional change. A new depositional and post-depositional history is proposed for the Ferndale site-complex that brackets cultural deposition to between 5000 and 4000 BP, not the approximately 5000 years of activity initially asserted.

The model implying the Nooksack delta has been active for much of the Holocene is rejected because of the unusually small size of the modern Nooksack delta and the presence of marine shellfish and fish remains at the inland site-complex that date to between 5000 and 4000 BP. A survey of mid-Holocene faunal assemblages from upper-delta sites located on neighboring coastal river systems shows dynamic subsistence patterns across the mid- to late-Holocene horizon. These changes are thought to reflect adaptations to changing environmental conditions associated with the onset of delta progradation after 8000 BP. The Ferndale record however does not fit this pattern. Continuity in relative abundance of rocky shore shellfish and marine fish remains between 5000 and 4000 BP at 45WH34 are suggestive of a stable rock substrate shoreline during a period generally associated with seaward delta growth marked by accumulation of soft sediment, environmental change towards inland terrestrial/riverine ecosystems and human adaptation. These observations suggest a temporal delay in Nooksack delta development occurred and support the late-Holocene avulsion. Further support for a late-Holocene avulsion includes geological and pedological evidence for a relatively stable alluvial landscape between 10,000 and 4000 BP at the Ferndale site-complex. After 4000 BP there is evidence for increased flood regimes that produced higher frequencies of silt and clay in the upper shell midden horizons. Whether or not increased alluvial activity is attributable to an avulsion event that eroded occupations subsequent to 4000 BP or altered subsistence or settlement patterns remains unclear. Possible explanations for cultural changes after 4000 BP include adaptations to newly formed riverine/terrestrial ecosystems, site relocation downstream to new estuarine and littoral zones where access to shellfish and fish resources was more direct, or a combination of both.
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Anthropologists recognized nearly a century ago that environment does not cause culture, but many have since shown that environment and culture are inextricably intertwined (Sandweiss 1996:127). The last three decades of archaeological research on the Southern Northwest Coast reflect an ecosystem approach emphasizing interactions between multiple cultural and environmental variables:

Although this approach is critiqued for masking some cultural variations, it has nevertheless proved very productive in some areas of research. Environmental change has often been, and continues to be, an important component of cultural history. Archaeologists are uniquely situated to trace environmental change and its long-term human consequences. (Sandweiss 1996:127)

Different factors (e.g. landscape, floral, faunal, climatic and cultural) can initiate systemic disequilibrium resulting in the appearance, reorganization, or abandonment of prehistoric settlements (Waters 1992:5). Models explicating prehistoric human adaptive strategies for the Pacific Northwest Coast have traditionally emphasized either cultural or landscape factors. Explanations for adaptation initiated by changing landscape factors most frequently address the biological and archaeological implications of relative sea level change (e.g. Fladmark 1975; Grabert 1983). Because the implications of relative sea level change are wide-ranging and often produce results specific only to an individual site, this study offers an alternative approach.

Recognizing that prehistoric Northwest Coast hunter-fisher-gatherers preferably occupied ecotonal estuarine and deltaic positions, and that in most areas sea levels were near their present positions by 5000 years ago, I consider river change to be an equally powerful factor influencing cultural adaptations. This view emphasizes the unique characteristics of the individual river system and the watershed that constrains it. It also builds on previous research showing how environmental change in coastal river systems has affected patterns of human subsistence and settlement at global (e.g. Stanley and Warne 1997), regional (e.g. Waters 1992) and local scales (e.g. Stilson 1972).
Previous research in the Southern Northwest coast, particularly centered around the Fraser River, has shown that coastal riverine and estuarine systems played a central role in the development, structure and maintenance of complex economies. Understanding Holocene environmental change is central to anthropological interpretation because attempts to offer ecological explanations for differences in cultural systems are dependent upon the capacity to compare and contrast different evolutionary contexts (i.e. ecosystems) (Schalk 1977:207). Understanding river change, specifically mid- to late-Holocene delta progradation, is key to explicating the timing and nature of human activity at the Ferndale site-complex, a 5,000 year old shell midden inland on the upper delta of the Nooksack River.

It has long been recognized that the lower Nooksack River is, and has been, a dynamic fluvial system, particularly in its lower reaches near the delta and estuary (Easterbrook 1962, 1971; Jones and Jones 1973; Kovanen 2002; Reagan 1917; Wahl 2001; Whatcom County 1998). Despite the known socioeconomic importance of the Nooksack River to prehistoric (Grabert 1983; Grabert and Griffin 1983; Griffin 1984; Reagan 1917), ethnohistoric (Boxberger 1989; Collins and Sheikh 2002; Judson 1984; Kangas 1993; Reid 1987; Richardson 1975; Richardson and Galloway 1989; Stern 1932; Tremaine 1975, 1983; Wahl 2001) and modern populations (Boxberger 1989; Jones and Jones 1973; Whatcom County 1988, 1998, 1999), little attention has been paid to its Holocene geological or biological development. Recognizing that environmental change in coastal river systems can affect patterns of human subsistence and settlement, the paucity of quantitative environmental data regarding lower Nooksack River change is considered a major limiting factor to the quality of anthropological research. Despite the many benefits of a multidisciplinary approach to the archaeology of alluvial landscapes (cf. Brown 1997; Dincauze 2000; Holliday 1992; Nicholas 1988; Reitz et al. 1996; Stein and Farrand 2001; Waters 1992), few studies have attempted to define important interactions between cultural and environmental variables for the lower Nooksack River watershed.

One exception however is Grabert's 1983 interpretation of lower and middle Nooksack River valley prehistory. His analysis frequently invoked environmental explanations for the type and location of archaeological deposits he encountered. Despite his attempts to define human-environment relationships, Grabert was severely limited by a small Holocene environmental database, thus he was unable to develop a model for prehistoric lower Nooksack River land use that accurately reflected prehistoric environmental conditions. A newly expanded geological database, in concert with more recent alluvial geoarchaeological method and theory, provides both the opportunity and framework for reassessing lower Nooksack River prehistory.

Over three decades ago archaeologist Garland Grabert of Western Washington University surveyed and excavated the 6-mile (10 km) inland lower Nooksack River Ferndale site-complex. It is located in western Whatcom County, northwestern Washington State. By far the most unique feature of the Ferndale site-complex are deposits containing remains of processed marine shellfish. Unto themselves shell middens are not unique, in fact they are the most visible class of remains on the Pacific Northwest Coast, that materials associated with these shellfish deposits were dated to nearly 5000 years old and today are located 6 miles from the coastline is, however, considered anomalous. Several lithic scatters found on the surface of the adjacent terrace were
recorded as separate sites, but believed by Grabert to be related to, as well as predating, the oldest component at 45WH34.

Based on his 1972 excavation of the site-complex shell midden (45WH34) Grabert attempted to place the site-complex in environmental context. His working hypothesis, as stated in his site-complex summation *Ferndale in Prehistory: Archaeological Investigations in the Lower and Middle Nooksack Valley*, utilized geological evidence to aid in inland archaeological site prospection and interpretation (Grabert 1983). Grabert (1983) attempted to delineate relationships between geological and archaeological data. His hypotheses were never fully explored and remain wholly speculative. Grabert suggests cobble tool deposits found in association with terraced terminal-Pleistocene sediments at Ferndale provided evidence for elevated paleoshoreline positions. Grabert (1983) also suggests the site-complex shell midden (i.e. 45WH34) and terrace sites might provide data reflecting relative sea level change and show chronological continuity between the "older" terrace components and the basal strata of the shell midden. Thus Grabert indirectly recognized the cultural consequences of delta progradation.

Rather than focusing on Holocene sea level change as a prime mover for prehistoric land use patterns, this study emphasizes the role of changing river systems on human patterns of subsistence and settlement. Cultural response to river change at regional scales includes the migration of prehistoric settlements upriver or downriver through time. The fundamental assumption behind the chronological ordering of archaeological sites across the landscape is that prehistoric people found it advantageous to locate their sites in close proximity to a particular landscape (often estuarine or littoral zones) where they had uninhibited access to a specific resource, or set of resources (Waters 1992:272). On the Atlantic Northeast Coast of North America there is evidence that the earliest and longest occupied sites tend to be found on the lower parts of the river, near the oldest part of the estuary, and more recent occupations are found upstream (Thornbahn and Cox 1988:175). For the Atlantic Coast Charles River (Dincauze 1973) and Merrimack River (Barber 1979), archaeologists hypothesize that the estuaries forming after the transgression (i.e. advance) of salt water up these river valleys attracted prehistoric groups to these settings because of an abundance of food resources there, especially shellfish and anadromous fish (Thornbahn and Cox 1988:175). Conversely, on the Gulf Coast Mississippi River delta prehistoric hunter-gatherers are believed to have "pursued" estuarine, littoral and nearshore resources seaward through time in response to mid- to late-Holocene delta progradation, eventually leaving behind a chronological sequence of archaeological sites across the landscape (Gagliano 1984; McIntire 1971; Waters 1992:272). Unlike transgressive landscapes, in progradational settings the earliest sites tend to be found inland where the paleodelta was first established, with sites becoming younger towards the modern shoreline.

Fundamental to environmental archaeological research, and to this study of the Ferndale site-complex, are the notions that although environment does not cause culture, environment and culture are inextricably intertwined, and that geoarchaeologists are uniquely situated to trace environmental change and its long-term human consequences. Geoarchaeology is a major branch of environmental archaeological research that utilizes the methods and theories of earth sciences (Butzer 1982). Because geoarchaeology provides input as to why people were at a certain location, what they did there, and what has happened to their record since they left
(Cremeens 2004:39), it is an important addition to more traditional views of lower Nooksack River prehistory. Archaeological geology is geology pursued with an archaeological bias or application (Butzer 1982:5). Application of archaeological geology research to the lower Nooksack River area can also be used to refine and expand more traditional geological views of lower Nooksack River development. Both theoretical frameworks apply equally well to the intentions of this study. The interpretation of past human ecology, subsistence strategies, and settlement patterns is enriched by the addition of soil and sediment analyses to archaeological interpretation (Scudder 1996:55). Conversely, archaeologists are uniquely situated to trace geological change and its long-term human consequences.

A geoarchaeological assessment of lower Nooksack River prehistory is warranted for several reasons. Only four studies (Montgomery 1979; Grabert 1983; Grabert and Griffin 1983; and Griffin 1984) have considered lower Nooksack River prehistory, and of these, only Grabert (1983) addressed the upper delta. All of these studies are over twenty years old and none utilized geoarchaeological approaches. They referred to, but did not test Easterbrook’s model of lower Nooksack River delta development (i.e. Easterbrook 1962, 1973). A recently expanded geological database has led to the development of a new model (Pittman et al. 2003) that directly challenges Easterbrook’s assumptions. This provides the opportunity to apply archaeological data to testing these competing models, and in the process, to better understand the paleoenvironment in which the occupants of the Ferndale site lived.

Easterbrook (1962, 1971) dates the beginning of Nooksack delta growth to the terminal-Pleistocene Sumas Stade of Fraser Glaciation, when meltwater streams first began depositing sediment into the sea at a level within a few tens of feet of the present.

These early deltaic deposits are now buried beneath the modern floodplain and delta. In its early phases of development the delta was well upstream, at least as far as Ferndale, and what is now Lummi Peninsula was an island, separated from the mainland by arms of the sea on either side. Accumulation of sediment at the delta over a period spanning perhaps 9,000 to 10,000 years in post glacial time caused it to extend southward until it reached the island (now Lummi Peninsula) and annexed it to the mainland. (Easterbrook 1971:29)

Utilizing aerial photo interpretation of oxbows and previous geological studies of the Sumas Valley (i.e. Cameron 1989) Pittman et al. (2003) have recently argued for a late-Holocene avulsion of the lower Nooksack River. They propose the Nooksack River drained north into the Canadian Fraser River for much of the Holocene period, only to avulse to its present watershed sometime during the late-Holocene period. I extend this model and suggest that without the Nooksack River's sediment load, the small local coastal plain watershed (i.e. without the Nooksack River) was incapable of delivering the necessary sediment required to fully initiate delta progradation. In essence this extension of their model views the avulsion event and initial delta construction as concomitant events. Under this view the timing of the avulsion event is also the timing of initial delta progradation. Pittman et al.’s model can be clearly delineated from earlier attempts by Easterbrook (1962, 1971) to explicate lower Nooksack River Holocene geological history.
In light of our understanding of alluvial geoarchaeology method and theory (e.g. Brown 1997; Ferring 1992; Gladfelter 2001), and Waters (1992) chronological ordering model, both Easterbrook’s (1971) and Pittman et al.’s (2003) models have predictable outcomes for prehistoric populations occupying the lower Nooksack River during the mid- to late-Holocene period. Easterbrook’s developmental scheme places the lower Nooksack River in its present watershed by 9000 BP and suggests the delta has prograded seaward (i.e. away) from the site-complex at a steady rate to its modern position since that time. Under this Model it is expected that archaeological deposits and associated geological materials at the Ferndale site-complex should increasingly reflect inland riverine/terrestrial conditions across the mid-Holocene horizon. Delta sites with evidence of coastal adaptations subsequent to 45WH34 should be located downstream of Ferndale and should reflect gradual delta growth.

The developmental scheme of Pittman et al. (2003) suggests the lower Nooksack River did not occupy its present watershed until late in the Holocene, thereby delaying the onset of delta progradation. Under this model it is expected that archaeological deposits and associated geological materials at the site-complex should reflect a small and geologically stable river valley (i.e. not including the Nooksack River), and proximal stable marine paleoshorelines, until the late-Holocene avulsion and concomitant onset of delta progradation. Delta sites with evidence of coastal adaptations subsequent to 45WH34 should be located downstream of Ferndale, should reflect rapid delta growth, and the chronological sequence should reflect the late-Holocene timing of delta progradation.

To test these models and their relevance to lower Nooksack prehistory I correlate geographical, geological, pedological and archaeological data for the lower Nooksack River. The structure of this paper is divided into four parts. In Chapter Two I trace the paucity of alluvial geoarchaeological studies on regional delta landscapes; this is remedied by a survey of southern Pacific Northwest Coast delta archaeology. Data is derived from the Fraser River delta, the Skagit River delta, and Nooksack River delta. A survey of southern Coast delta archaeology between 1895 and 1970 provides important insight into late-19th century delta conditions as well as insights into geomorphology, soils, hydrology, floral and faunal succession, environmental richness, sea level change, delta progradation, and issues of site preservation in assessing archaeological context. A subsequent discussion of delta archaeology since 1970 emphasizes mid-Holocene estuarine and delta adaptations in the Strait of Georgia/Puget Sound region. Of greatest interest to this study is Stilson's (1972) model developed on the Puget Sound Skagit River delta that allows archaeologists to predict changes in the zonal ratios of the faunal assemblages at a hypothetical site whose inhabitants were utilizing marine resources and who were affected by delta progradation. His model is applied to the shellfish and fish remains recovered from the Ferndale site-complex shell midden (Chapter Four) and provides additional evidence for mid-Holocene environmental conditions. Chapter Two concludes with a survey of lower Nooksack River archaeology, including the Ferndale site-complex, and considers their age in light of their location within the watershed.

Chapter Three provides a foundation for considering the lower Nooksack River in geoarchaeological context. An examination of alluvial geoarchaeological method and theory is followed by considerations for
lower Nooksack River geography, ethnography, flora and climate, geology and pedology. Hydrological data, geological data and pedological data all show the Ferndale site-complex exists at a transitional zone on the coastal plain landscape. It is concluded the area due south of the present City of Ferndale, which is approximately 1/2 mile downstream of the Ferndale site-complex, likely represents the position of the mid-Holocene paleoshoreline, the mid-Holocene estuary, and the area where initial delta construction occurred.

Chapter Four describes field and laboratory methods used in this study, as well as results. This includes defining analytic units and a proposed chronostratigraphic sequence for the Ferndale site-complex shell midden. Results of twelve new radiocarbon assays, sedimentological, and pedological studies are subsequently used to refine that chronostratigraphic sequence. Other geoarchaeological considerations include investigations of fish and shellfish remains from the Ferndale site-complex shell midden, geoarchaeological investigations at the upper delta East Ferndale site-complex, and consideration for Stein's black midden soils. Chapter Four concludes with a proposed depositional and post-depositional history for the Ferndale site-complex.

In Chapter Five I reassess lower Nooksack River prehistory. Implications are discussed for the Ferndale site-complex, for lower Nooksack River change, and for locating mid- to late-Holocene delta sites.
Chapter 2
DELTA S IN SOUTHERN PACIFIC NORTHWEST COAST PREHISTORY

Marine deltas, especially upper delta landscapes, have several characteristics that are particularly relevant to this study. Deltas are highly dynamic geological systems and processes of delta change can alter the distribution and interaction of terrestrial, aquatic, and marine ecosystems. One notable environmental characteristic unique to upper delta settings is their transitional nature, particularly in terms of river flow, valley constriction, sediment erosion and deposition, and biology. When viewed together the environmental and cultural systems that comprise the delta ecosystem provide evidence for a unique and complex relationship between the delta landscape and the people who occupy them.

Upper delta settings are culturally significant because they represent an ultimate ecotone encompassing inland forest landscapes, wetland and riverine dominated riparian corridors and floodplains, and marine dominated coastal systems. Apart from the river, which dissects the delta landscape to act as a travel corridor for both humans and their prey (e.g. ungulate, salmon), marine deltas are also biologically productive and diverse systems that provide people with a broad range of resources, including forest resources such as big game, cedar and other flora, aquatic resources including waterfowl and flora, and important marine resources such as shellfish, fish and large mammals.

Ethnographic data presented below for the south-central Pacific Northwest Coast and lower Nooksack River exemplifies the important relationships between coastal river systems and indigenous Peoples. Together with the survey of the Southern Northwest Coast delta archaeology that follows, there is strong evidence that the delta environment is, and has been, inextricably intertwined with the cultures that occupy these unique settings.

For the purpose of this discussion the term "delta" is applied broadly to include the entire delta landscape, including the river, estuary, delta floodplain, delta shoreline, backswamps, and bordering forested terrace landscapes. Deltas are characterized by extensive and varied wetland habitats (e.g. oxbows, backswamps, brackish swamps), therefore a model that provides insight into relationships between evolving delta landscapes and adaptation is Nicholas’ (1998) discussion of the significance of wetlands to foragers (see
Nicholas describes human adaptive strategies associated with wetlands that are demonstrated in the archaeological record. These include reduced mobility, surplus production and storage, territoriality, social stratification, increased population densities, gender-specific activities, and greater local cultural and economic diversity. Coles and Coles (1989) identify two key characteristics that draw people to the wetland environment, technology and food. Desirable wetland resources for technological application include reeds and rushes for thatch, matting, basketry, willow for basketwork, and nettles for textiles (see Turner 1998). Food resources include reptiles, amphibians, birds, fish and mammals. The medicinal value of wetland plant species should also be considered (Nicholas 1998).

Ethnographic data shows that riverine and estuarine systems were central to south-central Northwest Coast Peoples. Boxberger (1997:258) observes that although the importance of fisheries resources varied from group to group, in general it is safe to say that anadromous salmon was the most important prey species utilized on the Northwest Coast. In 1940 Marian Smith (1969:1-7) described how rivers, and the alluvial valleys that constrain them, permeated the consciousness of local populations.

The Indians of this region were supremely conscious of the nature of the country in which they lived. They were completely aware of its character as a great water shed. From the geographical concept of the drainage system they derived their major concept of social unity. Thus, peoples living near a single drainage system were considered to be knit together by that fact if by no other. (Smith 1969:2-3)

In describing expressions of cultural identity on the lower Fraser River, Carlson (2001:24-29) observes that:

Watersheds (or their equivalents) form the geographical basis for the relationships between associated Coast Salish towns and villages popularly known as "tribes." Some of the larger Coast Salish watersheds, like the Skagit, are home to more than one tribal group. Within the Strait of Georgia/Puget Sound region, however, the massive lower Fraser watershed stands apart, connecting no less than 24 subwatersheds, each of which rivals in scale and significance those around which other Coast Salish tribes are anchored. Coast Salish have generally regarded ocean waters as free and open passageways for transportation and communication (although specific fishing sites are owned). Rivers are considered more restricted avenues controlled by the local watershed’s occupants. In this capacity they represent the core of potentially larger tribally claimed territories. The lower Fraser below the Fraser Canyon is unique in that, symbolically, it has generally represented an extension of the ocean. (Carlson 2001:24)

In his 1955 Katzie Ethnographic Notes, Suttles (1979) provides a detailed ethnographic account of a lower Fraser River watershed. Reid (1987) and Collins (1974) provide thorough ethnohistoric accounts for the "riverine" Nooksack and Upper Skagit Peoples, respectively.

Indigenous groups who utilized lower Nooksack River resources can include the Nooksack (Reid 1987; Richardson 1974; Richardson and Galloway 1989), Skelaxan (Richardson 1974; Richardson and Galloway 1989; Riley 1955; Suttles 1951; Stern 1934); Lummi (Stern 1934; Suttles 1951), Semiahmoo (Barnett 1955; Suttles 1951), Nwahwa (Reid 1987; Suttles 1951), Sumas (Duff 1952) and Chilliwack (Wells 1987) as well as other lower Fraser River groups collectively known today as the Sto:lo (Carlson et al. 2001).

The most thorough ethnographic treatment of the Nooksack River is Reid’s (1987) Ecological Perspective on the Intergroup Relations of the Nooksack Peoples. Maps speculating on the distribution and
The Ferndale site-complex is centrally located within the ethnographically described territory of the Skalakin. According to Richardson and Galloway (1989) the name Skalakin usually refers to:

.a group of people occupying this area in the early to middle 19th Century. Some time prior to 1820, the Sq’ela’xen group occupied the mouths of the (lower) Nooksack River and controlled the surrounding salt water areas including Lummi Bay and portions of Bellingham Bay. Sq’ela’xen also refers to a Lummi fishing site on the lower river. (Richardson and Galloway 1989:1)

Stern (1969), writing in 1934, Suttles (1951:34-35) and Riley (1955) document local myth describing a small locally named group, the Skalakin (also referred to as Skalakan, Skalexan, Schalachen, Skalakhan, Sq’ela’xen, or Skolahun), who once occupied lower Nooksack River territory. Suttles (1951) asserts the Skalakin were the group Lummi mythology suggests were killed or driven from the lower Nooksack River by the Lummi, whose territory today includes the lower Nooksack River delta. Curtis (1913) used genealogy to date this event to approximately 1820. Grabert (1983:4) speculates that late-prehistoric Skalakin activity may be represented in the Ferndale site-complex at 45WH42.

The upper delta area below the Ferndale site-complex has been defined as the "boundary" delineating the Lummi and Nooksack territories. Suttles (1951:33) delineates the boundary between the downriver Lummi and the upriver Nooksack as the "mouths of the Nooksack River and its courses up to a spot just below Ferndale." It is at this point that the riparian corridor transitions from a restricted valley to a broad delta floodplain, and also where logjams once accumulated (see Wahl 2001) creating a distinct biological boundary between constricted riparian ecosystems upstream, and broader more marine dominated wetland floodplain systems downstream. Curtis (1913:30) observed that the Nooksack "occupied the watershed of three forks of the Nooksack river (which head in the vicinity of Mount Baker) and the broad valley of the main stream as far down as the site of Ferndale." Collins (1980) describes similar cultural patterns on the Skagit River delta, which again seems to reflect the unique geological and biological characteristics of south-central Northwest Coast deltas. For the Skagit River, Collins observes that the boundary delineating the Upper Skagit and Lower Skagit "were formed by the two mile long log jam west of Mount Vernon" (Collins 1980:5).

Linking archaeological and ethnographic data together provides a broader picture of riverine land use here. Evidence shows the Nooksack River region was frequently utilized for much of the mid- to late-Holocene period, beginning at least by 5000 years ago at Ferndale (Grabert 1983) and continuing through to modern times (see Boxberger 1989). This fact most certainly reflects the centrality of riparian corridors to human ecological system. Lowland riparian areas along large rivers used to provide productive wildlife habitat, but has been highly modified by humans (Bolton and Shelberg 2001). Riparian habitats provide large mammals (e.g. opossum, beaver, fox, mink, otter, elk, and deer), as well as humans, with an abundance of prey and
carrion, a productive and varied plant community, reduced winter snow accumulation, early spring green-up, aquatic habitat and transportation corridors.

Large deltas on the south-central Pacific Northwest Coast are geographically limited to the southeastern seaboard of an inland seaway known as the Strait of Georgia and Puget Sound. The largest of these deltas, as illustrated in Figure 2.00, are associated with the Fraser and Skagit Rivers. The massive Fraser and Skagit delta complexes flank the comparably small Nooksack River delta to the north and south, respectively.

Figure 2.00. Satellite photo, the southern Strait of Georgia and northern Puget Sound showing the Fraser/Nooksack coastal plain and deltas (center), Skagit River delta, Vancouver Island, San Juan Archipelago, Coast and Cascade mountain ranges, and Fraser River sediment plume. From a geological and ecological perspective the Nooksack River lowlands are more similar to the Fraser River lowland than any other area in the Puget Sound area. Top of photo is east. Modified from NASA/JSC (1989).
These deltas provide important cultural and environmental data to which lower Nooksack River development can be compared. Initial delta construction on both the Fraser and Skagit Rivers is dated to 9000 years ago (Williams 1988; Williams and Roberts 1989; Thompson 1978b) with progradation rates increasing across the mid-Holocene horizon following sea level stabilization. Notable differences however exist between these deltas and must be considered in discussions of regional delta prehistory. These differences reflect the individual character of the river and the watershed that constrains it.

Today the Nooksack River delta encompasses a subaerial area of approximately 13.8 square miles (22 sq. km) and a linear distance of some six miles (10 km). In contrast, the Fraser River delta encompasses a subaerial area of approximately 220 square miles (354 sq. km) and a linear distance of some 15.5 miles (25 km) (Ham 1982). As suggested earlier, and presented in greater detail in Chapter Three, there is increasing evidence suggesting the small size of the Nooksack delta is a function of a major late-Holocene avulsion event resulting in delayed onset of delta progradation (Pittman et al. 2003).

**DELTA ARCHAEOLOGY: 1895-1970**

In spite of a predominantly culture-historical focus the environmental setting of cultural groups intrigued early archaeologists, this interest included the archaeology of delta landscapes. Pioneering archaeological work on the south-central Pacific Northwest Coast began in the 1870s with the avocational research of James Richardson, James Deans, George Dawson and others (see Matson and Coupland 1995:38-41). These first studies were primarily concerned with site descriptions, the excavation of cairns on Vancouver Island, and speculations about the origin of the local indigenous peoples (Preckel et al. 1991).

In 1895 Canadian Charles Hill-Tout, an avocational archaeologist and ethnologist, reported on the archaeology of southwestern British Columbia (Hill-Tout 1895; Maude 1978). His work provides the earliest commentary on the effects of delta progradation on the regions cultural and environmental record. Hill-Tout used tree-ring analysis, delta sedimentation rates, and presence/absence of shell midden to date the Marpole site (DhRs1) rather correctly at about 2,000 years ago (Carlson 1990). In describing the Marpole site, or what he referred to it as the "Great Fraser Midden," Hill-Tout observed:

The existence of so extensive a midden, composed so largely of the remains of shell-fish that belong to salt water, at such an unusual distance from the nearest clam and mussel-bearing beds of today, was for a time a puzzle to me. I could perceive no satisfactory reason why these midden-makers should have chosen this particular site for their camping ground instead of one five or six miles farther down the bank and nearer to the present source of supply of these much-coveted dainties of their larder. And upon discovery, a little later, of other middens still higher up the river by fifteen or sixteen miles, the puzzle became proportionally greater. I found it difficult to believe that the enormous mass of shell-fish whose remains enter so largely into the composition of these great piles had been laboriously brought up against the stream in canoes or "packed" on the backs of the patient "klutchmans." It was too contrary to the genius of the people to suppose this. Making a brief survey of the district, a little later, the fact was disclosed that the mouth of the river was formerly some twenty miles higher up than it is at present. And, further, that the large islands, now inhabited by
ranchers, which bar in mid-stream the onrush of the annual freshets, must once have had no existence at all, and even after their formation had begun must have existed for a considerable period as tidal flats, such as are seen today stretching beyond the whole delta for a distance of five or six miles. That these islands were once tidal flats is certain from the fact that the water from the wells dug on them by the ranchers is so brackish that the water from the Fraser is preferred to it. And, further, that when in this condition they afforded shelter to the shell-fish similar to those whose remains are found in the middens near by, is clearly evidenced by the fact beds of similar shells to those whose remains are frequently met with, in situ, as I have been credibly informed, when digging for water in the interior parts of the islands. (Hill-Tout 1895:21-22)

Based on his examination of landlocked Fraser River shell midden sites, Hill-Tout (1895:22) concluded: "I could no longer resist the inference that they had been formed when the islands opposite and below them were tidal shell-bearing flats; and I have since found no reason for questioning that conclusion."

American archaeologist Harlan I. Smith (Smith 1903, 1907; Smith and Fowke 1901), of the Franz Boas' led Jesup North Pacific Expedition, conducted fieldwork in the British Columbia and Washington area. Between 1897 and 1903 Smith investigated sites on the Fraser, Nooksack and Skagit River deltas. Smith's work is viewed as almost entirely descriptive, "and he tended to operate without stratigraphic and taxonomic markers" (Carlson 1990:108). Smith did however comment on variations between deltaic and coastal shell middens, as well as the favorable environmental conditions of delta occupations:

On the whole, the difference in character between the delta shell-heaps and those of the coast seems to be due to the blackness of the surrounding soil, poor drainage, and the dissimilarity between the mode of life of a delta and that of a seacoast people. The difference between the various delta shell-heaps seems to suggest that the culture of the inhabitants of the Lower Fraser River appear to be more highly developed than that of other parts of the coast, probably on account of a more favorable environment and a location where intercourse between tribes of different cultures was greater than in the neighboring deltas. (Smith 1907:436)

Smith perceived the Fraser River delta as environmentally distinct and as a cultural center.

The shell-heaps of the lower Fraser River appear to have certain peculiarities of their own, and vary in detail not only from most of the shell-heaps of the coast region, but also from those of the delta areas of the Stilaguamish and Skagit Rivers. The objects secured from the former are more numerous and of a higher artistic value than those found in the coast shell-heaps, or even in those of other deltas. (Smith 1907:436)

In 1905, while employed as an Indian Agent with the Lummi Indians, American Albert Reagan conducted archaeological investigations in "Lummi-Nooksack Country" (Reagan 1917). Reagan recognized that inland shell middens were generally older than coastal ones; that deposition rates of delta sediments could be used to estimate the age of archaeological sites; and that prograding delta sediments could bury or destroy floodplain sites.

The archaeological remains found here are middens and mounds. The middens are of two classes, ancient and recent. As will be seen by examining the map [Figure X] of the Lummi
Reservation, a portion of it is marked "glacial deposits." This was an island until in recent times. The delta deposits of the Nooksack and Red or Lummi rivers were filled in by said rivers against this island till it is now mainland. These deposits are more than 30 feet thick, as is shown by the findings of logs at a depth of 30 feet at several places in the delta area. These middens are covered over with from a foot to three feet of sand and loam, and over them were growing trees that must have been 500 years old. This would make the middens quite ancient, if the rate of delta depositing was as slow formerly as now, probably 1,500 years old. More ancient midden heaps were found farther inland in the middle Nooksack Valley and at the foot of the Sumas mountains and on eastward to the vicinity of Sumas Lake in Canadian territory. Some of these midden remains are very extensive. They are many miles inland and must have been thrown from the Indian kitchens when Georgian Bay [Strait of Georgia/Puget Sound] had its eastern shore line at the very foot of the Sumas mountains. Judging from the appearance of the country and the geological data one can gather concerning this region, these middens must be 2,000 years old. (Reagan 1917:25-26)

Reagan makes similar statements regarding archaeological remains found inland along the Fraser River, including one site, a "large midden on the right bank of the south arm of the Fraser, a few miles up from its present mouth", one at Hammond, and "at many other places" (1917:28-30).

Figure 2.01 is Reagan's 1917 geoarchaeological map of the lower Nooksack River delta. He determined that inland delta shell middens were older than coastal ones and were deposited at a time when the sea intruded further inland than today. Reagan also provided evidence for the destructive nature of prograding deltas. The lower right inset in Figure 2.01 is a Nooksack River village site that was "mostly destroyed by the encroachment of the Nooksack River" (Reagan 1917:26). Reagan concludes:

..with reference to the middens, the ancient middens are mostly inland, that is, away from the present shoreline. [Artifacts] were made when the shoreline was farther inland than now and are now all overgrown with an ancient forest. The later middens are usually along the present shoreline, are comparatively shallow and are not so rich in relics as the older and more extensive heaps. (Reagan 1917:31)

Following these early studies no major archaeological research was published on the Northwest Coast until after World War II (Matson and Coupland 1995:40). The most significant post-war research in the region emerged from Canadian Charles Borden's excavations on and around the Fraser River delta, including sites at Point Grey, Marpole, Locarno Beach, Stselax, and Whalen Farm. Borden (1950, 1951) proposed a three-period sequence based on comparisons of assemblage content and stratigraphic position. The Early Period (later termed Locarno Beach Phase) was characterized as an "Eskimoid culture," the Intermediate Period (later termed Marpole Phase) was marked by "interior cultures in a state of transition" to a maritime economy, and the Late Period (later termed Stselax) marked by the emergence of complex coastal hunter-gatherer societies, or what Borden termed "Developed Southern aspect of the Northwest Coast culture."

Introduction of radiocarbon dating allowed Borden (1968, 1970) to expand his three-period Fraser River delta sequence into five named archaeological phases, each with its own distinctive set of artifacts (Preckel et al. 1991:82). The Locarno Beach Phase (2800 to 2200 BP) was seen as an early developmental stage of the later Marpole Phase (2400 to 1500 BP).
Figure 2.01. Map, Reagan's 1917 geoarchaeological sketch of the Nooksack River delta. He determined that upper-delta shell middens were older than coastal ones, were deposited at a time when the sea intruded further inland than today, and could be destroyed or buried by prograding delta sediments. *Modified from Reagan (1917:25).*
Borden saw the Marpole Phase as a cultural climax marked by trade, large houses, wealth items, and carved art. Borden (1968) suggested the Whalen II Phase (1600 to 1150 BP) represented the arrival of an "alien" people to the Fraser delta, whereas the undated Pre-Stselax Phase and Stselax Phase (700 to 150 BP) represented late prehistoric ancestors to contact period groups.

The early 1970s marked a period of transition for southern Northwest Coast archaeology. Before this time few regional chronologies existed for much of the Northwest Coast region (see Matson and Coupland 1995:44-46). By the mid-1970s however, lengthy, detailed chronologies existed for many areas of the Northwest Coast, including the Fraser River delta (Borden 1970). It was during this period that the introduction of newly refined environmental chronologies were integrated into the archaeological record. Some researchers, like Borden (1968, 1970, 1975), synthesized regional archaeological data, and through comparison with an improved geological and climatic database, attempted to define broad patterns of cultural change for the southern Northwest Coast.

As illustrated in Figure 2.02, Borden (1975) correlated lower Fraser Canyon archaeology with new geological and climate data from the late 1960s and early 1970s to provide support for his early-Holocene Pasika and Milliken Phases. Borden applied an integrated geoarchaeological approach to delineate the complex fluvial history associated with the area, and to dispel incongruities with the glacial record (i.e. that the area could not have been occupied, as it was glaciated between 10,500 and 10,000 BP). Similarly, archaeologists working in the Strait of Georgia and other coastal regions, such as Mitchell (1971) (described in detail later), took the same environmental archaeological approach to illuminate regional cultural patterns. Such regional studies, however, had varying success in light of later studies. While more recent archaeological periods (i.e. after 3000 BP) were well-described and numerous, thus providing a database worthy of comparison, the paucity of data for mid-Holocene and earlier periods proved difficult to place in a regional context, as is seen in recent critiques of Borden's (1975) work in the lower Fraser Canyon (see Haley 1987, 1996).

Unlike the integrated regional syntheses of Borden (1975) and Mitchell (1971), other archaeologists began to focus on particular aspects of prehistoric Northwest Coast culture (Matson and Coupland 1995:46), including social organization (e.g. Ames 1981, 1983, 1985; Matson 1983), economics (Burley 1979; Croes and Hackenberger 1988; Schalk 1977), and adaptation to changing coastal landscapes (e.g. Fladmark 1975; Ham 1976; Matson 1976; Stilson 1972).
Figure 2.02. Chart, Borden’s 1975 geoarchaeological chronology for the lower Fraser River canyon. *Modified from* Borden 1975:Figure 5.
DELTAS AND THE POST-1970 DISCUSSION OF MID-HOLOCENE ADAPTATIONS

A shift in archaeological research occurred in the late 1960s and early 1970s. Although many culture historians had earlier recognized the overall abundance of Pacific Northwest coastal ecosystems, few researchers attempted to define and correlate regional patterns of human-environment relationships. In the 1970s research became increasingly directed towards a synthesis of data (Preckel et al. 1991:83). The emerging trend was towards the development of cultural models for specific regions of the Northwest Coast (e.g. Mitchell 1971; Burley 1980; Ham 1982; Carlson 1983). From the 1970s on, focus shifted from more simplistic culture historical views of the landscape (i.e. environmental determinism) to a more explicit focus on correlating site-level data to regional patterns, as well as recognizing the complexity of human-environment relationships. This focus has since grown into a concerted effort to delineate the complex relationships between culture and the ecological systems in which prehistoric populations lived (e.g. Isaac 1988; Blukis Onat 1989).

Before proceeding to the survey of mid-Holocene delta adaptations, brief attention is given to relevant studies that focus on the role of geography and coastal ecology in Northwest Coast prehistory. Researchers such as Mitchell (1971), Schalk (1977) and Yesner (1980) provide an important framework for the subsequent consideration of mid-Holocene adaptive strategies.

Yesner (1980) considers the ecology and prehistory of maritime hunter-gatherers. He describes coastal settings as having a high number of ecological niches, or being ecologically packed (1980:729). This is a result, in part, of migratory species (e.g. salmon, waterfowl) commonly associated with coastal settlements. Further, coastal settings tend to exhibit greater species diversity. Therefore during the most critical times of the year, when the biomass of preferred prey species is low, alternate resource sustenance exists as a buffer. This view parallels Ames and Maschner’s (1999:116) discussion of "secondary resources" as playing as essential an economic role, if not greater, as did salmon in the development of complexity.

Yesner (1980:729-730) also examines settlement patterns on coastal landscapes. He notes that coastal settlement patterns tend to favor: (1) complex coastlines where protective and productive bays are found; (2) areas associated with streams or lakes serving as additional habitat for waterfowl and fish as well as a source of fresh water; (3) areas close to upwelling zones; (4) strandflat zones where shellfish or other invertebrates are available; and (4) good areas for beaching boats. Coastal settlements tend to be optimally located to take advantage of several resources from a single location, particularly low-cost, easily exploited resources that also serve as emergency food reserves. Coastal settlements are frequently located near intertidal strandflats where sessile invertebrates are easily accessible, near marine or aquatic bird colonies or flyways, near free ranging pelagic mammals, near ocean fish, near anadromous fish runs, and near important terrestrial and aquatic resources.

Barnett (1955) and Mitchell (1971) consider Strait of Georgia prehistoric settlement in light of weather, season, enemies and resources. Barnett predicts that winter villages were likely all located "out of reach of storms and marauding strangers" and in areas where winter hunting, fishing and shellfishing were
possible (1955:18). Based in part on this view, Mitchell (1971) suggests villages were likely to be found on the mainland or larger islands and along estuaries and rivers.

Anthropologists including Langdon (1977) and Kew (1992) believe that fishing technologies may have developed so that large numbers of salmon could be caught where they are most nutritious, in the approaches to the river or in the estuary (Stevenson 1998:21). Thus prehistoric groups occupying estuarine positions had an advantage over upriver settings where salmon have lost nutritional value ascending the river to spawn. Schalk (1977) provides another reason why estuarine settlement may have been considered strategic:

Although the occurrence of a poor run of fish may be unpredictable temporally, the spatial consequences are highly predictable. Within a single drainage, this is largely the result of direction of fish migrations. Because all fish are bound for the upper drainage must first pass through the lower part, it is evident that a poor year on the lower river is almost certain to be a worse year at points upstream. (Schalk 1977:239)

Based on the modern geomorphic position of the Ferndale site-complex, and in light of our knowledge of delta progradation, it is expected that during the mid-Holocene period this now landlocked locale met many, if not all, of these environmental criteria for coastal settlement. Understanding the role of geography in prehistoric decision-making regarding subsistence and settlement provides an important framework for the subsequent consideration of mid-Holocene adaptive strategies.

Approximately 8000 years of human occupation have been established for the Fraser River delta (Matson 1976:17). Subsistence data from the mid-Holocene period (i.e. 6000 to 4000 BP) is well documented for the Fraser delta at the Glenrose Cannery (Matson 1976), St. Mungo Cannery (Boehm 1973), and Crescent Beach (Ham 1976) sites. Data from other deltas and estuaries in the southern Strait of Georgia/northern Puget Sound region is minimal (Matson and Coupland 1995:100,118). The deltaic position of these Fraser River delta sites was well understood by the researchers, who documented a wide range of resources from maritime, littoral and terrestrial environments.

Matson (1992) suggests that prior to 4500 BP there was a generalized foraging adaptation that included coastal and riverine resources, but was not focused on them. At Glenrose Cannery terrestrial game was the dominant focus. The initial coastal occupation began at 4500 BP and is characterized by a broad-spectrum adaptation in which salmon still are not a focal resource. Matson (1992) has used the term "Initial Coastal Adaptations" to define the period surrounding 4500 to 3500 BP. Ames and Maschner (1999) demarcate 3500 BP as separating earlier Archaic traditions from later "Northwest Coast traditions." For Matson and Coupland (1995) 3500 BP corresponds with the presence of a distinctive "Northwest Coast Pattern." However, Eldridge (1991) suggests that if early data continues to accumulate supporting the hypothesis of complexity, the model of development of Northwest culture may have to be scaled back through time, at least around the mouth of the Fraser River.

Human use of riverine and estuarine systems in the southern Pacific Northwest Coast region dates to the early-Holocene period (i.e. 10,000 BP to 6000 BP) when people utilized alluvial systems of varying size and form, ranging from large rivers such as the Columbia (Cressman et al. 1960; Minor 1983, 1984) and Fraser (Borden 1960, 1961, 1975; Matson 1976) to smaller rivers and streams such as those associated with sites Bear
Cove (Carlson 1979), Namu (Carlson 1996), Marial (Schreindorfer 1988), Tahkenitch (Minor and Toepel 1986), Chester Morse Lake (Samuels 1993) and Olcott (Kidd 1964). Although these sites represent both coastal and inland riverine manifestations, riparian corridor and riverine prey species ungulate, waterfowl and salmon were important. Faunal preservation at these early-Holocene sites is generally poor, consisting mainly of lithics associated with poorly stratified alluvial and glacial deposits, thus they are difficult to date. Rarely preserved riparian-wetland flora must be also considered another important riparian corridor resource (e.g. Cressman 1977; Eldridge 1991; Stevenson 1998; Bernick 1988; Croes 1976; Croes and Blinman 1980; Gunther 1995; Turner 1998; Turner et al. 1983). Subsistence strategies during this early period, known as the Old Cordilleran culture, which dates between 9000 and 4500 BP, are believed to be broad-spectrum, with mobile hunter-gatherers utilizing a wide range of coastal plain and foothill resources.

The upper Fraser River delta Glenrose Cannery archaeological site (DgRr 6) is one of the most thoroughly analyzed, correlated, and published cultural and environmental records for the Pacific Northwest Coast of North America. Major excavations at Glenrose Cannery were undertaken in the 1970s by Simon Fraser University and University of British Columbia (Matson 1976). Three components were recovered from the terrestrial portion of the Glenrose Cannery site: the Old Cordilleran (between 8150 to 5500 BP); the St. Mungo (4300 to 3300 BP); and the Marpole (2300 to 2000 BP). These cultural periods were first proposed by Borden in 1970, later refined by Mitchell in 1971, by Borden in 1975, and by Matson in 1976 and 1992, and have been recently reframed by Matson and Coupland (1995:68-117).

The 8500-year-old Glenrose Cannery site is the oldest estuarine occupation in southern British Columbia and adjacent Washington State. The site-complex is located approximately 14 miles (23 km) upstream of the modern Fraser River delta front, on the south bank of the River between Annacis Island and the foot of the Surrey Uplands (i.e. Panorama Ridge). Despite the sites inland position, during much of the site's occupation the Fraser River delta prograded seaward past it, thus the site-complex area gradually changed from a shallow embayment with a rocky foreshore, to estuarine tidal flats, and finally to a riverine locale (Matson 1976). When first occupied Panorama Ridge was a rocky shoreline peninsula extending into the Strait of Georgia adjacent to the mouth of the Fraser River (Hebda 1977). The immediate environs of the site have two positive factors that conditioned its use: a more gradual slope of Panorama Ridge than is usual in that general area, and a small freshwater stream that now empties under the Glenrose Cannery site (Matson and Coupland 1995).

The lowest component of the Glenrose site is associated with the Old Cordilleran period. This component is notable for having relatively small inclusions of well-preserved faunal remains and bone and antler tools (Matson 1976). Five samples were radiocarbon dated from this component, and because the oldest material dated was from about one meter above the basal sterile layer, which is at least two to three meters above modern sea level, the beginning of the occupation is estimated at circa 8500 BP and lasted until at least 5500 BP. Matson interprets the Old Cordilleran assemblage as belonging to the same cultural tradition as the Dalles site, located on the lower Columbia River in Washington State (see Cressman 1960). Notable technologies at Glenrose include abundant chipped stone, cobble tools, leaf-shaped points, antler wedges, and a
single barbed-antler point. Due to the abundance of deer and elk (i.e. wapiti), Matson determined the pre-5000 BP component to be indicative of a large terrestrial mammal based economy. Crushed bay mussels (*Mytilus edulis*) were present below the 8250 BP radiocarbon-dated strata and shell lenses are found throughout the entire component. The presence of bay mussel indicates these early occupants were utilizing a proximal near-shore rocky littoral environment. Matson concludes that the Old Cordilleran component at Glenrose Cannery is indicative of a seasonal use of the coast by a group really adapted to land mammal resources.

Approximately 1000 meters downstream of Glenrose is the St. Mungo Cannery site (DgRr 2). It is the type-site for the St. Mungo phase (Calvert 1970; Matson 1976, 1981). The St. Mungo phase is one of three cultural manifestations delineated for the lower Fraser River/southern Strait of Georgia area for between 4500 and 3300 BP. The southern Strait of Georgia archipelago "Mayne phase" (Carlson 1970) and lower Fraser River canyon "Eayem phase" (Borden 1975), along with the Fraser River delta St. Mungo phase, are tied together into Borden's (1975) Charles culture. Matson and Coupland (1995:98) believe that the evidence supports Borden's interpretation wherein all three culture-types are considered parts of a larger whole. The St. Mungo phase is the best known of these three phases. The St. Mungo period is known from two sites on the Fraser River delta, St. Mungo Cannery (Calvert 1970; Boehm 1973; Mackie 1982; Ham *et al.*1986) and Glenrose Cannery (Matson 1976, 1981), and a third off-delta site at Crescent Beach in Boundary Bay (Ham 1982; Percy 1974; Matson *et al.* 1991; Matson 1992). These three Charles period sites have recently been the focus of much attention (e.g. Pratt 1992; Matson and Coupland 1995; Eldridge 1991; Stevenson 1998).

During the Charles period (i.e. 4500 to 3300 BP) at the St. Mungo site bay mussel was the most important shellfish, while elk was by far the most frequent mammal encountered, followed by deer and seal (Ham *et al.* 1986). This distribution is similar to those recovered from the St. Mungo component at Glenrose Cannery (Matson and Coupland 1995:110). The St. Mungo component at Glenrose (i.e. 4500 to 3000 BP) shows both a continuation of Old Cordilleran procurement strategies as well as a marked intensification of littoral and riverine resources (i.e. *Mytilus*, soft-sediment clams, and salmon) (Matson, 1976; 1988). Rates of both terrestrial mammals (i.e. deer and elk) and marine mammals (i.e. seal) remain constant (Matson 1976). Utilization of *Mytilus* continues but in much higher rates. This intensification is evidenced by the high concentration of *Mytilus*, up to 40% by weight, in the shell midden (Ham 1976). Notable environmental adaptations include the introduction of birds (Matson 1976) and soft sediment clams (Ham 1976) to the St. Mungo assemblage. These adaptations are believed to be a response to estuary infilling and delta progradation initiated by stabilizing mid-Holocene relative sea levels (Ham 1976; Matson 1976). In contrast to the Old Cordilleran component at Glenrose:

...the St. Mungo component is clearly based on coastal and riverine resources-shellfish and fish. The shellfish alone appear to be more important than all the mammals combined (Ham 1976; Matson 1981). Matson (1976) believes that fish were at least as important as shellfish. (Matson and Coupland 1995:109)
Hutchings and Campbell (in press) have recently reviewed some of these relationships in light of their work on the Nooksack River delta. They suggest exploitation of Roosevelt elk herds in coastal plain river valleys played an important role in the development of semi-sedentism and focal foraging strategies. They also note that early Fraser River delta sites, particularly Glenrose Cannery, are localized expressions of Stanley and Warne’s (1997) global models. They suggest the role of delta building as a synchronous regional process deserves more exploration.

In 1990 waterlogged cultural materials were found along a 250-meter stretch of Fraser River beach fronting the Glenrose Cannery site (Eldridge 1991:iii). Under the beach surface Eldridge identified alternating layers of culturally sterile compact silty clay and sandy shell hash. The shell hash included large quantities of mussel and clam, fire-altered rock, and lithic debitage. Also encountered were mammal bone and antler remains and tools, and perishable wood and bark artifacts. Wood and bark materials included basketry, a carved wooden tray, a wooden wedge, cordage, detritus, and hundreds of wooden stakes. This assemblage represents the oldest wet-site collection from the Pacific Northwest Coast; six radiocarbon samples date from 4590 to 3950 years ago.

Eldridge (1991) dated a waterlogged basketry fragment recovered by private collectors from Glenrose Cannery to 4000 years ago, thus making it the oldest perishable artifact recovered from the Pacific Northwest Coast, only to be exceeded globally by materials recovered from the 5000-year-old Swiss Lake Villages (Croes 1976).

Basketry items are of particular interest due to their sensitivity to cultural processes. Northwest Coast baskets show very strong traditions over thousands of years within ethnic areas, and long-term differences between ethnic areas. The seven basketry fragments from Glenrose are beautifully made, with care evident in the close, even spacing, and the closely matched materials. There is a strong emphasis on wrapping techniques (as distinct from plaiting, twining, or coiling). The wrapping technique is generally associated with Wakashan heavy-duty carrying baskets, although ethnographic Salish made and used similar baskets. Although the basketry from the Glenrose site is generally similar to the historic Wakashan baskets, there are differences. Similarly, some details correspond to 2,000 year-old baskets from the Coast Salish territory. Although the sample is too small to make statements about potential ethnic connections with any confidence, the possibility exists of ancestral connections to both Salish and Wakashan speaking groups. (Eldridge 1991:iii)

The hundreds of stakes in oblique rows along the riverbank that Eldridge (1991) identified were the remains of fish weirs and traps. The large number of salmon bones in the shell hash layer supports Eldridge's inference:

That intensive salmon harvesting, processing and storage were well established at the mouth of the Fraser by 4600 years ago. Added to other data, it appears many of the components of the Northwest Culture, including massive architecture, hereditary status, and ranking were in place by this early date. (Eldridge 1991:iii)

Stevenson (1998:220-238) examines three wet-site components from the Fraser River delta and estuary. These site components include the 25-kilometer inland Glenrose Cannery site St. Mungo component (4600 to 4000 BP), the 3000-year-old Musqueam Northeast site (DhRt 4) that is one kilometer from the mouth.
of the Fraser, and the nearly 2000-year-old Water Hazard site (DgRs 30) in Tsawassen at Boundary Bay. Stevenson notes that previous archaeological models of fishery evolution emphasizing salmon procurement and processing may obscure how the overall fishery developed. She proposes instead that understanding how a range of fish was used in the area through time can provide a more complete picture of how the fishery operated and developed.

The evidence from wet-sites in the Fraser River estuary region supports the suggestion that although the same set of riverine resources were exploited between 4600 and 2000 years ago, the primary procurement methods changed significantly during this period. The focus of the technology progressed out from the tidal banks of the estuary into the river itself. Simple traps used 4600 years ago at Glenrose Cannery were, by 3000 years ago, replaced or supplemented by a gill net technology at Musqueam Northeast. By 2000 years ago, trawl nets similar to the ones known historically had probably been established to exploit salmon. This scenario does not imply a direct lineage of technology. When viewed locally, the sequence may have been from tidal traps to nets, rather than a developmental progression of net technology downriver. (Stevenson 1998:233)

The presence of fish weirs 4500 to 4000 years ago at the mouth of the Fraser River is directly opposed to much of the present assessment of the origin of fish traps and large scale harvesting and storage, and the development of complex societies on the Northwest Coast (Eldridge 1991:87-88).

Burley (1980) considers the mouth of the Fraser River to have more abundant alternate resources and more difficult access to salmon compared to the Fraser River Canyon. However the data from the St. Mungo site suggests salmon fishing and storage to have been very important by the Charles period. The evidence from Glenrose confirms that intensive salmon harvesting were well established at the mouth of the Fraser by 4500 BP, some 1500 years prior to the earliest known weir features in southeast Alaska. (Eldridge 1991:88)

As suggested by Eldridge (1991) and Matson and Coupland (1995), there is an increasing body of data suggesting social complexity in the Charles period. At Glenrose Cannery there is evidence for intensive harvesting of anadromous fish (i.e. salmon); at St. Mungo large plank houses had differential amounts of wealth and status goods; at Tswassen Charles period burials had immense numbers of ground stone beads (Eldridge 1991:88). Eldridge notes that:

If data continues to accumulate supporting the hypothesis of complexity, the model of development of Northwest culture may have to be scaled back through time, at least around the mouth of the Fraser River. The period of four to five millennia ago appears to be even more pivotal to the development of the Northwest Coast culture type than previously thought. (Eldridge 1991:88)

It should be clear by now that changes to mid-Holocene delta landscapes affected patterns of subsistence and settlement across the mid-Holocene horizon. This leaves one final question left that is central to our consideration of lower Nooksack River prehistory, and all deltas for that matter. How can we link all of these environmental and cultural processes into a single, coherent and testable model?
In an attempt to explicate human response to delta change for the Skagit River, Stilson (1972:56-60) developed a model that enabled him to predict changes in the zonal ratios of the faunal assemblages at a hypothetical site whose inhabitants were utilizing marine resources and who were affected by delta progradation. In this hypothetical site a Rocky Saltwater Beach subzone/Marine zone assemblage would initially predominate. The main constituents would be rocky shore shellfish and marine fish, with little terrestrial mammal hunting. As the delta prograded seaward, littoral gathering would decrease in economic importance as rocky shore shellfish were killed by the delta sediments and replaced by less abundant soft-sediment bivalves. Fishing and hunting of land mammals would increase in economic importance to compensate for lessening numbers of shellfish. Through time the incidence of marine fish would decrease as they were driven away by the delta’s incursion, and freshwater fish would replace them. Stilson's model provides another framework for analyzing lower Nooksack River prehistory. It is described in greater detail and applied to the Ferndale site-complex faunal assemblage in Chapter Four.

This survey of southern Pacific Northwest Coast delta archaeology has provided a wide array of perspectives concerning the complex development of prehistoric delta life. While many of these views are likely applicable to the study of lower Nooksack River archaeology, a paucity of geological and environmental data greatly limits our ability to test many of the Fraser River models here. Unlike the Fraser River delta, which is the most intensively studied area on the southern Coast, archaeological investigations on the smaller and more remote Nooksack River delta are fewer in number, and consequently the overall development here is less clear. Thus comparisons between the two coastal river systems present a unique challenge (cf. Matson and Coupland 1995:100). Taken together however the following survey of lower Nooksack River archaeology provides a broader picture of the Nooksack River region than previously seen. This picture provides evidence for strong ties between the two regions. These similarities are not only rooted in cultural ties fostered by the proximity of the two river systems, but also perhaps in how these prehistoric groups responded to changes in the delta landscape.

**LOWER NOOKSACK RIVER ARCHAEOLOGY**

Alluvium, the central geological theme in this discussion, is a general term for hydraulically deposited sediment resulting from the operations of rivers. Alluvium is particularly relevant to southern Pacific Northwest Coast archaeologists because early- to mid-Holocene sites are often found on terminal-Pleistocene ecotonal landforms, "commonly at the edge of terraces overlooking river valleys or the sea (Miss 1992:11)." Sites dating to the mid- to late-Holocene also fit this spatial pattern. In his study of Sumas River Valley sites Montgomery (1979:189) observes that, of the seven sites and two minor loci he surveyed, all "were situated on the stream terrace crest, in close proximity to the adjacent waterway." A discussion by Grabert (n.d.) addressing inland sites of Whatcom County provides results similar to those of Montgomery. Of the 12 inland coastal plain and montane sites discussed by Grabert (pgs. 17-18:Table 1), 10 are located in alluvial valleys.
all no less than 170 areas of cultural interest (including prehistoric, ethnohistoric, and historic locations) are located along a 37-mile stretch of lower Nooksack River floodplain (Whatcom County 1998) and all require understanding how alluvial processes may have influenced cultural activity at these sites in the past, or may affect their status in the future.

Garland F. Grabert (1923-1987) of Western Washington University (1967-1987) recorded, excavated, and interpreted much of the known Holocene cultural record for Whatcom County including important sites at Ferndale (45WH34), Birch Bay (45WH09), Cherry Point (45WH01) and Semiahmoo Spit (45WH17). Grabert's research is described in his numerous article summaries and publications and, inclusive of his students work, includes reference to changing coastal landforms (e.g. relative sea level change, spit and delta development), the effects of geological change on the archaeological record, rock pavements, rock hearth features on beach deposits, clay lined hearths, shell middens, cobble tool industries, lithics, inland sites, and faunal remains (Larsen and Lewarch 1995:26).

The survey presented here considers work conducted along the lower Nooksack River and delta by Grabert and his students. These studies include Grabert's 1972 (1983) work at the Ferndale site-complex, Montgomery's (1979) examination of prehistoric settlements in the Sumas Valley, Grabert and Griffin's (1983) investigations in the lower Nooksack River delta and Lummi Peninsula area, and K. Griffin's (1984) survey and analysis of prehistoric settlements on the lower Nooksack River delta, along the Lummi River. Following commentary on Grabert's working hypothesis and Mitchell's (1971) consideration of the lower Nooksack River in his "Gulf of Georgia archaeological area," a summary of lower Nooksack River archaeology is presented in chronological order.

In 1970 Grabert's working hypothesis was as follows: (1) isostatic land emergence in post-Pleistocene time has decreased shoreline length in the Fraser Delta region creating concentrated littoral populations; (2) the most desirable ecological niche for early man, in this region at least, was an ecotone - in this case the transition zone between forest and sea; and (3) early sites should be found on uplifted strandlines (Larsen 1971:5). This hypothesis formed a unified geological, biological and cultural context around which Grabert and his students could explain patterns of change or stability in the archaeological record. These geoarchaeological and paleoecological hypotheses have, in varying form, pervaded much of the prehistoric record of western Whatcom County (e.g. Gaston 1975; Grabert, n.d., 1970, 1972; Grabert and Larsen 1971, 1975; Grabert, Cressman and Wolverton 1978; Grabert and Griffin 1983; K. Griffin 1984; Larsen 1971, 1972; Montgomery 1979; Schwartz and Grabert 1973), including Grabert's 1972 (1983) work at the Ferndale site-complex.

Grabert's observations and hypotheses have also been considered beyond western Whatcom County. In their study of the southern Puget Sound West Point archaeological site Larson and Lewarch (1995) write:

Grabert's ideas about subsistence/settlement organization of early coastal hunter-fisher-gatherers are particularly relevant for interpretation of the West Point data. He even predicted the probable existence of sites such as West Point below contemporary beaches. In summary the early coastal adaptations documented by Grabert in the Bellingham area serve as useful analogs to the West Point cultural evidence in southern Puget Sound. (Larson and Lewarch 1995:1-26 - 1-28)
Grabert recognized the important role of Holocene geological processes in the formation of the archaeological record but he conducted no systematic analysis. With the exception of Larsen's (1971) interdisciplinary geoarchaeological work at the Birch Bay Osier site (45WH24) little quantitative geoarchaeological data exists for western Whatcom County. Because none of Grabert's hypotheses were ever tested beyond Birch Bay the potential for regional bias remains high (cf. Grabert 1983:5) and may have widespread implications (cf. Larson and Lewarch 1995). Grabert was not alone in his application of interdisciplinary research to Strait of Georgia/Puget Sound archaeology.

From an archaeological perspective southern Strait of Georgia coastlines, particularly the Fraser River delta, have been the most intensively studied landscapes on the southern Pacific Northwest Coast. However, because interdisciplinary research generally occurs at site-level or local scales and requires accurate environmental data, regional perspectives considering human-environment relationships are rare (see Bobrowsky 1990). Mitchell (1971:18-19) considers the environmental, archaeological, and ethnohistorical "distinctiveness" of the southern Strait of Georgia and ranks subareas (1971:44) based on these observations. Accordingly, the southern Strait of Georgia is a subarea characterized by an:

...abundance of archaeological remains, in terms of sites, burials, and artifacts. It may be divided further into: River Delta and Southern Gulf Archipelago; and Fraser River, extending from about Chilliwack at least into the Fraser Canyon and possibly throughout the Canyon. (Mitchell 1971:40)

Figure 2.03 is Mitchell's 1971 map of his "Gulf of Georgia archaeological areas." As shown the lower Nooksack River area is centrally located within four of Mitchell's defined archaeological areas. Sphere 1 is the "River Delta and Southern Gulf Archipelago area" that corresponds to the Fraser River "salmon-run" portion of the southern Straits/San Juan Archipelago ecosystem. Riverine, estuarine, and marine fishing groups occupied this area. Spheres 2 and 4 are the "inland" portion of the lower Fraser River Valley (i.e. the area upstream and downstream of the coastal plain/foothill boundary) and the entrance to Puget Sound, respectively. These areas were inhabited by riverine fishing groups, some Straits reef-netting groups, and the "northernmost diversified fisherman (those having the Skagit and Stilliguamish salmon runs in their territories (Mitchell 1971:44)."

Mitchell, however, questioned the relationship between the Nooksack River (sphere 3) and his larger "River Delta and Southern Gulf Archipelago" area.

Two regions should, perhaps, stand out on their own as distinct subareas, but archaeological data are so few there is little that can be said about them. These regions include the Nooksack River drainage, which possibly is most like the Fraser River subarea (Emmons 1952:53), and the Strait of Juan de Fuca, which may belong with the Southern Gulf or the Northern Puget Puget Sound archaeological subregions. (Mitchell 1971:44)
Working in northwestern Whatcom County Jeannette L. Gaston (1975) tested Mitchell's delineations and, based upon excavations of the Simonarson (45WH48) and Semiahmoo Spit (45WH17) sites near Blaine, asserted an archaeological affiliation with other "Gulf of Georgia" cultures.

It is evident from these two sites, and others from northwest Washington, that the Fraser Delta cultural sequence extends into Washington. Present evidence from the Skagit Delta suggests fewer cultural ties with this area and may delineate the southern boundary of this cultural scheme. The Fraser Delta sequence is not only applicable to coastal sites however. The Ferndale Site (45WH34) is located about six miles inland from Bellingham Bay, yet contains a cultural continuum to that of the Fraser Delta. (Gaston 1975:111)

Mitchell's (1971) multidisciplinary ecological and archaeological assessment has had a great impact on Whatcom County archaeology. Many Whatcom County archaeologists make reference, implicitly or
explicitly, to Mitchell and therefore his work must be considered in surveys of prior assessments, like those presented below for the lower Nooksack River.

Apart from early work by Reagan (1917), the first concerted effort to explicate prehistoric patterns of subsistence and settlement on the lower Nooksack River was undertaken by Garland Grabert in 1972. Grabert's initial interest in the lower Nooksack River Ferndale site-complex was in response to queries by the now deceased landowner, Robert G. Smith, regarding the numerous artifacts he encountered on his property. An initial survey by Grabert produced evidence of prehistoric occupation including fish bone, shellfish, fire-cracked rock, stone points and cobble tools. Grabert then initiated a subsequent and more intensive survey of the floodplain and adjacent elevated terraces. This ultimately led to the discovery and delineation of the Ferndale site-complex. This was followed by the 1972 excavation of the site-complex shell midden, 45WH34.

The 1972 survey focused primarily on a 3/4-mile stretch of an elevated terrace above the modern Nooksack River floodplain, and two areas of the active floodplain. Survey of the approximately 15-meter ASL (Above Sea Level) terrace resulted in the delineation of five archaeological sites (i.e. 45WH36, WH37, WH38, WH39, WH40). Although Grabert refers to these sites in his 1983 report, his commentary is generally limited to the "early age" and "linear distribution" of the cobble tools found there. The terrace sites are described in greater detail in corresponding site-forms (Grabert et al. 1972). Materials recovered from these terrace sites are defined as "lithic scatter" recovered from the A horizon of Lynden sandy loam soils. According to Grabert (1972:16) lithic scatter includes chipped stone tools, cores, flakes, cobble/pebble tools and fire modified rock. The 1972 survey also included the modern floodplain area and resulted in the further delineation of sites 45WH42 and 45WH34.

The area associated with 45WH42 (approximately 1/2 mile upstream of 45WH34) produced a white clay trade pipe (in landowner Smith's personal collection) and fish bone. 45WH42 was situated near another site situated across the Nooksack River at the mouth of Tenmile Creek that produced a seated human figure bowl (for description see Duff 1956:32; for photo see Whatcom Museum 1968:15), adzes, and several other items (Grabert 1983:7). Grabert asserted 45WH42 and adjacent areas were the remains of a late-prehistoric village. "This locus may be the site of the historic Lummi village site of Skalaxen (Stern 1934:115-120; Suttles 1951:35), believed to be the most inland village of the these people (1983:4)."

On the floodplain downstream of WH42 Grabert encountered "lanceolate bipoints" and "large flake implements' on the:

..low ridge of 45-WH-34 where shell bits and fire spalls were found among roots of wind-fallen trees and stumps. Assessment of the site's size suggested that cross-trenching might be the most profitable technique of sampling. (Grabert 1983:4)

In 1972 Grabert, along with a Western Washington University archaeology field school, began excavation of 45WH34. Grabert implemented a three-meter grid system for horizontal and vertical control and used an Interstate-5 bridge pier for datum (1983:8). The zero-stake was referenced to a USGS benchmark located in Ferndale and was determined to be 9.6 meters ASL. A total of ten two by two meter cuts were excavated,
ultimately forming a segmented east-west trench crossed by a shorter north-south trench. Grabert estimates over 60 cubic meters of fill were removed.

During the 1972 survey of the Ferndale site-complex and excavation of the site-complex shell midden Grabert (1983:5) attempted to identify patterns in the archaeological record that reflected known or expected changes in the natural environment, particularly relative sea level change. In retrospect three key factors can be considered central to Grabert's initial assessment: (1) the Ferndale site-complex was located 6.5 miles (10.4 km) up the Nooksack River from the modern shoreline; (2) the site-complex included culturally processed shellfish and fish that likely represented prehistoric use of a proximal shoreline; and (3) the presence of cobble tools and flake tools found along the surface of a raised 10,000 year old terrace was evidence for occupation dating to the early- to mid-Holocene period.

Grabert (1983) forwarded two models for the Ferndale site-complex that delineated relationships between geological and archaeological data. One model forwarded by Grabert suggested cobble tool deposits found on, and in, terraced terminal-Pleistocene sediments at Ferndale provided evidence for elevated paleoshoreline positions (see Grabert 1979; Larsen 1971, 1972).

At the time Grabert and his student Curtis Larsen firmly believed that sites containing cobble (or pebble) tools located on these elevated western Whatcom County terraces were indicative of early-Holocene paleoshoreline occupation, thus providing evidence of contemporary paleoshoreline positions. Although Larsen (1971) conducted geological studies of cobble tool sites above Birch Bay his primary evidence for the antiquity of these sites was purely archaeological. The age of local cobble tool deposits, as envisioned by Larsen and Grabert, was an extension of Borden's (1968, 1970) Early Pebble Tool Tradition developed for the southern Pacific Northwest Coast. Borden's proposed late-Pleistocene to early-Holocene age for these deposits however has since been discounted. Reanalysis of cobble tool deposits in the Fraser River valley by Haley (1987, 1996) places them into a 6000 to 3000 BP (before present) timeframe rather than the initially proposed 12,000 to 9000 BP timeframe. Haley's study raises important questions regarding the timeliness of Grabert's (1983) interpretations of the Ferndale site-complex assemblages and Larsen's proposed archaeological and geological sequences for Birch Bay.

Grabert (1983) forwarded a second model linking environmental and cultural change in his effort explicate prehistoric conditions at the Ferndale site-complex. Like the previous model it was never fully explored and remains purely speculative to date. Unlike the previous model it seems to have greater relevancy and explanatory power in light of the cultural deposits and geographic position of the site-complex. The second model is an extension of the previous model in that Grabert hoped the site-complex shell midden (i.e. 45WH34) and terrace sites might provide data reflecting relative sea level change and show chronological continuity between the "older" terrace components and the basal strata of the shell midden. It can be differentiated from the prior model in that Grabert recognized, in an indirect way, the cultural consequences of delta progradation.

Apart from Grabert's statement of these hypotheses at the outset of his 1983 monograph, Ferndale in Prehistory, he did not test these models nor did he adequately extrapolate upon them. Although he applied the
terms "Olcott" and "Old Cordilleran" to the terrace deposits (1983:61), suggesting an early- to mid-Holocene age, Grabert seemingly abandoned his sea level stillstand hypothesis for the site-complex. Despite not quantifying faunal remains, and obtaining only three 14C dates, Grabert did however conclude the Ferndale site-complex represented "continued human use of the area during all stages of mid- to late-Holocene coastal evolution, beginning as an inland estuary occupation and ending as a six-mile inland riverine site (1983:59)."

Grabert (1983) proposed a six period culture sequence spanning the last 5000 years, identified general stratigraphic events and correlated his cultural sequence to Borden's (1970) Fraser River cultural sequence. Based on the presence of cores, cobble and flake tools, the absence of cultural deposits (the absence of stratified cultural deposits?), and the linear distribution of chipped stone artifacts along this terrace Grabert proposed the Ferndale I Period (1983:13). He suggested the Ferndale I assemblage predates 4800 BP and was limited to flake core, and chopper implements "with chipped stone artifacts distributed nearly 3/4 mile along the terrace in the immediate vicinity, and within a radius of three miles or so in similar terrace contexts where selective collecting was less likely (1983:16)." Grabert also believed a direct relationship existed between Ferndale I and the open coast Birch Bay site (i.e. 45WH24); this view was based upon similarities in formal characteristics of assemblages (i.e. presence of cobble tools) and geographic position above modern sea level.

Grabert (1983) defined a Ferndale II Period that he believed represented a cultural layer with only flake and core tools that possibly was a derivative of upper terrace Ferndale I. The Ferndale II Period was present only at the base of 45WH34 which he 14C dated to 4800 BP. Subsequent cultural periods identified by Grabert, again based on his artifactual analysis, include the Mayne Phase, Locarno Beach Phase, Marpole Phase and Stselax" Phase. According to Grabert no shellfish appear until the Mayne Phase. He identified four occupation levels attributable to the Ferndale I Period and notes the first two levels contain no shellfish while the last two bear traces of decayed blue mussel.

While the presence of three 14C dates, two of which date to approximately 1000 BP, and a third at nearly 5000 BP, in association with the larger inland alluvial site-complex hint at the potential cultural and environmental importance of the site-complex, little is actually known regarding the geology and ecology of this locale. While Grabert proposed two cogent environmental archaeological models for the site-complex they remain untested. This reassessment of lower Nooksack River Prehistory considers the geoarchaeology and paleoecology of the Ferndale site-complex and attempts to refine and expand Grabert's initial hypotheses. Part of the reassessment considers all major studies for the lower Nooksack River.

Keith Montgomery (1979) examined prehistoric settlements in the inland lower Sumas Valley located approximately 15 miles (24 km) northeast of the Ferndale site-complex. Montgomery's examination of some 16.8 acres of the lower Sumas Valley led him to observe that, of the seven sites and two minor loci he surveyed, all were situated on the stream terrace crest, in close proximity to the adjacent waterway. All of these sites were small single component locales, lacking complex stratification (1979:196). Because of poor preservation at the Sumas sites faunal remains were non-existent with the exception of small fragmentary specimens of shell recovered from 45WH04. His reconstruction of the inland subsistence-settlement system indicates "a rather intensive utilization of the Sumas microenvironment. the duration of site utilization varies
considerably, ranging from brief resource procurement to semi-permanent habitation (1979:196).” The artifactual material from these sites suggest to Montgomery “affiliations with both coastal and interior prehistoric sites (1979:196).” Although no radiocarbon dates were obtained from the Sumas sites:

"Typologically this series of related sites is placed within the Marpole Phase time period, 400 B.C. to A.D. 400. Not only do these sites exhibit a characteristic Marpole Type artifactual assemblage, but they lack cobble choppers and flake tools associated with earlier lithic assemblages. (1979:197)

Garland Grabert and Gene Griffin (1983) conducted archaeological investigations in the lower Nooksack River delta and Lummi Peninsula area southwest (i.e. downstream) of the Ferndale site-complex. Their study allowed them to make two general statements regarding the study area: (1) the peninsula area has been intensively used for several millennia, and (2) all or most of the environmental zones and their related resources have been used by what appears to be a consistently increasing population (1983:148). They suggest the demographic changes may have been the results of simple in situ population growth, in-migration, or a combination of both. Apart from of a single site, 45WH98, containing a "large cobble tool assemblage" with "no diagnostic points or knives" and resting upon "redeposited glacial drift" that was designated by Grabert and Griffin (1983:149) as an early-Holocene occupation, no sites in the lower Nooksack delta area predate 2500 years ago. Using artifact typology and limited radiocarbon dating Grabert and Griffin correlate Lummi Peninsula sites to Mitchell's (1971) culture sequence for the southern Strait of Georgia (1983:148).

Grabert and Griffin (1983:153) identify seven sites with artifacts attributable to the Locarno Beach period (i.e. between 3000 BP and 2200 BP) on the uplands proximal to the delta. Artifactual assemblages from these Locarno Beach components include pebble/cobble tools, large ground slate points, chipped slate knives, stemmed chipped points, microblades, and toggling harpoons. Materials from two of these sites were 14C dated to 2410 +/-60 BP (45WH100) and 2040 +/-190 BP (45WH114). 45WH100 is located on the north shore of Lummi Bay near Sandy point. 45WH114 is located on the seaward point of the Peninsula at Gooseberry Point. All the known sites of this period are located on bays, lagoons or coves and are limited in distribution to the western portion of the Lummi Peninsula.

Grabert and Griffin (1983:153) identify six sites attributable to the Marpole period (i.e. between 2200 BP and 1500 BP). One of these sites, 45WH111, was 14C dated with a result of 1590 +/-60 BP. Artifactual assemblages from these Marpole components include many artifacts similar to those of Locarno Beach, but also contain distinctive non-toggling harpoons, unilaterally barbed bone and antler points, more use of ground slate, somewhat larger ground nephrite celts and diminished use of chipped stone.

Kristen Patterson Griffin (1984) conducted an archaeological survey and analysis of prehistoric settlements on the lower Nooksack River delta. Her work along the lower Lummi (or Red) River, which empties into Lummi Bay, demonstrates that the area bears evidence of prehistoric utilization. The area surveyed by Griffin was divided into four general zones. These include: (1) margins of the Lummi River channel, (2) natural levees and high ground within the Lummi River floodplain, (3) margins of the Lummi River floodplain and portions of the upland terraces adjacent to the floodplain, and (4) the portion of the
Lummi Peninsula shoreline directly south of the Lummi River delta. Griffin's (1984) work expanded on Grabert and Griffin's (1983) observations that virtually all identifiable environments had a role in the prehistoric economy by documenting the intensive use of delta-front and floodplain landscapes.

**HYPOTHESIS DEVELOPMENT FOR THE STUDY AREA**

Contributions to lower Nooksack River prehistory, as illustrated in Figure 2.04, have addressed four geographical areas: the Sumas River Valley (Montgomery 1979), the upper delta Ferndale site-complex (Grabert 1983), Lummi Peninsula (Grabert and Griffin 1983) and the lower Lummi River (K. Griffin 1984). The latter three of these studies evaluate prehistoric human subsistence and settlement patterns in areas affected by Holocene delta progradation. While not commonly associated with the Nooksack River today, the Sumas River Valley may have once been the main channel for the Nooksack River throughout much of the Holocene period (Pittman et al. 2003) thus Montgomery's (1979) archaeological study is highly relevant when reassessing lower Nooksack River prehistory.

These archaeological assessments however are considered "contextually incomplete" because to date no definitive geological model exists explicating Holocene lower Nooksack River development. As Waters and Kuehn note:

> Because the landscape on which people lived was dynamic and continually changed, the record of prehistoric activities across the landscape has been differentially preserved and destroyed. Insightful reconstructions of human organizational (settlement) systems from the archaeological record requires a full understanding of the geological forces and history that shaped that record. (Waters and Kuehn 1996:483)

Further, attempts to offer ecological explanations for differences in cultural systems are dependent upon the capacity to compare and contrast different evolutionary contexts (i.e. ecosystems) (Schalk 1977:207). Thus reassessing lower Nooksack River prehistory requires a full understanding of the geological forces and history that shaped that lower Nooksack record. Such understanding is lacking for the Nooksack watershed and is considered a major limiting factor to the success of anthropological knowledge here.

Based in part on observations similar to Waters and Kuehn (1996) and Schalk (1997), this reassessment considers three interrelated elements of alluvial archaeology in a coastal setting: Holocene coastal river change, human response to Holocene coastal river change, and the post-depositional effects of river change on the archaeological record. Increased awareness of the processes and products of alluvial change permits more insightful reconstructions of prehistoric human organizational systems, the ability to compare and contrast different evolutionary contexts, and allows for the successful and efficient implementation of future Cultural Resource Management strategies. Overcoming the paucity of geological and archaeological data for the lower Nooksack River region however requires the application of models developed for other delta landscapes.
The preceding survey of delta archaeology provides many examples relevant to the three key elements of alluvial archaeology outlined above. Researchers have shown that globally modern marine deltas began to form from approximately 8500 to 6500 years ago (Stanley and Warne 1994) and conditions in and around deltas (i.e. accumulation of fertile soil, reliable water supply, perennial aquatic food sources, ease of travel and

Figure 2.04. Map, approximated positions of lower Nooksack River archaeological surveys set on pre-avulsion Nooksack River map: 1=Montgomery (1979); 2=Grabert (1983) and this study; 3 =Griffin (1984); 4 =Grabert and Griffin (1983). Top is north. Modified from Pittman et al. (2003).
trade) were attractive to human immigration and settlement (Stanley and Warne 1997). On the Pacific Northwest Coast archaeologists have shown that humans occupied the Fraser River delta soon after its formation 9000 years ago (Matson 1976) and that older delta sites are either eroded or buried by prograding delta sediments or located inland on bordering terraces and uplands (Borden 1970) but may also occur on annexed islands (Thompson 1978b). Older delta sites are not only difficult to access but are located away from the modern shoreline that has been the main focus of previous research in most parts of the Northwest Coast and it is likely an extensive upper-delta record still exists (Hutchings and Campbell in press). Also, younger delta sites containing evidence of marine subsistence strategies (e.g. littoral and marine fauna) are found closer to the modern shoreline (Hill Tout 1895; Reagan 1917).

Important conclusions can also be drawn concerning human response to coastal river change on the southern Northwest Coast. A survey of mid-Holocene faunal assemblages from upper-delta sites located on the neighboring Fraser River delta provides evidence for dynamic subsistence patterns during this period. Such changes are thought to reflect adaptations to changing environmental conditions associated with the onset of delta progradation after 9000 BP. Changes in relative abundance of marine species at these delta sites that can be attributed to delta progradation include the introduction of soft sediment shellfish species (Ham 1976; Matson 1976), the introduction of birds (Matson 1976) and the intensification of anadromous salmon resources (Matson 1976) marked by changing fishing technologies possibly related to delta progradation (Stevenson 1998).

Stilson (1972) provides a cogent model for prograding southern Northwest Coast deltas that links environmental change and human subsistence. In his hypothetical delta site a Rocky Saltwater Beach subzone/Marine zone assemblage would initially predominate and would be represented archaeologically by rocky shore shellfish and marine fish, with little terrestrial mammal hunting. As the delta prograded seaward littoral gathering would decrease in economic importance as rocky shore shellfish were killed by the delta sediments and replaced by less abundant soft-sediment bivalves. Fishing and hunting of land mammals would increase in economic importance to compensate for lessening numbers of shellfish. Thus, through time the relative abundance of marine fish would decrease and aquatic fish would increase.

This reassessment of lower Nooksack River prehistory utilizes this knowledge of delta development and human response to delta progradation to test two models of Nooksack River development. One developmental model forwarded by geologist Easterbrook (1962, 1971) places the lower Nooksack River in its present watershed by 9000 BP. Application of this model to lower Nooksack River archaeology suggests the delta has prograded seaward (i.e. away) from the Ferndale site-complex at a steady rate to its modern position. Under this model it is expected that archaeological deposits and associated geological materials at the site-complex should increasingly reflect inland riverine/terrestrial conditions across the mid-Holocene horizon. An alternative model forwarded by geologists Pittman et al. (2003) suggests the lower Nooksack River did not occupy its present watershed until late in the Holocene thereby delaying the onset of delta progradation. Under this model it is expected that archaeological deposits and associated geological materials at the site-complex
should reflect a small and geologically stable river valley (i.e. not including the Nooksack River) and proximal stable marine paleoshorelines until the late-Holocene avulsion and concomitant delta progradation.

Based on the outcome of this test we then can apply geological data to mid- to late-Holocene lower Nooksack River site location. This integrated model is based on what Waters (1992) terms the "chronological ordering" of archaeological sites on a prograding shoreline. If Easterbrook's model is accepted then mid-Holocene sites containing evidence of marine subsistence strategies (e.g. shellfish, marine fish) should be located "farther inland on the older landforms, with sites becoming progressively younger in a seaward direction where the youngest delta landforms are preserved (Waters 1992:274)." Alternatively, if Pittman et al.'s model is accepted then mid-Holocene sites containing evidence of marine subsistence strategies should also exist inland on older landforms, except for an unusually extended period of time. Thus the movement of sites seaward through time should accordingly not be recognizable until the Nooksack avulsed to its present watershed and initiated delta progradation, perhaps as recently as the last 1000 years.

Although this study considers the entire mid- to late-Holocene lower Nooksack River archaeological record it emphasizes the mid-Holocene period upper delta record, particularly the Ferndale site-complex. The upper delta landscape and mid-Holocene period are emphasized for two main reasons: (1) the inland geographic location of the site-complex places it in a position predicted to be maximally affected by increasing delta progradation rates resulting from stabilizing mid-Holocene sea levels and delta progradation; and (2) the presence of the site-complex shell midden (45WH34) contains clear evidence of coastal adaptations 14C dated by Grabert (1983) to between approximately 5000 and 1000 BP.

The research area emphasized here is defined as the "upper Nooksack River delta." As Figures 2.05 and 2.06 illustrate, the upper Nooksack River delta is an area covering some three square miles of the lower Nooksack River near Ferndale and includes Holocene sediments of the Nooksack River delta, as well as bordering upland terraces composed of older Pleistocene glacial and post-glacial sediments. The research area is centered on Nooksack River Mile Six (RM 5.5) near the City of Ferndale, it extends upriver to the Ferndale site-complex (RM 6), and downriver to Hovander Bend (RM 5). This area is deemed archaeologically and geologically significant because it represents the location where the prehistoric river system evolved, at some time in the Holocene, from an inland estuary to a prograding marine delta. Prehistoric shell midden sites-complexes like those at Ferndale and East Ferndale lie within the approximately three-square mile upper delta area. They are believed to reflect proximal positions of the prehistoric estuary and shorelines. Geological and faunal evidence from such delta sites, in conjunction with other lower Nooksack River archaeological studies, can provide important evidence for past environmental and cultural conditions on the lower Nooksack River.
45WH36, WH37, WH38, WH39, and WH40

45WH34

45WH42

45WH96

East Ferndale sites

45WH95

”Hovander Bend” logjam

45WH19

Figure 2.05. Map, upper Nooksack River delta locales mentioned in text shown on a 7.5 minute Ferndale Quadrangle map. Empty red circles are known prehistoric archaeological sites, two-toned dots are archaeologically surveyed areas, and solid red dots are areas observed and discussed by the author.
The Upper Nooksack River Delta Area

- Ferndale site-complex RM 6
- East Ferndale site-complex RM 5.5
- Hovander Bend RM 5.0
- Active floodplain
- Tennant Lake complex
- Ten-mile Creek
- Barrett Lake
- ~2 miles to Bellingham Bay
- ~1 mile to Lummi Bay

Figure 2.06. Aerial photo, approximated positions of terrace/floodplain boundaries (dotted yellow lines) shown on a color aerial photo of the upper Nooksack River delta region. Note the increasingly larger floodplain width below River Mile 6 (RM6). Top is north. Modified from WADOT 2000.
This study considers lower Nooksack River prehistory in light of a dynamic fluvial landscape. This is achieved by placing data in geoarchaeological context. Geoarchaeological research is considered a major component of the larger fields of contextual archaeology (Butzer 1982) and environmental archaeology (Dincauze 2000; Reitz et al. 1996). As Sandweiss (1996) suggests, archaeologists are uniquely situated to trace environmental change and its long-term human consequences. The first section of this chapter addresses geoarchaeological method and theory for alluvial landscapes. It is shown that different processes, including coastal river change, can initiate systemic disequilibrium resulting in the appearance, reorganization, or abandonment of prehistoric settlements (Waters 1992). Two methods discussed here, the evaluation of sediments and soils in archaeological context, are particularly useful tools for describing such relationships. Utilizing hydrologic data and geological data, the remaining sections frame the Ferndale site-complex in geographical context. It is shown that although there is no consensus regarding the Holocene history of the lower Nooksack River, there is sufficient evidence to suggest the Ferndale site-complex exists, and existed, at a transitional position on the landscape where the paleoshoreline, paleoestuary, and initial delta building existed during the mid-Holocene period. Two competing developmental models are presented that explicate lower Nooksack River development. These models provide the basis for evaluating the environmental and cultural record preserved at the Ferndale site-complex.

ALLUVIAL GEOARCHAEOLOGY: METHOD AND THEORY

has been promoted, in part, by the abundance of stratified sites associated with riverine settings, and by the utility of cultural-geological successions that link past human and environmental events (Larsen and Schuldenrein 1990:161).

Geoarchaeology has been defined as archaeological research that utilizes the methods and theories of earth sciences (Butzer 1982). Geoarchaeological investigations are concerned with context and form a major component of what Butzer (1982) and Schoenwetter (1981) term "contextual archaeology" (Waters 1992:3).

Contextual archaeology is a systems approach in which the contextual components of the human ecosystem (flora, fauna, climate, landscape and human culture) are reconstructed and the interactions between them are used to explain cultural stability and change. People develop an adaptation that is in a state of dynamic equilibrium with other components of the human ecosystem. This adaptation is maintained as long as the cultural subsystem is flexible enough to adjust itself to internal stresses and external changes in other parts of the ecosystem. However, if the intensity and duration caused by change in one or more components is greater than the ability of the cultural system to endure, the system will be sent into disequilibrium and will trigger changes in human behavior. (Waters 1992:4)

Different processes can initiate systemic disequilibrium resulting in the appearance, reorganization, or abandonment of prehistoric settlements (Waters 1992:5). Many Pacific Northwest Coast archaeologists have considered these processes. Factors relevant to the Ferndale site-complex are provided as examples and, when available, local or regional examples are provided. Systemic disequilibrium resulting in adaptation can be initiated by changing:

1. Landscape factors: including changes in relative sea level change (e.g. Cannon 2000; Duff 1963; Heatherington et al. 2003; Fladmark 1975; Grabert and Larsen 1975; Larsen 1971, 1972; Stright 1995), river avulsion (Grabert and Griffin 1983) and delta progradation (Ham 1976; Stilson 1972);
2. Floral factors: including changes in distribution and type of plant assemblages (e.g. Ham 1976; Hebda and Matthewes 1985; Hutchings and Campbell in press);
3. Faunal factors: including changes in composition, distribution or seasonality of species (e.g. Fladmark 1975; Ham 1976; Hutchings 2003b; Hutchings and Campbell in press; Stilson 1972);
4. Climatic factors: including drought or increased rainfall (e.g. Hebda and Matthews 1985); and
5. Cultural factors: including subsistence (e.g. Cannon 1996; King 1950; Wessen 1988), mobility (e.g. Ames 2002; Cannon 1991; Coupland 1988; Wood and Matson 1973), technological innovation (e.g. Croes and Hackenberger 1988; Stevenson 1998; Schalk 1977), and population pressure (e.g. Croes and Hackenberger 1988).

Because these factors are part of the larger ecosystem, they may act alone or in combination to initiate behavioral responses (Waters 1992:5). Processes considered in this analysis are primarily limited to changing landscape and faunal factors associated with lower Nooksack River change that may have initiated human adaptation or subsequently altered the record of such an activity. Human adaptation to changing river systems can occur at global (e.g. Stanley and Warne 1997), regional (e.g. Waters 1992), or local scales (e.g. Stilson 1972).

Cultural response to river change at global scales includes the near-synchronous settlement of marine deltas between 8500 and 6500 BP (i.e. years before present). Stanley and Warne (1997:1-7) examined thirty-four documented archaeological sites, dated >5000 BP and located in and around marine deltas, to evaluate
early occupation of Holocene deltas worldwide. Modern marine deltas began to form from approximately 8500 to 6500 years ago (Stanley and Warne 1994), and their survey distinguishes at least 16 archaeological sites dated to 7700 BP, which indicates that these resource-rich ecosystems were used by humans soon after their development. They link deceleration in the rate of Holocene sea-level rise with the near-synchronous development of deltas and human occupation of these coastal plains. Their integrated geological and archaeological database shows that conditions in and around deltas (e.g. accumulation of fertile soil, reliable water supply, perennial aquatic food sources, ease of travel and trade) were attractive to human immigration and settlement. In a recent discussion concerning the importance of deltaic wetland resources to southern Northwest Coast economies, Hutchings and Campbell (n.d.) suggest that the role of delta building as a synchronous regional process deserves more exploration.

Cultural response to river change at regional, or intra-watershed, scales include the migration of prehistoric settlements upriver or downriver through time. As previously mentioned, the basic assumption behind the chronological ordering of archaeological sites across the landscape is that prehistoric people found it advantageous to locate their sites in close proximity to a particular landscape (often estuarine or littoral zones), where they had easy access to a specific resource or set of resources (Waters 1992:272-274). The chronological ordering of sites can result from a single transgressive sequence (e.g. Barber 1979; Dincauze 1973), a singe progradational sequence (e.g. Gagliano 1984; McIntire 1971), or multiple sequences resulting in a highly complex record (see Waters 1992: Figure 6.14). On the Atlantic Northeast Coast of North America there is evidence that the earliest and longest occupied sites tend to be found on the lower parts of the river, near the oldest part of the estuary, and more recent occupations are found upstream (Thornbahn and Cox 1988:175). On the Mississippi River delta, hunter-gatherers are believed to have "pursued" estuarine, littoral and nearshore resources seaward through time in response to the prograding delta (Gagliano 1984; McIntire 1971). Unlike transgressive landscapes, in progradational settings the earliest sites tend to be found inland where the paleodelta was first established, with sites becoming younger towards the modern shoreline.

Localized cultural response to river change involves viewing the archaeological record from a single, fixed, location. Stilson (1972:56-60) examines human response to delta change for the southern Pacific Northwest Coast Skagit River. His work at three northern Puget Sound Skagit River delta sites allowed him to predict changes in the zonal ratios of the faunal assemblages at a hypothetical site whose inhabitants were utilizing maritime resources and who were affected by delta progradation. His model shows zonal changes in relation to delta progradation: initially, the Rocky Beach Littoral and Marine area would be present. As the delta brought sediments to this area, a Soft-Sediment Littoral environment would replace the Rocky Shore. Soon the area would become deltaic tide prairies and salt water marshes, an Aquatic area. In this hypothetical site a Rocky Saltwater Beach subzone/Marine zone assemblage would predominate. The main constituents would be rocky shore shellfish and marine fish, with little terrestrial mammal hunting. As the delta prograded seaward, littoral gathering would decrease in economic importance as rocky shore shellfish were killed by the delta sediments and replaced by less abundant soft-sediment bivalves. Bivalves favoring sand would not necessarily increase because a sand environment is related to other factors besides the presence of deltaic
activity. Fishing and hunting of land mammals would increase in economic importance to compensate for lessening numbers of shellfish. The incidence of marine fish would decrease as they were driven away by the delta’s incursion, and aquatic fish would replace them. The most widely recognized of these localized responses on the southern Pacific Northwest Coast is the frequently observed transition from rocky shore Mytilus in lower and older stratigraphic levels to soft sediment shellfish in upper and more recent levels.

Environmental changes have often been cited as an explanation for the mussel-clam shift. For the Skagit River Stilson (1972) ties the shift to changes in intertidal environments, particularly the siltation of rocky shores. Grabert et al. (1978) suggest the same condition at Semiahmoo Spit in Washington, and Ham (1976) describes a similar one at the Fraser Delta in British Columbia. They argue that epifaunal mussel communities declined with the reduction of their habitat and were gradually replaced by infaunal clam communities expanding with the growing sand and mud flats. Such changes would probably be gradual, and we should be able to relate intertidal changes to postglacial sea level adjustments. (Wessen 1988:199)

Alluvium, the central geological theme in this discussion, is a general term for hydraulically deposited sediment resulting from the operations of rivers and includes the sediments laid down in river channels, floodplains, lakes, fans at the foot of mountain slopes, and estuaries (AGI 1962). Alluvium aggrades in the floodplain as the river shifts its location laterally, creating vertical accretion (or bottom stratum) deposits; when discharge overflows the channel and inundates the plain, vertical accretion (or top stratum) deposits aggrade (Gladfelter 2001:93). Deposition of lateral accretion sediments is within and proximal to the river channel. Vertical accretion sediments accumulate beyond the river channel in the floodplain. Archaeological sites that were close to the channel frequently become buried or eroded.

Alluvium is of interest to archaeologists for two reasons: 1) alluvium is a common matrix for artifacts, and floodplains and fans are common settings for archaeological sites, and 2) alluvium and its hydrogeomorphic context may indicate characteristics of past hydrological conditions and, consequently, of a paleoenvironment (Gladfelter 2001:93). Regional and local geological sequences encompass many of those influences that watersheds impose on their channels: runoff patterns, sediment sources, channel gradient, hydraulic roughness, valley form, watershed size, and the responsiveness of a stream or river to change. The geological setting of river basins, and of individual stream reaches, will determine what types of channel morphology and habitat features occurred under natural conditions.

Because soils that form in alluvial valleys can also provide evidence for the age and geomorphic/environmental contexts of archaeological sites, soil sciences, particularly pedology, can enhance our understanding of how humans may have responded to stability or change in alluvial systems (Ferring 1992). Holliday (1992) and others examine soils in an archaeological context and show how soils can be used for reconstructing past landscapes and landscape evolution, for use in estimating the age of surfaces and depositional episodes, and for providing physical and chemical indicators of human occupation.

Pedology is the scientific study of soils and their weathering profiles. Pedogenesis, or soil formation, is brought about by a series of specific changes that can be grouped into four broad processes: (1) transformations, such as mineral weathering and organic matter break down, by which some soil constituents
are modified or destroyed and others are synthesized; (2) *translocations*, or movements of inorganic and organic materials from one horizon up or down to another, the materials being moved mostly by water but also by soil organisms, (3) *additions* of materials to the developing soil profile form outside sources, such as organic matter from leaves, organic matter from human activity, dust from the atmosphere, or soluble salts from the groundwater, and (4) *losses* of materials from the soil profile by leaching to groundwater, erosion of surface materials, or other forms of removal (Brady and Weil 1999:62–63). These processes, particularly transformation and translocation, often result in the accumulation of materials in a particular horizon. On floodplains the rate of soil development is inversely proportional to the rate of overbank deposition, so when alluviation decreases or stops, then organic rich A horizons can develop (Brown 1997). A horizons can be preserved under floodplain sediments and are useful for determining past floodplain conditions.

By understanding pedogenic processes researchers gain a logical framework for understanding the relationships between particular soils and landscapes and ecosystems in which they function, or functioned in the past (Brady and Weil 1999:63). Because archaeologists are concerned with landscape and ecosystem development, soil science is recognized as an invaluable addition to more traditional archaeological methodologies (e.g. Holliday *et al.* 1993; Stein 1993).

Soil science (particularly pedology) and archaeology are closely allied in their temporal and spatial scales, and among the earth sciences, pedology is most similar to archaeology in operational and processual scales. These similarities in scales are apparent in both regional and site-specific studies...The scalar compatibility of archaeology and pedology strongly argues for pedologists and pedologic perspectives to be involved in all phases of archaeological research. (Holliday *et al.* 1993:29)

## THE LOWER NOOKSACK RIVER

Much of the Nooksack River watershed occurs in the steep and mountainous foothill terrain of the Cascade Mountain Range in Whatcom County, which at one point extends across the Canada/U.S. international border (Whatcom County 1988). The Nooksack River watershed falls into the Canadian Coast Mountains and Islands unit (Hebda 1995) and the American Puget Trough Province, Puget Sound area (Franklin and Dyrness 1988). The Coast Mountains and Islands unit encompasses Vancouver, Queen Charlotte, and Strait of Georgia Islands, the high elevation Coast Mountains, and low elevation Strait of Georgia trough landscapes.

Franklin and Dyrness’ (1988) Puget Trough Province extends the length of Washington State from the Canadian Border to the Willamette Valley in Oregon. The southern half of the Province is dominated by the Cowlitz River Valley while the northern portion is a depressed, glaciated area that is now partially submerged by Puget Sound (1988:17). Fluvial geomorphologists refer to the area as the Puget Lowland. According to Booth *et al.* (2003), the Puget Lowland:

… shows the interplay of recent fluvial activity superimposed on a much longer history of tectonic, volcanic, and glacial action...Its counterparts to the north and south, the Georgia
Depression and the Willamette Lowland, share many of same elements of geological history and fluvial activity. (2003:15)

The Cordilleran Ice Sheet at its late Wisconsin maximum, approximately 14,500 BP, was approximately 1800 m thick over the Fraser/Nooksack Lowland (Easterbrook 1962) and extended approximately 80 km south of Seattle (Kovanen 2002:164). During deglaciation, the ice sheet thinned and backwasted to the Strait of Juan de Fuca, where invasion of seawater beneath the glacier approximately 12,500 BP triggered rapid breakup of the ice. Melting of debris-laden ice, floating in marine water up to approximately 180 m above modern sea level, deposited glaciomarine sediments over a wide area (approximately 18,000 km²). Following emergence of the lowland at approximately 11,600 BP, the remnant of the ice sheet readvanced several times. These rapid environmental changes took place during the Everson Interstadte and Sumas Stade.

Apart from the significant effects of deglaciation (e.g. glaciomarine sedimentation, post-glacial land emergence, sea level rise) occurring during the terminal-Pleistocene and early-Holocene, the most significant change to the Holocene coastal riverine landscape was the formation of marine deltas. Deltas are discrete shoreline protuberances formed where rivers enter oceans, semi-enclosed seas, lakes or lagoons and when the supply of alluvial sediment exceeds the rate of distribution by oceanographic processes (Elliot 1986). Marine deltas develop from the complex interaction between sediment grain size, river velocity, outflow friction from the bed, and outflow buoyancy in the riverine/marine mixing zone (Orton and Reading 1993). Marine deltas fill the mouths of valleys once drowned by the late-Quaternary sea level rise (Wright 1985). High sea level increases sedimentation rates on deltas because sediment is trapped by the rising water, thus inhibiting sediment removal by currents (Boggs 2001). Deltas are classified as being either constructive or destructive (Boggs 2001). The active, constructional phases of delta outbuilding are dominated by sedimentation and progradation of deltaic deposits seaward. Modern marine deltas began to form from approximately 8500 to 6500 years ago (Stanley and Warne 1994) and conditions in and around deltas (i.e. accumulation of fertile soil, reliable water supply, perennial aquatic food sources, ease of travel and trade) were attractive to human immigration and settlement (Stanley and Warne 1997).

If the Nooksack River delta is typical of most marine deltas, as Easterbrook (1962) infers, then the lower 13.8 square mile delta floodplain, or zone of deposition, represents the mouth of a valley once drowned by terminal-Pleistocene relative sea level rise (Wright 1985). Stable sea levels occurring here by approximately 6000 to 5000 years ago likely increased sedimentation rates on the delta because the rising water trapped sediment, ultimately inhibiting sediment removal by currents (Boggs 2001; Stright 1995; Williams and Roberts 1989).
**Hydrology**

The Nooksack River watershed encompasses some 825 square miles with an elevation range from sea level to over 10,000 feet (see Whatcom County 1988, 1998, 1999). As Figure 3.00 shows, the watershed stretches over 70 river miles, east to west, beginning at sea level at the Puget Sound shoreline, to its maximum on the heavily glaciated 10,778 foot (3285 m) stratovolcano Mt. Baker, lying some 31 linear miles (50 km) east of Bellingham. Pyroclastic flows originating on Mt. Baker have been recorded as far downstream as Deming (see Gardner et al. 1995).

The three main forks of the upper Nooksack River drain steep glacially carved valleys that converge upstream of the town of Deming. The Nooksack mainstem enters the lower-lying coastal plain, or Whatcom Basin, some five miles downstream of Deming near Nugent's Corner (Whatcom County 1988). The Whatcom Basin is that portion of the Nooksack River watershed that occupies the low elevation coastal plain below Deming. The lower Nooksack River floodplain is the portion of the Whatcom Basin lying below 100 feet elevation that is flooded.

![Figure 3.00. Chart, showing Nooksack River gradient extending from Sea Level at the Puget Sound shoreline below Ferndale (bottom left), to the Upper Basin above Deming. Modified from Whatcom County 1999:Figure 3.3.](image-url)
We can describe the Nooksack River watershed in terms of an idealized fluvial system (following Schumm 1972). As shown below in Figure 3.01, the Ferndale site-complex exists at the transition between Zones Two and Three. Zone Two is the middle portion of the system that functions as the sediment transfer zone and in this case represent the portion of the river on the coastal plain. Zone Three is the lower portion of the system and is the delta which functions as the area of deposition.

The modern Nooksack River Basin can be visualized using Schumm’s (1972) model of an idealized fluvial system. Dominant features include:

**Zone 1** - the upper portion of the system that is the watershed or drainage basin; this portion of the system functions as the sediment supply.

**Zone 2** - the middle portion of the river system; this portion of the system functions as the sediment transfer zone.

**Zone 3** - the lower portion of the system may be a delta, wetland, lake, or reservoir; this portion of the system functions as the area of deposition.

*Figure 3.01. 45WH34 as an idealized fluvial system.*  
Schematic adapted from Watson et al. (1999:28).
The Ferndale site-complex is located at a transitional position in terms of its specific hydrogeomorphic characteristics. Table 3.00 are river reach descriptions for the Nooksack River. Reaches are defined to a large degree by two characteristics, gradient and floodplain. At 6.5 miles inland the Ferndale site-complex exists at the transition between Reaches One and Two. The width of the Nooksack River floodplain ranges from 1/4 mile upstream near Deming to four miles at its delta (approximately from Sandy Point to Marietta). The Ferndale site-complex shell midden, 45WH34, is located on the active floodplain between Nooksack River Reach One (RM 0-6) and Reach Two (RM 6-15.3) (Whatcom County 1999:2-2). At this point the River is a pastoral stream with a gradient of less than 5 feet per mile and an average bank height of 10 feet. It is typified by a single, wide, near-level floodplain, with large point bars and steep outer banks. The bedload is typically medium sand to silt size particles.

Table 3.00. River Reach Descriptions

<table>
<thead>
<tr>
<th>River reach</th>
<th>River mile</th>
<th>River channel</th>
<th>FEMA 100-year floodplain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Length (miles)</td>
<td>Gradient (ft/mile)</td>
</tr>
<tr>
<td>1</td>
<td>0 to 6.0</td>
<td>6.0</td>
<td>1.8</td>
</tr>
<tr>
<td>2</td>
<td>6.0 to 15.3</td>
<td>9.3</td>
<td>2.3</td>
</tr>
<tr>
<td>3</td>
<td>15.3 to 23.6</td>
<td>8.3</td>
<td>4.9</td>
</tr>
<tr>
<td>4</td>
<td>23.6 to 36.6</td>
<td>13.0</td>
<td>21.3</td>
</tr>
</tbody>
</table>

Modified from Whatcom County 1999:Table 2.1

Two maps on the following pages provide different views of the Ferndale site-complex in relation to the lower Nooksack River floodplain. They are shown to highlight the unique position of the site-complex in relation to the upstream and downstream reaches of the Nooksack River. Figure 3.02 is Reach One (RM 0-6) and shows the site-complex on the 100-year floodplain. Figure 3.03 is Reach Two (RM 6-15.3) and shows the site-complex on the 100-year floodplain. Note the difference in floodplain size above and below the site-complex.
Figure 3.02. Map, showing lower Nooksack River Reach One (RM 0-6), 100-year floodplain, and the Ferndale site-complex. *Modified from Whatcom County 1999: Figure 2.1*
Figure 3.03. Map, showing lower Nooksack River Reach Two (RM 6-15.3), the 100-year floodplain and the Ferndale site-complex. *Modified from* Whatcom County 1999: Figure 2.2
**Flora and Climate**

The hydrogeomorphic transition at the Ferndale site-complex and River Mile Six influences local riparian biology. Although studies provide evidence for modern and historic ecological conditions, how stable these patterns were 5000 years ago is unclear because the geological setting of river basins, and of individual stream reaches, determines what types of channel morphology and habitat features occurred (Booth *et al.* 2003).

In describing British Columbia's vegetation and climate history, with a focus on 6000 BP, Hebda (1995) synthesizes available data for the Fraser River lowland. He concludes that the 6000 BP horizon followed climatic adjustments marked by both cooling and increased mean precipitation. Williams and Hebda (1991) report a climatic sequence on the Fraser River delta based on temporal changes in the flora of deltaic wetlands. They describe 6800 BP as marking a transition from herb- to shrub-wetland vegetation. They note an increase of arboreal taxa including Western hemlock (*Tsuga heterophylla*), spruce (*Picea* spp.), pine (*Pinus* spp.), and alder (*Alnus* spp.). Hebda (1995) believes this record is the result of a regional transition from an open state to a forested state and is the product of cooler and wetter climatic conditions. He suggests this period also marks an increase of the culturally significant (see Stewart 1984) Western red cedar (*Thuja plicata*). Hebda and Mathewes (1985) cite *Thuja* as occurring in low frequency throughout the region from between 10,000 and 6,000 BP. Both cedar and hemlock began to expand following 6,800 BP and likely dominated the Fraser/Nooksack lowland by 5,000 BP. Cooling temperatures and increased rainfall also resulted in the increase of deltaic wetland and riparian habitat (Hebda 2000; Hutchings and Campbell *in press*).

DiDomenico (1982) used data from early explorers, settlers, and General Land Ordinance (GLO) surveys to reconstruct the Nooksack River lowland vegetation at the time of European settlement. He showed that the settlement period forest pattern was a complex mosaic of different aged stands of variable species composition, dependent on location with regard to topography (drainage pattern), substrate, and the history of human and natural disturbance. Information provided by early explorers and surveyors suggests that Douglas fir (*Pseudotsuga menziesii*) dominated most forest communities on uplands and glacial outwash terraces. Western red cedar (*Thuja plicata*) was more abundant and codominated (with *Pseudotsuga*) undisturbed stands on relatively well-drained terrain. *Thuja* became more important towards the wetter end of the moisture gradient. The importance of *Thuja* in former Nooksack Lowland forests over a wide variety of habitats was greater than its importance in Puget Trough forests (DiDomenico 1982:88).

Relatively well-drained uplands and glacial outwash terraces were characterized by stands dominated by *Pseudotsuga menziesii* and *Thuja plicata*. Western hemlock (*Tsuga heterophylla*) was important but its distribution was sporadic. Bigleaf maple (*Acer macrophyllum*) was the most widely distributed deciduous tree species. The most frequently reported undergrowth species were Vine maple (*Acer circinatum*), blackberry (*Rubus* sp.), willow (*Salix* sp.), and ferns. Reports of "logs on the ground" were fairly common (DiDomenico 1982:86).

Forest stands on wetter sites, including upland depressions and glacial outwash terraces, were dominated by *Thuja plicata* and *Pseudotsuga menziesii*. Stands containing *Picea sitchensis*, *Alnus rubra*, and...
Paper birch (*Betula papyrifera* spp.) occurred towards the wetter end of the moisture gradient. *Picea* and *Alnus* dominated some communities. The most frequently reported undergrowth species (particularly forest openings) were *Acer circinatum*, *Salix* spp., *Spiraea douglasii*, *Rubus* spp., *Alnus*, and *Pyrus fusca* spp., *Pseudotsuga*, *Thuja*, *Betula*, *Acer macrophyllum*, *Tsuga heterophylla*, and *Picea* were reported more frequently as undergrowth than on relatively well-drained forest. (DiDomenico 1982:86-87).

Nooksack River alluvium was characterized by variable species composition dependent on frequency of flooding and distance from the river. Areas frequently flooded and nearest to the river were dominated by *Alnus rubra*, and *Salix* spp. Areas farthest from the river that were less frequently flooded and had better soil development were characterized by a mixed forest. Stands variously dominated by *Picea sitchensis*, *Thuja plicata*, *Alnus rubra*, and Black cottonwood (*Populus trichocarpa*) were characteristic of intermediate areas. Stands on well-developed soils least frequently flooded and on drier area (natural levees) were dominated by *Pseudotsuga menziesii*, *Thuja plicata*, *Picea sitchensis*, *Acer macrophyllum*, and *Tsuga heterophylla* (DiDomenico 1982:87).

Forest stands at the edges of swamps and marshes were dominated by *Alnus rubra*, *Tsuga heterophylla*, *Thuja plicata*, *Picea sitchensis*, and *Pyrus fusca*. *Tsuga* was more important in these areas than elsewhere. Vegetation characteristic of peat in depressions on glacial outwash terraces included *Picea sitchensis*, *Alnus rubra*, *Thuja plicata*, *Pinus contorta*, *Salix* spp., *Pyrus fusca*, *Tsuga heterophylla*, *Spiraea douglasii*, *Vaccinium oxycoccus*, and *Ledum groenlandicum*.

More recently Collins and Sheikh (2002) describe historical riverine dynamics and habitats of the lower Nooksack River. They compiled maps and field notes from the GLO survey from 1859-1893, U.S. Coast and Geodetic Survey charts from 1887 and 1888, and aerial photographs from 1938 and 1944, into a GIS database. Their data were used to map the channel, wetland, forest and oxbow ponds in the Nooksack River valley at several different times during Euro-American settlement. Figure 3.04 shows the position of the Ferndale site-complex on Collins and Sheikh's (2002) map that approximates 1880 conditions.

Historically the greater Nooksack delta (including the Lummi and Nooksack rivers) included extensive estuarine and riverine-tidal freshwater wetlands, primarily on the Lummi River side, which has been the dominant outlet to salt water until the mid 1800s. Upstream of the delta, glacial processes created distinctly different valley topography in different parts of the study area, which in turn influenced the river morphology and valley landforms. Upstream of the delta, in the lower mainstem (to about Everson), the influence of a Pleistocene ice sheet that entered the valley from the north through the Sumas Valley created a broad, low-gradient valley. Holocene (post-glacial) deposition by the Nooksack River built up the river and its meander belt by typically 3-4 meters above the valley bottom. Extensive wetlands (primarily scrub-shrub, with beaver dams) occupied low areas marginal to the meander belt. (Collins and Sheikh's 2002:i)

Based on GLO field notes Collin's and Sheikh (2002:ii) conclude the pre-Euro-American-settlement forest was dominated by hardwoods, most commonly red alder (*Alnus rubra*), which accounted for 42% of all bearing trees. Western red cedar (*Thuja plicata*), while only one-fourth as common as alder, was the most common conifer as well as the largest tree. Among conifers, Sitka spruce (*Picea stichensis*) grew in low elevations. Among hardwoods, Pacific crabapple, willow and
birch grew in the lowest elevations, black cottonwood in moderate elevations, and alder in all elevations. In the Nooksack River delta, red alder was the most common streamside tree, with Sitka spruce and Black cottonwood being the only large-diameter trees, and Sitka spruce the dominant conifer. Western red cedar was the largest tree away from riverbanks.

Figure 3.04. Map, environmental conditions on the lower Nooksack River approximately 1880. EEW=estuarine emergent wetland; ESW=estuarine scrub-shrub wetland; RTS=riverine-tidal scrub-shrub wetland; PSW=palustrine scrub-shrub wetland; PFW=palustrine forested wetland. Modified from Collins and Sheikh (2002:Figure 6-2).
Evolution of the Fraser-Nooksack River System

For the last five decades geologists have entertained a broad range of possibilities in their effort to explicate the fluvial history of the Fraser/Nooksack Lowland. Many of these have direct implications for the Ferndale site-complex record. Because of limited quantitative geological data many of these proposed evolutionary models verge on speculative (with the exception of Cameron's 1989 study) and are further limited by the paucity of local relative sea level data. The most recent models are better grounded in quantitative geological data but lack of relative sea level data for the lower Nooksack River area hampers these as well.

Armstrong (1960) suggested the Fraser River could have flowed south through the Sumas Valley enroute to Bellingham and Lummi Bays. Such a route would place the massive Fraser River directly in front of the Ferndale site-complex. Easterbrook (1962, 1971) has proposed the development of the early Nooksack River occurred between approximately 10,000 and 9000 years ago and resulted in the accumulation of sediment at the delta over a period spanning perhaps 9,000 to 10,000 years in post-glacial time. Matthews (1972) has asserted the Nooksack River must have entered the Sumas Valley enroute to the Fraser River for a portion of the post-glacial period. This view was based solely on topographic analysis and supported by his observation of accumulations of sphagnum peat in recesses of the walls of the Nooksack River's former floodplain (see Cameron 1989:21).

Cameron (1989) reconstructed the post-glacial geomorphic history of the Sumas Valley and addressed the question of whether the Fraser could have flowed through the Sumas Valley enroute to the Lummi and Bellingham Bays. Based on the presence of a lobe of Nooksack alluvial fan gravel and sand in the southern portion of the valley that would have blocked any southward flow of Fraser River, and the absence of Fraser sediments in the Sumas Valley (except in a limited region in the extreme northern tip of the Sumas Valley), she rejects the theory that the Fraser River flowed through the Sumas Valley enroute to the ocean in the Holocene period.

More recently, Pittman et al. (2003) have attempted to refine the early observations of Matthews (1972) and Cameron (1989). Based on the numerous relict channels and oxbows in the Sumas valley that are consistent in size and radius of curvature with the modern Nooksack River, the depth and distribution of flood deposits, as well as alluvial fans that have been truncated by channel migration, Pittman et al. assert that at some point in the late-Holocene the Nooksack River avulsed from the Sumas Valley into a remnant glacial outwash channel that is its present channel course into Bellingham Bay. Thus they suggest the Nooksack was flowing north into the Fraser for much of the Holocene period.

At this time there is no consensus among geologists as to the evolution of the lower Nooksack River. This fact limits our ability to place the lower Nooksack River archaeological record in proper geological context. The following survey of lower Nooksack River geology is meant to highlight the complexity of discussing local archaeology in light of terminal-Pleistocene to late-Holocene geological change. Following consideration of relative sea level change, a summary of terminal-Pleistocene and Holocene Nooksack
Lowland geology is presented. Terminal-Pleistocene geology is an important component of Ferndale-site-complex geoarchaeology because the upper terrace sites exist in sediments deposited during this period.

Relative sea level change plays a central role in determining when and where shorelines exist, or once existed. Although geologists working in the Whatcom County area have intensively studied terminal-Pleistocene land-sea relationships (see Kovanen 2002; Kovanen and Easterbrook 2002; Kovanen and Slaymaker 2003), Holocene sea level change, particularly for the mid-Holocene period considered here, remains poorly understood. Thus, at this time local relative sea level data cannot be considered in this study. However, generalized regional sea level curves can be applied with great caution, as notable differences in relative sea level patterns can occur over short distances. Figure 3.05 is a generalized relative sea level curve for the southern Pacific Northwest Coast and is based on studies by Beale (1990), Clague et al. (1982), Mathews et al. (1970), and Stright (1995). Rapid dessication of late Pleistocene Cordilleran glaciers between 13,000 years ago and 11,500 years ago resulted in a rise of regional sea levels of up to 200 m (Kovanen 2002) and a rapid emergence of land due to crustal unloading (James et al. 2000). Lower sea levels dominated between 10,000 and 8000 BP. After 8000 BP relative sea levels rose to near present levels by approximately 5000 BP. Included in Figure 3.06, which is an illustration of the generalized relative sea level curve for the Fraser Lowland, are expected fluvial and deltaic responses to relative sea level changes. Based on this generalized model, and recognizing the paucity of local sea level studies, my analysis assumes sea levels achieved near present conditions by 5000 BP.

Figure 3.05. Chart, showing generalized relative sea level curve for the southern Pacific Northwest Coast and expected alluvial/delta responses.
The Sumas Stade was formally defined by Armstrong et al. (1965). It began with emergence of the lowland following deposition of Everson glaciomarine sediments and ended with the disappearance of the Cordilleran Ice Sheet from the area. Sumas Drift includes lodgement till, minor flow till, ice-contact sand, gravel, till, proglacial deltaic sand and gravel, glaciofluvial channel and floodplain sand and gravel, which cover a large part of the Fraser Lowland. The Sumas Stade dates to between 11,500 and 10,000 BP.

Easterbrook (1962) identified terminal moraines located near the town of Sumas, Washington, demarcating the maximum extent of Sumas Stade glacial advance. He identifies the melting of the Sumas lobe as having occurred no later than 10,000 years ago, as evidenced by 14C dated wood extracted from local peat bogs. Meltwaters of the Sumas lobe deposited sediments into troughs separating the Mountain View, Blaine and Lummi uplands, filling them to near present levels. Modern Nooksack River sediments now overlie these alluvial deposits.

The Sumas Stade represents the last phase of the Fraser glaciation. During this phase glacial ice stood just north of the Canadian border with a lobe extending southward across the border at Sumas. Meltwater streams flowing southward from the glacier built an outwash plain from the Canadian border to Lynden and from Everson westward nearly to Ferndale. The outwash plains consist of gravel near the glacial margin, but grade downstream to sand near Lynden and Laurel respectively. Abandoned meltwater channels are preserved in the outwash plain between Everson and Laurel. The outwash plains have been filled with peat and are now occupied by lakes such as Wiser, Fazon, Fountain, and Green…Radiocarbon dates from the base of the bogs indicates that the glacial meltwater ceased to flow about 10,000 years ago. Other examples of abandoned meltwater channels are the valleys of Tenmile Creek and Squalicum Creek. (Easterbrook 1971:25)

More recent work by Easterbrook and others (e.g. Kovanen 2002; Kovanen and Easterbrook 2002; Kovanen and Slaymaker 2003) have refined and expanded the Nooksack Lowland terminal-Pleistocene geological history. Figure 3.06 is Kovanen's (2002) shaded topographic model of the Fraser/Nooksack Lowland. Figure 3.07 is Kovanen and Easterbrook's (2003) shaded topographic model of a portion of the Fraser Lowland, with lines representing the approximate ice-margin positions of remnant Cordilleran ice during the Sumas (SI, SII, SIII, SIV) interval between ~11,600-10,000 BP. While the proximity of line SI to Nooksack River Mile Six (and the Ferndale site-complex) raises some interesting questions concerning possible relationships between post-glacial geology and later fluvial conditions, Figure 3.09 is provided instead to highlight the complexity of early to mid-Holocene archaeology in western Whatcom County. A highly dynamic terminal-Pleistocene and early-Holocene geological history is, and will continue to be, a great challenge to local archaeologists. New research, particularly Kovanen and Slaymaker’s (2003) work on the Lake Terrell upland, also highlights the need to reassess early archaeological models forwarded by Grabert and others (e.g. Grabert 1983; Grabert and Larsen 1971, 1975; Larsen 1971, 1972).
Figure 3.06. Map, shaded topographic model of the Fraser/Nooksack lowland showing the Sumas River Valley (SRV) and the lower Nooksack River study area (red box). For reference, the positions of the Fraser River delta Glenrose Cannery and St. Mungo sites (top left) and the Nooksack River delta Ferndale site-complex (bottom) are provided and are denoted by the two-toned dots. *Modified from* Kovanen 2002.
Figure 3.07. Map, shaded topographic model of a portion of the Fraser Lowland, looking northeast. Lines represent the approximate ice-marginal positions of remnant Cordilleran ice during the Sumas (SI, SII, SIII, SIV) interval between ~11,600–10,000 14C yr BP. The black dots show the location of radiocarbon dates (70 dates; 24 on marine shells, 46 on wood and peat) associated with moraines, outwash surfaces and channels, lakes, and stratigraphic sections. White-filled features are abandoned meltwater channels and the raised Campbell River delta. Two-toned dot near SI line represents approximated position of the Ferndale site-complex. Modified from Kovanen (2002); Kovanen and Easterbrook (2003).
Easterbrook provided the first intensive examination of Whatcom County geology. His research emphasized late-Pleistocene glacial deposits, although he provides important commentary on post-glacial landscape change (see Easterbrook 1962, 1966, 1971, 1973). Easterbrook has identified four major lithologic units as dominating the Whatcom Basin, as illustrated in Figure 3.08. These include recent alluvium of streams, spits and deltas, typified by the floodplains and deltas of the Nooksack River and local streams; outwash deposits of late Pleistocene Sumas outwash alluvium, typified by sands, silts and clays found in the lowlands of the Whatcom Basin; Quaternary deposits of the Bellingham glaciomarine drift; and the late-Cretaceous to early-Tertiary deposits of the Chuckanut Formation.

Figure 3.08. Map, geology of western Whatcom County. The Ferndale site-complex is geologically bound by fill terrace terminal-Pleistocene Sumas Stade glacial outwash (Qso) sediments and the younger sediments of the modern Nooksack River floodplain (Qal). Modified from Easterbrook (1962).

Easterbrook (1962) proposed that the development of the early Nooksack River occurred between approximately 10,000 and 9000 years ago. Holocene delta progradation resulted in approximately 10 linear km of floodplain development, included the capture of the Lummi peninsula and the formation of twin deltas feeding Lummi and Bellingham Bays (1962:122). In a period of 50 years during the last century the delta
above high tide has advanced one mile into Bellingham Bay (Easterbrook 1971). Easterbrook dates the beginning of Nooksack delta growth to the Sumas Stade of Fraser Glaciation when meltwater streams first began depositing sediment into the sea at a level within a few tens of feet of the present.

These early deltaic deposits are now buried beneath the modern floodplain and delta. In its early phases of development the delta was well upstream, at least as far as Ferndale, and what is now Lummi Peninsula was an island, separated from the mainland by arms of the sea on either side. Accumulation of sediment at the delta over a period spanning perhaps 9,000 to 10,000 years in post glacial time caused it to extend southward until it reached the island (now Lummi Peninsula) and annexed it to the mainland. (Easterbrook 1971:29)

As a contribution to the 1973 *Nooksack River Plan* Jones and Jones (1973:5) created a map series depicting the terminal-Pleistocene and Holocene evolution of the lower Nooksack River. Although poorly referenced, the series apparently reflects their interpretation of regional geological studies. One map depicts the Lummi peninsula as an island and in the process of being accreted to the mainland via delta progradation. Another (1973:6) depicts the Nooksack River flowing north into Canada as a tributary to the Fraser River; this perspective is likely based on the work of Matthews (1972), although it is not cited. The accompanying caption to this map states: *Nooksack Indian Legend: Nooksack Flows North Into Fraser*. In the caption Jones and Jones note:

Only a natural levee in the Everson area keeps the Nooksack from flowing into the Fraser River. Nooksack Indian legends indicate that the Nooksack River may at one time have flowed north into the Fraser. (1973:6)

More recently Cameron (1989:112) attempted to reconstruct the post-glacial geomorphic history of the Sumas Valley and address the question of whether the Fraser could have flowed through the Sumas Valley in post-glacial times. Her field sampling included a linear transect down the Nooksack River, terminating approximately 1.5 km upstream of the Ferndale site-complex. As illustrated in Figure 3.09, Cameron asserts:

The theory that the Fraser River flowed through the Sumas Valley enroute to the ocean in the Holocene is rejected. This conclusion is based on the presence of a lobe of Nooksack alluvial fan gravel and sand in the south portion of the [Sumas] valley which would have provided a formidable obstacle to any southward flow of water. In addition Fraser sediments were not found in the Sumas Valley, except in a limited region in the extreme northern tip of the Sumas Valley. (1989:113)
Pittman et al. (2003) have recently refined the early observations of Easterbrook (1962) and Cameron (1989). They provide evidence for a late-Holocene avulsion of the Nooksack River; "an event that has great implication for international interest because of concerns with cross-border flooding, volcanic hazards and future avulsion potential, but has had little study to date (Pittman et al. 2003)." While earlier geological work by Cameron (1989) demonstrated that thick deposits of bedload originating from the Mount Baker volcano underlie the Sumas River valley, Pittman et al. suggest that the Nooksack River, which heads on Mount Baker, flowed north through the Sumas Valley into the Fraser River for much of the Holocene.

Pittman et al. (2003) note that the Nooksack River drains more than 1400 square kilometers at the point where it would flow north to the Fraser, making it one of the larger tributaries to the Fraser. They assert that at some point in the late-Holocene the Nooksack River avulsed from the Sumas Valley into a remnant glacial outwash channel that is its present channel course into Bellingham Bay, some 58 kilometers south of where the Fraser meets the Pacific Ocean.

Numerous relict channels and oxbows in the Sumas valley, consistent in size and radius of curvature with the modern Nooksack River, the depth and distribution of flood deposits, as well as alluvial fans that have been truncated by channel migration, further suggest the Nooksack’s northward Holocene course through the Sumas Valley to the Fraser. Two much smaller streams, the Sumas River and Johnson Creek, now flow northward in the Sumas Valley within these oversized relict channels. The abundance and morphological newness of the remnant channels, Native American legend, and various radiocarbon dates indicate that

Figure 3.09. Map, Sumas Valley showing subsurface fans of coarse debris (stippling) that were constructed in the valley by the post-glacial Nooksack (south fan) and Chilliwack Rivers (north fan), top is north. Modified from Cameron (1989).
the Nooksack River avulsed from the Fraser basin to its modern course to Bellingham Bay in the late Holocene. (Pittman et al. 2003)

Figure 3.10 are Pittman et al.’s (2003) aerial photos of the drainage divide between the Nooksack River Basin and Fraser River Basin and show the relict Nooksack River channel on the Sumas River. Figures 3.11 and 3.12 are Pittman et al.’s proposed pre- and post-avulsion maps for the lower Nooksack River.
Figure 3.10. Aerial photos, showing Drainage Divide between Nooksack River Basin and Fraser River Basin (top) and a relict Nooksack River channel on the Sumas River (right). Modified from Pittman et al. (2003).
Figure 3.11. Map, pre-avulsion Nooksack River, top is north. *Modified from* Pittman *et al.* (2003). For scale see map on following page.
Although it does not directly aid in ascertaining the accuracy of the two geological models singled out here (i.e. Eastetbrook 1962, 1971 and Pittman et al. 2003), historical data provides valuable information concerning more recent changes in lower Nooksack River geography. Historic modification to the lower Nooksack River including channel straightening and large woody debris (LWD) removal have permanently

altered the delta landscape from its prehistoric state ultimately altering floodplain soils and sediments as well as the composition and distribution of fish (Pess et al. 2003) and flora (Collins and Sheikh 2002). Such modifications may also affect archaeologist's ability to understand past landscape conditions thus hindering their ability to locate or interpret prehistoric deposits. Historic accounts of lower Nooksack River conditions and pioneer settlement can be found in Winthrop (1862), Reagan (1917), Judson (1984, reprinted from 1925 edition), Hawley (1945), Jeffcott (1995, reprinted from 1949 edition), Tremaine (1975) and in recent discussions by Wahl (2001), Collins and Sheikh (2002), and Kangas (1995).

Prior to European settlement and development of the lower Nooksack River area, some 150 years ago, the valley was dominated by extensive and diverse wetlands (Whatcom County 1999:2-1). Early surveys show that a 200 square mile wetland existed in the Sumas River Valley between the town of Nooksack and the Fraser River. Massive logjams reduced the gradient and velocity of lower Nooksack River flow, trapping sediment and diverting flows into slow moving side channels. Lower Nooksack River floodplains were typified by braided channels with areas of sloughs, swamps and grassy marshes. A one-mile long logjam at Hovander Bend, just below Ferndale, channeled River flow west across the delta into Lummi Bay. Removal of logjams and other channel modifications in this area diverted flow east into Bellingham Bay, where it remains today (see Wahl 2001). Wahl (2001) provides a detailed chronology of geological changes to the lower Nooksack River in historic times.

Figure 3.13 is an 1856-1858 U.S./Canada Boundary Survey map depicting the Nooksack draining into Lummi Bay before channel modification. Some ten years earlier, in 1855, the Treaty of Mukilteo was signed that reserved the Island of Chah-choo-sen (i.e. now Lummi Peninsula) for exclusive Indian use. The island was defined as being situated in the Lummi River, at the point of separation of the mouths emptying onto Lummi and Bellingham Bays (Wahl 2001:39).

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Figure 3.13. Map, 1856-1858 U.S./Canada Boundary Survey map of Nooksack River delta. Note the Nooksack River is emptying southwest into Lummi Bay with flow coming directly from the Hovander Bend logjam at Tennant Lake. Modified from Collins and Sheikh (2002).
Geomorphic Setting of the Ferndale Site-Complex

In this thesis I use soil geomorphology to evaluate the depositional environment and ages of land surfaces associated with cultural activity at the Ferndale site-complex. Soil geomorphological studies fall within one of the four following areas: (1) the development of a soil chronosequence that can be used to estimate the ages of surficial deposits; (2) the use of soils as indicators of long or short term stability; (3) the use of soil property relations to determine climatic change; and (4) the interaction of soil development, rainfall infiltration, and erosion of hillslopes (Birkeland 1990). My research attempts to delineate soil chronosequence that can be used to estimate the ages of alluvial deposits at the Ferndale site-complex as well as utilizing soil data as indicators of landscape stability.

The study of soils in archaeological context offers a different perspective than for considerations of alluvial sediments alone. Soil science, particularly pedology, and archaeology are closely allied in their temporal and spatial scales:

...and among the earth sciences, pedology is most similar to archaeology in operational and processual scales. These similarities in scale are apparent in both regional and site-specific studies. At large (regional) scales, soil stratigraphy has long been used in archaeology for correlating sites and for dating. Soil-geomorphic investigations also are compatible in scale to regional archaeological investigations, focusing on dating, environmental reconstruction, and landscape evolution...At small (site-specific) scales, the focus of pedology -the soil profile- is similar in scale to many archaeological sites (tens of millimeters to a few meters thick) and the scale of many pedological features is similar to that of archaeological features (a few millimeters to tens of centimeters). Soil variability at small scales as a function of slope, drainage, or lithologic change is a common theme in pedology and is also of archaeological significance for stratigraphic correlation and interpretation of site formation processes...The scalar compatibility of archaeology and pedology strongly argues for pedologists and pedological perspectives to be involved in all phases of archaeological research. (Holliday et al. 1993:29)

The majority of soils in the northern Puget Basin are formed in glacial materials under the influence of coniferous forest vegetation (Franklin and Dyrness 1973:17). Haplorthods (brown podzolic soils) are most common and contain moderately thick forest floor layers with well-developed humus layers. A thin weakly developed A2 horizon is typical under the humus layer. This is underlain by an iron- and humus-enriched B horizon which is usually reddish brown in color. Soil texture is commonly gravelly sandy loam, and profile depths averages about one meter. Underlying parent material are either loose gravels and sands or hard, cemented till.

The geomorphology and soils of Whatcom County reflect a sequence of depositional and erosional events that represents an episode in time that can be delineated as a set of geomorphic surfaces (Goldin 1986). A geomorphic surface is a mappable area of the earth's surface that has a common history; the area is of similar age and is formed by a set of processes during an episode of landscape evolution (SSSA 2001). A geomorphic surface can be erosional, constructional or both. The surface shape can be planar, concave, convex, or any combination of these. The geomorphic history of Whatcom County reflects a sequence of depositional and erosional events that are the result of glacial and fluvial processes (Goldin 1986:61). Because each sequence of
erosion and deposition represents an episode in time, they can be delineated as a set of geomorphic surfaces. The soils associated with a particular geomorphic surface are recognized primarily by contrasts in drainage and the texture of the parent material.

The soils associated with a particular geomorphic surface are recognized primarily by contrasts in drainage and the texture of the parent material and, as in other geomorphic settings, soils that form in alluvial valleys provide evidence for the age and geomorphic/environmental contexts of archaeological sites (Ferring 1992). There are two distinct forms of alluvial soils: terrace soils and floodplain soils (Gerrard 1995). Both types of alluvial soils are mapped for the Ferndale site-complex (see USDA 1992: map sheet 25). Terraces are abandoned surfaces not related to the present stream and are composed of two parts: the scarp and the terrace behind it. Floodplains are surfaces related to the present stream, in this case the Nooksack River.

Sumas Stade glaciofluvial outwash sediments form the terrace of the Ferndale site-complex and are collectively referred to as a fill terrace. A fill terrace is composed entirely of sediment laid down during a period of aggradation.

Marine and stream terraces are found in the Whatcom Basin, both recording changes in relative position of sea level during the late-Pleistocene. The stream terraces are in part remnants of outwash deposits laid down during the Sumas Stade, and in parts remnants of the former floodplains of the Nooksack River and its drainage system. Marine terraces occur near the present shoreline and also at several places along the Nooksack Valley. A broad expanse of outwash terraces occurs south of the Nooksack River between Everson and Ferndale. These terraces correspond to the broad outwash terrace north of Lynden, the principal difference being the abandoned outwash channels cut into the southern terraces. Both sets of terraces belong to the Sumas Stade. (Easterbrook 1971:29)

Unlike the terrace sites at the Ferndale site-complex the shell midden, 45WH34, is located on the active floodplain at an intermediary position between the foot of the outwash terrace, the floodplain levee, an adjacent topographic depression, and the Nooksack River. These landforms have likely contributed to formation of both the shell midden and adjacent floodplain soils. Gerrard (1995:112) highlights the consequences of such a geomorphic position in that movement of soil and sediment across the tread and down the steep slope of the riser often makes the topographic feature indistinct and the resultant soils very complex. This point may partially explain the complexity of cultural deposits preserved in the shell midden (cf. Grabert 1983:8).

As shown in Figure 3.14, Goldin (1986:61) has delineated four geomorphic surfaces in northwestern Whatcom County. They are:

**Surface 1:** The lower, active flood plain of the Nooksack River.
**Surface 2:** The higher of the two floodplains and includes the levees, the valley flat, and the modern delta of the Nooksack River.
**Surface 3:** Dominantly outwash terraces but includes proglacial lacustrine terraces.
**Surface 4:** Consists of glaciomarine deposits having eolian mantle that includes volcanic ash.
Figure 3.14. Maps, showing the Ferndale site-complex and River Mile Six (RM 6) on a geological map (top) and in relation to Goldin's (1986) mapped geomorphic surfaces. Note the transitional position of the site-complex on both maps. *Modified from* Easterbrook (1962) and Goldin (1986).
Surface One consists of the lower, active flood plain of the Nooksack River (Goldin 1986:61). It is the depositional and erosional environment of the river channels and associated with point bars and channel filling. It is generally underlain by coarse alluvium and is subject to annual flooding. The deposits are pebbles, sand, and silt. The landscape configuration is not stable and changes rapidly as a result of water cutting new channels, abandoning older channels, and moving alluvial deposits downstream. The principal soil of Surface One are Mt. Vernon soils. Surface One dates to the late Holocene.

Surface Two consists of the higher of the two floodplains and includes the levees, the valley flat, and the modern delta of the Nooksack River (Goldin 1986:64). The deposits generally are stratified sand, silt and clay. The alluvium is derived from a variety of rocks but is dominated by andesite and metasedimentary material. Alluvial fans and coastal beaches are included in this unit. Some organic deposits occur in former quiet backwater areas. Soils of this surface have few prominent morphological features; they are differentiated mainly by the texture of the parent material. Most of the soils have a fluctuating water table as indicated by mottling in the underlying material within a depth of 20 inches. The soils on the river terraces and flood plains are very deep, are nearly level, and have a mollic epipedon. The moderately well drained Mt. Vernon soils are examples of these soils. The soils on the delta are very deep, are very poorly drained, and contain sulfidic material. The principal soils are Eliza and Tacoma Deposition on this surface started after the Sumas Stade of the Fraser Glaciation about 10,000 years ago. No properties associated with volcanic ash are evident in the soils. Since the ash in the western part Whatcom County originates from Mount Mazama, the lack of Mazama ash within this surface indicates that the surface is younger than 6,600 years. This surface probably dates to the middle- to late-Holocene.

Surface Three is dominantly outwash terraces but also includes proglacial lacustrine surfaces (Goldin 1986:64). The outwash consists of sands with various amounts of gravel. Depressions in the outwash terraces, both channels and kettles, commonly contain organic deposits. Lakebeds and low relief, abandoned channels that are filled with organic material are typical of surfaces of this age in Western Oregon and south-central Washington. The glaciolacustrine deposits consist of consist of silt and clay, which are distinctly varved in some areas. A thin layer of eolian material, which includes volcanic ash, mantles this surface. Surface Three is the oldest surface related to the present drainage system. The ancient drainage pattern parallels that of the modern floodplain indicating that the Nooksack River is a remnant of the preexisting drainage system. The ability of the proglacial streams to carry material was greater than that of the modern Nooksack River, and the valley was broader, as is indicated by the deposits, which are coarser and more extensive than modern alluvial material. C14 dates obtained from the base of organic deposits range from 9,920 to 9,300 BP.

Surface Four is dated to 12,090 to 10,730 BP (Goldin 1986:64). The parent material is glaciomarine drift deposited during the Everson Interstade of the Fraser Glaciation prior to the inception of the Sumas Stade. Dates from marine terraces and bogs indicate that the area was rapidly isostatically uplifted during this time. As mapped by Goldin (1986), the Ferndale site-complex does not include geomorphic Surface Four.
As shown in Figure 3.15, in cross-section the Ferndale site-complex is centrally positioned between the Nooksack River channel (Surface One) and the glaciomarine deposits that form the Lake Terrell upland (Surface Four). Based on Goldin's delineation it is expected that cultural deposits at the site-complex are likely to be associated with geomorphic Surfaces Two and Three.

Figure 3.15. Map, showing the Ferndale site-complex in relation to Goldin's (1986) geomorphic surface cross-section of the lower Nooksack River valley. The Ferndale site-complex includes Surfaces Two and Three. *Modified from* Goldin (1986).
This geoarchaeological investigation of the Ferndale site-complex can be divided into two broad categories, soils and sediments. These categories provide the methodological framework for geoarchaeological analysis. Although soils and sediments are closely related (i.e. sediments are the parent material for soils), they are applied to the site-complex in two different ways. On-site data is limited to reanalysis of cultural sediments and other information collected by Grabert during the 1972 excavation of 45WH34. New off-site data was collected from excavated soils pits from across the Ferndale site-complex, and outside the boundaries of mapped terraces sites and 45WH34. New samples include both soils and sediments. The objective of off-site data collection was twofold: one objective was to delineate geomorphic surfaces and determine the relative ages of the surfaces; a second objective was to provide control samples against which the cultural and non-cultural sediments from 45WH34 could be correlated.

Field and laboratory analyses of soils were conducted to provide evidence for the age and geomorphic/environmental contexts of the entire site-complex, including the terrace, backswamp and floodplain. The ultimate goal is to provide evidence for how humans, or evidence of past human activity (i.e. the archaeological deposits), may have changed in response to environmental stability or change (see Ferring 1992). Field and laboratory analyses of sediments were conducted to enhance site-complex soil data as well as to identify temporal and spatial patterns of erosion and alluviation that may have produced differential preservation and visibility of past human activity.

Another type of intrasite analysis that is explored in Chapter Four is Stein's (1992a) model for two-toned shell middens. Like the San Juan Island British Camp shell midden (Stein 1992a), 45WH34 displays a two-toned stratification with dark-colored fine-grained sediment in the lower portion of the midden and light-colored fine-grained sediment in the upper portion. Although the results provided here are inconclusive regarding the effects of hydrologic change on 45WH34 stratification, I suggest the dual stratification likely contributed to Grabert's (1983) assertion that more cultural components existed than are actually present. Chapter Four concludes with a comparison of geological data to new fish and shellfish data for 45WH34, as
well as correlation to models of delta adaptation. The unexpected addition of Reid and Hale's (2001) analysis of the East Ferndale shell midden site, of which I was allowed to actively participate in by obtaining 14C dates, also provides additional data regarding mid- to late Holocene lower Nooksack River geoarchaeology.

**ANALYTIC UNITS AND PROPOSED CHRONOSTRATIGRAPHY FOR 45WH34**

Analytic units are site elements synthesized into common sense descriptive units (e.g. settlement, settlement element, cultural feature, depositional feature, erosional feature, or artifact) (Wandsnider and Dooley 2004). Synthesized from these units are histories that can be used to support statements about past behavior. Analytic Units (AU’s) are intended to be chronologically meaningful and allow differentiation of inter-site assemblages.

Grabert (1983:Figure 5) presents a set of AU's for 45WH34 in that he correlated strata between units in an effort to make a statement about past human behavior at the site. Based on what he believed was disturbed stratification resulting from numerous cultural reoccupations of 45WH34, Grabert notes:

> ...I have elected to try discern and describe an order of events in the zonation (Figure 5), realizing that this can only be an approximation for the middle of the sequence. Features of the site consisted of the pit dwelling (not visible from the surface) and several cooking and disposal pits. The housepit seems to have been used sporadically over two or more hundred years then possibly re-used for a brief interval. Post-house pit occupation appears not to have been frequent nor long protracted. Table 1 presents interpretations of the cultural periods and site utilization during these periods. (Grabert 1983:11)

Because he lacked 14C dates for components above or below many of these and other features, and presumably relied primarily upon field observation, important questions may be raised concerning the accuracy of such specific observations, particularly regarding the timing and nature of his proposed AU sequence.

Utilizing both cultural and non-cultural strata concurrently, Grabert summarized his observations in the form of a stratigraphic event sequence. An example of a typical field description upon which the AU’s were correlated (and delineated) is provided in Table 4.00. Based in part on such field observations Grabert correlated AU’s from across the east-west trench to create his *East-West Stratigraphic Section of 45WH34* (Grabert 1983:12-Figure 5), shown in Figure 4.00. His logic for correlating the east-west trench (as illustrated) can be found in his sequence of three tables developed to explicate the "event sequence" for the site. As illustrated in Table 4.01, Grabert proposes a cultural sequence for 45WH34 that spans nearly 5000 years and includes such activities as hunting, fishing, collecting, ceremony, winter residence in a pithouse, and in late prehistoric times an open camp with evidence of woodworking and fishing. Grabert refined this view in his *General Stratigraphic Events at 45WH3*, which is shown in Table 4.02, which was subsequently compared to Borden's (1970) cultural sequence for the Fraser River delta (see Table 4.03).

Grabert drew two major conclusions from his developmental sequence for 45WH34, one of which addresses temporal and cultural issues and the other environmental factors. First, there is no doubt that Grabert believed the site represents some 5000 years of cultural activity. He raised the possibility that the lower
components of 45WH34 (i.e. stratigraphic Zone 1a in Table 4.02 and Ferndale I Period in Table 4.01) might predate 5000 BP and be related to the archaeological sites consisting of cores, choppers, and flake tools located on the adjacent terrace (1983:11, 16). Thus, from a temporal perspective, Grabert posited that the Ferndale site-complex represented cultural activities (i.e. Period I to Period II in Table 4.01) beginning over 5000 BP with cultural strata being deposited during each subsequent millennia up until abandonment sometime between A.D. 1200 and 1800. As illustrated in Table 4.03, Grabert (1983) identified the presence of all the phases in Borden's (1970) Fraser River delta sequence, apparently based on specific artifact styles, although he did not specifically identify these artifacts in his report.

A second conclusion drawn from Grabert's developmental sequence for 45WH34 addresses the environmental, or non-cultural, accumulation at the site. As shown in Table 4.02, Grabert lumps cultural and non-cultural into a single column devoted to Depositional Agency. One problem with such an approach is the belief that all materials that are not shell, ash or charcoal were deposited under "natural" conditions, in this case denoted as alluvium. That some sand, silt or clay was not imported as construction materials is difficult to accept, particularly in light of Grabert's own findings downstream from Lummi Peninsula sites where baked and non-baked clay lenses were frequently encountered in association with prehistoric shell midden sites (see Grabert and Griffin 1983:37, 59, 78, 80, 81, 83, 86, 102). A second problem with the simplistic designation of alluvium (which I assume refers primarily to sand size particles) is that such sediments seemingly only exist in small pockets rather than as continuous strata across the site (or multiple units). Another important issue is the difficulty in interpreting the significance of such designations as very little alluviation (e.g. Zone 2), some alluviation (e.g. Zone 3a), alluvial band (e.g. Zone 1b) and alluvium (e.g. Zone 5 and Zone A). It seems reasonable to accept that two major episodes of alluviation occurred at the site, those being the coarse alluvial sands (i.e. Zone A) underlying the cultural deposits and those strata overlying the site (i.e. Zones 5-8 [see Table 4.02]). The designation of the smaller pockets of alluvium within the cultural layers, however, may be less reliable. With the exception of Zone 3a only the basal strata are referred to as having alluvial bands or some alluvium. Recognizing that small quantities of alluvium may have accumulated naturally via erosion from the proximal (and elevated) sandy terrace, or imported this same distance for use as construction material, it can be concluded that little or no significant non-cultural deposition occurred, with the exception of the basal and surficial strata.
### Table 4.00. Example of a field description, Cut N1W4 - North Wall

<table>
<thead>
<tr>
<th>Depth in cm</th>
<th>Soil description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>Turf, roots, and traces of fine shell. Gray silt with small sand components.</td>
</tr>
<tr>
<td>10-20</td>
<td>Some matrix, larger crushed shell components.</td>
</tr>
<tr>
<td>20-30</td>
<td>Darker gray with larger shell fragments with bedding with local sand and charcoal.</td>
</tr>
<tr>
<td>30-40</td>
<td>Stratified shell with larger fragments, pebbles, charcoal.</td>
</tr>
<tr>
<td>40-50</td>
<td>Gray ash, silt, some shell, lens of gray ash, shell, sand and pebbles.</td>
</tr>
<tr>
<td>50-60</td>
<td>Similar to 40-50cm but more whole shell. Cockle predominant but clam present.</td>
</tr>
<tr>
<td>60-70</td>
<td>Base of shell lens with abrupt transition to dark brown sand with charcoal.</td>
</tr>
<tr>
<td>70-80</td>
<td>Similar to 60-70cm but with fire broken rock and charcoal strata &lt;3cm thick.</td>
</tr>
<tr>
<td>80-90</td>
<td>Same as 70-80cm with local sand and clay lenses.</td>
</tr>
<tr>
<td>90-100</td>
<td>Same as 80-90cm.</td>
</tr>
<tr>
<td>100-110</td>
<td>Similar to 80-90cm with a locally dense charcoal layer, bands of sand, Fossil A horizon.</td>
</tr>
<tr>
<td>110-120</td>
<td>B-color horizon. Brown sand with larger silt/clay composition, transition to sand.</td>
</tr>
<tr>
<td>120-130</td>
<td>Basal alluvial sand, light gray, small pebbles, poorly bedded.</td>
</tr>
</tbody>
</table>

From 1972 field notes of Karr, pg.77 and Grabert, pg.75

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![Figure 4.00. Grabert's East-West Stratigraphic Section of 45WH34.](image)

*Modified by Gillis (2003) from Grabert (1983:12-Figure 5)*
Table 4.01. Grabert's *Proposed Culture Sequence at 45WH34.*
*Modified from Grabert (1983:13-Table 1)*

<table>
<thead>
<tr>
<th>Date or Period</th>
<th>Contents</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>VI. Late Prehistoric</td>
<td>Fire-broken rock, fish vertebrae, some bone and antler artifacts, little chopped stone.</td>
<td>Timber cutting and rough working/fishing. Apparently an open camp, with filling of the vestiges of the housepit. Flooding and surface activities probably moved shell and superficial materials into pit.</td>
</tr>
<tr>
<td>V. Pithouse occupation between 1,000 and 1,360 years ago.</td>
<td>Some debris, probably faunal remains and broken woodworking tools spread over the contemporary land surface. Some silt bands suggest slack water deposits from flooding.</td>
<td>Winter residence is suggested by the semi-permanent dwelling. Excavation of the dwelling heaved up artifacts of Whalen II and Narpole similarities and even penetrated the deepest occupation levels.</td>
</tr>
<tr>
<td>IV. Narpole Phase and Whalen II contemporaneity</td>
<td>Harpoons, pendants, fish spears, and barbs, some smaller stemmed points of basalt.</td>
<td>Fishing and perhaps other seasonal occupation. Decorative items suggest ceremonial, perhaps winter season occupation.</td>
</tr>
<tr>
<td>III. Locarno Beach Phase and probable bipoles of basalt, more stemmed points, some suggesting a variant of side-notching.</td>
<td>Gulf island artifacts, fishbone and animal bone and some antler wedges suggest a variety of activities discussed in text.</td>
<td>Deeper shell deposits</td>
</tr>
<tr>
<td>II. Ferndale II Period (Fig. 16) (Mayne Phase contemporaneity?)</td>
<td>Lanceolate bipoles (?), flake tools, cores, perhaps choppers.</td>
<td>Hunting, plant collection, fishing, few traces of shellfish use, and none in the very deepest strata. One C-14 assay, ca. 4200 B.P.</td>
</tr>
<tr>
<td>I. Ferndale I Period (Fig. 11)</td>
<td>Cores, choppers and flake tools on terrace.</td>
<td>Uncertain activities, possibly as in Ferndale II.</td>
</tr>
</tbody>
</table>
Table 4.02. Grabert's General Stratigraphic Events at 45WH34. Modified from Grabert (1983:14-Table 2)

<table>
<thead>
<tr>
<th>Event Zone</th>
<th>Depositional Agency</th>
<th>Cultural Components and Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 8</td>
<td>Flood siltation, A-horizon formation, forest duff.</td>
<td>Mixed deposits from windfall upheaval, and root penetration.</td>
</tr>
<tr>
<td>Zone 7</td>
<td>Earlier siltation and humus formation, soil from a few S1-W3, and S1-W4. Mixture of cultural features.</td>
<td>Possibly two fire pits, one in period artifacts.</td>
</tr>
<tr>
<td>Zone 6</td>
<td>Only one major feature, derived from garbage fill of a remnant pit, flood silt.</td>
<td>Artifacts of mainly the late pre-historic period, bone and antler. Lithic items may have derived from slump of Zone 5 walls.</td>
</tr>
<tr>
<td>Zone 5</td>
<td>Upper housepit fill, debris and alluvium accumulated during abandonment.</td>
<td>This event seems to predate the major occupation of the pit-dwelling between 1,210 and 1,030 years ago.</td>
</tr>
<tr>
<td>Zone 4</td>
<td>Zone 4 appears to be the larger housepit fill.</td>
<td>This period may be related to pre-staelaxW. Bone and antler materials derived from Marpole age deposits the dwelling intruded.</td>
</tr>
<tr>
<td>Zone 3a</td>
<td>Shell and ash accumulation. Some alluviation also noted.</td>
<td>Marpole to Lacarno Beach age deposition, some lanceolate points and bone and antler objects. Cultrally similar to 3a.</td>
</tr>
<tr>
<td>Zone 3</td>
<td>Shell and ash accumulation, in pit earlier than than of 3a.</td>
<td>Locarno Beach and earlier Phases.</td>
</tr>
<tr>
<td>Zone 2</td>
<td>Deepest firepit, depth to 140 cm: very little alluviation noted.</td>
<td>Mayne Phase similarities. Flake and core tools, biface points, little bone.</td>
</tr>
<tr>
<td>Zone 1d,1c</td>
<td>Bands of shell, ash, and charcoal, some alluvium.</td>
<td>Flake tools only. Termed Ferndale II period.</td>
</tr>
<tr>
<td>Zone 1b</td>
<td>Charcoal and alluvial band with no shell remains visible.</td>
<td>Cultural layer with only flake and core tools. Possibly derivative of Ferndale I on high terrace; ca. 4,180 years +.</td>
</tr>
<tr>
<td>Zone 1a</td>
<td>Charcoal band, no shell.</td>
<td>No cultural deposit observed.</td>
</tr>
<tr>
<td>Zone A</td>
<td>Coarse alluvial sand, Sumas outwash, reworked; steeper river gradient?</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.03. Grabert's Comparison of the Borden Sequence with 45WH34. Modified from Grabert (1983:13-Table 1)

<table>
<thead>
<tr>
<th>Borden Phases</th>
<th>Time Period</th>
<th>45-WH-34</th>
</tr>
</thead>
<tbody>
<tr>
<td>StaelaxW</td>
<td>A.D. 1200–1800</td>
<td>Zones 5, 6, 7, and 8.</td>
</tr>
<tr>
<td>Pre-StaelaxW</td>
<td>A.D. 700–1200</td>
<td>Zone 4 and possibly strata outside housepit.</td>
</tr>
<tr>
<td>Marpole</td>
<td>400 B.C. to A.D. 300</td>
<td>Zone 3a and possibly some of the comparable strata in cuts not shown in Figure 5.</td>
</tr>
<tr>
<td>Locarno Beach</td>
<td>1230–400 B.C.</td>
<td>Zone 3, and strata in cuts not shown in Figure 5.</td>
</tr>
<tr>
<td>Mayne Phase (Gulf Islands and earlier) (Mitchell 1970)</td>
<td>2890 to 1200 B.C.</td>
<td>Zones II–1d.</td>
</tr>
<tr>
<td>Mayne Phase (perhaps prior to Mayne date)</td>
<td></td>
<td>Zone 1a. Possibly some or all of Ferndale I assemblage.</td>
</tr>
</tbody>
</table>

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One goal of this research was to reanalyze the cultural and natural stratigraphy and define new AU's. My initial assignment of new AU's for 45WH34 was based on multiple lines of evidence including excavation descriptions, profile descriptions, sediment descriptions, recovered sediment samples, and site profiles drawn during the 1972 excavation. Because the 1972 profile descriptions were vague, incomplete and inconsistent, the AU definitions relied only on the most obvious characteristics (e.g. color, presence/absence of shell or sand).

On-site sediment analysis was constrained by Grabert's (1983) 1972 excavation of 45WH34. Grabert utilized 3X3 m grid units for horizontal control while arbitrary 20 cm levels maintained vertical control. Other than a few pedestaled features no unit excavations at 45WH34 significantly deviated from the 20 cm vertical sequence, however bulk sediment samples were described and recovered at 10 cm increments. Because excavation and material recovery occurred at arbitrary levels, as opposed to natural levels dictated by observable changes in depositional or post-depositional histories (e.g. sedimentary textures, bedding characteristics, presence/absence of shellfish), reanalysis of quantitative data, be it sediment characteristics, artifact type, or faunal assemblage, across the site is difficult to any degree of accuracy. This is further complicated by the fact that the depositional and post-depositional stratigraphy at the site is extremely complex.

Profiled excavation levels were vertically gridded into 20 cm increments and strata were grouped into analytical units that reflected related depositional and post-depositional histories. Related histories were defined primarily on the basis of Grabert's drawing, *Stratigraphic Event Sequence, East-West Section, 45WH34* (1983:12, Figure 5), 20 unit profiles drawn by excavators (all excavated units have a minimum of one profile sketch), and sediment descriptions made for samples collected from three units: N1W4, S1W2, and N3W4. Table 4.04 is a synthesis of the three profile descriptions for the sediment samples. Descriptions are shown correlated to approximate depth to assist in examination of sediments because data supplied by Grabert is either lacking or inconsistent. The far right column in Table 4.04 provides additional comments by the profilers. Once defined, AU's were treated as arbitrary and tentative pending future inter-unit correlation (e.g. 14C dates, faunal analysis, lithic analysis, sediment data). To date neither 14C dating, faunal analysis or geological date has significantly challenged the initial definition of AU's.
Table 4.04. New stratigraphic correlation of excavation levels in the north trench, based on west wall profile drawings

<table>
<thead>
<tr>
<th>Approximate depth below datum (cm)</th>
<th>S1W4</th>
<th>N1W4</th>
<th>N2W4</th>
<th>N3W4</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-20</td>
<td>Surface at ~20cm</td>
<td>Surface at ~18cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-30</td>
<td>Surface deposit to ~45cm, Evidence of disturbance.</td>
<td>Fine sand and broken shell Pinches out at S. end of unit</td>
<td>Surface at ~30cm, 38cm at N. end</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-40</td>
<td>Poorly stratified shell at S.W. end</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40-50</td>
<td>Dense finely crushed shell mud profile, looks disturbed and infilled with silt-clay (darker gray color) Housepit feature?</td>
<td>S. end has sand and broken shell followed by distinct pockets of concentrations of whole shell; sand and broken shell, and concentrations of whole shell</td>
<td>Distinct cap of silt and clay leveling previously uneven surfaces.</td>
<td>Surface at ~40cm, 60cm at N. end</td>
<td></td>
</tr>
<tr>
<td>50-60</td>
<td>N. end of unit has very dense, finely crushed shell at 60-80cm and underlies Continuous horizon of dark alluvial, no shell</td>
<td>Center of unit shows mounded shell with complex horizons of whole burnt clam shell over dense finely crushed shell, pinches out to N.</td>
<td>Dark humus clay zone thickening to N. drainage and pinching out into S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-70</td>
<td>80cm and underlies Dense finely crushed shell</td>
<td>Continuous lenses of poorly stratified shell overlying dense coarse shell. Both pinch out to N.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70-80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80-90</td>
<td>Base of unit at 80cm</td>
<td>Continuous lenses of poorly stratified shell overlying dense coarse shell. Both pinch out to N.</td>
<td>Poorly stratified shell</td>
<td>Silt clay from 100cm to base of unit at 120cm</td>
<td></td>
</tr>
<tr>
<td>90-100</td>
<td>Dark humus clay zone (culture bearing) 85cm to base of unit at 120cm</td>
<td>110-120cm is a continuous lens of sand-yellow, brown and black. Base of unit at 120cm</td>
<td>Silt from 100cm to base of unit at 120cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100-110</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>110-120</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Alluvial cap of sand over N1W4, silt and clay over N2W4, and clay over N3W4. Over N2W4 this deposit has clearly infilled depressions and thickens towards the N. drainage.
As a result of this reanalysis five Analytical Units were proposed for 45WH34. They are greatly simplified from the complex stratigraphy proposed by Grabert (Figure 4.00). Analytic Units are numbered AU I through AU V, with AU I representing the deepest level. Table 4.05 are the proposed AU’s and include a definition, approximate location and depth of the AU. These five Units represent three distinct stages of cultural and natural deposition. Grabert attributed a span of 5000 years to the deposition of AU’s II, III, and IV.

<table>
<thead>
<tr>
<th>AU</th>
<th>Definition</th>
<th>Location and depth</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>AU V</td>
<td>Plow zone, turf</td>
<td>Plow zone is present in all units and dominates to ~20 cm</td>
<td>AU V</td>
</tr>
<tr>
<td>AU IV</td>
<td>Gray to brown undisturbed alluvium</td>
<td>Undisturbed alluvium is present in units S1W3, S1W4, S1W5, S1W6, S1W7 and N2W4. AU IV is most dominant in S1W7 (~60%) and S1W5 (~55%).</td>
<td>AU IV</td>
</tr>
<tr>
<td>AU III</td>
<td>Stratified midden soil with pockets of whole to fine-crushed shell</td>
<td>AU III (stratified midden soil) is most dominant at WH34 and covers ~1/3 of the entire site. AU III is represented in every unit and is dominant between ~40 cm and 100 cm.</td>
<td>AU III</td>
</tr>
<tr>
<td>AU II</td>
<td>Dark midden soil with a sandy matrix</td>
<td>AU II (dark sandy midden) is present in all unit and dominates between ~100 cm and 140 cm.</td>
<td>AU II</td>
</tr>
<tr>
<td>AU I</td>
<td>Sterile, coarse alluvial sand</td>
<td>AU I is present in only two units; SIW5 at ~160 cm to 180 cm and NIW4, ~140 cm to 160 cm.</td>
<td>AU I</td>
</tr>
</tbody>
</table>

AU I is culturally sterile coarse alluvial sand that underlies the entire site. These basal alluvial sands are likely associated with the 10,000-year-old Sumas Stade glaciomarine outwash sands that comprise the upper terrace of the Ferndale site-complex. Although AU I and the overlying AU II contain the largest volume of coarse sand at the site, they are different in three significant ways: AU II contains cultural material and shell parts while AU I does not; AU I contains a higher percentage of larger-grained sediments than AU II; and AU I is believed to be capped by a paleosol (i.e. buried soil horizon) on which cultural activity initially occurred. Assuming the basal materials are indeed Sumas Stade outwash sands, and based on Grabert’s (1983) basal calibrated 14C date of 4900-4600 BP, AU I can fall somewhere between 10,000 and 5000 BP.

AU II and AU III contain stratified shell deposits ranging from whole shell, to finely-crushed shell, to a “dark midden soil”, these deposits are the source of florally- and faunally-turbated shell found at the surface.
at 45WH34. These two AU's contain the greatest density of tools, faunal remains, and have the greatest stratigraphic complexity, this likely the result of post-depositional alteration resulting from prehistoric excavation of pits. AU II and AU III are delineated by a distinct textural and color transition wherein the lower and horizontally continuous AU II "dark midden soil" abruptly changes to a lighter-colored AU III horizon of complex stratified midden containing pockets of whole shell and fine-crushed shell. AU's II and III comprise the anthropogenic "midden complex," and based on Grabert's two uncalibrated 14C dates of 1200 and 1030 BP, they fall between approximately 5000 and 1000 BP.

AU IV and AU V contain little or no shell, are generally lighter in color and tend to be finer grained than lower deposits, and contain far less lithic and faunal remains than in AU II and AU III. General lack of stratified shell in AU IV distinguishes it from the lower AU III. AU IV is delineated from the uppermost AU V based on the amount of disturbance in the horizon. AU V is a plow zone denoted by a very high amount of mixing as a result of agricultural plowing, bioturbation (specifically burrowing rodents) and floral turberbation. Together AU IV and AU V are suggestive of a flood event that deposited silts and clays and formed an alluvial cap some 30 cm deep that buried much of the site. AU IV is believed to a relatively undisturbed record of this event. Assuming the two approximately 1000 BP 14C dates are not intrusive, the alluvium in AU's IV and V likely post-date 1000 BP.

Based on this simplified sequence of events some important questions and observations can be formulated. First, because Grabert did not explicitly incorporate the North Trench into his event sequence, what can its addition to the refined sequence tell us about the cultural and non-cultural sequence of site development at 45WH34? Second, is the refined AU sequence proposed above simply "lumping" strata whereas Grabert "split" them apart, and more importantly, how can we test whether the refined (lumped) sequence is more valid than Grabert's complex sequence?

Grabert believed that much of the northern and southern extent of 45WH34 was eroded during formation of the modern flood channel (1983:11). Despite this observation he made no explicit attempt to incorporate the excavated North Units into his developmental sequence. My inclusion of North Units N1W4, N2W4 and N3W4 into the refined sequence supports his observation for site erosion. Note that in Table 4.04 the approximate depth below datum increases significantly from S1W4 and N1W4 as one proceeds north across N2W4 and N3W4 towards the north drainage. The most abrupt transition occurs between N2W4 and N3W4 where the depth below datum drops from approximately 30 cm (N2W4) to approximately 60 cm at its most northern extreme in N3W4. That cultural features abruptly terminate in N3W4 (with the exception of poorly stratified shell at depth of 90 cm) as one approaches the north drainage, coupled with the presence of dark humus clay that thickens to the north, suggests the formation of this drainage may well have eroded the northern edge of N2W4. Subsequent filling of this drainage, possibly the result of the adjacent wetland expanding, is likely responsible for the organic rich clay deposits present. At this time little can be said regarding the cultural implications of the North Units. However, because of the high density of cultural materials encountered in such a small area (45WH34 is less than 10X10 meters), it seems highly likely that the pre-erosion site boundary (i.e. the site area prior to natural flood erosion) and the pre-disturbance site boundary.
(i.e. the site area prior to agricultural plowing and drainage modifications) encompassed a much larger area of the floodplain than what remains today.

The second question addresses the significance of "lumping" strata in the simplified developmental sequence versus the "splitting" done by Grabert in his sequence. Determining which of these approaches is more valid is crucial to understanding the cultural development of 45WH34. Did Grabert's "oversplitting" of the strata lead him to define too many cultural components simply based on the complexity of 45WH34? Conversely, does the "lumping" of strata in the refined sequence oversimplify the depositional history of the site? The great complexity of Grabert's developmental sequence is supported by only three 14C dates, suggesting he may have been premature in attributing so many cultural components to such a long period of time (i.e. 5000 years) for 45WH34. As Stein et al. (2003) have recently shown:

Large, complex archaeological sites are often characterized by only a handful of radiocarbon dates. This practice encourages indiscriminant dating of sites for the sole purpose of determining age. If a more rigorous dating scheme is employed and accumulation rates are calculated, otherwise invisible aspects of human behaviour become apparent. Issues central to settlement pattern analysis, such as abandonment and reoccupation events, population fluctuations, building activities, and activity areas are more easily identified when accumulation rates are calculated. (Stein et al. 2003:297)

In their study Stein et al. (2003) calculated accumulation rates for seven shell midden sites located in the San Juan Islands. They selected eighty-two charcoal pieces according to a comprehensive horizontal and vertical sampling regime and radiometrically dated them. Their results show that accumulation rate calculations suggest that large archaeological sites, like the San Juan Island shell middens, do not always represent continuous human occupation characterized by gradual accumulation of material.

Rather, these large complex sites accumulated during short-duration occupations that were repeated infrequently in the same area. This research recommends that numerical accumulation rates be calculated using at least two calculations; the excavation unit accumulation rate and the entire site accumulation rate, and that the excavation unit accumulation rate is the more useful scale for interpreting settlement history. Calculations of these rates focus the multifaceted interaction between human behaviour and natural processes in a way that qualitative guesses cannot. (Stein et al. 2003:297)

Disregarding Grabert's (1983) artifact typology (which represents the bulk of his chronological data), and recognizing the significance of Stein et al.'s study to the study of Pacific Northwest Coast shell middens, it is possible that 45WH34 may well represent a much shorter period of time than the 5000 years Grabert proposed. In this study, new 14C data from 45WH34 is used to test whether the refined (lumped) sequence is more valid than Grabert's highly complex sequence. It is believed this test can provide more accurate information about the timing and nature of cultural activity at 45WH34.
Samples for radiocarbon (14C) dating were selected to test the validity of Grabert's (1983:Figure 5) highly complex stratigraphic event sequence for 45WH34 versus the simplified developmental sequence outlined above. The primary objective of this test is to develop a chronostratigraphy for 45WH34 that will help better explain the cultural and environmental conditions (depositional and post-depositional) under which the site formed.

A total of fifteen 14C dates have been obtained for materials recovered from 45WH34; this number includes the three assays obtained by Grabert (1983) for which we lack exact provenience. Of the twelve samples recently submitted, six assays were obtained for woody materials, two for bone, and four for invertebrate shellfish parts. Because of expectations of disturbance in AU's IV and V no materials were submitted for dating from them. As shown in Table 4.06 the results of 14C analysis reflect two distinct clusters of dates.

Cluster one includes seven assays that date between 5300 and 4400 Cal. BP. All dates in cluster one derive from AU’s II and III. Four shellfish samples were dated to between 4970 and 4890 BP. Four wood samples were dated to between 4370 and 4000 BP. The age, artifact assemblage (Grabert 1983) and faunal remains (Nokes pers. comm. 2004) of AU’s II and III are comparable to Borden’s (1975) Charles Culture, which has maximum ages ranging from 5420 BP to 3500 BP (Pratt 1992), and the St. Mungo phase with a range of 4500 to 3500 BP (see Matson and Coupland 1995:98).

Cluster two is represented by five 14C dates and, with the exception of sample number 511, all fall within 57 cm of the surface. Three of the new dates (i.e. samples 585, 511, 85) are similar in age to the two younger dates previously obtained by Grabert, and thus could potentially support Grabert's interpretation of a pre-Stelax occupation. However, current analyses of the faunal remains and lithic analyses do not indicate a disturbed cultural assemblage in the levels associated with these dates. Nokes (2004 pers comm) has found high consistency in faunal remains throughout the levels and with strong similarities to St. Mungo components on the Fraser River delta, as well as general continuity in the type of mammals being processed here. Thus there seems to be little evidence to support Grabert's argument for a 1000 BP occupation.

Two lines of argument can be formed to suggest these dates represent intrusive events rather than the result of cultural activity as Grabert asserted. As shown in Figure 4.01, excavation photos reveal numerous exposed tree stumps and roots during the initial stages of the 1972 excavation. When coupled with Grabert's (1983:4) observation that "further examination of the low ridge of 45-WH-34 where shell bits and fire spalls were found among roots and wind-fallen trees and stumps," I am led to conclude that these dates represent intrusive tree roots. A second argument is based on the type of materials submitted for dating; all assays in cluster two represent wood samples. Had they been shell or bone another conclusion may be required. That the area was impacted by bioturbation should not be surprising, but it may be significant to explanations of the extreme mixing and deeply turbated areas that extend through AU V into AU IV. Tree throw is proposed as a
critical factor in the complex soils found on the terrace and is likely responsible for the integration of cobble artifacts into the sediments there.

### Table 4.06. 45WH34 Radiocarbon Ages in Chronological Order

<table>
<thead>
<tr>
<th>Lab #</th>
<th>Conventional 14C age (BP)</th>
<th>2 sigma calibration intercepts (Cal BP)</th>
<th>Analytic unit; Cut</th>
<th>Depth (cm)</th>
<th>Material type</th>
<th>Sample or bag #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta 187080</td>
<td>4970 +/- 80</td>
<td>4970-4560</td>
<td>III; S1W6</td>
<td>100-120</td>
<td>shell</td>
<td>1082</td>
</tr>
<tr>
<td>Beta 187078</td>
<td>4960 +/- 70</td>
<td>4920-4570</td>
<td>III; N1W4</td>
<td>20-40</td>
<td>shell</td>
<td>219</td>
</tr>
<tr>
<td>Beta 187079</td>
<td>4850 +/- 80</td>
<td>4830-4410</td>
<td>III; S1W3</td>
<td>40-60</td>
<td>shell</td>
<td>38</td>
</tr>
<tr>
<td>Beta 192795</td>
<td>4890 +/- 70</td>
<td>4840-4500</td>
<td>S1W7</td>
<td>20-40</td>
<td>shell</td>
<td>173</td>
</tr>
<tr>
<td>Beta 176489</td>
<td>4370 +/- 90</td>
<td>5300-4820</td>
<td>II; S1W2</td>
<td>117</td>
<td>wood</td>
<td>249</td>
</tr>
<tr>
<td>Beta 192797</td>
<td>4230 +/- 70</td>
<td>4880-4560</td>
<td>S1W5</td>
<td>40-60</td>
<td>bone</td>
<td>96</td>
</tr>
<tr>
<td>Beta 176488</td>
<td>4220 +/- 40</td>
<td>4850-4800; 4770-4630</td>
<td>II; S1W2</td>
<td>130</td>
<td>wood</td>
<td>232</td>
</tr>
<tr>
<td>RL 249</td>
<td>4180 +/- 120</td>
<td>4900-4600</td>
<td>S1W2</td>
<td>x</td>
<td>wood</td>
<td>x</td>
</tr>
<tr>
<td>Beta 192796</td>
<td>4150 +/- 60</td>
<td>4840-4520; 4470-4450</td>
<td>S1W6</td>
<td>60-80</td>
<td>bone</td>
<td>263</td>
</tr>
<tr>
<td>Beta 176490</td>
<td>4000 +/- 40</td>
<td>4540-4400</td>
<td>III; N2W4</td>
<td>41-44</td>
<td>wood</td>
<td>465</td>
</tr>
<tr>
<td>RL 275</td>
<td>1200 +/- 100</td>
<td>x</td>
<td>S1W6-W7?</td>
<td>x</td>
<td>wood</td>
<td>x</td>
</tr>
<tr>
<td>Beta 176492</td>
<td>1110 +/- 50</td>
<td>1160-930</td>
<td>III; S1W7</td>
<td>55-57</td>
<td>wood</td>
<td>585</td>
</tr>
<tr>
<td>RL 274</td>
<td>1030 +/- 100</td>
<td>x</td>
<td>S1W6-W7?</td>
<td>x</td>
<td>wood</td>
<td>x</td>
</tr>
<tr>
<td>Beta 176491</td>
<td>890 +/- 60</td>
<td>930-680</td>
<td>II; S1W7</td>
<td>92</td>
<td>wood</td>
<td>511</td>
</tr>
<tr>
<td>Beta 176487</td>
<td>330 +/- 70</td>
<td>520-280; 170-150</td>
<td>III; S1W7</td>
<td>33</td>
<td>wood</td>
<td>85</td>
</tr>
</tbody>
</table>

X=Grabert's 1983 dates

<table>
<thead>
<tr>
<th></th>
<th>Conventional Range</th>
<th>2 Sigma calibrated Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster one</td>
<td>4970-4000 BP</td>
<td>5300-4400 Cal BP</td>
</tr>
<tr>
<td>Cluster two</td>
<td>1200-330 BP</td>
<td>1160-150 Cal BP</td>
</tr>
</tbody>
</table>
Based on the new 14C dates the chronostratigraphic sequence for 45WH34 can be significantly refined. Closeness of dates between AU’s II and III indicate one major occupational component rather than the 5000-year sequence asserted by Grabert (1983). AU I still falls between approximately 10,000 and 5000 BP. AU’s II and III comprise the anthropogenic "midden complex," and based on the new 14C dates, now falls between approximately 5000 and 4000 BP rather than 5000 and 1000 BP. Because of the likelihood of root intrusion, AU’s IV and V are believed to post-date 4000 BP rather than representing a 1000 BP occupation.

Other data acquired from the radiocarbon dating process includes the floral identification of wood samples submitted for 14C dating. Floral identification by Stenholm (2003 pers. comm.) indicates presence of cottonwood (*Populus* spp.), water birch (*Betula occidentalis*), Western hemlock (*Tsuga heterophylla*), Douglas fir (*Pseudotsuga menziesii*), Western red cedar (*Thuja plicata*) and Yew (*Taxus brevifolia*). These species are representative of the diverse environmental conditions on the upper-delta landscape and include important riparian indicators cottonwood (*Populus* spp.) and birch (*Betula* spp.). Yew is most commonly found along streams and damp slopes and is well known for its strength and resiliency (Turner 2001:100). It was prized among Native Peoples and frequently traded into the interior where it did not occur naturally. Yew was used to make implements such as bows, wedges, clubs, paddles, digging sticks, prying sticks, adze handles and harpoon shafts.

Figure 4.01. Photo, tree stumps and roots exposed during initial stages of excavation at 45WH34. From 45WH34 photo collection, WWU Department of Anthropology.
SAMPLING THE FERNDALE SITE-COMPLEX

Sediment and soil sampling of the Ferndale site-complex occurred in three stages. Initial excavation and sampling by Grabert (1983) took place in 1972. New data was collected in 2001 and 2002 by the author with the assistance of faculty and students from Western Washington University.

In 2001 soil and sediment samples were collected in an effort to determine the feasibility and direction of future sampling efforts. Soil and sediment samples were collected from three test pits representing different geomorphic positions (i.e. terrace, floodplain, levee) outside the boundaries of 45WH34 and 45WH39. The objective of this preliminary study was to determine the depositional histories of the terrace, the toe slope adjacent to 45WH34, and the levee. Three sampling methods, excavated pit, push probe and auger were utilized to ensure the most comprehensive and efficient collection. The excavated pits allowed for examination of exposed stratigraphic profiles and selective bulk sampling. The push probe was used to extract sediments (up to 3 m) underlying the excavated pit while maintaining an intact stratigraphic profile. The bucket auger was applied to obtain deeper sediment (up to 6 m) underlying the excavated pit. This method does not maintain an intact stratigraphic profile. The pits were excavated outside of the boundaries of mapped sites and no prehistoric artifacts were encountered. A sawed bovine femur was encountered at the toe slope position indicating historic activities in this area. The 2001 excavated pits correspond to positions W1, W4 and W9 in Figure 4.02. Data collected in 2001 were analyzed and used to develop a more extensive sampling strategy. Results of this study were presented at the 2002 meeting of the Northwest Anthropological Conference (Hutchings and Carlson 2002).

The third, more intensive session of soil and sediment sampling and field analysis occurred in 2002 with the assistance of a Western Washington University soils class, under the guidance of Dr. Andy Bach of Western Washington University. The primary objectives were to field-describe the excavated soil pits, test the accuracy of USDA (1992) soil maps, delineate depositional and erosional histories of the different geomorphic positions, and to collect bulk samples for lab analysis. Excavated soil pits, push probe and bucket auger were utilized. As shown in Figure 4.02, a total of 17 pits were excavated in two linear transects from all geomorphic positions at the site-complex, including terrace tread, terrace shoulder, terrace mid-slope, terrace toe, backswamp, floodplain and levee. The west transect was chosen to sample landforms between terrace sites 45WH39 and WH38, and avoid the floodplain site WH34. The east transect was chosen to sample landforms between terrace sites WH38 and WH37. Bulk samples were collected from each described soil horizon along the two transects. The soil test units were georeferenced (Figure 4.02) for relocation.

Laboratory analysis of soils and sediments were conducted for two reasons, to refine soil data and to better understand patterns of geological change, or stability, occurring within 45WH34. Methods for laboratory analysis of Ferndale site-complex sediments and soils were consistent with those described by Stein (1992) for her sediment analysis of the British Camp shell midden. Samples were passed through 1/4 and 1/8 inch screen before being prepared for specific processing. Faunal remain (e.g. shellfish parts and fish bone) were separated.
for analysis while the remaining sediments were prepared for grain size analysis, dry color description, carbonate analysis, organic matter content analysis and pH measurement.


Results of laboratory analysis are provided in Appendix A. Appendix A includes color descriptions, calcium carbonate results, organic matter results and pH results for 79 samples recovered from across the Ferndale site-complex. 36 of the samples analyzed represent the bulk samples collected from units N1W4, S1W2, and N3W4 during the 1972 excavation. The remaining 43 samples represent individual horizons of nine soil test pits excavated in 2002. Soil pits chosen for analysis include test units W1, W2, W3, W4, W5, W9, E1, E2 and E4. Emphasis was placed on the west transect because of its proximity to WH34 and the number of artifacts encountered. Test units E1, E2, and E4 were chosen because they contained artifacts and because units W1, W2, W3 and W4 show evidence of excessive agricultural disturbance.

The following photo series (Figures 4.03 - 4.21) represents a sample of soil profiles from various geomorphic positions at the Ferndale site-complex. Soil profiles are presented for test units W1, W 2, W 3, W 4, W 5, W 7, W 8, W 9, E1, E2, E6, and E7. Culturally modified lithics and "introduced" materials (i.e. not naturally occurring sediments or clasts) were encountered in test units W2, W3, W4, W5 and E1 and E2 (see Figure 4.02). These are shown in Figures 4.05, 4.07, 4.09, 4.11, 4.12, 4.17 and 4.19. Artifacts were collected, cleaned and are now stored at Western Washington University, Department of Anthropology.
Figure 4.02. Map, showing GIS data points for 2002 excavated soil pits. West transect (W1-W9) is at left and East transect (E1-E9) is at right. 45WH34 is at bottom left and is approximated by dashed line. Triangles represent soil pits where artifacts were encountered.
Figure 4.03. Photo, 2002 soil test unit W1, terrace tread-Lynden sandy loam.
Figure 4.04. Photo, 2002 soil test unit W2, terrace shoulder-Lynden sandy loam.
Figure 4.05. Photos, artifacts from 2002 soil test unit W2 including fire cracked rock, flakes, flaked cobbles, mudstone (top left) and cobble tool (bottom right inset).
Figure 4.06. Photo, 2002 soil test unit W3, terrace mid slope-Lynden sandy loam.
Figure 4.07. Photo, 2002 artifacts from soil test unit W3 including quartzite cobble (bottom left), mudstone (top left), rock fragments, and spall? (at right).
Figure 4.08. Photo, 2002 soil test unit W4, terrace toe - Puget silt loam. This discontinuity likely represents disturbance from agricultural activity.
Figure 4.09. Photos, artifacts from 2002 soil test unit W4 (top left) and broken dacite contracting stem point (at right). All materials came from 0-40 cm BSL.
Figure 4.10. Photo, 2002 soil test unit W5, floodplain-Saturated Mount Vernon loam/Puget silt loam.
Figure 4.11. Photo, 2002 artifacts from soil test unit W5, top left is beaked cobble tool
Figure 4.12. Photo, 2002 artifacts from 15-30 cm BSL in TUW6 (no photo of excavated test unit). Both are flaked cobbles, bottom cobble is heavily oxidized.
Figure 4.13. Photo, 2002 soil test unit W7, floodplain-Mount Vernon fine sandy loam.
Figure 4.14. Photo, 2002 soil test unit W8, floodplain-Mount Vernon sandy loam.
Figure 4.15. Photo, 2002 soil test unit W9, floodplain-Mount Vernon sandy loam.
Figure 4.16. Photo, 2003 soil test unit E1, terrace tread-Tromp loam.
Figure 4.17. Photos, artifacts from 2003 soil test unit E1, cobble tool.
Figure 4.18. Photo, 2002 soil test unit E2, terrace shoulder-Tromp loam.
Figure 4.19. Photo, artifacts from 2002 soil test unit E2 (top left) and cobble.
Figure 4.20. Photo, 2002 soil test unit E6, backswamp-Fishtrap muck.
Figure 4.21. Photo, 2002 soil test unit E7, backswamp-Fishtrap muck.
RESULTS OF SOIL TESTING

Soil testing was undertaken with the primary objective of determining soil types and revaluing relative ages of different geomorphic surfaces at the Ferndale site-complex. However, the unexpected discovery of buried artifacts at the terrace and terrace toe positions raised another important question regarding the effects of floraturalurbation on cultural deposits in Spodosols. While this section deals with issues of soils and soils distributions across different geomorphic surfaces at the site-complex, the following section addresses potentially important relationships between floraturalurbation and vertical artifact distribution of the Ferndale terrace sites.

Field and laboratory analysis of soils and sediments examined in 2001 and 2002 proved to be productive for delineating soils of different geomorphic positions at the Ferndale site-complex. Two objectives were identified prior to field sampling, both of which would aid in placing the site-complex in geoarchaeological context. One was to ground-truth USDA soil mapping; a second was to identify similarities and differences in soils at proximal geomorphic positions. Examination of the exposed profiles allowed the delineation of a local landscape history and provides a baseline for evaluating depositional and post-depositional changes that may have affected the archaeological record.

Although the soil test units were excavated outside of the known boundaries of sites 45WH34, 45WH39, 45WH38, and 45WH37, some artifacts were encountered. This unexpected discovery of artifacts in these test units suggests the Ferndale site-complex is more extensive than previously thought and that there may be no geographical distinction, and perhaps no cultural distinction, between the cultural deposits at 45WH34 and those on the adjacent terrace. The distribution of lithics clearly reflects geomorphic position. All lithics encountered derive from the terrace tread, scarp or toe, except for those proximal to 45WH34 (i.e. soils test units W4 and W5) on the floodplain.

Artifacts recovered included modified cobbles, flakes, and fire modified rock. Numerous unmodified lithics also encountered in these test units are believed to be imported lithics (or manuports) based on their distinct size difference when compared to the sediments that occur naturally across the Ferndale site-complex. Natural sediments at the site-complex are limited to coarse to medium sands and finer grained silts and clays, however some small pebbles can be found in limited distribution on the terrace.

Four principal soil types were identified that correlate to different geomorphic positions across the site-complex. These include: (1) terrace tread forest Spodosols; (2) terrace scarp and toe soils that are intergradational between terrace Spodosols, backswamp Mediaprists, and floodplain Fluvaquents; (3) floodplain Haplozerolls; and (4) levee Haploxerolls.

Terrace tread and shoulder soils are Lynden sandy loam and Tromp loam, which are Spodosols formed in 10,000 year old Sumas Stade glacial outwash sands. They are very deep, well drained to somewhat poorly drained soils on level to gently sloping outwash terraces (USDA 1992:10). The depth of the parent material, as delineated on the Interstate-5 geological cross-section (see Appendix A), is approximately 20 to 30 feet deep. The elevated terrace tread surface consists of Spodosols that reflect approximately 10,000 years of
soil development interrupted by episodes of aeolian contribution (i.e. ashfall and loess), treethrow, and historic period logging. Soils encountered include Lynden Series (Typic Haplorthods) and Tromp Series (Aquic Haplorthods).

Terrace scarp and toe positions are more complex and provide evidence of contributions from upslope terrace soils and sediments as well as more recent floodplain deposition. At locations where the terrace toe gradually transitions into depressions on the floodplain, soils are intergradational, with characteristics of both older terrace soils as well as younger backswamp sediments such as silt and clay. Terrace scarp and toe positions are intergradational between Spodosols and floodplain soils (e.g. muck or silt loam) and are greatly influenced both by materials being transported downslope resulting from localized erosion processes and alluvial deposition resulting from high floodplain waters, thus the soils at these ecotonal positions are a function of the scarp slope angle and the floodplain topography at the base of the slope.

Soils on the floodplain are determined by local topography and can be characterized as soils in depressions (i.e. the large backswamp or small, localized drainages) or soils at elevated positions (i.e. the area around 45WH34 and other broad toe-slope/floodplain boundaries). Soils present in the depressed backswamp are hydric Fishtrap muck soils (Typic Mediaprists) that are the result of silt, clay, and organic accumulation. Soils in localized drainages are the product of episodes of flood erosion and overbank deposition and are Puget Series (Aeric Fluvaquents). Soils at elevated positions on the floodplain along the west transect (i.e. soil test units W4 and W5) are disturbed in their upper levels and reflect younger soils (i.e. Puget Series) overlying older and intergradational toeslope Spodosols, as well as intensive agricultural activity (e.g. plowing and emplacement of a drain tile that runs southwest towards 45WH34). Soils associated with the levee reflect recent accumulation of medium to fine sands and silts deposited during episodes of overbank deposition; these soils are Mount Vernon Series (Fluvaquentic Haploxerolls).

Ground-truthing of USDA (1992) mapped soils in 2002 show them to be relatively accurate in light of the variable geomorphology. The most notable discrepancy is the presence of Tromp loam at the terrace shoulder position. USDA maps these soils as Lynden sandy loam. Although both soils are Spodosols, Tromp soils are only moderately well drained, whereas Lynden soils are well drained. Tromp soils are generally deeper; with a substratum of mottled sand and a weakly cemented lower upper horizon containing a greater volume of ortstein fragments. Ortstein is a cemented Spodic horizon.

**SPodosols, Floralturabation and Vertical Artifact Distribution**

The East transect terrace soil units exposed numerous ortstein fragments as well as cobbie artifacts stained from oxidation. The most heavily oxidized artifact at Ferndale was a cobbie tool encountered in soil Test Unit W6 at a depth of 40 cm, which lies on the floodplain at the base of the terrace. The deepest geofact was encountered at a depth of one meter in soil test unit W3, at the base of the B horizon. It is important to note that while artifacts recovered during this study were encountered at depth, Grabert's initial surveys and site-
complex boundary delineations were all based on surface surveys (see Grabert et al. 1972). That artifacts were encountered at depth in terminal-Pleistocene/early-Holocene sediments and soils could potentially support Grabert's (1983) interpretation for an early- to mid-Holocene occupation at the Ferndale site-complex.

At the Olcott site, an early- to mid-Holocene terrace site on the Stillaguamish River, Kidd (1964) encountered lithic artifacts heavily oxidized and welded with ortstein fragments. He used this observation, in part, to define an early age for these artifacts. While in some cases artifact oxidation and depth below surface may be reliably used as evidence for the age of buried artifacts (e.g. Anderton 1999), at Ferndale I believe it is more likely a function of local subsurface hydrology and floralturbation. Recognizing the massive size of historic and prehistoric trees in the area (see Figure 4.22), and that they also had extensive root structures, I conclude that both oxidation of artifacts, and depth at which they are found, reflect local geomorphic factors rather than the alternative, that they were part of a primary deposit. Incorporation of artifacts from the surface into deeper matrices is known to result from pedoturbation, particularly the dynamic effects of uprooting, or treethrow (Johnson and Watson-Stegner 1990). In the case of the Ferndale terrace sites, I assert uprooting has significantly altered the upper soil horizons, resulting in mixed near-surface horizons.

Figure 4.22. Photo, an 18-foot diameter cedar in the Nooksack River Lowland, ca. 1880. Modified from Johnson and Jeffcott (1978:14).
While uprooting likely played a role in disturbing near-surface cultural materials on the floodplain (i.e. 45WH34), because that area has been extensively plowed it is inherently difficult to delineate between natural (uprooting) and cultural (plowing) disturbances. Although the terrace has been disturbed through logging, these events are temporally and spatially limited. By this I mean logging on the terrace likely has only occurred several times since the late-1800s and its spatial effects (both vertical and horizontal) on soil decrease each subsequent logging event as trees (and the trees root systems) become increasingly smaller following each logging event (after initial historic period land clearing). There is also no evidence to suggest that this terrace was ever cleared for crops. It seems land clearing was only done for lumber, and possibly for cattle range in more recent years.

That the Tromp and Lynden series soils at the Ferndale site-complex noticeably lack E horizons leads me to conclude these terrace soils have been heavily turbated over the past 10,000 years since their deposition. That artifacts could be transported downwards (and to the surface where Grabert encountered them during his pedestrian survey) by uprooting is well documented, as discussed below. Numerous natural springs have been observed seeping from the outwash terrace into the backswamp. Buried and oxidized artifacts encountered on the terrace likely represent mid- to late-Holocene processes of pedoturbation and water table fluctuation, rather than being diagnostic of their age. This however does not imply artifacts, like cobble tools, encountered on the terrace may not predate the 5000-year-old shell midden. It is possible that at least some weathered and buried lithics here represent older cultural activities, that they date to the early-Holocene period however is less plausible.

Johnson and Watson-Stegner (1990) use their soil evolution model (1987) as a framework for evaluating pedoturbation in archaeological site formation. Their model recognizes pedoturbation as an aspect of regressive and progressive pedogenesis:

Soils evolve along progressive and regressive pathways, and although in many soils one pathway may predominate, all experience the effects of both during their evolution. Pedoturbation, a component of both pathways, may either regress soil formation by producing one layered mantles, or augment it by producing multi-layered mantles that may include surface stone pavements, subsurface stone lines and zones, and artifact horizons. The model of soil evolution provides a framework in which to improve understanding of soil genesis and landscape evolution, and resolve many geoarchaeological problems. (Johnson and Watson-Stegner 1990:556)

Johnson and Watson-Stegner conclude that floralturbation, particularly the dynamic process of uprooting, is responsible for many mixed, broken or interrupted horizons in forest soils, thus uprooting is an important consideration when considering archaeological sites in forest settings.

Progressive pedogenesis, or soil progression, is a developmental pathway determined by horizonation, developmental upbuilding, and deepening (Johnson and Watson-Stegner 1990:541). Horizonation refers to conditions, factors and processes that act on initial material and produce ordered soil profiles with genetic horizons. Collectively referred to as "vectors," they include the profile-ordering aspects of additions, removals, transformations, and translocations; the developmental feedbacks caused by pedogenic accessions, plus proanisotropic pedoturbations. Proanisotropic pedoturbations include the various soil mixing processes that act
to form, or aid in forming or maintaining, horizons or genetic layers in soils. *Developmental upbuilding* occurs when surface-added materials are pedogenically assimilated into the profile without profile-retardation effects. *Deepening* refers to the downward migration of the lower soil boundary via leaching and weathering.

Regressive pedogenesis, or soil regression, is a regressive pathway that reverses soil progression. Regressive pedogenesis is determined by *haploidization*, *retardant upbuilding* and *surface removal* (Johnson and Watson-Stegner 1990:542). *Haploidization* refers to factors and processes that produce simplified and/or rejuvenated profiles. They include the profile-disordering aspects of additions, removals, transformations and translocations. Unlike progressive pedogenesis, regressive pedogenesis is a function of proisotropic pedoturbations, which include the various soil-mixing processes that act to disrupt or destroy horizons or genetic layers, or prevent them from forming, as when trees are uprooted during storms. *Retardent upbuilding* occurs when allochthonous surface additions of eolian- and slope-derived material serve to impede horizon differentiation and deepening in any way. Such processes account for the minimally developed soils on some upland sites, and on most floodplains, catenary toeslopes, and other runon (i.e. aggrading) sites. In such cases, pedogenic assimilation does not keep pace with rates of accretion. *Surface removal* refers to erosion and mass wasting that occurs when removal is greater than deepening; thus the pedogenic pathway is regressive.

Floralturbation is a set of mixing processes by plants that may occur abruptly or slowly, depending on its form (Johnson and Watson-Stegner 1990:544). Forms of floralturbation are: (1) uprooting, or abrupt upheavals of soil held by roots of falling trees; (2) slow soil agitation through wind-induced tree sway; (3) creation of subsurface channels left by root decay that fill with foreign material; (4) slow volume and pressure increases via root growth; and (5) other forms. Of these various forms, uprooting is most dynamic and often has the most extreme degree of proisotropism.

Uprooting (also termed tree-tip, treethrow, tree-fall, root throw, tree tipover, windthrow, windfall, and blowdown) is responsible for many of the mixed, broken, or interrupted horizons in forest soils (Johnson and Watson-Stegner 1990:544). When uprooting homogenizes soil, it is a proisotropic process, and almost always occurs when the parent material is nongravelly. The often interrupted, disturbed, and discontinuous A and B horizons of forest soils attest to the regressive efficacy of most uprooting events. The products of uprooting episodes are mounds and depressions and are collectively referred to as cradle and knoll topography, mound and pit microlief, and microtopography. These landforms are of great interest to pedologists, yet remain poorly understood in the Fraser/Nooksack coastal plain region. Researchers have yet to determine if pit and mound microtopography were present on the historic sandy forest soils, or more importantly, what role, if any, uprooting played in regional soil development.

As shown in Figure 4.23, Johnson and Watson-Stegner (1990:546) illustrate how Haplorthods, like the terrace soils at the Ferndale site-complex, can regress to Udipsamments via uprooting. Thus floralturbation can transform a well-ordered Spodosol into a less ordered profile, or homogenize it, and in the process mix cultural materials upwards or downwards in a previously ordered profile.
Brewer and Merritt (1978) studied the effects of uprooting in Michigan and concluded that most uprootings are related to episodic windstorms and tornadoes (see Johnson and Watson-Stegner 1990:544-549). They assert that: wind forces applied to crowns are responsible for most windthrow; taller trees are most susceptible; and waterlogged soils with claypans optimize conditions for windthrow; and an estimated 5000 to 3000 years are necessary for the total soil surface to be disturbed by windthrows. Lyford and MacLean (1966) described the effects of treethrow on selected forested areas in New Brunswick, Canada. They determined their research area contained 35 percent mounds and 10 percent pits, thus roughly half the forested area was occupied by mound and pit microrelief. In each mound there was some inversion or disruption of A and B horizons.

Armson and Fessenden (1973) studied the effects of forest uprooting on O and E horizons in the Great Lakes region. They conclude that disturbance by uprooting is infrequent relative to O horizon formation but frequent relative to E horizon formation. Armson and Fessenden suggest this indicates that uprooting microtopography is not recent, but reflects an older history of disturbance. Troedsson and Lyford (1973) observed the effects of uprooting in forested soils of Sweden. They suggest that disturbance and overturning of soil is responsible for variations between and within B horizons (see Johnson and Watson-Stegner 1990:Figure 9). Schaetzl (1986:181) examined treethrow pits and mounds in sandy Spodosols in Michigan to determine their internal soil horizonation. He found that on gentle slopes of uniform sandy parent material, uprooting causes horizon mixing and profile simplification, regardless of the direction of treefall.
Little is known regarding the frequency or effects of uprooting on soil development on the Fraser/Nooksack lowland outwash terraces. Some insight, however, can be drawn from proximal southern Northwest Coast areas. In their analysis of Holocene fire history of the coastal temperate rain forest of western Vancouver Island, Gavin et al. (2003:188) describe the terraced cedar-hemlock forest soils there as showing "a pit and mound topography developed from tree tip-ups."

Dorner and Wong (2003) consider natural disturbance dynamics in coastal southern British Columbia. Their study emphasizes the southern Northwest Coast between Haida Gwaii/Gueen Charlotte Islands and Northern Vancouver Island/northern Strait of Georgia. They also drew heavily from the published literature from other coastal regions, particularly southeast Alaska, the southern mainland, the part of Vancouver Island not emphasized in their study, and the US Pacific Northwest. Dorner and Wong discuss potential limitations and caveats in cases where they believe that the applicability of results and conclusions to the Coastal Information Team (CIT) area might be limited.

Blowdown, largely attributable to the frequent cyclonic storms originating over the Pacific, is one of the key disturbance agents in the coastal landscape. The severity of wind effects is determined by topographic exposure to prevailing winds, as well as tree species and growth form, stand structure and site characteristics, and the amount of precipitation accompanying the storm. The vast majority of openings created by wind are small canopy gaps. Patches of partial or complete canopy blowdown up to several hundred hectares in size have been reported along the coast of British Columbia and southeast Alaska. However, stand replacing blowdown is likely very rare in the CIT area, except possibly for the most wind-exposed parts of the landscape, such as the west coast of Haida Gwaii. The primary mode of mortality during windstorms is stem snap. Fallen trees serve an important ecological role as large woody debris, which is a key feature of both terrestrial and hydro-riparian habitat. Uprooting of trees during windstorms, although comparatively rare, provides habitat for various species and helps to maintain soil productivity. Dorner and Wong (2003)

Dorner and Wong (2003:Table A) compile estimates of patch size, frequency and spatial distribution for stand replacing disturbance agents. When considering wind as a disturbance agent, mean patch size affected is between 5 to 15 hectares. The term disturbance return interval is used to mean the average time between consecutive disturbance events at a given point in the landscape. The return interval for windblown sites is approximately 50 to 300 years, while more sheltered sites are between approximately > 300 years to never. Sites more susceptible to wind disturbance are those in valley bottoms directly exposed to southerly storms; on SW to SE slopes, especially near the ridge; recent edges; and those closer to coast. Frequency estimates are uncertain since the literature does not provide formal analyses for blowdown frequency. Blowdown statistics include events where up to 90% of trees are left standing and should therefore be considered only partially stand replacing. The occurrence of stand-replacing blowdown is dependent on exposure to strong winds. The actual proportion and distribution of susceptible (i.e. exposed) sites in the CIT area has not been formally determined. Most likely areas where exposed sites may occur include the west coast of Haida Gwaii, northern Vancouver Island, as well as potentially some outer coast areas on the mainland coast.

The effects of uprooting and other forms of regressive pedogenesis on forest soil development, and ultimately archaeological sites in forest settings, are poorly understood for the Northwest Coast. Future
research is necessary to confirm, or refute, the hypothesis forwarded above. If pit and mound microtopography, in any form, is confirmed for the historic or prehistoric Fraser/Nooksack coastal plain, a reevaluation of archaeological stratigraphy in forest settings is warranted.

TESTING STEIN'S TWO-TONED SHELL MIDDEN MODEL

Since Grabert's (1983) initial work at 45WH34, important questions have been raised regarding post depositional weathering of shell midden deposits, and more importantly, how such a process may adversely affect archaeological interpretation. Stein's (1992a) work at a San Juan Island shell midden has shown that coastal shell middens can become chemically weathered as a result of hydraulic changes within the aquifer resulting from mid- to late-Holocene sea level rise. The effects of groundwater saturation on shell midden sites are crucial because the stratification that the groundwater produces is not culturally relevant and the difference in color of fine-grained sediment is frequently used to group artifacts in a site.

As illustrated in Figure 4.24, 45WH34, like the San Juan Island British Camp shell midden, displays a two-tone stratification of dark-colored fine-grained sediment in the lower portion of the midden, and light-colored fine-grained sediment in the upper portions of the midden. What role this characteristic played in Grabert's (1983) analysis is unclear. It is possible it contributed to his assertion that more cultural components existed than are actually present. Data discussed below are limited to 45WH34 only and consider calcium carbonate results, organic matter results and pH results. Interpretation of 45WH34 data is based on Stein's (1992a) discussion of the San Juan Island British Camp shell midden stratigraphy.

Stein (1992a:137,150) used sediment analysis to test the hypothesis that the lower portion of shell middens can become saturated as the groundwater infiltrates the pores and permeates the sediments. Infiltration results from sea level rise and the subsequent saturation changes the color of the fine-grained sediment from light to dark, and differentially weathers the lower portion of the midden. This indicates that leaching has taken place and supports the interpretation that groundwater has produced the apparent stratification, and not a function of cultural change. An attempt was made to test Stein's hypothesis at 45WH34, but because of limitations resulting from Grabert's data collection method the test provided inconclusive results. While Stein and others have considered the effects of sea level rise on coastal shell middens, 45WH34 may have been similarly affected by changes in local hydrology, particularly the effects of channel development, floodplain aggradation and formation of extensive backswamp complexes. A total of 43 samples were analyzed for 45WH34 and off-site units and are presented in Appendix A for future analyses.
Figure 4.24. Photo, Two-toned stratigraphy as seen in excavation photo of 45WH34, unit N1W4. Grabert's (1983) 4180 BP 14C date derived from the second arrow from the bottom. *Modified from* Grabert's field photo (1972).
Calcium carbonate percentages in 45WH34 correlate to the presence or absence of shellfish in the associated strata. As seen in Figure 4.25, this is most clear when comparing units N1W4 and S1W2. No shells are recorded below approximately 80 cm in N1W4, this is reflected in the increase of carbonates between 60 and 70 cm.

Figure 4.25. Graph, showing percent calcium carbonate at 45WH34, units N1W4 and S1W2.
Organic matter (OM) percentages in 45WH34 are generally highest near the surface and reflect modern soil forming processes and the promotion of grass vegetation through farming (see Stein 1992:140). As shown in Figure 4.26, in S1W2, N1W4 and N3W4 OM percentages peak within 30 cm of the surface. The only variation noted in lower levels is in S1W2 where OM percentages spike between 120 and 150 cm below the surface. This spike may reflect the buried soil horizon (i.e. paleosol) described by Grabert (1983) that comprised the initial living surface 5000 years ago. Absence of the spike in units N1W4 or N3W4 can be explained by the shallower depths these units were excavated to.

Figure 4.26. Graph, showing percent organic matter at 45WH34, units N1W4, S1W2 and N3W4.
Two recent studies have analyzed fish and shellfish remains from 45WH34 in an effort to place the Ferndale site-complex in environmental context. Hofkamp and Pfandler's (2004) and Rosevear's (2004) preliminary analysis of 45WH34 faunal remains is used here to test the two geological models of lower Nooksack River development. Their assessments provide important evidence for mid-Holocene lower Nooksack River marine, littoral and riverine conditions.

The activity patterns of animals are a result of the complex interactions between foraging efficiency, social activities, and environment (Aschoff 1964). Patterns of activity and habitat use are adaptations to spatial and temporal variation in numerous environmental variables, including climate, hydrology, geology, pedology, and biology. These variables in part define where, when and how animals interact. How animal interact during periods of river change is a central concern in archaeological research (e.g. Fladmark 1975; Stilson 1972; Thorbahn and Cox 1988) because of expected impacts on prehistoric patterns of hunting, fishing, collecting and settlement. Paleoecological investigations of Ferndale site-complex faunal assemblages consider what fish and shellfish data can tell us about mid-Holocene environmental conditions.

As previously mentioned, Stilson (1972) has developed a model linking human and environmental conditions that considers delta change on the southern Pacific Northwest Coast. Stilson (1972) defined zonal relations for the Skagit River Delta Area, as shown in Figure 4.27. His study of Skagit River delta shell midden sites allowed him to develop a model showing expected changes in the zonal ratios of the faunal assemblages at a hypothetical site whose inhabitants were utilizing Maritime resources and who were affected by delta progradation. Figure 4.28 shows his results in the form of zonal changes in relation to delta progradation. Initially, Rocky Beach Littoral and Marine area would be present. As the delta introduced sediments to this area, a Soft-Sediment Littoral environment would replace the Rocky Shore. Soon the area would become deltaic tide prairies and salt water marshes, an Aquatic area. Eventually, as the mouth of the river moved away, the area would become a segment of the alluvial flood plain, part of the Terrestrial zone.

These determinations allowed him to predict changes in the zonal ratios of the faunal assemblages at a hypothetical site whose inhabitants were utilizing Maritime resources and who were affected by delta progradation, as shown in Figure 4.29. In this site a Rocky Saltwater Beach subzone/Marine zone assemblage would predominate. The main constituents would be rocky shore shellfish and marine fish, with little terrestrial mammal hunting. As the delta prograded, littoral gathering would decrease in economic importance as rocky shore shellfish were killed by the delta sediments and replaced by less abundant soft-sediment bivalves. Bivalves favoring sand would not necessarily increase because a sand environment is related to other factors besides the presence of deltaic activity. Fishing and hunting of land mammals would increase in economic importance to compensate for lessening numbers of shellfish. The incidence of marine fish would decrease as they were driven away by the delta’s incursion, and aquatic fish would replace them.
The study of fish remains from archaeological sites offers important information on past environmental conditions and human behavior. As a contribution to study of the Ferndale site-complex, undergraduate researchers Hofkamp and Pfandler (2004) analyzed fish remains from 45WH34. The fish parts were recovered from the three column samples used in sediment analysis. The assemblage included 4020 fish elements, with approximately 85%, or 3434 elements, of the assemblage identified.
The objectives of Hofkamp and Pfandler's (2004) study were twofold: to taxonomically identify as large a percentage of the fish assemblage as possible and to compare variation in the relative frequency of taxa to three different models: gradual delta progradation (i.e. Easterbrook's model, 1971), rapid delta progradation (i.e. Pittman et al's model, 2003), and variation due to cultural factors. An expectation for gradual delta progradation is a gradual increase in the relative abundance of anadromous to marine species through time (i.e. Stilson 1972). An expectation for rapid delta progradation is a rapid increase in the relative abundance of anadromous to marine species through time. An expectation for variation due to seasonal cultural deposition is no distinct vertical trends.

Hofkamp and Pfandler (2004) found no significant evidence to support the gradual delta progradation model. Their data does however provide some evidence for environmental stability in the marine and riverine systems proximal to 45WH34. Determination of relative abundance (i.e. NISP) of fish taxa by the previously defined Analytic Units (AU) illustrates the variation of taxa abundance in each AU. As illustrated in Figure 4.30, only two significant changes in abundance are recorded. One is the increase in flatfish and decrease in salmon between AU's II and III. The other is the gradual increase in saltwater indicator dogfish through time. The latter may be evidence for marine conditions persisting near Ferndale across the mid-Holocene horizon.

Stronger evidence for delayed delta progradation can be found in comparisons of percentages of marine fish taxa versus anadromous fish taxa by AU. As shown in Figure 4.31 there are no distinct vertical trends in either marine or anadromous taxa through time. This pattern may reflect general stability in the marine environments between 5000 and 4000 BP. This pattern does not reflect Stilson's (1972) model of cultural response to delta progradation. His model predicts that though time fish assemblages in delta sites should increasingly reflect riverine conditions. Conversely, abundance of marine species should decline though time as the delta progrades seaward away from site. That marine species decline by 10 percent between AU's III and V is considered irrelevant as I believe AU's IV and V to be significantly disturbed. Further, as Hofkamp and Pfandler observe, preservation of fish remains are poor outside of the shell midden matrix, as are AU's IV and V. Hofkamp and Pfandler also consider sampling bias a critical factor in the success of fish bone analysis. As mentioned previously, the researchers also considered a non-environmental factor in their analysis. Because no distinct vertical trends were observed they consider seasonal cultural deposition a valid interpretation.
Figure 4.30. Table, showing percent of fish taxa by NISP by analytic unit. Modified from Hofkamp and Pfandler (2004).

Figure 4.31. Table, showing comparisons of percentages of marine fish taxa versus anadromous fish taxa by analytic unit. Modified from Hofkamp and Pfandler (2004).
A second study also considers 45WH34 faunal remains in light of delta change. Rosevear (2004) considers shellfish remains in light of Stilson's (1972) model. The study of mollusks from archaeological sites, known as malacoarchaeology, offers information on multiple dimensions of environmental conditions and human behavior, including those related to rituals, economies, and the interaction between humans and the environment (Sandweiss 1996:127). Under Stilson's model the effect of delta change on shellfish abundance is marked by a decrease in rocky shore indicator Mytilus and increase in soft sediment shellfish.

Environmental changes have often been cited as an explanation for the mussel-clam shift. For the Skagit River Stilson (1972) ties the shift to changes in intertidal environments, particularly the siltation of rocky shores. Grabert et al. (1978) suggest the same condition at Semiahmoo Spit in Washington, and Ham (1976) describes a similar one at the Fraser Delta in British Columbia. They argue that epifaunal mussel communities declined with the reduction of their habitat and were gradually replaced by infaunal clam communities expanding with the growing sand and mud flats. Such changes would probably be gradual, and we should be able to relate intertidal changes to postglacial sea level adjustments. (Wessen 1988:199)

Like Hofkamp and Pfandler (2004), Rosevear (2004) obtained faunal samples from the bulk samples derived from S1W2, N1W4 and N3W4. Rosevear determined the MNI (Minimum Number of Individuals) and NISP (Number of Identifiable Species) for shellfish at 45WH34 and determined that rocky shore indicators mussel and barnacle are the most frequently occurring marine shellfish species throughout the site; hard substrate shellfish dominate the samples; and that no significant change in taxa occurred across the site. Based on these factors he forwarded three possible explanations. One conclusion emphasizes an optimal foraging model and suggests 45WH34 may have been abandoned when mussel populations had been exhausted. This approach is similar to one forwarded by Botkin (1980) for a coastal site in California. He suggests predators (in this case, humans) will exploit a particular prey species until it is no longer profitable, due to its reduction from predation pressure, and they will shift to a different prey. Croes and Hackenberger (1988) propose a similar model for the southern Northwest Coast Hoko Rockshelter site. Rosevear also recognizes the implications seasonal occupation may have on the types and quantity of shellfish at WH34. A final explanation considers the prevalence of mussel and barnacle at WH34 as reflecting a dominantly rocky shore littoral environment throughout the sites occupation. Based on the geographic position of the site and evidence derived from the fish analysis I believe the latter explanation to be the most valid. Paucity of archaeological and environmental data for coastal Whatcom County however limits the degree to which any of these explanations can be accepted as archaeological fact. As Wessen (1988) illustrates, there is a need for more studies concerning cultural explanations of mussel-clam shift.

Cultural explanations for the mussel-to-clam change have been relatively limited, and they usually are related to ideas about increasing sophistication about the maritime environment. The notion, first articulated by King (1950) at the Cattle Point site on San Juan Island, suggests that mussels were relied upon earlier, because, as epifaunal animals, they are more readily visible; the targeting of clams, buried in sediments, came later. This model is potentially compatible with ideas about changing intertidal environments, and it should reflect the resource shift relatively early in the occupation period. (Wessen 1988:199)
Recent archaeological investigations at East Ferndale, located approximately .75 miles downstream (i.e. south) of the Ferndale site-complex, provided a unique opportunity to compare local geological and cultural histories, and examine sedimentation rates on a culturally significant upper delta floodplain. Archaeology was conducted at East Ferndale by Alfred Reid Archaeological Consultants (ARAC) in response to the proposed excavation of a water retention pond for the city of Ferndale. Excavation of the retention pond exposed logs buried 20 feet below the floodplain surface. Recognizing the potential for relevant data concerning upper delta sedimentation rates, and the proximity of East Ferndale shell midden site, I was granted permission to retrieve wood samples and submit them for 14C dating with funding from Western Washington University. It was hypothesized that the depth of these trees may reflect mid-Holocene upper delta geological conditions, specifically the elevation of the paleo-river system. Dating the trees might then provide data relevant to mid- to late-Holocene sedimentation rates on the upper delta landscape.

Previous archaeological investigations had delineated both prehistoric and early historic activity at this location (Reid and Hale 2001). In addition to being the historically significant location of the East Ferndale town site, the site-complex also includes the second most inland shell midden on the Nooksack River, 45WH34 being located just upstream. Apart from shellfish deposits, the site-complexes also share similar geomorphic relationships. The East Ferndale site-complex encompasses both the active Nooksack River floodplain and an elevated terrace. Unlike 45WH34, the shell midden here is positioned at the terrace shoulder position. Based on an understanding of the Ferndale site-complex it was expected that evidence of prehistoric activity would extend beyond the terrace toe to include the floodplain surface. Unlike the Ferndale site-complex however, no prehistoric cultural materials were located on either the terrace toe or floodplain surfaces. As shown in Figure 4.32, evidence of prehistoric activity was geographically limited to the terrace tread and scarp only. Conversely, early period historic deposits were primarily found clustered in depressions on the active floodplain surface. As discussed below, these distributions are indicative of a dynamic alluvial system.

Prehistoric materials on the terrace documented by ARAC included marine shellfish fragments, fire cracked rock, flakes from manufacturing stone tools, a broken biface, and a projectile point with a broken tip that is tentatively dated to the Locarno Beach phase (i.e. 3500 to 2400 BP) (Reid and Hale 2001). Excavated test units on the terrace tread exposed intact stratified shell midden deposits between 17 cm and 39 cm below the surface. The midden was exposed in four different locations on the terrace tread and included charcoal and fire cracked rock. Excavated units on the terrace scarp exposed unstratified shell deposits between 18 and 40 cm below surface and abruptly disappeared downslope before reaching the terrace toe. Reid and Hale (2001:3) tentatively concluded that because midden did not taper with the landform, "this former coastal beach was down cut by the meandering river channel to create the present terrace."

Despite a plethora of historical evidence documenting Euro-American settlement, development and layout of the East Ferndale town site, relatively few early historic artifacts were encountered. Early Euro-American settlement period deposits that were preserved were consolidated in localized depressions on the
floodplain. I suggest paucity and distribution of historic artifacts are attributed to frequent and often catastrophic flooding on this part of the River.

As excavation of the retention pond reached its required depth of 20 feet below the floodplain surface coarse gravels were unearthed and ultimately exposed five or six waterlogged and well preserved trees. Because the trees were resting on coarse river washed gravels, and were buried by 20 feet of alluvial silt, I determined that 14C dating of the trees could enhance our understanding of upper delta basal geological development; expand the lower Nooksack River radiocarbon database; provide additional data for studies at the Ferndale site-complex; and possibly provide an explanation for the pattern of artifact distribution described above.

Figure 4.32. Map, showing distribution of prehistoric deposits (solid pattern) and historic deposits (stippled pattern) at East Ferndale. Modified from Reid and Hale (2001).

Large Woody Debris (LWD), common in Pacific Northwest rivers, can be seen today grounded atop gravel bars upstream of Ferndale. This is likely the same process involved in the deposition of LWD recovered from the East Ferndale retention pond. Presence of well-preserved bark structure and one intact root system suggests the trees had not spent a significant amount of time in the highly erosive river environment.
Deposition of these trees is clearly associated with a high-energy alluvial system; stream flow had to be significant enough to both deposit the coarse sediments and perch the LWD atop the sands and gravels.

The top photo in Figure 4.33 shows the position of the LWD relative to the Nooksack River levee, retention pond, and terrace shell midden at East Ferndale. The photo was taken from the terrace and is looking northwest across the Nooksack River floodplain and levee. The recovered LWD was waterlogged and encrusted with coarse, well-rounded, Nooksack River sands and gravels. A sample of these sediments was collected from the base of the excavated pit for future analysis. The bottom two photos in Figure 4.33 show the LWD recovered from the bottom of the excavated pit. The two trees from which 14C were taken are shown along with their corresponding radiocarbon assays.

Results of 14C dating produced surprising results. Assays of 240 +/-50 BP (Cal 1660 AD) and 420 +/-50 (Cal 1450 AD) reveal a pattern of rapid floodplain aggradation. Using the younger date of 1660 AD, in conjunction with the date of Euro-American settlement on this floodplain, approximately 1900 AD, we can develop a local alluvial chronology that sufficiently explains the distribution of archaeological materials here.

Accumulation rates of sediments at East Ferndale, based on 14C dating, were both rapid and voluminous. Between 1660 AD and 1900 AD, a period of 240 years, some twenty feet of floodplain aggradation occurred. This accumulation of sediment formed the platform upon which the historical town of East Ferndale was formed. Subsequent erosional events, which are well documented for the city of Ferndale and the Nooksack River, likely contributed to the poor preservation of early historic cultural activity.

It is asserted that the absence of prehistoric cultural deposits on this particular part of the floodplain is likely a function of late-Holocene erosion, or possibly that the landform had not yet been deposited. The 14C dates obtained from 20 feet below the active floodplain surface show the avulsion event postdated prehistoric occupation. Thus any evidence of prehistoric use of the floodplain at East Ferndale associated with the terrace shell midden, assuming it was in existence at the time of occupation, has been eroded via natural fluvial processes.
Figure 4.33. Top: LWD was recovered from sands and gravels encountered at the base of the 20-foot deep East Ferndale retention pond. Bottom: The LWD was waterlogged and encrusted with coarse Nooksack River gravels. Two conventional radiocarbon dates produced the calibrated dates shown. The 240 BP date provides a limiting date for the avulsion event.
Chapter Four presents new geoarchaeological data for the Ferndale site-complex and shell midden. It includes definition of Analytical Units, 14C dating, sedimentological and pedological analysis. Five Analytic Units (AU's) were defined for 45WH34. They are based on regional geological data and definable stratigraphic characteristics (i.e. particle size, texture, color, presence/absence of shellfish, horizontal continuity) derived primarily from Grabert's 1972 excavation profiles. Definition of AU's allows for vertical and horizontal intersite correlation of archaeological and geological materials as well as providing the basis for a chronostratigraphic sequence. The chronostratigraphic sequence was refined to a three-stage model and proceeded as follows.

Based on twelve new 14C dates the chronostratigraphic sequence for 45WH34 was refined. Significant inversion of 14C dates between AU's II and III however prohibited a five-part chronostratigraphic sequence. Instead the three stage developmental model was used. AU I fell between approximately 10,000 and 5000 BP. AU's II and III were dated to between approximately 5000 and 4000 BP. Because of the likelihood of root intrusion AU's IV and VI were believed to post-date 4000 BP.

Prior to soil and sediment analysis it was difficult to provide acceptable explanations for the complexity of the stratigraphy, and for the number of cultural episodes Grabert assigned to 45WH34 (i.e. Grabert 1983:Figure 5). AU I represents a culturally sterile basal sand strata underlying 45WH34. AU I is composed of Sumas Stade glacial outwash sands that form a localized erosional depression on the floodplain. I suggest it represents reworked sediment, dates between 10,000 BP and 5000 BP. AU I is capped by a paleosol (Grabert 1983) suggesting general stability of the floodplain landscape during this period and provides evidence that the outwash depression, and AU I, formed nearer to 10,000 BP than the later date of 5000 BP. Apart from Grabert's field observation of the paleosol, the only evidence of its existence is a spike in organic matter content between 130 cm and 150 cm in the lowest two levels of S1W2. This spike is attributed to a buried soil horizon based solely on comparison to the mean organic matter content for the C horizons of terrace spodosols, which is 2.49 %. In comparison the mean organic matter content for the two samples between 130 cm and 150 cm in S1W2 is 32.1 %. Relationships can also be defined between the basal strata of WH34 and the terraces. I assert that although lithologically they are the same material, and they represent the same depositional episode, the Sumas Stade materials underlying the floodplain surfaces are the result of a later (i.e. after 10,000 BP) erosional event that formed the cut terrace we see today as forming the active floodplain depression. However, more recent levee construction and floodplain aggradation has buried and constrained the cut terrace, ultimately producing what looks to be a very typical floodplain surface. The floodplain surface around 45WH34 is likely the product of cultural mounding and natural erosion that together produced the slightly elevated topography we see today.

Superior to AU I is AU II, which represents initial human occupation at WH34. AU II is characterized by dark colored, poorly stratified shell midden soil with a sandy matrix and, based on the oldest uncalibrated 14C assay, dates to 4370+/90 BP. The youngest 14C assay for AU II is 4220+/40 BP. These assays however
present a problem; despite being deeper than assays for the superior AU III, both 14C dates are significantly younger. This inversion may represent an intrusive event or be the result of cultural mixing. No matter the cause, the inverted 14C dates highlight the complex stratigraphy of the site. At this time AU II and the overlying AU III cannot be differentiated, together they form the entirety of *in situ* cultural activity at WH34. The only distinction between the two is the change from darker and more poorly preserved sediments in AU II and lighter colored, better preserved materials in AU III. Although there is no clear evidence at this time, I assert the abrupt transition is *not cultural*. Instead I believe it is a function of acidic soil conditions dominant during the initial phases of cultural activity. After shellfish parts accumulated soil chemistry changed, ultimately leading to better preservation in the upper strata. Further, the influence of local subsurface flow under WH34 derived from numerous proximal local springs on the terrace, in addition to increased flow after levee construction which channeled water towards WH34, acted to leach the lower levels, ultimately producing the distinct two-toned stratigraphy we see today.

AU III is characterized as stratified midden soil with pockets of whole to finely-crushed shell. By volume AU III is most dominant at WH34; it encompasses approximately 1/3 of the total site. The oldest uncalibrated 14C assay for AU III is 4970+/−70 BP. The youngest two assays are 1110+/−50 BP and 330+/−70 BP. Both of these young dates are considered intrusive and likely represent the decomposing roots of tree stumps encountered by Grabert during excavation. The upper boundary separating AU III from the superior AU IV is marked by an unconformity. The unconformity likely represents an erosional event that may have destroyed or reworked the upper portions of AU III, and likely any easily identifiable evidence of subsequent cultural activity at WH34. The unconformity more clearly represents a depositional episode; this view is based on a notable increase in silts and clays recorded in the overlying sediments that comprise AU IV.

AU IV is characterized as gray to brown undisturbed silty clay alluvium. AU IV is distinct from underlying deposits in regards to its finer grain size, lighter color and fewer cultural deposits. AU IV is interpreted as a depositional episode that buried a large portion of WH34. In cross-section relatively deep "trough-like" features were observed on the mapped unit profiles. It was initially believed these were the plow scars but there is also evidence to suggest they may represent infilled treethrow pits.

AU V includes those near-surface deposits impacted by agricultural plowing and surface/near-surface bioturbation. Commentary by Grabert (1983:4) and photos from the 1972 excavation clearly reveal "roots and wind-fallen trees and stumps," AU V is designated a plowed A soil horizon (i.e. Ap horizon). Analysis of seven aerial photos dating between 1933 and 2000 (i.e. 1933, 1951, 1961, 1975, 1986, 1995, 2000) shows the ground surface of WH34 remained undisturbed until 1975. This land disturbance may in fact be the result of the 1972 excavation. It could be concluded that following clearance for excavation this area of the floodplain became integrated into the plowing regime. Maps subsequent to 1975 all show evidence of being cleared. At this time little else can be said regarding AU V other than it represents a highly disturbed floodplain.

Analysis of terrace soils provides evidence for soil homogenization and allows the development of a model to explain the nature of the terrace landform since cultural activity there. It is asserted that although numerous artifacts were encountered at depths of nearly three feet and were oxidized, it is impossible at this
time to assign an exact age to them. The effects of pedoturbation have mixed both the soils and the cultural record to a point where the chances of locating primary deposits would be difficult. Based on Grabert's observation (1983), and evidence presented here for larger site boundaries, cultural activity on the terrace, at least at 45WH39, and possibly 45WH38, are more likely contemporaneous to activities at 45WH34, thus they likely date to between 5000 and 4000 BP, and possibly later. No evidence exists to support the assertion that they date to the early- to mid-Holocene, as suggested by Grabert (1983).

What can geoarchaeological studies at East Ferndale tell us about the upstream Ferndale site-complex? About the geological development of the lower Nooksack River? To begin with, it is clear that the mid- to late-Holocene geological development of the upper Nooksack River delta is highly complex. As shown at East Ferndale, periods of erosion and aggradation can occur within short periods of time and can have dramatic effects on the landscape. The effects of erosion on the archaeological record are highlighted at East Ferndale. These observations may provide important clues to interpreting the post 4000 BP events at 45WH34. C14 data and faunal data (Nokes 2004: pers.comm.) for the Ferndale site-complex suggest procurement and settlement strategies remained consistent between 5000 and 4000 BP. After 4000 BP some unknown event, triggered by cultural change, environmental change, post-depositional alteration to the archaeological record, or some other factor, left the record in such a state that we cannot easily interpret it. This does not mean however that we cannot speculate on what remains of that record. Based on the effects of erosion at East Ferndale described here, we can form a simple hypothesis to explain the post 4000 BP record at 45WH34.

Based on geological data for 45WH34 it is clear that an unconformity exists between 4000 BP and the overlying alluvial deposits. That the unconformity represents a period of erosion followed immediately by a period of deposition is at this time speculative. However, personal observations of flooding at 45WH34 lead me to conclude that this is a likely scenario. As Grabert (1983:15) observed, because of the land slope to the south towards the outlet channel it is likely that little of pithouse dwelling remains there, as it has been eroded during formation of the flood channel. Future analyses of the Ferndale site-complex, particularly those attempting to identify post-4000 BP cultural activity, must consider that deposits may have been reworked and subsequently redeposited into depressions, as was described for the East Ferndale floodplain.
Chapter 5
DISCUSSION AND IMPLICATIONS

Today the Nooksack River delta encompasses a subaerial area of approximately 13.8 square miles (22 sq. km) and a linear distance of some six miles (10 km). The modern delta shoreline (i.e. RM 0) is approximately four miles wide (i.e. from Sandy Point to Marietta). River Reach One (i.e. RM 0 to 6) has an average floodplain width of 2.8 miles and gradient of 1.8 ft/mi. Upriver from Reach One is Reach Two (i.e. RM 6 to 15.3) that begins at the Ferndale site-complex (i.e. RM 6). Reach Two has an average floodplain width of 1.1 miles and a gradient of 2.3 ft/mi. Thus the geographic position of the Ferndale site-complex within the modern drainage represents an abrupt transition from broad and level floodplains downstream to narrower floodplains with steeper river gradients upstream. The presence of a 5000 year-old shell midden at RM 6 suggests that this area may well represent the position of the mid-Holocene paleoshoreline, paleoestuary, and paleodelta. To test this hypothesis the two available, and notably different, models for lower Nooksack River geological development are considered.

Easterbrook (1962, 1971) dates the beginning of Nooksack delta construction to the terminal-Pleistocene Sumas Stade of Fraser Glaciation, when meltwater streams first began depositing sediment into the sea at a level within a few tens of feet of the present.

These early deltaic deposits are now buried beneath the modern floodplain and delta. In its early phases of development the delta was well upstream, at least as far as Ferndale, and what is now Lummi Peninsula was an island, separated from the mainland by arms of the sea on either side. Accumulation of sediment at the delta over a period spanning perhaps 9,000 to 10,000 years in post glacial time caused it to extend southward until it reached the island (now Lummi Peninsula) and annexed it to the mainland. (Easterbrook 1971:29)

I make several assumptions in order to correlate the Ferndale site-complex geoarchaeological record to Easterbrook's model. While these assumptions may extend beyond his original intent, such additions are needed to provide a simplistic, complete and testable model. First, Easterbrook suggests basinal infilling occurred over a period of some 10,000 to 9,000 years, and based on our understanding of delta building processes, I assume delta building rates increased significantly after 6,000 BP, with the majority of
progradation and aggradation occurring after 5000 BP, when sea levels stabilized. A second and bolder assumption is that mid- to late-Holocene delta building was a relatively continuous (i.e. uninterrupted) process. This view, although not realistically reflecting natural delta building conditions, is necessary to clearly differentiate it from the alternative model presented below. In reality, delta building is a highly complex processes influenced by many variables (e.g. relative sea level change, precipitation, upriver geological conditions, sediment loads), most of which remain undefined for the region discussed here.

Pittman et al. (2003) have recently offered a strikingly different view of lower Nooksack River development. They argue for a late-Holocene avulsion of the lower Nooksack River wherein the Nooksack River drained north into the Canadian Fraser River for much of the Holocene period, only to avulse to its present watershed sometime during the late-Holocene period. They observe:

The Nooksack River drains more than 1400 square kilometers at the point where it would flow north to the Fraser, making it one of the larger tributaries to the Fraser. At some point in the Late Holocene the Nooksack River avulsed from the Sumas Valley into a remnant glacial outwash channel that is its present channel course into Bellingham Bay, some 58 kilometers south of where the Fraser meets the Pacific Ocean (Pittman et al. 2003)…Numerous relict channels and oxbows in the Sumas valley, consistent in size and radius of curvature with the modern Nooksack River, the depth and distribution of flood deposits, as well as alluvial fans that have been truncated by channel migration, further suggest the Nooksack’s northward Holocene course through the Sumas Valley to the Fraser. Two much smaller streams, the Sumas River and Johnson Creek, now flow northward in the Sumas Valley within these oversized relict channels. The abundance and morphological newness of the remnant channels, Native American legend, and various radiocarbon dates indicate that the Nooksack River avulsed from the Fraser basin to its modern course to Bellingham Bay in the late Holocene. (Pittman et al. 2003)

In order to draw testable implications from Pittman et al.’s model, I assume that if the Nooksack River was absent from its present course for much of the mid- to late-Holocene period there would have been a stable non-prograding shoreline at its mouth. This analysis assumes that the amount of local infilling from the local watershed (i.e. without the Nooksack River) draining into the basin downstream of the Ferndale site-complex was of too small a volume to significantly impact littoral biological processes there, or human subsistence and settlement strategies at 45WH34. Neither does this analysis deal with the possibility that the Nooksack River avulsed multiple times. In short, I link the timing of the presence of the Nooksack River in its present channel into Lummi and Bellingham Bays with the timing of initial delta progradation. In other words, I assume the avulsion event and initial delta progradation and aggradation are concomitant events.

As noted earlier, Easterbrook’s (1971) and Pittman et al.’s (2003) models have predictable outcomes for prehistoric populations occupying the Ferndale site-complex during the mid-Holocene period, and for the alluvial deposits that form the matrix of archaeological deposits there. Easterbrook’s developmental model places the lower Nooksack River in its present watershed by 9000 BP and suggests the delta has prograded seaward (i.e. away) from the site-complex at a steady rate to its modern position since that time. Under this model it is expected that sediments, soils, and associated archaeological deposits at the site-complex should increasingly reflect inland riverine/terrestrial conditions across the mid-Holocene horizon. This view is similar
to the one forwarded by Grabert (1983:5). Further, shellfish species procured from the paleoshoreline and deposited at 45WH34 should increasingly reflect a soft-sediment substrate that is typical of prograding shorelines (see Stilson 1972).

Alternatively, Pittman et al.'s (2003) model suggests the lower Nooksack River did not occupy its present watershed until late in the Holocene and the onset of delta progradation was delayed. Under this model it is expected that archaeological deposits and associated geological materials at the site-complex should reflect a small and geologically stable river valley (i.e. without the Nooksack River) and proximal stable marine paleoshorelines until the late-Holocene avulsion and concomitant delta construction.

**DISCUSSION**

Based on the geological evidence at hand I believe there is more support for late-Holocene avulsion and delta development than for steady delta progradation over the last 9000 years. Geological data supporting the avulsion centers on the unusually small size of the Nooksack River delta, which is measured by the shallow depth of Holocene delta sediments (Nikzad et al. 2002; Reagan 1917; WADOT 1954) and its limited subaerial extent. In a 70-year period preceding 1967 the Bellingham Bay lobe of the delta prograded one mile (Sternberg 1967), a significant proportion of its total length of some six miles (10 km). Another model suggests that if the delta prograded at an average rate of 13.3 yards/year it could have theoretically constructed some 20 miles (32 km) beyond the Ferndale site-complex in the past 5000 years (this study does not consider process of sediment removal by oceanographic processes, which would effectively inhibit the delta from ever achieving this size) (Hansen and Ferry 2002).

A total of fifteen 14C dates, including three from Grabert's study (1983), provide evidence for a 1000-year long occupational sequence between 5000 and 4000 BP at 45WH34. This conclusion is in direct contrast to Grabert's (1983:13) findings; based on his artifact typology he suggested later occupations dating around 2000 BP, 1000 BP and late-prehistoric times. New 14C data, however, suggests only one component can be delineated for WH34. The component produced ten 14C dates that are bracketed between conventional radiocarbon ages of 4970 +/-80 BP and 4000 +/-40 BP. Five 14C assays post-dating 4000 BP are considered intrusive and likely reflect the tree roots exposed during the 1972 excavation. Based on the age of cultural activity at WH34, and similarities in faunal remains (Nokes pers. comm. 2004) to St. Mungo period occupations at Glenrose Cannery and St. Mungo Cannery on the Fraser River delta, the Ferndale site-complex is attributable to the Charles Period (see Borden 1975:97; Matson and Coupland 1995:116).

The addition of archaeological data to lower Nooksack River geology provides additional support for a late-Holocene avulsion. Because sites containing marine mollusks are usually located adjacent to marine shorelines (e.g. Bailey and Parkington 1988; Stein 1992a), marine shellfish processing at RM 6 by 5000 years ago is suggestive of a proximal paleoshoreline. Analysis of shellfish and fish remains from 45WH34 by Rosevear (2004) and Hofkamp and Pfandler (2004) does not support Stilson's (1972) model for human
adaptation to a prograding delta. If the delta was prograding across the mid-Holocene horizon, as suggested by Easterbrook (1962, 1971), then rocky shore shellfish and marine fish species should, through time, be increasingly replaced by soft sediment shellfish and anadromous fish species, respectively. If delta progradation was not initiated until late in the Holocene, as suggested by Pittman et al. (2003), then the relative abundance (i.e. NISP) of marine shellfish and marine fish species should remain relatively constant until the avulsion event and concomitant delta progradation. Analysis of shellfish and fish remains from 45WH34 suggests continuity in subsistence strategies between 5000 and 4000 BP, suggesting a stable (or only slightly changing) environment during this period.

Rosevear (2004) concludes that shellfish MNI and NISP data show that rocky shore indicator species Mytilus (mussel) and Balanus (barnacle) are the dominant taxa. Prevalence and continuity of these rocky shore species at 45WH34 suggest the paleoshoreline between 5000 to 4000 BP consisted of rocky substrates. Hofkamp and Pfandler (2004) show the relative abundance (NISP) of all five AU's shows salmon to be the dominant species (by NISP), followed by dogfish and flatfish. Excluding noted change occurring between AU's III and IV, analysis of relative abundance across AU's suggest continuity through time.

Analysis of mid- to late-Holocene faunal assemblages from upper-delta sites located on the Fraser and Skagit Rivers reveal dynamic subsistence patterns (e.g. Boehm 1973; Calvert 1970; Ham 1976; Matson 1976; Stilson 1972). Notable adaptations at these locales include increased presence of soft-sediment shellfish species and aquatic bird species. Such changes are thought to reflect adaptations to changing environmental conditions associated with delta progradation after 8000 BP. The Ferndale record however does not fit this pattern. Continuity in relative abundance of rocky shore shellfish and marine fish remains at 45WH34 between 5000 and 4000 BP are suggestive of a stable rocky substrate shoreline during a period generally associated with seaward delta growth marked by accumulation of soft sediment, environmental change towards inland terrestrial/riverine ecosystems and human adaptation. These observations provide evidence for a temporal delay in Nooksack delta development, and therefore support Pittman et al.'s (2003) avulsion model. Further support for the late-Holocene avulsion includes geological and pedological evidence. The buried paleosol underlying 45WH34 indicates a relatively stable alluvial landscape between 10,000 and 4000 BP. After 4000 BP there is evidence for increased flood regimes that produced higher frequencies of silt and clay in the upper shell midden horizons. Whether or not increased alluvial activity is attributable to an avulsion event that eroded occupations subsequent to 4000 BP, or altered subsistence or settlement patterns, remains unclear. Possible explanations for cultural changes after 4000 BP include cultural adaptations to newly formed riverine/terrestrial ecosystems, site relocation downstream to new estuarine and littoral zones where access to shellfish and fish resources was more direct, or a combination of both.

As illustrated in Figure 5.00, the delayed onset of delta progradation, as interpreted from geoarchaeological analysis of 45WH34, may reflect pre-avulsion conditions on a previously unnamed river system that flowed past Ferndale into a local bay. During the early- to mid-Holocene period this local drainage, termed here Skalakin River watershed, occupied a preexisting and incised glacial outwash channel formed approximately 10,000 years ago. Geographical evidence suggests the Skalakin River estuary may have been
positioned immediately downstream of the site-complex near the present town of Ferndale for much of the mid-Holocene period. The Skalakin River drained a small watershed into the now infilled Skalakin Embayment. Today the modern Nooksack River occupies the prehistoric Skalakin River channel and the Skalakin Embayment is buried under late-Holocene sediments deposited during the post avulsion period.
Figure 5.00. Maps, the Ferndale site-complex (45WH34) and Skalakin Embayment under pre-avulsion and post-avulsion conditions. The Ferndale site-complex is on or near the paleoshoreline and paleoestuary (top map) until the avulsion (bottom map) and concomitant delta progradation (dotted red lines in embayment). The modern delta position (dotted black line) is approximated on both maps. Modified from Pittman et al. 2003.
Sediment data, soil data, and archaeological data can be integrated to create a model of Holocene fluvial history for the Ferndale site-complex (Figure 5.01). This eight-stage developmental model considers relative sea level change, the timing and nature of major erosional and depositional episodes, soil ages, and geoarchaeological data from the Ferndale site-complex. Dotted red lines indicate pedogenesis (stages B-H), habitable landforms (stages B-H) and paleosols buried by depositional events (stages E-F). Arrows indicate erosional episodes (stages B, D, F, G and H). Solid horizontal blue bars indicate dated periods of floodplain habitation (stages E-H) and solid horizontal black bars indicate periods of alluviation (stages G and H). In the descriptions of Table 5.01 that follow, time periods are correlated to 45WH34 Analytic Units and are indicated by the AU number in parentheses, e.g. (AU I).
A. 10,000-9000 BP - Post-glacial braided river system deposits glacial outwash sands to form the fill terrace (i.e. geomorphic Surface Three). The ability of these proglacial streams to carry material was greater than that of the modern Nooksack River, and the valley was broader, as is indicated by the deposits, which are coarser and more extensive than modern alluvial material; C14 dates obtained from the base of organic deposits range from 9920 to 9300 BP (Goldin 1986).

B. ~9300 BP - Rapidly lowering relative sea levels initiates channel incision and/or lateral channel migration that erodes outwash sands to create the cut terrace we see today (i.e. the terrace scarp and the portion of modern floodplain underlain by outwash sands that form the linear floodplain depression). Genesis of upper terrace Spodosols (i.e. dotted red line). (AU I)

C. ~9000-8000 BP - Nooksack River flows north through the Sumas Valley leaving the small Skalakin River to occupy the abandoned outwash channel; stable fluvial conditions permit paleosol genesis on floodplain (i.e. lower dotted red line).

D. ~8000-6000 BP - Lower relative sea level causes the Skalakin River to incise further into the abandoned outwash channel. By 6000 BP rising sea levels may have initiated some localized aggradation, but because the Skalakin River was well below 45WH34, no alluviation occurred there. Unabated soil development on both surfaces.

E. ~6000-5000 BP - Stabilizing relative sea levels allow the Skalakin River valley to mature. Initial occupation at 45WH34 by 5000 BP; cultural activities (solid blue line) occur on Skalakin floodplain paleosol surface. (AU II)

F. 5000-4000 BP - Evidence of shellfish processing and marine/anadromous fishery at 45WH34 suggest a proximal rocky marine shoreline and estuary that either franched WH34, or more likely were slightly situated downstream between the present City of Ferndale and the Tennant Lake complex (i.e. ~RM 6). (AU II and III)

G. Post-4000 BP - Nooksack River avulses to its present channel into Strait of Georgia/Puget Sound. Increased fluvial activity may have eroded portions of WH34. Alluvial deposition of sands, silts and clays form an "alluvial cap" over WH34 and mark an increase in fluvial activity. The alluvial cap shares strong similarities to the young Mt. Vernon series soils that are found on proximal levee surfaces. (AU IV and V)

H. Historic and Modern conditions - A long and naturally constructed (and unmodified) levee upstream of WH34 restricts floodwaters from easily returning to the main channel, instead flow parallels the Nooksack River (i.e. Yazoo-style) through the backswamp depression to a downstream outlet at WH34. During periods of high flow floodwater is pooled above WH34. This pool empties through a small channel that cuts into 45WH34 before returning to the main Nooksack channel. Because WH34 is a raised mound and is already incised by a main floodplain channel it is highly susceptible to erosion. 14C dates from the East Ferndale site-complex are suggestive of a dynamic fluvial landscape, marked by both erosion and aggradation, at least for the past 250 years. The channel-spanning logjam downstream at Hovander Bend (i.e. southwest of Tennant Lake) played a major role in forming the post-avulsion floodplain landscape on the lower Nooksack River. By impounding water and raising river levels, episodes of erosion and aggradation likely increased. Conversely, when the river avulsed around the Hovander Bend "Jam" river levels lowered and flood frequencies upriver at WH34 were reduced.

There are several weaknesses in this eight-stage developmental model. The most prominent is a lack of supportive geological data from other upriver or downriver locales (other than geological cross-sections for the two bridge crossings). The location of the Ferndale site-complex within the system may also create biased results in light of the overall lower Nooksack River system. Because aggradation and degradation can occur simultaneously in different parts of the same drainage basin, extrapolation in space and time from just one place of observation may be invalid (Gladfelter 2001). This fact is best highlighted in the results from the East Ferndale site-complex. There, C14 dates provide evidence for a dramatic change in flow regime and 20 feet of floodplain aggradation in the time since 250 BP, despite the fact that just upstream 45WH34 remained relatively unaffected by fluvial activity for the past 5000 years. Other than illuminating the dynamic nature of the lower Nooksack River, the geology of the East Ferndale site-complex provides little direct evidence for
conditions upstream at the Ferndale site-complex. The paucity of Holocene geological data greatly limits the accuracy of the eight-stage model (because little data exists to validate or invalidate it) and its applicability to other positions on the lower Nooksack River.

These weaknesses illustrate the five interpretive challenges for archaeologists working in humid alluvial environments identified by Gladfelter (2001). Future geological and archaeological study of the lower Nooksack River will hopefully address these issues more fully:

1. *Location within the system.* Aggradation and degradation can occur simultaneously in different parts of the same drainage basin and, thus, invalidate extrapolation in space and time from just one place of observation.

2. *Sensitivity.* One climatic event may trigger different responses within a drainage basin depending upon prior conditions; a saturated matrix, for example, will reach equilibrium before an unsaturated one, consequently, because prior conditions and nearness to the threshold the same (climatic) event can trigger major or insignificant responses the evidence for which depends on one's place of observation.

3. *Convergence.* Different causes can result in the same response: aggradation results from changes in base level, from change in the precipitation/potential evapotranspiration ratio, or from change in surface cover. Different causes or processes that result in the same effect may compromise interpretation based on form alone.

4. *Complexity.* Geomorphic thresholds can be exceeded because of intrinsic adjustments. For example, a change in sediment concentration will occur by bank erosion, by channel scour, and by increased hillslope erosion. When a system may be unable to adjust in a "progressive or systematic fashion...behavior can be episodic with periods of aggradation interrupting degradation...This produces a very complex geomorphic and stratigraphic record, the details of which cannot be attributed to external influences but rather to the adjustment of the system itself.

5. *Spatial and temporal scales.* Complexity within the fluvial system increases as area and scale increase: (a) as time spans become longer, average rates of change decrease; the older the alluvial sequence, the smaller the proportion of time it represents and the more incomplete the gradational record becomes (b) there is a direct relationship between the size of the basin and the detail and complexity of the gradational record; the smaller basin retains a smaller portion of the alluvial history of an area. There are, therefore, inverse relationships between the accuracy of postdiction and the size of the fluvial system, and the length of time over which the extrapolation is made (Gladfelter 2001:114-115).

Because the eight-stage developmental model is derived from geoarchaeological data from the Ferndale site-complex, it is directly applicable only to that portion of the fluvial system. It must also be considered subject to change. However, based on the evidence at hand, particularly the paleoecological evidence for a marine embayment fishery and rocky substrate shellfishery between 5000 and 4000 BP, it seems a temporal delay in delta progradation likely occurred until after 4000 BP. Whether or not this pattern is a product of pre-avulsion conditions, as suggested here, or other factors that remain unexamined (e.g. localized relative sea level change or upriver geological factors), remain unclear. It should be expected that future geological study of the area would identify a more complex fluvial history than the one presented here. It is possible, if not probable, that multiple avulsion events occurred through time. This possibility, combined with expected variation in upstream sediment contribution through time, supports the view of a more complex fluvial history. At this time the Ferndale site-complex record most clearly reflects a temporal delay in
Netting (1986) considers human problems and the relevance of ecological research; his views provide an excellent terminus to this section of the discussion. Netting asserts that within the academic discipline of anthropology, the significance of a theory or interpretation often depends on whether specialists can be persuaded of its validity.

An attractive or novel idea is one that makes sense of disparate and previously unrelated facts. The formulation that appears more comprehensive, parsimonious, and elegant is accepted. Research findings that seem consistent are seldom checked by other scientists, restudies are rare, and there is no laboratory situation for experimental manipulation of the data of human ecology...Ecologically-oriented research has the potential of speaking directly to contemporary concerns...Proposed changes must be examined before they are implemented, and means such as environmental and cultural impact statements have been developed to do this...Intelligent planning requires the input of social science, and ecological anthropologists must accept this as both a responsibility and a challenge. Moreover, action or applied research carries the opportunity for actually testing our hypotheses. The "proof of the pudding" is not solely in its digestibility. (Netting 1986:90-91)

This reassessment of lower Nooksack River prehistory presents new ideas that, if accepted, will significantly alter how anthropologists view the human ecology of the Fraser/Nooksack Lowland. The broad geological, cultural and archaeological implications of this study demand future reanalysis.

**Implications for the Ferndale site-complex**

Based on the geoarchaeological and paleoecological data discussed here, Grabert's (1983) initial interpretations of the Ferndale site-complex can be reconsidered and a refined and updated cultural and environmental chronology can be presented. Grabert forwarded two hypotheses that linked archaeological and environmental data in his effort to explicate the nature of the Ferndale record. He suggested that the upper terrace is the result of higher Holocene sea levels, and that sites found on those terraces reflect early- to mid-Holocene cultural activity associated with those raised paleoshorelines. Neither of these views are supported by this research. He also suggested the later occupation of the shell midden site 45WH34 might reflect adaptive strategies to sea level stabilization between 6000 and 5000 years.

Geological and archaeological evidence presented here suggests that the terrace sites are more likely contemporaneous to, or subsequent to, cultural activities at 45WH34, and not an early- to mid-Holocene occupation as Grabert proposed. The hypothesis posited here suggests that the Ferndale site-complex terrace sites most likely reflect local and specialized land use associated with 45WH34, and the depth at which artifacts such as cobbles tools are encountered does not reflect their early-Holocene age, but instead are likely the product of soil mixing resulting from florationurbation. Lack of E horizons in terrace Spodosols provides some evidence for soil homogenization, a forest soil characteristic produced by the dynamic processes of root growth, root rot, and uprooting. The west soil transect excavated in 2002 provides evidence that 45WH34 and
the terrace site 45WH39 are also larger than previously believed. Based on this observation it seems that no significant spatial break exists between these two sites, thus suggesting these sites may be temporally related. Because 45WH39 extends farther northeast along the terrace than Grabert suggested, it is also likely 45WH39 and 45WH38 are also similarly related. It is proposed here that the terrace sites, at least 45WH38 and 45WH39, represent an extension of 45WH34, thus they likely also date between 5000 and 4000 BP. This view however, is not sufficiently substantiated at this time.

Grabert also suggested that the later occupation of 45WH34 might reflect adaptive strategies to sea level stabilization between 6000 and 5000 years, possibly resulting in site usage change "from an essentially estuarine or coastal situation to an inland place, where different resources might have been collected." Environmental archaeological modeling of the Ferndale site-complex discussed here sheds light on mid-Holocene subsistence and settlement patterns. The timing and nature of 45WH34 suggests the Skalakin River estuary and paleoshoreline was a particularly attractive environmental setting for locating a relatively large, semipermanent settlement. Re-analysis of the Ferndale site-complex and 45WH34 provides evidence for a semipermanent (Gillis pers. comm. 2004; Grabert 1983) upper-estuarine occupation. Faunal remains being examined by Nokes (pers. comm. 2004) suggest a broad-spectrum subsistence strategy was employed where mid-Holocene hunter-fisher-gatherers frequently entered nearshore-marine, littoral, riverine, riparian-wetland, and forested upland ecosystems in pursuit of marine bay fish and shellfish, salmon, waterfowl, beaver, elk, deer, and bear, among others. Based on the diversity of terrestrial and marine species however, it does not seem the estuary itself was the primary focus of activity. Faunal and geographical evidence suggests instead that between 5000 and 4000 years ago the Ferndale site-complex may have been positioned slightly upriver of the estuary where it was centrally located amid freshwater and brackish wetlands, forested uplands, and open marine waters. Thornbahn and Cox (1988) describe a similar pattern for the Northeast Coast of North America. Like Ames and Maschner's (1999:116) "secondary resources" concept, they recognize that most prehistoric groups utilized a wide array of ecosystems rather than a limited set of resources procured from a single ecosystem like the estuary or littoral zone. Based on data from coastal Rhode Island, Thornbahn and Cox (1988:179) suggest prehistoric groups found it economically advantageous to occupy alluvial landscapes slightly inland of the estuary. There they could take advantage of the resources in several environmental zones (e.g. uplands, wetlands, prairies, marine shorelines) as opposed to focusing solely on estuarine resources (e.g. marine fish, shellfish). Acceptance of this alternative could challenge the model presented here because positive geographic correlation between shell midden deposits and proximal paleoshorelines would be rendered less meaningful than previously thought. Upper-delta shell middens dating to the mid-Holocene, like 45WH34, may represent resources transported some distance from the shoreline, at an economic cost, in exchange for the economic benefits of direct access to important terrestrial resources (e.g. ungulate). The use of boats to transport marine resources to 45WH34 may help explain such a pattern.
Implications for lower Nooksack River prehistory

A temporal delay in delta progradation and concomitant late-Holocene avulsion can be used to explain the age and type of sites encountered as a result of previous lower Nooksack River archaeological studies. Based on the survey of lower Nooksack River archaeology presented in Chapter Two, some new observations can be made.

Keith Montgomery (1979) examined prehistoric settlements in the inland lower Sumas Valley located approximately 15 miles (24 km) northeast of the Ferndale site-complex. Montgomery's examination of some 16.8 acres of the lower Sumas Valley led him to observe that, of the seven sites and two minor loci he surveyed, all were situated on the stream terrace crest, in close proximity to the adjacent waterway. Although no radiocarbon dates were obtained from the Sumas sites:

…typologically this series of related sites is placed within the Marpole Phase time period, 400 B.C. to A.D. 400…Not only do these sites exhibit a characteristic Marpole Type artifactual assemblage, but they lack cobble choppers and flake tools associated with earlier lithic assemblages. (1979:197)

Because Montgomery encountered sites only on terrace crests that were "in close proximity to the adjacent waterway," I suggest the young age he attributes to them reflects patterns of land use associated with either the more recent Sumas River or the later stages of the Nooksack River when it occupied the Sumas Valley. That Montgomery's survey did not encounter "older" sites may be a result of his survey method, which reflected the modern Sumas River "microenvironment," rather than recognizing the possibility that older sites may either be buried under Nooksack River floodplain sediments or on paleoterraces much farther from the modern Sumas River where the Nooksack River may have once been.

In Chapter Two, two important observations were drawn from Grabert and Griffin's (1983) study of the Lummi Peninsula and adjacent delta landscapes that are relevant to this reassessment. One observation concerns the apparent shift of marine fishing and shellfishing sites from an inland position at the Ferndale site-complex between 5000 to 4000 BP downstream to on and around the modern Nooksack River delta by no earlier than 3000 BP. The second observation concerns commentary by Grabert and Griffin that links patterns of shifting site locations between the Locarno Beach period and later Marpole period to a Nooksack River avulsion where the River shifted from Lummi Bay to Bellingham Bay. The assertions made earlier in Chapter Two suggest these observations were speculative, but did draw some possible inferences in light of the two geological models. At this time evidence for delayed delta progradation and concomitant avulsion do not illuminate such assertions. Thus at this point in time they remain speculative. That Grabert and Griffin did not encounter "older" lithic sites on the delta landform does however illuminate the value of geology in archaeological study. As described below, their inability to find "old" sites on the "young" delta is a logical consequence of delta building.

Kristen Patterson Griffin (1984) conducted an archaeological survey and analysis of prehistoric settlements on the lower Nooksack River delta. According to Griffin's study of the lower Nooksack River delta
the apparent absence of "older" sites along the Lummi River may be due to a number of factors tied to changes in the river system that may have buried and/or eroded all but the most recent cultural deposits in the process of delta progradation and seasonal flooding (1984:65). Based on studies presented here regarding the geological development of marine deltas a more likely conclusion for this area of Nooksack River delta is that "older" occupations never existed at the floodplain surface (i.e. where Griffin was surveying). Although older deposits may indeed have been buried at depth or eroded from the terrace/floodplain boundary, sites found in situ at the surface of the delta floodplain cannot predate delta formation. Viewing Griffin's study area in Figure 2.04 (Chapter Two), and considering Pittman et al's (2003) model, this may not have occurred until as recently as the last millennia. Under this view Griffin's (1984) inability to find "old" sites on the "young" delta is logical.

Implications for lower Nooksack River site location

Geoarchaeological and paleoecological modeling of the Ferndale site-complex also provides insight for applying geological data to mid- to late-Holocene lower Nooksack River site location. I suggest lower Nooksack River archaeological sites that postdate no earlier than 4000 BP and contain evidence of marine subsistence strategies should be found downstream of the Ferndale site-complex and decrease in age as one travels seaward. Alluvial sites located adjacent to the site-complex and postdating no earlier than 4000 BP should, through time, increasingly reflect land use patterns associated with riverine/terrestrial ecosystems.

As described in Chapter Two, sites in alluvial and coastal settings are subject to a variety of natural processes that may preserve or erode them. Sites preserved in alluvial settings are typically preserved through burial. Sites like the Ferndale site-complex can also be preserved because they are partially protected from the destructive forces of fluvial activity. Older sites are more frequently located and preserved at backswamp/terrace interfaces, or ecotones. Ecotones are zones where two or more communities meet. This zone of intergradation may be a narrow or wide, local or regional (Smith 1974:251). At the Ferndale site-complex, as well as other backswamp/terrace interfaces along the lower Nooksack River, ecotones are narrow, local and abrupt. Abrupt ecotones frequently result from an abrupt change in soil type or soil drainage. Backswamps along the lower interior setting of floodplains may preserve surface or near-surface sites, and the oldest sites on the floodplain are likely to be found there (Gladfelter 2001:103).

Lewis (2000:525) estimates the combined effect of sea level rise and land subsidence on archaeological site distribution on low-energy coasts (which both the Strait of Georgia and Puget Sound are) that are characterized by minimal wave action and current action. He suggests the combined effect of sea level rise and land subsidence is to bury archaeological sites more or less intact beneath muck, sand, and water rather than erode them away. "Buried sites offer essentially the same research potential as unburied sites; they are simply harder to study. The low-energy coast, because it can act as an agent of preservation rather than destruction, is therefore interesting from the archaeological perspective (Lewis 2000:525)."
Chapter 6
POSTSCRIPT

The lower Nooksack River corridor is becoming an increasingly popular area for settlement as populations continue to grow in Whatcom County. Impacts commonly associated with population growth, such as housing developments, road improvements, flood control practices, wastewater treatment facilities and floodplain enhancement projects, have the potential to negatively impact nonrenewable prehistoric and historic cultural resources. Because archaeological sites have the potential to not only inform us about past cultures, but as shown here, they also provide invaluable data regarding past environmental conditions. As pressure on cultural and environmental resources increases, successful management requires a better understanding of the evolution of these interrelated systems.

Currently a lack of integrated and updated research hinders our understanding of coastal river change, and human responses to such changes, for the lower Nooksack River. Such knowledge is important as it allows for the impacts of future change to be understood and predicted with greater confidence (Pye and Allen 2000). The current political and social climate surrounding the status of Puget Sound/Strait of Georgia rivers, estuaries and marine waters suggests such work is both desired and necessary for policy makers and interest groups to make informed decisions.

Numerous public and private interest groups promote policy-making regarding coastal and estuarine zones (Pye and Allen 2000:1). The impetus for such political decision-making is grounded in economics (e.g. seaports and their role in intra/international transportation/trade), marine resource extraction (e.g. commercial fishing, recreational fishing); recreation (e.g. fishing, boating, whale watching, bird watching, swimming); water allocation (e.g. human consumption, agricultural needs, industrial needs); flood control (e.g. diking); water quality (e.g. drinking water, freshwater and marine habitats; nature conservation (e.g. flora, fauna, wetlands) and cultural resource management (e.g. historic and prehistoric sites).

Pye and Allen (2000) see these interests as inherently conflicted. They view managers of these policy-making groups as having to compromise or make decisions based on a prioritized course of action that reflects
economic, political and legal constraints. Pye and Allen envision the end-result of this conflict as necessitating an:

…urgent need for a better framework of background environmental data and more effective and reliable management tools, founded on sound scientific understanding, which can provide the necessary guidance and basis for policy formulation. (Pye and Allen 2000:1)

In their view, the key to a successful management strategy is an understanding of the basic physical, chemical, biological, and human properties and processes that affect coasts and estuaries, including their interactions and variability on different time and spatial scales." Therefore locating and interpreting prehistoric and historic archaeological sites is an important component of this process, as such archaeological sites necessitate proper protection. The need for protection and interpretation is highlighted by recent destruction to a large portion of the Ferndale site-complex.

Recent unpermitted construction activities at the Ferndale site-complex highlights the benefits of environmental archaeological research to the management of cultural resources in Whatcom County. In the process of completing this project the private property on which the Ferndale site-complex sits was sold to a new owner. As shown in Figure 5.02, the new owner, without consulting local authorities or obtaining a permit, excavated a massive trench in 2004 that extended much of the length of the site-complex, and in the process disturbed the southern margin of the terrace complex.

Figure 5.02. Photos, disturbance to the Ferndale site-complex terrace/backswamp interface, May 6, 2004.
Efforts to assess and mitigate damage to the Ferndale site-complex by Alfred Reid Archaeological Consulting (ARAC) has benefited from the geoarchaeological data gathered and interpreted for this study. To date, damage assessment has revealed many lithic artifacts encountered at the surface of the disturbed area. As shown in Figure 5.03, these artifacts include cobble tools and flakes similar to those described by Grabert (1983). Knowledge of site-complex soils has allowed ARAC to successfully reconstruct the disturbance activities and will aid in mitigation and future site protection.

It is expected that mitigation will involve refilling the trench following screening of all surface soil horizons (i.e. A and B horizons). These horizons are identifiable in the backfill pile as they differ greatly in color and texture from the sandy outwash parent material. As a result of the trenching new soil profiles were exposed; while some profiles are similar to those described in the test units excavated for this project, others differ greatly. As illustrated in Figure 5.04, the newly exposed profile reveals a high degree of variation between soils forming in concave positions versus those forming in convex positions. Thus a high degree of variability occurs in these outwash soils over a very short distance. There is also clear evidence that the natural spring has affected a large area of the terrace immediately adjacent (northeast) to 45WH34.

Following assessment and mitigation of the disturbed areas of the site-complex, it is expected a long-term management plan will be agreed upon that will protect the area from future disturbance. Of greatest concern is 45WH34 as it is highly susceptible to erosion during periods of overbank flooding. As shown in Figures 5.05, 5.06 and 5.07, 45WH34 is currently being impacted by a drainage channel running past the eastern portion of the shell midden.

Figure 5.03. Photos, artifacts encountered in disturbed backdirt pile from the Ferndale site-complex terrace near sites 45WH37 and 45WH38: two views of a flake (left and middle), flaked cobble tool (right, top) and hammerstone (right, bottom).
Figure 5.04. Photos, newly exposed 9300-year-old terrace soils. The top two soils are at a concave position and their development has been inhibited by surface water. The bottom soil is at a convex position and reflects better soil drainage.
Successful management of 45WH34 requires an understanding of local hydrology. As described in this report and illustrated in Figure 5.05, the Nooksack River mainstem frequently overbanks the levee upstream of the Ferndale site-complex distributing large volumes of water parallel to the River and down the backswamp towards 45WH34. Figure 5.06 shows the path of overbank flow in 2002 down the floodplain (upstream of 45WH34), and as shown in Figure 5.07, overbank flow returns to the mainstem via a small channel abutting 45WH34. This process is currently eroding the eastern portion of the shell midden. Similar processes likely contributed to the destruction of 45WH34 in the past. Appendix B contains technical flood data from the Ferndale Gauge for the 2002 and 2003 flood events described here.

Figure 5.05. Photo, patterns of overbank flow at the Ferndale site-complex during large 2003 flood event. Looking NE across Nooksack mainstem from I-5 bridge. View is northwest.
Study site following recession of floodwaters. Note standing water in topographic lows.

Figure 5.06. Photos, direction of flow at 45WH34 during and following large 2002 flood event. In the top photo the entire backswamp is draining back to the Nooksack mainstem via a small channel beside WH34. The complex floodplain topography is highlighted as the floodwaters receded (bottom photo) leaving standing water in the topographic lows.
Modern fluvial processes at 45WH34

Erosional processes at 45WH34

Figure 5.07. Photos, erosional processes at 45WH34. Overbank flow in winter 2003 can be seen riffling before entering the drainage channel beside 45WH34 (top). Scouring is evident at 45WH34 post-flooding (bottom photo).
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APPENDIX A
Results: Color, CaCO$_3$, OM, and pH.

Appendix A: Results- Color, CaCO$_3$, OM, and pH

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Appendix A continued: Results- Color, CaCO$_3$, OM, and pH

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### Appendix A continued: Results - Color, CaCO$_3$, OM, and pH

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1. AU/Horizon - Analytic unit (AU) or soil horizon from which the sample originated.
2. Color - Munsell soil color - d=dry color/m=moist color.
3. Shellfish - This designation refers to the relative amount of shellfish visually identified in the corresponding <1/8 inch sample used for these analyses; 1=1% to 33% of the sample is composed of shellfish parts; 2=33% to 66%; and 3 has >66%.
4. % CaCO$_3$ - This is a quantitative determination of the calcium carbonate (CaCO$_3$) content in the sample. The calcium content of strata in a midden is increased by the presence of bone, human and animal excreta and soft tissue, wood ash, mollusk shells and bark.
5. % OM - This test measures the moisture content, ash content, and other organic materials present in the sample. The organic matter found in midden strata is increased by all cultural inputs, especially grasses, excreta, and most foodstuffs.
6. pH - This measurement determines the degree of acidity or alkalinity in soil materials suspended in water and a 0.01 M calcium chloride solution. The pH of strata in a midden is raised by the presence of wood ash and mussel shells, which contain calcium carbonate, calcium hydroxide, calcium sulfate, iron and magnesium salts, as well as sodium and potassium carbonates and hydroxides. In addition, all bone and tooth materials will raise the pH.
7. ASTM, 2000
APPENDIX B: OVERBANK FLOW AT 45WH34

Observed and measured flooding at 45WH34, Feb. 24, 2002 and measured streamflow between 1950 and 2000 (bottom).

Study site overbank flow, near maximum flood stage. 
Looking southeast.

45WH34 is completely inundated

Direction of flow

12213100 Nooksack River at Ferndale

12213100 Nooksack River at Ferndale

USGS 12213100 NOOKSACK RIVER AT FERNDALE, WA
APPENDIX B continued: OVERBANK FLOW AT 45WH34

Observed and measured flooding at 45WH34: Oct. 16, 2002.
The PDF process has altered several images in this thesis, ultimately detracting from their original quality. They are provided in this folder and should be printed and inserted in place of the corresponding PDF pages. The pages included here are: page 10 (figure 2.00); page 32 (figure 2.04); and page 52 (figure 3.05).
carrion, a productive and varied plant community, reduced winter snow accumulation, early spring
green-up, aquatic habitat and transportation corridors.

Large deltas on the south-central Pacific Northwest Coast are geographically limited to the
southeastern seaboard of an inland seaway known as the Strait of Georgia and Puget Sound. The largest of
these deltas, as illustrated in Figure 2.00, are associated with the Fraser and Skagit Rivers. The massive Fraser
and Skagit delta complexes flank the comparably small Nooksack River delta to the north and south,
respectively.

Figure 2.00. Satellite photo, the southern Strait of Georgia and northern Puget Sound showing the
Fraser/Nooksack coastal plain and deltas (center), Skagit River delta, Vancouver Island, San Juan
Archipelago, Coast and Cascade mountain ranges, and Fraser River sediment plume. From a geological
and ecological perspective the Nooksack River lowlands are more similar to the Fraser River lowland than
any other area in the Puget Sound area. Top of photo is east. *Modified from NASA/JSC (1989).*
The preceding survey of delta archaeology provides many examples relevant to the three key elements of alluvial archaeology outlined above. Researchers have shown that globally modern marine deltas began to form from approximately 8500 to 6500 years ago (Stanley and Warne 1994) and conditions in and around deltas (i.e. accumulation of fertile soil, reliable water supply, perennial aquatic food sources, ease of travel and

Figure 2.04. Map, approximated positions of lower Nooksack River archaeological surveys set on pre-avulsion Nooksack River map: 1 = Montgomery (1979); 2 = Grabert (1983) and this study; 3 = Griffin (1984); 4 = Grabert and Griffin (1983). Top is north. Modified from Pittman et al. (2003).
Lowland geology is presented. Terminal-Pleistocene geology is an important component of Ferndale-site-complex geoarchaeology because the upper terrace sites exist in sediments deposited during this period.

Relative sea level change plays a central role in determining when and where shorelines exist, or once existed. Although geologists working in the Whatcom County area have intensively studied terminal-Pleistocene land-sea relationships (see Kovanen 2002; Kovanen and Easterbrook 2002; Kovanen and Slaymaker 2003), Holocene sea level change, particularly for the mid-Holocene period considered here, remains poorly understood. Thus, at this time local relative sea level data cannot be considered in this study. However, generalized regional sea level curves can be applied with great caution, as notable differences in relative sea level patterns can occur over short distances. Figure 3.05 is a generalized relative sea level curve for the southern Pacific Northwest Coast and is based on studies by Beale (1990), Clague et al. (1982), Mathews et al. (1970), and Stright (1995). Rapid dessication of late Pleistocene Cordilleran glaciers between 13,000 years ago and 11,500 years ago resulted in a rise of regional sea levels of up to 200 m (Kovanen 2002) and a rapid emergence of land due to crustal unloading (James et al. 2000). Lower sea levels dominated between 10,000 and 8000 BP. After 8000 BP relative sea levels rose to near present levels by approximately 5000 BP. Included in Figure 3.06, which is an illustration of the generalized relative sea level curve for the Fraser Lowland, are expected fluvial and deltaic responses to relative sea level changes. Based on this generalized model, and recognizing the paucity of local sea level studies, my analysis assumes sea levels achieved near present conditions by 5000 BP.

Figure 3.05. Chart, showing generalized relative sea level curve for the southern Pacific Northwest Coast and expected alluvial/delta responses.