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Archaeological Geology and Postglacial Development of the Central Penobscot River Valley, Maine, USA

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ARCHAEOLOGICAL GEOLOGY AND POSTGLACIAL DEVELOPMENT OF THE CENTRAL PENOBSCOT RIVER VALLEY, MAINE, USA

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Dissertation Advisor: Dr. David Sanger

An Abstract of the Dissertation Presented
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The purpose of this interdisciplinary study is to provide a geological and environmental context for the Late Pleistocene and Holocene Native American occupation of the central Penobscot River Valley, Maine. In addition, this work provides a model for the regional synthesis of geological, archaeological, and paleoenvironmental data in order to examine large-scale patterns of archaeological site formation and preservation.

The postglacial central Penobscot Valley experienced varied and rapid landscape changes. Withdrawal of the Laurentide Ice Sheet was followed by marine transgression and regression. Subaerial exposure initiated landscape development. The postglacial Penobscot River rapidly excavated a channel through glacial sediments, creating a series of fluvial terraces. Fluvial erosion formed local, bedrock base levels that separated the river from the influence of sea level, trapping coarse-grained sediment within the channel, and initiating fine-grained sedimentation on floodplains, along islands, and at tributary mouths.

Localized isostatic adjustment, in the form of a northwestward migrating postglacial forebulge affected local drainage patterns. This included decreasing the discharge of the Penobscot River by shifting the outlet of the state's largest lake, Moosehead, from the Penobscot watershed into that of the Kennebec River. In the areas to either side of the Penobscot River, a combination of low relief and impermeable sediments led to the formation of extensive lakes. Initially unproductive, by the Early Holocene, these lakes hosted a rich marsh ecosystem before vegetational succession produced the peatland-dominated landscape seen today.

Native American occupants of the region lived within this dynamic environment, and adapted their subsistence strategies to the shifting mosaic of habitats and resources. This study illustrates that site formation and preservation are strongly influenced by local geology and environment, and that these factors play an important part in the understanding of past lifeways. Additionally, this effort demonstrates the usefulness of regional geological and environmental context in the identification of areas of high archaeological potential, and develops a model applicable to fluvial settings in glaciated terrains, worldwide.

ACKNOWLEDGEMENTS

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I would like to acknowledge the many people who helped with this study. David Sanger, chair of my committee, has provided advice and encouragement throughout this long endeavor. He has nurtured my understanding of archaeology in the field, classroom, and thought-provoking discussions. Other committee members, Daniel Belknap, Harold Borns, J. Steven Kite, Daniel Sandweiss, and Thomas Weddle have all been generous with their time and academic insights. Chris Dorian, Karen Mack, Julia Daly, and Allen Gontz assisted in various field portions of the investigations (usually under adverse weather conditions). Steve Bicknell provided excavation reports, maps, and photographs with unfailing ability and cheerfulness.

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Chapter 1

INTRODUCTION

The Late Pleistocene and Holocene Native inhabitants of northern New England lived within a dramatically changing landscape. Geomorphic and environmental variations produced a shifting mosaic of habitats and resources. This interdisciplinary study uses archaeological geology to combine the results of geological, archaeological, and paleoenvironmental investigations to provide an environmental context for the human occupation of the central Penobscot Valley. In addition, the wealth of stratigraphic and chronologic information provided by archaeological excavations is combined with geological research to develop a postglacial history of the Penobscot River. The effect of these geological and environmental processes on site formation and preservation in postglacial fluvial landscapes is examined.

The hunter/gathers of the Penobscot River region were linked to the environment through resource utilization, occupation sites, and travel routes. Any variations in geomorphology, climate, or faunal and floral distribution had direct impacts on their survival strategies. The extent of environmental influence on social and spiritual matters may never be known, but the strong linkage between humans and their surroundings suggest an effect beyond physical issues of survival.

Previous work has indicated that this environment was not static through time. The landscape we see with modern eyes has changed profoundly since deglaciation and the arrival of the region's first occupants. Within 14,000 years, the area has experienced full glaciation, the withdrawal of a continental ice sheet, marine inundation, and the development of postglacial drainage patterns. Climatic variability and landscape evolution created a varying pattern of floral and faunal resources and geomorphic features. These changes presented a dynamic environment to the local populations who depended upon the abundance and continuity of natural resources for survival.

Geological and Environmental Context

This investigation places humans and the materials they produced within the environmental context of the place and time of occupation. This context is important in that it involves factors that influenced the vital components of resources, shelter, and travel. Without this information, the archaeological record is limited to artifact types, numbers, and distributions. It is difficult to meaningfully address past lifeways without an understanding of the environment in which people lived.

Environmental conditions are not the sole determinants of human behavior. However, geology, climate, vegetation, and human-generated landscape alteration inevitably impact societies and societal interaction. As suggested by Sanger et al. (2003), individuals in these groups choose or reject locations to satisfy perceived needs, whether strictly related to environmental factors, or dictated by cultural imperatives. Variations in site location and organization through time may be driven exclusively by environmental conditions, cultural considerations, or a combination of these factors. Cultural biases in site use and selection may be subtle, but examination of regional geological and environmental information allows ecological influences to be evaluated. Within individual sites, geological or environmental changes are represented by variations in sediment texture, color, and bedding, the types of artifact classes present, and floral and faunal remains.

In a region of dynamic landscape changes, such as the Penobscot Valley, sedimentation and erosion shape the interpretation of the archaeological record through site formation and preservation. These geological processes affect archaeologically important issues, such as depth of burial, separation of cultural horizons, artifact distribution, and site preservation. However, these geological processes are largely controlled by variations in climate, vegetation patterns, geomorphology, and human landscape alteration. Knowledge of past environments is necessary for developing site location models, as well as analysis of known sites.

Environmental setting is important in archaeology in that it provides a contextural frame of reference for artifacts. It also allows the investigator to visualize the habitat for the time period of interest. In northern New England, the present day landscape is significantly different from that throughout much of the past. Human intervention and natural landscape development have significantly changed the character, distribution, and flow of surface water in the Penobscot watershed, as well as others in the region. Paleoenvironmental records suggest that climatic conditions and vegetation patterns have varied through time.

Geological studies within the region suggest geomorphic changes related to deglaciation, marine inundation, and subsequent landscape formation. Without knowledge of past environments, archaeological interpretations based on the present landscape contain a bias that may range from subtle to potentially damaging.

Interdisciplinary Studies in the Penobscot Valley

This study is founded on a tradition of interdisciplinary efforts focused on the archaeological record of the Penobscot Valley. Initiated by David Sanger, University of Maine, the first interdisciplinary investigation in the region examined the archaeology, geology, and paleoenvironment of the Hirundo Site (Sanger, et al., 1977, 2003), located on Pushaw Stream, a tributary of the Penobscot River (Figure 1.1). This approach provided a springboard for other site-specific and regional studies within the Penobscot drainage. This work firmly established the importance of context in understanding the archaeology of the region (Kelley and Sanger, 2003; Sanger et al., 2003). Excavation of the deeply stratified Brigham and Sharrow Sites on the Piscataquis River, a tributary of the Penobscot (Figure 1.1) (Petersen, 1991; Petersen et al., 1986; Petersen and Putnam, 1992; Putnam, 1994), illustrated the linkage of geological setting and processes with site preservation. Application of this model to the central Penobscot Valley led to the discovery of similar sites at Blackman Stream (Sanger et al., 1992), Gilman Falls (Sanger, 1996; Sanger et al., 2001), the Beaver Site, and the Bob Site

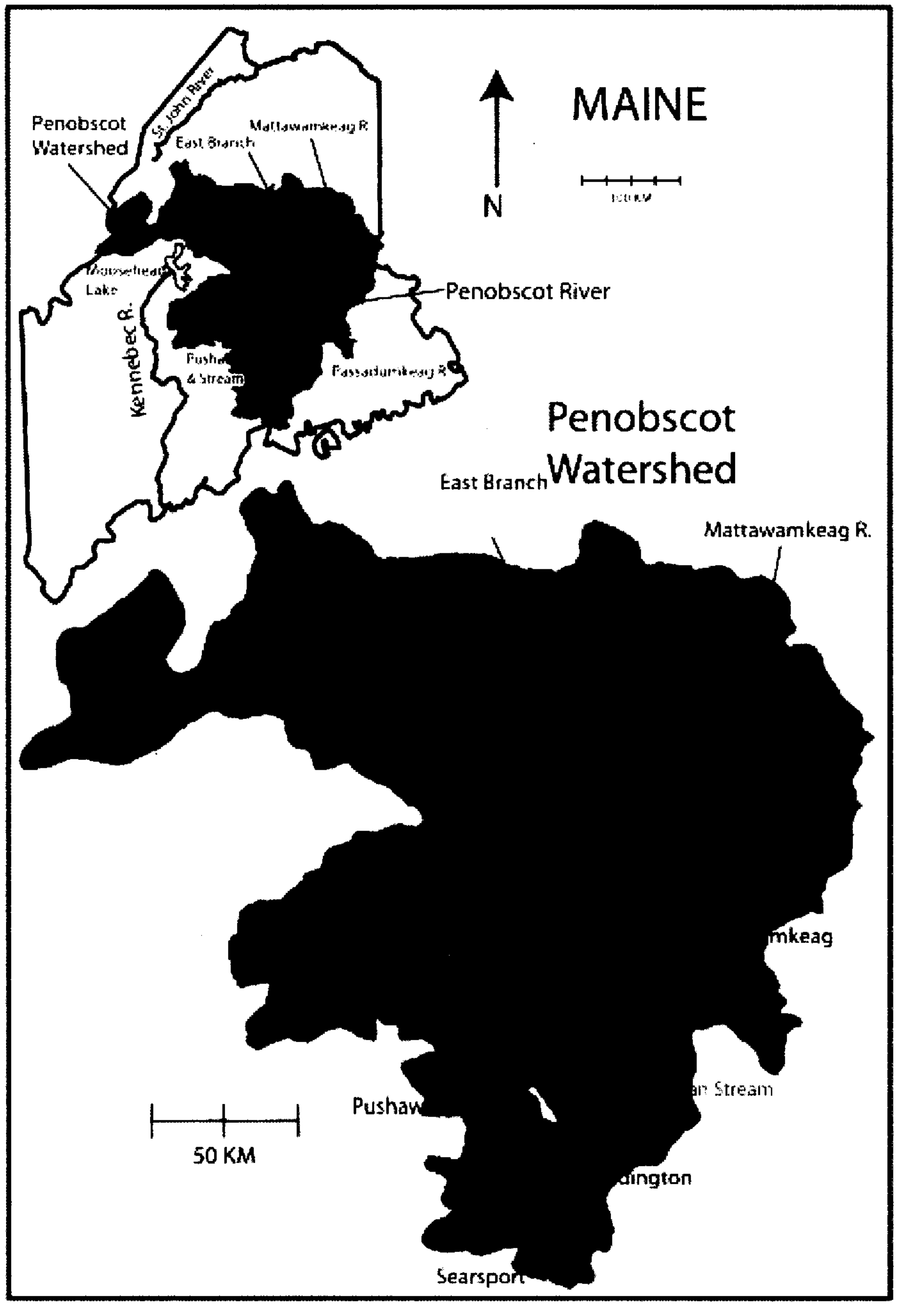


Figure 1.1: Map of the Penobscot River watershed. Archaeological sites are shown in red.

(Mack et al., 2002) (Figure 1.1). Paleoenvironmental studies (Almquist-Jacobson and Sanger 1995, 1999) emphasized the importance of changing habitats, as well as variations in floral and faunal resources, on site location. Lake-level studies at Mansell Pond, within the central Penobscot River drainage, recorded detailed water balance and vegetation history from the Late Pleistocene through the Holocene (Almquist et al., 2001).

Geological information relating to deglaciation, landscape formation, and river development established a framework for the environmental data. Paleobotanical studies provided insights about changing vegetation patterns, habitats, and climatic variations. The results of detailed archaeological excavations at several locations within the region yielded a detailed examination of the material culture of the area, as well as the opportunity to examine numerous stratigraphic sections in detail. Although the focus of this study is the region to either side of the main stem of the Penobscot River between Old Town and Bangor, Maine (Figure 1.1) the geological processes affecting the Penobscot River operated on a larger scale. For this reason, discussions of deglaciation, isostatic adjustment, and river valley development moved beyond the immediate study area.

This study represents the compilation of over 10 years of detailed archaeological investigation in the Penobscot Valley, as well as geological studies and paleoenvironmental inquiries conducted during the same time period. Archaeological excavations offered a window into the alluvial stratigraphy of the area by providing the opportunity to examine sedimentary sequences in a variety of locations. Diagnostic artifacts and radiocarbon dating of archaeological material provided a chronology used in a number of applications: determining the occupation history of the area, examining sediment accumulation rates, and establishing the timing of changes in depositional regimes. Geological studies addressed the timing and style of deglaciation and the formation of associated landforms, postglacial isostatic adjustment, and relative sea-level changes. Paleoenvironmental studies speak to changes in regional vegetation, habitat dynamics, and local water balance information. The combination of these three lines of information provided a detailed analysis of changing patterns of resource procurement and use, travel patterns, and site locations. Collaboration and integration of ideas from a variety of disciplines were included in site location and excavation strategies, and facilitated interpretation of archaeological data during and after excavation.

Archaeological Geology or Geoarchaeology?

What to call this interdisciplinary effort is not clearcut. The title of the subdiscipline created by combining geology and archaeology has produced a debate concerning varying goals and orientation of studies [See Thorson (1990) and Thorson and Holliday (1990)]. Two major approaches: archaeological geology and geoarchaeology have emerged. Rapp and Hill (1998, p. 2) differentiate between the two approaches with the following definitions; "Archaeological geology is geology performed with at least the partial objective of being useful to archaeology, and see geoarchaeology as "...part of archaeology… and is the use of geologic concepts, methods, and knowledge base in the direct solution of archeological problems." Butzer (1982) describes archaeological geology as geology conducted with archaeological goals, and views geoachaeology as archaeology with the application of geological methods. In the research undertaken for this study, different topics could well satisfy one or another of these definitions. At one time, at any given site, questions ranged from strictly archaeological to those definitively geological. In light of this observation, it is up to the author to choose the term best suited. In this case, archaeological geology is selected because it represents a combination of the two disciplines, and the underlying geological focus of the effort.

Radiocarbon Chronology: The Common Thread

The challenge of any interdisciplinary study is to combine information from a variety of single discipline studies to create a unified result. The first step in this process is to find a common thread that will allow chronological correlation and comparison of data from one field to another. Radiocarbon dating provides this link. Although limitations exist with both the method and the types and associations of material used for dating, this technique provides the best tool for comparing data from different disciplines.

Dates in this study will be presented as radiocarbon years before present (BP). Individual dates in are presented as ^{14}C years BP at one sigma accuracy, are presented in Table 1.1. The results of calibration using Calib 5.0.2 (Stuiver et al., 2005), and are presented on Table 1.1.

Table 1.1 Radiocarbon Dates Used In This Study (All dates calibrated using Stuiver et al., 2005)

Site	Sample #	^{14}C age yr BP	Material Dated	95.4 % (2s) Cal Age Ranges	Relative Area Under Distribution
Hirundo		4295±95 BP	charcoal	cal BP 4570: cal BP 5072 cal BP 5107: cal BP 5129 cal BP 5166: cal BP 5277	0.920668 0.010439 0.068893
Hirundo		4325±100 BP	charcoal	cal BP 4590: cal BP 4590 cal BP 4616: cal BP 4765 cal BP 4784: cal BP 5145 cal BP 5153: cal BP 5288	0.000467 0.135276 0.731821 0.132436
Young	SI-3324	3105±50 BP	charcoal	cal BP 3210: cal BP 3415 cal BP 3420: cal BP 3443	0.967767 0.032233
Young	SI-3322	3335±65 BP	charcoal	cal BP 3403: cal BP 3433 cal BP 3436: cal BP 3719	0.023792 0.976208
Young	SI-3321	3360±50 BP	charcoal	cal BP 3466: cal BP 3709 cal BP 3711: cal BP 3715	0.99692 0.00308
Young	SI-3325	3425±60 BP	charcoal	cal BP 3486: cal BP 3502 cal BP 3506: cal BP 3524 cal BP 3555: cal BP 3841	0.011899 0.013305 0.974796
Young	SI-3319	3465±55 BP	charcoal	cal BP 3586: cal BP 3603 cal BP 3608: cal BP 3871	0.018218 0.981782
Young	SI-3318	3650±65 BP	charcoal	cal BP 3733: cal BP 3743 cal BP 3775: cal BP 3790 cal BP 3826: cal BP 4154 cal BP 4210: cal BP 4211	0.00466 0.007368 0.987541 0.000431
Young	SI-3317	3670±80 BP	charcoal	cal BP 3729: cal BP 3747 cal BP 3767: cal BP 3792 cal BP 3824: cal BP 4240	0.008167 0.012177 0.979656

Young	SI-3326	3715±60 BP	charcoal	cal BP 3979: cal BP 4104 cal BP 4107: cal BP 4149	0.768399 0.231601
Bob	Beta-66766	3560±70 BP	charcoal	cal BP 3644: cal BP 3661 cal BP 3685: cal BP 4000 cal BP 4034: cal BP 4080	0.012897 0.943552 0.043551
Bob	Beta-57356	3700±80 BP	charcoal	cal BP 3832: cal BP 4294 cal BP 4335: cal BP 4336	0.999655 0.000345
Bob	Beta-55414	3790±90 BP	charcoal	cal BP 3925: cal BP 3953 cal BP 3956: cal BP 4421	0.01991 0.98009
Bob	Beta-105170	4650±70 BP	charcoal	cal BP 5068: cal BP 5109 cal BP 5123: cal BP 5168 cal BP 5173: cal BP 5180 cal BP 5275: cal BP 5585	0.033153 0.03762 0.003325 0.925902
Gilman Falls	A-7042	3590±150	charcoal	cal BP 3484: cal BP 3536 cal BP 3553: cal BP 4297 cal BP 4330: cal BP 4351 cal BP 4373: cal BP 4380	0.017228 0.973696 0.006917 0.002159
Gilman Falls	A-7041	4140±130	charcoal	cal BP 4258: cal BP 4264 cal BP 4268: cal BP 4270 cal BP 4288: cal BP 4975 cal BP 5018: cal BP 5030	0.001606 0.000787 0.993875 0.003732
Gilman Falls	B-38499	4160±70	charcoal	cal BP 4453: cal BP 4461 cal BP 4520: cal BP 4848	0.008213 0.991787
Gilman Falls	A-7043	4180±80	charcoal	cal BP 4446: cal BP 4471 cal BP 4515: cal BP 4867	0.017824 0.982176
Gilman Falls	A-7044	4425±125	charcoal	cal BP 4653: cal BP 4669 cal BP 4704: cal BP 4757 cal BP 4809: cal BP 5330 cal BP 5376: cal BP 5456	0.004323 0.017079 0.94616 0.032438

Gilman Falls	A-7045	5950±165	charcoal	cal BP 6408: cal BP 7174 cal BP 7220: cal BP 7236	0.994777 0.005223
Gilman Falls	A-7046	6290±160	charcoal	cal BP 6795: cal BP 7485	1.
Gilman Falls	A-7097	6380±65	charcoal	cal BP 7173: cal BP 7222 cal BP 7235: cal BP 7425	0.090182 0.909818
Gilman Falls	A-6696	6840±50	charcoal	cal BP 7588: cal BP 7764 cal BP 7771: cal BP 7786	0.971744 0.028256
Gilman Falls	A-6698	7285±80	charcoal	cal BP 7956: cal BP 8218 cal BP 8240: cal BP 8308	0.931434 0.068566
Gilman Falls	A-7049	7670±240	charcoal	cal BP 7980: cal BP 9034 cal BP 9048: cal BP 9087	0.99154 0.00846
Mackowski Farm		8561±49	charcoal	cal BP 9471: cal BP 9609 cal BP 9612: cal BP 9624	0.988096 0.011904
Blackman Stream	Beta24347	2110±70	charcoal	cal BP 1927: cal BP 2213 cal BP 2219: cal BP 2310	0.826257 0.173743
Blackman Stream	Beta-21682	7400±140	charcoal	cal BP 7951: cal BP 8447	1.
Blackman Stream	Beta-22125	7760±130	charcoal	cal BP 8363: cal BP 8983	1.
Blackman Stream	Beta-21681	8360±150	charcoal	cal BP 8992: cal BP 9630 cal BP 9647: cal BP 9655	0.998349 0.001651
Ayers Rapids 1		1600±60	charcoal	cal BP 1354: cal BP 1618 cal BP 1675: cal BP 1686	0.989648 0.010352
Ayers Rapids 2		3080±120	charcoal	cal BP 2955: cal BP 3562	1.

Moosehead Lake Outlet		8750±40	Plant remains	cal BP 9563: cal BP 9572 cal BP 9584: cal BP 9590 cal BP 9595: cal BP 9902	0.012779 0.006486 0.980735
Moosehead Lake Outlet	OS 38711	8890±50	Plant remains	cal BP 9781: cal BP 9849 cal BP 9862: cal BP 9877 cal BP 9885: cal BP 10190	0.060365 0.013462 0.926173
Moosehead Lake Outlet	OS 38710	8830±40	Plant remains I	cal BP 9703: cal BP 9962 cal BP 9985: cal BP 10044 cal BP 10054: cal BP 10152	0.672922 0.098038 0.229039
Moosehead Lake Outlet	OS 38709-	8640±45	Plant remains	cal BP 9533: cal BP 9693	1.
Moosehead Lake Outlet	OS 38708	8890±50	Plant remains	cal BP 9781: cal BP 9849 cal BP 9862: cal BP 9877 cal BP 9885: cal BP 10190	0.060365 0.013462 0.926173

Several factors that may influence radiocarbon dates in the region include the incorporation of "old" carbon from bedrock or marine sources. The local bedrock within the study area is slightly calcareous in locations, but is not thought to significantly impact dates from "old" carbon in ground or surface water (pers. comm., NOSAMS staff, 1/2003). Terrestrial wood charcoal and plant remains make up the majority of material used for radiocarbon dating. Although rates of isotope fractionation vary in different materials, causing ranges in age of several hundred years (Rapp and Hill, 1998), this issue is not deemed of great importance in this study. Dates are used for broad correlation ranging from 100's to 1000's of years, not divisions within centuries. Only one radiocarbon date from a marine organism is used. Beta Analytical (pers. comm., 2004) suggested that due to the estuarine nature of the sample, no marine reservoir correction was required.

Dissertation Organization

The geological, archaeological, and paleoenvironmental regional setting of the study area is presented in Chapter 2. This chapter includes previous work and new information used for later interdisciplinary interpretations. Chapter 3 presents the archaeological geology of archaeological sites within the study area arranged by geographic localities. Chapter 4 combines geological and archaeological information to develop a history of the postglacial development of the Penobscot Valley. Chapter 5 is a discussion of the archaeological geology of the central Penobscot Valley. The conclusions of this effort are presented in Chapter 6.

Wider Applications

Why study such a locally narrow, yet topically broad subject? First, this interdisciplinary archaeological geology study provides the necessary information to place archaeological interpretation within the context of the environment experienced by the region's native inhabitants, and to understand how each site was formed and preserved. If the goal of archaeology is to understand past lifeways (Thomas, 1989), rather than produce a catalogue of artifacts, this context is essential.

As a result of providing this context, the archaeological record of the region can be examined in light of preexisting models and suppositions. On closer examination, it was determined that settlement patterns developed elsewhere may not be directly applicable to this area, and need to be refined using local geological and paleoenvironmental information.

A second, broader motive is to develop a method of inquiry that can be applied to the many geographically similar regions that exist around the world. The processes that created the central Maine landscape have analogues around the world in areas that have experienced postglacial isostatic adjustment and landscape development. This study establishes a pattern for examining such areas in terms of archaeology and archaeological geology context.

Chapter 2

REGIONAL SETTING

The Penobscot River watershed encompasses 24,306 km^2 of central Maine (Figure 2.1). It is the largest river system in the state, when defined on the basis of drainage area and average discharge (465 m^3/sec) (U.S. Army Corps of Engineers, 1990). The river is more than 250 km long, from the headwaters of either of two major tributaries, the East and West Branches, to its mouth in Penobscot Bay. Originally the watershed was slightly smaller, but construction of a dam in 1840 shifted the drainage of Chamberlain and Telos Lakes from the Allagash/St. John watershed into the East Branch of the Penobscot (Barrows and Babb, 1912). The Penobscot watershed is bounded to the east by that of the St. Croix, and to the west by Moosehead Lake and the Kennebec River watershed. Moosehead Lake has an area of 303 km^2, and is Maine's largest lake. It is located immediately to the south of the West Branch of the Penobscot, and forms the headwaters of the Kennebec River system. Other major tributaries of the Penobscot include the Mattawamkeag, Passadumkeag, and Piscataquis Rivers.

Geology and Geomorphology

Calkin (1960) divided the Penobscot drainage into three sections: 1) the West and East Branches and the main stem to Medway, 2) the section from Medway to Bangor, and 3) from Bangor to Penobscot Bay. Kelley et al. (1988) further subdivide the Medway to Bangor reach on the basis of distinct geologic

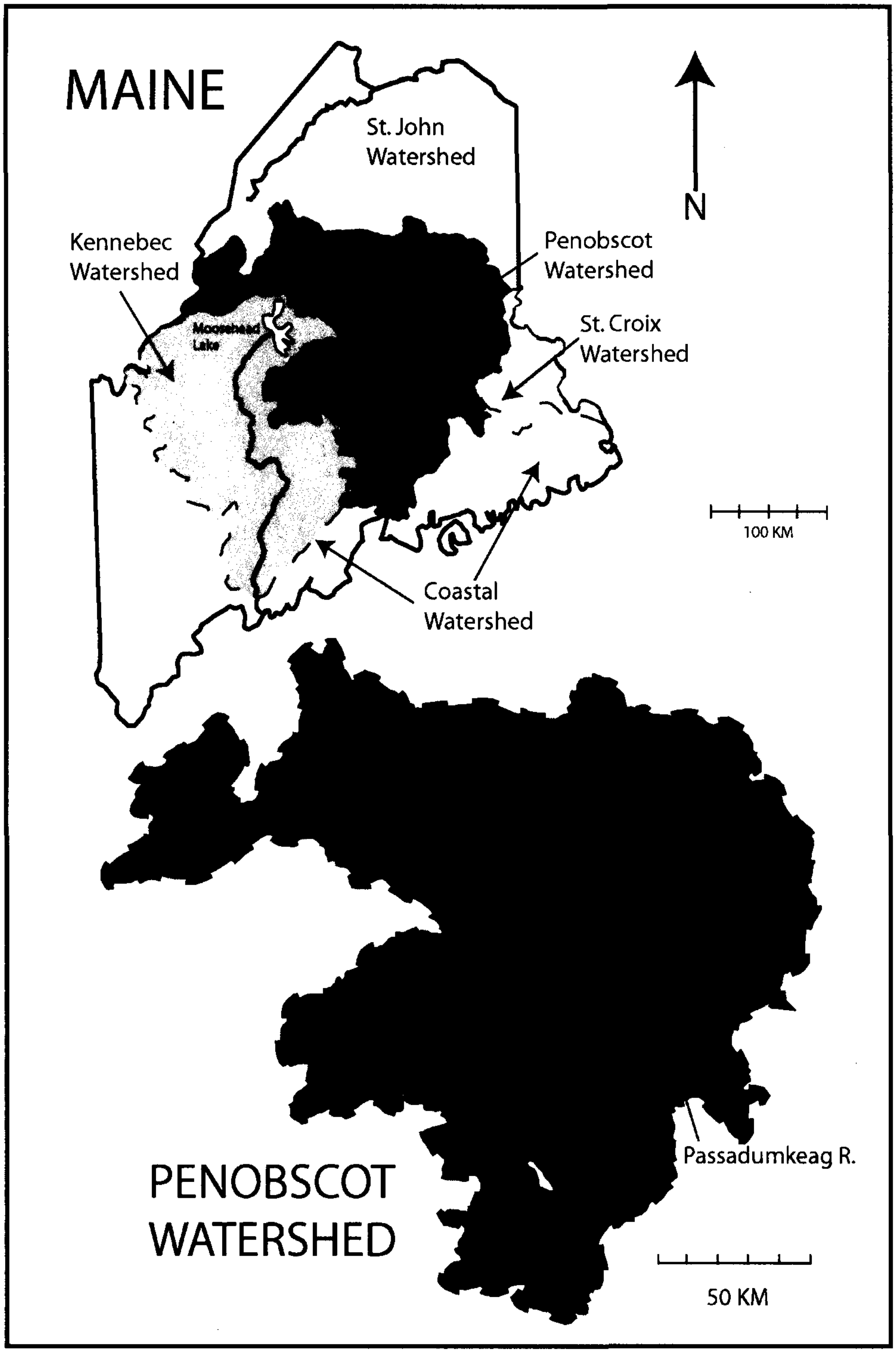


Figure 2.1: Location of the Penobscot watershed, Maine.

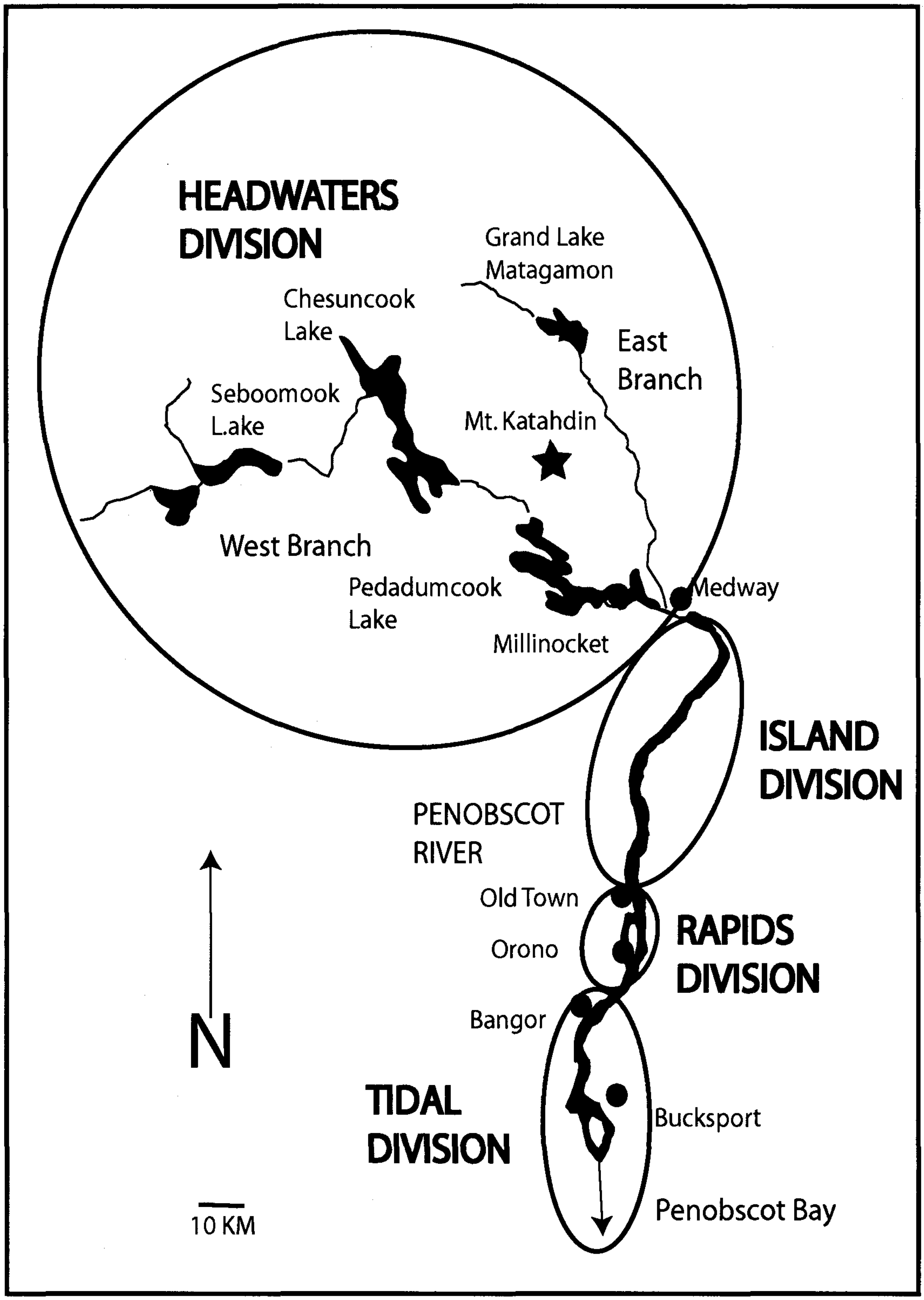


Figure 2.2: Geomorphic divisions of the Penobscot River. Modified from Kelley et al. (1988).

and geomorphic features (Figure 2.2). The West and East Branches are designated as the “Headwaters Division”, an area of steep gradients in mountainous terrain. The “Island Division” is a low-gradient area that encompasses the region from Medway to Old Town, and is characterized by a series of numerous islands and rapids and a broad floodplain. The reach from Old Town to Bangor, the “Rapids Division”, has an increased gradient when compared with the Island Division, and includes a number of bedrock rapids. It lacks the numerous islands of the reach immediately upstream. The section from Bangor to Penobscot Bay is tidally influenced, and, therefore, is identified as the Tidal Division. Fringing salt marshes, bedrock exposures, and bluffs of glaciomarine sediments, as well as a lack of rapids and falls characterize this portion of the river, which widens at its mouth to form Penobscot Bay.

In the following discussion of these divisions of the Penobscot River, bedrock geology and geomorphology are presented together. The two are closely linked, in that the bedrock geology of the area forms the framework for the river and its valley, and influences the development of many of the geomorphic features.

Headwaters Division

The Headwaters Division of the Penobscot River encompasses the area upstream of the confluence of the West Branch and the East Branch at Medway (Figure 2.2). It is a mountainous, high relief area typical of the Central Maine

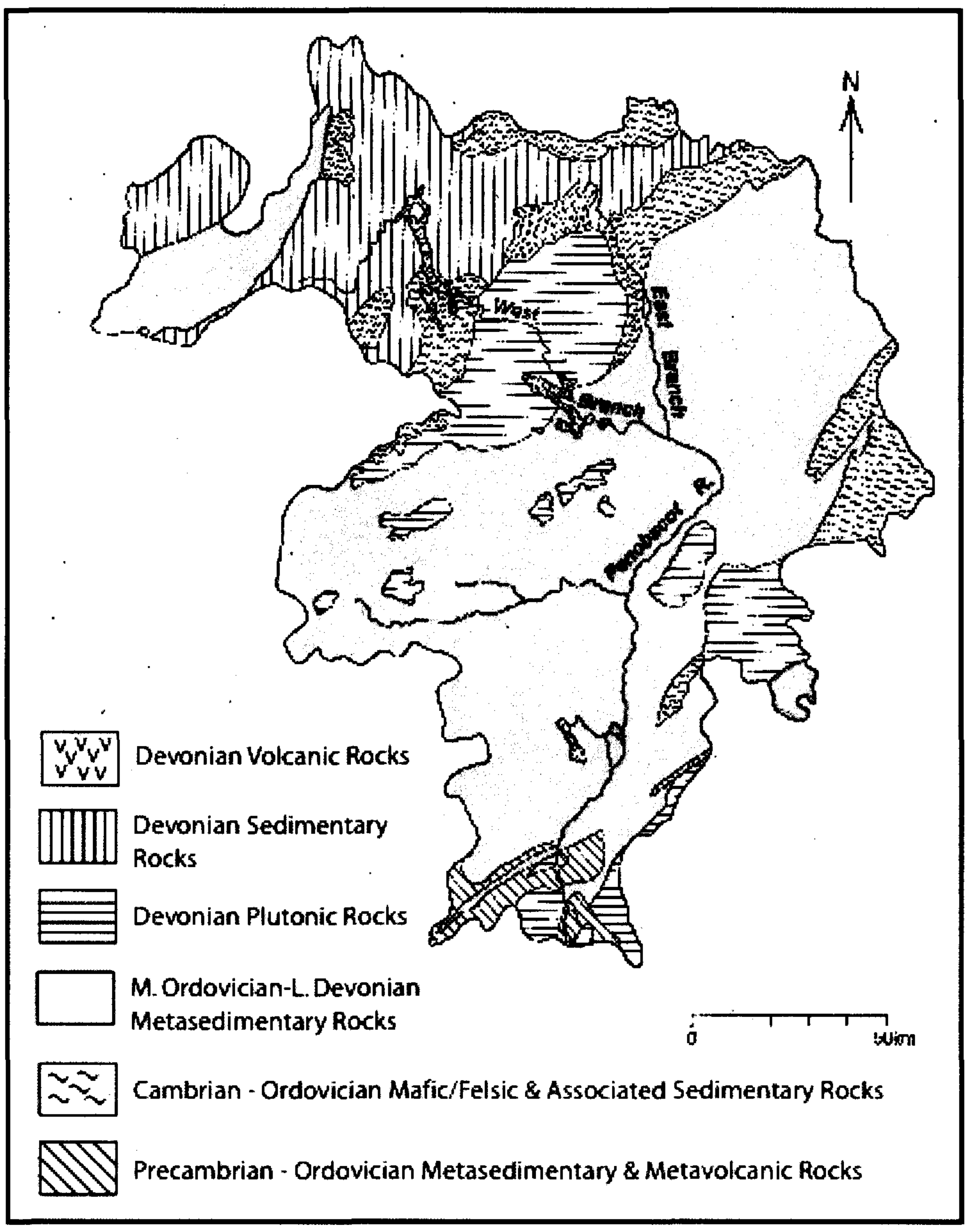


Figure 2.3: Bedrock geology of the Penobscot River watershed. Modified from Osberg, et. al. (1985).

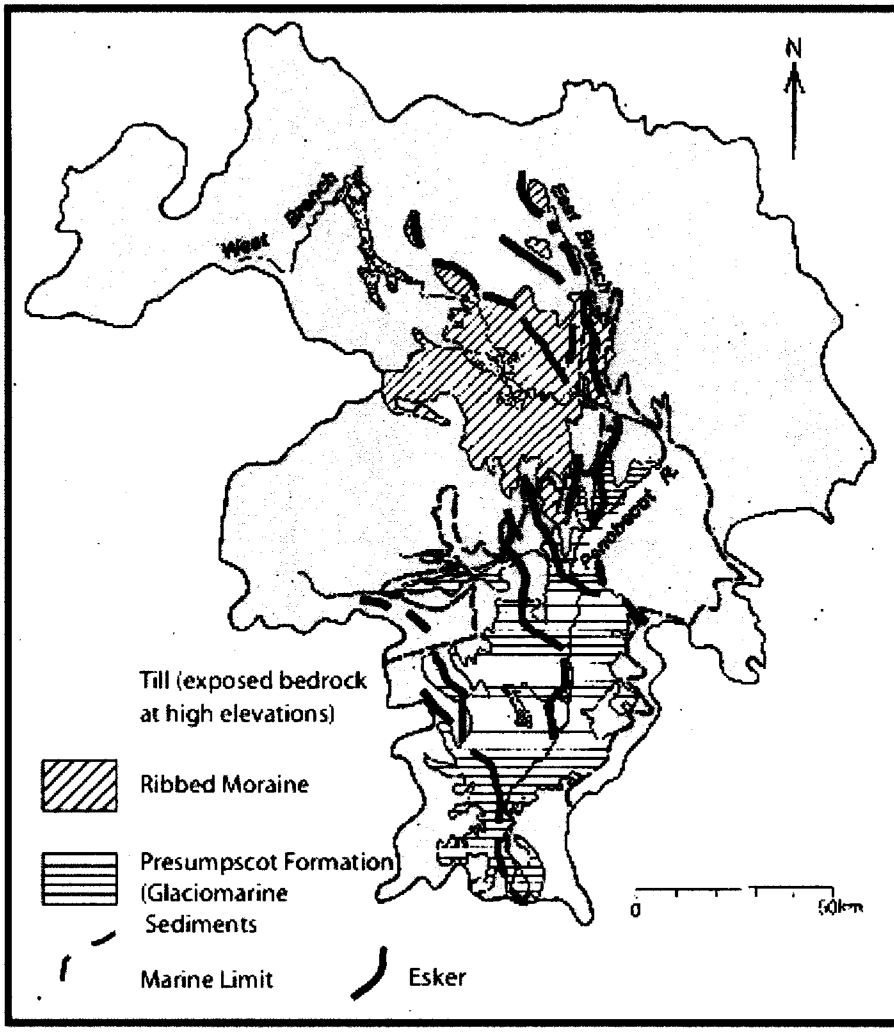


Figure 2.4: Surficial geology of the Penobscot River watershed. Modified from Thompson and Borns (1985)

Highlands (Denny, 1982). This region is underlain by igneous and low to medium grade metamorphic rocks of lower Paleozoic age (Figure 2.3). The most prominent geologic feature is the Katahdin massif, a Devonian-age granite associated with felsic volcanics (Osberg et al., 1985). In other portions of the upper reaches of the basin, erosion-resistant, contact metamorphic rocks form mountains, while coarser-grained granite bodies are generally associated with lakes (Hanson and Caldwell, 1989). Low- to medium-grade metasedimentary rocks underlie the valleys (Hanson and Caldwell, 1989). Two broadly upwarped synclinoria bring older, more resistant, metamorphic and igneous rocks to the surface, forming local topographic highs to the east and west of the Katahdin area (Osberg et al., 1985).

Exposed rock surfaces are common at higher elevations, but topographically lower areas are mantled by till, with outwash deposits concentrated in mountain valleys. A broad area of ribbed moraines exists to the south of the Katahdin massif (Thompson and Borns, 1985) (Figure 2.4). In this region the till is derived from primarily granitic sources and has a sandy matrix.

A well-developed, north-northwest to southeast trending esker system, with associated subaqueous fan deposits and glaciomarine deltas, heads in this portion of the drainage, and extends through all four divisions (Thompson and Borns 1985), (Figure 2.4). Glacial lake deposits have been noted in a few locations (Lowell and Crossen, 1983), and more are likely to be found when additional, detailed surficial mapping occurs within the region. Hooke and Borns (pers. comm., 2003) note the presence of a series of gravel terraces in the upper Penobscot Valley. These terraces appear to be similar in composition and form to those mapped in the upper Kennebec Valley (Borns and Hagar, 1965), and were formed during and after the deglaciation of the region.

Many tributary streams, ponds, and lakes are present in this portion of the drainage, with significant alteration of the natural flow by a sequence of dams built for log driving and hydroelectric power generation. Unaltered portions of the river in the East and West Branches of the Penobscot have narrow channels confined by bedrock outcrops and thick deposits of till and glacial outwash. Bedrock and coarse-grained lag deposits, developed from glacial sediments, characterize the channel, forming steps, pools, and waterfalls characteristic of mountainous headwater streams (Church, 1992). Islands are rare, and are limited to gravel bars formed during high flow events, primarily the spring freshet, or are erosional remnants of eskers.

Island Division

The Island Division of the Penobscot River from Medway to Old Town (Figure 2.2) is markedly different from that of the upper reaches of the watershed in bedrock geology and, correspondingly, in topography. Fine-grained metamorphic, lower Paleozoic-age rocks of the Vassalboro and Madrid Formations outcrop throughout most of this area (Figure 2.3). The easily eroded strata of these rock types form a broad valley, with gentle, rolling topography typical of the New England Coastal Lowlands (Denny, 1982). Devonian-age granitic plutons intrude these rocks near Lincoln, creating a region of moderate relief just to the east of the main stem of the river (Osberg et al., 1985) (Figure 2.3), and confining lateral migration of the river to the east in this area. Bedrock exposures occur intermittently in the area adjacent to the main stem of the river, and form low relief, polished and striated outcrops and rapids. In a few locations, such as Mattaseunk, Howland, and West Enfield, hydroelectric dams have been built on these bedrock outcrops, creating extensive headponds and drowning rapids identified in Treat's (1820) survey of the river. In other locations, boulder lags formed by the erosion of moraines create rapids.

Bedrock outcrops, thick deposits of till, or glaciofluvial deposits serve to confine the river in the upper portion of this geomorphic division, creating a straight channel pattern with 3 - 4 meter high banks and few islands. South of the juncture of the main stem of the Penobscot River and the Mattawamkeag River, the channel becomes more sinuous. In this portion riverbanks are lower, 3 - 5 m in height, and islands more common. Most of the islands are low, 3 - 5 m in relief, elongate features and range in length from 0.5 to 1.5 km in length. A few islands are more rounded in outline and higher, with 6 -20 m of relief. The distribution of the islands varies from infrequent overlapping islands to frequently overlapping islands with two or three "split" flow branches (Kellerhals and Church, 1989).

The elongate islands in this portion of the river have an outcrop pattern similar to depositional bars associated with braided streams (Figure 2.5). Dudley and Giffen (2001) note the similarity of the morphology and composition of these

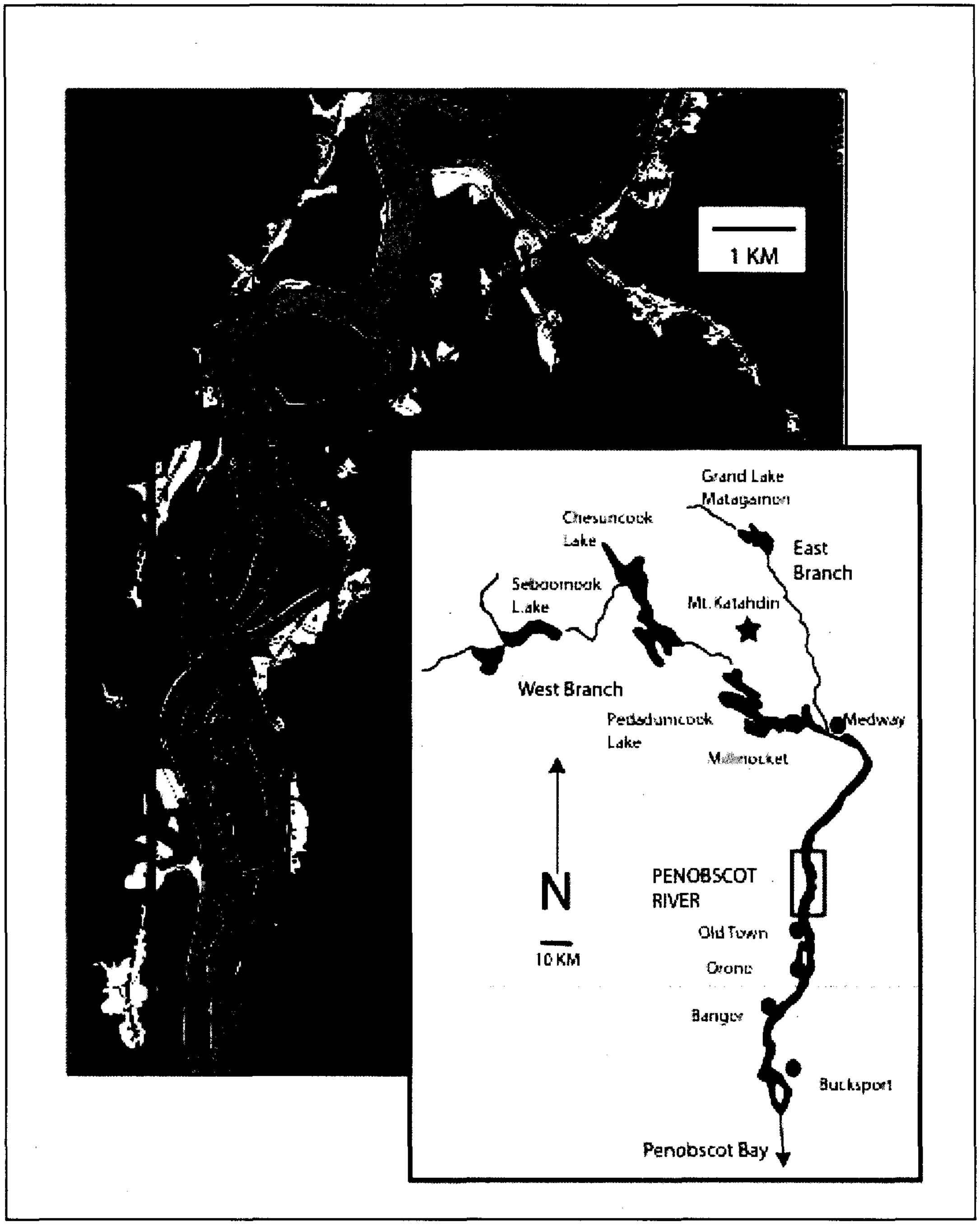


Figure 2.5: Central Penobscot River islands with braid bar geomorphology.

islands to fluvial braid bars. In this portion of the river, each series of depositional islands is associated with a set of rapids.

Surficial deposits in this portion of the drainage include esker segments, glacial outwash, till, and modern alluvium (Thompson and Borns, 1985) (Figure 2.4). Moraines may be present in the region, but their subduded topography makes identification difficult. Much of the landscape below 60m in elevation is draped with the glaciomarine Presumpscot Formation (Bloom, 1960, 1963). Within this division of the river, the unit is primarily composed of blue-gray, silty clay. Dropstones are common, and range in size from pebbles to boulders. Aeolian deposits have been identified in a few locations in the Lincoln area (Thompson and Borns, 1985). Hooke and Borns (pers. comm., 2003) note the presence of several terraces in this section of the river valley, but have not established the continuity of these features with similar features in upstream and downstream portions of the valley. Modern swamps and bogs are ubiquitous in the low-relief portions of the drainage, while numerous lakes are present in the region of granite and gabbro intrusions to the east of this river section (Thompson and Borns, 1985; Osberg et al., 1985).

A sediment sampling program and a geophysical survey using side-scan sonar and ground-penetrating radar found that the channel in this region was composed primarily of rock and gravel. Finer-grained sediments are associated with islands, tributary mouths, and in the headponds of dams (Dudley and Giffen, 1999). Gravel and cobbles, as well as large boulders, occur in the river channel in several locations, and are interpreted as lag deposits developed from the erosion of glacially derived sediments formed at steeper river gradients related to Late Pleistocene/Early Holocene relative sea level fall.

The Stillwater River separates from the main course of the Penobscot River in the southern portion of the Island section, north of Indian Island (Figure 2.6), and flows to the northwest, until reaching the northern tip of the island, and turning to mirror the predominately south to southwest flow of the Penobscot. The Stillwater rejoins the Penobscot at the south end of Marsh Island. A secondary channel carries water from the Penobscot into the Stillwater along the southern margin of Orson Island. The flow in the Stillwater is controlled by a hydroelectric dam that spans the Penobscot between Old Town and Bradley and control structure across the Stillwater at Gilman Falls in West Old Town.

The Stillwater River has a meandering channel pattern from the junction with the Penobscot at Old Town to Gilman Falls. Prominent meander scars are readily apparent on aerial photographs of this reach of the river (Figure 2.6). Low, depositional islands occur at several locations, and a prominent gravel bar, submerged at high to moderate flow is located across the Stillwater on the northern side of Orson Island (Sanger, pers. comm., 2003). This type of channel pattern is unusual for the Penobscot River. Meandering channels are found on portions of tributary streams, such as the Piscataquis River, upstream of Howland, but not within the Penobscot Valley, proper. South of Gilman Falls, the character of the Stillwater changes, and has the characteristics of the Rapids Division of the main stem of the Penobscot River.

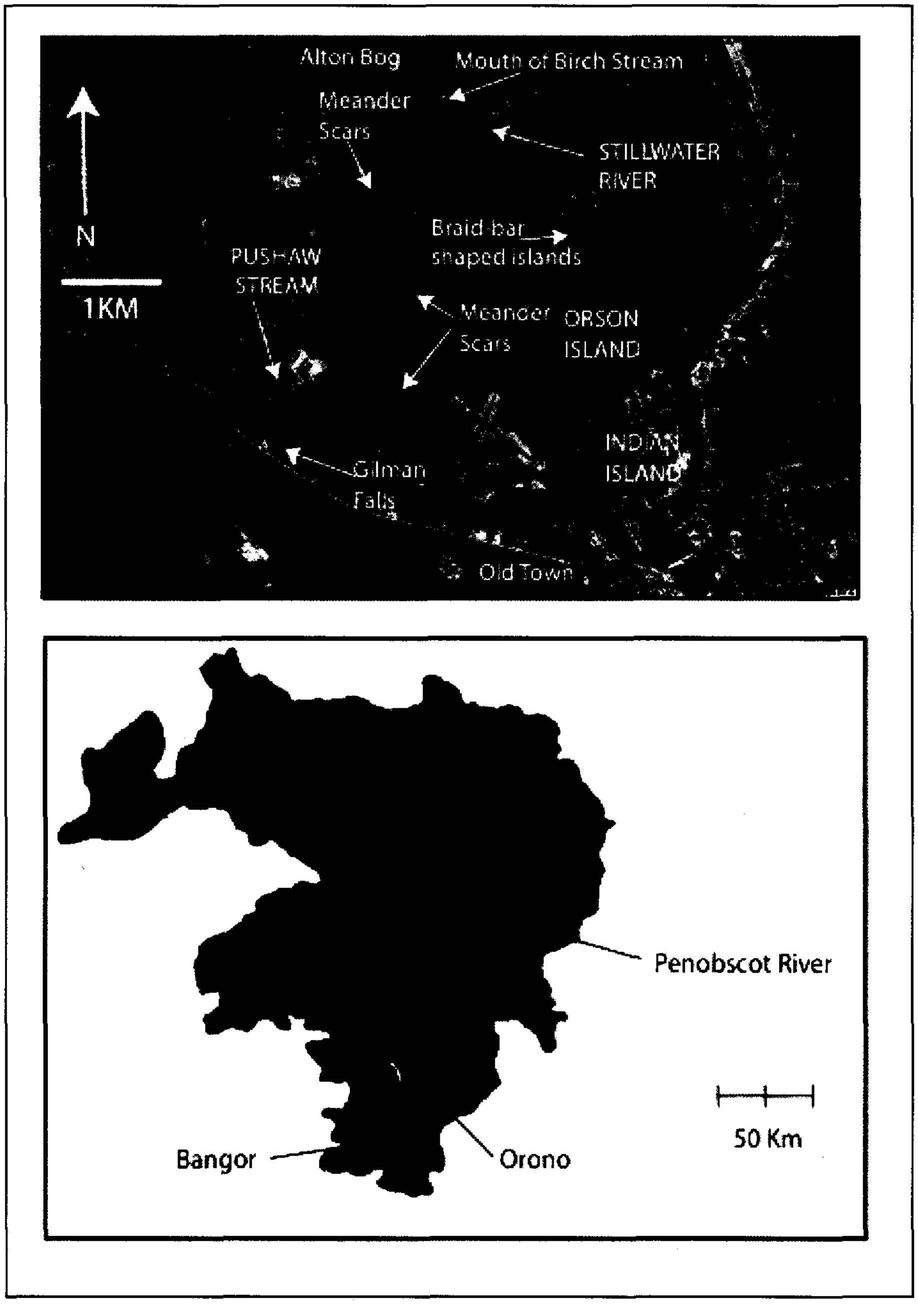


Figure 2.6: Stillwater River (USGS Aerial Photograph)

Rapids Division

The Rapids Division of the Penobscot River extends south from the Old Town/Milford Falls on the Penobscot River to Bangor, and from Gilman Falls on the Stillwater River to Bangor (Figure 2.2). Although the bedrock and surficial geology of this section is similar to that immediately to the north, some significant geomorphic differences separate this portion of the river from those up and downstream.

In this division, as in the Island division, the broad, low relief valley is underlain by easily eroded lower Paleozoic metasediments (Osberg et al., 1985). However, this section of the river is distinguished by a series of rapids and falls and a lack of depositional islands. The rapids are created by erosion-resistant, quartz-rich beds in the Silurian/Orodivician Vassalboro Formation that trend roughly perpendicular to the flow direction of both the Stillwater and the Penobscot Rivers. These features form a sequence of local base levels, separating this and upstream portions of the river from the influence of sea level variations after their establishment. Dams are built on these bedrock rapids in several locations, and create large headponds, dramatically changing the river's appearance from its natural state. Treat's (1820) description of this portion of the river lists 17 rapids and falls, 6 of which are no longer recognizable due to inundation by impoundments (Figure 2.7).

As in the upstream Island section, the Late Pleistocene Presumpscot Formation mantles much of the landscape. Where it is present, topography is low and rolling, with tributary streams occupying gullied valleys. Till is exposed

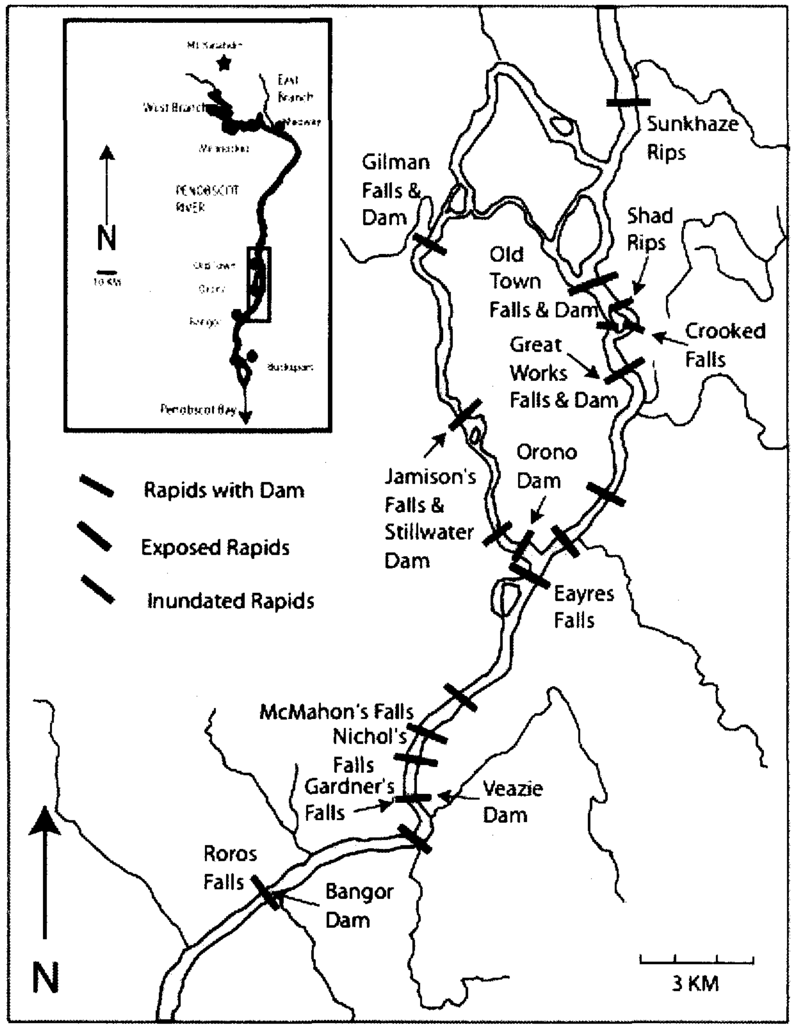


Figure 2.7 Map of the Central Penobscot River showing location of modern and inundated rapids shown on Treat's (1820) map.

at the surface at higher elevations, and has a thick, clay-rich matrix as a result of its derivation from fine-grained metamorphic rocks. Esker segments are common, and parallel the Stillwater River on its west bank (Figure 2.4). Well-developed flights of terraces are present in Old Town, Orono, Bangor, and Brewer. South of Orono, the river has formed bluffs up to 12 m high by downcutting through the Presumpscot Formation and till. For most of this reach, the channel pattern of both the Penobscot and the Stillwater River in the rapids section falls within the straight classification of Kellerhals and Church (1989), with banks ranging from 1 to 3 m in height.

Tidal Influence Division

The head of tide is currently located at Bangor, creating a 40 km long estuary (Figure 2.2). A pronounced change in the character of the landscape is the result of a change in underlying bedrock types. South of Bangor, the lower Penobscot flows through a region of low mountains formed by granitic plutons, volcanic rocks, and more resistant high-grade metamorphic rocks (Figure 2.3). Bedrock cliffs confine the river in several locations. Bluffs composed of till, glaciomarine and glaciofluvial deposits and up to 12 m high are common. Rapids and falls are absent, giving the river a more mature appearance, as contrasted with the youthful, deranged setting upstream. Fringing salt marshes are developed in the mouths of tributaries and small indentations in the shoreline. A large salt marsh is present along the South Branch of the Marsh River, to the west of the main stem of the Penobscot near Bucksport.

Immediately south of Bucksport, the river divides into the main channel and the Eastern Channel to flow around Verona Island. Although mantled with glacial deposits, Verona Island is bedrock-cored and has primarily rocky banks. The divided channel rejoins south of Verona Island and continues south where the river widens dramatically, forming Penobscot Bay.

Summary

The appearance of the present day Penobscot River is the result of a combination of factors. Bedrock geology provides the framework on which the river valley is developed, and influences topography through differential erosion and variations in rock structure. Surficial material deposited by the last continental glaciation mantles the landscape, filling pre-existing topographic lows and providing an abundance of sediment available for reworking by fluvial activity following deglaciation. The unique combination of underlying bedrock and surficial deposits has created four distinctly different geomorphic divisions within the Penobscot River drainage.

The numerous rapids and waterfalls of the Headwaters, Islands, and Rapids Divisions of the river indicate that these portions of the river are post-Pleistocene channels superimposed on the landscape. The open, broad valley of the Lower Penobscot River indicates that, in this location, the Penobscot has reoccupied an early, pre-Wisconsinan channel.

Late Pleistocene Glacial History

Laurentide Ice Sheet in Maine

The advance and retreat of the Late Wisconsinan Laurentide ice sheet, the last of the Pleistocene ice advances in the region, set the stage for the development of the post-glacial Penobscot River through the interaction of deposition, erosion, and isostatic adjustment. This continental ice mass entered Maine from the St. Lawrence lowlands approximately 30000 ^{14}C yrs BP, and flowed southeastward across the state, reaching its maximum extent on the continental shelf 18000 to 2000 ^{14}C yr BP (Mayewski et al., 1981; King, 1996). The ice sheet retreated from its terminal position, which extended from Browns and Georges Banks in the Gulf of Maine, to Long Island, New York, and through northern New Jersey, to a position approximating the present day Maine coast by 14000 ^{14}C yrs BP (Thompson and Borns, 1985). Reconstruction of the 14000 ^{14}C yr BP ice front position from moraines and other ice contact features show a broadly lobate margin (Retelle and Weddle, 2001; Hunter and Smith, 2001).

Although eustatic sea level at this time was 110 m lower than present (Fairbanks, 1989), isostatic depression of the region by weight of the ice sheet resulted in a regional relative sea-level highstand in Maine of 60 m above present at the coast and 120 m above present at the edge of the marine limit near Millinocket (Belknap, et al. 1987: Barnhardt et al., 1995: Thompson and Borns, 1985). Below the marine limit, marine transgression was synchronous with ice sheet recession. Deglaciation occurred primarily along an oscillating, marine ice front that deposited a broad series of recessional moraines (Borns et al., 2004; Thompson and Borns 1985). Marine conditions extended inland as the ice continued to retreat, forming embayments in the Penobscot and the Kennebec valleys (Thompson and Borns, 1985). Ice contact features, such as recessional moraines and eskers are common in the inundated region (Thompson and Borns, 1985). Glaciomarine deltas and other associated coarse-grained features mark the most landward extent of the marine invasion (Thompson and Borns, 1985). Formerly submerged areas are frequently mantled with the blue-gray, silty, glaciomarine Presumpscot Formation that contains cold water, marine fauna (Bloom 1960, 1963; Thompson and Borns, 1985).

Rapid recession of the ice sheet above the marine limit deglaciated inland Maine by 10000 ^{14}C yrs BP, with the exception of remnant ice caps in northern Maine (Borns et al., 2004). Recent investigations in northern Maine suggest reactivation and local advance of these ice caps during the Younger Dryas, prior to melting by 10000 ^{14}C yr BP (Borns, et al., 2004).

Glaciation of the Penobscot Valley

Striation patterns on glacially smoothed and polished bedrock and large-scale, glacially sculpted landforms indicate a general northwest to southeast ice flow direction throughout the region (Thompson and Borns, 1985). However, most of the glacial deposits exposed in the Penobscot Valley record deglaciation processes. The record of pre-recessional deposits in the valley is limited to exposures at Eddington and Sears Island (Figure 2.1). The Eddington bluff, on the east bank of the Penobscot River, was revealed by fluvial oversteepening of unconsolidated bluffs, and is composed of four till units, separated by rhythmite layers, and capped by a glaciomarine unit (Brady, 1982). A multiple till exposure, composed of two tills separated by a layer of water-laid sediments on Sears Island was described by Rand and Gerber (1975). Brady (1982) interprets the Eddington deposits to represent an oscillating ice margin, or a series of minor readvances that only reached the more southerly Searsport location one time. Unfortunately, no organic material has been recovered to provide a chronology for these events.

Deglaciation of the Penobscot Valley

Because much of the central and lower Penobscot Valley is located at an elevation below the 60 m marine limit (Thompson and Borns, 1985; Belknap et al., 1987, Barnhardt et al., 1995), the deglaciation of this region took place as a receding tidewater glacier (Dorion et al., 2001). Reconstruction of the central and lower Penobscot Valley during maximum inundation shows a broad embayment extending inland almost 200 km from the present day coast (Thompson and Borns, 1985). A series of islands south of modern day Bangor formed a narrow strait and separated the embayment from the open ocean. North of this constriction, a broad open bay approximately 100 kilometer in length and width occupied the present-day central Penobscot Valley (Dorion et al., 2001).

Analysis of faunal assemblages and the isotope geochemistry of both marine bivalves and benthic foraminifera in the area suggest arctic to subarctic marine conditions existed at the time of deglaciation (Dorion et al., 2001). Geochemical analysis also indicates the presence of a strong density gradient at the ice front, with fresh meltwater flowing over marine waters of normal salinity, consistent with a tidewater glacier environment (Dorion et al., 2001). Cotter's (1985) analysis of foraminifers from the central Penobscot Valley suggested a strongly marine environment on the east and central portion of the embayment, with a less saline interval noted on the west side, corresponding to an greater meltwater contribution.

A number of deglaciation scenarios have been proposed. Several authors suggested an extensive marine reentrant in the Penobscot Valley with large land-based ice lobes to the east and west (Stuiver and Borns, 1975; Smith, 1985; Davis and Jacobson, 1985). However, supporting evidence in the form of cross cutting striations is limited, and may suggest reentrants on a much smaller (1-5 kilometer) scale (Dorion et al., 2001; Kaplan, 1999). Other investigators have proposed a relatively straight margin with a uniform thickness and slope across the region based on the position and continuity of ice marginal deposits (Hunter and Smith, 2001) and eskers (Shreve 1985a, b). Dorion et al. (2001) advocate a rapid, almost instantaneous disintegration of the ice sheet in the marine embayment based on difficult to differentiate radiocarbon dates in the lower and central portion of the valley. These seemingly near synchronous dates may be the result of problems related to radiocarbon dates from this time interval.

Calibration of ^{14}C dates in the late Pleistocene yield calibrated calendar ages with a range of several thousand years, suggesting that deglaciation of the Penobscot Valley may not have been geologically instantaneous, but occurred over several thousand years. (Stuiver et al., 1993)

An additional problem exists when attempting to use both terrestrial and marine material to assign ages to the deglaciation and marine regression of the area. Discrepancies exist between terrestrial and marine radiocarbon dates due to the "reservoir effect", or the lag time required for mixing of atmospheric carbon in the ocean (Stuiver et al., 1991; 1993). Dorion et al (2001) use the standard -400 year marine reservoir correction for the North Atlantic, and propose that the ice margin receded to the upper portion of the valley by 13,100 (corrected) ^{14}C yr. BP. Borns et al. (2004) note the approximate 600-year difference between stratigraphically similar terrestrial and marine material in the region, and suggest that the unique circulation of the Gulf of Maine requires use of -600 years as a correction for marine samples. These authors locate an ice margin near the marine limit at 12800 (corrected) ^{14}C yrs BP, and north of much of the Penobscot Valley by 12000 (corrected) ^{14}C yrs BP.

As sea level fell, the exposed landscape was mantled with fine-grained glaciomarine sediments deposited during the maximum extent of the marine invasion. Prior to the establishment of widespread vegetation, precipitation-driven erosion rapidly removed the fine-grained silts and clays from topographic highs within the lowland, creating localized exposures of till, sand, and gravel below the marine limit. Also, wind-driven erosion and transport of the abundant, fine-grained glaciomarine sediment created localized deposits on the eastern side of the valley. These features have been mapped in the upper Penobscot Valley, near Lincoln (Thompson and Borns, 1985). Aeolian deposits have been recognized in reconnaissance mapping of the Bradley area (pers. comm. Locke and Dorian, 2000), and may be related to early aeolian erosion of exposed post-glacial lakeshores or glaciomarine deposits.

Isostatic Adjustment

As discussed above, depression of the earth's crust, and the associated marine inundation of the isostatically lowered region played a major role in the style of deglaciation and resulting deposits in the Penobscot Valley. The response of the same area to glacial unloading played an equally important part in shaping the post-glacial landscape. Evidence from the region suggests that isostatic adjustment occurred on two scales: one regional, responsible for the large-scale marine transgression and subsequent regression seen in coastal and central Maine, and the other more localized as the landscape experienced either the relaxation of a regional tilt to the north (Barnhardt et al., 1995) or the northwestward migration of a postglacial forebulge(s) (Peltier, 1994).

The relative sea level curve developed for the coast of Maine (Belknap et al., 1987, Barnhardt et al., 1995) (Figure 2.8) shows evidence for both scales of isostatic adjustment. Maximum marine inundation at the coast of 60 m above present sea level occurred circa 13000 ^{14}C yrs BP. Relative sea

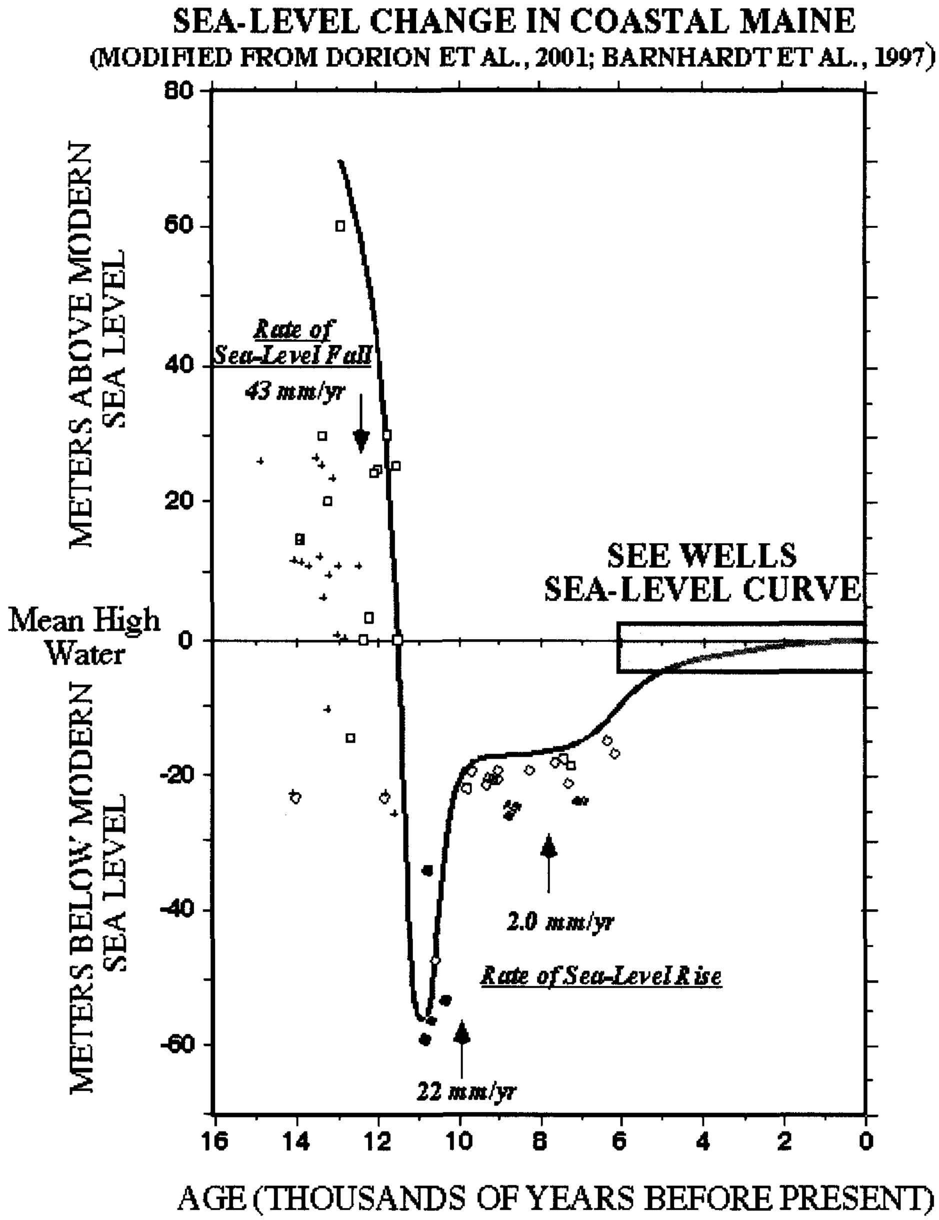


Figure 2.8: Maine relative sea-level change (Modified from Dorian et al., 2001, Barnhardt et al., 1997).

level then dropped rapidly to a low stand position of 60 m below present sea level at 10800 ^{14}C yrs BP. The lowstand position was short-lived, and was followed by rapid sea-level rise that slowed abruptly between 10000 to 8000 ^{14}C yrs BP. After this virtual stillstand, sea level continued to rise at a slower rate to present. Barnhardt et al. (1995) demonstrate that the circa 10800 ^{14}C yrs BP lowstand occurred as a result of isostatic rebound reaching equilibrium with rising eustatic sea level. The still stand occurred as a result of the additive affects of eustatic sea level rise and continued isostatic adjustment in the form of a migrating postglacial forebulge. Comparison of the Maine curve with relative sea level curves developed for other portions of New England and the Maritimes by Barnhardt et al. (1995) recognized similar and sequential changes in the rate of sea level rise within the same time range in data from Nova Scotia (Stea et al., 1994) and the St. Lawrence Valley of Quebec (Dionne, 1988).

Evidence of localized isostatic adjustment has been recognized in other portions of Maine and adjacent Canada. Kite (1979) investigated the postglacial geologic history of the St. John River Valley, to the north of the Penobscot drainage (Figure 2.1). His investigations focused on the development and drainage of an extensive moraine-dammed lake, Lake Madawaska, and associated landforms. One of these landforms is an extensive, high terrace that appears to extend through study area into the lower St. John Valley. Kite (1979) ties aggradation of the terrace sediments with Early Holocene differential rates of uplift between the upper and middle St. John Valley, possibly associated with a

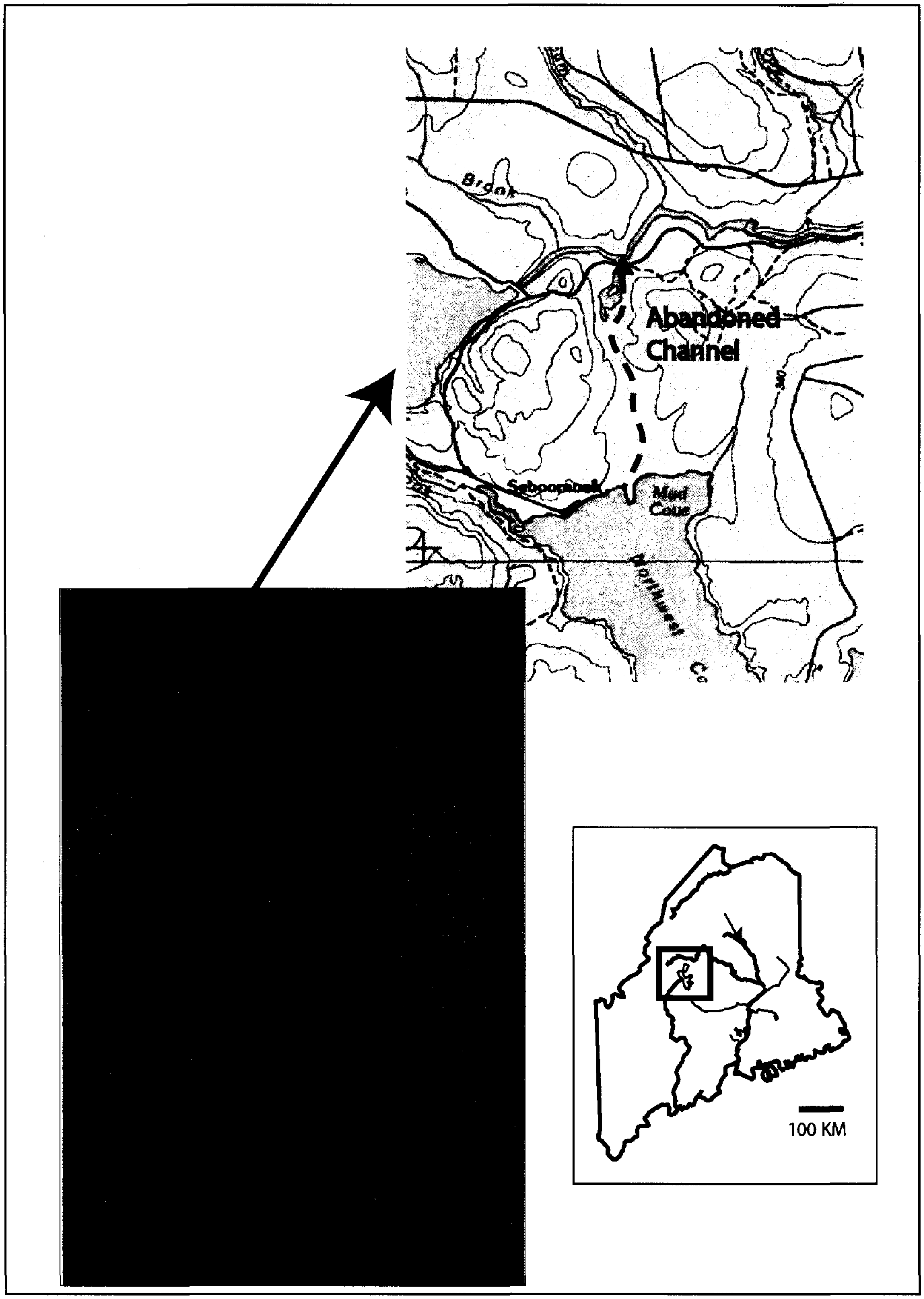


Figure 2.9: Location Map of Moosehead Lake and abandoned outlet channel

migrating forebulge, producing large volumes of sediment that were carried, and then deposited in downstream locations. Balco et al. (1998) investigated local, post-glacial isostatic adjustment in the Moosehead Lake region of north central Maine. Currently, Moosehead Lake forms the headwaters of the Kennebec River, which drains through two outlets at the southern end of the Lake (Figure 2.9). The northernmost end of the lake is less than 5 km from the West Branch of the Penobscot River, and is separated from that drainage by a low divide of approximately 4.5 m of relief. Using seismic reflection and side-scan sonar, supplemented by coring, Balco et al. (1998) identified lower-than-present shorelines in the southeastern portion of the lake and a higher, abandoned outlet that drained Moosehead Lake into the West Branch of the Penobscot River at Northwest Carry (Figure 2.9). Balco et al. (1998) obtained a single, bulk radiocarbon date from this abandoned outlet of 8,370$\pm$40 BP, providing a minimum date for the isostatically-driven abandonment of the outlet, and change in local land surface tilt.

On the basis of Balco's work, Kelley carried out a more detailed investigation of the abandoned Moosehead outlet. Examination of the paleo-outlet using ground-penetrating radar defined a 3 km-long channel (Figure 2.10), bordered by till to the west and frequent outcrops of bedrock to the east Presently, the abandoned channel is filled with peat deposits, small ponds, and alder swamps. Cores from a pond in the northern portion of the paleo-channel (Figure 2.10) recovered over 4 m of peat and gyttja. The organic-rich sediment at the base of each core is interpreted as an initial, post-fluvial still-water deposit,

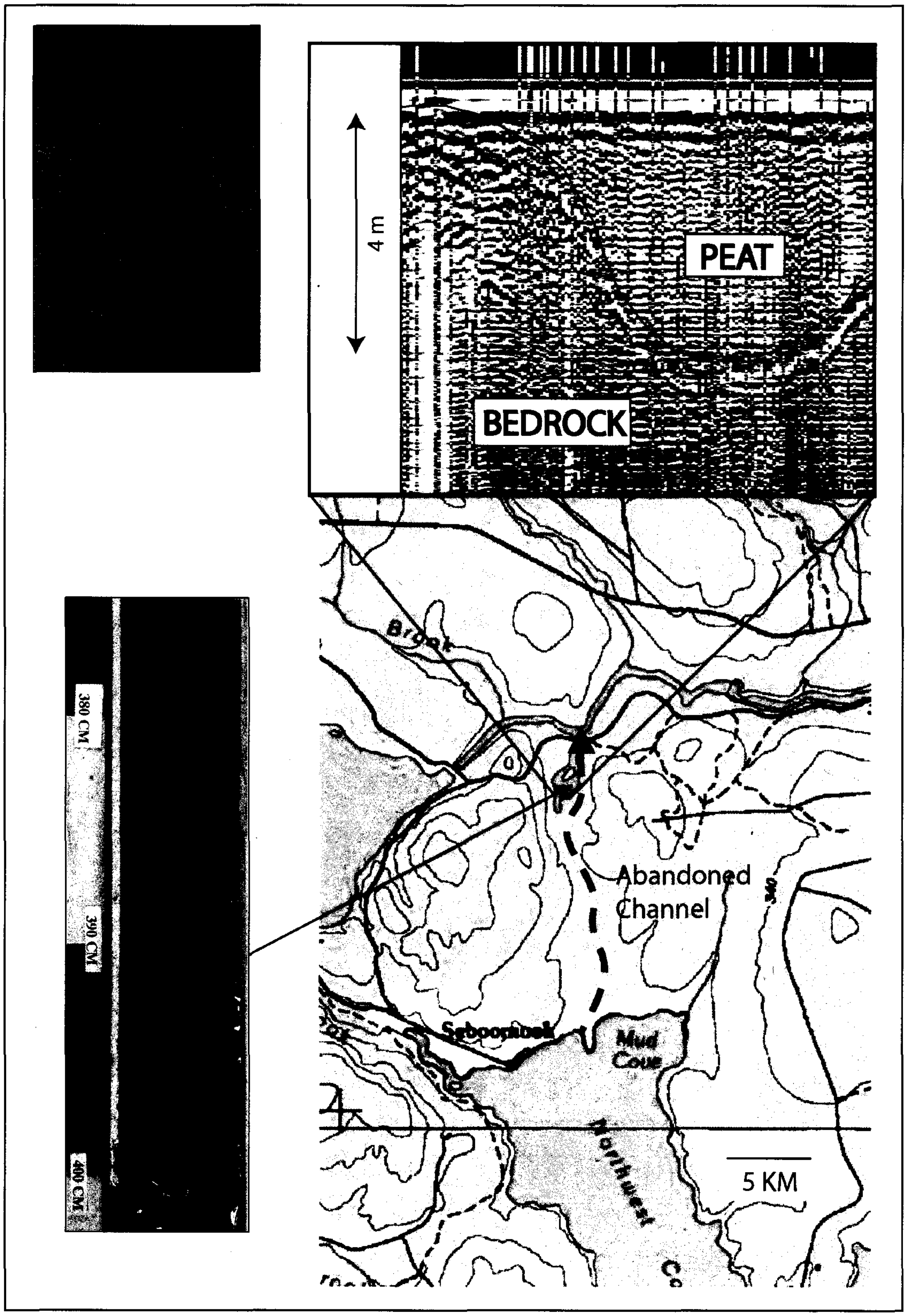


Figure 2.10: Ground-penetrating radar profile and peat core from the abandoned outlet at Moosehead Lake.

and yielded radiocarbon dates of 8890±50 ^{14}C yrs BP and 8640±40 ^{14}C yrs BP, confirming Balco's original date and interpretation.

The loss of the Moosehead drainage had potentially significant effects on the discharge and sediment load of the Penobscot River. Modern stream gage records suggest the magnitude of the shift in drainage between the two rivers. From 1920 to 1938, gages existed simultaneously at Moosehead Outlet, The Forks, and Waterville on the Kennebec River, and at Medway and West Enfield on the Penobscot (USGS 2004a,b,c) (Figure 2.11). During that period, Moosehead Lake supplied the Kennebec River with an average annual streamflow of 52 m^3/s. This value represents 74% of the average annual Kennebec River discharge for the period at The Forks, and 25% of the average annual discharge for the period at Waterville. If the Moosehead outlet value isadded to the 1920-1938 average annual flow of the Penobscot, it would increase the discharge of the West Branch of the Penobscot River by 50% at Medway, 100 km from the abandoned outlet, and 16% at West Enfield on the main stem of the Penobscot River, approximately 200 km downstream (Table 2.1). While these values may not be directly representative of early Holocene conditions, they represent the best available estimates of simultaneous flow in each river.

River discharge is currently seasonally pulsed in New England due to spring rains coupled with snow melt (Magilligan and Graber, 1996), with the highest stream flow values in the Kennebec and Penobscot Rivers occur during

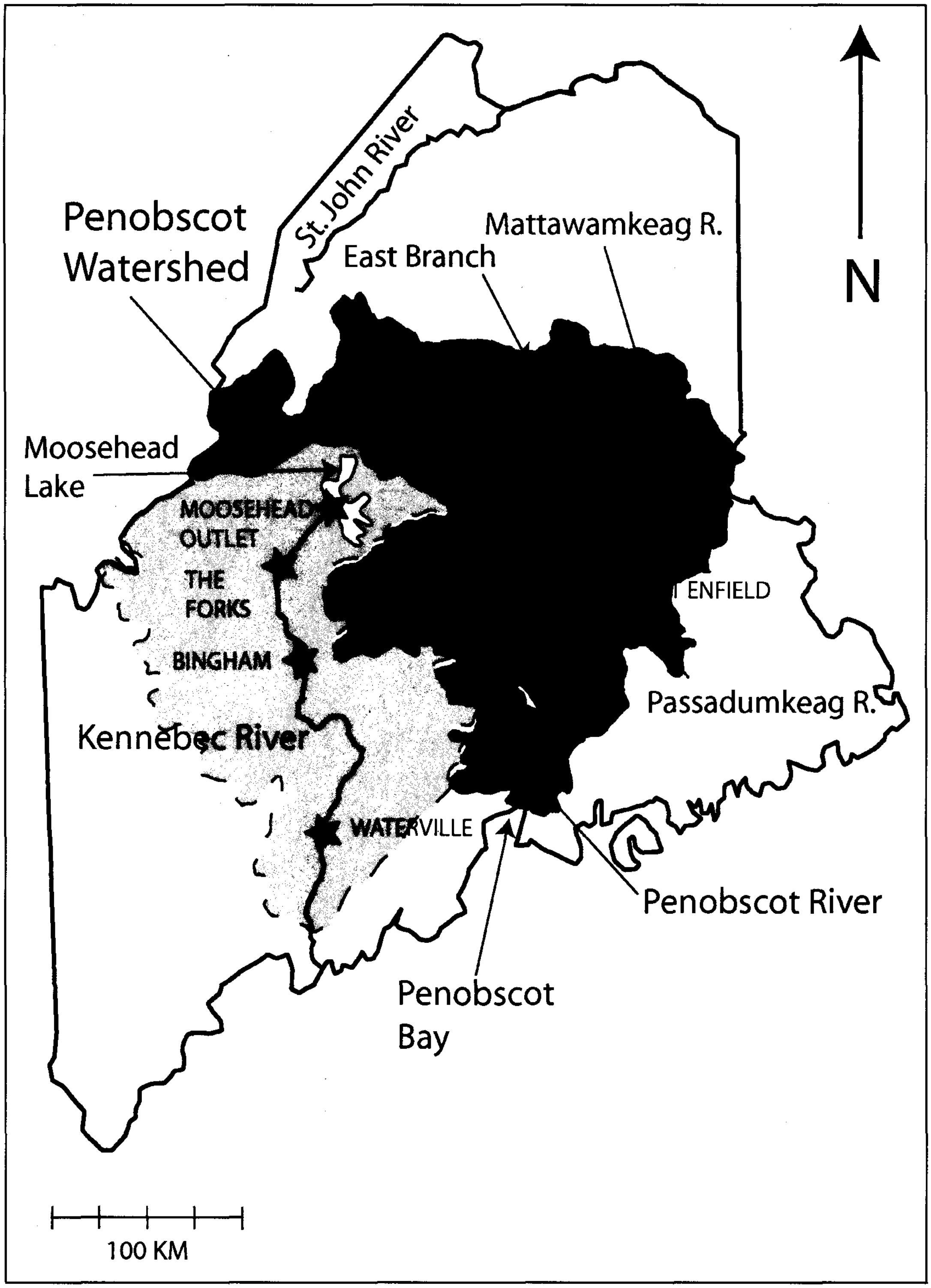


Figure 2.11: Locations of stream gages used in this study

Year	Moosehead (m^2/sec)	The Forks (m^2/sec)	Bingham (m^2/sec)	Waterville (m^2/sec)	Medway (m^2/sec)	West Enfield (m^2/sec)	1	2	3	4	5
1920	2270	2982		8409	4203	14340	0.54	0.16	0.76		0.27
1921	1928	2441		5423	4012	10590	0.48	0.18	0.79		0.36
1922	1844	2407		7094	3362	10700	0.55	0.17	0.77		0.26
1923	1469	2223		6583	2872	10300	0.51	0.14	0.66		0.22
1924	1674	2220		5561	3185	8628	0.53	0.19	0.75		0.30
1925	1810	2420		7105	3226	11260	0.56	0.16	0.75		0.25
1926	1782	2285		5712	3643	11370	0.49	0.16	0.78		0.31
1927	1704	2414		7746	3488	12340	0.49	0.14	0.71		0.22
1928	2355	3068		9223	4892	13360	0.48	0.18	0.77		0.26
1929	2187	2802		6591	3733	10680	0.59	0.20	0.78		0.33
1930	1752	2414		5973	3290	10150	0.53	0.17	0.73		0.29
1931	1268	1762	3032	5591	3153	10080	0.40	0.13	0.72	0.42	0.23
1932	1540	2227	4064	7241	3361	12130	0.46	0.13	0.69	0.38	0.21
1933	1951	2543	4240	6374	3711	10340	0.53	0.19	0.77	0.46	0.31
1934	1517	2084	3806	5928	3303	11770	0.46	0.13	0.73	0.40	0.26
1935	1787	2439	4202		3201	10150	0.56	0.18	0.73	0.43	
1936	2216	3081	5477		4219	15129	0.53	0.15	0.72	0.40	
1937	1942	2676	4880		3928	11560	0.49	0.17	0.73	0.40	
1938	1956	2814	4692		3754	12430	0.52	0.16	0.70	0.42	
average	1840	2490	4299	6704	3607	11437	0.51	0.16	0.74	0.41	0.25

1. Moosehead discharge compared to West Branch discharge at Medway, 2. Moosehead discharge compared to Penobscot discharge at West Enfield, 3. Moosehead discharge compared to Kennebec discharge at the Forks, 4. Mooshead discharge compared to Kennebec discharge at Bingham, 5. Moosehead discharge compared to Kennebec discharge at Waterville

Table 2.1: Stream gage data from the Moosehead/Kennebec/Penobscot drainages, 1920-1938, USGS 2004a,b,c

the spring freshet between late March and late April. Since a large portion of the snowmelt contribution is derived from high relief areas in the Central Highlands, the magnitude of the spring freshet is especially sensitive to changes in discharge in the upper reaches of these rivers.

While we do not have evidence of seasonal variability in the Early Holocene Penobscot, modern studies of the Kennebec River show that it directly contributes sand to the inner continental shelf and adjacent beaches for one to two months during its annual freshet (Fenster et al., 2001; FitzGerald et al., in press). The remainder of the time, it imports sand from offshore into its estuary. Loss of 25% of its annual discharge, especially 74% of the contribution from the high-relief portions of the drainage basin in the spring, would reduce or entirely prevent the Kennebec River from delivering sand to the sea during many years (Fenster et al., 2001, FitzGerald et al., in press). There are no comparable data on the velocity profile and competence of the Penobscot River, but clearly its competence was greater prior to the loss of discharge from Moosehead Lake. Furthermore, the discharge was lost at a time when the gradient was slightly steeper during a lower-than-present sea level, and many reaches of the Penobscot River were likely floored by coarse deposits in equilibrium with higher discharges. These coarse-grained deposits served to armor the riverbed, and prevent further erosion after the shift in the lake outlet circa 9000 ^{14}C yrs BP.

All available evidence (Belknap et al., 1987, Stuiver and Borns, 1975, Schniker, 1974) indicates that local isostatic adjustment of the Penobscot Valley ended in the Early Holocene, and that later changes in discharge and competency of the river are related to paleoclimatic and human factors.

Summary

Although the advance and retreat of the Late Wisconsinan Laurentide ice sheet occurred largely before human entry into the region, these events set the stage for the development of the post-glacial landscape occupied and exploited by humans. Influenced by the bedrock framework of the area, glaciers sculpted and smoothed the region by erosion and deposition. Large-scale isostatic adjustment of the region led broad variations in sea level. These changes profoundly influenced the landscape and the formation of the post glacial Penobscot River, which will be discussed in a later chapter. Localized isostatic changes in the region changed watershed boundaries, affecting regional river discharge and sediment loads. Recognition of this process in the Moosehead Lake region suggests that localized isostatic adjustment may have had other, as yet unidentified, ramifications for the developing Penobscot River.

Paleoenvironment

Vegetational Change

Davis and Jacobson (1985) created a broad-scale Late Pleistocene and Early Holocene paleoecological reconstruction for northern New England and adjacent areas in Canada by combining palynological data from 51 radiocarbon dated lake sediment/pollen cores, published ice-front positions, and published sea-level positions for the region. Their reconstructions show a changing mosaic of vegetational patterns as ice and marine waters receded from the area, and successive waves of forest types advanced into the area.

Mixed woodland consisting of poplar, spruce and other taxa dominated the lower and central Penobscot Valley by 12000 ^{14}C yrs BP. Tundra vegetation persisted in the higher elevations of the granitic highlands to the east and west of the river. Poplar-dominated woodlands separated the western portion of the valley from the tundra of interior Maine. By 11000 ^{14}C yrs BP, mixed woodland expanded into most of the Penobscot drainage, with tundra vegetation concentrated in the north and on isolated highlands. Poplar woodland dominated the Moosehead/West Branch region. Closed forest composed of poplars, spruce, pine, birches, elm, larch, ironwood, ash, balsam fir, and oak dominated most of the Penobscot drainage by 10000 ^{14}C yrs BP. Only the upper reaches of the Penobscot watershed contained more open, mixed woodland, and this vegetation was replaced by the northward advancing forest by 9000 ^{14}C yrs BP.

Gajewski (1987) completed the first investigation of Late Pleistocene through Holocene vegetation change in the region at Caribou Bog, east of Pushaw Lake (Figure 2.1). Almquist and Sanger's (1995) analysis of the pollen record from Mansell Pond, a small kettle pond approximately 5 km north of Caribou Bog (Figure 1.1), provided more detailed information on changes in upland vegetation in the central Penobscot Valley.

Comparison of the latter portion of Davis and Jacobson's (1985) regional record with Almquist and Sanger's (1995) work shows some localized variations in Early Holocene vegetational succession. Davis and Jacobson (1985) show that central Maine at 10000 ^{14}C yrs BP was dominated by closed forest. Almquist and Sanger's (1995) work suggests that spruce/poplar woodland persisted in the area until 9200 ^{14}C yrs BP, when it was replaced by pine forest. This difference may be attributed to the affect of local microclimates on vegetational succession not identified in the older, broader study, or the possible association of poplar woodlands with the extensive lakes that may have occupied this area, and were not recognized in 1985. Almquist and Sanger (1995) recognize a relatively high frequency of charcoal in the sediment from this period, generally thought to be indicative of frequent fires spawned by a dry climate. The presence of lakes during a time of dry climate will be discussed in Chapter 4.

Almquist and Sanger's (1995) work shows a record of changing vegetation at Mansell Pond thought to be representative of the central Penobscot Valley. Pine forest dominated the upland from 9000 ^{14}C yrs BP until 7400 ^{14}C yrs BP, but changes in secondary taxa show a decrease in boreal species and an increase in more temperate vegetation with time. By 8400 ^{14}C yrs BP, oak, sugar maple, elm, and alder were important components of the forest surrounding Mansell Pond, with charcoal amounts indicative of continued fires in the area. Hemlock abruptly replaced pine as the primary forest component at 7400 ^{14}C yrs BP, and persisted until 6400 ^{14}C yrs BP. At this time pine again became the prevailing tree species in the Mansell Pond area, although regional studies show hemlock remains a dominate species though this time (Davis, 1981). Increased charcoal amounts in this portion of the core suggest a rise in fires related to drier conditions. The pine forests were supplanted by hemlock circa 5700 ^{14}C yrs BP. During this second phase of hemlock prominence, the forest became more closed, with beech and birch present, and fires were not as prevalent as in the preceding time period. Hemlock declined rapidly at 4700 ^{14}C yrs BP in the Mansell Pond area, as it did though out northeastern North America. After the "Hemlock Crash", forests in the central Penobscot Valley were composed of beech and birch, with subsidiary pine and oak. At 3400 ^{14}C yrs BP hemlock once more appeared in the area, replacing the pine and oak. This vegetation change formed a birch, beech and hemlock forest, although hemlock never regained its dominant role in the forest composition. By 2000 ^{14}C yrs BP, spruce and balsam fir appear in the pollen record at Mansell Pond, and other species, such as hemlock, beech, and maple, began to decline. The waning of these species, combined with the expansion of more boreal trees, such as junipers, cedars, poplars and tamarack, is interpreted to represent broad-scale climatic cooling. This forest composition persisted until European agricultural and forestry practices affected the vegetation of the region.

Paleohydrology

Mansell Pond was also the site of the first paleohydrologic study in central Maine. Almquist et al. (2001) used a transect of cores across the pond to evaluate and date lake level changes as reflected by sedimentary units and macrofossils. Mansell Pond was an ideal location for such a study, in that it is a

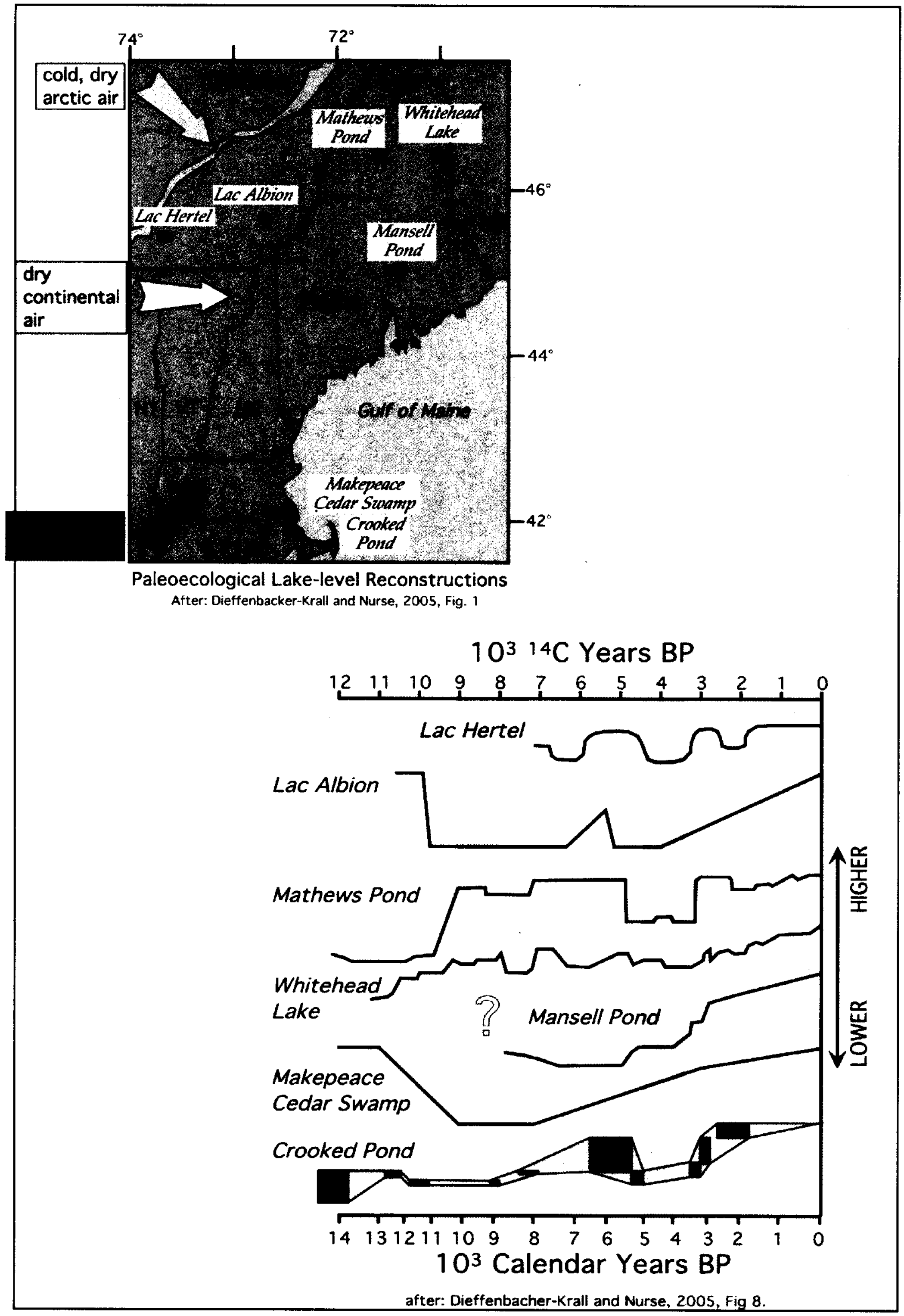


Figure 2.12: Lake level curves from New England and adjacent Canada. Figure by Belknap, 2005

small pond with a very limited catchment area and is fed primarily by precipitation.

Analysis of the Mansell Pond record showed distinct variations of lake levels through time (Figure 2.12). Initial sediment deposition began in the basin by 9450 ^{14}C yrs BP, with lake levels rising until 9000 ^{14}C yrs BP. From 8000 to 6000 ^{14}C yrs BP water levels fell, with the lowest level persisting for approximately 1000 years. At 5000 ^{14}C yrs BP, lake levels began to rise, at first rapidly, and then with a "still-stand" from 4500 ^{14}C yrs BP to 3500 ^{14}C yrs BP. After this point in time, the lake level rose to approximately its modern water level, with a rapid rise occurring between 3225 and 2780 ^{14}C yrs BP,

This record is in general agreement with the more recently published paleohydrologic studies completed in northern Maine at Matthews Pond and Whitehead Lake (Dieffenbacher-Krall and Nurse, 2005) (Figure 2.12). Major differences between these records consist of the length of the Early Holocene low lake stand, and the persistence of the mid-Holocene dry period (Figure 2.12). The Mansell Pond record shows a Early Holocene drop in lake level, followed by an extended low stand, while the northern Maine record records a similar drop, but of shorter duration (8000-7200 ^{14}C yrs BP). Both records find a period of low lake levels at the mid Holocene. In the case of northern Maine, this period lasted almost 2,000 years, while it was significantly shorter in the Mansell Pond record. Both records show a rise in water levels through the Late Holocene.

Dieffenbacher-Krall and Nurse (2005) correlate their lake level information with regional climate patterns to reconstruct changing meteorological conditions in the region. While the outburst of Lake Aggassiz into the North Atlantic, circa 7650-7200 ^{14}C yrs BP, is generally linked with period of climatic cooling in Greenland and locations around the North Atlantic Ocean (Barber et al., 1999), Dieffenbacker-Krall and Nurse (2005) suggest that, at least in Northern New England, climatic drying was a significant result of this event, and correlates with the lower lake levels observed between 8000 and 7000 ^{14}C yrs BP in northern New England and Quebec paleohydrologic records (Yu et al., 1997; Muller, et al., 2003; Lavoie and Richard, 2000; Almquist et al., 2001)(Figure 2.14).

They correlate onset of the mid-Holocene dry period with the 1500-year cycle of the cool and dry climatic conditions associated with the Holocene Dansgaard-Oeschger event at 4800 ^{14}C yrs BP. They link the extended mid Holocene lowered lake level with major changes in circulation patterns over North America that created cool, dry climatic conditions that were recorded as lowstands paleohydrologic studies in lakes in New England and Quebec, and (Yu et al., 1997; Muller, et al., 2003; Lavoie and Richard, 2000; Almquist et al., 2001) (Figure 2.15). All records from the region show general agreement with Late Holocene lake-level rise, but Matthews Pond and Whitehead Lake show the rise as taking place as a series of oscillations, rather than a smooth rise to present.

Paleogeography

Paleogeoraphic investigations suggest an Early Holocene landscape much different than that seen at present. Hu and Davis (1995) cite evidence of open water in the Caribou Bog region circa 12500 BP, and suggest the lack of organic sediment in the base of cores from Caribou Bog indicates an unproductive lake at this location from its inception at 12500 to 10400 C^{14}yr BP when evidence of floating, vascular plants appears. They also note that this abrupt increase in organic sediment is found at the same time period in other lakes throughout Maine, suggesting a climatic influence, perhaps the warming following the Younger Dryas event, now recognized in Northern Maine (Borns, et al., 2004).

Building on earlier work in the area, a series of paleogeographic reconstructions of the Pushaw Lake/Caribou Bog/Whitten Bog Complex (Almquist and Sanger, 1995,1999) were created using analysis of 31 peat cores combined with radiocarbon chronology (Figure 2.13a). These reconstructions show the relative extent of water, peatlands, and cattail marshes at time periods through the Holocene. The amount of surface water in the lower portion of Pushaw Stream is estimated by extending water bodies along contour lines identified from the work of Almquist and Sanger (1999). Based solely on extrapolations of water extent, this is only an approximation of the changing conditions in this area through time. The nature of the confluence of Pushaw Stream with the Stillwater or a possible lake in this location is unknown at present, and requires more work to produce definitive results. However, this method provides a starting point for paleogeographic reconstruction in the lower Pushaw Stream area, and allows comparison of the geological and environmental data with the stratigraphy and chronology revealed at the archaeological sites within the Pushaw Locality.

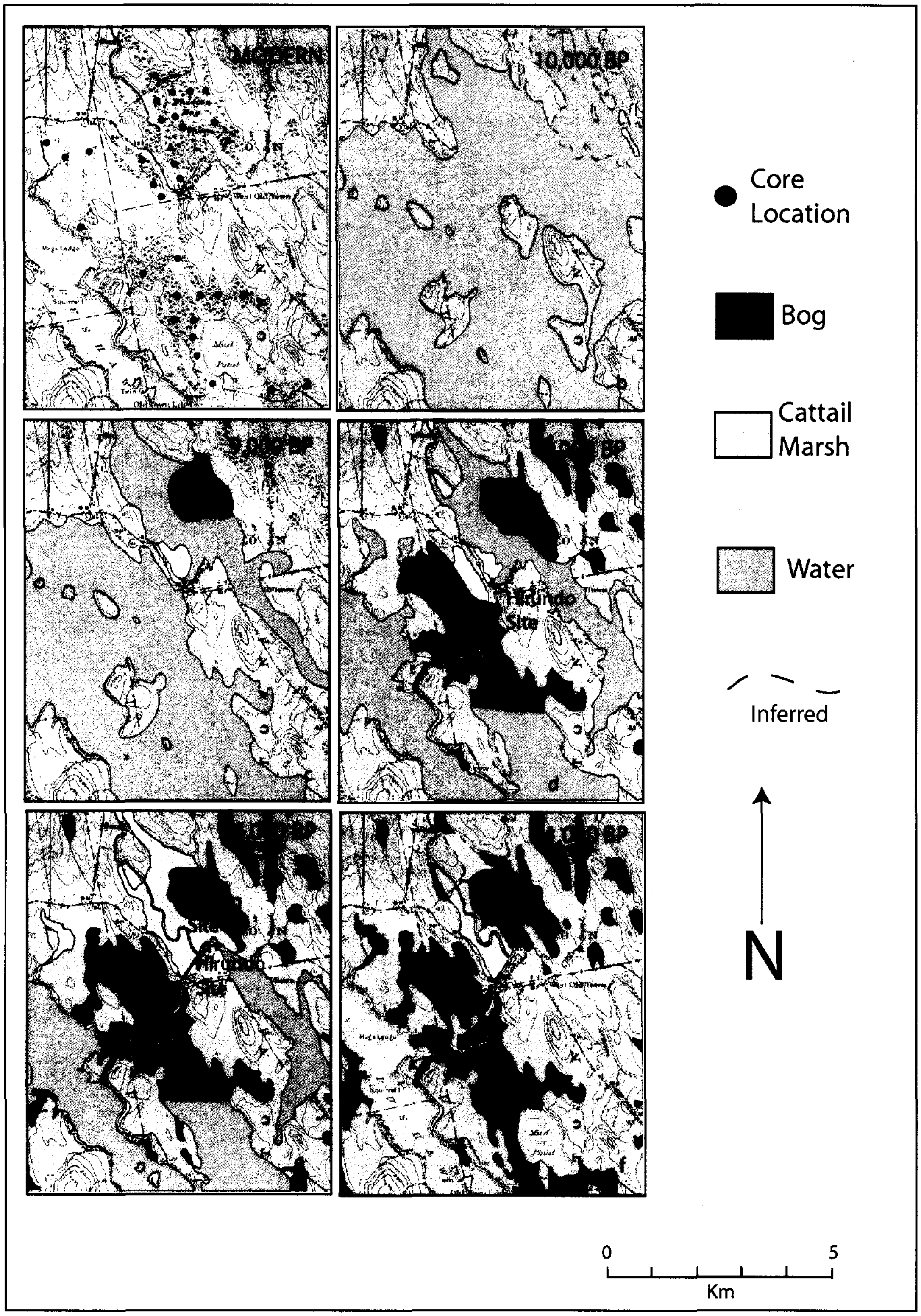


Figure 2:13: Paleogeographic reconstructions of the Pushaw/Whitten/Caribou Bog region. (Modified from Almquist and Sanger (1999).

At 10000 ^{14}C yrs BP, an extensive lake covered much of the Pushaw/Caribou bog/Whitten Bog region (Figure 2.13b), including lower Pushaw Stream. By 9000 ^{14}C yrs BP open water was less widespread, and had separated into two discrete basins, occupying the modern day Pushaw/Mud Pond/Caribou Bog area and the Whitten Bog/Pushaw Stream region (Figure 2.13c). At this time, a limited peatland formed in the northeastern portion of the Whitten Bog area.

Open water continued to decrease with time, as peatlands expanded in Whitten Bog and Caribou Bog by 8000 ^{14}C yrs BP (Figure 2.13d). Pushaw Lake began to approach its present day form, but much of the southern portion of Caribou Bog remained open water, as did the eastern portion of Pushaw Stream. Cattail marshes appeared on the northeastern portion of Caribou Bog and the southwestern portion of Whitten Bog. Peatland replaced the cattail marshes in Caribou Bog by 6000 BP (Figure 2.13e). In Whitten Bog, cattail marsh filled the areas previously occupied by open water. The lower Pushaw Stream area was still occupied by standing water, as was the southern portion of Caribou Bog. Almquist and Sanger's (1999) paleogeographic reconstruction shows establishment of modern landscape conditions by 1000 ^{14}C yrs BP. Pushaw Lake, Mud Pond, and Pushaw Stream were at approximately their current size and configuration. Peatlands had reached near modern proportions, with some cattail marshes lingering on the banks of Dead Stream near the confluence with Pushaw Stream, and north of Whitten Bog (Figure 2.13f).

Summary

Several lines of evidence have been used to develop a paleoenvironmental history of the central Penobscot Valley. The combination of vegetational change and paleohydrological data give central and northern Maine one of the most complete environmental and climatic records for New England and Atlantic Canada. This information on climatic and habitat changes provides an important framework for understanding Late Pleistiocene and Holocene human use of the region.

Archaeology

Archaeological investigations along the Penobscot River of Maine have been focused on the central portion of the Penobscot Valley. The first recorded excavations in the region were those of "Red Paint" cemeteries conducted by Warren K. Moorehead in the early 1900's (Moorehead, 1922). Walter B. Smith, a geologist, published an account of archaeological findings in the Bangor area in 1926. Formal academic or professional studies of the region ended with Smith, until the 1976 arrival of Dean Snow at the University of Maine, and then his successor, David Sanger.

Sanger oversaw the first interdisciplinary study of an archaeological site in the region by assembling a research team that included a Quaternary geologist, soil scientist, paleoecologist, and radiocarbon specialist (Sanger et al., 1977; Sanger and MacKay, 1973). Later work in the region was concentrated on cultural resource management issues related to the re-licensing of two hydroelectric reservoirs (Milford and Veazie) and permitting for the construction of a third (Ayers Rapids). Following the interdisciplinary model established earlier, geology and paleoecology were important components of this effort.

The results of the cultural resource management related-work are impressive. Nearly 200 sites were identified along the banks of the Penobscot and tributary streams, with 26 sites analyzed as part of detailed Phase II or III investigations (Discussed in more detail in Chapter 3.). Paleoecological studies established a Holocene water balance for the region, investigated the development of wetland environments in one of the reservoir catchments, and established a history of vegetation change through time. Geological studies lead to an understanding of archaeological site formation and preservation in the area, as well as contributing to the understanding of the postglacial geological evolution of the Penobscot drainage basin.

Outside the central Penobscot Valley, archaeological investigations have been limited and site specific. Early twentieth century excavations of "Red Paint" cemeteries in several locations provided insight to burial practices, but little to the understanding of lifeways of the time (Snow, 1980). More modern surveys and excavations have been cultural resource management investigations associated with reservoir relicensing (Howland reference) and construction (Petersen and Putnam, 1992). In each case, a bit more information was added to the archaeological record, but in a location dictated by development, not research questions.

In the central Penobscot Valley, cultural resource management investigations focused on the specific areas affected by the reservoirs. Although of potential archaeological interest, locations outside of the immediate reservoir area were considered beyond the study area. This concentration on modern river and tributary environments creates a bias in the regional analysis of archaeological sites. For example, in the case of meandering reaches of the Penobscot or Piscataquis, obvious older channels marked by meander scars with high archaeological potential for Early to Late Holocene age sites were not included in the survey because they were not directly impacted by impoundment fluctuations. Surveys did not continue past tributary mouths, potentially missing sites associated with upper portions of drainage sub-basins. The resulting survey provided an in depth examination on one environmental setting available to past occupants of the region, but left a tantalizingly large area unexplored.

Introduction: Culture History of the Penobscot Valley

The culture history of Maine has been divided into 4 major periods: Paleoindian, Archaic, Ceramic (Woodland), and Contact (Historic), with subdivisions present within each period. Periods and their subdivisions are recognized on the basis of diagnostic artifacts and/or chronology provided by radiocarbon dating. Chronological divisions of the archaeological periods vary slightly from author to author. Divisions used in this presentation are drawn from Sanger (2005). Ceramic period subdivisions are after Petersen and Sanger (1991) (Table 2.2). The recognition of each of these subdivisions is based on

DIVISION	TIME (^{14}C yrs BP)
Paleoindian Period	
Fluted Point tradition	11,000-10,000
Late Paleoindian tradition	10,000-9,500
Archaic Period	9,500-3,000
Early Archaic	9,500–7,500
Middle Archaic	7,500-6000
Late Archaic	6,000-3,000
Late Archaic: Laurentian tradition	6,000-4,500
Small Stem Point tradition	5,000-3,800
Late Archaic: Moorehead phase	4,500-3,700
Late Archaic: Susquehanna tradition	3,800-3,000
Ceramic Period (Woodland)	3,000-400
Early (CP 1)	3,000-2150
Middle (CP2, 3)	2150-1350
Late (CP 4,5,6)	1350-400
Early and Late Contact Period (CP 7)	450-200

Table 2.2: Culture history periods of Northern New England. (Sanger, 2005)

changes in the technology, materials, and styles employed in the creation of stone tools and ceramic vessels.

Paleoindian Period.

The Paleoindian Period represents the oldest known occupation of the region, and is characterized by a diagnostic artifact suite containing fluted bifaces constructed from fine-grained, cryptocrystalline and volcanic rocks (Spiess et al., 1998). Sites from this time period related to lithic procurement are located to the north at chert outcrops Munsungan Lake, Maine (Bonnichsen, 1981; 1982), and to the west at Berlin, New Hampshire (Boisvert, 1992)). Occupation sites exist in the region, and include Debert, Nova Scotia to the north (MacDonald, 1968) several sites in southern Maine, (Spiess et al., 1998) and the large Bull Brook site in Massachusetts (Byers, 1954; 1956).

Evidence for Paleoindian subsistence strategies is limited. Faunal and floral remains are generally absent at Paleoindian period sites. Within New England, caribou hunting has been suggested by the presence of limited caribou remains at the Vail site in Maine (Gramly 1992) and the Bull Brook (Byers, 1954, 1956) and Whipple (Curran, 1984) sites in Massachusetts. Nicholas (1982, 1983) and Dincauze and Curran (1977) developed the Glacial Lake Mosaic/Early Riverine Model that ties Paleoindian occupations to a broader subsistence pattern offered by proglacial lakes and the wetlands and drainage networks that develop from these environments. Ethnographic studies of northern Canadian aboriginal tribes is frequently used as a model for the highly mobile Paleoindian

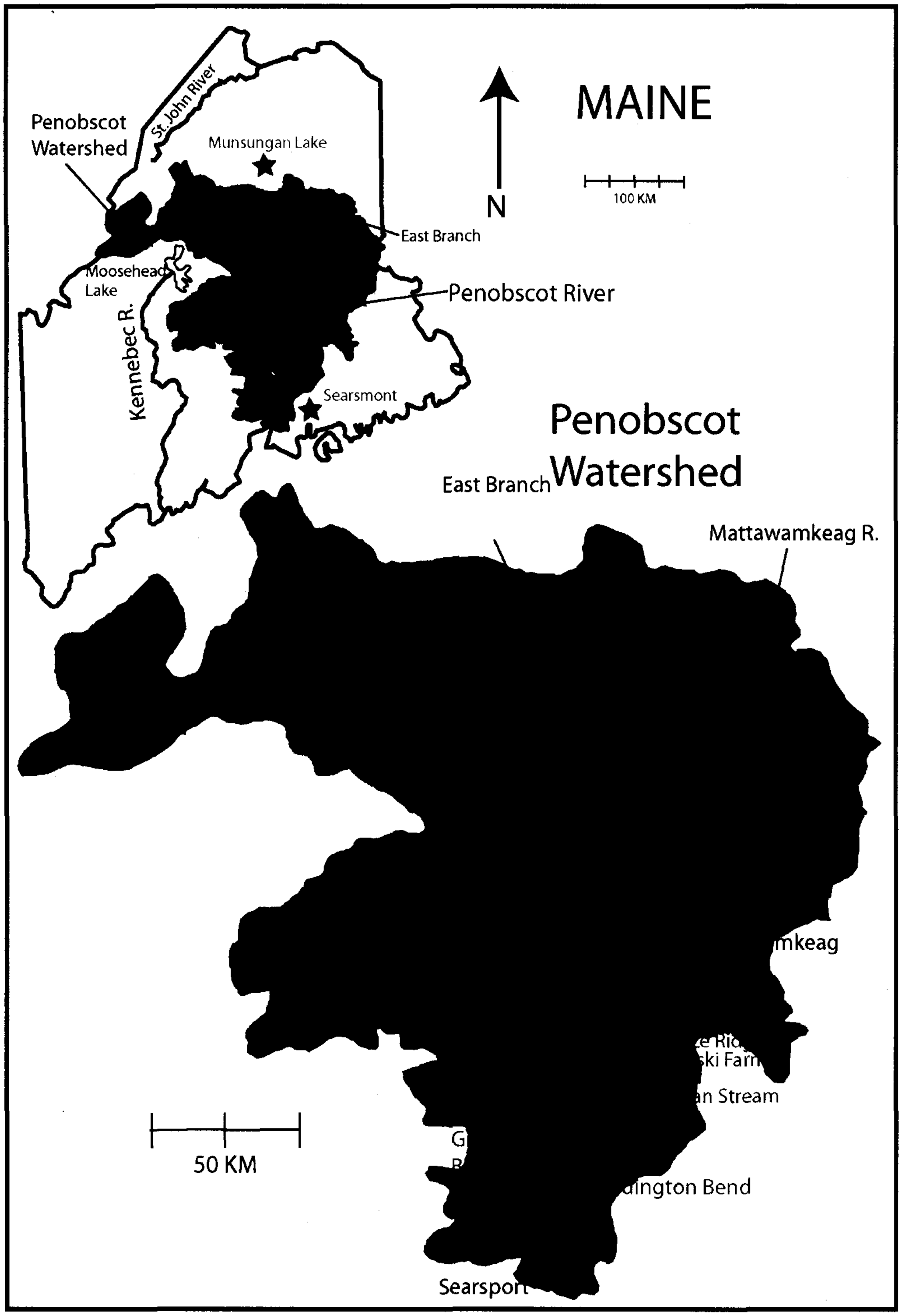


Figure 2.14: Archaeological sites in text.

hunter/gathers on the basis of similarity of environmental and climatic setting, but little evidence beyond stone artifacts has been found at sites of this period.

The Paleoindian period is subdivided into an earlier "Fluted Point tradition" (11000 – 10000 ^{14}C yrs BP) and a later "Late Paleoindian period" (10000 - 9500 ^{14}C yrs BP). Sites of these two periods are differentiated by lithic technology, but also often occur in different environmental settings.

Fluted Point Tradition. The diagnostic artifact of this tradition is the "fluted point", an elongate biface having a distinctive flake scar, or flute, created by the removal of a channel flake from one or both faces of the tool (Snow, 1980; Spiess et al., 1998). Other characteristic artifacts include unifacial endscrapers, usually made from single flake, with a spur, or graver, on one or both ends, and *pieces esquillees,* created from thick flakes or core fragments (Snow, 1980; Spiess et al. 1998).

Frequently, sites associated with this tradition are positioned on sandy substrates in a slightly sheltered location with close access to water and a sweeping view of the landscape, or are located adjacent to a lithic source area (Spiess et al. 1998). This site location model has been interpreted as indicative of a subsistence strategy based on hunting of herding animals, such as caribou (Spiess, et al., 1998). In Maine, Fluted Point tradition sites are encountered to the north in the vicinity of Munsungan Lake (Bonnichson 1981, 1982) and to the south of the Penobscot drainage (Figure 2.14). The Munsungan Lake sites are related to the exploitation of the Munsungan chert, a rock type represented by artifacts at a number of Paleoindian sites both in Maine and other portions of

New England (Pollock et al., 1999). The majority of sites to the south appear to fit the traditional location model: positioned on sandy substrates, with access to water, and with views of the surrounding landscape. The closest Paleoindian site to the central Penobscot Valley is in the Searsmont area (Cox et al., 1994) (Figure 2.14).

Late Paleoindian Period. Chronologically, the Late Paleoindian period follows the Fluted Point tradition. In northern New England, the Maritime Provinces, and Quebec, the Late Paleoindian is distinguished by a change in lithic technology from fluted bifaces to parallel-flaked, lanceolate bifaces. These artifacts are produced from many of the same high quality, exotic lithic types associated with fluted points. Sites with these diagnostic artifacts are widely distributed in Northern New England and adjacent Canada in a variety of settings, from coastal to interior. In southern New England, Early Archaic period notched points of several different styles replace the parallel-flaked bifaces of the northern New England (Dincauze, 2001). Dincauze (2001) suggests that both the parallel-flaked, lanceolate and notched points are coeval.

The setting of Late Paleoindian sites also is different from Fluted Point tradition sites. While the earlier sites have been noted primarily on high sandy settings with sweeping vistas, Late Paleoindian sites are more frequently associated with fresh water bodies, either lakes or rivers (Borque, 2001). Borque also notes that Paleoindian sites usually exist as singe component sites, while Late Paleoindian sites often are the oldest of a series of occupations at a locality, signaling the first occupation of a developing landform. This association with fresh water bodies also suggests a change, or broadening, of resource exploitation. However, more detailed analysis awaits discovery of sites with faunal and floral remains.

Two Late Paleoindian sites have been identified in the central Penobscot Valley. The base of a single, parallel-flaked biface and a few flakes were found at Blackman Stream (Figure 2.14) (Sanger et al., 1992), and represents the oldest human use of the site. A more complete parallel-flaked biface was found in possibly mixed context at the Eddington Bend site (Figure 2.14)(Sanger et al., 2003). Neither Late Paleoindian site was directly associated with material suitable for dating, but an Early Holocene age is suggested for each, based on stratigraphic position within the site in the case of Blackman Stream, and correlation based on artifact typology at Eddington Bend.

Archaic Period

The Archaic period is marked by an abrupt change in lithic technology in Northern New England and the Canadian Maritimes. Fluted bifaces disappears from the archaeological record, as do gravers. Nonlocal rock types used in the manufacture of Paleoindian tools appear less frequently in Archaic period sites, and are generally replaced by locally available sedimentary and metasedimentary rock types. Ground stone tools are first seen in the New England/Maritimes archaeological record during the Archaic Period, and range from large celts and adzes to thin and delicate slate "bayonets". This shift in emphasis from exotic lithic sources to more locally available materials has been interpreted by Fitting (1968) as representing the development of territorial bands, interrupting Paleoindian travel and trade networks. In this scenario, regional styles supplant the earlier broad uniformity of form and technology

The Archaic period is also associated with the "Red Paint Indians". Popularized by the excavations of Willoughby (1898, 1935) and Moorehead (1922) in the early 20th century, this term is used to describe burials characterized by inclusion of red ochre and a distinctive set of ground stone grave goods. These features often lack human remains due to the acidity of the soils in interior New England and the Maritimes. Skeletal material, as well as preserved antler, tooth, and bone artifacts are recovered from burials where shell middens or carbonate bedrock buffered soil pH. Burial ceremonialism using red ocher is recognized throughout the Archaic, but reaches fluorescence at the end of the period (Robinson, 1996).

In the interior, the association of sites with water bodies continues from the Late Paleoindian into the Archaic, suggesting the persistence of the earlier settlement/subsistence pattern. In Maine and the Maritimes, sites from the Archaic period have been found along major rivers, tributary streams, and wetlands. In southern New England, Archaic period sites are also allied with large wetlands (Forrest, 1999; Nicholas 1998).

Traditionally, the Archaic period has been divided into the Early (9500 – 8000 ^{4}C yrs BP), Middle (8,000 –6,000 ^{14}C yrs BP), and Late (6,000 - 3,000 ^{14}C yrs BP) periods (Fitzhugh 1972; Snow, 1980). Robinson (1992) discussed continuity within the Early and Middle Archaic periods, and suggests the term

"Gulf of Maine Archaic tradition" for the technological complex extending from 9500 to 6000 BP^{14}C yrs BP. Sanger (2005) sees no "culturally siginificant" events in northern New England that can be used to distinguish one period from the other. Where available, radiocarbon dates can be used to assign site components to the Early or Middle Archaic. However, when chronology is limited to using diagnostic artifacts, the period is best described as the Early/Middle Archaic, the useage that will be followed here. The Late Archaic is further subdivided to reflect changes in technology and burial tradition.

Early/Middle Archaic Period. During the mid-twentieth century, the apparent absence of Early and Middle Archaic period sites in New England and the Maritimes was attributed to low population densities in the region as a result of the low carrying capacity of Early Holocene boreal forest (Ritchie, 1965; Fitting, 1968). In Maine, Sanger (1979) suggested that, in addition to the Ritchie-Fitting hypothesis, the lack of sites may be a result of incomplete data, coastal site destruction due to sea level rise, and/or changes in migratory fish exploitation caused by changes in migration paths due to alterations in river gradients.

The discovery of deeply stratified sites containing Early and Middle Archaic components, first at the Sharrow and Brigham sites on the Piscataquis River a major tributary of the Penobscot (Petersen et al., 1986; Petersen and Putnam 1992) and at Blackman Stream (Sanger et al., 1992) and Gilman Falls site (Sanger, 1996; Sanger et al., 2001) in the central Penobscot Valley (Figure 2.14), established the presence of people in the region during this time period. Early Archaic components were also identified at the Beaver Site (adjacent to

Gilman Falls) (Belcher and Sanger, 1988). More recently, Robinson has identified an Early Archaic component at the Mackowski Farm site on the Penobscot River (Figure 2.14). In addition, the Gilman Falls site (Sanger, 1996) (Figure 2.18) has been identified as a Middle Archaic quarry and workshop site used in the production of groundstone rods between 6300 –7300 ^{14}C yrs BP (Sanger et al., 2001).

The association of these sites with major waterways within the region validates Fitting's (1968) hypothesis that river valleys would represent ecologically attractive microclimates in a generally forested region. Faunal analysis of remains from Early and Middle Archaic lake and riverine sites in the region found evidence of utilization of a wide range of fish, mammals, birds, and reptile species (Spiess, 1992). The presence of anadromous fish, such as shad, salmonids, and eels suggests seasonal occupations to exploit specific resources. Forrest's (1999) work at the Sandy Hill site in Connecticut records Early Archaic use of wetland vegetation, including cattails.

Early and Middle Archaic lithic technology includes both chipped and ground stone. The central Penobscot Valley lies in the area dominated by the Gulf of Maine Archaic, a technological tradition identified by Robinson (1992). The artifact suite of this tradition is composed of groundstone tools, including celts and full-channel grooved gouges. Artifacts are generally made from locally available material, and some sites of this age contain quartz cores and unifaces, and projectile points of chert or other fine-grained rock types are notably absent. In the Penobscot Valley, an area underlain by low-grade metamorphic rocks, a unique technology, characterized by ridged, felsite hammerstones, was created to reduce the thinly bedded local lithologies.

Quartz scrapers and quartz debitage are noted in Early Archaic components in New Hampshire (Maymon and Bolian, 1992) and Maine (Petersen and Putnam 1992), and are described as "expediency" tools. The presence of large, crudely shaped tools, presumably used for cutting and choppin, are identified in Early Archaic components in New Hampshire (Maymon and Bolian,1992), Vermont (Thomas 1992), and at Blackman Stream in the central Penobscot Valley (Sanger et al., 1992).

In contrast, Early/Middle Archaic sites to the east of the Kennebec and Androscoggin Rivers, south and east of the Penobscot, are typified by bifaces of the Neville-Stark Complex (Dincauze, 1976). Neville points have triangular blades and tapering stems, and date to between 8000 and 6500 ^{14}C yrs. BP. Stark points date between 6500 and 6000 ^{14}C yrs. BP, and have less distinct shoulders and pointed stems (Deal, 2001). These forms appear to have technological links to projectile points in the southeastern US (Anderson, 1996), and may represent a northward movement of technological styles. Although found occasionally in the Penobscot Valley and to the north, they represent a minor portion of the archaeological record in these areas.

Sanger (2005) suggests that this technological divide may be related to environment and lithic resources. The area to the east of the Kennebec has a much broader outcrop pattern of low-grade metamorphic rock types, and is characterized by widespread peatlands. Forrest's (1999) recognition of an artifact suite similar to Robinson's (1992) Gulf of Maine Archaic Tradition in an Early Holocene wetland setting in Connecticut may support this environment-technology linkage. The presence of Neville-Stark complex artifacts east of the Kennebec and Gulf of Maine Archaic to the west and south illustrates that any border between technological styles at this time was a porous one, but with different resources and potentially related but distinct lifeways on either side.

Ground stone tools first appear in the Early Archaic (Petersen and Putnam, 1992), and are produced by a sequence of pecking and grinding. By the Middle Archaic, a wide range of ground stone tools are noted from a variety of locations, both in occupation and mortuary sites. Common artifact groups represented in collections are celts, gouges, adzes, stone rods, ulus, and plummets.

Limited direct evidence supports the presence of a bone and antler technology during the Early and Middle Archaic. However, this may be the result of poor preservation, rather than lack of manufacture. Petersen and Putnam (1992) note the presence of bone tools dated at 7500-7300 ^{14}C yrs BP from L'Anse Amour in Labrador, where limestone associated with a burial created a favorable environment for the preservation of organic remains. The same authors also identified manufacture scraps and one possible antler tool fragment circa 8500 ^{14}C yrs BP, as well as bone and antler tools dated circa 6000-5800 ^{14}C yrs BP at the Sharrow site.

A mortuary subsystem, the Morrill Point Complex (8000 to 6500 ^{14}C yrs BP) (Robinson, 1992), is associated with the Gulf of Maine tradition, and is characterized by burials accompanied by red ocher and ground stone artifacts with lesser numbers of flaked stone tools (Robinson, 1992). Two sites associated with this complex occur in the central Penobscot region, the Passadumkeag Sand Pit site (Moorehead, 1922) and the Sunkhaze Ridge site (Harnden, 1922; Robinson, 1987) (Figure 2.14). Both sites contained red ocher concentrations, and were assigned to the Morrill Point Complex on the presence of groundstone rods and full channel gouges (Robinson 1992).

Late Archaic Period. The Late Archaic period is subdivided into the Laurentian tradition (6000-4500 ^{14}C yrs BP), the Small Stemmed Point tradition ((5000 – 3000 ^{14}C yrs BP), the Moorehead Burial tradition (4500-3700 ^{14}C yrs BP), and Susquehanna tradition (3800-3000 ^{14}C yrs BP). The overlapping chronology of these subdivisions hints at the complexity of the archaeological record during this time period. While the culture history sequence in the Early Holocene of Maine appears to pass sequentially from Paleoindian to Gulf of Maine Archaic, the following periods are not so easily divided by chronology. Sites in Maine show a progression of groundstone tool styles continuing with modifications from the Early Archaic, combined with the additions of artifact styles that appear to arrive from sources outside the region. Bone, antler, and native copper artifacts are also associated with the Late Archaic (Cox, 1991).

Large, side-notched Otter Creek projectile points are associated with the earliest portion of the Laurentian period (Funk, 1988) and are part of a Late Archaic stylistic sequence developed in New York State (Ritchie 1965). Otter Creek points are the diagnostic feature that marks the beginning of the Late

Archaic in Maine (Mack, et al. 2002). Ranging in age from 5800 to 4500 ^{14}C yrs BP (Sanger and Newsome, 2000), they have been found at several sites with the Penobscot Valley, including the Hirundo (Sanger et al., 1977), Young (Borstel, 1982), and Bob Sites (Mack et al. 2002) on Pushaw Stream and Gilman Falls (Sanger, 1996) on the Stillwater River (Figure 2.18).

The Small Stemmed Point tradition (Bourque, 1995) is based on small, narrow-stemmed projectile points, typically made of quartz, from the Turner Farm site in Penobscot Bay. Found most commonly along the coast, these artifacts do appear in the central Penobscot Valley at Eddington Bend (Petersen and Sanger, 1987) and at sites along Pushaw stream (Mack et al., 2002). Because of their association with groundstone artifacts typical of the Gulf of Maine Archaic period (Middle Archaic), Bourque (2001) feels that the Small Stemmed Point tradition is derived from the older cultures within the region.

Late Archaic period burials associated with red ochre exist in Maine and the Canadian Maritimes. Described as the Moorehead burial tradition by Sanger (1973), this term applies only to specific mortuary practices, and appears in numerous cemetery sites in the central Penobscot Valley: Indian Island (Robinson, in press), Old Town (Robinson, in press), Bradley (Belcher, et al., 1994) and Eddington Bend (Petersen and Sanger, 1987). These sites are generally located on a sandy ridge overlooking the river or a tributary, and are composed of a number of deposits or red ocher with a variety of grave goods. Due to the acidic nature of the soil, no organic material remains, but from size and orientation, the burials are thought to represent inhumations. Characteristic artifacts associated with the red ochre deposits include elongate, groundstone "slate" bayonets, groundstone plummets, and gouges made from a distinctive, green volcanic rock (Snow, 1980). Occupation sites are not generally associated with these cemetery sites.

Susquehanna tradition sites include both burial and occupation sites, and are well represented in the central Penobscot Valley. Susquehanna components appear at the Young (Borstal, 1982), Hirundo (Sanger et al., 1977), Bob (Mack et al., 2002), Eddington Bend (Moorehead, 1922) and Gilman Fall sites (Sanger et al., 2001). Eddington Bend and the Young site contain burials. The Young site burial is dated to circa 3700 ^{14}C yrs BP. Susquehanna burials are differentiated from those of the Moorehead burial tradition by the presence of cremation burials rather than inhumations. Both burial and occupation sites contain stone tools produced from a technology different than that used in either the Laurentian or the Gulf of Maine Archaic. This apparent replacement of burial practices and tool technology, as well as overlapping radiocarbon dates has been interpreted by several researchers as representative of the movement of a culturally distinct people from the south and west into the region (Bourque, 1971, 1975, 1995; Sanger 1975; Snow, 1980). The transition of the Susquehanna to the following Ceramic period is not well understood (Mack et al., 2002).

Ceramic (Woodland) Period

Ceramics appear in the Maine archeological record at approximately 3,000 ^{14}C yrs BP, and persist from this point through the Historic period. The sudden and striking appearance of these artifacts in the archaeological record marks a major innovation in regional technology, and gives the Ceramic period its name. Although the term, Ceramic period, is widely used in Maine and the Canadian Maritimes, "Woodland" or "Maritme Woodland" is also used to describe the same interval.

Subdivisons (CP1-CP6) within the Ceramic period are based on changes in manufacturing styles, decoration, and surface treatment (Petersen and Sanger, 1991). Vessels are made from slabs or clay coils, and can be thick or thin-walled depending on time of production. Temper materials include sand, rock fragments, crushed shells, and fiber in Maine. Surface decoration ranges from cord or fabric impression, stamping, smoothing, or the presence of punctations. Rim forms vary through time, being simple, castellated, or collared. For most of the Ceramic Period, pots were generally cylindrical with pointed bases. Later, more globular forms associated with Iroquian production appear in the archaeological record.

While each subdivision of the Ceramic period chronology is characterized by distinctive traits, the overall sense is one of continuing experimentation and refinement. This ceramic tradition ends with the Historic, or Contact period, when European goods, such as copper and iron pots and utensils, appear in the archaeological record.

The lithic technology of the Ceramic period is markedly different from that of the Archaic. Smaller bifaces produced from both local and high quality, aphanitic and cyptocrystalline rocks replace the large, broad, stemmed bifaces of the Archaic period, and appear to be better suited to bow and arrow technology (Mack, et al., 2002). Scrapers are also made from a wide range of lithic sources, and tend to be larger than those of the Late Archaic period (Sanger 1987). Groundstone tools are reduced from their earlier fluorescence, and are limited to pecked and ground celts and whetstones (Sanger 1979).

Another major Ceramic period innovation in New England was agriculture, although it appears to have been limited to the western and southern part of the state. Evidence from western Maine places maize production in that portion of the state by 1000 ^{14}C yrs BP, with maize-bean-squash cultivation by 460 ^{14}C yrs BP (Bourque, 2001). Champlain notes maize grown only as far east as Saco on the Kennebec (Bourque, 2001). There is no evidence of pre-European contact agriculture in the Penobscot Valley, in either the archaeological or ethnohistorical record.

Ceramic period sites are found both on the coast and in the interior. Coastal sites are associated with shell middens. These sites usually have a southern exposure and are associated with two or more resources, such as clam flats, landing sites, or lithic sources (Sanger, 1979). Interior sites are most frequently allied with water, either streams or lakes. On streams, locations at waterfalls or rapids and confluences of rivers and tributaries, appear to be preferred (Sanger, 1979). Lake outlets also appear to be favored locations (Sanger, 1979). Sanger (1987) suggests that these interior sites may represent use during hunting, fishing, or travel.

Evidence from shell middens shows Ceramic period occupants had a varied diet utilitzing both marine and upland species (Sanger, 1979, 1987). Interior sites lack the preservation of those on the coast, but suggest use of a wide range of floral and faunal resources (Mack et al. 2001). House pits discovered in shell middens suggest that coastal dwellers constructed semi-subterranean structures large enough to shelter small family groups. Evidence of shelters is extremely rare in the interior, and consists only of postmolds suggesting structures of varying size (Bourque, 2001).

Several authors (Peterson and Hamilton, 1984; Petersen and Sanger, 1991) note a difference in the twist of cordage used to decorate ceramic vessels. Z-twist cordage is used to decorate pots found primarily at coastal sites, while S twist cordage appears most frequently on ceramics from the interior. Petersen and Sanger (1991) also note a strong affiliation between Z twist decorated pottery and shell temper in both coastal and interior sites. These location specific differences in pottery manufacture and decoration may support Sanger's (1986) contention that separate coastal and interior populations existed in Maine prior to contact with Europeans.

Sites representing occupation of the region throughout the Ceramic period are abundant in the central Penobscot Valley, and are associated with the present riverbanks and tributary streams. No associated burial sites have been found in the region (Mack et al., 2002).

Contact (Historic) Period

The arrival of Europeans in Maine marked a radical change in the lifeways of the native inhabitants. At first, interactions were limited to trade, with European goods entering native occupations sites and native caught furs transported across the ocean. In the Penobscot Valley, this began in 1580 when John Walker acquired 300 pelts from native inhabitants (Bourque, 2001). Interactions continued, first amicable, then hostile. Epidemics of European diseases decimated Native populations, allowing European settlers to move more readily into Native lands. Fewer in number, social systems disrupted, Native populations became a marginalized part of Maine and New England society.

The landscape changes brought about by timber harvesting, agriculture, and industry also reshaped the land. Dams were built across the Penobscot and many of its tributaries, first to provide power for sawmills, later to produce electricity. The headponds associated with these dams drowned rapids, changing the look and the processes associated with the Penobscot system. Sediment released by logging and agriculture swept into the region's streams. Dam construction, logging practices, and pollution changed patterns of fish migration. The river we see today is a much different river from that used by the land's original inhabitants. This changed landscape and ecological system cannot be used as an analogue for investigating the region's archaeological record.

Chapter 3

GEOARCHAEOLOGY OF LOCALITIES WITHIN THE CENTRAL PENOBSCOT VALLEY

Introduction

A discussion of the geoarchaeology of the central Penobscot Valley requires examination at a variety of scales. Using Willey and Phillips (1958) descriptions of spatial divisions in archaeology, the smallest unit is the site, or ..."minimum operational unit of geographical space". In the case of multi-component sites, each specific component is viewed separately, and represents a finite time period with a constant geomorphic and environmental setting and resource base. Excavation of a site produces a wealth of material that provides detailed information about that specific location. Artifact assemblages suggest activities carried out at the site, and allow interpretations of lifeways. Stratigraphic and geological analysis of site sediments offers information relative to paleogeographic setting, as well as site formation and preservation. Diagnostic artifacts and/or numerical dates provide chronology in conjunction with stratigraphy. Although organic remains are rare in interior New England, when available, faunal and floral analysis can provide insights relative to resource use and seasonality.

To step beyond the narrow focus of the site, initial geoarchaeological analysis in this study is carried out at the locality level. Wiley and Philips (1958) define a locality as "...geographical space small enough to permit the working assumption of complete cultural homogeneity at any given time". In the central Penobscot Valley, archaeological sites are grouped into localities on the basis of common geograpraphic location, to produce 8 localities: Pushaw/Dead Stream (2 sites), Lower Pushaw Stream (7 sites), Pushaw/Stillwater Confluence (4 sites), Indian Island (5 sites), Bl;ackman Stream (2 sites), Ayers Rapids, (2 sites), Eddington Bend (1 site), and Mackowski Farm (1 sites) (Figure 3.1).

Sites in each locality are discussed individually in terms of archaeology and stratigraphy, but geoarchaeological interpretations are performed on the locality level. Within a locality, environment, access to resources, and general geomorphology are assumed constant at each specific time period, but necessarily through time. Some sites within localities contain several components, providing information on environmental and geomorphic conditions through time. Use of locality level analysis allows comparison among geographic locations and provides the basis for the larger scale regional analysis in a later chapter.

Pushaw Stream Localities

Geomorphology and Geology

Pushaw Stream drains approximately 685 km^2 of central Maine (Barrows and Babb, 1912), and flows approximately 65 km through several lakes, ponds, and a large wetland system before entering the Stillwater River, a branch of the Penobscot River (Figure 3.2). The stream is located in a region of moderate relief (approx 30 m) formed by bedrock ridges composed of the Late Ordovician

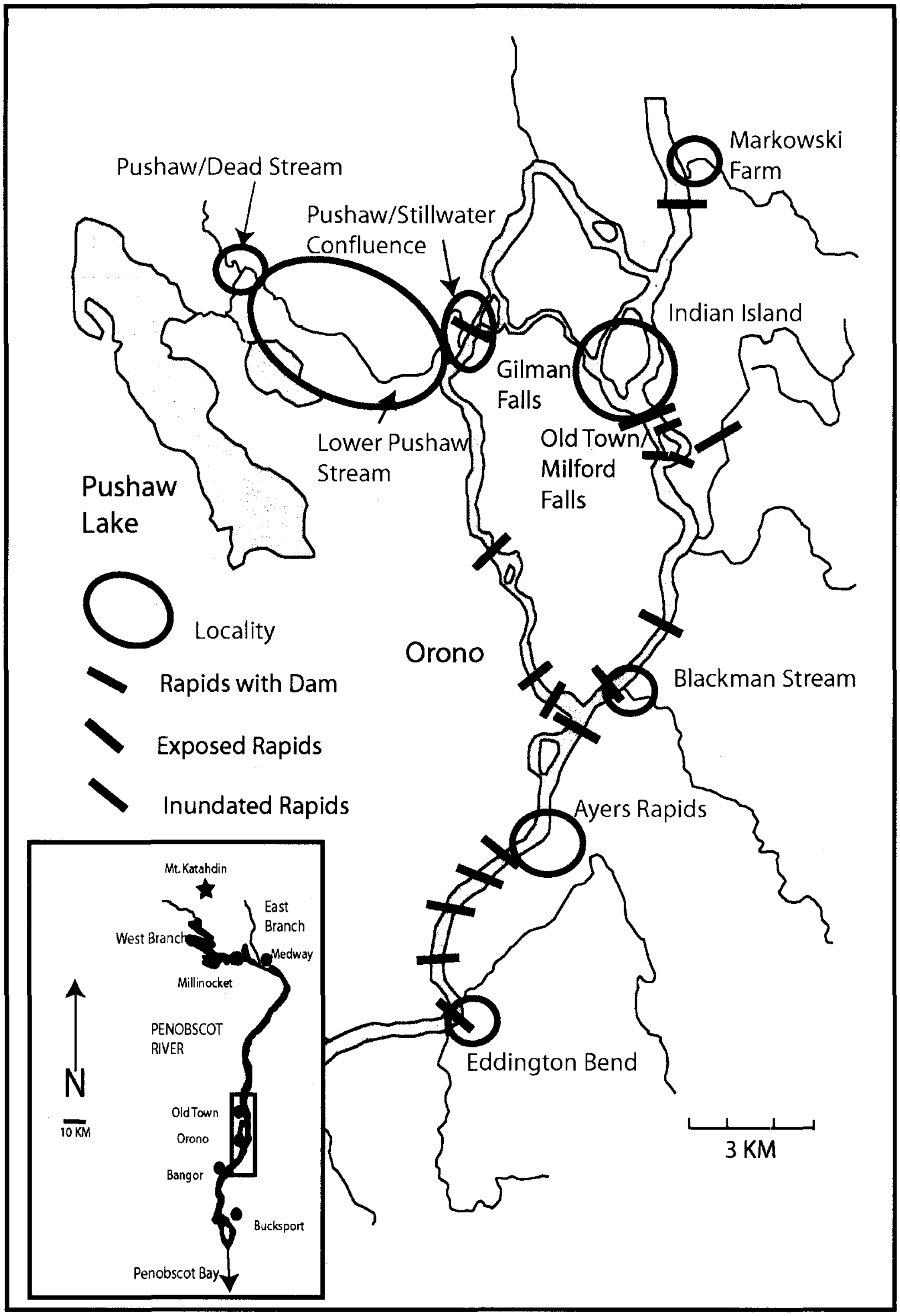


Figure 3.1: Study area showing location of archaeological localities and rapids.

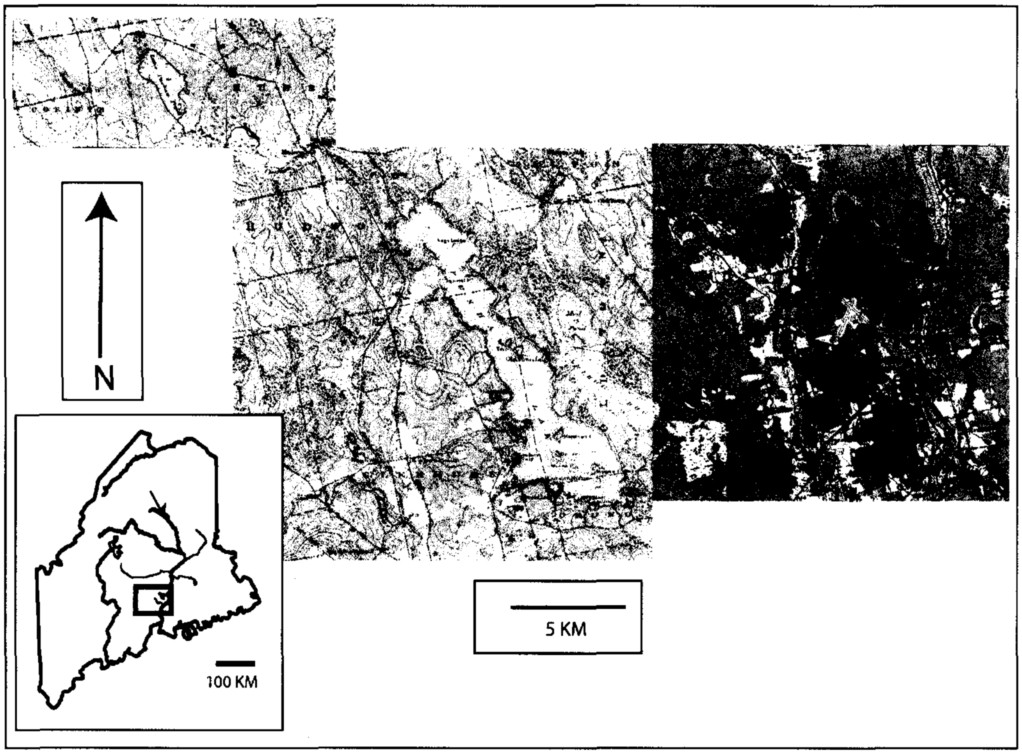


Figure 3.2: Pushaw Stream

to Early Silurian Vassalboro Formation, a grey to green phyllite (Osberg et al., 1985). An undulating till surface overlies much of the bedrock in the region. This deposit is mantled by the fine-grained, glaciomarine Presumpscot Formation (Thompson and Borns, 1985). The course of the stream is generally unconfined in wetlands. In areas of till or Presumpscot Formation outcrop, banks range in height from less than a meter to 2-3 m in height, and the stream is moderately confined. Rapids occur where bedrock rises to the surface.

The outlet portion of the stream flows east and then north from Pushaw Lake, through the extensive wetlands of the Caribou/Whitten Bog Complex. In this region, banks are generally low, and the meandering stream is not confined. The course of the stream then turns to the southeast, around a till-covered bedrock ridge. Rapids occur in this area where bedrock outcrops at the surface. Down stream of the rapids, the stream widens for approximately 3.5 km, and wetlands occupy the stream banks. As the local relief increases, the stream channel narrows, and bank heights increase. Small wetlands occur in lower areas, but stream banks are primarily developed in till and glaciomarine sediments. The stream makes an abrupt turn to the north approximately 2 km from the confluence of Pushaw Stream and the Stillwater River. Here the stream flows along the western bank of a large esker, before flowing through a cut in the deposit, and turning south to the confluence with the Stillwater. Although sites have been recorded near the outlet of Pushaw Lake, little work has been conducted in that area. In this study, research interest is focused on the eastern portion of the stream, between the outlet of Pushaw Lake and the Stillwater River

(Figure 3.1). Sites at the confluence of Pushaw and Dead Streams will be considered as the Pushaw/Dead Stream Locality and sites along the lower portion of the stream will be considered as the Lower Pushaw Stream Locality. Sites clustered at the mouth of Pushaw Stream, at the confluence of Pushaw Stream and the Stillwater River, will be considered as part of the Pushaw/Stillwater Confluence Locality (Figure 3.1).

History of Archaeological Research in the Pushaw Stream Localities

Archaeological investigation of the area began with MacKay's excavations of the Hirundo Site beginning in 1971 (Sanger et al., 1977), and continued with Borstel's work at the Young Site (Borstel, 1982) (Figure 3.3). Relicensing of the Milford Reservoir by Bangor Hydro Electric lead to cultural resource management evaluations of the mouth of Pushaw Stream (Belcher and Sanger 1988a). Later recognition of greater impoundment limits expanded the study into the lower portion of Pushaw Stream (Klink, 1991: Fenton, 1991).

Phase I investigations of the eastern portion of Pushaw Stream included walk-over survey and shovel test pit excavations of the area influenced by the Milford Reservoir created by the Milford and Gilman Falls dams in Old Town and Milford (Figure 3.1). Thirty-eight sites were identified along the banks of the stream, indicating widespread use of the area prior to Aboriginal/European contact (Klink, 1991). Of these sites, five in the Pushaw Locality area have been excavated at a Phase II level with one continuing to Phase III. The goals of these excavations were to determine the dimensions of the site, the nature and extent

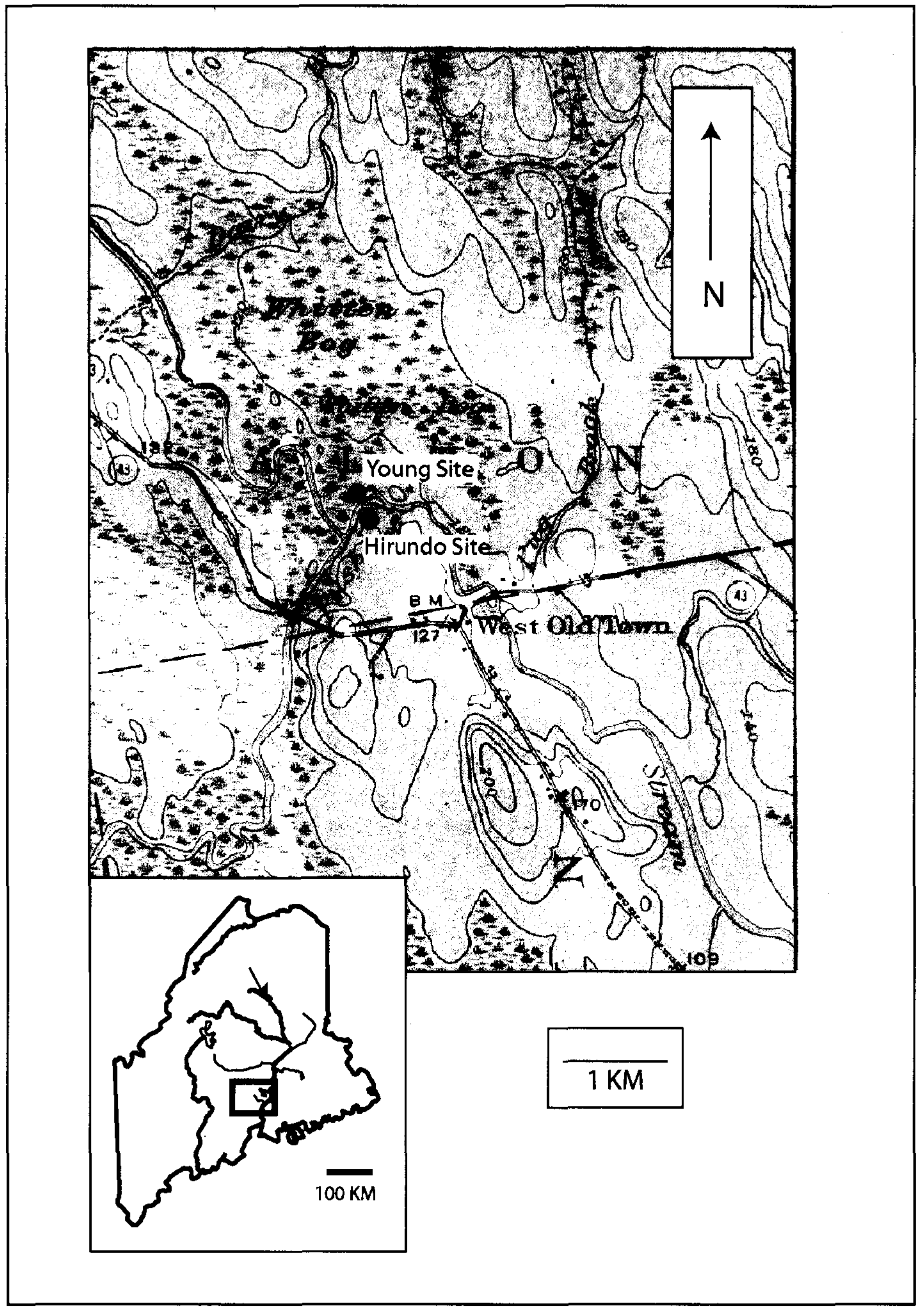


Figure 3.3: Archaeological sites in the Pushaw/Dead Stream Locality

of cultural and stratigraphic deposits, the extent of site disturbance, and the overall archaeological significance of each site. These investigations greatly expanded the understanding of the geological and archaeological history of thearea by combining sedimentary history with the chronology provided by diagnostic artifacts and radiocarbon dating.

Pushaw/Dead Stream Locality

The Pushaw/Dead Stream Locality encompasses the Hirundo and Young archaeological sites, located near the confluence of Pushaw Stream and Dead Stream, approximately 5.5 east of the outlet of Pushaw Lake and 7 km from the confluence of Pushaw Stream and the Stillwater River (Figure 3.3). The Hirundo Site is located on the south bank of Pushaw Stream, near the confluence of Pushaw and Dead Streams, on the property of the Hirundo wildlife reserve (Sanger et al., 1977; Sanger, 1979)(Figure 3.3). The site is situated at rapids formed where the Late Ordovician to Early Silurian Vassalboro Formation (Osberg et al., 1985) outcrops at the surface. The Young Site is located on the north bank of Pushaw Stream, opposite the Hirundo site.

Hirundo Site (Site 73-9). The Hirundo Site was the first site on the Pushaw Stream to be excavated as part of an organized, professionally supervised archaeological project. It was also the first in the region to employ an interdisciplinary approach to site excavation and interpretation.

Table 3.1: Hirundo Site (73-9) Stratigraphy (from Sanger et al., 1979)

Zone (Stratum)	Color	Sediment Texture	Depth below surface (cm)	Thickness	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I	Black	Organic-rich sediment			Modern circa 3050-2150 ^{14}C yrs BP[2] (Early Ceramic period) Stemmed bifaces, drills, celts circa 3 900-2800 ^{14}C yrs BP [2] (Susquehanna)	Topsoil – Terrestrial organic material combined with fine-grained alluvial sediments (A Horizon)
II	Tan	Sandy silt with boulders			4,295±95 ^{14}C yrs BP 4,325±100 ^{14}C yrs BP Groundstone tools, Otter-creek style projectile points, chipped stone bifaces and scraprs (Laurentian)[1,2]	Fine-grained alluvial sediments deposited on boulder lag developed from till. (B Horizon)
III	Light	Sandy clay with boulders			circa 7,000 ^{14}C yrs BP[2] Neville-type bifaces, felsite cores and large flakes, quartz scrapers Early -Middle Archaic	Fine-grained alluvial sediments deposited on boulder lag developed from till. (B Horizon)
IV		Poorly sorted			> circa 7,000 ^{14}C yrs BP[2] Early -Middle Archaic	Till (C Horizon)

Three distinct sedimentary zones (strata) were identified at the Hirundo site (Sanger et al., 1977) (See Table 3.1), overlying a basal deposit of till. This concept of zonation is used to characterize individual stratigraphic units. This differs the manner in which zones used at the Bob and Gilman Falls sites (described later), where Zones referred to a stratigraphic horizon characterized by artifacts of a specific time period. At the Hirundo site, Zone (Stratum) I is composed of dark, organic-rich topsoil, and mantles the site. Zones II and III are predominately fine-grained, with Zone II composed of tan sandy silt and Zone III of light sandy clay. Both zones are associated with boulders. Zone III is not continuous across the site.

Six archaeological assemblages were identified at the site (Sanger et al., 1977; Sanger, 1979). Assemblage 1 is the oldest component at the site, and occupies the lowest stratigraphic position, resting on the till surface of Zone (Stratum) 4. This assemblage contains Neville type bifaces, many felsite cores and large flakes, three other bifaces, and many quartz scrapers. On the basis of the presence of the Neville-like point and numerous quartz scrapers the assemblage may date to the Early to Middle Archaic period, circa 7,000 ^{14}C yr BP (Sanger et al., 1977; Robinson 1992). Assemblage 2 appears in Zones (Strata) I and II, and is composed of groundstone tools and Otter Creek-type projectile points, as well as chipped stone bifaces and scrapers. This group of artifacts is associated with the Laurentian tradition. The charcoal from a feature associated with Assemblage 2 artifacts returned radiocarbon dates of 4,295$\pm$95 ^{14}C yr BP and 4,325$\pm$100 ^{14}C yr BP, and is thought to correlate with the end of

Assemblage 2 (Sanger et al., 1977; Sanger, 1979). Assemblage 3 is a Susquehanna component associated with Zone (Stratum) 1, and is composed of stemmed bifaces, drills, and celts. Assemblages 4 and 5 are assigned to the Ceramic period, and are found in Zone (Stratum) 1.

Young Site Site (73-10). The Young Site was the next Pushaw Stream site to be professionally investigated. Although Borstel (1982) did not employ the interdisciplinary approach focused on Hirundo, he did pay a great deal of attention to geologic setting and soil analysis. A geologic map of the site area by Borstel (1982: 8) shows irregular, till deposits surrounded by glaciomarine sediments. Alluvial sediments occur at the mouth of Dead Stream and on either side of the stream downstream from the site. A detailed topographic map of the site indicates that most cultural activity was focused on a knoll that rises approximately 3 m above the stream surface.

Borstel (1982) described soil stratigraphy in culturally modified and undisturbed settings, and recorded soil colors and conducted textural analyses. Unfortunately for present day readers, Borstel employed a soil horizon classification system not currently in use, and definitions for each horizon are not presented. To allow comparison to other stratigraphic sequences in the region, Borstel's sequence has been reinterpreted using his soil horizons as equivalents of the strata system used by other surveys in the area

Borstel (1982) recognized seven distinct strata, two upper organic-rich layers and five developed in geologic materials (See Table 3.2). Not all strata occurred in each excavation unit, probably due to localized geological and

Table 3.2: Young (73-10) Site Stratigraphy (from Borstel, 1982)

Stratum	Borstel (1982) Horizon	Color	Sediment texture [1]N19E52 [2]N27E59 [3]N36E57	Depth below surface (cm)	Sedi-ment Thick-ness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Artifacts	Geological Interpretation
I	Pad	5YR3/1, 7.5YR4/0, 7.5YR3/0, 10YR3/2 Very dark gray, dark gray, very dark gray, very dark grayish brown	Organics	0	0-5			Accumulation of terrestrial organic material (O Horizon)
II	Mixed	7.5YR4/2,5 YR3/2 Brown-dark brown, dark reddish brown	32%sand, 57%silt, 11%clay[1]	0-5	0-20			Terrestrial organic material and alluvial sediments (A Horizon)
III	A2	7.5YR8/0 White	13%sand, 72%silt,15%clay[3]	7-10	3-10			Elluviated (leached) horizon, colluvial & alluvial deposition (E Horizon)
IV	B21	7.5YR5/6, 2.5YR6/8, 5YR5/4, 2.5YR6/6,7.5YR6/6,5YR5/8 Strong brown, light	31%sand, 59% silt%, 10%clay[1] 12%sand, 70%silt, 18% clay[2] 17%sand, 78%silt,	15-35	7-12	circa 3050-2150 ^{14}C yrs BP[2] (Early Ceramic period) 3751±60 ^{14}C yrs BP 3105±50 ^{14}C yrs BP (Susquehanna[1])	Vinette 1, Early Ceramic stemmed and nonstemed bifaces	Illuviated Fe and Mg in colluvial & alluvial sediments. (Bs Horizon)

		red, reddish brown, reddish yellow, yellowish red	6%clay[3]			circa 4500-3700 BP[2] (Moorehead) circa 4500-5500 ^{14}C yrs BP[2] (Laurentian)	stemmed bifaces, perforators groundstone artifacts, stemmed bifaces, a grooved pebble, and a plummet	
V	B22	5YR4/3, 10YR5-7/4, 7.5YR7/8 Reddish brown, yellowish brown-very pale brown, reddish yellow	7%sand, 74%silt, 20%clay[1] 5%sand, 77%silt, 18%clay[2] 11%sand,76 % silt, 13%clay[3]	30-35	5-25			Illuviated Fe and Mg in alluvial overbank sediments (Bs Horizon)
VI	B3	5YR4/4, 5YR6/4, 7.5YR5/4, 7.5YR6/8 Reddish brown, light yellowish brown, brown,	2%sand, 79%silt, 19% clay [1] 3%sand, 73%silt, 25%clay[2] 8%sand, 76%silt, 16%clay[3]	35-40	5-35			Illuviated Fe and Mg in alluvial overbank sediments (Bs Horizon)

		reddish yellow						
VII	C	7.5YR4/2, 5YR4/4, 5YR6/3, 5G6/1,7.5Y R5/2, 10YR6/3 Brown to very dark brown, reddish brown, light reddish brown, greenish gray, brown, pale brown	Silty (30%sand, 59%silt, 10%clay) with cobbles to compact, blocky silt (3%sand,72 %silt, 25%clay[2])	40-75	Base not excavated			Material with cobbles is till. Compact silt is glaciomarine or lacustrine sediments (C Horizon)

pedological process. In general, the soils are primarily very fine-grained, and are dominated by the silt fraction, with lesser amounts of sand and clay (See Table 3.2). When the horizon descriptions are compared to current soil horizon definitions, the soil profiles most closely equal those of a spodosol. This matches the Penobscot County Soil Survey identification of soils at the Young Site as part of Thorndike series, a well-drained shallow to moderately deep spodosol developed in slaty till (Goodman, 1963). The only profile that is significantly different from the others, N27E59, is located on the downstream slope of the knoll that dominates the site. The C horizon at this location is described as a greenish gray, blocky, compact silt, instead of the till found at the base of other profiles. This description matches that of the glaciomarine Presumpscot Formation or lacustrine sediments. The upper portion of the profile matches that of a spodosol, indicating that pedogenesis was uniform across the site.

Borstel (1982) characterizes the site stratigraphy as "...coarse grained, so that from the base of the excavations to the surface, artifacts tend to be younger, but sharp stratigraphic boundaries are lacking." (p. 80). He identifies four archaeological components, the Moorehead/Laurentian tradition, the Susquehanna, and the Early Ceramic period. At the Young Site, the Laurentian tradition is associated with groundstone artifacts, stemmed bifaces, a grooved pebble, and a plummet. The Susquehanna component is identified on the basis of diagnostic stemmed bifaces, perforators, and radiocarbon dates of 3751$\pm$60 BP to 3105$\pm$50 ^{14}C yrs BP. The Ceramic period component is characterized by pottery similar in appearance to Vinette I pottery and diagnostic Early Ceramic stemmed and nonstemmed bifaces. The presence of the three components suggests an occupation of at least 3,000 to 1000 years in length (Borstel, 1982), but potentially ranging from 5,000 to 1,000 C^{14} BP. with apparent abandonment of the site after the Early Ceramic period.

Geoarchaeology of the Pushaw/Dead Stream Locality. The Hirundo and Young Sites are located near the confluence of Pushaw and Dead Streams, where Pushaw Stream bends to flow around a local topographic high (Figure 3.2). From the outcrop of bedrock in the streambed, it is surmised that this change in local topography is bedrock-cored. The presence of till in the base of excavation units both sites, suggests that in this area bedrock is mantled with till, a common stratigraphic sequence in the Penobscot Valley (Thompson and Borns, 1985). The top of the till was eroded by flood events, creating a lag deposit. When interstices between the lag boulders were large enough to trap sediment, alluvial deposition created Hirundo Zones (Strata) II and III. This deposition occurred at times when higher, standing or slowly flowing water covered the site area, during flood events when water was ponded behind downstream rapids, or when the Stillwater River flowed back into Pushaw Stream, blocking outward flow.

The sediments exposed in excavations at the Young Site appear to be formed primarily from sediments contributed by overbank flooding and slopewash from the topographically higher to lower portions of the site. The presence of a well-developed spodic horizon across much of the site suggests that deposition in the topographically higher portions of the site is limited enough in time and amount to allow pedogenesis to take place. However, Borstel (1982) notes that the lower, presumably more frequently inundated, locations do not exhibit the reddened B horizon. This may represent areas where deposition is too great or too rapid to allow mobilization of iron and magnesium to form the red illuviated zone.

Diagnostic artifacts spanning the Middle Archaic through the Ceramic periods, combined with Historic period material suggests compression of over 7,000 years of geological processes into a sequence less than a meter thick at the Hirundo Site (site records). This indicates that deposition has been remarkably slow, or the area has experienced a complex history of deposition and erosion. A dense pavement of fire-cracked rock in one portion of the site suggests deflation during flood events (Sanger, pers. comm., 2005). The lack of a well-developed soil profile in other portions of the site indicates that sediments and overlying organic material have been disturbed too frequently for pedogenesis to take place, and indicates against slow deposition. However, the preservation of intact hearth features indicates that, at least in portions of the site, surface erosion during flooding has not been too extensive since the middle Holocene. The combination of artifacts from Asemblages 3,4, 5, and 6 (Late Archaic through Late Ceramic) in Zone 1 suggests some mixing, probably the result of deflation and redeposition of material on the surface, as well as bioturbation due to roots, tree throws, and burrowing animals. The combination of these observations suggests that the Hirundo site frequently undergoes flooding which removes some or all of the overlying organic material, as well as some of the underlying sediment. The position of the site near rapids precludes deposition during most floods. Only situations that create standing water, such as large flood events add sediment to this stratigraphic sequence. Minor changes in surface topography may serve to preserve sediment in one location, and allow its removal in others.

At the Young Site, archaeological evidence suggests occupation extending from the Late Archaic Laurentian tradition through the Early Ceramic period. The preservation of coarse stratigraphy, but lack of detailed stratigraphic separation, suggests that bioturbation, combined with rare, large magnitude flood events mixed the sediments just enough to smear boundaries, but not enough to completely deflate and redeposit material. The presence of a well-developed spodic horizon over much of the site also supports a scenario of limited deposition with little surface erosion. The presence of Early Ceramic period material near the surface indicates minimal deposition in the last few thousand years.

Paleogeographic and paleoenvironmental reconstructions of the Pushaw/Caribou Bog/Whitten Bog Complex by Sanger and Almquist (1999) suggest that occupations in the area were, at least in part, controlled by the timing of subaerial exposure of the site locations and the presence of wetland resources. These reconstructions show the Pushaw/Dead Stream Locality inundated, and unavailable for occupation until circa 8000 C^{14} BP when water levels fell below the Hirundo location (Figure 2.13). At this time, the adjacent Young Site was either still inundated, or present as a small, isolated island without evidence of occupation. The greenish-gray clay exposed in the base of the stratigraphic section in the lowest portion of the site may be lake clay deposited during the Early Holocene inundation of the area. The cattail marshes identified by Almquist and Sanger (1999) in proximity to the site provided rich faunal and floral resources for Early to Middle Archaic period occupants of the Hirundo Site (Figure 2.13). This Early Holocene inundation of the area explains the lack of Paleoindian or Late Paleoindian period occupation in the area.

By 6000 ^{14}C yrs BP, lower Pushaw Stream was still inundated, but the Hirundo and Young site areas were exposed. The Hirundo site shows indications of continued occupation, and the earliest occupation of the Young dates to the Laurentian tradition, circa 5,000 ^{14}C yrs BP. At this time, both sites occupied a position near the inlet to the lake formed in the lower Pushaw Stream area. The paleoenvironmental reconstructions show that both sites were adjacent to extensive cattail marshes.

Occupation at the Young Site continued through the Late Archaic and into the Early Ceramic period (Borstel, 1982), and into the Late Ceramic period at the Hirundo site (Sanger et al. 1977). Although paleogeographic and environmental reconstructions are not available for the time period spanning the Early and Middle Ceramic periods, the 1000 ^{14}C yrs BP reconstruction, roughly correlative with the Late Ceramic, shows essentially modern conditions, with a limited cattail marsh adjacent to the sites. Why the Young Sites were abandoned after the Early Ceramic period, while the Hirundo site continued to see human use is unknown. Perhaps the diminished size of the cattail marsh shown in the 1000

^{14}C yrs BP reconstruction represents floral and faunal changes that could not support occupation of two sites, or that other, richer areas were available as the landscape changed in the last 3,000 years. However, the Early Ceramic period materials at the Hirundo and Young sites, as well as locations within the Lower Pushaw locality, represent occupation during a time period generally thought have low population densities in New England (Fiedel, 2001).

In summary, the use of the Hirundo and Young Sites were tied to the Early Holocene geologic and environmental development of the region. It appears as though favorable locations at the confluence of Pushaw and Dead Streams were occupied nearly as soon as they were available, and the site desirability may have been tied to nearby resource-rich cattail marshes, as well as a position on the edge of an Early/Middle Archaic period lake. Abandonment of the Young Sites following the Early Ceramic period and continued use of the Hirundo site may be tied to changing environmental conditions as the landscape approached its modern form, or may be the result of culturally driven factors that leave no evidence in the archaeological record.

Lower Pushaw Stream Locality

The Lower Pushaw Locality encompasses the lower portion of Pushaw Stream, from the location where the stream makes an abrupt turn to the north, approximately 9 km from the confluence of Pushaw Stream and the Stillwater River, to the position where the stream cuts through a large esker, approximately 2 km before joining the Stillwater River (Figure 3.4). Five sites are included in this locality. Four, 74-152, -136, -147, -142, and –81, were investigated at the Phase II level. Site 74-148, the Bob Site was the location a Phase III excavation program.

Site 74-152. Site 74-152 (Fenton 1991) is located on the north bank of Pushaw Stream, approximately 5 km downstream from the Young and Hirundo Sites, and 1 km upstream from sites 74-136 and 74-148 (Figure 3.5). While the immediate site area is relatively level, the site is located on the flank of a till or bedrock cored hill. The site is bisected by an abandoned road and bridge site, forming an upstream and downstream component with distinctly different sedimentary settings. Two sedimentary strata were identified at the upstream site, five at the downstream location (Table 3.3).

The upstream section (Table 3.3a) shows some evidence of scouring by eddies probably created by the road/bridge remains during high flow events. The 10-20 cm-thick A horizon noted in other portions of the locality was absent, and only an organic root mat capped the sediments. The light brownish grey clay found beneath the root mat represents slackwater deposition when ponded water occurs in this location.

The downstream portion of the site (Table 3.3b) is characterized by coarser sediments, and shows no evidence of surface scouring. The coarse sediments at the base of the sequence may represent a lag deposit developed from the till. The presence of coarse and medium sand capping the gravel

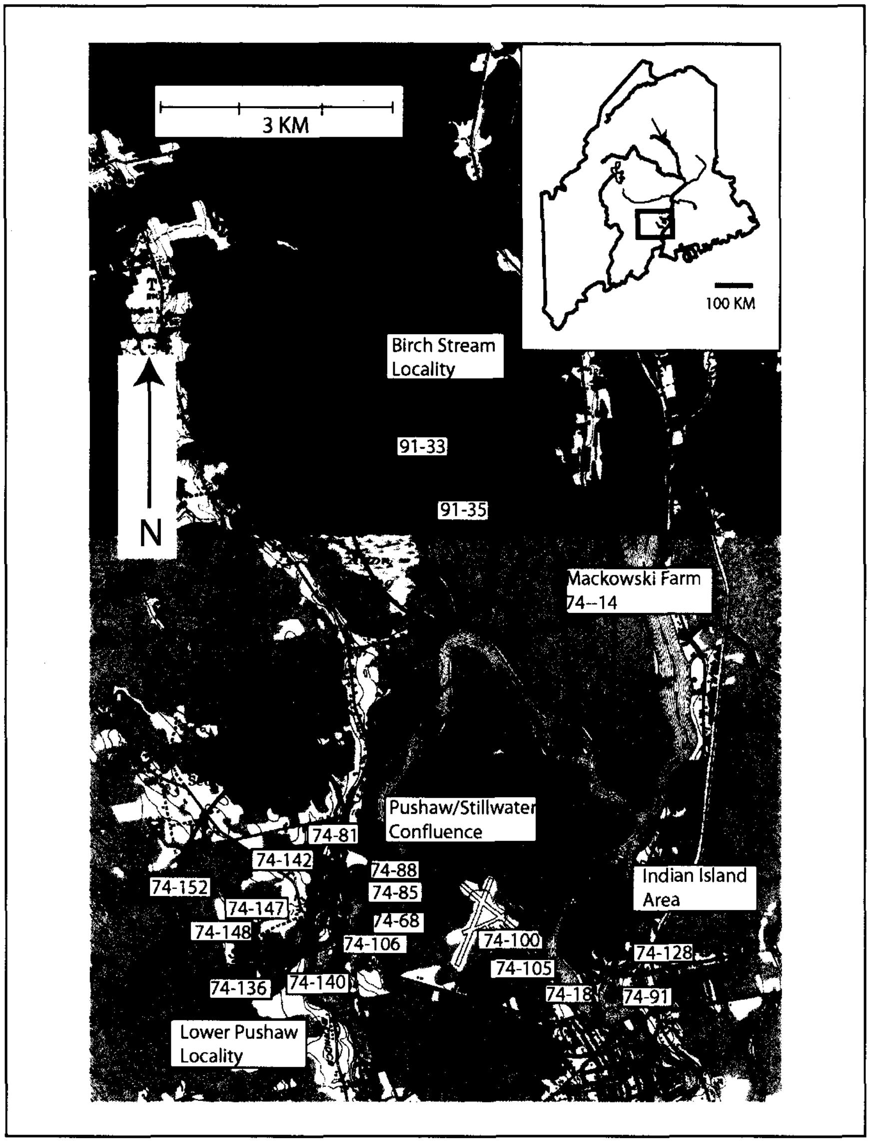


Figure 3.4: Archaeological localities in Pushaw/Stillwater/Penobscot confluence

Table 3.3a: Site 74-152 Upstream Portion Stratigraphy (from Fenton, 1991)

Stratum	Color	Sediment texture	Depth below surface (cm)	Geological Interpretation
I	Dark brown	Organics - Roots	0	Terrestrial organic material (O Horizon)
II	Light brownish grey	Clay	10?	Slackwater/overbank deposition (C Horizon)

Table 3.3b: Site 74-152 Downstream Portion Stratigraphy (from Fenton, 1991)

Stratum	Color	Sediment texture	Depth below surface (cm)	Sediment Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I	Dark Brown	Organics - Roots	0	10?		Terrestrial organic material (O Horizon)
II	7.5YR 3/2 Dark brown	Organics, fine sandy silt loam	10?-	20	circa 3050-400BP[2] (Ceramic period) circa 3 900-2800 BP [2] (Susquehanna) circa 4500-3700 BP[2] (Moorehead) circa 5500-4500 BP[2] (Laurentian)	Topsoil – Terrestrial organic material combined with fine-grained alluvial sediments (A Horizon)
III	7.5 YR 4/6 – 10YR 4/4 Strong brown to dark yellowish brown	Medium to coarse sandy loam	20	15		Alluvial sediments, sandy sediments indicate deposition by flowing water. (B Horizon)
IV	10 YR 4/4 to 2.5 Y 5/4 Dark yellowish brown to light olive brown	Medium to coarse sandy loam with gravel	35	30		Alluvial sediments, sandy sediments indicate deposition by flowing water. Gravel may be deposited, or part of lag (B Horizon)
V		Gravel and cobbles	65 to base of excavation	35+		Lag developed on top of till deposit (C Horizon)

represents deposition by flowing water. The higher flow velocities represented by these sediments may be the result of a local constriction in the stream caused by the till deposit. This constriction may be the reason bridge was located at this site.

Both sequences show some soil development, though that of the upstream portion is weaker. This may be due to the more frequent inundation of the upstream sediments, as well as the fine-grained nature of the material.

Lithic artifacts associated with the Late Archaic (Laurentian, Susquehanna, and Moorehead traditions) were recovered, as well as nondiagnostic ceramic sherds. Fenton (1991) characterizes the site as an unstratified habitation site. The mixed nature of the artifacts may be the result of bioturbation combined with erosion and redeposition during flood events.

Bob Site (74-148). The Bob Site is named for Robert Wengryznek, who brought the site to the attention of archaeological surveyors during the Phase I investigations of 1991 (Klink, 1991). In 1992, Phase II excavations took place. The site was declared eligible for the National Register of Historical Places in 1992, and Phase III investigations took place in 1993. The total area excavated at the site was 61.75m^2 (Mack et al., 2002).

The site is located on the north bank of Pushaw Stream, approximately 13 km downstream from the outlet of Pushaw Lake, and 8 km downstream from the above described Young and Hirundo Sites (Figure 3.4). It is directly across Pushaw Stream from site 74-136 (described below). The site is placed between an upstream bend in the river and a downstream bedrock-controlled narrows.

The site contains three distinct topographic areas that appear to correlate with discrete archaeological assemblages (Mack et al., 2002). Area A is located at the downstream portion of the site. To the east, the land surface slopes toward a wetland that delineates the site's downstream boundary. The upstream portion of Area A is level, and was approximately 1 m above the 1993 stream level. Area B occupies the top of a high knoll or ridge, as well as the steeply sloping hillside from the top of the knoll to the stream bank. In this location the bank is almost vertical, and appeared to be actively eroding in the period from 1991-1993. Even at low water, the shoreline at this portion of the site was extremely narrow. Area C, to the west of the knoll, slopes gently to the stream. A wetland to the west marks the upstream boundary of the site. A portion of the bank in this area is armored with large boulders, either as a lag deposit produced as a result of erosion of the underlying till, or as bank stabilization emplaced as part of the historic use of the site. The latter has been documented by historic artifacts in excavation units and an exposed historic dump.

Six geologically distinct strata were identified at the Bob Site on the basis of color, texture, grain size, and sorting (Mack et al., 2002)(Table 3.4). The sediments vary widely in grain size and sorting across the site, in response to differing localized geological conditions. Cultural disturbance is evident is some areas. Not all identified strata are present in all locations.

Table 3.4: Bob Site (74-148) Modified from Mack et al., 2002

Stratum	Area	Color	Sediment texture [1]N21E19, Area A, Upstream [2]Various locations, Area A Downstream [3]N100E9.5, Area C	Depth below surface (cm)	Sediment Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Artifacts	Geological Interpretation
I	A	Dark brown	0% gravel, 95% sand, 4% silt, 2% clay[1]	0	10-35	Modern circa 1665 -1769AD (precontact European) circa 700 ^{14}C yrs BP[2]	Ruppert shot Ceramics	Organics & alluvial sediments (O/A Horizon)
II	A	Yellowish brown	0% gravel, 91% sand, 6% silt, 3% clay[1]	15-60	10-45	(Late Ceramic period) circa 1650 ^{14}C yrs BP[2] 2280$\pm$70 ^{14}C yrs BP[1] 2920$\pm$60 ^{14}C yrs BP[1] (Early Ceramic period)	Ceramics Chipped stone tools Ceramics Chipped stone tools	Alluvial, overbank deposits (B Horizon)
III	A	Dark gray black	0% gravel, 95% sand, 4% silt, 1% clay[2]	40-75	5-45	3790$\pm$90 ^{14}C yrs BP[1]		Alluvial, overbank deposits, organics & cultural material (Ab Horizon)
III	A	Dark gray black	0% gravel, 87% sand, 9% silt, 2% clay[2]	40-75	5-45	3700$\pm$80 ^{14}C yrs BP[1] 3560$\pm$70 ^{14}C yrs BP[1] (Susquehanna) 4650$\pm$70 ^{14}C yrs BP[1]		Alluvial, overbank deposits, organics & cultural material (Ab Horizon)
III	A	Dark gray black	0% gravel, 92% sand, 7% silt, 6% clay[2]	40-75	5-45	(Laurentian)	Large to medium Otter Creek style bifaces Groundstone ulu	Alluvial, overbank deposits, organics & cultural material (Ab Horizon)

IV	A	Olive brown	0% gravel, 65% sand, 24% silt, 11% clay[1]	30-80	15-25			Alluvial, overbank deposits (Bb Horizon)
	A	Olive brown	0% gravel, 87% sand, 12% silt, 1% clay[2]	30-80	15-25			Alluvial, overbank deposits (Bb Horizon)
V	A	Blue gray	0% gravel, 77% sand, 17% silt, 6% clay[1]	50-110+	30+			Glaciomarine or lacustrine sediments (C Horizon)
VI	A	Olive		85-95+	10+			Till (C Horizon)
I	B	Dark brown		0-20	10-20			Organics & alluvial sediments (O/A Horizon)
II	B	Yellowish brown		10-50	25-30			Alluvial, overbank deposits (B Horizon)
I	C	Dark brown	44% gravel, 20% sand, 16% silt, 20% clay[3]	15-30	15-30	<3,000 ^{14}C yrs BP[2] (Early Ceramic period)	Cache of scrapers and retouched flakes	Organics & alluvial sediments (O/A Horizon)
II	C	Yellowish brown	66% gravel, 20% sand, 5% silt, 9% clay[3]	15-70	15-55	>3,000 ^{14}C yrs BP[2]		Alluvial, overbank deposits (B Horizon)
	B	Olive		50-60+	10+			Till (C Horizon)
	C	Olive	47% gravel, 36% sand, 10% silt, 7% clay[3]	40-50+	10+			Till (C Horizon)

Stratum I, the uppermost stratigraphic layer occurred in all portions of the site. Stratum I included an organic-rich upper layer, as well as a lower portion with significantly higher mineral soil components. Stratum I is dark brown in color, and represents the O and A horizons of a soil profile. In Areas A and B, it is described as a fine sand with silt, but in area C, it is composed of coarser sand with silt and gravel. It is thickest in the downstream portion of area, and thinnest on the top of the knoll.

Stratum II underlies Stratum I across the site, and is equivalent to the B horizon of soil science terminology. It is generally yellowish brown in color, but also appears as dark yellowish brown or grayish yellow brown. In a few locations, Stratum II is strong brown to orange in color. An ashy, white elluviated E horizon was associated with Stratum II in two areas on either side of the knoll, indicating formation of a spodosol, and limited alluvial deposition. The texture of Stratum II varied with location. In the downstream portion of Area A, Stratum II is composed of fine to very fine sand with silt. Little or no gravel is noted in the deposit. However, in the upstream portion of Area A, the relatively fine sediments of Stratum II become coarser with depth, and include dense gravel and cobbles. In Area B, Stratum II resembled that found in the upstream portion of Area A. In Area C, Stratum II was generally coarser grained, coarsening with depth and grading into the underlying till (Stratum VI). Cultural disturbance, as well as bioturbation, was the greatest in this stratum in the downstream portion of Area A.

Strata III, IV, and V occur only in the downstream portion of Area A. Stratum III is dark gray to black or reddish in color, and fine-grained in texture. Stratum IV is also fine grained, but lighter in color, primarily olive brown. In some parts of the excavation, Stratum III appeared to be composed of Stratum III material mixed with sediments from the underlying Stratum IV. Originally thought to be a discrete depositional layer, textural analysis of the sediments demonstrated that Stratum III and the underlying Stratum IV differed primarily in color. This finding, combined with the large number of artifacts associated with Stratum III, suggests that geologically these deposits may be one sedimentary layer sharing a similar depositional history. Stratum III was colored by the presence of culturally incorporated charcoal, as well as organic material from a pre-existing forest floor. Elevated total phosphate values in Stratum III also suggest human and natural additions of organic material to the sediments. Stratum V is composed of hard, compact, blue gray clay, either of glaciomarine or lacustrine origin.

Six cultural zones are identified at the Bob Site (Mack et al. 2002). These zones refer to human activities and artifacts associated with one or more stratum. The combination of bioturbation and reoccupation without significant accumulations of sediment created stratigraphic units that represent a wide time span. Like the Young site, the archaeological material at the Bob site is coarsely stratified, with older material lower in the sequence, but without cultural components occurring in association with discrete stratigraphic units.

The oldest cultural component, Zone 5 is identified on the basis of large to medium side-notched (Otter Creek) bifaces representing the Laurentian tradition (Mack et al., 2002). Several of these bifaces were recovered from the base of Stratum III, and are associated with charcoal radiocarbon dated at 4650±70 ^{14}C yrs BP. Other Otter Creek Points have been found on the stream bank, presumably eroded from the site. Other artifacts correlative with Zone 5 are a ground slate ulu found during the Phase I survey and a plummet found at the base of Stratum III.

Zone 4 represents the Susquehanna tradition (Mack et al., 2002), and appears to occupy the upper portions of Stratum III. Radiocarbon dates from charcoal from a hearth in this portion of Stratum III returned a date of 3560±70 ^{14}C yrs BP. Other charcoal samples from the upper portion of Stratum III dated at 3790±90 ^{14}C yrs BP and 3700±80 ^{14}C yrs BP. These dates imply a Susquehanna presence, but no diagnostic artifacts were found in association. In addition, the Susquehanna dates come from the same strata as diagnostic Laurentian tradition Otter Creek bifaces, implying that the deposit represents approximately 1,000 years of geologic processes.

Zone 3 is defined primarily by the presence of Early Ceramic period ceramics in association with features representing hearths and activity areas in strata I and II in Area A (Mack et al., 2002). Chipped stone artifacts are also a large part of the Zone 3 artifact suite. The oldest Zone 3 date is 2920±60 ^{14}C yrs BP from hearth charcoal with Early Ceramic period pottery, placing the chronological beginning of Zone 3 circa 3000 ^{14}C yrs BP. A second charcoal sample from another hearth returned a date of 2280$\pm$70 ^{14}C yrs BP, also within the range of the earliest portion of the Ceramic period. Pottery associated with the later portion of the Early Ceramic Period is not found in association with dateable material, but correlation with other sites in the region suggests Zone 3 extends to circa 1650 ^{14}C yrs BP.

Based on associated ceramics, Zone 2 represents the time period from 1650 BP to 700 ^{14}C yrs BP, the Middle Ceramic to the Late Ceramic period (Mack et al., 2002). All Zone 2 artifacts occur in strata I and II, and all Zone 2 features occur in the downstream portion of Area A. While pottery dominates the Zone 2 collection, a wide range of stone tools is attributed to this component. The youngest artifact from this zone is a pre-European ceramic vessel, dated to circa 700 ^{14}C yrs BP.

Zone 1 represents Historic use of the site (Mack et al., 2002). The oldest artifact from this zone is metallic Rupert shot, manufactured 1665 AD –1769 AD. This material and a clay pipe stem probably relate to Native use of European goods, prior to European contact in the area. Other historic material dates to the 19th and 20th centuries.

Zone 6 is found only in Area C, and consists of a cache of scrapers and retouched flakes at the interface of Strata I and II (Mack et al., 2002). No datable material or diagnostic artifacts were found with the cache. The artifacts are unusually large for their type. They are twice as long and almost weigh almost twice as much as typical Ceramic period scrapers from the region (Mack et al., 2002). Similar specimens are described from the Early Ceramic period of New

Brunswick, dated to circa 3000 BP (Blair, 2000). On the basis of this evidence, the cache is tentatively correlated with the Early Ceramic Period.

The sedimentary and archaeological sequence at the Bob Site represents over 4,000 years of periodic human use, with the Ceramic period occupations being the most extensive. The sediments making up these deposits were deposited in a variety of processes, dependent on location. Fluvial action has eroded the upstream portion of the site, Area C, removing the finer sediments and creating the coarsest deposits found at the site. Higher water velocities created by the constriction in the stream at this location accentuated this process. The primary geologic process in Area B appears to be erosion, as evidenced by the steep bank in this portion of the site. Local topography focuses the strongest stream flow on this portion of the bank. Area A receives some sediment from slope wash from the knoll in Area B, but most of the sediment accumulated in this portion of the site is the result of overbank sedimentation during high flood events. Standing approximately 1 m above modern summer stream level, this location was probably a terrace situated above the floodplain prior to dam construction. In such an elevated position, it would receive sediment only during larger floods rather nearly yearly accumulation as takes place on the flood plain. The presence of Stratum III suggests a period of reduced sedimentation and erosion that permitted the accumulation of terrestrial organic remains as well as cultural material. The overlying sediments attest to a change in local conditions that deposited fine-grained alluvial deposits during floods.

Site 74-136. Site 74-136 (Fenton, 1992) is located on the south bank of Pushaw Stream on a low terrace adjacent to Pushaw Stream (Figure 3.5). Due to a rise in local water levels associated with the Milford and Gilman Falls dams, this area is now included in the current floodplain of the stream. A small stream forms the eastern boundary of the site, while small sphagnum bog is located to the south. A bedrock ridge composed of the Vassalboro Formation forms the western edge of the site. The original site extent may have been as large as 4300 m^2 and potentially extends beneath the adjacent bog, although testing did not take place in this area. As much as 50 m^2 may have been lost to bank erosion (Fenton, 1992). The site is generally level, with minor variations in surface topography. A small levee, less than 0.5 m high, is located along the riverbank, and is has formed as the combined result of overbank and ice-push deposition.

Six stratigraphic units have been identified at this site (Table 3.5). Stratum I represents the uppermost soil layer, the A horizon, and is composed of a combination of terrestrial organic material and alluvial sediments. Stratum II and V, differ primarily in color, with both being fine-grained. Stratum III was slightly coarser-grained, and occurred as a lens within Stratum II. Stratum IV is a cultural deposit, and appears intrusive into Stratum V. Stratum VI forms the base of the observed section, and is composed of clay. In many cases, contacts between units were gradational. Analysis of the vertical and horizontal provenience of bifacially worked tools indicates that the site has no "discrete intact cultural components" (Fenton, 1991:43). An Otter Creek Point (5,000 – 4200 ^{14}C yrs BP) and a biface with Susquehanna affinities

Table 3.5: Site 74-136 Stratigraphy (from Fenton, 1991)

Stratum	Color	Sediment Texture	Depth below surface (cm)	Sediment Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Artifacts	Geological Interpretation
I	10YR3/3 Dark brown	Organics with silty sand	0	10-20	Modern[2] circa 1350-400 BP[2] (Later Ceramic period)	Ceramics	Organic rich accumulation – forest floor (O Horizon)
II	10 YR5/6, 2.5Y5/4,5Y6/2 Light olive brown mottled with reddish brown and light olive gray	Silty clay loam	20	40	circa 2150-1350 BP[2] (Middle Ceramic period) circa 3050-2150 ^{14}C yrs BP[2] (Early Ceramic period)	Ceramics Ceramics	Slackwater/overbank deposition Mottling from variations in water table (C Horizon)
III	10 /YR5/6, 2.5Y5/4, 5Y6/2 Yellowish brown mottled with reddish brown and light olive gray	Sandy silty clay loam	Lens within stratum ii	10-15			Flood deposit (C Horizon)
IV	2.5Y 5/4, 7.5YR 5/8, 2.5YR4/8 Reddish brown, strong brown, red	Silty clay loam with charcoal Flecks, ochre (?)	60	10	circa 3900-2800 ^{14}C yrs BP[2] (Susquehanna) circa 5500-4500 ^{14}C yrs BP[2] (Laurentian)	Biface Otter Creek biface	Feature (Cultural horizon)
V	10YR5/6, 2.5Y5/4, 5Y6/2 Yellowish brown mottled with reddish brown and light olive gray	Silty clay loam	70	15			Slackwater/overbank deposition Mottling from variations in water table (C Horizon)

VI	5Y6/2, 10YR5/6 Light olive gray mottled with yellowish brown	Clay	75 to 90 (base)				Slackwater/overbank deposition Mottling from variations in water table (C Horizon)

(3,800-3,200 ^{14}C yrs BP), in a mixed stratigraphic setting represents the Late Archaic period. Early Ceramic period (3,050-2,150 ^{14}C yrs BP) sherds were also found. Middle Ceramic period (2150-1350 ^{14}C yrs BP) pottery sherds and Late Ceramic period (1350-400 ^{14}C yrs BP) sheds appear to be in correct stratigraphic order, with the older material found between 20-30 cm below the surface, and the younger at 10 to 20 cm below surface (Fenton, 1991).

The fine-grained nature of the sediments at this site suggest deposition from slow moving or standing water, perhaps as slackwater deposition as flooding in the Stillwater River caused tributary drainages to fill during flood events. The diagnostic Otter Creek point places timing of the deposition of sediments at between 5,500 and 4500 ^{14}C yrs BP years ago, although at the adjacent Bob Site, this artifact is associated with a radiocarbon date of 4650 ± 70 ^{14}C yrs BP (Mack et al., 2002). The stratigraphically mixed nature of the artifacts indicates mixing by some combination of bioturbation and/or sediment removal and redeposition. The Middle and Late Ceramic period stratigraphy may represent more uniform conditions within the last 2,000 years, or a decrease in erosion of the terrace surface as sedimentation increased its elevation above stream level.

In a streamside location, the lack of a well-developed soil profile is indicative of a very young or wetland setting (Buol et al., 1997). In the case of site 74-136, this is attributed to the modern floodplain setting. The presence of archaeological material dating to the Middle Holocene suggests that the sediments have been in place for sufficient time for soil formation (see Young

Site description). However, the mottling noted in the strata descriptions is characteristic of waterlogged conditions (Brady and Weil, 1996), consistent with the site's location on a modern floodplain.

Site 74-147. Site 74-147 is located on the north bank of Pushshaw Stream, near sites 73-136, 74-140, and 74-148 (Figure 3.4). The site occupies a generally level area, 70m long, along the stream bank, and extends 30 m inland. An outcrop of the Vassalboro Formation occurs streamside at the downstream portion of the site, and slopes into the water. At pre-dam water levels, this bedrock outcrop may have been the site of a rapids or waterfall (Mack et al., 2002).

Three distinct stratigraphic units have been identified at site 74-147 (Table 3.6). All contain fine-grained sediment. Stratum I is composed primarily of organic material with some mineral constituents, and is the A soil horizon. Stratum II is predominately dark yellowish brown, but local reddening of the soil may be related to the development of the B horizon. Both Strata II and III were deposited in slowly flowing or ponded water.

Artifacts of Archaic and Ceramic periods were found in a mixed context. Recovered ceramics are not diagnostic. The mixing of artifacts spanning a several thousand-year time period indicates either extensive bioturbation of cultural deposits, and/or significant erosion and redeposition of artifacts during flood events. The presence of the bedrock outcrop may produce local turbulence

Table 3.6: Site 74-147 Stratigraphy (from Fenton, 1991)

<table>
<tr><th>Stratum</th><th>Color</th><th>Sediment texture</th><th>Depth below surface (cm)</th><th>Sediment Thickness (cm)</th><th>Dates
[1]Radiocarbon
[2]Diagnostic Artifact</th><th>Artifacts</th><th>Geological Interpretation</th></tr>
<tr><td>I</td><td>Dark brown (?)</td><td>Sandy silt loam
High organic content</td><td>0</td><td>10?</td><td rowspan="3">Modern to Late Archaic

circa 6000 BP[2]</td><td rowspan="3">Plummet</td><td>Organic rich soil horizon (A)</td></tr>
<tr><td>II</td><td>Dark yellowish brown
Local reddening</td><td>Silt loam</td><td>10(?)</td><td>30</td><td>Slackwater/overbank deposition
Reddening = B horizon (?)</td></tr>
<tr><td>III</td><td>Light olive brown</td><td>Silt-clay</td><td>40</td><td>40+</td><td>Slackwater/overbank deposition</td></tr>
</table>

during high flow events that would create local scouring of deposits. Back flow from the Stillwater River during large floods would then create a low flow/ponded situation conducive to fine-grained deposition.

Site 74-140. Site 74-140 (Fenton, 1991) is located on the southern bank of Pushaw Stream, just before the stream channel swings to the north to flow along an esker (Figure 3.4). Although currently on the floodplain of the modern Pushaw Stream, it occupies a small portion of what was the first terrace adjacent to the stream prior to dam construction. Phase II excavations were recommended for this site due to the number of redeposited artifacts discovered on overbank deposits during the Phase I survey. However, flooding during the 1991 field season precluded excavations. The following site description is based on notes from the Phase I shovel test pits dug in 1990.

Four strata were recognized at site 74-140 (Table 3.7). All deposits were composed of fine-grained sediments, however Stratum I was composed primarily of organic material, and represents the A soil horizon. The fine grain size of these strata is suggestive of deposition in standing or slowly flowing water. Stratum IV may also have been deposited as the result of deposition in ponded water, but the abrupt color change suggests a different mode of deposition. Stratum IV may be composed of lacustrine sediments formed in the extensive Early Holocene lake in the area, or represent the top of the Late Pleistocene glaciomarine sediments.

Table 3.7: 74-140 Site Sratigraphy (from Fenton, 1991)

Stratum	Color	Sediment texture	Depth below surface (cm)	Sediment Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Artifacts	Geological Interpretation
I	Dark brown	Organics with silty sand	0	10	2800-400 ^{14}C yrs BP[2] (Ceramic Period)	Ceramics	Organic rich soil horizon (O/A Horizon)
II	Light brown	Silty sand	10	15	2800-400 ^{14}C yrs BP[2] (Ceramic Period)	Ceramics	Slackwater/overbank deposition Mottling from variations in water table (B Horizon)
III	Light brown with darker brown and orange mottling	Silty sand	25	15	2800-400 ^{14}C yrs BP[2] (Ceramic Period)	Ceramics	Slackwater/overbank deposition Mottling from variations in water table (B Horizon)
IV	Whitish gray with orange mottling	Sandy silt	40	60+	circa 6,00-3,000 ^{14}C yrs BP[2] Late Archaic	Groundstone fragment	Slackwater/overbank deposition (?) Lacustrine (?) Glaciomarine (?) Mottling from variations in water table (C Horizon)

No diagnostic artifacts were recovered. However, groundstone fragments suggest an Archaic period occupation. Without diagnostic artifacts or radiocarbon dating, little can be said regarding the age of the sediments, except that they appear to have been accumulating since approximately 4,000 years ago.

Site 74-142. Site 74-142 (Fenton 1991) is situated on a low terrace on the west bank of Pushaw Stream, 2 km from the confluence of Pushaw Stream and the Stillwater River (Figure 3.4). The site is adjacent to the flank of a large esker, and is located immediately upstream from a sharp bend in Pushaw Stream where its flows through a break in the esker and joins the Stillwater River.

Four distinct strata were identified at the site (Table 3.8). Stratum I represents the O horizon, or surface, organic-rich layer. Stratum II is the underlying A horizon composed of decomposed organic material combined with alluvial sediments. Stratum III is composed of light olive brown, fine-grained alluvial sediments. Strata IIIa and IIIb are found at the top of Stratum III and are associated with cultural activity at the site. Stratum IIIa is dark brown in color, while Stratum IIIb is yellowish brown. Stratum IV formed the base of excavations, and is light brownish gray clay Two distinct occupations were recognized at the site. Undiagnostic pottery sherds were encountered throughout the stratigraphic sequence, and may be related to two hearth features. Biface fragments and unifacial scrapers.

Table 3.8: Site 74-142 Stratigraphy (From Fenton, 1991)

Stratum	Color	Sediment Texture	Depth below surface (cm)	Sediment Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Artifacts	Geological Interpretation
I	10YR2/2 Dark Brown	Silty Loam with roots, twigs, and leaf mold	0	15			Terrestrial organic material combined with fine-grained alluvial sediments (O Horizon)
II	10YR4/3 Dark brown	Fine silt	15	15	circa 3050-400 ^{14}C yrs BP[2] (Ceramic period)	Ceramics	Terrestrial organic material combined with fine-grained alluvial sediments (A Horizon)
III	2.5YR 5/3 Light olive brown	Sandy silt	30	20			Fine-grained alluvial sediments (C Horizon)
IIIa	7.5YR4/4 Darker brown	Sandy silt	within Stratum III	10	circa 5000-3050 ^{14}C yrs BP[2] (Late Archaic period)	Plummet Groundstone fragment	Cultural material
IIIb	10YR 5/6 yellowish brown	Sandy silt	within Stratum III	10			Associated with cultural material
IV	2.5YR6/2 light brownish gray clay	Clay	50	50+			Glaciomarine or lacustrine clay (C_1 Horizon)

may also be associated with the Ceramic component. A possible Late Archaic presence is identified on the basis of a plummet and a groundstone fragment.

Due to the mixed archaeological sequence, it is difficult to assign a time of formation to the upper five strata. The basal clay, originally interpreted as glaciomarine clay (Fenton 1991), predates occupation, providing a minimum date correlative with the late Archaic, or circa 5000 ^{14}C yrs BP. The mixing of the upper strata indicates bioturbation and/or deflation and redeposition during flood events. There is little evidence of soil formation, other than the development of an A horizon by the combination of organic material with underlying alluvial sediments. This indicates that sedimentation and/or mixing is too rapid for pedogenesis to take place.

Site 74-81. Site 74-81 (Belcher and Sanger, 1988a) is located on the west bank of Pushaw Stream, near the confluence of the stream and the Stillwater River (Figure 3.4). It is approximately 500 m upstream from the Route 43 bridge crossing over Pushaw Stream. The site and surrounding areas are primarily low lying and dominated by marsh. Bedrock outcrops near the site, and scattered ledges are exposed at the edge of Pushaw Stream. Survey of the area in 1988 noted extensive fluvial erosion and ice scour related to the large flood of the previous April.

Four, fine-grained strata were identified at the site (Table 3.9). Stratum I is composed of a dark brown sandy silt, and differs from the underlying Stratum II only in color, presumably from the inclusion of terrestrial organic material. Stratum III is similar to Stratum II in texture and color, with the exception of

Table 3.9: Site 74-81 Stratigraphy (from Fenton 1991)

Stratum	Color	Sediment Texture	Depth below surface (cm)	Sediment Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I	Dark brown	Sandy silt	0	20	20th to 19th century[2]	Terrestrial organic material combined with fine-grained alluvial sediments (A Horizon)
II	Yellow brown	Silt	20	15	2150-700 BP[2]	Alluvial sediments (B horizon?)
III	Yellow brown (with mottling)	Silt	35	10	Ceramics (Middle to late Ceramic period) circa 5000-3050 BP[2] (Late Archaic period)	Alluvial sediments (C horizon?)
IV	Dark brown	Silty clay	45	35+		Alluvial sediments, laucustrine? glaciomarine sediments (C horizon?)

Stratum III having iron mottling, an indication of being subjected to a fluctuating ground water table. Stratum IV is composed of dark brown, silty clay, and appears as a discontinuous layer between Strata II and III.

Archaeological material recovered at Site 74-18 indicates a Late Archaic occupation. Pottery fragments found at the site can only be assigned to the Middle or Late Ceramic, while Historic period material represent 19th and 20th century use of the site.

The mixed sediments at the site make correlation between stratigraphic units and archaeological artifacts difficult. The site survey noted extensive bioturbation by roots, in addition to potential fluvial erosion and redeposition of material. The fine nature of the sediments suggests deposition in slowly flowing or ponded water. The location of this site near the confluence of Pushaw Stream and the Stillwater River indicates that backflow from the river during high flow events may frequently pond water in this area. The darker brown, Stratum IV may be a buried soil horizon, or be related to cultural activity that added charcoal and organic material to the soil, creating a darker layer.

Geoarchaeology of the Lower Pushaw Locality. The Lower Pushaw Locality experienced dramatic geological and environmental changes that shaped human use of the region through varying site attributes and resource availability. With the exception of Area B at site 74-148 (Bob Site), which is located on a knoll, all the sites in the locality are composed of alluvial sediments.

At some sites diagnostic artifacts, sometimes combined with radiocarbon dates provides a chronology for stratigraphic sequences. In other locations, mixed stratigraphy or a lack of diagnostic artifacts limited interpretations. In the discussion below, site-specific information from individual excavations is combined with regional geological, vegetational, and climatic information to investigate the physical factors that influenced human decisions relative to occupation areas and resource procurement in this area.

The earliest occupation noted in the Lower Pushaw Locality is the Laurentian period, noted at sites 74-152, -136, -140, -142, and -148. Occupations of this time period are noted primarlily on the basis of diagnostic, Otter Creek projectile points, but are associated with a radiocarbon age of 4650±70 ^{14}C yrs BP at the Bob Site, 74-148. The remainder of the Late Archaic is represented by Susquehanna diagnostic material at sites 74-152, -136, -147, -140, -142, and –148. The Bob Site, 74-148, also produced radiocarbon dates of 3560±70 ^{14}C yrs BP and 3700±80 ^{14}C yrs BP from charcoal associated with Susquehanna artifacts. The Ceramic period is well represented in the Lower Pushaw Locality. Early Ceramic period material was recovered from the Bob Site, 74-148, as well as charcoal that returned dates of 2280±70 ^{14}C yrs BP and 2920±60 ^{14}C yrs BP. Early Ceramic diagnostic material was also found at site 74-136. Middle Ceramic period material was discovered at sites 74-136 and 74-81, and Late Ceramic pottery was recovered at the Bob site, 74-148, 74-136, and 74-81. Sites 74-140 and 74-142 had undifferentiated Ceramic components.

Examination of the occupation ages for the Lower Pushaw Locality shows a strong Late Archaic through Ceramic period useage with no evidence of Early or Middle Archaic occupation. The Early/Middle Archaic component at the

Hirundo site, as well as others in the Penobscot Valley, Blackman Stream and Gilman Falls (both discussed later) and within the region, such as Brigham and Sharrow on the Piscataquis River, and tributary of the Penobscot, demonstrates that people were in the area. This absence of Early and Middle Archaic sites in the Lower Pushaw Locality suggests that this area either did not preserve a record of occupation at this time, or people chose not to utilize the area.

Paleogeographic reconstructions of the Pushaw Lake/Caribou Bog/Whitten Bog Complex (Almquist and Sanger, 1995,1999) (Figure 2.13) suggest that environmental factors strongly influenced occupation of the locality. From 10,000 BP to 8000 ^{14}C yrs BP open water occupied much of the area that now forms Pushaw Lake and its associated bogs. By 8000 ^{14}C yrs BP the lake began to approach its present day form, but much of the southern portion of Caribou Bog remained open water, as did the eastern, lower portion of Pushaw Stream. As noted above, the Hirundo site was subaerially exposed, and occupied, circa 7,000 ^{14}C yrs BP, but much of the local landscape was still inundated. While no paleogeographic or environmental reconstructions are available for the Late Archaic/Early-Middle Ceramic time period, the widespread occupation of the Lower Pushaw Locality sites during the Laurentian period at suggests that Pushaw Stream had nearly reached its present day form circa 5000 ^{14}C yrs BP.

Use of the area through the Late Archaic and Ceramic periods indicates a resource base attractive to humans. Early Ceramic period sites are thought to be relatively rare in New England (Fiedel, 2001), but two, 74-136 and the Bob Site, 74-148 are noted in the Lower Pushaw Locality.

Summary. In summary, the linkage between environment and human occupation are well illustrated by the close connection between timing of landscape change and occupation at archaeological sites in the Pushaw Locality. The lack of Paleoindian and Late Paleoindian sites are attributed to a lack of subaerially exposed locations within the stream valley. This suggests, however, that suitable occupation locations for during these time periods exist on the Early Holocene lakeshores. The Hirundo site appears to have been occupied close to the time of exposure of the site, and may have been situated to take advantage of developing marsh habitat. The occupation of the Hirundo and Young sites took place at the inlet to a lake near a broad expanse of rich wetland, as the area was exposed by falling water levels. The lower Pushaw Stream valley was occupied as water levels dropped and inhabitants took advantage of streamside environments. Not only does this analysis help to explain the pattern of aboriginal settlement in the area, it suggests previously unrecognized areas of high archaeological potential for Early Holocene occupation.

Pushaw/Stillwater Confluence Locality

Geomorphology and Geology. As noted previously, Pushaw Stream drains approximately 685 km^2 of central Maine (Barrows and Babb, 1912), and flows approximately 65 km through several lakes, ponds, and a large wetland system before entering the Stillwater River, a branch of the Penobscot River (Figure 3.2). The stream is located in a region of moderate relief (approx 30 m) formed by bedrock ridges mantled with till and overlain by fine-grained glaciomarine sediment (Osberg et al., 1985; Thompson and Borns, 1985).

The Pushaw/Stillwater Confluence locality is a geologically complicated area. Lower Pushaw Stream flows generally northwest to southeast before turning abruptly to the north flowing against the regional drainage pattern for 1.2 km along the flank of a large esker. The stream then flows through a 6 m high break in the esker, and turns to the south, following the east side of the feature for .7 km before entering the Stillwater River.

The Stillwater is composed of two channels that break away from the Penobscot River between 3 and 4 km to the east of Gilman Falls to flow to the northwest for 2 and 3 kilometers before following the regional south and southeast drainage pattern. (Figure 2.1) The Late Pleistocene and Early Holocene development of this area is not well understood, and the number of abandoned channels and meander scars immediately upstream of this area suggest a complex post glacial history.

Immediately to the south of the confluence, a resistant bedrock ridge composed of the Silurian/Ordovician Vassalboro Formation (Osberg, et al., 1985) is oriented perpendicular to the direction of the river. This bedrock outcrop forms a 0.5 km long sequence of rapids and falls, known as Gilman Falls. Gilman Falls is part of a 25 km long series of waterfalls and rapids that extends from the Old Town area downstream to Bangor (see Chapter 2, Regional Setting, Geology and Geomorphology, p. 12).

The bedrock of the Pushaw/Stillwater confluence area is composed of a low grade, chlorite-rich metasedimentary sequence of granofels, phyllite, and quartzite (Sanger et al., 2001). Bedrock cleavage in the vicinity of the falls dips steeply between 55° and 65°, intersecting bedding planes at 40° to 90°. In some locations, this combination of cleavage and bedding planes causes the rock to break into long, thin fragments with parallelogram-shaped cross-sections. This combination of lithology and local structural geology created a lithic resource exploited by Middle Archaic period occupants of the region.

Presently a dam extends across the Stillwater River, pinned to the bedrock on either side of the channel and on the south end of Gilman Falls Island, located on the upstream side of the falls (Figure 3.4). Construction of this feature is responsible for increased bank erosion due to raised water levels and ice erosion during the spring freshet.

History of Archaeological Excavations in the Pushaw/Stillwater Confluence Area. The archaeology of the Pushaw confluence area was investigated as part of a cultural resource assessment related to relicensing of the Milford Reservoir, a headpond created by a series of dams on the Penobscot and Stillwater Rivers. Until this time, the area had not been systematically surveyed, although earlier excavations had been carried out at the Hirundo and Young sites in the Pushaw locality. This survey noted the presence of a large number of previously unidentified archaeological sites in the area.

Site 74-106 (Gilman Falls). The Gilman Falls Site (Sanger et al. 2001; Sanger et al., 1994) is located on the north end of the island at the upstream portion of Gilman Falls (Figure 3.4). The island is located at the confluence of Pushaw Stream and the Stillwater River. The site is composed of approximately 80-200 cm of alluvial sediments deposited on the metasedimentary rocks of the Kenduskeag Unit of the Vassalboro Formation (Griffen 1976a, 1976b).

The sedimentary sequence at the site is characterized as fine-grained alluvial sediments over stratified gravel and sand or polished bedrock (Table 3.10). Nine distinct strata are identified on the basis of sediment grain size and color. While some individual sedimentary units vary in thickness throughout the excavated area, most strata are continuous across the site. Strata I, Ia, and IIb are slightly more clay-rich than the more sand-rich lower Strata III, VI, and VII. This fining upward sequence is common in floodplain sediments (Reinck and Singh, 1980). Small amounts of gravel occur in Strata III, IIIa, IIIb, and VI, as small (5x5x2 cm) lenses or layers of small gravel (0.5 cm in diameter). No artifacts, charcoal, or debitage are associated with these gravel deposits. The transition from stratified, coarse-grained material or bedrock to massive, fine-grained deposits is abrupt across the base of the entire excavation.

Bright to faint red, laterally extensive horizons are encountered at several

Table 3.10: Gilman Falls Site (74-106) Stratigraphy (From Sanger et al., 1994)

Stratum	Color	Sediment Texture	Depth below surface (cm)	Thickness (cm)	Zone	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I	10YR5/3 Brown	31%sand,33%silt,36% clay (nonorganic portion)	0-25	5-25		Circa 5000-1350 ^{14}C yrs BP[2] Late Archaic to Middle Ceramic	Terrestrial organic material combined with fine-grained alluvial sediments (A Horizon)
IIa	5YR5/6 Yellowish red	28%sand,38%silt,35% clay	0-55	0-20	1		Illuviated Fe and Mg in alluvial sediments. (Bs Horizon)
IIb	10YR 6/4 Yellowish brown	30%sand,39%silt,31% clay		5-40		3590±150 ^{14}C yrs BP (Susquehanna)	Alluvial sediments (C Horizon)
IIc	5YR5/8 Yellowish red	Fine sand, silt, and clay		5-40			Associated with tree roots
IId	2.5YN8 White	Fine sand, silt, and clay		0-10			Elluviated (leached) horizon, & alluvial deposition (E Horizon)
B Horizon	5YR4/6 Yellowish red	Fine sand, silt, and clay with minor gravel		0-10	2		Buried illuviated Fe and Mg in alluvial sediments. (Bs_1 Horizon)
IIIa	10YR5/4 Yellowish brown	Fine sand, silt, and clay with minor gravel		0-40			Alluvial sediments (B_1 Horizon)
IIIb	7.5YR6/4 Light brown	Fine sand, silt, and clay with minor gravel		0-20			Alluvial sediments (B_1 Horizon)
III (upper)	2.5Y4/4 Olive brown	2% gravel, 43%sand, 29%silt, 27% clay		0-30		4140±130 BP, 4160±70 ^{14}C yrs BP 4180±80 BP, 4425±125 ^{14}C yrs BP	Alluvial sediments (C_1 Horizon)

						5950 ± 165 ^{14}C yrs BP (Laurentian)	
III (lower)						6290 ± 160 BP, 6380 ± 65 ^{14}C yrs BP, 6840 ± 50 ^{14}C yrs BP, 7285 ± 80 ^{14}C yrs BP (Middle Archaic)	
B Horizon	5YR4/6 Yellowish red	2%gravel,38%sand,30 %silt, 31%clay		0-10			Buried illuviated Fe and Mg in colluvial & alluvial sediments. (Bs_2 Horizon)
IV	10YR5/4 Light brown	Fine sand, silt, and clay		0-20	3		Alluvial sediments (B_2 Horizon)
VI	2.5YR4/4 Olive Brown	1%gravel,48%sand,27 %silt, 25%clay		0-50			Alluvial sediment (C_2 Horizon)
VII	10YR5/2 Grayish brown	56% sand,24%silt, 21%clay		0-25			Bedded sand, silt, and clay (C_3 Horizon)
VIII	2.5YR4/4 Reddish brown	Gravel, coarse sand, medium sand		0-35			Bedded gravel and sand (C_3 Horizon)

elevations throughout the site excavation. These horizons occur immediately below the modern A Horizon (Stratum I), 60-70 cm below the surface (below Stratum II), and 100-120 cm below the surface (below Stratum III), and range from distinct, sharply bounded layers 5-10 cm thick, to broad, diffuse bands 15-30 cm thick. Texturally, they are identical to the surrounding sediments. On the basis of color, lateral extent, and fine-grained texture, these horizons are identified as spodosols (Fernandez and Osher, personal communication, 2000; Brady and Weil, 1996:87-88; Callum, 1995). While not continuous across the site, they are differentiated by stratigraphic position and associated artifacts.

The Gilman Falls site has an extensive Middle Archaic component, as well as material representative of a much smaller Early to Middle Ceramic period occupation. Three stratigraphic zones were identified on the basis of stratigraphy and artifacts. Zone 1 encompasses Strata I and IIa, and shows evidence of disturbance, primarily by tree roots. Archaeological material in Zone 1 ranges in age from Late Archaic through Middle Ceramic periods. Zone 2 includes Stratum IIb and the upper portion of Stratum III. Radiocarbon dates from this zone range from circa 3900 ^{14}C yrs BP at the top to circa 6000 ^{14}C yrs BP at the base. However, most of the dates cluster between circa 4000 to 4400 ^{14}C yrs BP. Artifacts representing the Laurentian and the Susquehanna traditions are found in Zone 2. Zone 3 contains a Middle Archaic assemblage, and contains a 20-30 cm thick layer of the lower portion of Stratum III, the underlying buried spodic horizon, where present, and upper portion of Stratum IV and VI where the spodic horizon is absent. Total inorganic phosphate analyses of this horizon were substantially higher than values from other levels in the site.

Beaver Site Site (74-85). Site 74-85 (Belcher and Sanger, 1988a) is located on a peninsula at the confluence of Pushaw Stream and the Stillwater River, with Pushaw Stream to the west and the Stillwater to the east (Figure 3.4). With the exception of two low ridges, one paralleling the river on the center of the site and one on the eastern edge, much of the site is low-lying with pockets of marsh vegetation. The eastern bank of the site shows evidence of erosion, as does the surface of the site.

Stratigraphically, the site is divided into three portions, the eastern ridge adjacent to the Stillwater River, the low-lying central portion, and the western ridge (Table 3.11 a, b, c). All sequences are composed of fine sediments deposited on compact silt, but differ in the thickness and number of individual units present. The eastern portion, adjacent to the Stillwater River, has a total of seven distinct strata (Table 3.11a), all fine-grained, with finer silts at the base of the section. This grain size distribution is opposite of what is expected in floodplain settings, and may be the result of higher water levels and velocities as a result of dam construction, or slightly higher water velocities over the raised ridge surface. Stratum I corresponds to the A soil horizon. The underlying unit, Stratum II has the gray brown color and coarser texture observed in sediments associated with the April 1987 flood in the region. Strata III, IV, V, and VI appear to be fine-grained alluvial sediments deposited in standing or slowly flowing water during flood events. Stratum V shows mottling characteristic of sediments in the

Table 3.11a: 74-85 (Beaver Site) Eastern Portion (From Belcher and Sanger, 1988a : pp 139-140)

Stratum	**Color**	**Sediment Texture**	**Depth below surface (cm)**	**Thickness (cm)**	**Dates [1]Radiocarbon [2]Diagnostic Artifact**	**Geological Interpretation**
I	2.5YR4/4 Brown	Sandy silt with root mat	10-20	10-20		Terrestrial and alluvial sediments (A Horizon)
II	2.5Y5/2 Gray brown	Sandy silt	10-25	5-12		Alluvial sediments
III	2.5Y5/4 Yellow brown	Silt	25-30	7-15		Alluvial sediments
IV	10YR 5/6 Yellow brown	Silt	40-45	7-15		Alluvial sediments
V	7.5YR5/6 to 5YR5/8 Dark brown to yellow red	Silt	43-50	10-20	(Late Ceramic)	Alluvial sediments
VI	2.5 Y5/6 Yellow brown	Silt	53-55	5-30		Alluvial sediments
VII	2.5Y6/4 Yellow brown	Silt (compact)	90-?	35-?		Alluvial sediments?

Table 3.11b: 74-85 (Beaver Site) Central Portion (from Belcher and Sanger 1988, pp. 137-138)

Stratum	**Color**	**Sediment Texture**	**Depth below surface (cm)**	**Thickness (cm)**	**Dates** [1]**Radiocarbon** [2]**Diagnostic Artifact**	**Geological Interpretation**
I	10YR3/3 Dark brown	Silty sand	0-35	7-35		Terrestrial organics and alluvial sediments (A horizon)
II	10YR6/1 Gray	Silt	7-60	7-50	1600-1200 ^{14}C yrs BP (Middle Ceramic period)	Alluvial sediments
III	10YR5/8 Yellow brown	Clayey silt (compact)	35-?	60-?		Alluvial sediments

Table 3.11c: 74-85 (Beaver Site) West Portion (From Belcher and Sanger, 1988a; pp. 135-136)

Stratum	Color	Sediment Texture	Depth below surface (cm)	Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I	10YR3/3 Dark brown	Sandy silt 18% sand, 55% silt, 27 clay	0-13	10-13		Terrestrial organics and alluvial sediments (A horizon)
II	10YR3/3 Dark brown	Fine sand 16% sand, 53% silt, 31 clay	10-27	7-20		Terrestrial organics and alluvial sediments (A horizon)
III	10YR6/8 Brown yellow	Fine sand 21% sand, 52% silt, 28 clay	0-30	0-12		Alluvial sediments
IV	10YR6/8 Brown yellow	Silt (loose) 12% sand, 66% silt, 22 clay	27-41	5-13		Alluvial sediments
V	2.5Y6/4 Yellow brown	Silt (with charcoal flecks) 9% sand, 53% silt, 38% clay	35-50	3-20		Alluvial sediments
VI	10YR6/6 Brown yellow	Silt (compact) 4% sand, 44% silt, 52% clay	37-67	15-35		Alluvial sediments
VII	10YR4/3 Dark brown	Silt (compact with charcoal) 4% sand, 44% silt, 52% clay	60-82	5-10		Alluvial sediments/Cultural (?)/Buried Soil (?)
VIII	5Y7/2	Silt	75-92	5-22		Lacustrine (?) sediments

	Light gray	(compact) 26% sand, 33% silt, 41 clay				
IX	10YR5/4 Yellow brown with rust mottles	C oarse silt 16% sand, 34% silt, 47% clay	75-100	10-25		Lacustrine (?) sediments
X	10YR 5/4 L:ight gray	Silt (compact) 20% sand, 37% silt, 43% clay	105-?	20-?		Glaciomarine (?)/Lacustrine (?) sediments

upper portions of fluctuating groundwater table. The compact silt at the base of the section appears to be similar to the overlying sediments in color and texture, rather than displaying the distinctive blue-gray color associated with glaciomarine sediments or gray, Early Holocene lacustrine sediments.

Sediments in the central, lower portion of the have a similar, but compressed section relative to that to the east. Stratum I is composed of dark brown, silty sand, and forms the A soil horizon. Stratum II is made up of gray silt, and is interpreted to be recent flood deposits. In Stratum III, a yellow brown, compact silty clay, forms the base of the section. All sediments are interpreted to be alluvial in origin.

The western ridge stratigraphic sequence is composed primarily of fine sand and silt. Strata I and II comprise the organic-rich A horizon, and overly a sequence of yellow brown to brown yellow silt. Stratum VII is notably different. While similar in texture to the overlying sediments, it is dark brown in color and contains small pieces of charcoal. This stratum may represent a buried soil or an occupation surface. The light gray, compact silt of Stratum VIII may be the upper portion of the Late Pleistocene glaciomarine deposit or Early Holocene lacustrine sediments. Gravel was exposed at the base of the deepest excavation of the western ridge, and may represent Late Pleistocene outwash or an Early Holocene gravel bar.

A date of circa 8100 ^{14}C yrs BP with associated artifacts places the earliest known occupation of the Beaver Site in the Early Archaic period, earlier than that noted at the adjacent Gilman Falls site. Late Archaic material was recovered at depth from the side of the site adjacent to the Stillwater. However, the overwhelming amount of archaeological material at the site comes from the Ceramic period, with the material becoming sequentially younger moving toward the bank of the Stillwater.

Site 74-68. Site 74-68 (Belcher and Sanger, 1988a) is located on the east bank of the Stillwater River, upstream of the Gilman Falls dam, and opposite the confluence of the Stillwater River and Pushaw Stream (Figure 3.4). The site is bounded to the north by a small, seasonal stream and wetland, and to the south by a parking lot adjacent to the dam. Survey work in 1988 noted that the site was experiencing extreme erosion. Five strata were identified, all generally fine-grained (Table 3.12). Strata I and II are both composed of silty sand, with Stratum I a darker brown color, probably due to the incorporation terrestrial organics, forming an A horizon. Strata III and V are composed of fine clayey sand and silt, with Stratum IV present as a 20 x 10 cm lens of fine sand in Stratum III at its base.

The large number of decortification flakes found in the Phase I survey of this site suggested an Archaic lithic reduction station at this site. However, fewer artifacts were found during the Phase 2 survey than expected. Two bifaces, one chipped and one ground slate, are correlated with an Archaic occupation, the oldest at the site. A Ceramic period biface suggests an occupation during this interval, although no pottery sherds were recovered.

Table 3.12: Site 74-68 Stratigraphy (from Belcher and Sanger, 1988a)

Stratum	Color	Sediment Texture	Depth below surface (cm)	Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I	10YR4/3 Brown to dark brown	Silty sand	0-5			Terrestrial organics and alluvial sediments (A horizon)
II	10YR4/4 Dark yellow brown	Silty sand	5-10			Alluvial sediments
III	10YR5/6 Yellow brown	Fine clayey sand	10-40			Alluvial sediments
IV	7.5YR5/4 Brown	Fine sand	30-40			Burrow? Buried soil?
V	10YR6/4 Yellow brown, mottled	Fine to medium clayey silt (compact)	40-50			Alluvial sediments

Site 74-88. Site 74-88 (Belcher and Sanger, 1988a) is located on the western bank of the Stillwater River, opposite Orono Island, 0.8 km upstream from the confluence of Pushaw Stream and the Stillwater River (Figure 3.4). The banks are generally low and muddy, with occasional bedrock outcrops. A bedrock knoll forms the northern portion of the site, and the shoreline becomes increasingly lower to the south.

Sediments at the site vary with topographic location. Sediments deposited on the bedrock knoll consist of silts deposited over a layer of large cobbles. Below the knoll, fine sands are deposited on compact, mottled silt, and with some spodic development. The upper strata are horizontally bedded, but lower levels showed a pronounced dip to the east. A representative stratigraphic section is presented in Table 3.13.

Archaeological material indicates late 19th to 20th century occupation of the site. A diagnostic, small-stemmed biface, suggests a Late Ceramic period occupation. An Early Ceramic or Late Archaic period presence may also be present, based on a single, felsite, unstemmed biface.

Geoarchaeology of the Pushaw Confluence Locality. The Middle Archaic quarry and manufacturing site at the Gilman Falls site (74-106) provides the most complete stratigraphic record within the locality. A sedimentary sequence representing over 7,000 years in slightly over 2 meters of sediment was exposed at the extensive excavations at the site. The preservation of this site is due to its location above the Gilman Falls rapids and at the mouth of Pushaw Stream. This

Table 3.13 Site 74-88 Stratigraphy (from Belcher and Sanger, 1988a: pp. 142-142

Stratum	Color	Sediment Texture	Depth below surface (cm)	Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I	Dark brown	Silt	0-20	10-20		Terrestrial organics and alluvial sediments (A horizon)
II	Brown yellow	Sandy silt	10-60	10-50		Alluvial sediments
III	Yellow brown	Silt	37-85	5-35		Alluvial sediments
IV	Yellow brown	Silt	40-70	5-40		Alluvial sediments
V	Yellow brown	Silt (compact)	60-75	0-15		Alluvial sediments
VI	Yellow brown	Silty clay (very compact)	60-?	70-?		Alluvial sediments

position created a situation favoring the deposition of fine-grained sediments at the end of flood events, building a thick, well-stratified deposit. The bedrock exposed at the base of the section was polished and striated by the action of the Laurentide Ice Sheet, which receded from the area at approximately 12000-13000 ^{14}C yrs BP (Borns et al., 2004). The stratified sand and gravel deposits overlying the bedrock (Stratum VIII) suggest river flows of alternating velocity, which decreased gradually with time. A sudden change in the regime of the river caused the abrupt change in sediment texture noted at the contact of Strata VI and VII. Coarser sediments are generally absent from the upper portion of the section, with the exception of the small gravel lenses in Strata III, IIIa, IIIb, and IV. These deposits may represent coarse material transported and subsequently redeposited by melting of ice chunks stranded on the island during the spring freshet. This phenomenon is observed along the banks of the modern Stillwater River. The upper, finer-grained strata are interpreted as alluvial sediments deposited when floodwater is ponded behind the constriction created by the rapids.

The red, discontinuous horizons identified above as spodosols are interpreted to be soil horizons formed during periods characterized by generally conditions, with little inundation or sedimentation. The uppermost reddish layer represents the modern spodic horizon, while those lower in the section correspond to buried spodosols. These horizons represent time earlier periods, circa 4000 ^{14}C yrs BP and 7500 ^{14}C yrs BP, and generally correlate with the periods of low precipitation recorded in the paleohydrologic record developed for

Mansell Pond (Almquist, et al., 2001), less than 10 km north of Gilman Falls. Low precipitation indicated by stable lake levels led to a fall in river levels and little sedimentation, providing adequate time for pedogenesis to take place. The relative lack of sediment separating the Middle and Late Archaic components in the upper and lower portion of Stratum III may be attributed to a period of low precipitation correlated with low deposition noted at Mansell Pond at circa 6,000 ^{14}C yrs BP. The lack of spodic horizon development at this time may be related to high amount of cultural activity and soil disturbance at the site, combined with generally higher water tables.

Archaeologically, the site is important as a quarrying and production location of stone rods in the Middle Archaic period (Sanger et al., 2001). Stone rods in various stages of completion, including numerous performs, compose the largest component of artifacts in the deepest horizon, Zone 3. These artifacts, combined with battered nodules linked to rod production and portions of unworked bedrock led to the recognition of the Middle Archaic quarry component of the site. The tendency of the rock to break into elongate pieces with a diamond shaped cross-section is thought to have been important in the production of these artifacts. Radiocarbon dates from Zone 3 indicate that most of the activity and sedimentation in Zone 3 took place in an approximately 1,000 year time period, between circa 6300 ^{14}C yrs BP and 7300 ^{14}C yrs BP. These rods are associated with Moorehead burial tradition cemeteries, and have been recovered from the Sunkhaze Ridge cemetery, 6 km to the east of the Gilman Falls site (Robinson, 1992). Sanger et al. (2001) note that the most extensive use of the Gilman Falls site coincides with the use of stone rods in Moorehead mortuary ceremonialism, and declines sharply after that period.

The stratigraphy of the Beaver Site site (74-85) provides interesting insights relative to both site formation and the geological processes operating in the confluence area. Evidence of Early Archaic occupation was found at the base of a 1 m thick sequence of fine-grained sediments deposited on gravel on the western ridge of the site. This location is currently removed from either the Pushaw or Stillwater sides of the site by 10's of meters. In addition, Ceramic period artifacts recovered from the Stillwater side of the site become sequentially younger with proximity to the riverbank. This pattern suggests that while the Beaver site experienced vertical accumulation of sediments, the site also grew through lateral accretion.

The fine-grained sediments exposed in excavations at site 74-68 formed in a similar manner as those at the Gilman Falls site on the opposite side of the Stillwater River. The fine-grained texture of the sediments indicates deposition by slowly flowing, or ponded water. The basal compact clayey silt may be the upper portion of fine-grained glaciomarine sediments or lacustrine sediments. The upper fine sand and silt were deposited by slowly moving water related to high flow events ponded behind the falls and rapids. The thinner stratigraphic sequence present at site 74-68 may be related to the site being more distant from the sediment contributed to the confluence area by Pushaw Stream. The initial Archaic presence at the site may be related to the activities at the Gilman Falls site, or represent independent use of the site at another time.

The sediments at site 74-88 are indicative of a changing geologic setting. The presence of a well-developed spodosol in the lower portion of the site indicates that recent deposition has been relatively slow, and has not overwhelmed soil-forming processes. This lack of sediment or evidence of erosion and redeposition indicates that the primary water flow is to the eastern side of Orono Island, rather than in the channel bounding the site. However, the dipping layers noted at the base of the section represents that at one time, this location formed the western bank of the river, and since that time, the primary flow of the river has moved to the east, allowing the accumulation of horizontal layers of alluvial sediments. In the bedrock knoll location, the presence of the cobble lag on the top of the knoll suggest that the knoll is composed, at least partially, of till which has been winnowed by fluvial activity or redeposited material from the nearby esker. The fine-grained upper sediments are probably alluvial, deposited during flood events, or at a time earlier in the area's complex geologic history.

In summary, the geologic setting of the Pushaw confluence locality has shaped the preservation of the area's archaeological record. The thick accumulation of fine-grained sediments at sites 74-106 and 74-85 (Gilman Falls and Beaver sites), points to the importance of proximity to local base levels and confluence locations in site preservation. The local base level created by the bedrock rapids and falls at Gilman Falls created a situation that favored high accumulation rates of fine-grained sediments by ponding in the later stages of flood events. The significantly thinner alluvial deposits on the eastern bank of the

Stillwater River at Gilman Falls at site 74-68 illustrates that maximum sediment contribution, and hence site preservation, occurs at locations adjacent to the tributary mouth. This may be in part due to sediments contributed by the tributary, Pushaw Stream. The flow of main stem water back into the smaller stream during at the peak of the flood also creates a situation that retains sediment in the tributary and near tributary mouth area. These two factors led to the preservation of materials from the Early Archaic through the Ceramic period in at the Gilman Falls and Beaver Sites in the immediate confluence area.

Accumulation of sediment at site 74-106 (Gilman Falls) appears to have taken place predominately by vertical accumulation, with younger Ceramic period material in stratigraphic position above the older, Middle Archaic artifacts. At site 74-85 (Beaver Site), the interior portion of the site had evidence of vertical sediment accumulation. The site also appears to have grown due to lateral accumulation, as evidenced by the successively younger Ceramic period artifacts from the interior of the site to the water's edge. This difference in depositional style at two adjacent sites may be the result of the sites' locations with respect to the mouth of Pushaw Stream. Site 74-85 is adjacent to the mouth of Pushaw Stream, and may have been built by sediment from water moving out of the stream and flowing over the peninsula into the Stillwater River or vice versa. Current erosion of Ceramic period material from the banks suggests changes in erosion and deposition patterns related to land and water use patterns associated with European-style agriculture and industrial patterns.

Birch Stream Locality

Birch Stream is a tributary of the Stillwater River, and drains a series of northwest-southeast trending wetlands, the largest of which is Alton Bog (Figure 3.4). The stream is approximately 37 km long, and drains an area of approximately 85 km^2. The western boundary of the drainage is dominated by a large esker. The eastern boundary is composed of a series of low, till-covered bedrock ridges that separate the drainage from that of the main stem of the Penobscot River.

The two sites that make up the Birch Stream locality were excavated at the Phase II level (Fenton 1991) after Phase I survey (Klink 1991) was completed as part of the Milford Reservoir relicensing project.

Site 91-33

Site 91-33 (Fenton, 1991) is situated on the east bank of Birch Stream in the southern portion of Alton Bog, approximately 3 km from the junction of Birch Stream and the Stillwater River (Figure 3.4). The site is positioned at on the northern bank of the confluence of a small, unnamed tributary stream and Birch Stream.

Four distinct strata are identified at this site (Table 3.14). The uppermost unit, Stratum I is composed primarily of organic material, and corresponds to the O horizon of soils terminology. Stratum II underlies Stratum I, and is brown in color, and made up of fine-grained sediments, primarily silt and clay. The color is attributed to the inclusion of organic material incorporated with fine-grained silt

Table 3.14: Site 91-33 Stratigraphy (from Fenton, 1991)

Stratum	Color	Sediment Texture	Depth below surface (cm)	Thickness	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I	Dark Brown	Organic Rich	0	6		Organic-rich Root Mat (O Horizon)
II	10YR5/3 Brown	Clay Loam	6	15		Terrestrial organic material and alluvial sediments
III	Light brown	Clay Loam	21	10		Terrestrial organic material and alluvial sediments
IV	Blue Gray	Clay	31-?	20+		Glaciomarine or lacustrine sediments

and clay. Stratum III is also fine-grained, but slightly lighter in color than Stratum II. Fenton (1999) identifies Stratum IV as composed of glaciomarine clay, presumably on the basis of color and texture. Recent work in the region (Almquist and Sanger, 1999) shows the presence of extensive Early Holocene lakes in a similar setting in the Pushaw basin, suggesting that these fine-grained sediments in Alton Bog may be lacustrine in origin.

Although Phase II work was recommended at this location on the basis of cultural material (one flake) in the Phase I survey, no other artifacts were recovered. Without material suitable for radiocarbon dating or the presence of diagnostic artifacts, little can be said about the timing of deposition in this area.

Site 91-35

Site 91-35 (Fenton, 1991) is located on the east bank of Birch Stream, approximately 1 km downstream from site 91-33 (Figure 3.4). The site is situated on a sloping surface at the base of a till-covered bedrock ridge to the east of thesite. Boulders, cobbles, and pebbles are present on the surface, and represent colluviation from the till-covered ridge.

Three stratigraphic units were identified at the site (Table 3.15). Only Stratum II is composed solely of fine-grained sediments, and is interpreted to be an alluvial deposit. Stratum I is associated with large rocks, pebbles, and cobbles, as well as fine-grained sediments. This assemblage represents a

Table 3.15; Site 91-35 Stratigraphy (from Fenton, 1991)

Color	Sediment Texture	Depth below surface (cm)	Thickness	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
10YR 2/2 Very dark brown	Silty loam with large rocks	0-25	6		Terrestrial organic material, alluvial and colluvial sediments (A Horizon)
10YR3/6 Dark yellowish brown	Sandy silt	25-35	15		Alluvial sediments (B or C Horizon)
2.5Y4/3 Olive brown	Silty sand with gravel	35-50	10		Alluvial sediments and colluvial/and or lag deposit (C Horizon)

combination of alluvial and colluvial material. Stratum III is composed of fine-grained material and gravel. The finer material is probably alluvial in nature, but the coarser material may represent colluviated material from the till-covered ridge, or a lag deposit formed by the erosion of the underlying till.

The site appears to have been the location of a 18th or 19th century occupation, as evidenced by gunflints, ceramics, nails, bottle and window glass. No Ceramic period pottery was recovered, although a small number of formed unifacial scrapers are interpreted to represent a brief Ceramic period occupation. Two groundstone fragments and a stone rod are suggestive of an Archaic occupation, and represents the earliest, recognized use of the site.

Geoarchaeology of the Birch Stream Locality

Geoarchaeological interpretation of the Birch Stream area is constrained by a lack of direct paleoenvironmental information and limited excavations. Without direct information about the development of the bog, it is assumed that Alton Bog, which is drained by Birch Stream, developed in a manner similar tothat described by Almquist and Sanger (1999) for the nearby Pushaw /Whitten Bog complex. If the fine-grained clay at the base of Site 91-33 is lacustrine in origin, it indicates that the Birch Stream sites were inundated in the Early Holocene, and unavailable for human use until lake levels fell and local surface drainage was established The initial Archaic occupation noted at site 91-35 is generally correlative with the ages of the first recognized occupation of sites in the Lower PushawStream Locality. This similarity in age of occupation may suggest that, like the lower Pushaw Stream area, Birch Stream was not used by used by humans until the Archaic because much of the basin was occupied by standing water. If Alton Bog was the location of an extensive lake, its outlet would coincide with the location of the present day Birch Stream (Figure 3.4), due to geomorphic constraints. It is possible that the section of the Stillwater River that flows north, against the regional direction of stream flow, occupies a pre-existing lake outlet. It is possible that Early Holocene local isostatic adjustments may have played a role in the formation of the Stillwater River at this location.

Indian Island Locality

Indian Island occupies 2100 a in the Penobscot River, immediately upstream from the Old Town/Milford falls. Moderate relief, approximately 6 m, characterizes most of the island, although Oak Hill in the south central portion of the island, stands 21 meters above the surrounding landscape. Bedrock is exposed at numerous locations on the island and around its margins. Surficial material exposed on the island ranges from glacial to fluvial deposits.

The island is currently the home of the Penobscot Indian Nation. Early European visitors to the area noted the presence of a large Penobscot camp in this area (Treat, 1820), and artifacts recovered from the island suggest an occupation of many thousands of years. The island's importance as a major town site appears to have grown in the mid 19^{th} century (Thoreau, 1987), perhaps as a result of European settlement pressure in the surrounding region.

The sites discussed below are located on the margins of Indian Island, or on adjacent islands. They have been included in the Indian Island locality primarily on the basis of location, but the geomorphic setting of each is also similar. Other sites are known on Indian Island, but because they are in the interior of the island, the discussion of their stratigraphy does not contribute to this study.

Site 74-128

Site 74-128 (Belcher and Sanger, 1988a) is located on the southeastern edge of Indian Island, overlooking the Penobscot River (Figure 3.4). It is situated on a generally level surface in a field approximately 1 m above the summer river level. In 1988, the edge of the site closest to the river was experiencing severe erosion. The inland portion of the site was covered by fill. Excavations carried out as a portion of the Phase II Milford Reservoir survey were conducted in the narrow strip of unfilled land adjacent to the river.

The site stratigraphy exposed in excavations consisted of a plow (AP) horizon over well-sorted medium sand, underlain by rounded cobbles and pebbles at 140-150 cm below the surface (Table 3.16). Artifacts suggesting occupation from the Late Archaic to the present were encountered in a mixed context at the site, and included a ground slate bayonet with a hexagonal cross section (Phase 1), Middle Ceramic Period pottery sherds, and 18^{th} to 20^{th} century historic material. Agriculture, bioturbation, erosion, and fluvial activity contributed to the lack of distinct stratigraphy at this site. The well-sorted medium sand layer

Table 3.16 Site 74-128 Stratigraphy (From Belcher and Sanger, 1988a)

Stratum	Color	Sediment Texture	Depth below surface (cm)	Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I		Terrestrial organic material and well-sorted medium sand	0-50	50	Present day to 5000BP[2] (Modern – Late Archaic mixed context)	Terrestrial organics and alluvial sediments, evidence of cultivation (AP Horizon)
II		Well-sorted medium sand	50-140	90		Alluvial sediments
III		Rounded pebbles and cobbles	140-?	?		Alluvial sediments

and the underlaying rounded pebbles and cobbles indicate that, at one time, this location was part of the stream channel, and was an area of active deposition.

Site 74-18

Site 74-18 (Belcher and Sanger, 1988a) is located on the southern end of Indian Island (Figure 3.4). It is the site of an aboriginal stockade that was burned by an English expedition in 1723. The site is immediately adjacent to the river, and has been disturbed by bridge construction. It is currently in a low and marshy location, although it is unlikely that this environment existed when the stockade was constructed. All excavations encountered highly disturbed sediments, making stratigraphic or archaeological interpretations impossible.

Earlier excavations by Snow (1970), prior to site disturbance, encountered complex stratigraphy, generalized as fine sands overlying silt and clay. Archaeological material recovered included groundstone artifacts, Ceramic period sherds, copper beads, and a fragment of bark fiber cordage, as well as post-European contact material. The presence of this diverse assemblage suggests occupation of the site from the Archaic through the historic period. Belcher and Sanger (1988a) suggest that intact sediments associated with a groundstone tool fragment may have been encountered at 60-70 cm below ground surface. Deposition of fine sands on silt and clay may be interpreted as alluvial deposition on glaciomarine or lacustrine sediments. The location of adefensive stockade in a currently marshy location suggests that modern logging structures, ferry operations, and bridge construction has significantly altered the depositional and erosional setting of this portion of the island.

Gut Island Site (74-91)

Site 74-91 (Belcher and Sanger, 1988a) is located on Smith Island, locally known as Gut Island, in the main stem of the Penobscot, near the east bank of the river at Milford. The site is to the east of Indian Island, and approximately .5 km upstream from the falls and rapids at Milford (Figure 3.4).

The small island, 170 m by 50 m, is low-lying, approximately 1 m above low water level, with bedrock outcrops on the north end of the island, and gravel and boulders on the south. The sedimentary sequence exposed in excavations reveals a fining upward sequence from coarse sand and gravel at the base to silty sands at the top of the section (Tables 3.17 a and b). The upper 30 -50 cm of the sequence is highly disturbed, and contains prehistoric, historic, and modern materials. In the southern portion of the island, lower sediments do not show evidence of mixing, and Late to Middle Archaic period groundstone artifacts represent an occupation of the southern portion of the island during this time period.

The bedrock outcrops at the upstream end of the site may be responsible for the island's formation. When annual maximum water velocities decreased enough to allow seasonal deposition of sediment, gravel, sand, and finally silty sand accumulated in the lee of the outcrops, forming an island. By the Early to Middle Archaic, the island had grown to an inhabitable size. Access to aquatic

Table 3.17a: Site 74-91 Stratigraphy-Northern portion (from Belcher and Sanger, 1988a, pp. 145-146)

Stratum	Color	Sediment Texture	Depth below surface (cm)	Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I	10YR2/2 Dark brown	Fine sand	0-10	5-10		Terrestrial organics and alluvial sediments (disturbed)
II	10YR2/2 Dark brown	Silty to fine sand	7-25	15-25	Modern to Middle Ceramic Period[2]	Terrestrial organics and alluvial sediments (disturbed)
III	10YR3/3 Dark brown	Fine to medium sand	25-40	7-15		Terrestrial organics and alluvial sediments (disturbed)
IV	10YR3/4 Yellow brown	Fine to medium sand	35-57	5-15		Alluvial sediments
V	10YR5/6 Brown yellow	Medium sand	50-110	30-50		Alluvial sediments
VI	10YR5/4 Brown yellow	Medium sand and gravel	80-120	15-?		Alluvial sediments
VII	10YR3/3 Dark brown	Medium sand	0-50	20		Burrow?

Table 3.17 b: Site 74-91 Stratigraphy Southern portion (from Belcher and Sanger, 1988, pp. 147-148)

Stratum	Color	Sediment Texture	Depth below surface (cm)	Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I	10YR2/2 Dark brown	Sandy silt	0-25	10-25	Present to circa 1200 ^{14}C yrs BP[2] Historic to Middle Ceramic period	Terrestrial organics and alluvial sediments (disturbed)
II	10YR3/4 Yellow brown	Sandy silt	0-30	0-15	Circa 6000-3500 ^{14}C yrs BP[2] Late to Middle Archaic period	Alluvial sediments
III	10YR4/4 Yellow brown	Medium sand	0-55	0-30		Alluvial sediments
IV	10YR5/6 Yellow brown	Medium sand	50-75	10-50		Alluvial sediments
V	2.5Y4/2 Dark grayish brown	Coarse sand	75+	10+		Alluvial sediments

resources and/or the limited isolation formed by the narrow, 6 m wide, channel from the riverbank that made this a desirable location for occupation and/or resource procurement.

Site 74-105

Site 74-105 (Belcher and Sanger, 1998) is located on the southwestern side of Indian Island, on a terrace approximately 1 to 2 m above river level (Figure 3.4). The site is positioned across a branch of the Penobscot River from site 74-100 on Orson Island. At the time of survey, the riverbanks were experiencing extensive erosion, forming low, erosional scarps fronted by sand and gravel beaches. Site stratigraphy is presented in Table 3.18, and consists of coarse-grained material at depth, topped by fine sediments. Boulders and cobbles were encountered 140 cm below surface, and were overlain by compact silt and sand lenses. These fine-grained deposits were overlain by a coarse sand which fined upward to a well-drained, medium sand layer, capped by a 35-50 cm thick plow zone. Local informants indicated that fill has been added to the site. Diagnostic artifacts found at site 74-105 included a Late Archaic period ground slate bayonet fragment and projectile point fragment. All identifiable pottery fragments are consistent with Middle Ceramic period production and decorative techniques.

Orson Island Site (74-100)

Site 74-100 (Belcher and Sanger, 1988a) is located on the southern end of Orson Island, immediately to the north and west of Indian Island (Figure 3.4)

Table 3.18: Site 74-105 Stratigraphy (from Belcher and Sanger, 1988a, pp. 159-160)

Stratum	Color	Sediment Texture	Depth below surface (cm)	Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I	10YR3/2 Gray brown	Fine sand, some sitlt	0-55	55	Present to circa 1200 ^{14}C yrs BP[2] Historic to Middle Ceramic period	Plow Zone AP horizon
II	10YR5/6 Yellow brown	Fine sand	55-75	15-20		Alluvial sediments
III	2.5Y5/4 Yellow brown	Coarse sand	75-95	10-20		Alluvial sediments
IV	2.5Y6'6 Yellow brown	Clayey silt	65-85	0-20		Alluvial sediments Discontinuous layer – soil? tree throws?
V	2.5Y5/4 Yellow brown	Compact silt	95-125+	25+		Alluvial sediments
VI	2.5 Y5/4 Yellow red	Fine sand	120+	10+	? circa 5000-3050BP[2] (Late Archaic period)	Alluvial sediments

The eastern portion of the site is located on a terrace that is 3 to 4 m above river level, and has evidence of historic occupation in the form of a house foundation and associated artifacts. In this area, a plow zone caps medium to fine sands overlying compact, iron-stained silt (Table 3.19). The western portion of the site is low lying and marshy, and was composed of thin sandy silt deposits overlying compact silt and sand. Deflation of sediments by sheet wash from the terrace or by alluvial activity is suggested for this area Diagnostic artifacts associated with the Archaic and Ceramic periods were recovered from the site, as well as. abundant historic material. Historic artifacts and Middle Ceramic period pottery sherds were recovered from the topographically higher, eastern portion of the site. Archaic period material, including a possible Middle Archaic full-grooved gouge poll and a Late Archaic plummet was recovered from the western, deflated portion of the site. Underwater survey of the area revealed the presence of flakes and cores up to 10 m from the shoreline of the site, suggesting the site has experienced significant erosion.

Table 3.19: Orson Island Site (74-100) Stratigraphy (from Belcher and Sanger, 1988a, pp. 154-155)

Stratum	Color	Sediment Texture	Depth below surface (cm)	Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I	Dark brown	Fine sand	0-5	5-7	Present to circa 1200 ^{14}C yrs BP[2] Historic to Middle Ceramic period	Terrestrial organics and alluvial sediments (disturbed)
II	Dark brown	Fine sand	5-15	10-15		Alluvial sediments
III	Brown	Fine silt	15-40	20-25	circa 5000-30501200 ^{14}C yrs BP[2] (Late Archaic period)	Alluvial sediments
IV	Yellow gray	Silt	40-45	0-5		Alluvial sediments
V	Brown gray	Silt	35-40	0-10		Alluvial sediments
VI	Gray brown	Silt	40-50	0-10		Alluvial sediments
VII	Yellow brown	Silt	40-60	10-20		Alluvial sediments
VIII	Brown yellow	Compact silt	60-75	10-15		Glaciomarine or lacustrine sediments
IX	Brown yellow	Compact clayey silt	75+	5+		Glaciomarine or lacustrine sediments
X	Iron mottled red brown	Compact clayey silt	80+	0-10		Glaciomarine or lacustrine sediments

Geoarchaeology of the Indian Island Locality

Local bedrock geology, in combination with fluvial processes, has shaped the Indian Island locality. The geology of Indian Island mirrors the regional pattern of a bedrock basement overlain with glacial sediments. Gut Island appears to have grown as an accumulation of alluvial sediments deposited in the lee of a bedrock obstruction in the Penobscot River channel. Although bedrock exposures were not noted at site 74-100 at Orson Island, its moderate relief (approximately 20 m), and topography consistent with the regional northwest-southeast bedrock trend suggests it is also underlain by till-draped bedrock. The Milford-Old Town falls are formed of an erosion-resistant ridge of the metasedimentary Vassalboro Formation (Osberg et al., 1985) that create a local base level that influences flow on both the main stem of the Penobscot and the Stillwater River.

With the exception of the eastern portion of site 74-100, all the sites in this location are incorporated in alluvial sediments. Ideally, this would provide stratified sites that would contribute to our understanding of the chronology of both the archaeology and geology of the area. However, all sites experienced some level of mixing of archaeological material from a wide time span, particularly mixing of Historic through Middle Ceramic period material in the upper portions of the sections. A few sites, 74-100 and 105, had distinct, but small Early, Middle, or Late Archaic components. Although assemblages like these can establish Native utilization of the area since the Archaic period, the geological information they provide is limited. On the basis of this data, it does appear that Orson Island were formed and habitable by the Early to Late Archaic periods.

In summary, the geoarchaeology of the Indian Island confluence area is not well understand due to the generally poor preservation of site stratigraphy. Native occupation of the locality reaches at least from the Middle Archaic period to present, and islands in this area appear to have existed in near to their present form by this time.

Mackowski Farm (74-14) Locality

The Mackowski Farm Locality is represented in this discussion by one site, the Mackowski Farm Site, 74-14 (Figure 3.4). It is located on the upstream bank of the confluence of Sunkhaze Stream and the Penobscot River, and is upstream of the Sunkhaze Rips, mapped by Treat (1820), but are now inundated by the headpond of the Milford Reservoir. The Sunkhaze Ridge site (Robinson, 1992), 74-10, a Middle Archaic period mortuary site, is located near the Mackowski Farm site, was excavated in 1922 and 1923, when sand pit operations exposed numerous red ochre patches associated with groundstone and chipped stone artifacts. The Sunkhaze Stream site, which is associated with Late Archaic artifacts higher in the stratigraphic sequence, is located on the opposite bank of Sunkhaze Stream, and was excavated in 1989.

Archaeological material has been collected at Mackowski Farm since the early 1900's. As the site of amateur collecting, it produced a number of artifacts from the Middle Archaic through the Ceramic period. Extensive collections of groundstone artifacts through Contact period material (lead baling seal and glass beads) (Robinson pers. comm., 2005) illustrate over 5000 years of occupation history. Top soil stripping operations removed the upper meter or more of sediment from most of the site circa 1970's. It was first professionally excavated in 1987, with additional work in 2003 and 2005.

Mackowski Farm Site, 74-14

The Makowski Farm site (74-14) is composed of a thick, 2+ m, sequence of fine-grained sediments resting on a boulder/gravel lag (Table 3.20). Strata descriptions are taken from the field notes and profiles completed by Brian Robinson in August of 2005. Individual stratigraphic units were identified on the basis of sediment texture and color. The upper 1+ m of the stratigraphic sequence are recorded from archaeological excavations. The lower 1+m is the result of bucket auger testing from the floor of an excavation unit.

The base of the section is placed at the level of refusal to bucket auger sampling, at 2.26 m below the current land surface. The refusal layer could not be sampled, but it is hypothesized the bottom of the sample is composed of the same the boulder/gravel exposed in the base of the adjacent Sunkhaze Stream. The lag deposit is topped by approximately 40 cm of gray sandy clay, which is overlain by over 1 m of sediments that fine upward from medium sand to sandy silt and clay. No artifacts were found in these lower sediments.

Table 3.20: Mackowski Farm Stratigraphy N66E25 East Wall (Robinson, pers. comm., 2005)

Stratum	Color	Sediment texture	Depth below surface (cm)	Sediment Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I		Organic material, fine sand, silt, clay	0	11		Plow Zone (AP Horizon) Developed after 1m+ stripped for top soil
A Zone	10YR 4/4 Dark yellowish brown		0-10	0-5	Middle Archaic[1] circa 6900 ^{14}C yrs BP	Paleosol
II	10 YR 5/6 Yellowish brown	Fine sand, silt, clay	19-21	21		Alluvial sediments
III	10 YR 5/8 Yellowish brown	Silt, Clay	20	10		Paleosol (?)
IV	10YR 5/2 (?) Grayish brown (?)	Fine sand, silt, clay	28-30	10-12		Alluvial sediments
V	10YR 4/4 Dark yellowish brown	Fine sand, silt, clay with charcoal flecks	40	5-8	Early Archaic[1] 8561 ± 49 ^{14}C yrs BP (From N69E22)	Paleosol (?) Living Surface (?)
VI	10 YR 5/8 Yellowish brown mottled with 10 YR 6/4 10 YR 5/8 Yellowish	Silt and clay with very fine sand	45-49	12-16	Early Archaic[2]	Alluvial sediments

	brown mottled with				(From N69E22)	
VII	10 YR 5/8 Yellowish brown mottled with 2.5Y6/4 (?) Light yellowish brown	Silt and clay with very fine sand	62	18	Late Paleoindian (?)[2]	Alluvial sediments
VII	Alternating layers of 10YR 4/4 Dark yellowish brown and 10 YR 5/6 Yellowish brown	Fine sand, silt and clay	80	12		Alluvial sediments
VIII	10 YR 6/4 (?) Light yellowish brown	Sandy silt	92	47		Alluvial sediments
IX	10 YR 6/2 Light brownish yellow	Sandy silt, medium sand	139	47		Alluvial sediments
X	10 YR 6/1 Gray	Sandy clay	186	40		Alluvial sediments
No sample	———	———	226	?		Refusal – Gravel/boulder lag?

A block of banded, black chert, 10cmx10cmx5 cm, was recovered from a 30 cm thick deposit of finer-grained, more compact, mottled fine sand, silt, and clay. Several chert and felsite flakes were associated with the larger piece of chert, but no diagnostic artifacts were recovered. The presence of this high-quality material, frequently associated with Paleoindian tool production, at a depth of almost 3 m below the original ground surface, and approximately 20 cm below diagnostic Early Archaic quartz debitage and scrapers, suggests it may be associated with Late Paleoindian use of the site. Early Archaic period use of the site is indicated by the previously mentioned quartz artifacts and a radiocarbon date from a single hawthorne seed of 8561 ± 49 ^{14}C yrs BP. The date is from feature filled containing abundant calcined fish bones and large felsite flakes and cores. This feature may be associated with a paleosol formed by natural pedogenic processes or anthrosol formed of human produced charcoal and organic remains. Two potential paleosols, distinguished by darker colors and slightly finer texture occur in the upper fine-grained sediments of the sequence. The upper paleosol lies just beneath, and sometimes is cut by, the plow zone, and is associated with a piece of charcoal that produced a radiocarbon date of circa 6900 ^{14}C yrs BP. As stated previously, the upper portion of the section was lost when the area was mined for topsoil.

Geoarchaeology of the Mackowsky Farm Site (74 -14)

The well-stratified sequence at the Mackowsky Farm site provides important information relative to the Early Holocene geologic development of the

Penobscot River. The abrupt change from the gravel/boulder lag at the base of the section to the overlying sandy clay deposit is indicative of an abrupt change in sedimentary regime. This layer is capped with over a meter of medium sand, indicative of a higher flow regime. While overlying sediments do become finer in some portions of the sequence, they never return to the clay-rich sediment of the deposit the rests on the gravel lag. This sequence suggest changing flow regimes at this location, from base level, water volume, or channel location changes.

Deposition of most of the remaining strata at the Mackowski Farm site is attributed to alluvial deposition, primarily during spring floods. These sediments enclose archaeological remains that are attributed to short-term occupations, and thus provide a time marker in sedimentary record. The exception to this style of deposition is the upper, dark yellowish brown horizon encountered just beneath the plow zone that is correlated with a Middle Archaic occupation uncovered at the nearby Sunkhaze Site. Formation of the paleosol may be related to reduced sedimentation brought about by a period of lower spring runoff. The Middle Archaic age of this feature is roughly correlative with the lower paleosol noted at the Gilman Falls site in the Pushaw/Stillwater confluence area

The archaeological material at the Mackowski site is indicative of short, but repeated visits to the area, perhaps to take advantage of the floral and faunal resources that existed at the mouth of Sunkhaze Stream and the nearby Penobscot River islands. Due to the proximity of the site, it is tempting to make an association between the Middle Archaic occupation at Mackowski and the mortuary site at Sunkhaze Ridge. More detailed analysis of archaeological sites in the region may help address this issue.

Blackman Stream Locality

The Blackman Stream locality consists of the Blackman Stream (74-19) and Peppard (74-20) sites (Figure 3.6), located on both sides of the confluence of Blackman Stream and the Penobscot River, and upstream from an unnamed bedrock rapids. Blackman Stream drains an extensive wetland to the east of the site, and cuts through Late Pleistocene/Early Holocene terraces before entering the river. Both sites are located on these terraces, and are approximately 4 m above summer water level in the Penobscot River. Only extreme floods, such as the April 1987 flood overtop these features.

Blackman Stream Site (74-19)

The Blackman Stream site has a long history in Maine archaeology. William Smith collected artifacts at this location in the early twentieth century, and artifacts associated with red ochre burials are known from the site (Sanger et al., 1992). Extensive amateur collecting and bulldozing related to modern cemetery expansion has disturbed portions of the site. Early to Middle Archaic Neville-Stark projectile points from a private collection suggested the possibility of an Early Holocene component, a rare occurrence in northern New England (Sanger et al., 1992). Testing at the Blackman Stream site took place in 1983 as part of cultural resource management efforts related to the proposed Basin Mills hydroelectric project (Sanger, 1984). More extensive, Phase II excavations were carried out in 1987 (Belcher and Sanger, 1988b, Sanger et al. .1992).

The Blackman Stream Site (Sanger, 1984: Belcher and Sanger, 1988b, Sanger et al., 1992) is located on the northern, upstream, side of the mouth of Blackman Stream, where it enters the main stem of the Penobscot River (Figure 3.5). The site consists of a broad terrace and a smaller, lower terrace that now forms the flood plain of the river. The upper terrace has a pronounced depression in the south-central portion. All excavations were placed on the upper terrace.

Phase II work at the site included 60 m^2 of excavation and two backhoe trenches oriented perpendicular to the bank in two locations (Figures 3.6 and 3.7). These trenches, combined with the numerous excavations, exposed a thick, complex sequence of fine-grained alluvial sediments capped by well-developed plow zone, and deposited on a coarse-grained lag deposit developed from the underlying till or bedded sand and gravel. Across site correlation of units was not possible, but the combination of radiocarbon dates and diagnostic artifacts provide chronology for the geological and archaeological development of the site.

Bedrock is not exposed at the site, but outcrops of the Vassalboro Formation (Osberg et al., 1985) are visible along the bank and in the river to the north and south. The rapids downstream of the site are developed on an erosion-resistant facies in this metasedimentary sequence. The deepest exposure of sediments at the site was in the base of the backhoe trenches and in excavations in the central portion of the site.

Bedded gravel and coarse to medium sand deposits were identified at the base of Blackman Stream backhoe trench #1 (BBHT#1) (Figure 3.6) and in nearby excavation units. Bedded pebbles in a coarse to medium sand matrix at the western end of backhoe trench # 1 had the texture and morphology of a gravel bar. Backhoe trench #2 (BBHT#2) (Figure 3.7) is located approximately 40 meters upstream of BBHT#1, and is positioned on a portion of the site that is topographically higher than the landscape dissected by BBHT#1 by at least a meter. The basal deposits in BBHT#2 were characterized by large clasts, boulders, cobbles, and pebbles, in a silt to clay or sand matrix. The material with a fine-grained matrix is interpreted to be till, while the deposit with the sandier matrix is thought to be water-washed till. Bedded sand and gravel analogous to the material in BBHT#1 are not exposed, although a limited deposit of massive coarse to fine sand and silt is draped over the till.

A layer of compact silt and clay caps the lower, predominately coarse-grained deposits in the backhoe trenches and deep excavation units. Deposits above this layer consist primarily of massive deposits of fine-grained sand, silt, and clay ranging in thickness from 20 cm in the northern portion of the site to 40cm in the south. Capping this sequence is an approximately 10 cm thick layer of darker, very fine to fine-grained sand. This layer forms a distinct and readily recognized horizon in unit walls in the southern, central, and a part of the western portion of the site. The horizon is identified as a buried soil horizon formed by pedogenic processes of through the accumulation of human-produced material

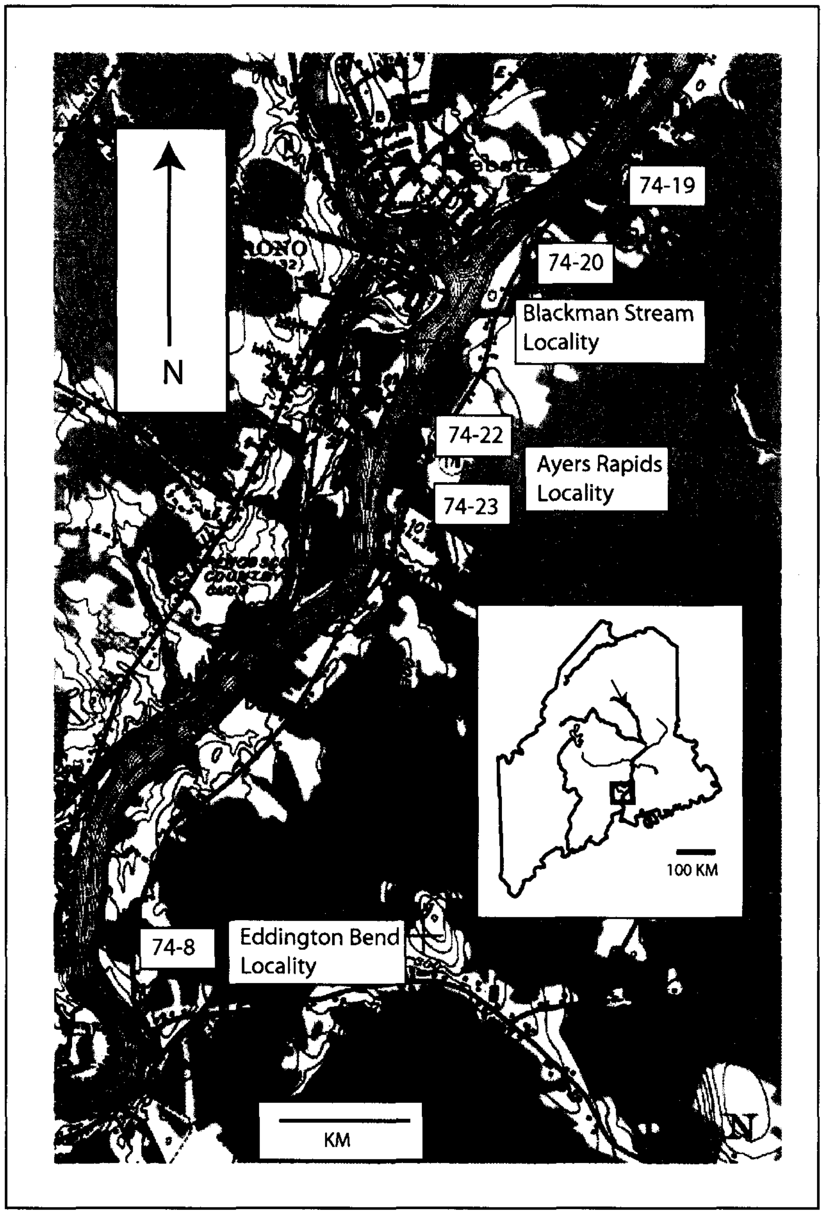
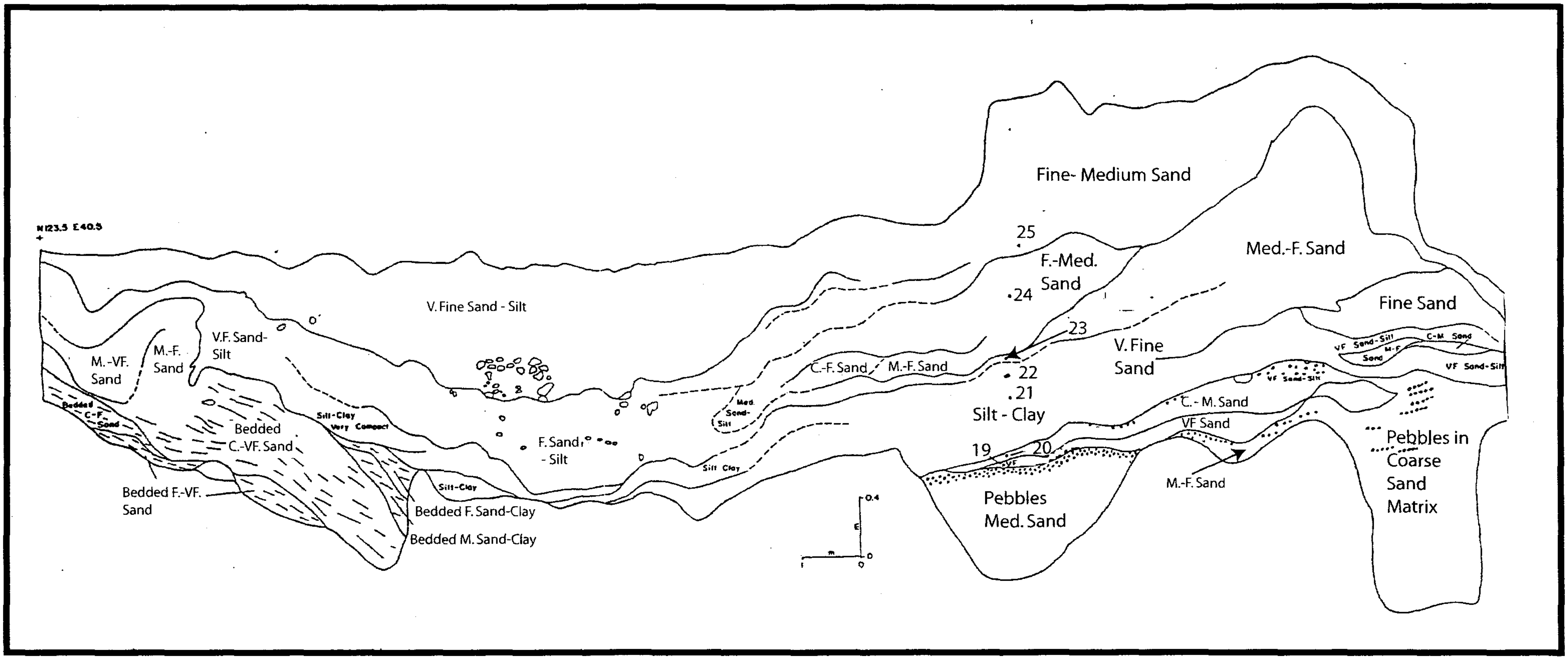


Figure 3.5: Blackman Stream, Ayers Raids, and Eddington Bend Localities



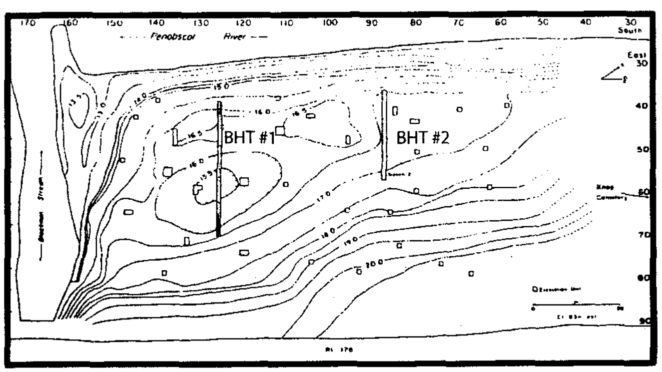
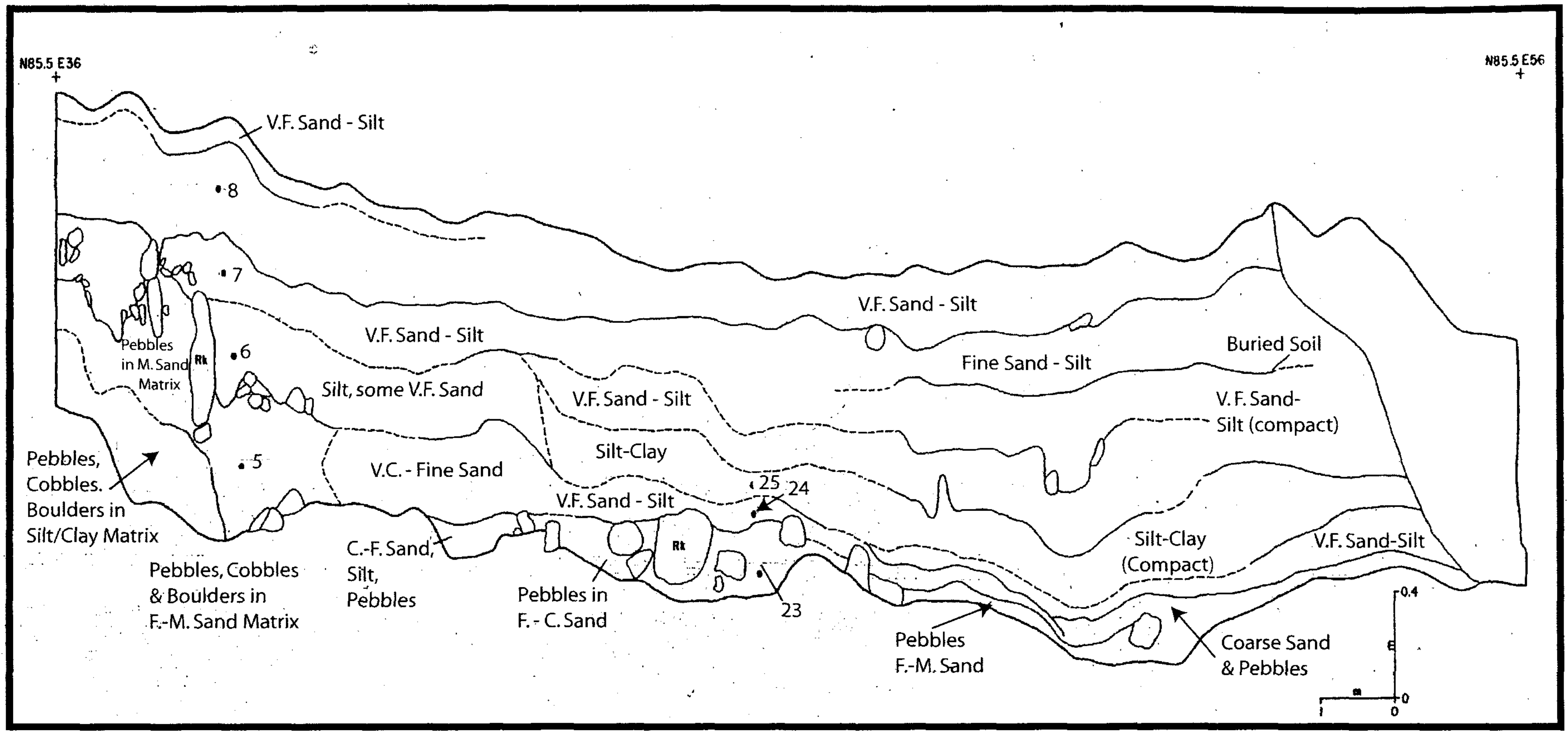


Figure 3.6: Blackman Stream Backhoe Trench #1
(Modified from Belcher and Sanger 1988b)

Sample #	% Very Coarse Sand	% Coarse Sand	% Medium Sand	% Fine Sand	% Very Fine Sand	% Silty Clay
19	15.4	9.3	17.7	29.2	14.5	13.9
20	12.1	14.5	45.9	21.0	4.0	2.5
21	0.3	1.4	5.7	29.8	24.5	38.2
22	0.3	1.6	17.6	39.9	14.9	25.7
23	0.5	2.6	32.6	48.4	9.2	6.8
24	4.3	19.9	41.5	25.4	4.9	4.0
25	3.7	10.6	35.5	25.1	10.8	14.3



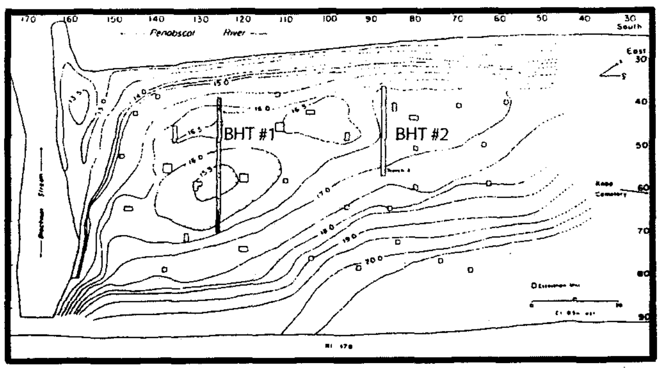


Figure 3.7: Blackman Stream Backhoe Trench #2
(Modified from Belcher and Sanger 1988b)

Sample #	% Very Coarse Sand	% Coarse Sand	% Medium Sand	% Fine Sand	% Very Fine Sand	% Silty Clay
5	0.2	3.0	33.6	36.8	18.9	7.5
6	3.1	2.8	2.6	3.9	20.3	67.5
7	0.1	1.1	13.8	36.8	18.8	29.4
8	0.3	1.3	6.9	36.5	25.4	29.6

from the surface has produced radiocarbon dates of 7400±140 ^{14}C yrs BP, (Neuendorf, et al., 2005). Several artifacts are associated with this horizon, and charcoal 7760±130 ^{14}C yrs BP, and 8360±150 ^{14}C yrs BP.

Sediments above this horizon range in thickness from 0.5 to 1 meter, and are differentiated on the basis of color and slight changes in grain size. Contacts between layers are frequently gradational. In BBHT#1, these fine-grained layers mirror the shape of the depression. Limited exposures of well-sorted sand were infrequently encountered. The top of the stratigraphic section is capped with a plow zone across much of the site.

The Blackman Stream site has the distinction of being one of only two sites in the central Penobscot Valley that have an identified Late Paleoindian component. The base of a single parallel-flaked biface produced from dark gray chert and a few felsite flakes were recovered from 2.17 m below the ground surface, in a compact silt layer overlying bedded sand and silt layers that capped coarse sand and gravel (Sanger et al., 1992). While not directly associated with the biface, four of the flakes have been identified as bifacial thinning flakes, and are thought to be part of the Late Paleoindian assemblage at the site. Although no datable material was found in association with the artifacts, a buried paleosol, described above, is positioned approximately 1 m above the biface. Radiocarbon dates place the age of the paleosol between 8,300 and 7,400 ^{14}C yrs BP. While sedimentation rates are difficult to estimate, it is reasonable to assume that the biface dates from at least 8500 ^{14}C yrs BP or earlier.

A diverse artifact assemblage was associated with the buried soil horizon, and is consistent with an Early Archaic designation. These include flaked biface fragments, a retouched scraper (uniface), slab-like choppers, battered cobbles, hammerstones, groundstone fragments of a gouge and adze, and a pecked rod and stones. Felsite cores and limited quartz flakes were also recovered. Radiocarbon dates, listed above, indicate that these artifacts were potentially deposited over a 1,000-year time span. They are similar to assemblages found in other alluvial settings, such as the nearby Hirundo Site (Sanger et al., 1977) and the Sharrow site (Petersen and Putnam, 1992).

Much of the younger archaeological material at the site was found in a mixed context. However, excavations at the central portion of the site produced evidence of intact Late Archaic and Ceramic period occupations. The Late Archaic period is represented by Laurentian tradition bifaces and a groundstone "slate" bayonet fragment. Excavations and amateur collections have recovered pottery from each of the Ceramic periods. Phase II work at Blackman Stream encountered a intact CP 2 feature that contained pottery and bifaces, and was radiocarbon dated to 1110 ± 70 ^{14}C yrs BP. Preservation of these distinct assemblages is attributed to continuous slope wash and alluvial deposition in the topographically lower portion of the site (Belcher and Sanger, 1988).

Peppard Site (74-20)

The Peppard Site (Belcher and Sanger, 1988b) is located on the southern, downstream side of the confluence of Blackman Stream and the Penobscot River

(Figure 3.5). The site is located on the upper of two terraces that are analogous to those recognized at Blackman Stream. Shovel test pits and excavations were placed primarily on the upper terrace.

The stratigraphy of the lower terrace consisted of a thin layer of fine-grained sediments on a gravel/boulder lag. The upper terrace stratigraphy was divided into two zones (Table 3.21). Zone 1 was identified as a 20 cm thick plow zone, and consisted of a mixture of dark brown, medium sand, silt and clay. Zone 2 consisted of approximately 1m of medium to fine sand, ranging in color from olive brown to yellow red, with only weak soil development in Stratum II. A thick, compact fine-grained deposit, analogous to that seen at the Blackman Stream site was deposited on a cobble/boulder lag at the base of the excavation units.

Artifacts recovered at the site ranged in age from Late Archaic to Ceramic periods 2 and 3, but occurred a mixed context with historic material. A hearth was discovered at the base of the plow zone on the upper terrace, but without diagnostic material.

Table 3.21 Peppard Site (74-20) Stratigraphy (from Belcher and Sanger 1989)

Strata	Zone	Color	Sediment Texture	Depth below surface (cm)	Sediment Thickness (cm)	Dates [1]Radiocarbon [2]Diagnostic Artifact	Geological Interpretation
I	I	10YR 3/3 Dark brown	Medium-fine sand	0	20	20th to 19th century[2]	Terrestrial organic material combined with fine-grained alluvial sediments (AP Horizon)
II	II	10YR 5/8 Yellow brown	Medium sand	20	20-30		Alluvial sediments (B horizon?)
III		2.5 YR 5/4 Olive brown	Medium sand	35	10	(Early -Mid Ceramic period) (Late Archaic period)	Alluvial sediments (C horizon?)
IV		2.5 YR 5/4 Olive brown	Fine sand	60	15-20	circa 5000-3050 ^{14}C yrs BP[2]	Alluvial sediments, (C horizon?)
V		10YR 6/2 Gray brown	Compact fine sand	80	45+		Lacustrine/Glaciomarine sediments3.20?

Geoarchaeology of the Blackman Stream Locality

The stratigraphic sequence exposed in the trenches and excavations at the Blackman Stream site provide a window into the geologic history of the central Penobscot Valley. The addition of chronology contributed by radiocarbon dates and diagnostic artifacts makes this an extremely useful location for piecing together the Holocene development of this portion of the Penobscot River Valley. The pebbles and coarse sand exposed in the base of the western portions of BBHT#1 and #2, as well as in the bottom of deep excavation units in the south central portion of the site, were deposited by high-velocity fluvial conditions. Their stratigraphic position below the radiocarbon-dated paleosol and the Late Paleoindian assemblage suggests that they were deposited before 9,000 ^{14}C yrs BP, and represent Late Pleistocene/Early Holocene fluvial deposition by the Penobscot River. Following the withdrawal of the Presumpscot-era estuary, the river responded to the falling base by downcutting through the accumulated glacial deposits. The rising base level related to rising sea level after 10,800 BP, coupled with large volumes of melt water and sediment, resulted in the deposition of coarse-grained, bedded deposits, such as those at the base of the Blackman Stream site.

The eastern side of BBHT#1 was located on the landward side of the depression that dominates the southern and central portion of the site. It is postulated that this depression represents an earlier channel of the Penobscot River. Sediments exposed in the base of this trench in this location are steeply dipping, bedded sand and gravel, and may represent point bar deposits developed on the side of the channel. No bedded sand or gravel deposits were noted in BBHT#2. The lack of bedded sand and gravel deposits, and the surface developed on till suggests fluvial erosion, but indicates that the position of the channel is topographically lower and to the west of the major portion of the trench. Pebbles and sand exposed in the base of BBHT#2 may be associated with this channel. Well-sorted sands deposited on the till surface in the eastern portion of BBHT#2 may also be related to the channel.

The origin of the compact silt and clay layer overlying the coarser deposits at the base of the trenches and excavations is unknown. The discovery of a diagnostic, Late Paleoindian artifact in this layer suggests an Early Holocene date of 9,000 or greater radiocarbon years ago for the abrupt change in sedimentary regime at this location. The slightly coarser, generally fining upward overlying sediments represent floodplain deposition, with some sediment contribution from slopewash from the adjacent steep bank to the east.

The Early Archaic age paleosol is thought to have formed at a time of limited sediment deposition, which allowed the formation of a soil layer, and accumulation of artifacts. The radiocarbon dates from the horizon suggest that time period encompassed almost a thousand years between 8,300 and 7,400 ^{14}C yrs BP. This time period corresponds to a time of falling lake levels in a paleohydrologic analysis at Mansell Pond, 15 km to the north of Blackman Stream (Almquist et al., 2001). Lake levels in this region fall in response to either decreased year-round precipitation, or decreased spring melt and runoff. Sedimentation on a floodplain would be most sensitive to decreased spring water volumes, when most of the sediment is transported in New England rivers (Magilligan and Graber, 1996). For this reason, the paleosol is interpreted to be representative of a time of regional lower winter precipitation causing reduced spring runoff.

The overlying sediments are attributed to fluvial sedimentation during floods and colluviation from the adjacent, steep bank. As both processes contribute fine-grained sediment to the section, it is difficult to determine the relative importance of each. The position of the site near the mouth of a tributary stream and upstream of a bedrock rapids may contribute to the ponding of flood sediments to the site. Personal observation after the April 1987 flood noted up to 3 cm of fine-grained sand on the top of the Blackman Stream site surface.

The sediments at the Peppard Site (74-20) were not studied as intensively as those at Blackman Stream. However, the stratigraphy is similar to that observed at the adjacent site, and they are interpreted to have formed in the same manner as those at Blackman Stream.

Ayers Rapids Locality

The Ayers Rapids locality consists of two sites, Ayers Rapids 1 and 2 (Belcher and Sanger, 1988), and is located on the east side of the Penobscot River, adjacent to the rapids (Figure 3.5). Ayers Rapids 1 is at the site of the proposed Basin Mills dam, and Ayers Rapids 2, downstream of Ayers Rapids 1, and is on the site of the associated powerhouse. An area of approximately 100 m of bedrock capped by soils separates the two sites. Archaeological investigations in the area between the two sites did not reveal any evidence of occupation.

Excavations at both sites were conducted in response to cultural resource management concerns related to the proposed dam and powerhouse. Phase I investigations took place in 1983. In 1984, additional shovel testing took place as the result of alterations in the project design plan. Phase 2 work on the site took place in 1987. Two backhoe trenches, oriented east-west, perpendicular to the direction of river flow, were excavated at Ayers Rapids 1, and one at Ayers Rapids 2 for stratigraphic control. Work at Ayers Rapids 1 proceeded as planned. However, land disturbance, consisting of deforestation and topsoil stripping, destroyed much of the surface archaeology at Ayers Rapids 2, and required a change in the excavation strategies.

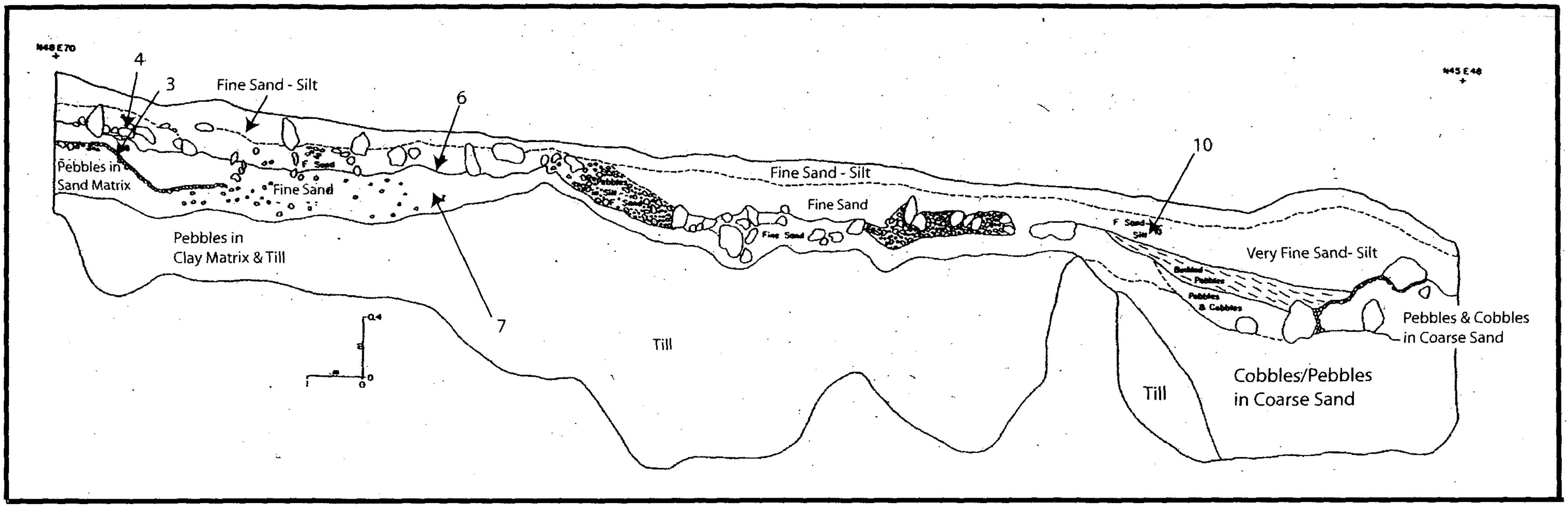
. This author provided the stratigraphic and geological material for Belcher and Sanger (1988b). The following discussion of the geology and stratigraphy of the Ayers Rapids sites 1 and 2 is excerpted from that report.

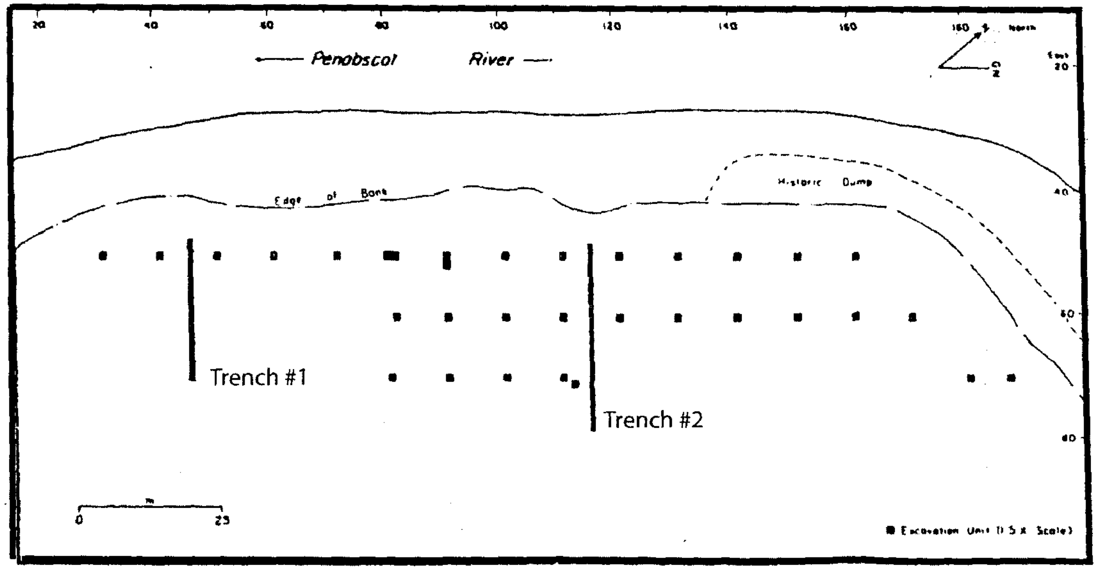
Ayers Rapids 1 (Site 74-21)

The Ayers Rapids 1 site is situated on a Late Pleistocene/Early Holocene terrace developed on the eastern side of the central Penobscot River (Figure 3.6). The terrace surface is approximately 20 meters above river level, and rises to the east and to a soil-covered bedrock knoll to the south. Outcrops of the Vassalboro Formation, a Lower Paleozoic grey-green phyllite, form the rapids and outcrop along the river.

Backhoe trenches and excavation units at Ayers Rapids 1 revealed an accretionary sequence of gravel, sand, silt, and clay. Backhoe trench (A1BHT) #1 (Figure 3.8), is located at the southern end of the site, at a slightly higher elevation than the terrace surface. Sediments exposed in the trench were deposited on clay-rich compact tills, capped by sandier water-washed tills for most of the entire length of the trench. A thick deposit of coarse sand and gravel was noted only in the base of the westernmost portion of the trench, and was capped by pebbles oriented in beds dipping to the west, toward the river. This deposit terminated against a 30 cm mound of pebbles and cobbles in a coarse sand matrix. The sediments exposed in A1BHT#1 generally increased in thickness, and decreased in grain size from the eastern to the western portion. Lenses of pebbles in a find sand and silt matrix were encountered in the fine sand layer above the till in the central portion of the trench. A continuous plow zone occupied the upper 10 to 15 cm of the trench surface deposits.

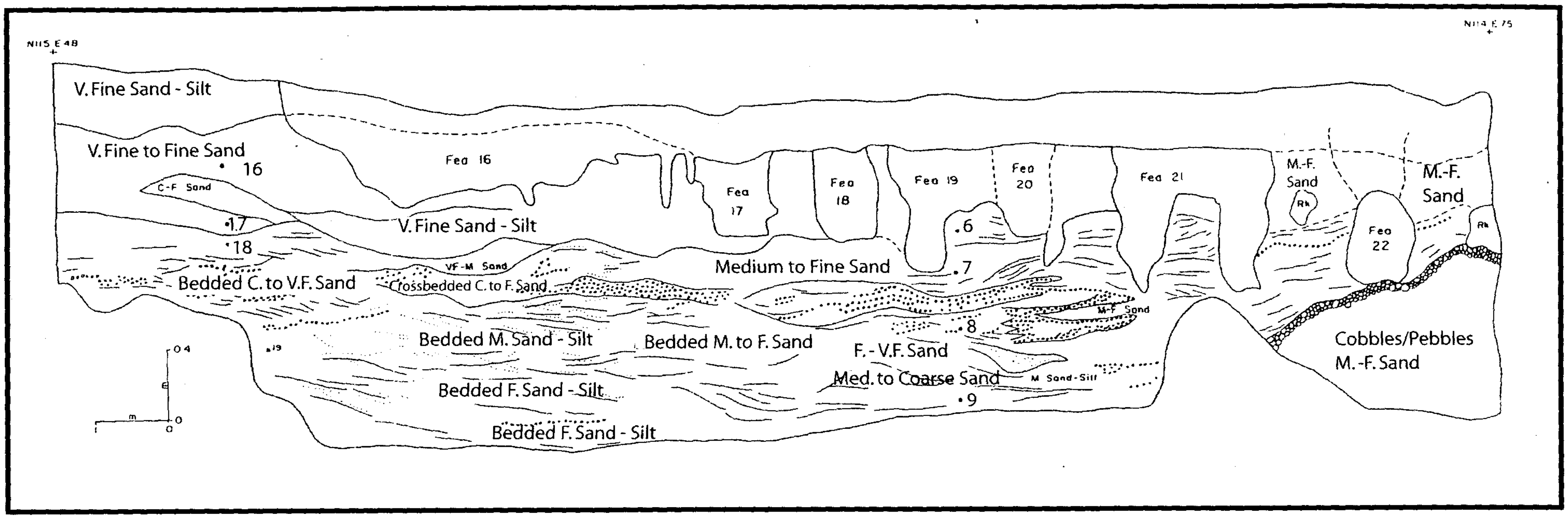
A1BHT#2 (Figure 3.9) was positioned across the main terrace surface. A thick, 1+ m, sequence of cross-bedded sediments, ranging in size from silt to pebbles was exposed in the eastern and central portion of the trench. The base of the western portion was dominated by a roughly, half-lens-shaped accumulation of cobbles and pebbles in a medium to fine sand matrix, over 1 m thick and 2.5 m. wide. A massive deposit composed of silt and sand capped the bedded deposits, and was in turn, overlain by a 10-15 cm thick plow zone. The plow zone truncates 7 large pit features that were intrusive into the massive sand and underlying bedded sediments. Ten additional pits and 2 hearths were.

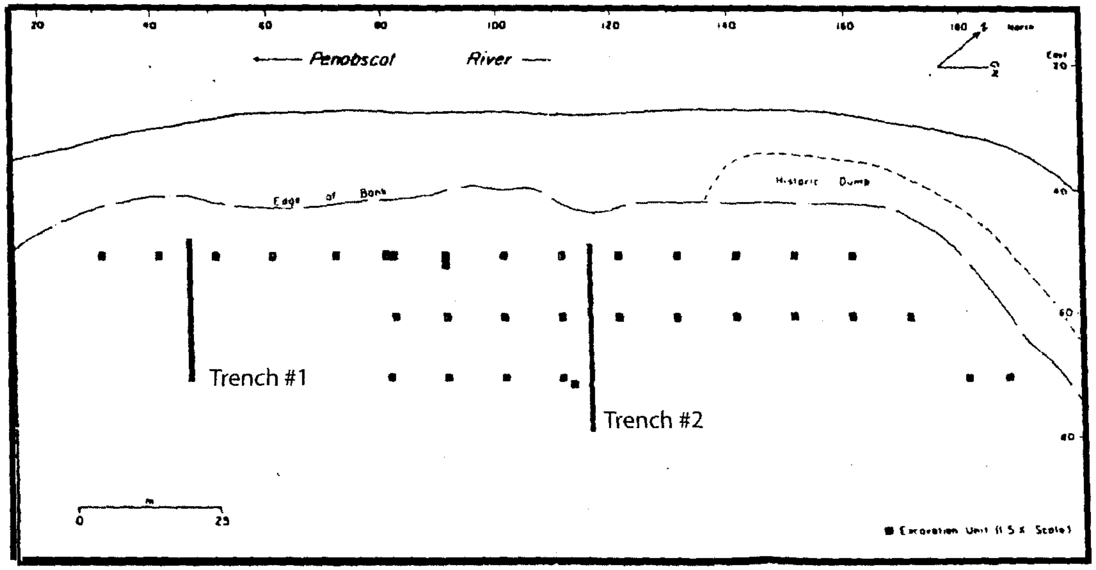




Sample #	% Very Coarse Sand	% Coarse Sand	% Medium Sand	% Fine Sand	% Very Fine Sand	% Silty Clay
3	19.3	7.5	11.2	18.6	14.8	27.6
4	7.5	1.5	11.1	30.3	23.6	24.3
6	2.1	1.1	10.9	33.4	27.8	17.0
7	37.4	5.1	2.1	10.1	11.2	16.2
10	1.4	1.3	8.5	33.0	26.9	29.0

Figure 3.8: Ayers Rapids 1 Backhoe Trench #1 (Modified from Belcher and Sanger 1988b





Sample #	% Very Coarse Sand	% Coarse Sand	% Medium Sand	% Fine Sand	% Very Fine Sand	% Silty Clay
6	0.1	0.8	17.5	40.6	29.4	11.6
7	0.5	1.3	26.5	39.8	20.3	11.6
8	26.3	8.1	22.1	24.8	15.3	3.5
9	14.7	1.7	6.6	17.8	39.4	16.7
16	0.2	1.0	24.8	37.6	23.2	13.2
17	0.0	0.9	13.8	31.7	28.7	24.9
18	2.0	3.1	25.7	37.8	26.8	5.4
19	0.9	1.0	2.2	10.3	63.1	22.5

Figure 3.9: Ayers Rapids 1 Backhoe Trench #2
(Modified from Belcher and Sanger 1988b)

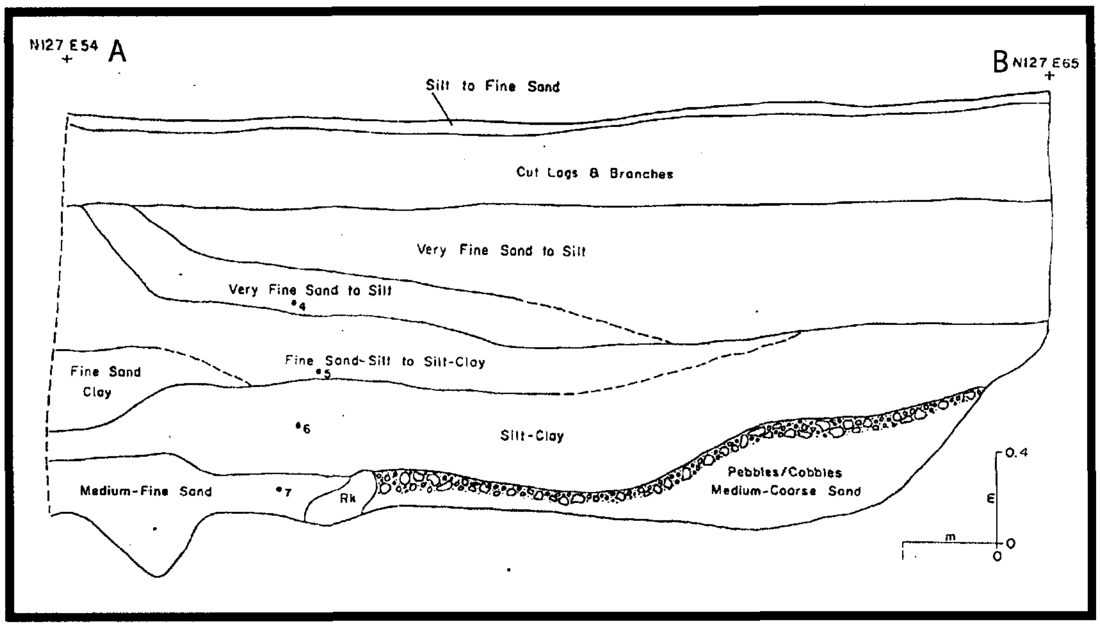
located at other portions of the site. All of these features were intrusive into the underlying sediments

The artifact assemblage at Ayers Rapids 1 is dominated by Middle Ceramic period material. Charcoal from a hearth associated with a large rim sherd of middle Ceramic period pottery returned a radiocarbon date of 1600$\pm$60 ^{14}C yrs BP, consistent with the chronological assignment determined by artifact attributes. A single Late Archaic feature containing a plummet and a small quantity of red ochre represents the earliest recognized use of the site. Charcoal from this feature was dated at 4020$\pm$60 ^{14}C yrs BP. This feature was also truncated by the plow zone, and appears to be excavated into the underlying sediments

Ayers Rapids 2

The Ayers Rapids 2 site is located to the south, or downstream, of Ayers Rapids 1, and on the site of the proposed powerhouse for the Basin Mills dam (Figure 3.5). The ground surface at this site is approximately 2m lower than the Ayers Rapids 1 terrace surface. Clearing and topsoil stripping damaged the near surface stratigraphy. The plow zone, noted in shovel test pits, was obliterated over most of the site. A depression that was present over most of the site, tentatively identified as an abandoned channel, was filled with bulldozed material.

An 11 m long, east-west backhoe trench (A2BHT) (Figure 3.10) exposed sediments to a depth of over 3 meters below ground surface. Most of the sediments exposed in the base of the trench were composed of pebbles and



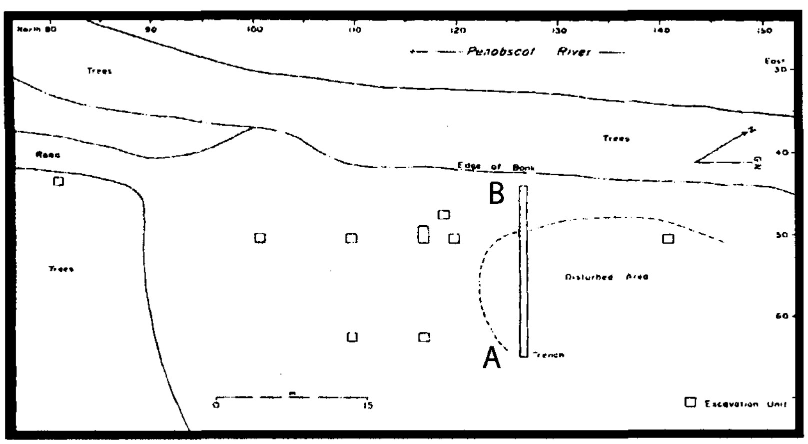


Figure 3.10: Ayers Rapids 2 Backhoe Trench #1 (Modified from Belcher and Sanger, 1988b)

cobbles in a medium to coarse sand matrix. The eastern portion of the trench base was characterized by well-sorted medium to fine sands. These deposits were overlain by 30 cm of silt and clay. The upper sediments in the section were massive layers composed of fine-grained sand and silt, differentiated on the basis of grain size and color. Contacts between units ranged from sharp to gradational. Stratigraphic units in the eastern portion of the trench dipped gently to the west. The upper portion of the stratigraphic sequence consisted of cut logs and branches from the deforestation of the site, covered with a thin layer of soil. The plow zone noted in shovel test pits in the area was apparently removed.

Archaeological excavation at the site identified the original plow zone beneath disturbed sediments in the southern, slightly lower portion of the site. A buried horizon was discovered beneath disturbed sediments in the central portion of the site. This dark grey silty sand contained charcoal, flakes, and fire cracked rocks. The horizon appears to rise to the modern, unaltered surface level. The buried horizon is absent in the area of the now-filled channel. Only one diagnostic artifact, a Middle Ceramic potsherd, was associated with the buried horizon. Another feature, a hearth was discovered in massive, fine-grained sediments 10 cm below the buried horizon. The hearth feature was encased by the sediments, but was associated with lithic artifacts and a large number of flakes covering a broad area. Charcoal from this hearth returned a radiocarbon date of 3,080$\pm$120 ^{14}C yrs BP, consistent with the artifacts present. This date indicates Late Archaic period use of the area.

Geoarchaeoelogy of the Ayers Rapids Locality

The backhoe trenches at Ayers Rapids 1 and 2 provide insight into the formation of a Late Pleistocene/Early Holocene river terrace. Formation of the terrace began with downcutting of the glacial and glaciomarine sediments along a broad surface as sea level fell. The till and water-washed tills exposed in A1BHT#1 at Ayers Rapids 1 document this phase. As flow became channelized, areas closer to the current river position were eroded more deeply. After this initial incision, alluvial deposits began to accumulate in response to a falling base level. High water velocities and large sediment loads deposited thick accumulations of bedded and crossbedded sediments, seen in the lower, eastern portions of Ayers Rapids 1 A1BHT#2. Gravel bars accumulated in the higher velocity locations in the active channels, and are represented by the accumulations of pebbles and cobbles in the western portions of all of the backhoe trenches in the Ayers Rapids Locality (A1BHT#1 and 2). In the Ayers Rapids 2 backhoe trench, A2BHT, a 30 cm thick silt-clay deposit caps the basal pebble/cobble deposit, indicative of an abrupt change in sedimentary regime. The same horizon is not noted above the topographically higher pebble/cobble deposits at Ayers Rapids #1. The remainder of the sedimentary sequence at both sites is formed of alluvial sediments deposited in a flood plain setting, which have been subsequently incised by the Penobscot River. The cause and timing of the base level changes that controlled the initial incision of the valley, and then caused the deposition of the terrace deposits is not known. It is possible that it is related to localized changes in stream gradient caused by the northwestward migration of a glacial forebulge in the Early Holocene.

All the archaeological features seen at Ayers Rapids #1 were intrusive deposits, and provide little information about the timing of sedimentation. Feature 2 of Ayers Rapids #2, however, was formed as part of the sedimentary sequence, and indicates that floodplain deposition was active circa 3,000 years ago. The presence of Middle Ceramic period cultural material in a buried horizon at Ayers Rapids 2 suggests that either alluvial sedimentation was reduced enough to allow pedogenesis to take place, or human activity was intense enough to create an anthrosol in this location during this time period.

Eddington Bend Locality

The Eddington Bend Locality is represented by a single site, the Eddington Bend Site (74-8). The cultural resources of the area have been recognized since the early 1900's. Walter B. Smith (1926) described a village and cemetery site at Eddington Bend as oriented along the riverbank, and containing numerous hearths and storage pits, as well as a cemetery consisting of red ochre deposits and "cremation pits." Following Smith's work, extensive amateur collecting disturbed the surface of a large portion of the site. On the author's initial visit in 1986, Smith's cemetery area had a "cratered" appearance from numerous illicit excavations. This portion of the site is now protected by a locked enclosure. More recent cultural resource management activities were associated with the construction of a new powerhouse at the site led to Phase I survey in 1984 and Phase II excavations in 1986. The Phase II work involved examination of 58 m^2 of the site, as well as 3 backhoe trenches (Figures 3.12, 3.13, and 3.14) oriented across the site and adjacent hillside to examine the local stratigraphy. This work exposed the till deposits that frame the eastern valley wall, as well as the alluvial sediments that make up the terrace. Phase III work, conducted in 1989, included a large block excavation, 7m x 7m in the terrace portion of the site, an 1 x 8 m.long trench across the upstream upland, and additional 1 x 1 m excavations in the adjacent hillsides. This work was terminated when a change in corporate plans cancelled the powerhouse development.

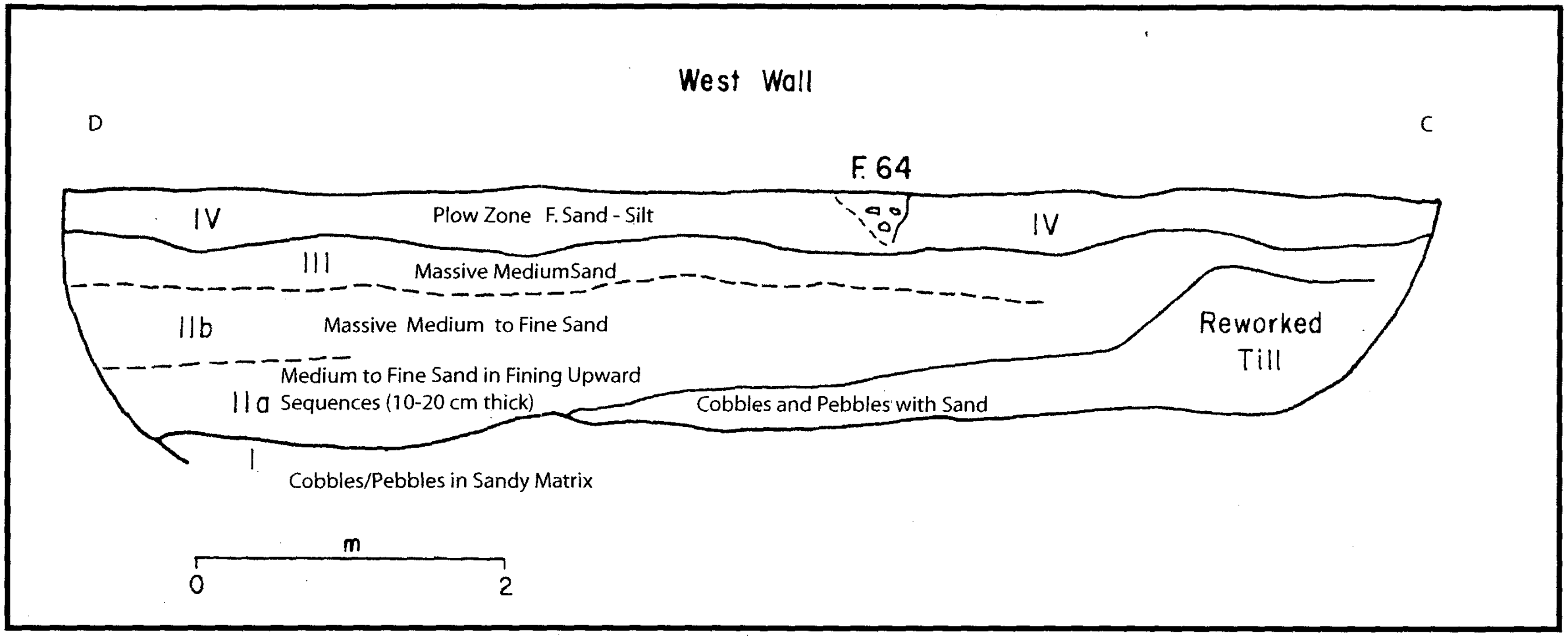
Eddington Bend Site (74-8)

The Eddington Bend Site (Petersen and Sanger, 1987) (Figure 3.5) is located on the east bank of the Penobscot River at the falls just upstream from a pronounced curve of the river in the town of Eddington. The site overlooks one of the premier Atlantic salmon pools in the eastern US. A hydroelectric dam, the Veazie Dam, is located adjacent to the site, and an associated fish ladder and stream-gauging tower were constructed at the northern edge of the site. The site has been disturbed by a variety of activities, including road and power line construction, farming, amateur and professional archaeological investigations.

The site is situated approximately 20 m above the river, and occupies the flat surface of a Late Pleistocene fluvial terrace, as well as the sloping hillside to the north and east of the site. The bank facing the river is steep and actively slumping. Outcrops of the lower Paleozoic Vassalboro Formation (Osberg, et al., 1985) are common along the river adjacent to the site, and at the northern end of the site. The Veazie Dam, adjacent to the site, is anchored on bedrock outcrops that formed the Eddington Bend rapids mapped by Treat (1820).

Limited excavations in the lower portion of the bluff directly below the site exposed a grey, clay-rich till containing striated stones resting directly on the glacially smoothed and striated Vassalboro Formation outcrops. A clay/silt-rich layer was also exposed in the bluff, approximately 2.5 m above the bedrock, and is interbedded between till layers. These sediments may correlate with the basal tills and rhythmites described by Brady (1982), at a bluff exposure on the east side of the river, approximately 1 km upstream from the Eddington Bend site. A boulder lag separates the stratified terrace deposits from the underlying till at this location. Till with a sandier matrix is seen at the base of a borrow pit developed in the downsteam end of the Eddington Bend site terrace. A similar, and probably correlative unit, is also exposed in the northeastern, basal portion of the stratigraphic sequence of backhoe trench (EBBHT) #3 (Figure 3.11), as well as in a borrow pit approximately 0.3 km upstream of the site.

The lower portion of the terrace sediments is exposed in pit at the southern end of the terrace. At this location, a 3 m thick imbricated cobble/pebble layer with an upper cap of clast-supported cobbles and pebbles with a coarse to fine grained sand matrix was revealed by mechanically clearing a portion of the slumped pit face. Clasts represent a variety of lithologies, not just the local Vassalboro Fm. The maximum clast size is approximately 7 cm in



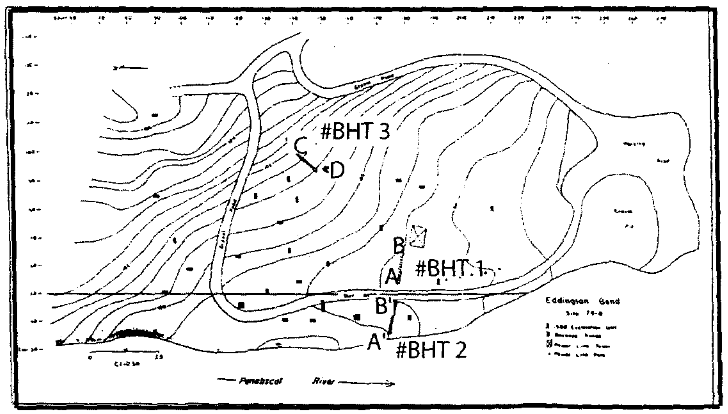


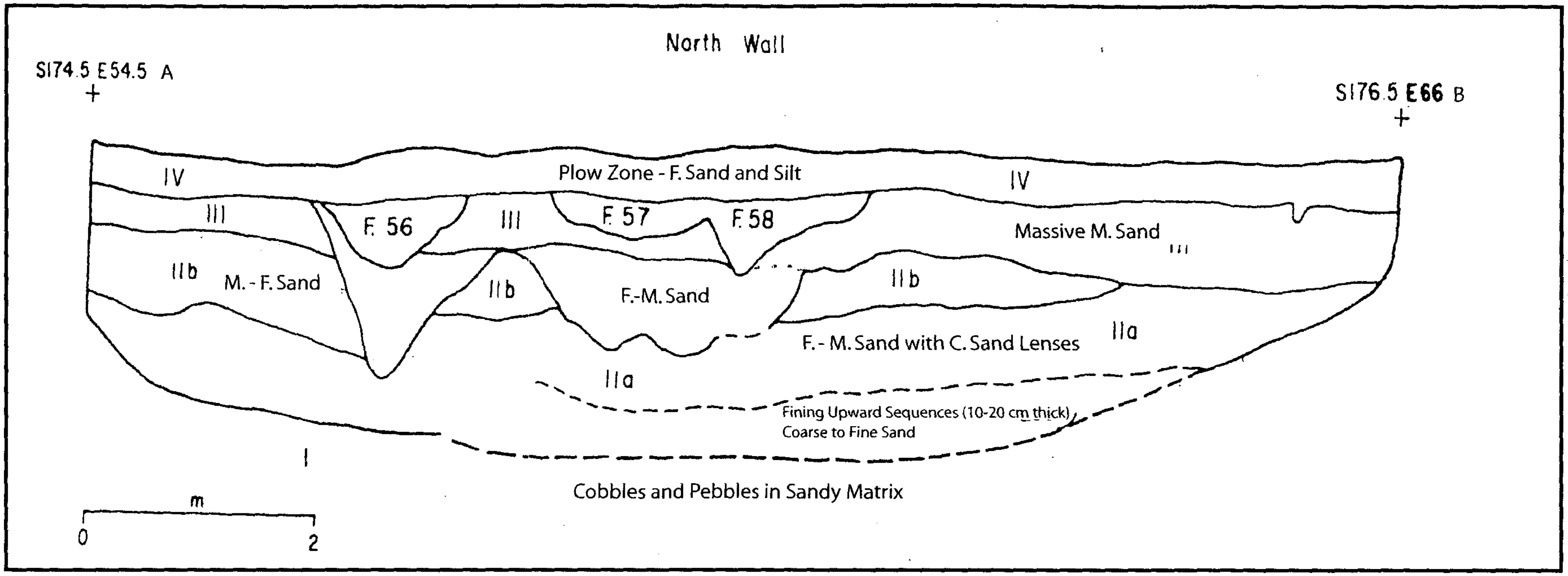
Figure 3.11: Eddington Bend Backhoe Trench #3 (Modified from Petersen and Sanger, 1987)

the longest direction of the clast. The upper portion of the pit, approximately 2.5 m, was heavily vegetated and could not be cleared. However, the upper portion of this sequence was exposed in the backhoe trenches, EBBHT #1 (Figure 3.12) and #2 (Figure 3.13), located approximately 30 m north (upstream) of the borrow pit.

The lowest unit, Stratum 1 in EBBHT #1 (Figure 3.12) and EBBHT #2 (Figure 3.13) is composed of cobbles and pebbles in a sand matrix, and, on the basis of lithology, matrix composition, and clast size, is believed to be correlative with the upper layer of cobbles and pebbles exposed in the nearby borrow pit, 30 m to the south. The upper portion of this unit is also seen in the southwest end of EBBHT#3, at approximately 2 m below ground surface. The base of the unit is not exposed in EBBHT #1 or #3, but on the basis of correlation, is thought to be approximately 3m in thickness. In EBBHT#3 (Figure 3.14), the base of the cobble/pebble unit is also not exposed, but terminates to the northeast against a poorly sorted unit with a sandy matrix, identified as water-washed till.

An iron-stained, coarse to medium grained sand is associated with Stratum I, fills spaces between clasts, occurs as a thin (5-10 cm thick) layer overlying the cobbles, and is present as lenses above the cobble layer in EBBHT #2. These lenses range in size from 1 m to 0.5 m in length, and are approximately .3 m in width. In EBBHT#2, the lenses are found in association with cross-bedded medium grained sands.

Sediments overlying Stratum I are subdivided into two substrata, IIa and IIb. Stratum IIa is composed of olive brown, fine to medium grained sand with



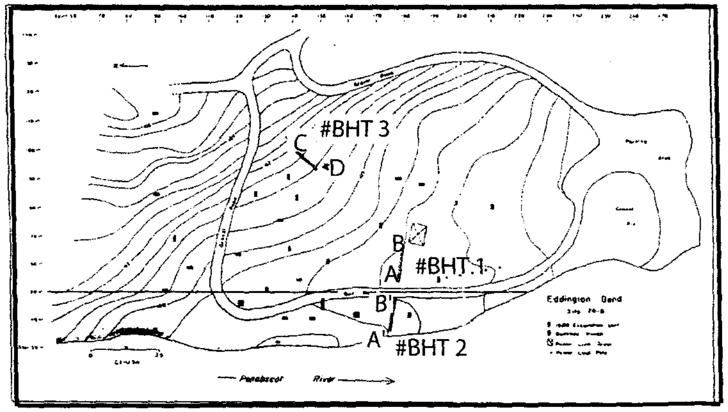
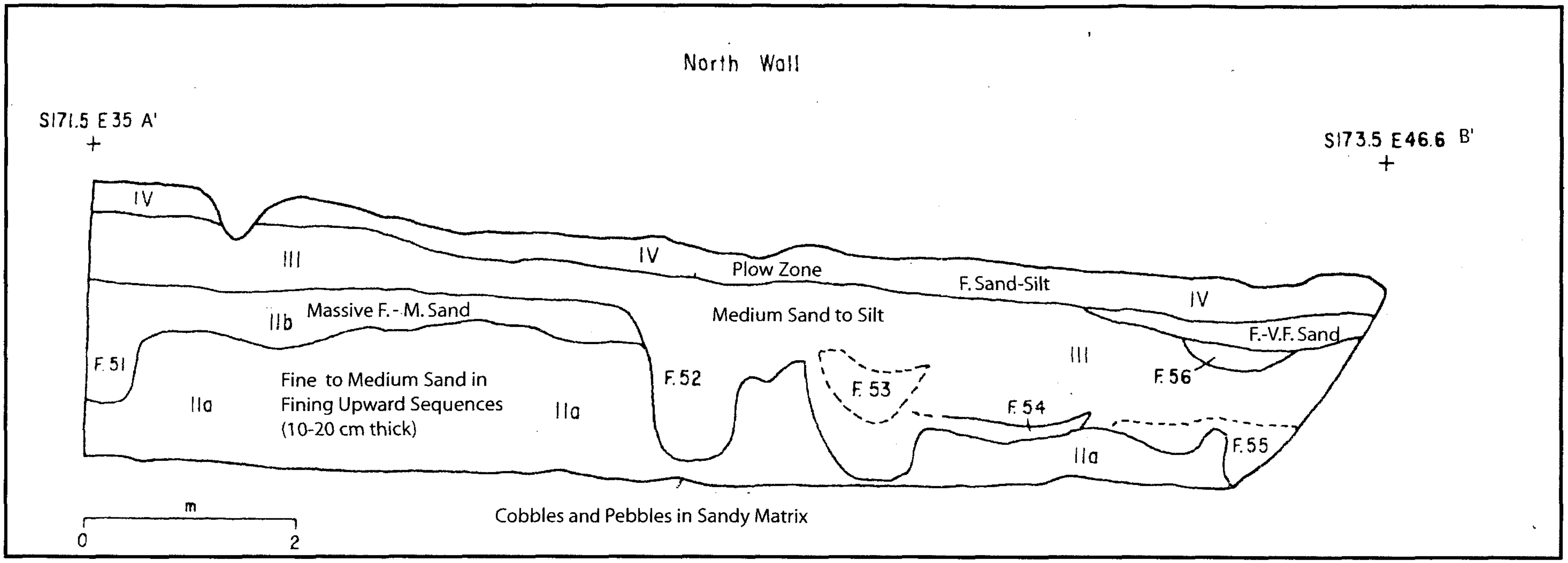


Figure 3.12: Eddington Bend Backhoe Trench #1 (Modified from Petersen and Sanger, 1987)



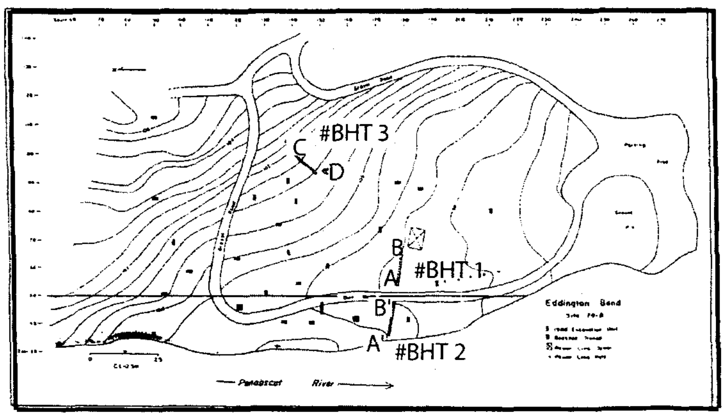


Figure 3.13: Eddington Bend Backhoe Trench #2
(Modified from Petersen and Sanger, 1987)

occasional coarse sand lenses. Stratum IIa is characterized by a series of sedimentary sequences composed of coarse to medium grained sand fining upward to very fine-grained sand and silt. Each sequence was approximately 10-20 cm in thickness and was laterally continuous for about at meter. Stratum IIa was observed in both EBBHT#1 and #2, and ranged in thickness from a maximum of 1.1 m in EBBHT#1 to a minimum of 30 cm in EBBHT#2. Stratum IIa was only faintly discernable in EBBHT#3.

Stratum IIb consists of olive brown, medium-grained to very fine-grained sand. The deposit has a massive appearance, and no sedimentary structures were observed. Stratum IIb is seen in the western portion of EBBHT#1 and the western and central portions of EBBHT#2. The unit is approximately 0.5 m in thickness where observed. In most of the profile visible in EBBHT#3, the fine sands that are directly above the reworked till were most similar to Straturm IIb in EBBHT #1 and #2,

Stratum III occupies the stratigraphic position above Stratum II. This deposit is composed of brown to grayish brown, medium-grained sand to silt. As with Stratum IIb, no sedimentary structures were observed in this stratigraphic unit. Stratum III is present in EBBHT#1 and 2, and ranges in thickness from a maximum of 1 m in the central portion of EBBHT#1 to a minimum of 30 cm in the western portion of EBBHT#2. Stratum III is present throughout the profile exposed EBBHT#3, and maintains a uniform thickness of approximately 0.5 m.

Stratum IV is the uppermost stratigraphic layer exposed in the backhoe profiles, and is composed of dark gray, organic-rich very fine sand to clay, and represents the plow zone from earlier farming activities at the site. Stratum IV is generally distributed across the site, except in areas where it has been mechanically removed and in areas where backdirt from amateur excavations (Stratum V) overlies Stratum IV. Stratum V was observed in excavation unites located adjacent to "amateur" excavations. It is composed of a mixture of Strata IV, III, and II, and varies in thickness.

Archaeological deposits at the Eddington Bend site revealed possible Late Paleoindian occupation, as well as established Late Archaic, Ceramic, and Historic periods. No diagnostic Early or Middle Archaic artifacts were recovered. A single, diagnostic Late Paleoindian parallel-flaked point was found at the northern edge of the terrace, in a massive sand layer approximately 80 cm below the surface. The massive sand unit is tentatively correlated with Stratum IIb on the basis of stratigaphic position, color, and grain size. Dating of scattered charcoal from the surface returned dates of 5389 ± 70 ^{14}C yrs BP and 6480 ± 70 ^{14}C yrs BP, too young to be associated with an artifact typically dated between 8500-9500 BP. A presumed Late Archaic plummet was found in close stratigraphic association with the Late Paleoindian biface, and the massive sand deposit containing the biface is stratigraphicaly below a large accumulation of fire-cracked rock associated with Late Archaic period artifacts.

Moorehead phase and Susquehanna tradition bifaces were recovered from the site, as were a ground slate bayonet and lanceolate point. Ground stone celts and a gouge, all associated with the Late Archaic period, were found in excavation units. Pottery recovered at the site is primarily representative of the Early Ceramic period, with a lesser amount of material attributable to the Middle to Late Ceramic periods. Material from a pot representing earliest Ceramic period, was identified in material from a private collection.

Features in the terrace area consist primarily of intrusive pit and trench features excavated into the upper 1 meter of sediments, and were assigned a Late Archaic to Ceramic period age on the basis of diagnostic artifacts. Historic material, including a modern sheep burial, was also encountered in the terrace area. Late Archaic and Ceramic period pits appeared as straight-walled or inverted bell-shaped features, ranging in depth from 0.5 to 1 m, and approximately 0.3 to 1 m. in diameter. In some cases, these pits were associated with charcoal and fire-reddened soils, and could readily be assigned the designation of hearths. In other situations, pits were identified on the basis of non-stratified fill and clear breaks in the stratigraphic sequence when viewed in profile, but could not be assigned a function, due to the lack of diagnostic artifacts. Long trenches, associated with large quantities of fire-cracked rock and post molds were identified as possible drying racks or roasting pits. One small, basin-shaped red ochre deposit containing calcined bone was encountered in the north wall of EBBHT#1. Forensic analysis did not identify human bone, and no diagnostic artifacts were recovered, limiting interpretation of the feature. The cemetery area, identified by Smith (1926) was not investigated.

Geoarchaeology of the Eddington Bend Locality

The Eddington Bend site area consists of Late Pleistocene/Early Holocene fluvial terrace sediments and those of the adjacent upland. The terrace deposits were deposited on fluvially excavated Pleistocene till deposits. Holocene colluviation has added to the upper portion of the terrace and hillside sedimentary sequence.

Exposures of clay-rich till at the base of the Eddington Bend section, and sandy-matrix till in the eastern valley wall in EBBHT#3 indicate downcutting of the valley, and fluvial reworking of marginal material. Although not dated at Eddington Bend, it is reasonable to expect that the erosion of the valley occurred in response to the rapid fall of sea level that following the draining of the ocean from the Penobscot embayment. Deposition of the Stratum I, the cobble and pebble is related to deposition by rapidly flowing water with a high coarse sediment fraction.

The fining upward sequences that characterize Stratum IIa indicate continued deposition, but by generally lower velocity water. In addition, the change from coarser to finer sediment in each sublayer of the unit may represent deposition during a single flood event. The sediments of Strata IIb and III represent increasing finer, floodplain deposition as the channel moved farther from the eastern side of the valley, and/or began incising the recently deposited coarser sediments, and could only overtop the terrace during high flow events. Eventually, downcutting lowered the channel to a level that precluded flood deposition on the terrace surface, which now is approximately 10 m above the river surface. A plow zone, Stratum III, developed during agricultural activities at the site during the last 200 years, caps the sequence.

The chronology of geological events at the site are not well constrained. The oldest artifact at the site is the Late Paleoindian parallel-flaked projectile point, found in three pieces at different excavation levels. Examination of the artifact revealed sharp edges, although it is possible that was broken or discard before completion (Sanger pers. commun., 2005). However the dates associated with the artifact and the context in which it was found are confusing. As noted previously, the dates are considerably younger than what would be expected of an artifact representative the Early Holocene. The association of the artifact with a groundstone plummet of the Late Archaic period, and no other flakes or older material in a massive, fine-grained floodplain deposit is curious.

Two primarily interpretations exist. Either the Late Paleoindian period projectile point represents primary deposition at the site, and dates the fine-grained deposit to the Early Holocene, or the artifact represents secondary deposition by human or natural processes approximately 5300 – 6500 ^{14}C yrs BP. The artifact's sharp edges and close association the three pieces suggest negligible water transport, even though it is found in a medium-grained sand, presumably alluvial sediment. The radiocarbon dates and stratigraphic association with younger artifacts suggests that the parallel-flaked biface may be an "heirloom" artifact, found by Archaic people at some other location, and deposited at the site during that time period. If this is the case, its presence provides no information on the timing of the deposition of the sediments at the site. Because most of the archaeological material is derived from intrusive features in the terrace deposits, the artifacts found in the terrace deposits do not aid in the developing a chronology for the site. Without further work at the site and within the region, the exact timing of valley incision and terrace formation cannot be determined.

In the Phase II report Kelley (in Peterson and Sanger, 1988) suggested that the intrusive features may have been capped by a layer of fluvial sediments within the last 1,000 years. Further experience in the area, suggests that floods of that magnitude are very rare. The lack of differentiation of the top of the pit features is not due to later deposition, but more reasonably due to mixing of the upper sediments by various forms of bioturbation after active fluvial deposition on the terrace ceased.

In summary, the excavations at Eddington Bend provided a window into the local stratigraphy, particularly the deposits that compose the alluvial terrace and the relationship between those deposits and those that compose the valley wall. The presence of the Late Paleoindian projectile point suggest a long-term occupation of the area, but the lack of a supporting radiocarbon date clouds the interpretation slightly.

Summary

Combining sites within a close geographic area into localities allows comparison of individual site setting, chronology, stratigraphy, and paleogeographic information. This produces as analysis that moves beyond the site-specific analysis of data, and produces the foundations for a broader understanding of the potential relationship of people and landscape through time. This is particularly important when examining hunting and gathering cultures, like those of the central Penobscot Valley, who exploited different portions of their surroundings as natural abundances of resources varied due to seasonal and environmental changes.

Late Paleoindian occupation of the region is documented at the Blackman Stream site by a diagnostic, parallel-flaked biface 1 m below a well-dated Early Holocene horizon. Artifacts and accompanying radiocarbon dates at the Hirundo, Blackman Stream, Mackowski Farm, and Gilman Falls sites establish the Early/Middle Archaic use of the area. Late Archaic and Ceramic period sites are numerous. The sudden appearance of sites of this age in the Lower Pushaw locality is tied to a major, mid-Holocene paleogeographic change as a stream environment replaced a formerly extensive lake system.

It should be noted that the analysis of localities focused on sites associated with the current channel of the Penobscot and Stillwater Rivers. This is not to suggest that sites do not exist outside this corridor, but that investigations were limited to this area by funding constraints. For a complete understanding of the lifeways of the region's inhabitants prior to European arrival, archaeological investigations now need to move way from the primary streams and rivers, and examine upland and lakeshore areas with high archaeological potential as indicated by site location models and paleoenvironmental and geologic reconstructions.

Chapter 4

POSTGLACIAL DEVELOPMENT OF THE CENTRAL PENOBSCOT RIVER VALLEY

Introduction

The focus of this study is to produce a developmental sequence for the formation of the central Penobscot River to allow examination of its geomorphic and environmental influences on the pre-European occupation of the region. Although geologically and geomorphically distinct, the central Penobscot is part of a larger, dynamic system, and the discussion of the formation of this portion of the river cannot be isolated from processes that have shaped the upstream and downstream reaches. For this reason, the discussion of the postglacial development of the Penobscot will move "farther afield" beyond the initial study area, and consider the processes that shaped the river as a system, but with an emphasis on the central Penobscot.

This chapter will first discuss available information about the Pre-Wisconsinan course of the Penobscot River. Then, geological, paleoenvironmental, and archaeological information will be used in an interdisciplinary approach to develop a post-glacial history for the Penobscot River. Geological data includes bedrock and surficial geology and geomorphology. This information provides details about the geologic framework of the river, as well as data relative to regional and localized isostatic adjustment. Paleohydrologic studies in the Penobscot Valley and the region have contributed detailed local water balance data that point to regional climatic variations through time. Paleoenvironmental and paleogeographic studies on both a local and regional scale provided vegetational history reconstructed from pollen analysis of wetland cores, and information relating to the history and distribution of lake extent in a portion the study area. Detailed archaeological investigations in the study area offered detailed stratigraphic information and chronology.

Pre-Wisconsinan Drainage Patterns of the Penobscot River

The Laurentide Ice Sheet was the last of a succession of Pleistocene ice sheets to advance and retreat across northern New England and the Maritimes (Stone and Borns, 1986). Successive glaciations smoothed the landscape by beveling topographic highs and filling topographic lows. Rivers typically occupy these low areas, and erode and rework the glacial fill. During each interglacial period, a river system developed on the newly exposed landscape. These new rivers developed either in locations coincident with previous courses, or in the face of glacially produced obstructions, carved new channels. Broad, deep valleys with well-developed channels characterize the older, reoccupied pre-glacial valleys. Rapids and waterfalls are characteristic of younger, deranged drainage.

The development of the post-Laurentide drainage pattern of the Penobscot River followed this interglacial pattern. The geomorphological characteristics of the river suggest a post-glacial course deranged, at least in part, from its pre-glacial course. The numerous rapids in the island and rapids divisions of the river are indicative of deranged drainage, as are poorly integrated systems characterized by adjacent extensive bogs and wetlands. The lower portion of the river, south of Bangor, flows through a well-developed valley, apparently occupying a pre-glacial channel.

Calkin's (1960) study of the Pre-Wisconsinan drainage pattern of the Penobscot River in the Bangor and Orono 15' quadrangles identified two potential courses of the pre-Laurentide Penobscot using landforms and depth to bedrock information (Figure 4.1). One proposed channel is west of the present day channel, and follows the trend of Pushaw Lake to Caribou Bog, and continues along topographic lows into Bangor where it meets the Kenduskeag Stream, and, finally, the present day Penobscot. The second course flows out of Alton Bog, runs along the west side of the Stillwater River channel, crosses the present day Penobscot at Veazie, and then runs along the east side of the Penobscot channel until intersecting with the present course in Bangor. This trend places much of the Pre Wisconsinan channel beneath a large esker that runs along the west side of the Stillwater River and then Penobscot River south of Orono. In his study, Calkin attributed derangement of the pre-glacial course of the river between Old Town and Bangor to filling of the river valley by glacial deposition, and discounted any effect of isostatic adjustment on the development of the modern day Penobscot.

Examination of bridge borings at Indian Island/Old Town, Bangor/Brewer, and Bucksport/Verona (ME DOT) show a bedrock-framed valley filled with glacial sediments (Figure 4.2). In the case of the Old Town section (Figure 4.2), the

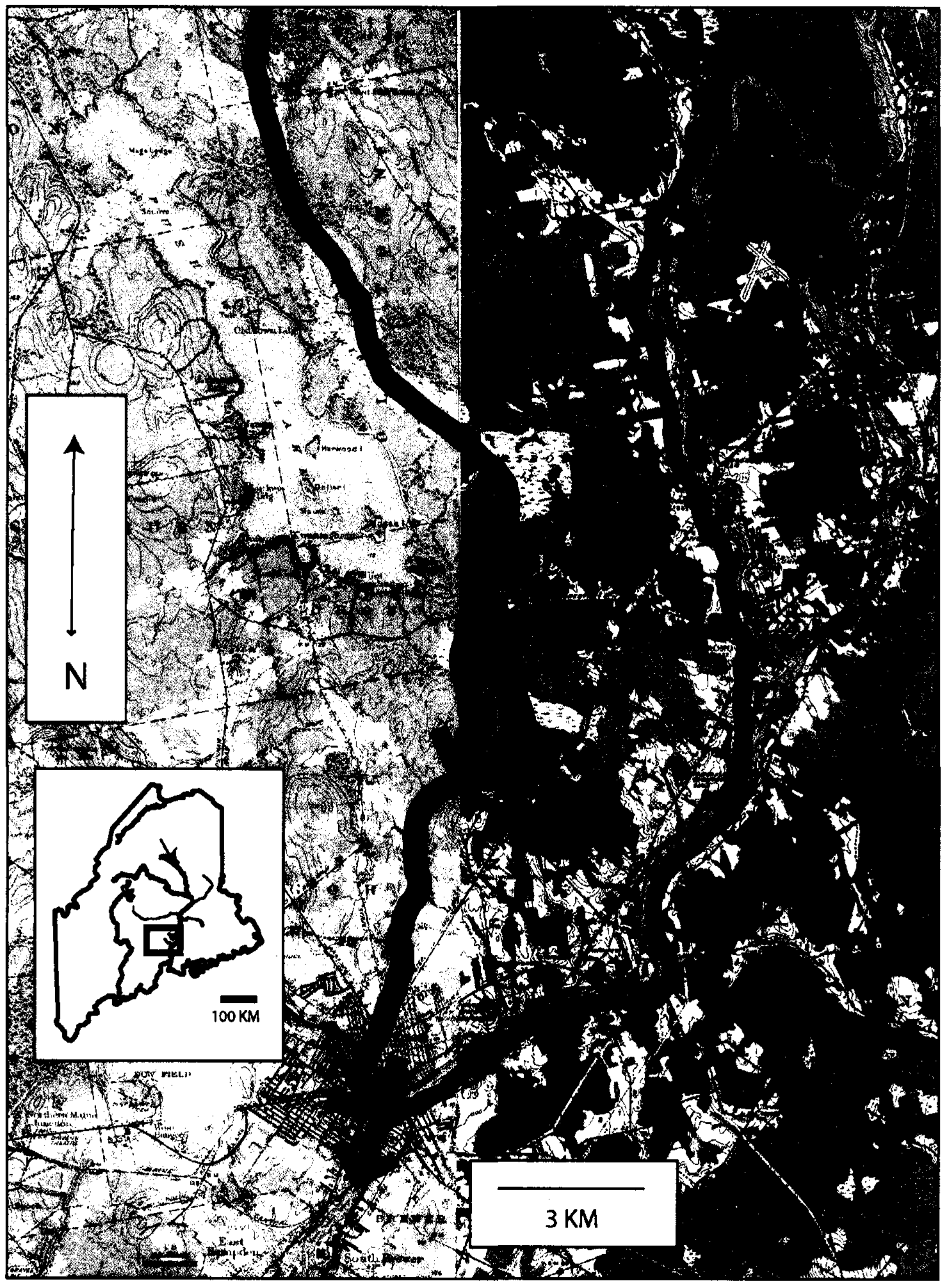


Figure 4.1: Pre-Wisconsinan course of the central Penobscot River (Modified from Calkin, (1960)

present day river appears to have abandoned a deeper, bedrock channel to the west, and flows over a bedrock falls. At Bangor/Brewer (Figure 4.2) and Bucksport/Verona (Figure 4.2), the Penobscot River occupies what appears to be an older, pre-existing channel, now partially filled with glacial and fluvial sediments. Soundings by Trefethern (1946) across the salt marsh at the mouth of the South Branch of the Marsh River at Frankfort (Figure 4.3), located a deep channel interpreted to be a pre-glacial course of the Penobscot River, now blocked by glacial debris and occupied by the extensive Frankfort salt marsh.

Post-glacial Development of the Penobscot River

Late Pleistocene/Early Holocene Coarse-grained Deposits

The early post-glacial history of the Penobscot River is tied to the Late Pleistocene relative sea level fall through the central and coastal region of Maine, discussed in detail in Chapter 2, Late Pleistocene Glacial History. This rapid fall in sea level produced steep river gradients that combined with large amounts of sediment and water from melting ice in the headwaters regions to produce the high velocity and high volume river conditions that shaped the initial Penobscot River valley.

At the relative sea-level high stand, circa 13000 ^{14}C yrs BP, the Penobscot Valley was inundated by a large marine embayment that extended inland to the confluence of the present day East and West Branches of the Penobscot River (Borns et al., 2004; Dorion et al., 2001, Thompson and Borns, 1985). At this

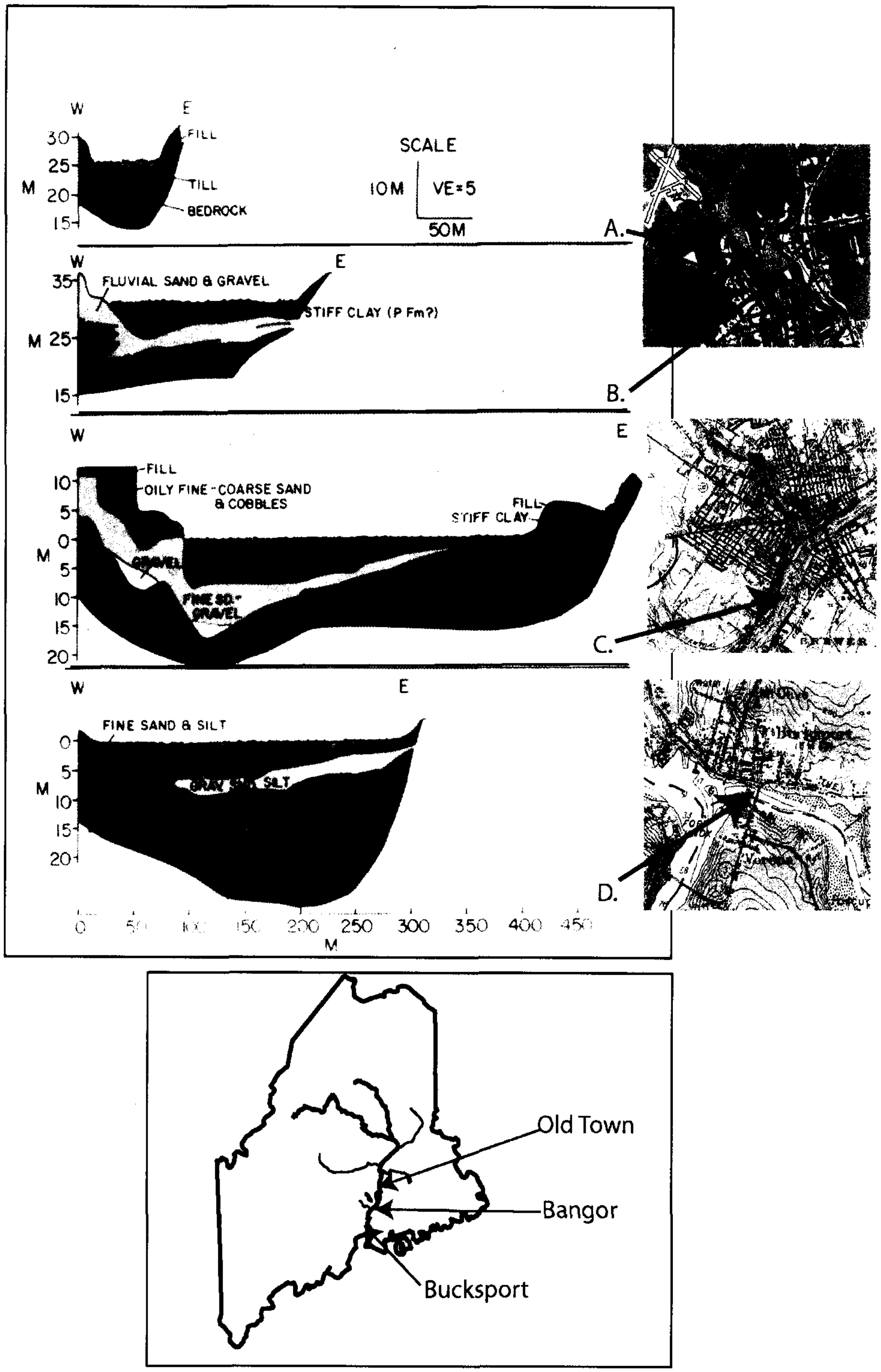


Figure 4.2: River cross-sections constructed from MDOT bridge borings. A. Stillwater River at Indian Island, Old Town B. Penobscot River at Center Street, Old Town, C. Penobscot River at Bangor D. Penobscot River at Bucksport/Verona

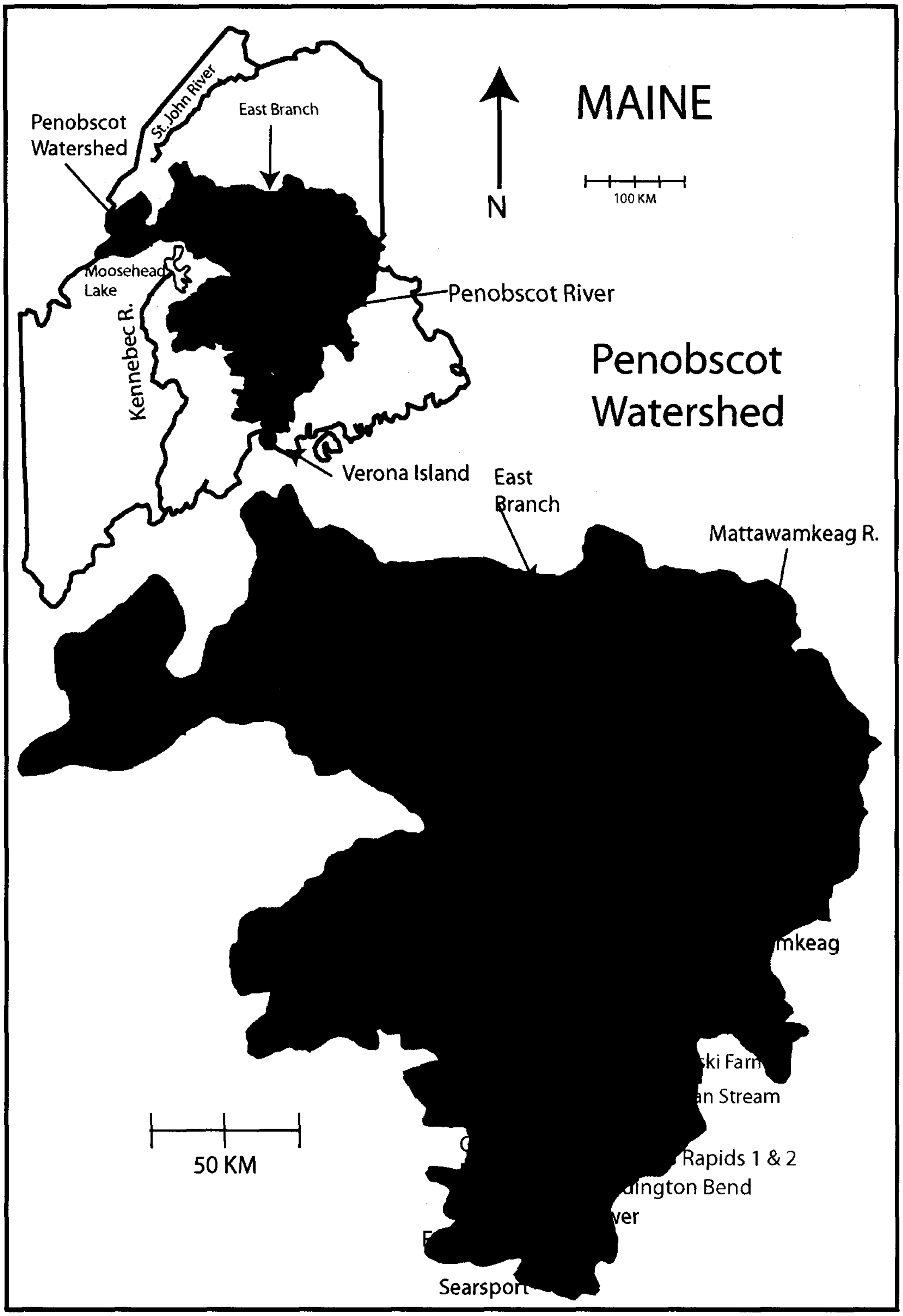


Figure 4.3: Location map showing sites mentioned in Chapter 4 text

time, the East and West Branches of the Penobscot carried melt water and sediment, and were graded to the relative sea level high stand. As sea level began to fall shortly after 13000 ^{14}C yrs B.P. in response to isostatically-driven uplift of the area, these streams began to incise and transport this recently deposited material, forming prograding outwash trains (Hooke, et al., 2006).

As sea level continued to fall, the mouth of the river moved to the south, and river processes were graded to a continuously falling sea level. Terraces noted in several portions of the valley are related to this period of regional sea level fall. Reconnaissance surficial mapping in the East Branch and the upper portions of the Island Division of the Penobscot River by Hooke and Borns (pers. comm., 2005) has identified a series of six gravel terraces ranging in elevations from 4 to 14 m above river level. Well-developed terraces are also noted along the Old Town, Orono, and Bangor/Brewer portions of the river. In the Old Town area, three, unpaired terraces eroded into till and composed of alluvial material are developed in a till-framed valley, and are at elevations of approximately 40 m to 30 m above sea level. The Orono terraces are located along the Stillwater River, and consist of 2 to 3 unpaired terraces ranging in elevation from 30 m to 20 m above sea level. In Bangor and Brewer, flights of terraces are present on both sides of the Penobscot River between 30m and 3 m above sea level, but detailed elevation determinations have not been completed, so it is not possible to ascertain if these terraces are paired. Reconnaissance level mapping in this area, using limited outcrops, suggests that the upper terraces in the Old Town and Bangor/Brewer area are erosional features formed by fluvial excavation of the glaciomarine Presumpscot Formation and till, while the terraces at Orono, as well as lower terraces at Old Town, Bangor, and Brewer maybe formed of alluvial material, deposited and then incised by river erosion. Hooke et al. (2006) interpret the northern most terraces as features formed as a subaerial outwash plain, subqequently incised when the rate of sea level fall exceeded the rate of outwash progradation. A similar mode of formation is posited for the more downstream depositional terraces, but the numerous bedrock outcrops along the river in the Island Division suggest a more complicated scenario of terrace formation. As river downcutting advanced and encountered bedrock ledges, these outcrops created local base levels, removing the terrace system from the effect of sea level. Any subsequent episodes of aggredation or incision in that reach would then be in response to variations in river discharge and sediment load, rather than sea level change. Additionally, coarse-grained material deposited behind the bedrock base level would be trapped behind these bedrock sills, and no longer able to move through the river system.

To date, the detailed work of establishing stratigraphic and chronologic correlations in the Penobscot terrace systems have not been completed. Stratigraphic information and chronology are only available for terraces that were the sites of archaeological excavation in the central Penobscot Valley. Detailed topographic maps of these sites were created, but not tied into local topographic survey benchmarks. This means that while elevations of deposits are accurately measured with respect to a site datum, they cannot be georeferenced in terms of the actual elevation of location, complicating terrace correlation.

At a reconnaissance level, it appears that the basal, coarse-grained deposits at Blackman Stream, Ayers Rapids 1, and Eddington Bend may be remnants of the of a prograding, coarse-grained alluvial deposit formed during the initial drop of sea level through the valley. All locations are at approximately 15 m above sea level, and have a similar internal stratigraphy: a coarse cobble/pebble deposit approximately 2 m below the surface in the portion of the terrace closest to the active river channel, topped by a sequence of finer sand and silt deposits. These coarse-grained deposits record a time of high velocity flow, created by steep gradients produced by falling sea level and high discharge volumes related to melting ice in the headwaters of the watershed.

At the Eddington Bend site, the most downstream of the three sites, the sand deposits overlying the gravels are composed of a series of fining upward sequences of coarse sand to very fine sand and silt representing deposition by a series of flood events. Massive deposits of fine sand, silt and clay, interpreted to be floodplain sediments cap fining upward sequences (Figures 3.11, 3.12, and 3.13). This entire sedimentary package now stands approximately 10 m above river level. This suggests that the terrace formation was graded to a much higher river elevation than present, and was abandoned as incision excavated the valley to the present local bedrock base level at Gardner Falls (Treat, 1820) approximately 1.5 km downstream from the site, and at an elevation of approximately 5 m above sea level.

At the Ayers Rapids 1 site (Figure 4.3), the gravels are topped by crossbedded sand with occasional gravel layers, that were in turn, overlain by massive fine-grained sediments identified as flood plain deposits (Figure 3.10). These interbedded sand and gravel deposits mark deposition by flowing, relatively high velocity water, in a channel or near-channel setting. The overlying fine-grained deposits may be caused by channel avulsion, establishment of a local base level, or a rapid change in river discharge

Coarse-grained sand and gravel was also exposed at the base of excavations at the Blackman Stream (74-19) site. Bedded sand and silt layers, indicating variable flow conditions in a channel or near channel location overlie the gravels. This sequence is somewhat similar to the preceding sites, although the sediments related to flowing water deposition are much thinner than those at Eddington or Ayers Rapids (Figure 3.7).

Artifacts and radiocarbon-dated charcoal from archaeological features, as well as correlation with the Maine coast relative sea level curve can be used to establish an approximate chronology for the deposition of the coarse-grained component of the central Penobscot Valley terraces. The best chronologic information for the landform comes from the Blackman Stream Site (74-19). Here, a diagnostic Late Paleoindian parallel-flaked point was recovered from 2.17 m below the ground surface, in the compact silt layer overlying the sand and gravel at the base of the section (Sanger et al., 1992). This style of artifact is interpreted to represent the time period ranging from 9500 to 8500 ^{14}C yrs BP. A date within this time period is supported by dates between 8,300 to 7400 ^{14}C yrs BP from charcoal associated with a buried soil approximately 1 m above the Late Paleoindian biface. Artifacts consistent with an Early Archaic age were recovered from this horizon. This evidence places the formation of the coarse-grained deposit prior to 9000 years ago, and indicates a Late Pleistocene to Early Holocene age for the coarse-grained deposits.

Correlation with the Maine coast relative sea level curve (Belknap et al., 1985; Barnhardt et al., 1995) using a isostatic tilt from the coast of 0.8 m/km, a distance of 40 km from the coast, and a local elevation of 15 m places sea level at the Blackman Stream location at this elevation at approximately 12750 ^{14}C yrs BP. The geomorphic position of the terrace relative to the river supports a post-glacial, Late Pleistocene age of the basal, coarse-grained facies of the terraces. The Ayers Rapids 1 and Blackman Stream deposits are within a few meters above the current river level, with local base levels fixed at bedrock ledges near each site. The Eddington Bend gravels, however, are approximately 10 m above the river, suggesting significant downcutting after terrace sediment deposition.

Thus, archaeological evidence and correlation with the Maine coast relative sea level curve suggests that the coarse sediments at the base of the Blackman Stream/Ayers Rapids 1/Eddington Bend terrace were formed as an outwash/fluvial deposit, linked to the rapid fall of sea level during the Late Pleistocene. The cross-bedded sand and gravel overlying the Ayers Rapid 1 gravels and the cyclic fining upward sequences capping the gravel at Eddington Bend are also linked to active channel or near channel deposition. This interpretation would then indicate that coarse-grained deposits upstream of this location formed at an earlier, higher than present sea level position, and similar, downstream deposits are correlative with later, lower sea level stands. However, lack of datable organic material from these deposits requires that they can only be assigned a Late Pleistocene age and placed in a relative order of events at this time.

Floodplain Deposits

Massive deposits consisting of fine sand, silt and clay cap the basal coarse-grained channel deposits in the central Penobscot Valley. These fine-grained deposits form the most common sedimentary unit exposed in archaeological sites in the central Penobscot Valley, and contain archaeological material representing the Early Holocene to modern time. These massive units vary in thickness from approximately 0.5 m to over 2 m, and show no internal structure. The fine grain size and lack of sedimentary structures suggest that these deposits formed as fine sand, silt, and clay settled out of low velocity or standing floodwaters. Sediment colors vary from yellow brown to olive brown. The fine-grained sequences can be subdivided on the basis of grain-size and color, but contacts between units tend to be gradational and poorly defined. Organic material is absent, with the exception of charcoal found in association with archaeological deposits. Buried soil horizons are encountered in these deposits at several locations, and will be discussed in a separate, later section of this chapter.

The age of the flood plain deposits varies with location. Archaeological material and associated radiocarbon dates provide a chronology for the dating of many of these sedimentary sequences. At Blackman Stream a diagnostic Late

Paleoindian biface in fine-grained sediments immediately above bedded sand and gravel signals a change in depositional style circa 9500 ^{14}C yrs BP. The basal portion of the Mackowski Farm site consists of over a meter of sediments beneath a buried soil and archaeological feature radiocarbon dated to circa 8500 ^{14}C yrs BP (Robinson, pers. comm., 2005). The earliest component of the Hirundo site consists of fine-grained flood deposits dated to circa 7000 ^{14}C yrs BP on the basis of diagnostic artifacts. Deposition of the lower portion of the Gilman Falls sequence, on the Stillwater River (Figure 4.3), is placed prior to 7000 ^{14}C yrs BP on the basis of radiocarbon dating of charcoal contained in an overlying spodic horizon. At the Beaver site (Figure 4.3), fine-grained sediments overlying gravel were associated with a radiocarbon date circa 8100 ^{14}C yrs BP. Chronologic information was not available for the basal portions of the flood deposits at the Eddington Bend or Ayers Rapids Localities.

At each of these locations, sediment grain size shifts rapidly from coarse-grained channel deposits or a boulder/cobble lag to overlying fine-grained sand, silt, and clay. This rapid shift marks a profound change in geological processes at each of these locations. In the Rapids division of the Penobscot River (Blackman Stream, Gilman Falls, Ayers Rapids and Eddington Localities), the river's channel is confined by bedrock or till exposures. If channel avulsion is responsible for rapid grain size shifts, the change in thalweg position is on the order of one to two modern channel widths, with the shift to the west at each location. In the Island Division of the River, the channel is not as well confined, and older, now abandoned channels are recognized, particularly to the east of the present day channel. It is most likely that these channels were operational when discharge volumes were higher in the Late Pleistocene, but this supposition has not been confirmed by dating. The circa 8500 ^{14}C yrs BP date at Mackowski Farm from a buried soil horizon above over meter of sand/silt/clay deposits on a gravel lag deposit suggests that the channel has been in its present location since the Early Holocene.

Other recognized geological events in the Penobscot valley that could be responsible for or contribute to an abrupt change in river discharge are a decrease in meltwater from the receding ice sheets, the shift in the outlet of Moosehead Lake from the Penobscot to the Kennebec drainage circa 9000 ^{14}C yrs BP, and the establishment of local bedrock base levels at numerous locations throughout the valley. The timing of a waning Younger Dryas meltwater contribution to the valley would be roughly coincident with the rapid shift from channel and near-channel to flood deposits in the Late Pleistocene or Early Holocene. However, the gradual decrease in water is anticipated to create a more gradational change, rather than the sharp contrast that is noted at these sites.

As discussed in Chapter 2, Balco et al. (1998) first recognized the change in the outlet of Moosehead Lake from the now abandoned channel at Northwest Carry to the current outlets forming the upper Kennebec River. Work completed as part of this study refined the timing of the outlet change to the earliest Holocene circa 9000 ^{14}C yrs BP, and used a decade of modern stream gage data to estimate the effect of the outlet change on the discharge of the two rivers. The analysis of stream gage data suggested an almost 75% increase in the discharge of the upper Kennebec, and a 50 % decrease in the discharge of the West Branch of the Penobscot River.

This change in discharge and accompanying sediment load of the Penobscot River is tied to the cessation of deposition circa 9000 ^{14}C yrs BP at a recently identified –30 m paleodelta in Penobscot Bay (Belknap et al., 2002, 2005) (Figure 4.4). The Penobscot paleodelta (Belknap et al., in press) possesses steeply dipping clinoform reflectors, appears graded to approximately -30 m depth, is buried by up to 10 m of modern mud, and has no surface expression on the seafloor. Cores into reflectors interpreted as foreset beds contain coarse sand and gravel. Radiocarbon dates from two articulated *Mya arenaria* shells in life position in tidal flat deposits over the delta indicate that the sandy delta terminated growth by ca. 8740 ^{14}C yrs BP (Barnhardt et al., 1997). A newer date of circa 8000 ^{14}C yrs BP (Belknap et al., in press) suggests the tidal flats over the delta persisted during this time of relatively slow sea level rise. A second, younger date of 5500 ^{14}C yrs BP, also acquired from the tidal flat deposits over the delta, is interpreted to represent incorporation of younger material through deposition and reworking of the tidal flat sediments. Tidal flat mud, then deeper water, fine-grained deposits, buried the deltaic sands, leaving no modern trace of a sandy, river-mouth setting (Barnhardt et al., 1996; Knebel and Scanlon, 1985).

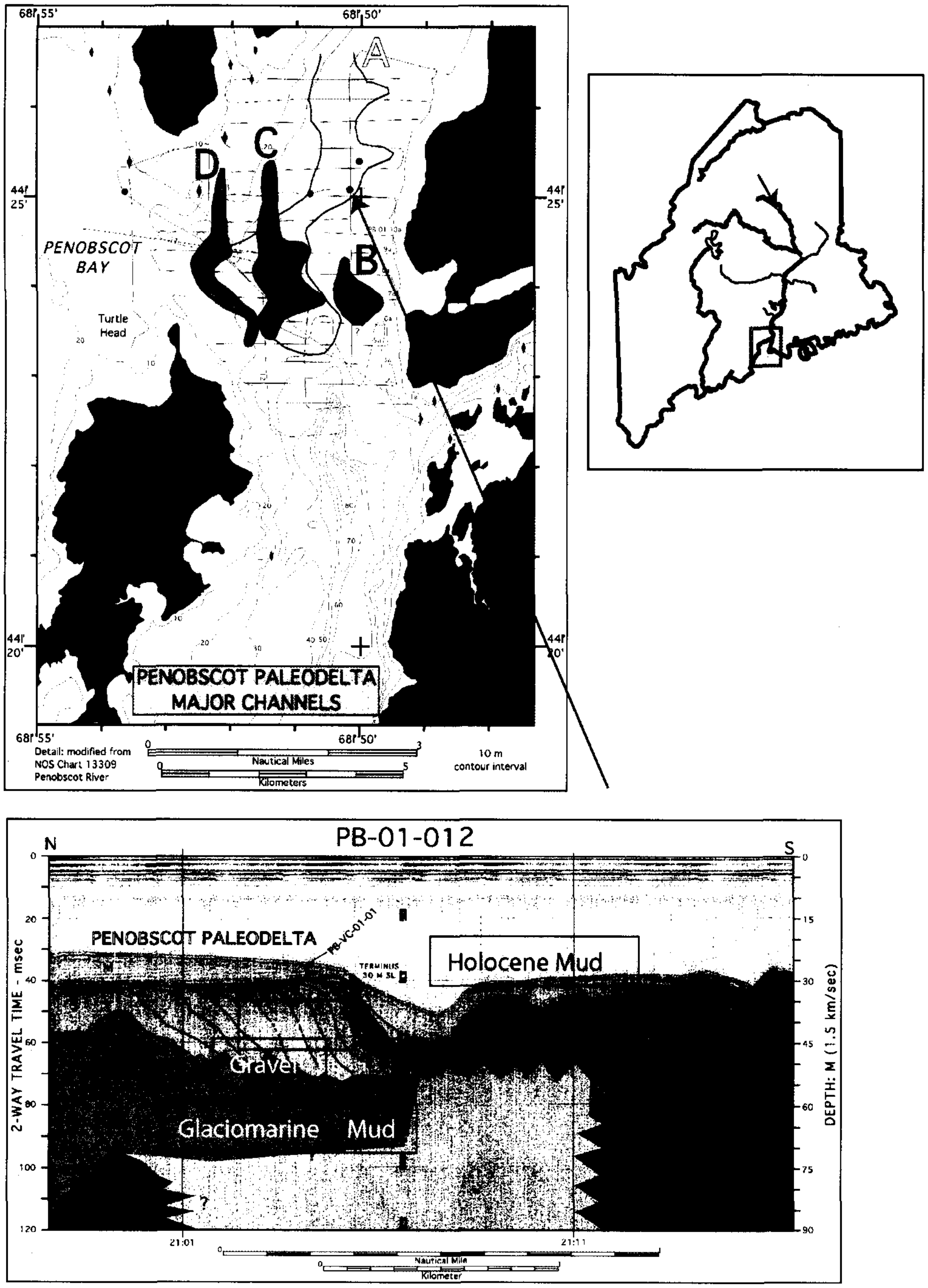


Figure 4.4: Penobscot Paleodelta and core location. Modified from Belknap et al. 2002, 2005.

Because river discharge is currently seasonally pulsed in New England due to spring rains coupled with snow melt (Magilligan and Graber, 1996), the highest stream flow values in the Kennebec and Penobscot Rivers occur duringthe spring freshet between late March and late April. Since a large portion of the snowmelt contribution is derived from high relief areas in the Central Highlands, the magnitude of the spring freshet is especially sensitive to changes in discharge in the upper reaches of these rivers. As described in Chapter 2, the capacity of the river to transport sediment is tied to discharge. While sediment capacity of the Penobscot has not been studied, investigations of the Kennebec (Fenster et al., 2001, FitzGerald et al., in press) show that the Kennebec exports sediment only during the two months of the spring freshet.

Recognition of the linkage in the timing of the cessation of deposition on a paleodelta in Penobscot Bay and the removal of the Moosehead contribution to the Penobscot suggests that the loss of the substantial spring freshet water and sediment volume lead to the termination of deltaic deposition. This same diminished spring freshet after the outlet change may have affected deposition within the valley by abruptly decreasing the capacity of the river.

Local, bedrock base levels have been noted at many locations within the central and upper Penobscot Valley. Numerous rapids and waterfalls are formed by these exposures of resistant bedrock that trend roughly perpendicular to the flow of the Stillwater and Penobscot Rivers. In many locations, overlying deposits of glacial, glaciomarine, and fluvial sediments were incised to bedrock by the early Penobscot, particularly as the river was responding to rapidly falling sea level prior to the relative sea level lowstand, and as coarse sediment loads were waning with increasing distance from the melting ice sheet. When the base of the channel reached bedrock, a local base level was established, and the upstream reach of the river was removed from the influence of sea level. This change in base level could result in an abrupt change in depositional style, producing a rapid change in sediment size from coarse to fine-grained sediment. Additionally, coarse-grained sediment behind each reach would be trapped, and unavailable for reworking and transport further in the system. For locations where the elevation of the bedrock sill was not significantly lower than elevation of flood events, flood deposits continued to add to the sediment accumulation.

This combination of changing river discharge, channel avulsion, and establishment of local, bedrock base levels are applicable to the stratigraphy observed at the sites on the main stem of the Penobscot from Blackman Stream upstream and on the Stillwater River. Following incision and formation of a local base level, human occupation of these locations between flooding episodes led to the formation of the stratified, multicomponent archaeological sites, with dates ranging from the Late Paleoindian period through modern time. However, the terrace deposits at the Eddington Bend and Ayers Rapids 1 sites appear to have a different geological history.

At Eddington Bend and Ayers Rapids 1, massive, fine-grained flood deposits overlie coarse-grained material in a situation similar to that observed at the upstream Penobscot and Stillwater sites. The primary difference lies in the nature of the extensive Late Archaic and Ceramic period features are present at these sites. Instead of the stratified settings noted elsewhere, at these sites, archaeological features exist as intrusions into the sediments from a surface obscured by the modern plow zone (Figures 3.8, 3.9, and 3.10). No archaeological material at these sites is older than circa 5000 ^{14}C yrs BP.

Both the Ayers Rapids 1 and Eddington Bend terraces are associated with a bedrock base level. Ayers Rapids, bedrock is located approximately 3 meters below the terrace surface level, is immediately downstream of the archaeological site of the same name. At Eddington Bend, bedrock is exposed in the river channel 10 meters below the surface of the terrace. The removal of both of these terrace surfaces from flood plain deposition prior to 5000 ^{14}C yrs BP appears to be associated with rapid incision through the terrace sediments to bedrock outcrops. This timing does not correspond to the sedimentary patterns noted at the archaeological sites upstream that show sedimentation throughout the Holocene.

No direct evidence exists for the timing of the downcutting and abandonment of deposition on these surfaces. Archaeological material provides a minimum date of circa 5000 ^{14}C yrs BP. While Late Pleistocene river incision related to relative sea level fall circa 12,000 ^{14}C yrs BP produces a surface available for occupation by 5000 ^{14}C yrs BP, it suggests that these surfaces remained unoccupied or with no evidence of occupation for over 5000 years. The alternative explanation is that the terraces formed as the result of a local, higher than bedrock elevation base level that persisted for some time after relative sea level fell through the Ayers Rapids/Eddington Bend portion of the river. The location and elevation of this base level is currently unknown, but geomorphic evidence suggests that it may have existed at Eddington Bend, where the Penobscot River makes a broad sweep around glacial deposits in its otherwise straight course (Figure 4.5). Further work will be needed to expand upon this hypothesis.

Two sites, Blackman Stream and Mackowski Farm show similar deposits at the base of the flood deposits not noted in other locations. The gravel at the base of the Blackman Stream sequence is overlain by bedded sand and silt topped by a layer of compact silt and clay, which is then overlain by coarser sand and silt floodplain deposits. At the Mackowski Farm site (74-14), the lag deposit at the base of the stratigraphic section is overlain by gray sandy clay, which is in turn capped by coarser sand and silt, interpreted to represent flood deposits. These two sequences appear to record an abrupt change in depositional environment at both locations, potentially not related to the establishment of the local base level at each site. In the case of the Blackman Stream deposits, the diagnostic Late Paleoindian biface dates this layer to circa 9,500–9000 ^{14}C yrs BP. The Mackowski Farm fine-grained deposit is approximately 1 m below an Early Archaic deposit identified on the basis of diagnostic aritifacts and associated radiocarbon dates. These two fine-grained deposits are potentially closely linked in time.

Conditions that produced these deposits may involve channel avulsion, an extreme drop in discharge, or a rapid change in base level. The Blackman Stream site is located on a portion of the river where till banks and bedrock

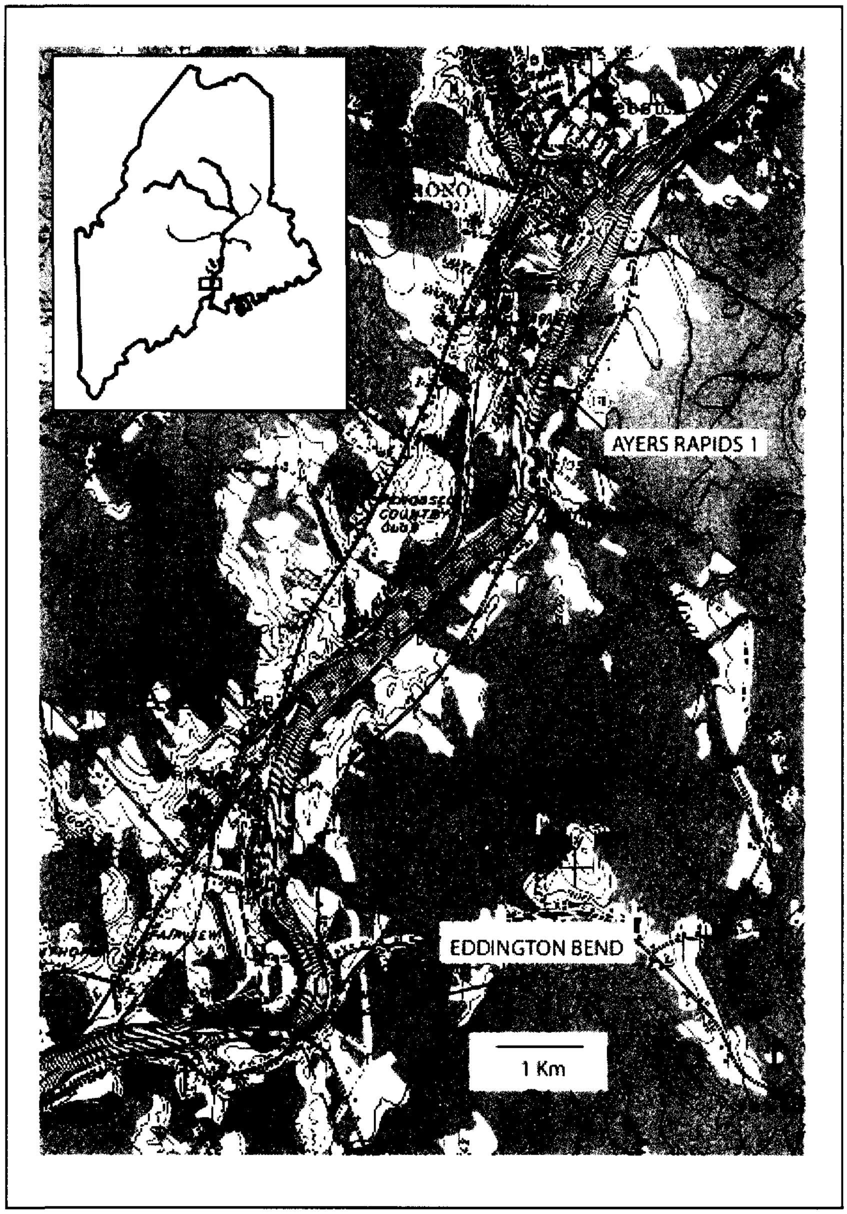


Figure 4.5: Location of Eddington Bend and Ayers Rapids 1

outcrops allow little lateral channel migration. However, archaeological excavations did uncover a higher than present channel, approximately 1 m above present river level in the eastern portion of the site. Compact silt/clay mantled this entire portion of the site. The Mackowski Farm site is located on a broad, low relief area where the river is poorly confined. If channel avulsion produced these deposits, it occurred at the same time in two separate reaches of the river. While possible, it appears unlikely that avulsion would take place at the same time in two different, spatially separated reaches of the rivers

Paleohydrological studies at Mansell Pond (Almquist et al., 2001) (Figure 4.3) suggest that Early Holocene climatic conditions were generally dry, as indicated by lower lake levels. Finer-grained fluvial sedimentary deposits could result from lower discharge spring freshets produced by relatively dry winters. However, other dry periods are noted in the lake level record, and none are associated with a variation in grain size as extreme as that seen at the base of these two sites, indicating that these deposits do not have a climatic control.

Although undocumented in the central Penobscot Valley, localized isostatic adjustment may have played a role in shaping these deposits. Work by Barnhardt et al., (1995) and Balco et al., (1998) indicates passage of a northwestward migrating postglacial forebulge through the region at this time. Studies of isostatic adjustment in the Moosehead region suggest shifting of the discharge of Moosehead Lake from the Penobscot to the Kennebec River prior to circa 9000 ^{14}C yrs BP, and see some evidence for the migration of a secondary wave through the region. This isostatically forced change in drainage areas profoundly affected the discharge of the Penobscot River in Seboomook region of the West Branch of the Penobscot and the upper reaches of the Kennebec River, and may have impacted other portions of the valley, as well.

The migration of a forebulge through the low relief central Penobscot Valley could perturbate local topographic gradients, influencing streams and lakes in the region. The numerous local base levels established at bedrock knickpoints would break the river into independent segments that would respond individually as local gradients changed. It is possible that the fine-grained deposits overlying the gravel at Blackman Stream and lag deposits at Mackowski Farm are related to a change in river velocity due to a change in local gradient. In addition, the silt deposits noted on the gravel terraces in the Greenbush area by Hooke and Borns (pers. comm. 2003) may be related to the same process. As local gradients shifted from dipping to the south to tilting to the north, the local base levels essentially became higher, creating a bedrock dam, forming a ponded area until water levels overtopped the sill, an new outlet was created, or gradients increased to the south with passage of the forebulge. Without more detailed investigation, with dating as a primary component, this idea remains an attractive, but unproven hypothesis.

Buried Soils

Darker colors and reddish-brown and yellow hues are associated with discrete, semicontinuous horizons identified as buried soil horizons. In some locations, these horizons are directly associated with artifacts and hearths. At other sites, the darker or reddish layers underlie strata with archaeological evidence. The broader term, buried soil horizon is used rather than the more specific term of paleosol because these features lack some to the characteristics of complete soils, and may represent more than one mode of formation. In all sites, buried A soil horizons are absent. It is not surprising that these organic-rich layers are not recognized. The region's soils are acidic, and organic material is not preserved. At archaeological sites, wood charcoal, charred seeds, and calcined bone fragments are the only remaining organic objects. The reddish layers are interpreted to be remnants of spodic (Bs) horizons formed by the illuviation of iron and magnesium from overlying horizons that were later removed by erosion or the dissolution of organic materials.

Well-developed spodic horizons were found at two locations, the Gilman Falls and Young Sites, with a faintly reddish to gray-brown horizon identified at Blackman Stream. The Gilman Falls site (Sanger et al. 2001; Sanger et al., 1994) contained three bright to faint red, laterally extensive horizons (Figure 4.6). These distinctive strata were identified as remnant, buried spodic horizons on the basis of color, lateral extent, and fine-grained texture. They occur 10-20 cm below the surface (immediately below the modern A Horizon), 60-70 cm below the surface, and 100-120 cm below the surface, and ranged from distinct, sharply bounded layers 5-10 cm thick, to broad, diffuse bands 15-30 cm thick. Texturally, they are similar to the surrounding sediments. While not continuous across the site, they are differentiated by stratigraphic position and associated

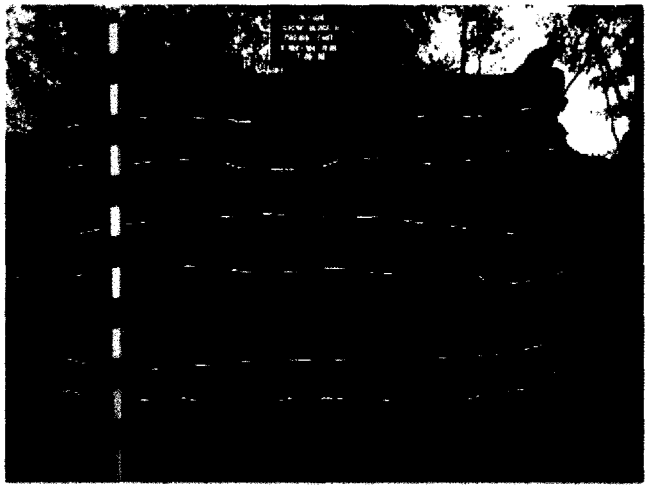


Figure 4.6: Gilman Falls Site buried soils.

artifacts. Approximate ages can be assigned each horizon on the basis of radiocarbon dating and diagnostic artifacts. As once near surface layers, they were exposed to surface processes, such as erosion, redeposition, and bioturbation, all of which serve to disrupt and "smear" internal stratigraphy. The association of the upper horizon with the modern A horizon suggests a modern age, but diagnostic artifacts ranging from the Late Archaic to the Middle Ceramic periods, represents a time range from 5000 to 1350 ^{14}C yrs BP. This stratum had little intact internal stratigraphy, primarily due to bioturbation. A radiocarbon date of 3590$\pm$150 ^{14}C yrs BP from beneath the horizon provides a maximum date for formation, if the material was in situ. It is unknown if this horizon represents conditions favoring spodic pedognesis in the past, or is the overprint of a modern process on older material. The middle paleosol is bracketed by the above-mentioned date, and five dates clustered between 4140$\pm$130 and 5950$\pm$165 ^{14}C yrs BP, placing its formation circa 4000-5900 ^{14}C yrs BP. The lower paleosol is capped by a series of dates ranging from 6290$\pm$160 to 7285$\pm$80 ^{14}C yrs BP, suggesting formation in circa 7,300 ^{14}C yrs BP.

Excavations at the Young Site 73-10 (Boerstal, 1982) at the confluence of Pushaw and Dead Streams also revealed a distinctive reddish, spodic horizon composed primarily of silt and clay, with minor amounts of sand. Like the upper spodic horizon at Gilman Falls, this layer is immediately below the present day O and A horizons. However, diagnostic artifacts in the horizon represent deposition circa 5000 to 3000 ^{14}C yrs BP. It is unclear if this sequence represents spodic development during deposition of the artifacts, or is a pedogenic process that is overprinted on the archaeological and geological record of the site. This range of dates, combined with the somewhat mixed stratigraphy of this relatively thin (<15 cm layer) horizon indicates little deposition during this time, and suggests that it may have been a surface subject to bioturbation for a long period of time.

Presently, spodic horizons are commonly developed in this region in upland, sandy areas dominated by coniferous vegetation. The presence of these features in the sedimentary record at Gilman Falls, a riverbank setting, suggests that at the time of formation, these areas experienced far less flooding than at other time periods. This time of significantly lower flooding may correspond to periods when the flow of the Stillwater River was reduced, either through climatic or post-colonial period modifications to river flow. Currently, a dam at Milford regulates the flow of water into the Stillwater, and maintains flow throughout the year. Without this control, a gravel bar at the Orson Island, at the head of the Stillwater River could serve as barrier at low flow conditions, intensifying the effect of climatic dry periods.

The darker horizons encountered at the Blackman Stream, Mackowski Farm and Bob sites, are interpreted to be buried soils. In some locations, the horizons include a faint red brown layer associated with the deposition of iron and magnesium, characteristic of a B horizon. At other sites, the buried horizon is gray to black in color, and appears to be composed of disseminated anthropogenically-produced charcoal mixed with alluvial sediments, and may be classified as an anthrosol (Glossary of Geology. 2005). In both cases, the buried soil horizons are associated with evidence of human activity, such as hearths and artifacts. The presence of such horizons may be interpreted as: (1) short-term use of the site by many people or (2) long-term use by fewer individuals. Radiocarbon dates from the Blackman Stream and Bob Sites support the latter interpretation, and will be discussed in more detail below. While archaeological remains are associated with these deposits, artifact distribution in stratigraphic sequences in the central Penobscot Valley is not restricted to buried soil horizons. This suggests that a particular set of circumstances not limited to human occupation was involved in horizon formation. .

A buried soil horizon was first identified in the central Penobscot Valley at the Blackman Stream site (74-19) (Belcher and Sanger, 1992) (Figure 4.7). It was discovered approximately 1 m below the surface, and consisted of a dark brown to black layer, approximately 10 cm thick, with some discontinuous faint red to red-brown coloration at the base of the layer. It was present in the interior portions of the site, and forms a generally concave surface, with its lowest area roughly coinciding with the present day lowest area of the site. The layer was most readily identified in wall profiles, and was associated with artifacts and a hearth feature. Charcoal from the hearth returned dates of 7400$\pm$140 ^{14}C yrs BP, 7760$\pm$130 ^{14}C yrs BP, and 8360$\pm$150 ^{14}C yrs BP. The buried soil lacks well-defined A and B soil horizons, and consists only of a distinctly darker layer in the sedimentary sequence, with a

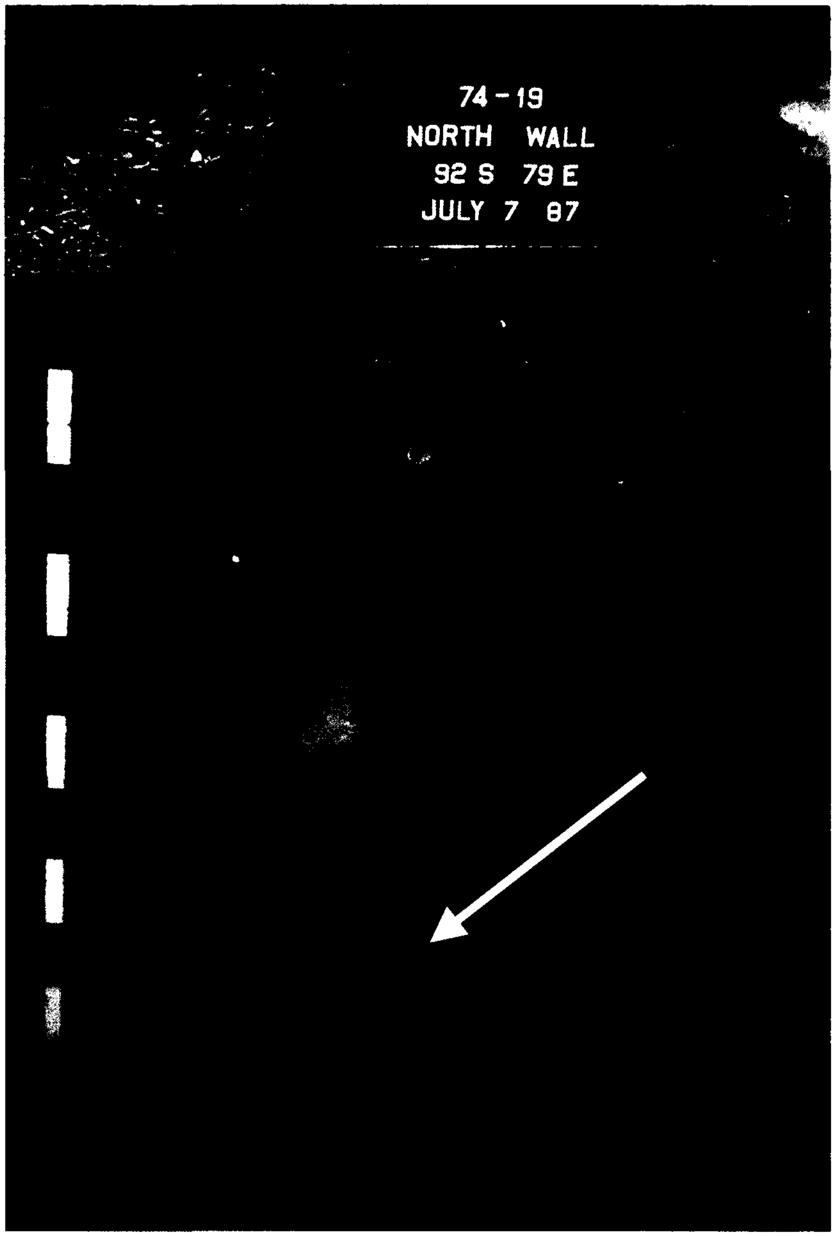


Figure 4.7: Buried soil (circa 7400 – 8400 ^{14}C yrs BP) Blackman Stream site indicated by arrow. Note large clasts associated with soil.

faint reddening of the sediments at the base of the layer observed in a few locations. The missing A soil horizon is attributed to the dissolution of organic material by the region's acidic soils. The faint reddening at the base is interpreted to represent a remnant or poorly developed spodic horizon. The source of the dark color has not been determined, but may be caused by the accumulation of anthropogenically-produced charcoal during occupation of the site.

Robinson (person. comm., 2005) identified a two buried soil horizons at the Mackowski Farm site (74-14) (Figure 4.8). The upper horizon was approximately 5 cm thick, and was composed of dark yellowish brown fine-grained sediment, and was associated with archaeological material. A charcoal sample from the upper horizon returned a date of circa 6900 ^{14}C yrs BP. A second horizon was encountered approximately 40 cm lower in the stratigraphic sequence, and was composed of dark yellowish brown fine sand, silt and clay flecked with charcoal flecks (Figure 4.8). It was dated using a single hawthorn nut from an associated feature, and produced a date of 8561 ± 49 ^{14}C yrs BP. The oldest date from Blackman Stream is close to the single date from the lower Mackowski Farm paleosol. These two horizons may be correlative, or represent two different events. Only more work, including additional dating, will address this issue.

A dark grey to black horizon was observed at the Bob Site (74-148) (Mack et al., 2001) on lower Pushaw Stream (Figure 4.9). This laterally extensive layer is 40 to 75 cm below the surface, beneath the modern A and B horizons, and is

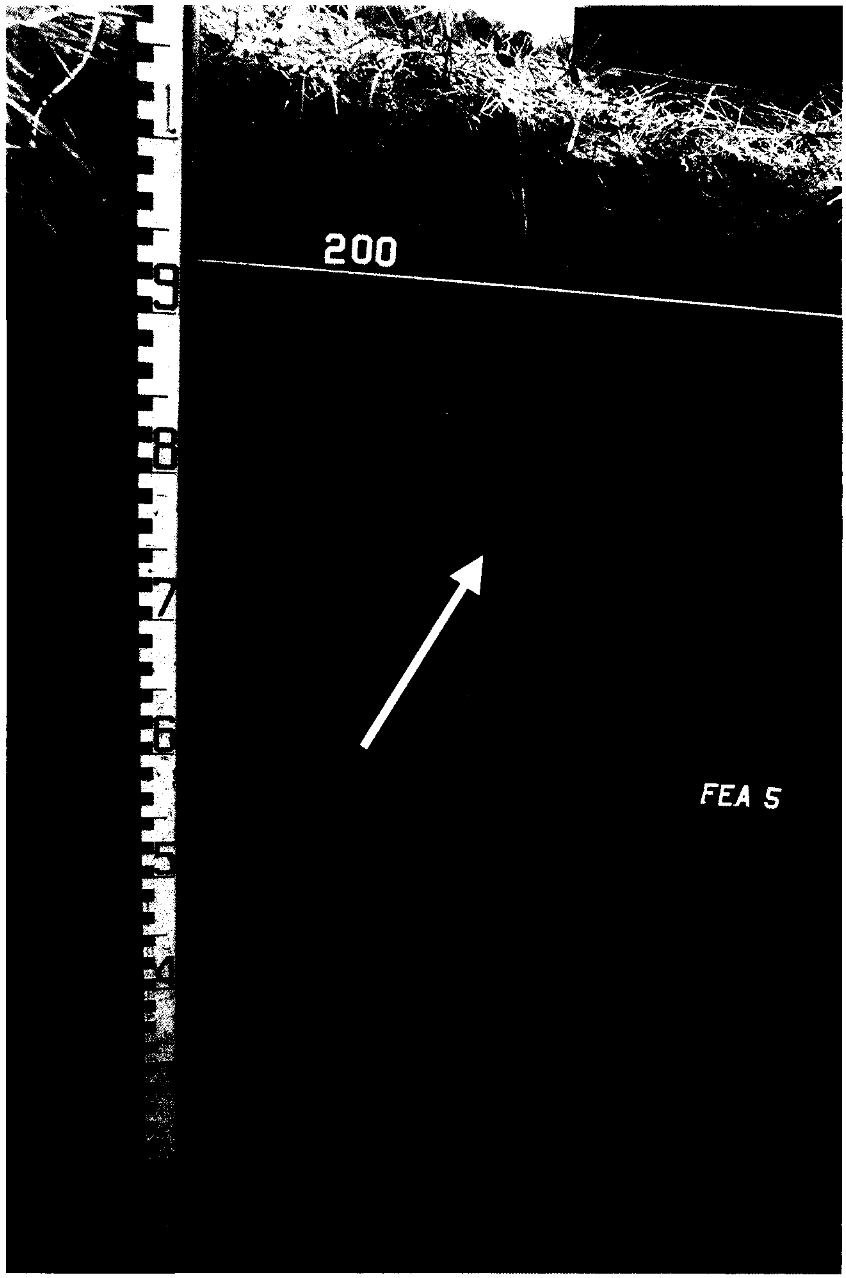


Figure 4.8: Buried soil (circa 6900 ^{14}C yrs BP) at the Mackowski Farm site indicated by arrow. Feature 5 produced a date of 8561$\pm$49 ^{14}C yrs BP from a single hawthorne seed.

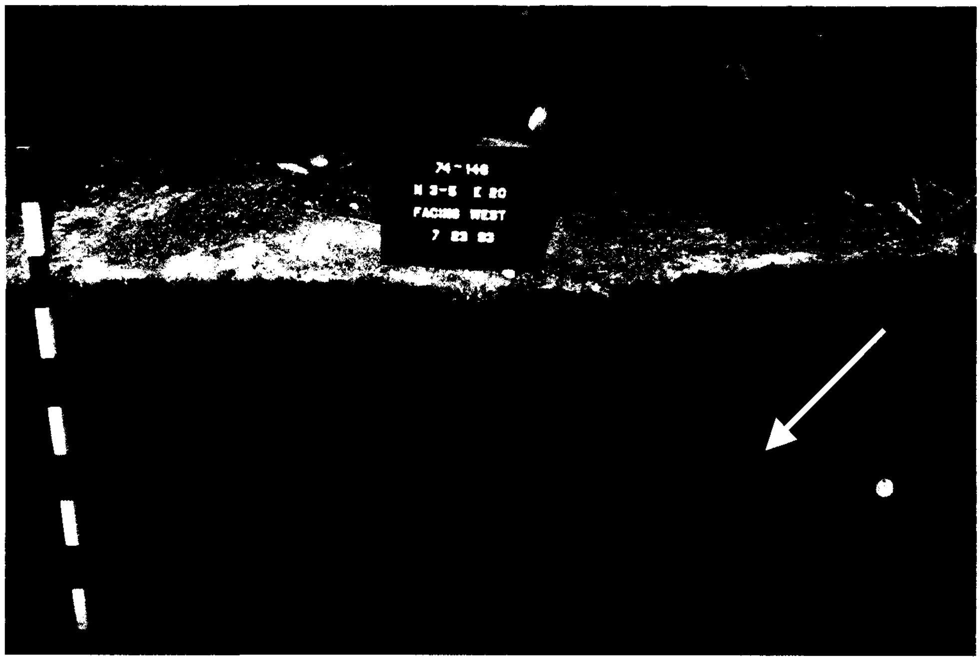


Figure 4.9: Buried soil (circa 3500 – 4600 ^{14}C yrs BP) at the Bob Site indicated by arrow.

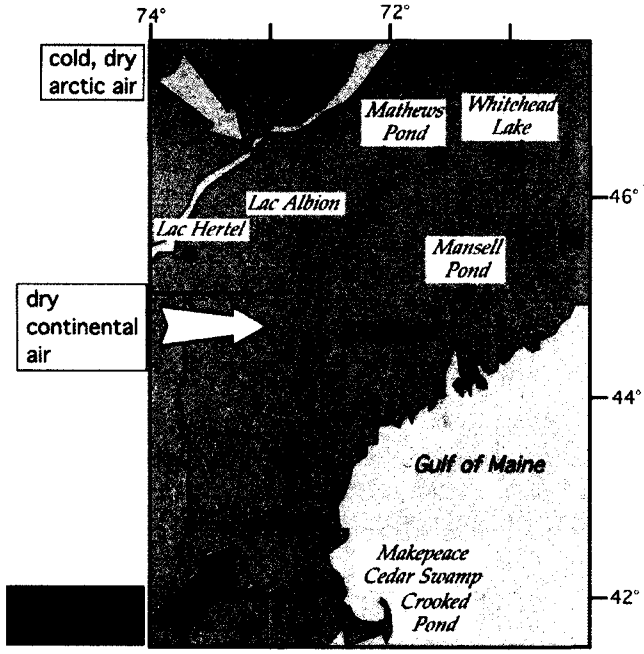
composed primarily of sand with minor amounts of silt and clay. The dark color of the buried horizon appears to be related to staining from anthropogenically-produced charcoal. Radiocarbon dates from the horizon range from 3560±70 to 4650±70 ^{14}C yrs BP, and are supported by diagnostic artifacts appropriated to this time period.

At each location, these horizons mark specific events in the formation processes at each site. However, when combined in a regional analysis examining the chronology and distribution of these buried soils, broader scale implications become apparent. The buried spodosols mark time periods when sites experienced upland conditions, interpreted here to mean stable vegetative cover, probably coniferous, and little or no flooding. The buried, darker, charcoal-stained horizons are also interpreted to represent times of less flooding at the site. At these locations, inundation would remove easily floated charcoal and increase sedimentation diluting the charcoal content, decreasing the color contrast with surrounding sediments, as well as inhibiting soil formation processes.

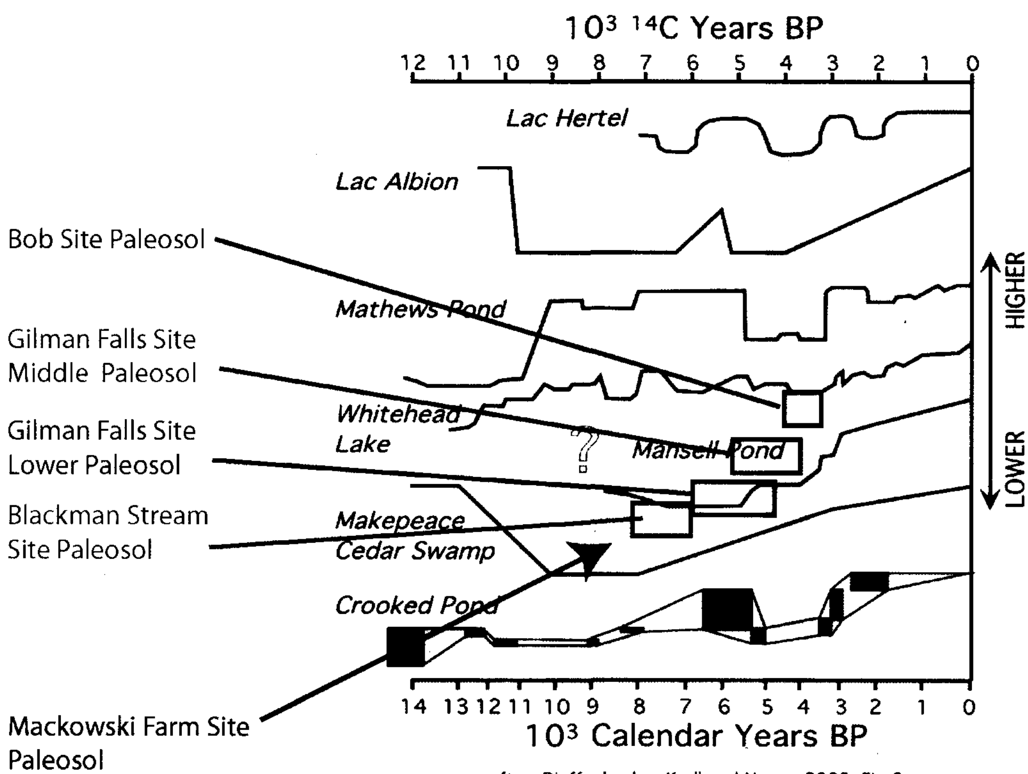
For these reasons, the buried soil horizons, both spodosols and anthrosols, are interpreted to mark periods of significant climate change within the central Penobscot Valley that affected the magnitude of flooding and sediment deposition at these locations. Because high discharge periods are generally related to the spring freshet in New England (Magilligan and Graber, 1996), a lack of sedimentation that promoted pedogenesis represents extended periods of low winter and spring precipitation conditions. Radiocarbon dates from archaeological settings, supported by diagnostic artifacts, allow dating of these periods of climatic variation.

In all cases, the periods of buried soil formation generally correspond to falling or low lake levels as noted at Mansell Pond (Almquist, et al., 2001), Matthews Pond and Whitehead Lake (Diffenbacher-Krall and Nurse, 2005) (Figure 4.10). This confirms the paleohydrological connection between buried soil formation and periods of lower precipitation as recorded in area lakes. It also suggests that there is a generally consistent regional signal that is present both in the lake and alluvial record.

Although not tightly correlated, there also seems to be some correspondence among the dates of the buried soils and recognized periods of global rapid climate change recognized by Mayewski, et. al., 2004). Dates associated with the buried soil at Blackman Stream and Mackowski Farm correlate with the widespread climatic disruption between 9000 and 8000 cal BP noted by Mayewski et. al. (2004) as a time of cooling over much of the Northern Hemisphere. The older of two dates at the Bob Site falls within the period of 6000 – 5000 cal BP that Mayewski et al. (2004) see as a period of rapid climate change corresponding to cool conditions in the higher latitudes. The dates from the upper spodic horizon at the Gilman Falls site and the youngest date at the Bob site correspond with a period of strong westerly winds and climatic instability between 3800-4200 cal BP (Mayweski et al., 2004). More work is required to establish the nature of the connection between these events. However, there appears to be a strong linkage between changes in winter storm tracks caused



Paleoecological Lake-level Reconstructions
After: Dieffenbacker-Krall and Nurse, 2005, Fig. 1



after: Dieffenbacher-Krall and Nurse, 2005, Fig 8.

Figure 4.10: Dates of Paleosols (Buried soils) compared to regional lake-level curves

by large-scale circulation patterns and New England precipitation variations (Dieffenbacher-Krall and Nurse, 2005). In summary, the archaeological excavations in the central Penobscot Valley provided a window into the Late Pleistocene and Holocene stratigraphy of the region's alluvial deposits. Using diagnostic artifacts and radiocarbon dates, achronology has been established for the formation of today's landscape. The initial post-glacial Penobscot River excavated a series of terraces in the glacial and glaciomarine deposits within the valley. Subsequently, widespread, coarse-grained material was deposited as a subaerial outwash plain, and then reworked by the meltwater charged river in response to a rapidly falling sea level. Depositional conditions at specific location were controlled by channel avulsion, establishment of local base levels, and isostatically controlled drainages shifts. At most locations, flood plain deposition became the primary sedimentary process. Abrupt changes from coarse to fine-grained sediment grain size may mark localized isostatic adjustment associated with the migration of a postglacial forebulge. Archaeological evidence suggests the existence of a temporary base level prior to 5000 ^{14}C yrs BP at or near Eddington Bend. Incision of this landform produced the terraces in the Eddington Bend and Ayers Rapids areas. Buried soils noted within the flood plain deposits at several locations document times of decreased river flow associated with local and regional climatic variations.

Lakes

The withdrawal of marine water from the central Penobscot Valley occurred as the result of postglacial uplift related to the isostatic adjustment following withdrawal of the Laurentide Ice Sheet in the Late Pleistocene. Areas immediately adjacent to the Penobscot River began to develop drainage patterns leading into the new Penobscot River as sea level dropped. The fine-grained glaciomarine sediment that drapes much of the landscape was rapidly eroded on hillsides, and formed numerous, distinctive gullies, presently occupied by underfit streams in the areas adjacent to the river. Interior drainage networks developed with time.

In low relief areas, these drainage networks were slow to develop. The largely impermeable glaciomarine silt and clay of the Presumpscot Formation blanketed the region's semi-permeable clay-rich till, and hindered infiltration. Almquist and Sanger's (1995) work in the Pushaw/Caribou Bog basin suggests that much of the area now covered by peat was the site of an extensive, Early Holocene lake. Their study (discussed in detail in Chapter 2, Paleogeography), established the existence of a broad, interconnected area of surface water that persisted from the Late Pleistocene through the Early Holocene, and diminished in the Mid Holocene to form the present-day stream pattern. It is important to note that these broad expanses of surface water existed at a time recognized as a period of low groundwater levels on the basis of paleohydrologic investigations in the study area and within the region (Diffenbacher-Krall and Nurse, 2005). In addition, these lakes persisted into the Early Holocene, through a period identified as a time of low discharge on the main stem of the Penobscot River using buried soil horizons at Blackman Stream and Mackowski Farm. Almquist and Sanger's (1995) work on vegetation change in the central Penobscot Valley interpreted the increased presence of charcoal in the Early Holocene portions of sediment cores as indicative of fires spawned by dry conditions. The combination of a generally dry climatic period and extensive surface water suggests mechanisms beyond precipitation runoff and accumulation.

The same lack of topographic variation and generally impermeable near-surface stratigraphy formed by clay-rich till capped by glaciomarine silt and clay is present in large areas on either side of the central Penobscot River. Investigations of several peat bogs in the area by Cameron (1984) characterize sediments at the base of all bogs surveyed as silt and clay, identical to the stratigraphy noted by Almquist and Sanger (1995) (Figure 4.11). If the Almquist and Sanger (1995) model of geomorphic development is applied to other low-relief portions of the central Penobscot Valley, the Early Holocene landscape was dominated by lakes and ponds (Figure 4.12) occupying areas now filled with peatlands during a time generally identified as . Early Holocene lake formation caused by low relief and a generally impermeable surface was exacerbated by local isotatic adjustment associated with the migration of a postglacial forebulge through the region. Work by Barnhardt et al. (1997) suggests that the dramatic slowing of the relative sea level rise circa 10000 ^{14}C yrs BP was related to the passage of the forebulge through the coastal portion of the state. Work by Balco (1998) and Kelley et al. (2005) shows passage of the forebulge through the.

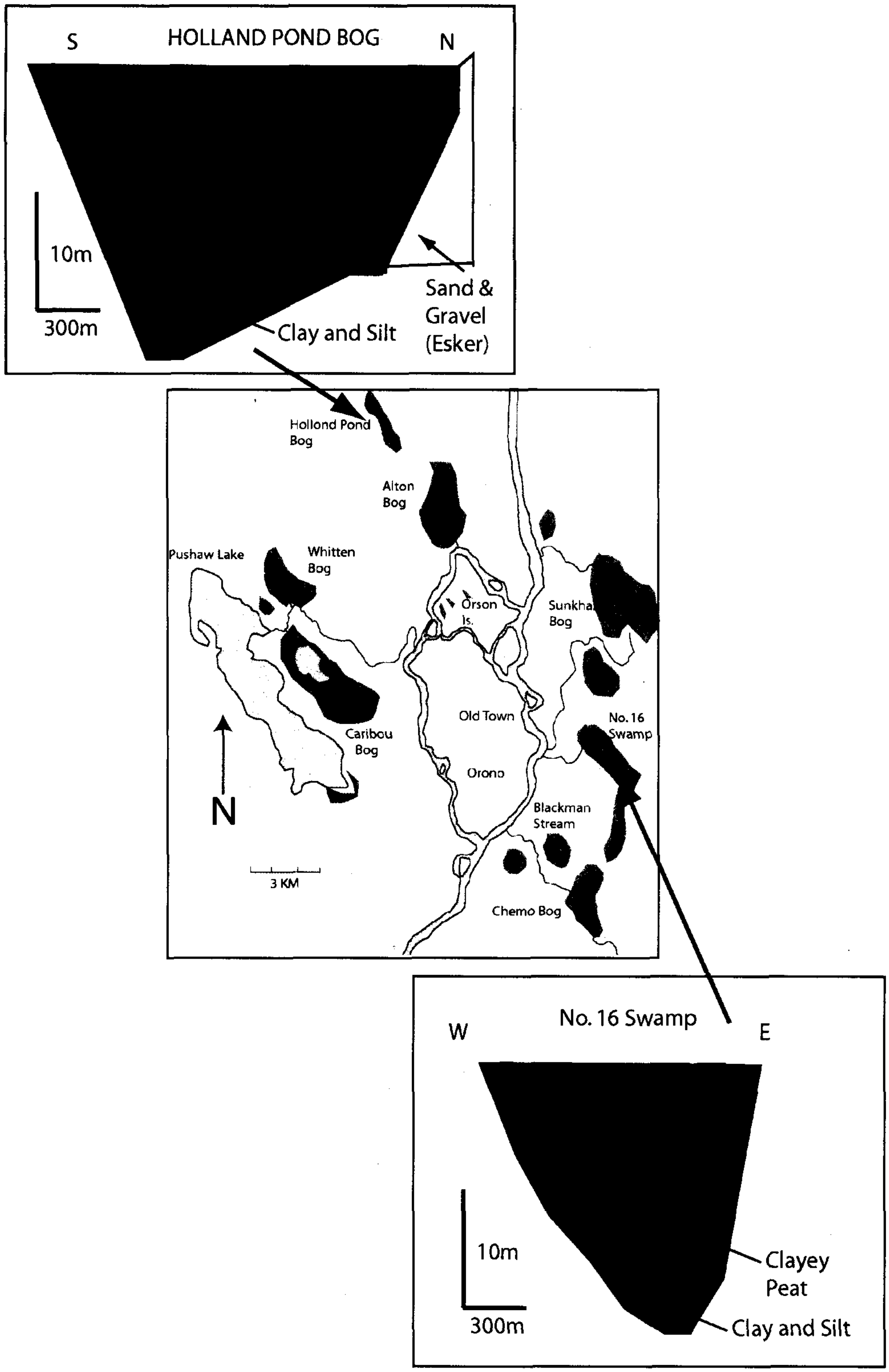


Figure 4.11: Location and stratigraphic cross sections of Holland Pond Bog and No. 16 Swamp. (Modified from Cameron, 1984)

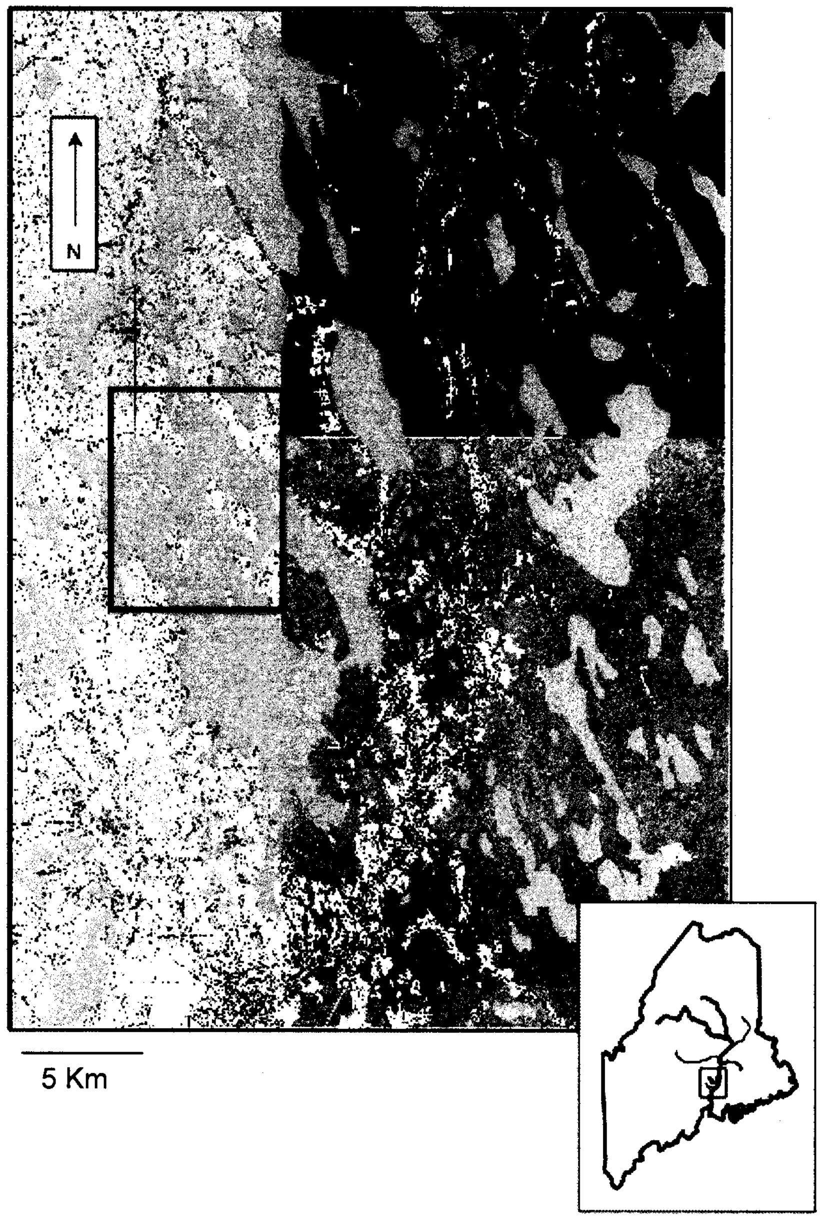


Figure 4.12: Distribution of Early Holocene lakes in the central Penobscot Valley using Almquist and Sanger (1995) to reconstruct water levels. Almquist and Sanger's (1995) study area outlined in red.

Moosehead region at approximately 9000 ^{14}C yrs BP. This places forebulge migration through the central Penobscot Valley between 10000 to 9000 ^{14}C yrs BP

In the low relief central Penobscot Valley, even a few meters of change in regional topographic gradient could interrupt developing drainage patterns. Following regional isostatic uplift circa 12000 - 11000 ^{14}C yrs BP, drainage networks formed as the Penobscot River excavated its valley, responding to rapid fall in sea level. At this time, the regional drainage pattern presumably flowed to the south. As the forebulge moved through the central Penobscot Valley circa 10,500 ^{14}C yrs BP, the regional topographic gradient decreased, and then shifted to the north. With passage of the bulge crest, the landscape then assumed a southward tilt, at first steeper, than back to the original gradient as the forebulge moved northward. The discharge of the Penobscot River may have been enough to continue southward flow, or was interrupted, as individual reaches of the river were ponded for short periods of time. However, localized northward tilt of this low relief region undoubtedly deranged the southward-integrated drainage of smaller streams and lakes. This would result in changes in the direction of stream flow and the expansion of lakes until north-draining outlets were established, or regional tilt was re-established to the south. The accentuated tilt to the south on the following limb of the forebulge may have created short-lived drainage paths that were abandoned as the landscape returned to its former position. Outlets on the south end of Pushaw Lake may have been active at this time. The Stillwater River, which forms a side-channel of the Penobscot, may occupy the outlet channel of a lake that filled the Alton Bog basin. The timing and mode of formation of the Stillwater River is unknown, but its contorted pattern, first flowing north, against the regional drainage direction, and then flowing to the south over a series of falls and rapids, suggests its formation may be linked with the changing environments and drainage patterns associated with Early Holocene isostatic adjustment.

Within the Pushaw drainage, archaeological material provides a chronology for the transition from widespread lakes to modern drainage patterns. No cultural material older that circa 5000 BP was recovered from archaeological sites in the Lower Pushaw Locality. Fine-grained alluvial sediments over compact silty clay deposits characterized the stratigraphy at these sites. The compact fine-grained material was originally interpreted to be glaciomarine in origin, and was tied to the Late Pleistocene marine inundation of the region (Fenton, 1991). Consideration of the model of Holocene paleogeographic changes for the Pushaw drainage (Almquist and Sanger, 1999) now suggests that these fine-grained sediments may record the presence of a lake in this area. This interpretation places human occupation of the area coincident with development of Pushaw Stream, circa 5000 ^{14}C yrs BP. While this timetable may not be directly applicable to other tributary drainages in the region, it provides a beginning for site location models for mid to Late Holocene occupation patterns.

Current River Conditions

At present, the flow of the central Penobscot River is heavily influenced by numerous hydroelectric and control dams that span both the main stem and the Stillwater portions of the river. While all the dams on the Penobscot River are designed to allow flow to pass, rather than create reservoirs, the construction of dams and the use of flashboards creates headponds and water levels higher than those expected without engineered alterations. Summer flow through the Stillwater River is controlled at the Milford Dam. Without this regulation, the Stillwater would experience a wider range of seasonal discharges. The artificially high water levels created by damming and flow regulation has lead to the inundation, fluvial erosion, and ice-scouring of archaeological sites on stream banks.

Limited studies of the surficial geology of the river in the Old Town area suggest a coarse-grained channel with fine-grained sediment associated with the downstream portions of islands and the mouths of triburtary streams (Griffen and Dudley, 2002). This runs counter to the general experience of fine sediment entrapment behind dams, but is similar to geological observations related to the removal of the Edwards Dam on the Kennebec River (Dudley, 1999).

This phenomenon is related to the geological history of the area. Following the late Pleistocene sea level fall through the region, the river was in equilibrium with high flow, high gradient conditions that swept most of the available fine sediment through the system. The establishment of local base levels at the bedrock outcrops blocked the reworking of the coarse sediment, and trapped it within individual reaches. Currently, fine sediment production is primarily limited to Holocene land surface erosion, rather than reworking of alluvial sediment. This Holocene-age sediment is frequently trapped at the mouths of tributary streams along the main stem. During high flow events, the higher velocity main stem flow moves into the mouths of tributary streams, creating a hydraulic dam. Sediment exiting the tributary, as well as entrained material in the primary stream is deposited in the lower velocity tributary mouth. This is the mechanism responsible for building the thick stratified sequences at the Blackman Stream, Mackowski Farm, and Gilman Falls sites. The same mechanism may be responsible for the accumulation of sediments in the Lower Pushaw Localities. Much of the remaining sediment is suspension accumulates in the eddy locations on the downstream portions of the islands in the Islands division of the river, as noted by Dudley and Giffen (2002).

Summary

The present day Penobscot River formed following the recession of the Laurentide Ice Sheet and regression of the isostatically induced marine invasion of the coastal and central portions of the drainage. In some locations, such as Bangor and Bucksport, the river occupies what appears to be a pre-Wisconsinan course, while in other locations, rapids and waterfalls attest to the formation of a new, post-glacial channel. Shifting of the regional isostatic tilt of the area by a northward-migrating forebulge changed the outlet of Moosehead Lake from the Penobscot drainage into that of the Kennebec circa 9000 ^{14}C yrs BP. Analysis of modern stream gage records suggest that this change profoundly affected the discharge of the upper portions of the Kennbec River and the West Branch of the Penobscot, but the impacts to the main stem were limited to a decrease in the magnitude and sediment load of the annual spring freshet.

The rapidly falling sea level that accompanied the marine regression through the region led to the rapid incision of the surfacial deposits of glaciomarine sediment and till. The combination of rapidly increasing stream gradients, large meltwater contributions, and high sediment loads led to the formation of prograding, coarse-grained deposits that form the basal deposits of terraces in portions of the central Penobscot Valley and may core the braid bar-shaped islands north of Old Town. As the sediment load of the river decreased these coarse-grained deposits were capped with finer-grained sediments, first representing channel or near channel flow, and then fine-grained, massive floodplain deposits that represent deposition through the Holocene at riverbank locations.

Numerous, erosion-resistant bedrock ridges trend across the region, and are oriented perpendicular to the river's flow direction. When fluvial downcutting reached these features, local base levels were established, separating individual reaches of the river from the effects of sea level variation and accentuating the development of floodplain deposits. Diagnostic Late Paleoindian and Early Archaic archaeological material recovered at the Blackman Stream and Mackowski Farm Sites suggests that most of these local base levels were established prior to circa 9000 ^{14}C yrs BP.

Archaeological evidence at the Eddington Bend and Ayers Rapids 1 Localities suggests that river incision at these two sites may have not followed the above-described chronology. Intrusive archaeological features circa 5000-1000 ^{14}C yrs BP on these terrace surfaces indicate that regular floodplain deposition ceased prior to this time period. It is postulated that these terraces formed during the Late Pleistocene sea level fall through the region, or were incised following the breaching of a temporary base level in the vicinity of Eddington Bend prior to 5000 ^{14}C yrs BP.

Compact, silt and clay deposits encountered near the base of the terraces in the Old Town/Orono region and capping terraces north of Old Town may have been formed by a variation in Late Pleistocene sea level or by ponding of water associated with localized isostatic tilting caused by migration of a postglacial forebulge through the region. Current relative sea level curves developed for the Maine coast show a steady and steep drop to a Late Pleistocene/Early Holocene lowstand circa 10,800 ^{14}C yrs BP (Belknap et al., 1987). Localized isostatic tilting has been recognized on the Maine relative sea level curve (Barnhardt et al., 1997) and in the interior (Balco et al., 1998, Kite et al. 19xx), but has not been established in the central Penobscot Valley.

Buried soil horizons were encountered in excavations at several archaeological sites in the central Penobscot Valley, and are interpreted to represent times of reduced sediment deposition, which allowed pedogenesis and the accumulation of human-generated material. These horizons were dated using diagnostic artifacts and/or radiocarbon dating of associated wood charcoal.

Predominately red to red brown horizons at archaeological sites at Gilman Falls and Blackman Stream were identified as buried spodic horizons. Gray-brown to black layers were interpreted to be anthrosols created through the incorporation of anthropogenically produced charcoal in alluvial sediments. The dates obtained for these horizons were compared to paleohydrologic records from three Maine lakes (Almquist et al., 2001; Diffenbacker-Krall and Nurse, 2005) and periods of global rapid climate change identified by Mayewski et al. (2004). In all cases, the soil horizons dated to periods of falling or stable lake levels, indicating reduced local precipitation, and in some instances, were correlative with identified periods of rapid climate change.

The presence of widespread Early Holocene lakes is postulated for the low-relief areas on either side of the central Penobscot Valley. Based on paleogeographic reconstructions of the Pushaw Lake/Mud Pond/Whitten Bog basin by Almquist and Sanger (1995), it is suggested that areas now occupied by peat bogs were the site of lakes and ponds formed by poorly integrated drainage caused by a combination of the low-relief topography of the area and a generally impermeable surface formed of glaciomarine silt and clay over clay-rich till. Extension of these water bodies may have been accentuated by the migration of a postglacial forebulge through the area circa 10000 ^{14}C yrs BP, which interrupted developing drainage patterns in the lower relief portions of the valley. Readjustment of the landscape during passage of the trailing limb of the forebulge may have briefly over steepened the area's regional southward tilt, creating now abandoned south-draining outlets for lakes and influencing drainage patterns. Relaxation of the surface following movement of the bulge through the area allowed continued development of drainage patterns, forming the present landscape.

Geological studies of the present day Penobscot have noted a coarse-grained channel with fine-grained sediment concentrated in tributary mouths and on the downstream end of islands (Dudley and Giffen, 2002). This is attributed to combination of the high gradient, high volume river conditions presenting the initial stages o river formation. Glacially produced fine sediment in the channel and tributary systems were swept out of the system in the Late Pleistocene and Early Holocene. Establishment of local base levels trapped course sediment within individual reaches. Holocene fine-grained deposition was concentrated in low velocity eddy conditions at the downstream end of islands and in slackwater conditions at tributary mouths and behind bedrock obstructions.

The present day Penobscot is much different in appearance from that used by pre-contact and early Historic period occupants of the region. Numerous dams constructed on bedrock outcrops have divided the river into a series of headponds, inundating rapids and falls. The dams create artificially high water levels throughout the year, and “damp” the effect of seasonal variation. Fluvial erosion and ice-scouring of riverbank archaeological sites have been noted throughout the region. This disparity between modern and past conditions is particularly important when considering archaeological site location and site preservation models.

Chapter 5

CHANGING LANDSCAPES, CHANGING LIFEWAYS?: ARCHAEOLOGICAL GEOLOGY OF THE CENTRAL PENOBSCOT VALLEY

Introduction

The Native American population of the central Penobscot Valley pursued a hunting/gathering lifestyle prior to the arrival of European explorers and colonists. Although agriculture was practiced west of the Kennebec River, and possibly in the northern Kennebec Valley (Bourque, 2001), inhabitants of the region to the north and east, including the Penobscot Valley, focused their subsistence strategies on hunting, fishing, and gathering wild plants. By following such a pattern, these people lived in close association with their physical environment, relying on the natural cycle of the seasons for food and shelter. The combination of their physical requirements and cultural strictures determined how they used the landscape and reacted to environmental change (Trigger, 1989).

In interior Maine, the archaeological record consists primarily of stone and ceramic artifacts, with faunal and floral remains limited to calcined or charred material. Little exists to provide insights into cultural intangibles, such as spiritual matters or societal guidelines. Ethnographic studies (Speck, 1997) provide some information, and can be applied to the past, but only with caution. Environmental records in the form of stratigraphic sections and paleohydrologic, paleovegetation, and paleogeographical investigations set the physical stage. When combined with chronology provided by artifacts and associated radiocarbon dates, a picture of a dynamic landscape emerges, but limited information to guide cultural interpretation.

Environment is not the sole determinant of human behavior. However, in this region, prehistoric environments are more readily described than the societal influences that shaped human culture. Thus, geoarchaeological discussion may appear to become an ecological deterministic explanation of lifeways and settlement patterns. This is not the goal of this examination. All the following interpretations are made knowing full well that human decisions regarding food, shelter, and transportation are based on more than environmental factors. This discussion seeks to examine site formation and preservation processes combined with landscape changes through time, and to suggest how these variables formed the archaeological record of the central Penobscot Valley.

Site Formation and Preservation

Archaeological sites form from the deposition of human-generated material. Material produced by daily living activities, tool production, and ritual activities is either purposely placed or unintentionally accumulates in activity areas. This material enters the archaeological record when it is preserved and later excavated.

Preservation often takes place as a result of geological processes. In the central Penobscot Valley, these geological settings can be divided into two general categories:

1. Occupation on pre-existing geological features that are preserved by a lack of subsequent human activity and minimal geological activity.

2. Occupation on developing geological features that are preserved by repeated cycles of deposition.

Sites in the first category are composed of archaeological material in the upper portions of geologic features thought to be older than the occupations they host. In the case of the Eddington Bend and Ayers Rapids 1 sites, Late Archaic and Ceramic period pit features were dug into terrace sediments. Accompanying hearths were at shallow depths (less than 50 cm), and covered by sediments emplaced by slopewash or soil forming processes. The terraces could not be directly dated, but their stratigraphy and elevation suggest initial formation from glacially-generated outwash as relative se a level dropped through the region, followed by floodplain deposition as discharge rates and sediment volumes decreased. At the Young Site, Late Archaic and Ceramic period artifacts were recovered from a spodosol developed on a till-cored knoll. Direct dating of the feature was not possible, but its morphology and composition indicate a glacial origin. Archaeological material was found within the soil horizon, with older material at the base. A lack of distinct stratigraphic boundaries is attributed to soil forming processes and bioturbation.

Archaeological sites formed in developing geological features can be grouped into two categories: shallow and deeply stratified sites. Shallow stratified sites are located along streams, and grow vertically with the addition of overbank sedimentation during flood events. Deeply stratified sites form at the mouths of tributary streams, immediately upstream of a local base level, and consist of 2+ meters of sediment. In at least one case, the Beaver Site, sediment was added the site both laterally and vertically. Sedimentation at these deeply stratified sites brought about by the ponding of floodwater at the local base level, with raising water levels forcing river flow upstream into tributary mouths. Known as hydraulic damming, this process prevents the tributary sediments from reaching the main stem of the river, and promotes deposition at the tributary mouth. Buried soil horizons have been encountered in deeply stratified sediments, due to the longer time period represented and a lack of bioturbation.

Shallow stratified sites have a distinct stratigraphic order, but are more likely to show evidence of some mixing by bioturbation or stream processes. Deflation, such as that at the Hirundo Site, produces compressed stratigraphic sequences by the removal of fine-grained sediment. In other locations, sedimentation rates appear to be too slow to protect sediments from bioturbation and near-surface processes, and causes "smearing" of boundaries. In these cases, a coarse stratigraphic sequence remains, but it is difficult to identify specific stratigraphic layers with individual archaeological time periods. The sites in the Pushaw Stream, Birch Stream, and Indian Island localities fall within this category.

The deeply stratified sites were encountered at the Blackman Stream, Gilman Falls, Beaver, and Mackowski Farm sites. They consist of distinct archaeological components within fine-grained floodplain deposits overlying bedded sand and gravel layers, well-sorted gravel, or polished bedrock. In each case, the transition from coarse-grained to fine-grained sediments occurs abruptly. The floodplain deposits are composed of sand, silt, and clay. Layers are distinguished by changes in color and grain size, although contacts are frequently gradational. Artifacts and associated hearths were encountered in distinct horizons, often separated by "sterile" layers. Buried soil horizons were encountered at the Blackman Stream, Mackowski Farm, Gilman Falls, and Bob Sites. Radiocarbon dating of these horizons indicated that these layers represent approximately 1000 radiocarbon years of deposition. The buried soils are correlated with periods of decreased sedimentation due to climatic changes that cause reduced winter and/or spring precipitation, and allowed pedogenic processes to take place and human-generated material to accumulate.

The excavation of archaeological sites within the central Penobscot Valley documents human presence in the region since the Early Holocene. However, this record is biased due to geographic limitations, erosion of existing sites, and areas of non-preservation. Because much of the study was focused on cultural resource management concerns, investigations were focused on stream bank areas potentially impacted by development or fluctuating water levels caused by dam operations. Occupation models developed by Almquist and Sanger (1999) and as part of this study indicate high potential localities exist at sites removed from stream banks. These include post-glacial lake shorelines, thorofares, areas adjacent to now vanished wetlands, and at once active, but now abandoned lake outlets.

It is hard to document what how much of the archaeological record has been lost to erosion, disturbance, or remains hidden from view. Sites have undoubtedly been removed or diminished by bank erosion, particularly in areas impacted by development. Other sites may not be recognized. Fluted Point tradition and Late Paleoindian sites are generally small, consisting of limited numbers of artifacts with little distinctive stratigraphy or coloration. These sites may be easily overlooked when roads are built across thorofare areas, or in sand and gravel mining. Due to the profound vegetation and drainage changes that have occurred in the region, sites occupying prominent Early Holocene landmarks, such as stream channels or overlooks, may now fade into unbroken forest. Sites located on once-active riverbanks or terraces may now be distant from active fluvial processes, or eroded by slope wash or agricultural or logging activities.

Other sites may remain undiscovered in deeply stratified settings. In the central Penobscot Valley, fine-grained sediment is concentrated at tributary mouths, immediately upstream of local base levels, and at the upstream and downstream ends of islands. All of the potential areas have not been surveyed. Much more may remain waiting underground.

Archaeological Geology

Many individual pieces of information from different disciplines suggested that the region's landscape had changed through time. Geological studies noted relative sea level variations. Paleoenvironmental investigations indicated variations in vegetation patterns and surface water exent. Paleohydrological research demonstrated significant precipitation fluctuations producing lake level changes through time. All of this information illustrated that the modern environment, even that recorded prior to large-scale industrial and agricultural development (Treat, 1820) was a poor model for environmental context of Native American occupation through time in the region.

While environment considerations are not the sole determinates of human behavior, geological and climatic changes created landscape and habitat variations that influenced Late Pleistocene and Holocene Native American occupants of the region. As hunter-gatherers, they relied upon access to a predictable cycle of faunal and floral resources. Modifications in timing, presence and absence of resources, or travel routes required shifts in procurement strategies, occupation locations, and movement through the area. All of which may be reflected in the archaeological record.

Because this study is based on numerous, detailed archaeological excavations focused on the central Penobscot River, lower Pushaw Stream, and the Stillwater River, it can begin to address the environmental context of archaeological sites on a regional basis. Conducted over a period of over 20 years, these excavations and associated paleoenvironmental studies afforded an opportunity to examine a portion of the region's archaeological record on a diversity of scales: site, locality, and region.

Examination of the stratigraphy of each site provided information on geological processes acting at each specific location. Diagnostic artifacts and radiocarbon dates supplied a chronologic framework for use within the site and for correlation across the region. Combining site-specific information for spatially grouped sites produced a locality-level analysis, allowing examination of geological processes and occupation site distribution for a specific region through time. Comparisons of locality descriptions then provided information for a regional geological and archaeological analysis. When combined with paleoenvironmental and paleohydrologic data for the area, sites were placed in an environmental context appropriate for their time of formation.

The result is demonstrates the dynamic nature of the landscape through time, and places the archaeological record within a regional environmental context. This allows re-examination of data and pre-existing models to refine our understanding of how people may have used regional resources and moved across the landscape.

Paleoindian Period (11000 – 9500 ^{14}C yrs BP)

Fluted Point Tradition (11000-10000 ^{14}C yrs BP)

The environment of the central Penobscot Valley during the Paleoindian period was one dominated by rapid change. Ice sheet recession, followed by marine inundation created a large, marine embayment in the central Penobscot

Valley circa 13000 ^{14}C yrs BP. Isostatic adjustment brought about rapid, relative sea level fall through the region from 12000 to approximately 10800 ^{14}C yrs BP (Belknap et al., 1987; Barnhart et al., 1995). The abundant meltwater provided by disintegrating glaciers to the north combined with falling base level to create a high-velocity, high-gradient river that rapidly excavated an initial course through the unconsolidated glacial sediments filling the Penobscot Valley. Work by Balco et al. (1998) and in this study (See Chapter 2 – Isostatic Adjustment) suggests that at this time, the discharge of the Penobscot was also augmented by the drainage of the Moosehead basin, flowing through a now abandoned northern outlet.

During this period of high discharge, the central Penobscot River is postulated to have been a multi-channel, braided stream. North of Old Town, braid bar-shaped islands are relicts of this high-energy environment. South of Old Town, where local relief is greater, the river has incised these deposits to form a series of terraces, with flood plain formation initiated circa 9500 ^{14}C yrs. BP.

Low relief portions of the valley on either side of the river were characterized by poorly integrated drainage systems. The lack of topograhy, combined with extensive surficial deposits of fine-grained, glaciomarine sediment led to the formation of large, low productivity lakes in the central Penobscot region levels circa 12000 to 10000 ^{14}C yrs. BP (Hu and Davis, 1995; Almquist and Sanger, 1999).

Paleoenvironmental reconstructions of the Late Pleistocene central Penobscot Valley by Davis and Jacobson (1985) show mixed woodlands composed of tundra species (sedges, willows, grasses, alder, and birch) combined with poplar and spruce. Highlands on either side of the valley were dominated by tundra vegetation, while a broad region of poplar-dominated woodland existed to the north and west. At the beginning of the Holocene, their reconstructions show the entire region as dominated by a mixed forest consisting of various species of poplar, spruce, pine, birch, elm, larch. ironwood, ash, balsam fir and some maple.

Paleohydrological studies in the region suggest that the Late Pleistocene was a time of higher water tables, suggesting greater precipitation (Nurse, 2003). However, a drop in water levels characterizes the Early Holocene (Almquist et al., 2001: Diffenbacher-Krall and Nurse, 2005). Nurse (2003) suggests that the higher Late Pleistocene lake levels in this region were related to large scale climatic patterns that produced higher snow accumulations in the winter, providing higher groundwater recharge rates. Shifts in these weather patterns brought less winter precipitation to the region, bringing lower groundwater tables and river discharge in the Early Holocene.

To date, no evidence of Paleoindian presence in the Penobscot Valley has been identified. The closest Paleoindian Period site to the Penobscot drainage is the Searsmont site, x km to the south (ref.). With evidence of Paleoindian use of the landscape surrounding the Penobscot drainage, it is hard to imagine that the region was ignored or avoided by Late Pleistocene/Early Holocene people.

Sanger et al. (2003) suggest a geoarchaeological explanation involving preservation of landforms and habitat to explain this apparent absence. Evidence from the central Penobscot Valley supports this hypothesis.

Analysis of geological and paleoenvironmental information for the Paleoindian period supports Sanger et al's (2003) interpretation. A combination of unique bedrock geology and glacial processes in the Penobscot Valley produced a rapidly changing suite of environments quite different from those to the south and north where much of the analysis of Paleoindian occupations has been done. Landforms and habitats recognized as attractive to Paleoindian use in other portions of the region, hence viewed as targets of investigation, were not as widespread, or present at all in the Penobscot Valley. As a result, a different model is required to understand Paleoindian use of the region.

Because the central Penobscot Valley does not contain any exposures of the lithic materials frequently used in Paleoindian tools, it was not likely to have been a destination for these resources. However, the Munsungan area to the north is well known as a source of distinctive red chert that has been found at Paleoindian sites throughout New England (Pollack et al., 1999; Spiess et al., 1998). Travel routes to and from Munsungan Lake to areas to the south may have traversed the Penobscot Valley, using eskers or stream valleys as travel paths, skirting the many large, interconnected lakes and associated wetlands that occupied much of the region north and east of Old Town (Figure 4.12).

Travel routes are postulated to have been located along rivers, eskers, and in thorofare areas between lake basins. Following previously developed

Paleoindian site location models, campsites would be located on dry areas with access to fresh water and a view of the surrounding landscape. Weather conditions dictated the necessity of shelter from winds or the advantage of a southern exposure. While fluvial sites along a rapidly down-cutting river have a poor preservation potential, higher terrace sites may survive. The Avon Site (Spiess and Hedden, 2000), located on a terrace associated with the Sandy River, near Phillips, Maine, may be an example of such a site. Its limited size and artifact collection led the excavators to interpret the site as a travel site utilized for a short time period by a small group. Lithic material at the Avon site was overwhelmed by Munsungan chert, suggesting an association with travel or trade to the Munsungun region. Within the Penobscot Valley, these high terraces are composed of glaciomarine silt and clay. While not ideal year-round campsites, they would prove adequate in dryer months.

Eskers could provide a dry, elevated travel route through a region of extensive lakes. In the central Penobscot Valley, numerous segments of the large Katahdin esker system are located on the west side of the main stem of the Penobscot. These landforms could provide camping sites, but may be difficult to identify 10000 or more years after occupation. Due to their raised nature of eskers, sites on these features would be characterized by low sediment accumulation, placing living surfaces or artifacts near the modern day surface, and within danger of erosion and bioturbation. Extensive sand and gravel mining of these deposits also provide a threat to esker sites. While the brilliant red ochre of "Red Paint" burials may attract attention, a limited locus of a few projectile points and or flakes could be easily overlooked in a commercial operation.

Aeolian deposits are located on the eastern side of the valley near Lincoln, to the north of the study area and along the eastern side of the central Penobscot Valley. In other portions of the region, such as Kennebunk Plains, Maine (Spiess and Mosher, 1994; Spiess et al., 1995), and Debert, Nova Scotia (MacDonald, et al., 1968), Paleoindian sites have been associated with aeolian deposits. In the Penobscot Valley, these features are limited in size and distribution, and are poorly studied. Vegetated and undeveloped, chance finds on Paleoindian material in these aeolian deposits are possible, but unlikely.

Travel sites in an area of extensive surface water may be located in "thorofares" that provide access from one lake basin to another. Site 153.88 and a nearby find spot (Spiess, 2002) near the connection between Eagle Lake and Chamberlain Lake in the Allagash region of Maine fits this model. The limited artifact suite may represent erosion of the site, or may suggest short-term use by a small group of travelers. The Searsmont Site, to the south of the Penobscot Valley (Cox and Spiess, 1999) may also occupy a similar location, if the surrounding freshwater marsh was once part of an extensive lake system, similar to that recognized in the Pushaw Lowlands area. As before, the low numbers of artifacts and limited distribution at the Searsmont site suggest short-term use by a modest sized group, such as a traveling or hunting party (Cox et al., 1994). To the north of the central Penobscot Valley, the abandoned outlet of Moosehead Lake into the Penobscot River may have been an important travel route, and could be expected to host evidence of human occupation prior to the outlet switch.

The subsistence strategies of Paleoindians are not well understood, primarily due to the poor preservation of organic remains from the time period. Snow (1980) suggests that New England Paleoindians were primarily hunters of migratory big-game animals who also used local resources as encountered. Spiess and Newby (2002) suggest that the hunting of migratory caribou may have provided a rich Late Pleistocene resource. Dincauz (1981) prefers a more generalistic hunter/gather model. Both Dincauz (1981) and Nicholas (1988) note the importance of glacial lakes to early occupants of southern New England.

The early unproductive nature of the lakes in the Penobscot Valley (Hu and Davis, 1995) suggests that early Paleoindian resource procurement focused primarily on plants and animals associated with the rapidly changing mixed woodland, river, and coastal environments of the region. At this point in time, lakes would represent minimal food resources and presented a barrier to travel. However, they may have also provided an advantage in hunting herd animals, such as caribou, by shaping migration routes and providing ambush opportunities.

The earliest Paleoindians in the region may have utilized marine and estuarine resources provided by the retreating embayment in the Penobscot Valley. Oldale (1985) suggests that coastal resources at this time would have been limited, because the rapidly falling sea level prohibited the development of marshes, the keystone of a coastal/estuarine food chain. However, the presence of walrus remains in Frankfort, Maine (pers. comm., R. Webb, 2000), suggests that marine mammals, and possibly birds, fish and invertebrates, may have been available to the earliest Paleoindians in the area.

Hunting locations may be in similar settings as the travel sites, or on the sediment-draped, but bedrock-cored higher-relief areas overlooking the lakes or valleys, particularly if associated with a spring or stream. These locations are the closest analogs the region has to many of the known Paleoindian sites in southern Maine. Many such locations exist to either side of the immediate Penobscot River valley, and would have provided sweeping vistas of the region These locations would be especially advantageous for hunters of herd animals moving through the area and channeled by the extensive lakes. However, to the author's knowledge, none of these areas have been investigated.

Late Paleoindian Period (10000 – 9500 ^{14}C yrs BP)

The Late Paleoindian Period in the central Penobscot Valley was a time of moderating river discharge as meltwater input decreased, and isostatic adjustment shifted the Moosehead drainage basin from the Penobscot watershed to that of the Kennebec River (Balco et al., 1998; this study, Chapter 2 and 4). Evidence from archaeological sites at Blackman Stream and Markowski Farm suggest that downcutting had reached local bedrock base levels, and floodplains had begun to form.

Davis and Jacobson (1985) suggest a gradual, thousand-year transition from open woodlands to closed forest by 10000 BP, related to climatic warming.

Almquist and Sanger (1995) place this transition later, circa 9000 BP at Mansell Pond in the immediate central Penobscot Valley region. They also note the presence of charcoal in sediments of this time period, indicative of fires brought about by dry conditions. Regardless of timing, as the forest cover closed, habitats changed, as did available resources. Animals and plants tied to open woodland and tundra settings were replaced by those associated with mixed woodlands. Migratory herds of caribou and other open terrain species would have been replaced by increasing numbers of woodland caribou, moose, white-tailed deer, and smaller mammals.

The extensive lakes still occupied the Pushaw/Caribou Bog area at this time, and are postulated to have occupied large areas in the low relief landscape on either side of the valley. As lakes became more productive in the Early Holocene (Hue and Davis), increasing floral and faunal resources may have attracted the attention of local inhabitants. Almquist and Sanger's (1999) work in the Pushaw Lake area shows the beginning of peatland development in the Whitten Bog area, but areas of extensive fresh water marshes. While peatlands offer limited resources, wetlands are associated with wide range of plant and animal resources. Use of these lakes by migrating waterfowl would have provided a rich, seasonal resource. As fish stocks developed, fishing could focus on both seasonally available migratory fish and year-round residents. Similar changes would be expected in the other shallow lakes in the area, but the timing and extent of peatland and marsh development cannot be determined without the extensive study of the sort undertaken by Almquist and Sanger (1999) in the Pushaw Lake/Caribou Bog area.

This increased focus on wetland resources may be responsible for the association of lakes and Late Paleoindian sites observed in other portions of the state (Bourque, 2001). An increase in available food resources may have allowed residents to shorten their hunting and gathering forays. Bourque (2001) also notes a reduction in the variety of chert represented at Maine Late Paleoindian sites. Whether the apparent change in lithic technology and material choice is related to a change in hunting styles, personal/sultural preference, or travel patterns brought about by shifting environmental conditions is not known.

The only identified Late Paleoindian artifacts in the Penobscot Valley are from the Eddington Bend and Blackman Stream sites, on the east side of the main stem of the Penobscot River. The Eddington Bend parallel-flaked biface was found with charcoal dated at 5389$\pm$70 ^{14}C yrs BP and 6480$\pm$70 ^{14}C yrs BP and a presumed Late Archaic plummet. This association presents difficulties in interpretation, and limits the utility of the artifact to provide chronological control. (See Chapter 3 – Eddington Bend Locality).

The Blackman Stream site find, however, was found in excellent stratigraphic context. Although not directly dated, the biface and associated flakes were found one meter below a buried soil horizon radiocarbon dated to 7400 – 8360 ^{14}C yrs BP, using charcoal from a hearth on the buried surface (Sanger et al., 1992). The sedimentation rate at the site during this time period is not known, but a date prior to circa 8500 BP, and potentially older is thought to be reasonable.

The stratigraphic context of the artifacts provides information relative to the environment and geological processes operating at the time of deposition. The presence of the biface and flakes in sand and silt overlying gravel suggests that at the time of site formation the river had changed depositional regimes. At Blackman Stream, the river has a straight channel form in a confined valley. The finer sediments are indicative of reduced capacity of the river, possibly a result of rising sea level, decreased discharge of the river, localized isostatic adjustment, or the establishment of a local base level in the form of a bedrock sill. If the deposition of fine-grained sediments is related to localized isostatic adjustment, work from the Maine coast (Belknap et al., 1987, Barnhardt et al., 1995) and Moosehead Lake (Balco et al., 1998, this study) suggest occurrence in the central Penobscot Valley between 10000 and 9000 BP. This is within the time frame suggested by the Late Paleoindian chronology from sites within New England and the Canadian Maritimes (Sanger, 2005). The presence of the Late Paleoindian artifact at the base of a generally fine-grained sequence suggests that the river was at or near the local base level created by a nearby bedrock outcrop. If the fine-grained sediments represent establishment of a local base level, they are most likely to coincide with the time of rapid downcutting, linked to rapid sea level fall, prior to 10800 ^{14}C yrs BP. This is older than the previous suggestion, but still within the range of accepted ages for Late Paleoindian occupation in the region. The overlying fine-grained sediments are interpreted as floodplain deposits, and indicate the development of a new environment at the river's edge during this time.

This limited number of Late Paleoindian sites in the central Penobscot Valley may be influenced by site preservation and/or site survey. By 9000 ^{14}C yrs BP years ago, rapid downcutting of the valley sediments was replaced by deposition of finer-grained sediments. This would act to preserve riverbank sites, but primarily at the base of deeply stratified contexts, under 2 m or more of sediments. In addition, it is important to note that the assemblage at the Blackman Stream site was composed of a projectile point and flakes, and more closely resembles the a Fluted Point tradition site than the more extensive, later Archaic sites of the region. This combination of depth of burial and limited artifact suite make such sites difficult to locate.

The presence of numerous lakes with developing biological activity in the region (Hu and Davis, 1995) may have also contained more available resources than those on developing floodplains. Even if seasonal runs of anadromous fish were established by this time, they represented a short season, while wetlands afforded a wider time range of resource availability. Lake of recognition of lake-side sites may be related to a generally poor understanding of lake shore locations, current forest or bog vegetation cover, and a focus on riverine sites as a result of cultural resource management studies.

Summary

In summary, the Paleoindian Period in the Penobscot Valley was a time of dramatic environmental change, focused on environments that were profoundly different than those seen today. Early in this time period, the marine-dominated Penobscot Valley was replaced by estuarine, and then, upland conditions. Extensive, unproductive lakes surrounded by open woodland dominated the landscape to either side of the developing river valley. Human resource procurement focused on the plants and animals associated with the tundra, woodland, river, and rapidly diminishing coastal and estuarine habitats. Lakes acted as barriers to land-based travel, but may have provided opportunities for hunting herd animals by focusing herd movement. Upland settings may have been attractive hunting and travel stations, but due to the region's geology, the sandy sites apparently preferred in other portions of the state are rare, suggesting a new model of site location may be applicable to this area.

Pronounced shifts in lacustrine, riverine, and upland settings characterize the Late Paleoindian Period. Evidence from environmental reconstructions suggests a warmer, drier climate, favoring a transition from open to closed woodland conditions. Faunal changes associated with the shift from tundra to forested landscapes may have affected hunting strategies. Lakes show evidence of developing floral and faunal resources. The decrease in river gradients due to rising sea level, opened new habitats for fish and riverbank resources. This change also allowed sites to be preserved through sediment accumulation.

Widespread, productive lakes with developing wetlands may have become a focus for resource procurement.

Archaeological investigations in the region have focused on riverine studies as a result of hydroelectric dam-related cultural resource concerns. Work pioneered by Almquist and Sanger (1999) and continued by this study demonstrates the potential importance of lakeshore and thorofare sites during the Paleoindian time period. A better understanding of lake levels through the Late Pleistocene and Early Holocene, as well as the development of the region's landscape through this time period, may provide the basis for investigations that will expand the archaeological record of this dynamic period.

Archaic Period (9500-3000 ^{14}C yrs. BP)

The Archaic Period marks a major revolution in the archaeological record of northern New England and the Maritimes. Stone tool technology changes dramatically. Fluted points made from cryptocrystalline quartz and volcanic rocks disappear, and are replaced by tools made from locally available material. Robinson (1992) recognizes an Early Archaic focus on quartz in some locations. Ground stone tools become important components of artifact suites. Burial ceremonialism is an important hallmark of the Archaic, and is associated with the incorporation of red ochre and specialized grave goods in inhumantions or cremation burials.

Stratigraphic sections at archaeological sites along the main stem of the central Penobscot River show the Archaic period to be a time of aggrading floodplains (Blackman Stream, Mackowski Farm and Indian Island Localities, Chapter 3). Buried soil horizons at the Blackman Stream. Mackowski Farm, Gilman Falls and Bob Sites indicate changes in fluvial sedimentation rates tied to variations in precipitation controlled by shifts in large-scale climatic patterns.

In the Pushaw/Caribou Bog area, Almquist and Sanger (1999) see the extensive Late Pleistocene/Early Holocene lakes evolve through the Archaic Period. Water levels fall, and cattail marshes and peatlands develop. The ratio of vegetational habitats change through time, and modern stream patterns are in place by the Late Archaic. These shifting habitats, with their associated floral and faunal resource bases must have impacted local inhabitants.

Early/Middle Archaic (9500– 6000 ^{14}C yrs. BP)

In the central Penobscot Valley, evidence of Early/Middle Archaic occupations has been found at the Hirundo (Sanger and Mackay, 1973; Sanger et al., 1977), Blackman Stream (Sanger et. al., 1992), Mackowski Farm (Robinson, pers. comm.) and the Beaver sites (Belcher and Sanger, 1988a). At Blackman Stream, the Early Archaic component overlies a deeply buried Late Paleoindian projectile point and flakes.

Stratigraphic sequences exposed at the Blackman Stream and Beaver sites consist of fine-grained, floodplain sediments, deposited on gravel. At the Mackowski Farm and Hirundo sites, floodplain sediments overlie a boulder/gravel lag deposit. Each of these sites is located at or near the mouth of a tributary stream, and upstream from a bedrock-cored rapids or falls. At all of the above sites, the transition from coarse to fine sediments is abrupt, and represents a change in river competence. This is attributed the establishment of local base levels at the rapids or falls associated with the location of each site, and the accumulation of fine-grained sediment contributed by the river and the tributary during flood events.

The change in fluvial processes also represents an environmental change along the riverbanks. A switch from an erosional to depositional regime seen at first in the Late Paleoindian period continued the development of floodplains, creating new, rich habitats hosting a variety of faunal and floral resources. Based on chronology provided by archaeological excavations in the area (see Chapters 3 and 4), the initiation of floodplain development began during the Late Paleoindian period, but continued throughout the Archaic. The presence of a buried soil horizon circa 8300-7400 ^{14}C yrs. BP at Blackman Stream and circa 8500 ^{14}C yrs. BP at Mackowski indicates reduced fluvial deposition during this period, and stability of the landform for approximately 1000 years.

Paleoenvironmental studies of the area suggest that the Early Archaic was a time of continued change in regional vegetation. Almquist and Sanger (1995) shows that white pine dominated the forest around the Mansell Pond region from 9000-7400 ^{14}C yrs. BP, with decreasing amounts of boreal species, and an increase of mountain maple. By 8400 ^{14}C yrs. BP, more temperate species, such as oak, ash, elm, and sugar maples appeared in the region, with less evidence of fern and herb pollen, suggesting a more closed forest habitat. An increase in floating aquatic vegetation in the pollen and macrofossil record is indicative of more organic material. Charcoal is also present in sediment cores from the pond, illustrating that forest fires were still common in the area.

Almquist-Jacobson and Sanger's (1999) paleohydrologic analysis of the Pushaw Lake/Caribou Bog area shows that Pushaw Lake was decreasing in size by 8000 ^{14}C yrs. BP, but the Pushaw Stream/Dead Stream area and Mud Pond still contained significant areas of open water (Figure 2.13). Cattail marsh continued to expand in the section of modern day Pushaw Stream, and appears to be associated with the intersection of a slope adjacent to the wetland. Peatland development continued in the Whitten Bog area and was widespread in the present day Caribou Bog (Figure 2.13). Presumably, similar changes were taking place in the other shallow lakes in the central Penobscot Valley, with peatland development progressing in some areas, and cattail marshes developing in others.

Nicholas (1988, 1991) recognized the importance of these wetlands to Early Holocene people, and developed the "Glacial Lake Basin Model" on the basis of his work in the Robbins Swamp of northwestern Connecticut. At Robbins Swamp, Nicholas identified 40 Early Holocene sites associated with landforms tied to the former lake. Nicholas (1988) contends that the site frequency is higher in Robbins Swamp than observed in other areas, and is related to the greater number of faunal and floral resources in the lake and its surrounding area. Forrest's (1999) work at the Sandy Hill site at the edge of the Cedar Swamp Basin in Connecticut (an Early Holocene wetland complex), revealed evidence of semi-subterranean pit houses dug into fine-grained glacial-lacustrine deltaic deposits. Floral analysis at the site suggests late summer and fall occupations, with indirect evidence supporting occupation in the winter, when pit houses would provide more shelter than traditional free standing structures.

Each of the Early/Middle Archaic sites in the central Penobscot Valley is located on a major stream, near the junction of a tributary and the larger stream. In each case, the tributary leads into an area that is currently a peatland, but hosted an extensive postglacial lake/wetlands complex in the Early/Middle Archaic, recognized in Almquist and Sanger's (1999) work or postulated on the basis of that work (Figure 5.1). In light of Nicholas and Forrest's work, the position of these sites suggests that they were located to take advantage of stream and floodplain resources, as well as nearby wetland flora and fauna. Forrest's discovery of potential winter occupation sites indicates that the combination of stream and wetland environments may have provided year-round resources. The investigated floodplain sites may represent late spring though fall occupations oriented toward harvesting waterfowl, native and migratory fish, and other resources, with other sites focused on different resources located on the edges of the wetlands. Little faunal or floral analysis has been carried out at Early/Middle Archaic sites in the study area due to a lack of preservation.

Though currently unsubstantiated, it is possible that during the Early/Middle Holocene, individual groups may have centered their seasonal round of floral and faunal resource acquisition on a particular stream/wetland complex. Additional work on the margins of these wetlands, particularly in areas amenable to semi-subterranean pit house construction may yield more

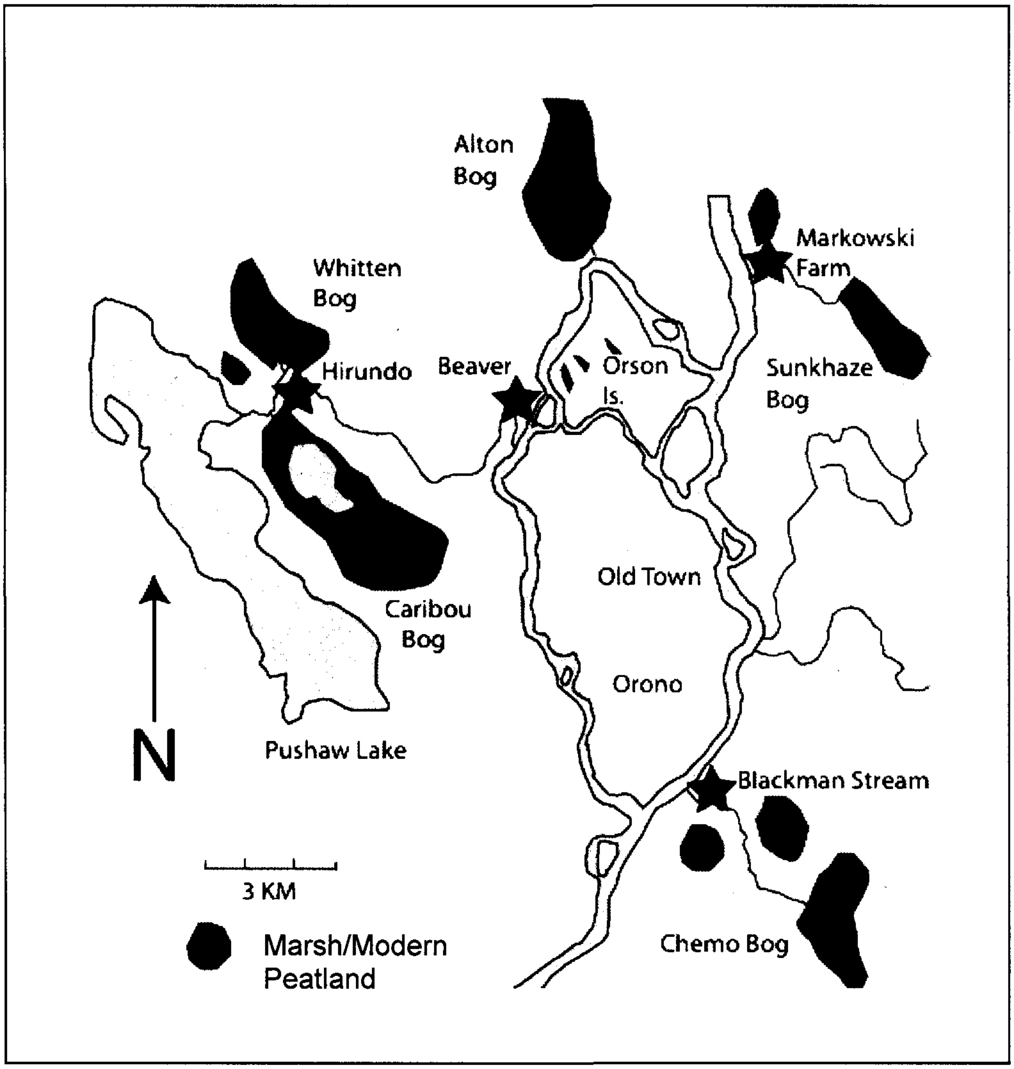


Figure 5.1: Location of Peonobscot River tributaries and marshes/modern peatlands.

information on seasonality and settlement patterns. As techniques improve to recover floral and faunal remains, more information may be available to examine resource procurement in more detail.

Excavations at the Gilman Falls site located a multi-component site with three distinct buried soil horizons. The lowest and earliest horizon, dated circa 6300-7300 ^{14}C yrs. BP, contained evidence of a Middle Archaic workshop centered on the production of stone rods from bedrock primarily quarried at the site (Sanger et al., 2001). The rods appear to have been produced using a combination of pecking and grinding, and involved the use of specialized hammerstones. Stone rods similar in appearance to those found in various stages of completion at Gilman Falls have been found in numerous Middle Archaic burials in the region. The artifact suite recovered from the Middle Archaic component suggests the site was located on the island largely for the specialized production of stone rods, not as an occupation or food resource procurement site.

The presence of the spodic horizon is interpreted to represent generally dry conditions at the site during this time period. The Mansell Pond record (Almquist et al., 2001) shows falling water levels at this time, but there are no correlative horizons on the main stem of the river within this time period. This suggests that conditions at Gilman Falls may be different than those at Mackowski Farm or Blackman Stream. Because these locations are within 10 km of each other, climatic conditions can be assumed to be constant. The other remaining variable is river flow in the Stillwater River (Gilman Falls) with respect to the main stem, the Penobscot.

The fluvial history of the Stillwater portion of the Penobscot River is poorly understood. Examination of topographic maps of the area shows the Stillwater's sharp bend to the northwest, against the regional flow direction, before turning and paralleling the Penobscot's path to the south, and the confluence of the two branches at Orono. If a period of reduced precipitation, as suggested by the Mansell Pond record, cut off flow in the Stillwater, but maintained flow in the main stem, upland conditions, and spodic development would take place at Gilman Falls, but not be seen at Blackman Stream or the Mackowski Farm site. The upper spodic horizons noted at Gilman Falls suggest that this situation occurred at least 2 other times in the interval from 4000 ^{14}C yrs. BP ago to the present. Since quarrying and artifact production appear to have been the primary activities at Gilman Falls in the Middle Archaic period, the impact of lowered water levels on floral or faunal resources would not have influenced occupation of the site.

The Early/Middle Archaic was a period of diverse, fresh water related resources in the central Penobscot Valley. Floodplain development, initiated in the Early Holocene continued, with one period of apparent non-deposition from circa 8400 to 7300 ^{14}C yrs. BP noted at Blackman Stream and Mackowski Farm. The lowest spodic horizon at the Gilman Falls site, dated to 6300-7300 BP, indicates generally dry conditions at the site at this time, and suggests that the Stillwater River may have been much reduced at this time due to climatic conditions.

In addition to resources provided by streams and floodplain environments, extensive lakes surrounded by forested uplands on either side of the Penobscot Valley provided resource-rich environments. Early/Middle Archaic occupation patterns in the central Penobscot Valley appear to be positioned to take advantage of each of these environments. Comparison of the region's two major technological traditions, Neville-Stark and Gulf of Maine Archaic, with regional bedrock and surficial geology suggests a linkage between Gulf of Mane artifact styles and a wetland environment. The discovery of the Middle Archaic workshop and quarry linked to the specialized production of stone rods, indicates these items had a particular significance to the Middle Archaic occupants of the region.

Late Archaic (6000-3000 ^{14}C yrs. BP)

The Late Archaic period of central Maine has a complexity of technological styles and potential outside influences only hinted at in the Early/Middle Archaic record. The appearance of artifacts associated with the Laurentian tradition from the New York/St. Lawrence region in the early portion of the Late Archaic marks an interaction with cultures from the west. The prevalence of Susquehanna material, with its southern, Mid-Atlantic overprint, poses the question of diffusion or migration near the end of the Late Archaic. In the central Penobscot Valley, all of this cultural change occurs on the canvas of a landscape approaching, but still different from the modern situation in both geography and vegetation.

The archaeological record of the earlier portion of the Late Archaic in the central Penobscot Valley is marked by the addition of large, side-notched, Otter Creek bifaces to the existing ground and pecked stone tool suite. These diagnostic artifacts are associated with the Laurentian Tradition (Ritchie, 1965), and are alternatively interpreted to represent a migration of people into the area from the west (Bourque, 1995), or a local adoption of a new point style from a region already linked to Maine by existing cultural bonds (Sanger, 2005). Sanger (2005) notes that these Laurentian features rarely occur east of the Kennebec River or on the coast, creating a potential connection between artifact type and the wetland/forest environment that characterized central Maine circa 6000 to 4500 ^{14}C yrs. BP.

On the main stem of the Penobscot, floodplain sites with a Laurentian component are typically part of a multicomponent site with earlier occupations. Along Pushaw Stream, a number of new sites appear, probably due to the change from an area dominated by surface water to a stream and floodplain setting. Almquist and Sanger's (1999) paleogeographic reconstructions of the Pushaw area show decreasing surface water extent at 6000 ^{14}C yrs. BP, and establishment of modern drainage conditions by 1000 ^{14}C yrs. BP (Figure 4.12). The presence of sites with a Laurentian component on lower Pushaw Stream indicates that the stream was nearing a near modern flow path and discharge by circa 5000-4500 ^{14}C yrs. BP. It is reasonable to assume that people occupied these previously unavailable areas when space and related resources developed. Late Archaic sites in this area are widely distributed along the stream, but appear to be concentrated in locations were a constriction in the stream channel occurs, or were local bedrock outcrops create local base levels (Mack et al, 200

Upland vegetation changes during this time period profoundly altered the character of the areas surrounding the river and wetlands. Almquist and Sanger's (1995) vegetational record from Mansell Pond indicates that white pine dominated the area's forest from 6400-5700 ^{14}C yrs. BP, with dry conditions early in the time period, and evidence for increased precipitation circa 5900 ^{14}C yrs. BP. Hemlock replaced pine as the dominant forest species circa 5700 ^{14}C yrs. BP, perhaps in response to wetter conditions. This forest setting was disrupted by the continent sudden disappearance of hemlock, dated by Almquist and Sanger at Mansell Pond at 4700 ^{14}C yrs. BP. This abrupt change in the forest composition, attributed to a pathogen, created a predominately hardwood forest made up primarily of beech and birch species.

Almquist and Sanger (1995) link the Late Archaic increase in beaver and muskrat remains in faunal analyses of central Maine sites during this time period to the increase in beaver forage provided by these hardwood stands. They also suggest that cooling climatic conditions may have reduced the viability of migratory fish as a resource. In light of the paleogeographic changes in the region, a switch in resource focus from cattail wetlands to beaver-ponds wetlands does not require a major change in orientation. However, the more restricted nature of the ponds, the addition of stream and floodplain resources, and the ease of travel on major streams may have increased the use of floodplain sites.

Migratory fish stocks that may have increased during the Mid-Holocene warm period, and decreased as conditions cooled circa 4000 ^{14}C yrs. BP, contributing to the decrease of fish in faunal remains. However, evidence from the Sebasticook Fish weir (Petersen et al., 1994; Miller, 2006), 40 km west of the study area, supports fishing through the Late Archaic. The construction and maintenance of a weir over a 4000-year time span suggests some continuity in the resource. The Sebasticook fish weir is in a setting geologically and geomorphically similar to Pushaw Lake, Mud Pond, and several other water bodies in the central Penobscot region. Investigations of these lake outlets could provide more information on weir fishing in the region.

These changes in site location from concentrations in tributary/outlet sites to more widely distributed floodplain sites follows Nicholas's (1998) concept of "ecological leveling", or movement of human activity from one environment to another as the balance of resource availability and diversity shifts with habitat succession. While the shift of focus from cattail to beaver wetland does not require a major lifeway alteration, the changing habitats and additional resources offered by developing floodplains may have influenced a change in settlement patterns.

In the central Penobscot Valley, as well as the rest of interior of Maine, there is surprising little evidence of occupation between the Laurentian tradition circa 4500 ^{14}C yrs. BP (4100 ^{14}C yrs. BP at Gilman Falls) and the Susquehanna tradition at 3800 ^{14}C yrs. BP (Sanger 2005). Susquehanna components are also noted at other sites in region, including the Young and Hirundo sites, indicating a widespread presence analogous to the earlier, Laurentian-associated occupations. Sanger (2005) notes the apparent linkage between Susquehanna sites and the distribution of hardwood/nut-bearing trees, suggesting that a lifestyle (and migrants?) dependent on the use of these resources could have entered the region following a major upland vegetational shift circa 3400 C ^{14}C yrs. BP (Almquist and Sanger, 1995).

The possibility exists that there is no gap, merely the inability to recognize the change from one technological style to another, although the widespread distribution of sites of both traditions, and the number of investigations by skilled archaeologists suggests something more complex than a failure to see the "missing link". Environmental issues may be involved, but present only a partial case. Archaeological excavations on floodplains along the Penobscot River show continuous floodplain sedimentation without obvious erosion surfaces or soil development related to this time period. A buried soil horizon (Stratum III) at the Bob Site on Pushaw Stream, interpreted as an anthrosol created by the buildup of human generated charcoal and debris, spans the Laurentian/Susquehanna "gap", with Laurentian material at the base of the horizon, and Susquehanna at the top. The intermediate spodic horizon at Gilman Falls, interpreted to represent an extreme reduction in flow conditions in the Stillwater River, overlies the Laurentian component at that site. The Mansell Pond paleohydrologic record (Almqist et al., 2001) for the period shows a brief pause in lake level increase at this time, but no large scale or long term changes. Broader scale climatic records (Mayewski, et al., 2004) show a 2000-year period of cooling typified by Northern Hemisphere alpine glacier advance circa 4000 ^{14}C yrs. BP. This period of cooling follows the Mid-Holocene Climatic Optimum, a time of generally warmer summers and cooler winters in the Northern hemisphere (Hewitt and Mitchell, 1998; Ganopolski, et al, 1998), perhaps stressing environments and inhabitants by affecting food supplies. All of this information suggests some climatic variability at the time of the apparent archaeological gap, insinuating the possibility of an environmental factor in societal change.

The end of the Late Archaic, or "Terminal Archaic' is marked at the Bob Site by the appearance of points similar to Orient Fishtail points seen as transitional to the Ceramic period by Ritchie (1965). At other sites in the area, the end of the Late Archaic is marked more by the appearance of ceramics , heralding the beginning of the Ceramic period, than by any clearly transitional Terminal Archaic material.

The Late Archaic of the central Penobscot Valley is a time of environmental and archaeological changes. Floodplains continued to develop on the main stem of the Penobscot River, while surface water and cattail marshes decrease in the lowlands to either side of the river. As bogs replaced lakes, streams began to take on a near-modern course, and floodplains started to develop on smaller streams. Climatic and pathogen related changes in vegetation caused forests to change character from pine dominated, to predominately hemlock, and finally overwhelmingly composed of hardwoods, such as birch and beech. Archaeologically, stylistic influences in the form

Laurentian and Susquehanna artifacts suggest a transfer of ideas or people from New York and the St. Lawrence Valley to the west and the Mid-Atlantic states to the south. Laurentian occupations in the central Penobscot Valley expand from Early/Middle Archaic locations at wetland tributary mouths to locations on newly exposed floodplains along Pushaw Stream, and possibly similar locations elsewhere. Faunal and floral analysis suggests an increasing dependence on beaver and muskrat, but the presence of the Sebasticook fish weir in a similar geomorphic setting as those available in study area lakes suggests some local emphasis on fishing. The transition from Laurentian to Susquehanna influence is not understood in this region, and an archaeological hiatus between these two traditions appears in the central Penobscot sites. Some environmental changes, including climate variation and shifts in vegetation patterns occur at this time period, but cannot be definitively linked to the apparent cultural change.

Ceramic Period (3000-400 BP)

The Ceramic (Woodland) period is marked by the sudden and striking appearance of pottery and a renewed use of cryptocrystalline lithic material in the archaeological record. Chronological subdivisions within this time interval are based on pottery attributes and distinctive projectile point styles. Fiedel (2001) notes the apparent lack of Early Woodland (Ceramic) sites in the northeastern US, and suggests an environmental cause. In a review of Fiedel's article, Robinson (2003) responds that the absence of Early Ceramic period (Woodland) material is based too strongly on a supposition that population densities can be determined from projectile point distributions. Robinson (2003) posits that the this focus on projectile point numbers and styles could lead to a misinterpretation of the archaeological record, and the creation of a hiatus that, in fact, does not exist.

Examination of the archaeological components of the central Penobscot Valley (Table 5.1), show that while Early Ceramic period sites are not as common as Late Archaic sites, they are far from absent. Early Ceramic sites appear to be most densely concentrated in the Pushaw localities, but also are found on the main stem of the river at both sites in the Blackman Stream locality, Blackman Stream and Peppard Sites, and the Eddington Bend Site. Diagnostic Early Ceramic material is not identified at the Mackowski Farm site or within the Indian Island, Birch Stream, and Ayers Rapids localities. Some of this apparent deficiency in artifacts may be cultural, but some may be geoarchaeological, as well.

Early Ceramic period components were identified on the basis of diagnostic, CP1 pottery at 6 out of 12 sites in the Pushaw Localities (Pushaw/Dead Stream, Lower Pushaw, and Pushaw Confluence). For comparison purposes, 9 of these sites had a definitive Late Archaic presence, and 2 contained material suggestive of Late Archaic occupation. At the other sites in the Pushaw Localities, Early Ceramic period occupation was either absent (1), or Ceramic period material was present, but not diagnostic (5). This relatively strong presence in the Pushaw drainage may be representative of

Table 5.1: Chronological Comparison of Archaeological Sites in the Central Penobscot Valley

Site #	Site Name	Locality	Geologic Setting	Late Paleo-indian	Early (E)/ Middle (M) Archaic	Late Archaic T(erminal) S(usquehanna) M(oorehead) L(aurentian)	Early Ceramic (CP1)	Middle Ceramic (CP2, CP3, CP4)	Late Ceramic (CP5-CP6)
73-9	Hirundo	Pushaw/ Dead Stream	Floodplain		X	X (S) 4,295±95 ^{14}C yrs. BP (L) 4,325±100 ^{14}C yrs. BP (L)	X		X
73-10	Young	Pushaw/ Dead Stream	Kame(?)			3751±60 ^{1} ^{4}C yrs. BP P (S) 3105±50 ^{14}C yrs. BP (S) X (M) X (L)	X		
74-152		Lower Pushaw	Floodplain			X (S) X (M) X (L)	----	----	----
74-148	Bob Site	Lower Pushaw	Floodplain			3790±90 ^{14}C yrs. BP (S) 3700±80 ^{14}C yrs. BP (S) 3560±70 ^{14}C yrs. BP (S) 4650±70 ^{14}C yrs. BP (L)	X		X
74-142		Lower Pushaw	Floodplain			X	----	----	----

74-81		Lower Pushaw	Floodplain			X		X	X
74-136		Lower Pushaw	Floodplain			X (S) X (M) X (L)	X	X	X
74-147		Lower Pushaw	Floodplain			X*	X*	X*	X*
74-106	Gilman Falls	Pushaw Confluence	Floodplain		6290±160 ^{14}C yrs. BP, 6380±65 ^{14}C yrs. BP, 6840±50 ^{14}C yrs. BP, 7285±80 ^{14}C yrs. BP (Middle Archaic)	3590±150 ^{14}C yrs. BP(S) 4140±130 ^{14}C yrs. BP (L) 4160±70 ^{14}C yrs. BP (L) 4180±80 ^{14}C yrs. BP (L) 4425±125 ^{14}C yrs. BP (L) 5950±165 ^{14}C yrs. BP (L)	X	X	
74-85	Beaver Site	Pushaw Confluence	Floodplain		X			?	?
74-68		Pushaw Confluence	Floodplain		?	?	---- ?	---- ?	---- ?
74-88		Pushaw Confluence	Floodplain			?	?		X
91-35		Birch Stream	Floodplain		?	?	?	?	?
74-128		Indian Island	Floodplain			X*(M?)		X*	
74-18		Indian Island	Floodplain		X?	X?	----	-----	-----
74-91	Gut Island	Indian Island	Island/ Floodplain		X	X		X*	X*

74-105		Indian Island	Floodplain			X		X*	X*
74-100		Indian Island	Floodplain		X	X		X*	
74-x	Mackowski Farm	Mackowski Farm	Floodplain		circa 6900 ^{14}C yrs. BP (M) 8561$\pm$49 ^{14}C yrs. BP (E)				
74-19	Blackman Stream	Blackman Stream	Floodplain	X	7400$\pm$140 ^{14}C yrs. BP (E) 7760$\pm$130 ^{14}C yrs. BP (E) 8360$\pm$150 ^{14}C yrs. BP (E)		X	1110$\pm$70 ^{14}C yrs. BP	X
74-20	Peppard Site	Blackman Stream	Floodplain			X*	X*	X*	X*
	Ayers Rapids 1	Ayers Rapids	Terrace/ Floodplain			4020$\pm$60 ^{14}C yrs. BP (L?)		1600$\pm$60 ^{14}C yrs. BP (CP2)	
	Ayers Rapids 2	Ayers Rapids	Terrace/ Floodplain			3,080$\pm$120 ^{14}C yrs. BP (T?)		X	
	Eddington Bend	Eddington Bend	Terrace/ Floodplain			X (S) X (M)	X	X	X

No Diagnostics/Radiocarbon Dates: 74-88, 74-68, 91-33, 91-35

Early Ceramic preference for this area based on cultural and/or environmental factors, or is a result of site preservation.

Some sites, like those that comprise the Birch Stream locality, are small, and may not have had a large range of artifacts at formation. Subsequent geological and biological processes at this site, and others like it, serve to disrupt and destroy the already scanty record, leaving little for the archaeologist to recover. At Mackowski Farm, topsoil-stripping operations removed almost a meter of sediment from the top of the site, and probably the complete Ceramic period record. In the Indian Island locality, many of the site descriptions characterize the upper portions of the sections as disturbed, either by fluvial or biological processes. Indian Island, the nearby islands, and riverbanks have experienced a wide range of disturbance, both by natural processes and human intervention. It is possible that less disturbance in these areas may have allowed recognition of Early Ceramic period occupations. The Ayers Rapids locality seems the most likely to have been intentionally avoided by Early Ceramic people. Although Ayers Rapids 2 has some problems with disturbance, the recognized Middle Ceramic presence at both sites and lack of Early Ceramic material, suggest that this site was not used, or only lightly occupied with no record during the Early Ceramic.

Fiedel (2001) suggests a climatic component to the absence of Early Ceramic period sites in the Northeast. As illustrated by the preceding discussion, Early Ceramic period sites are not absent from the central Penobscot Valley, but are, perhaps, reduced in number and scale than those of earlier or later time periods. No interruption of geological processes circa 3000 ^{14}C yrs. BP is noted at archaeological sites in the area. Almqujst and Sanger's (1999) paleogeographic reconstructions of the Pushaw basin suggest nearly modern conditions through the Ceramic period. The primary differences noted are in the extent of cattail marshes. Almquist and Sanger (1995) characterize the forest shift at 3400 ^{14}C yrs. BP as the "...last incidence of rapid vegetation change until recent centuries." (p. 217). At this time, the predominately birch/beech with pine and oak in drier areas changed to a mosaic of hemlock stands interspersed with birch and beech. The loss of oak may have affected human and animal populations dependent on acorn abundance. Mayewski et al. (2004) see a worldwide cooling period at approximately 3000 C^{14} yrs. BP, characterized in North America by an expansion of glaciers. This cooling may have led to the vegetation change noted by Almquist and Sanger (1995), and the precipitation patterns that led to the stillstand in lake levels noted at Mansell Pond at this time (Almquist, et al., 2001). As with the other instances of worldwide rapid climate change, it is not known if these changes were profound enough to effect human cultures in a way that would be recorded in the archaeological record.

Available paleogeographic and paleohydrologic information suggests that with respect to habitats, conditions in the Middle to Late Ceramic were generally similar to those seen today. Water levels at Mansell Pond rise steadily from circa 3000 ^{14}C yrs. BP to the present, indicating steady or increasing precipitation (Almquist et al., 2001). In the forests, spruce and fir composition increases circa 2000 ^{14}C yrs. BP at the expense of hemlock and other species, creating the modern forest. Worldwide climatic records indicate cooling periods circa 1000 BP and during the Little Ice Age.

The distribution of Middle and Late Ceramic period sites in the central Penobscot Valley increases relative to the number of Early Ceramic Period sites. As discussed previously, this may represent regional population dynamics, or site preservation issues. Because Ceramic period sites occupy the upper portion of the stratigraphic section, they are in the zone of active, modern bioturbation. At many sites (Table 5.1) the Ceramic component is mixed, and hard to assign to specific intervals. The sites in the area are mainly floodplain sites, and are also less likely to experience flooding and the addition of sediment, as thousands of years of sedimentation has raised the floodplain levels, requiring ever-larger floods to overtop the banks. There is some stratigraphic evidence at the Beaver site (74-85) that lateral accretion of the site took place at this time period. This phenomena has not been documented at other sites in the area, but may be related to the sites position near the mouth of Pushaw Stream.

Archaeologically, the Ceramic period represents a time of technological change in the central Penobscot Valley, as in other portions of the region. Pottery first appears in the Early Ceramic, and changes through time with respect to construction, materials, and decoration. Projectile points become generally smaller, and cryptocrystalline lithic materials appear more frequently in manufacture. The "missing" Early Ceramic (Woodland) discussed by Fiedel (2001) does not appear to be absent in the study area, particularly in the Pushaw localities. In other portions of the central Penobscot valley, along the Stillwater and main stem of the Penobscot River, the Early Ceramic is present, but reduced. Whether this site distribution pattern is the result of Early Ceramic period focus on smaller, tributary streams or site preservation is unknown, as the Ceramic component of several sites within the study area is mixed and does not contain diagnostic forms.

A series of habitat changes during the Ceramic Period brought the landscape to its present form. Forest composition shifted first from pine and oak to a mosaic of hemlock, birch and beech. The loss of acorns may have affected species dependent on this food resource, possibly humans as consumers of the nuts and the wildlife supported by acorn mast. Later, circa 2000 ^{14}C yrs. BP, climatic cooling fostered the spread of spruce and fir at the expense of hemlock.

Geological processes along the Penobscot River and Pushaw Stream appear to have remained relatively constant through the Ceramic period. Paleogeographic reconstructions in the Pushaw/Caribou Bog area (Almquist and Sanger, 1999) indicate that the primary change at this time was the diminishing extent of cattail marshes and the expansion of peatlands. Mayewski et al. (2004) note three periods of worldwide rapid climate change during this time interval. These occur circa 3000 and 1200 ^{14}C yrs. BP, and the more recent Little Ice Age. It is probable that these events had an effect on indigenous populations, but it is difficult to discern in the archaeological record.

Beyond the Penobscot Valley

No other archaeological region in Maine has been examined at this level of interdisciplinary study. The combination of a large number of sites in the area with broad geological and environmental information is rare. This database is largely the result of the insight and efforts of Dr. David Sanger of the University of Maine. His recognition of the importance of geological and environmental data in the analysis of past lifeways laid the groundwork for much of the interdisciplinary work in the area. The combination of information from the fields of archaeology, geology, paleohydrology, paleogeography, and palynology has produced an appreciation for the dynamic nature of the postglacial landscapes and habitats of the central Penobscot Valley. In addition, this study has provided insight into the site formation and preservation processes at work in the area.

Limited research in other river valleys in the state suggests that the techniques developed for the archeological geology study of the central Penobscot Valley are broadly applicable to areas of glaciated terrain, even if specifics are not. As an example, work along the central Kennebec River near Skowhegan (Mosher and Cranmer, 2003) and Norridegwock (Mack, et al., 2001)(Figure 5.1) and the Androscoggin River near Rumford (Hamilton and Mosher, 2000) (Figure 5.1) has shown an association between fluvial terraces and archaeological sites not observed in the central Penobscot Valley. In the central Penobscot Valley, sites are preserved in low terrace and floodplain sediments adjacent to stream channels, particularly in deeply stratified sites near tributary mouths. Most sites are multi-component sites, with the oldest

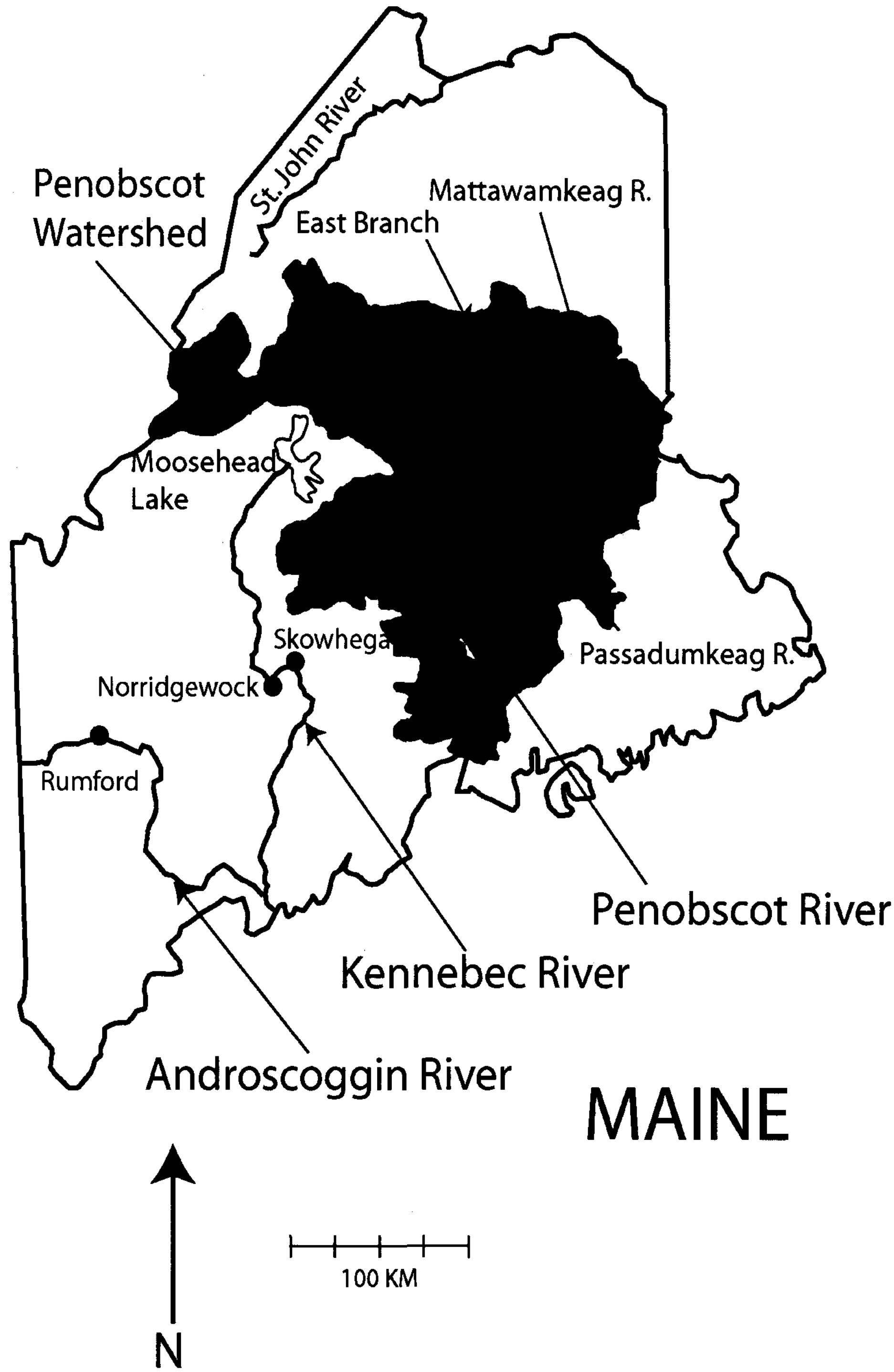


Figure 6.1: Location of archaeological sites on the Kennebec and Androscoggin Rivers

material buried beneath a meter or more of alluvial sediment. Only the Ayers Rapids 1 and Eddington Bend Sites show occupation of higher terrace surfaces. In these cases, active fluvial deposition on the terrace surfaces had ceased prior to the period of occupation, and all human activity occurred as intrusions into the sediments, rather than enclosed in an accumulating sedimentary sequence.

In the central Kennebec River near Skowhegan, floodplain sediments contained a record of Ceramic period occupations, while Susquehanna period and potentially older horizons were located on a terrace over 10 m above the floodplain surface (Mosher and Cranmer, 2003). The Bombazee West site, in Norridgewock on the Kennebec River, contained Ceramic period material recovered from stratified sediments in a small terrace approximately 20 m above river level (Mack et al., 2001). The Clark Farm Site, also on the Kennebec River near Norridgewock (excavation notes) contained archaeological material ranging in age from the Early/Middle Archaic through the historic period in stratified sediments in a terrace 3 to 5 meters above the river level. This level of sedimentation, combined with these elevations above current river level is not seen in the central Penobscot Valley.

Work at six sites at Rumford Falls on the Androscoggin River (Hamilton and Mosher, 2000), showed a linkage between bedrock outcrops and deeply stratified Early/Middle Archaic period occupations more similar to the Penobscot setting. These archaeological components are associated with buried soil horizons, and are generally correlative with the Early/Middle Archaic period occupation at Blackman Stream on the main stem of the Penobscot River. More limited Late Archaic period material was also associated with these landforms. Ceramic (Woodland) period sites were found in both established landforms and on newly forming floodplains.

On a general basis, archaeological sites in the Rumford Falls area on the Androscoggin River have much more in common in terms of geological context than those in the Kennebec Valley. Only a detailed study of the postglacial development of these river valleys and their sediments can address this issue. However, it appears that the Androscoggin and Penobscot share a general Late Pleistocene through Holocene development sequence, while the Kennebec was profoundly affected by the increased discharge and capacity related to the change in the Moosehead outlet location. This shift occurred in the Early Holocene, after the dramatic Late Pleistocene relative sea level fall through central and coastal Maine. The complex relationship between changing gradients and discharge volumes may be responsible to the variations in site location and preservation processes.

These limited case studies underline the importance of understanding the developmental sequence of river formation when attempting to use site location and preservation models in alluvial settings. While experience in the central Penobscot and Androscoggin River Valleys suggest the preservation of Early to Middle Holocene occupations in deeply buried, stratified deposits, the Kennebec River sites present a very different setting. Without understanding the geological events that shaped this valley, this discontinuity could appear to be strictly cultural, rather than influenced by environmental factors.

Thus, the interdisciplinary study of geology, archaeology, paleohydrology, paleogeography, climate change, palynology and paleobotany can be used to create an environmental context for archaeological sites. In addition, each of these disciplines is enriched by insights and observations from the other. Bedrock geology provides the framework on which a postglacial river develops. This development in controlled by isostatic adjustment in the form of relative sea level change and shifting drainage patterns. Paleohydrology contributes information relative to regional water balance and potential discharge variations. Paleogeographic and vegetation studies characterize environments affected by climate change, geology, and other factors. Archaeological components provide chronology and stratigraphy that aids in the interpretation of other disciplines.

As the geomorphology and habitats of dynamic landscapes change in response to climatic and geological factors, people respond by adjusting resource acquisition, occupation site selection, and travel patterns. These responses are often part of the archaeological record. Interpretation of this record, or its absence in some areas, can be made in strictly cultural terms. However, to do so potentially misses important components of human history

Chapter 6

CONCLUSIONS

Introduction

The phrase that characterizes the Late Pleistocene through Holocene Penobscot Valley is "environmental change." This change was the result of geologic and climatic variations that produced a dynamic mosaic of landscapes through time. This presented the Native inhabitants of the region with a fluid set of environments that required adjustments in resource use, occupation site location, and travel routes.

These changes also influenced the formation and preservation of the archaeological record and our interpretations of that record. Occupation models must not only consider resource bases and societal constraints, but also the formation processes that create and preserve archaeological sites for examination and analysis.

Following is a synthesis of the conclusions of this effort.

- The primary physical factors that influenced the formation of the postglacial central Penobscot Valley and its archaeological record are geology and climate change.

Geology shaped the Late Pleistocene and Holocene Penobscot Valley through bedrock geology and deglaciation. Bedrock geology provided the framework upon which the postglacial Penobscot River formed. In the central Penobscot Valley the most important components were the broad extent of the generally easily eroded Vassalboro Formation that created a low-relief landscape, and the individual erosion-resistant beds within the Vassalaboro Formation that formed the bedrock-cored local base levels that shaped the depositional history of the Islands and Rapids Divisions of the Penobscot River.

Deglaciation shaped the development of the central Penobscot valley through deposition, meltwater production, and isostatic adjustment. Glacial erosion of bedrock, followed by marine inundation created a stratigraphic sequence of semi-permeable clay-rich till overlain by impermeable fine-grained glaciomarine sediments. The receding Laurentide Ice Sheet provided large volumes of meltwater to the developing postglacial Penobscot River, creating a high discharge, high capacity river. Regional and localized isostatic adjustment associated with deglaciation provided the falling base level that produced rapid incision of the valley, followed by localized shifts in topography that created extensive lake/wetland complexes and influenced the discharge and capacity of the Penobscot River.

Climatic variations are noted in the central Penobscot Valley in local and regional paleohydrologic studies, the presence of buried soil horizons, and variations in vegetation patterns. Periods of lowered or stable lake levels circa 7500 to 9,000 ^{14}C yrs. BP and 3500 to 4400 ^{14}C yrs. BP are linked to large scale shifts in weather patterns that produced dry winters and lowered groundwater tables (Diffenbacher-Krall and Nurse, 2005). These periods are related by time with buried soil horizons noted at three archaeological sites within the study area (Blackman Steam, Mackowski Farm, Bob sites), and are thought to represent significantly lowered alluvial sedimentation rates associated with climatically-induced decreased discharge and capacity of the Penobscot River.

In the central Penobscot Valley, vegetation changes most closely related to climatic variations are the shift from tundra and open woodland to closed woodland at the end of the Pleistocene (Davis and Jacobson, 1985; Almquist and Sanger, 1995), the dominance of dry-adapted pine forest in the Early Holocene (Almquist and Sanger, 1995), and the expansion of boreal species in the last 2000 years, influenced by the Little Ice Age cooling (Almquist and Sanger (1995).

Vegetation variations are not exclusive recorders of climatic change, but can also be influenced by landscape changes and pathogens. Within the central Penobscot Valley, the succession of cattail marsh to peatland and beaver ponds followed localized isostatic adjustment and drainage network development. The spread of a pathogen is thought to have caused the dramatic "Hemlock Crash" in the mid Holocene, which removed hemlock as the dominant species in the forest.

- <u>If present in the central Penobscot region, Fluted Point tradition Paleioindian sites will be preserved along lakeshores associated wth the Late Pleistocene/Early Holocene lakes that dominated the landscape on either site of the Penobscot River.</u>

While people of this time period may have used the immediate river valley as a travel corridor, preservation potential in alluvial sediments is extremely low in the high energy, dynamic environment indicated by the coarse-grained deposits encountered in archaeological excavations along the main stem of the

Penobscot River. With little on the present day surface to suggest the morphology of these deposits, location of possible camp or hunting sites is difficult. The terraces associated with the Late Pleistocene have not been systematically surveyed, but site preservation potential is low, due to thousands of years of bluff edge erosion.

Paleogeographic reconstructions (Almquist and Sanger, 1999) show extensive Late Pleistocene and Early Holocene lakes in the Pushaw/Caribou Bog area. The unproductive nature of these lakes, documented by Hu and Davis (1995) suggests that these features did not provide a resource base. However, if this model is applied to geologically and topographically similar in the central Penobscot Valley, these large and interconnected lakes served to focus travel and game patterns through the region. Highest potential sites would be associated with lake margins, especially aeolian deposits, thorofare areas between lakes, or elevated surfaces such as eskers. The only Fluted Point tradition site in the region, the Searsmont site (Cox, et al., 1994)) is in a thorofare location between two wetlands, postulated to have been Late Pleistocene lakes.

- <u>Late Paleoindian period sites are associated with the nascent, Early Holocene floodplains along the central Penobscot River, but will be difficult to locate due to depths of burial frequently over 1 m.</u>

The Late Paleoindian parallel-flaked point and associated flakes recovered from Blackman Stream illustrates human use of developing floodplains in the Early Holocene. These developing floodplains may have provided travel pathways and floral and faunal resources. Preservation potential is excellent in these fine-grained soils, which are not exposed to erosion or surface disturbance. However, sediment accumulations of a meter or more will make identification of these sites difficult.

- Early Holocene lakeshores in central Penobscot Valley offer high potential locations for Late Paleoindian period sites.

  Paleogeographic reconstructions of lakes in the Pushaw/Caribou Bog area (Almquist and Sanger. 1999) show increasing Early Holocene productivity associated with cattail marshes. At present, the shorelines of these resource-rich areas have not been surveyed. Preservation potential is anticipated to be good to excellent, as these are low energy environments characterized by colluvium and peat accumulation. Late Paleoindian sites have been recognized in lakeshore settings in other portions of Maine.

- Deranged drainage patterns associated with the migration of a postglacial forebulge created now abandoned channels with high archaeological potential.

Balco et al. (1998) identified a northward draining outlet that connected Moosehead Lake with the West Branch of the Penobscot River. Work as part of this study defined the channel in the area adjacent to the West Branch, and refined the timing of the abandonment of the channel to circa 9000^{14}C yrs BP. During time of active flow, and immediately following abandonment, this channel would have provided a travel route from one major drainage basin (the Penobscot) to another (the Kennebec), as well as a corridor from the resources of the river to those of the lake. Field investigations in the area identified several areas untested areas adjacent to the channel that fit current archaeological site location models. Other isostatically influenced drainage channels may be associated with lakes and ponds within the region that may have hosted Late Pleistocene to Early Holocene occupations.

- Early to Middle Archaic occupation sites are preserved in deeply stratified sediments at the mouths of tributary streams that drain extensive marsh/peatland complexes, and may represent one component of a locally delimited seasonal round.

Almquist and Sanger (1999) noted the association of the Early Archaic component of the Hirundo site and the resource-rich cattail marshes of the adjacent Dead Stream. Sanger et al. (2001) described the linkage between the preservation of Early Archaic components in the Penobscot drainage with bedrock cored local base levels. Kelley and Sanger (2003) expanded this association to include fine-grained alluvial deposition in tributary stream mouths brought about by local, bedrock base levels. Analysis of Early/Middle Archaic site distributions in the study area reveals that all sites of this time period are preserved in these deeply stratified sediments, and that the tributary streams provide water access to areas that may have hosted Early Holocene cattail marshes. Only the Middle Archaic quarry site at Gilman Falls is based on the extraction of a particular rock type for specialized tool production. In other portions of New England, a strong association exists between freshwater marshes and Early Archaic occupations (Jones and Forrest, 2003; Nicholas, 1988, 1991; Forrest, 1999).

While the apparent linkage between sites and nearby marshlands in the central Penobscot Valley may be an artifact of site preservation, it may also represent the riverbank component of a seasonal round focused on marsh and floodplain resources. River bank sites would be the most attractive during the migratory movements of fish in the late spring and summer and waterfowl in the early fall. At other times, flooding and ice movement would render these sites potentially hazardous.

The differences between Paleoindian and Early/Middle Archaic period artifact suites are distinctive. Exquisitely made fluted and parallel-flaked points made of high quality cryptocrystalline quartz from a variety of sources are replaced by serviceable, but less dramatic tools produced from local lithologies. This concentration on local lithic resources has been interpreted by a number of authors to represent curtailed mobility.

In the central Penobscot Valley the rich, virtually year round resources from the wetlands and surrounding uplands combined with seasonal contributions from the nearby river reduced the necessity of long distance travel. Open floodplains may have provided comfortable summer campsites, while occupations in more sheltered wetland margins, such as those recognized in

Connecticut (Forrest, 1999; Jones and Forrest, 2003) would be more attractive winter habitations.

To date, the wetland margins or shorelines have not been investigated in the Pushaw/Caribou bog area or the areas postulated to have hosted lake and wetland complexes. Work adjacent to wetlands in southern New England by several workers has documented the importance of these areas to Native populations in the Early Archaic period. It is reasonable to assume that these similar areas in the central Penobscot Valley would have been equally attractive.

- <u>Occupation of the lower portions of Pushaw Stream does not appear until the Late Archaic because the current drainage pattern did not develop until the mid-Holocene. Following this model, Late Archaic occupations may be widespread along tributary streams within the study area.</u>

Comparisons of site locations and age of archaeological components shows that Early/Middle Archaic sites occur along the main stem of the Penobscot River, on the Stillwater River, and on the upper portions of Pushaw Stream, but not in the Lower Pushaw locality. Sites along the lower portion of Pushaw Stream all date to the Late Archaic, Ceramic, or Contact (Historic) period. The lack of earlier sites in this area is attributed to a lack of occupation area prior to the mid-Holocene. Using Almquist and Sanger's (1999) reconstruction, this area was inundated by freshwater lake and marsh until the modern drainage pattern was established in the mid-Holocene. If this pattern of stream development is applicable to geologically and topographically similar areas in the central Penobscot Valley, evidence of Late Archaic occupations may be present along tributary streams, particularly near constrictions in the stream or at rapids.

Additionally, the development of local drainage patterns in the mid-Holocene may be tied to the timing of weir fishing by allowing the concentration of fish in a well-defined channel. Several periods of Late Archaic period to younger weir use have been recognized in Sebasticook Lake, 40 km southwest of the study area (Petersen et al.,1994; Miller, 2006). Although weirs have not been recognized in lakes or ponds in the central Penobscot Valley, the use of this technology within the region suggests it may have been employed within the study area, and may be worthy of investigation. If the inception of weir fishing is correlative with the establishment of modern drainage patterns, it appears that the Lower Pushaw Stream area lagged behind the Sebasticook area by approximately 1000 years, based on available diagnostic artifacts. While hardly definitive, this tentative correlation provides an interesting detail to the history of landscape evolution in the region.

- <u>Buried soil horizons encountered in archaeological sites in the central Penobscot Valley represent times of decreased sediment accumulation, and are indicative of reduced river and stream discharge.</u>

Buried soil horizons were encountered at several archaeological sites within the central Penobscot Valley, and are identified as paleosols. In some locations, such as Gilman Falls, these soils were distinctly red in color, and are interpreted as spodic horizons, suggesting formation in dry areas dominated by coniferous forest. At other sites, the paleosols have a distinctly darker color, occasionally associated with a red-brown base. The darker color is attributed to the accumulation of anthropogenically-produced charcoal, with the reddish-brown layer associated with the accumulation of iron in the underlying B horizon. In all cases, A horizons are absent, probably due to the poor preservation of organic material in the region's acidic soils.

Radiocarbon dating of charcoal from these horizons demonstrated that their time of formation was not uniform across the region, and varied throughout the Early and Mid Holocene. Where multiple samples were obtained from a single horizon, a range of approximately 1000 years was common. Comparision of the dates of the formation of the paleosols with the paleohydrologic record for the region showed that most of the soils encountered in archaeological sites occur at the same time as dry periods in the Early Holocene from circa 9000 to 7400 ^{14}C yrs BP, and the Mid Holocene from circa 4300 to 3300 ^{14}C yrs BP

- <u>Early Ceramic period archaeological sites are common within the central Penobscot Valley, contrary to Fiedel's (2001) observation of the lack of Early Ceramic period sites in New England.</u>

Fiedel (2001) suggests that the lack of Early Ceramic period sites in New England is related to a period of rapid climate change. In the central Penobscot region, represented by the Mansell Pond record, and the broader New England area, a period of depressed groundwater tables (Diffenbacher-Krall and Nurse,

2005) coincides with the Late Archaic period. The date of a buried soil horizon at the Bob Site in the Lower Pushaw Locality falls within this time period, with evidence of an Early Ceramic period stratigraphically above the buried soil. This climatic and archaeological evidence suggests that the region did not experience an Early Ceramic climatic down turn or lack of occupation.

As mentioned above, the paleohydrological and paleosol evidence for climatically -driven lower groundwater and river discharge rates correlates with the Late Archaic period. This is a time of complexity in the northern New England archaeological record. Technological influences appear from the west (Laurentian) and the south (Susquehanna). It is also the time period associated with the striking ceremonialism associated with the Moorehead burial phase. It is currently unknown if this time of wide archaeological diversity, after an apparent Early/Middle Archaic period relative stability, is associated with climatically produced changes in the physical and biotic environment.

- <u>Some commonalities exist in evaluating the archaeological geology of postglacial river valleys, these factors include:</u>

1. Bedrock geology: Bedrock geology forms the framework on which the postglacial river develops. It controls the location and elevation of local base levels, as well as pre and postglacial valley shapes.

3. Isostatic adjustment: Rivers in areas that experienced postglacial marine inundation develop in response to rapid sea level fluctuations. The gradients created by these adjustments, combined with meltwater discharge influence the discharge volume and capacity of early postglacial rivers. Localized isostatic adjustments in the form of a migrating forebuldge can dramatically shift drainage patterns and the extent of surface water.

4. Climatic variation: Changes in seasonal temperatures and precipitation amounts can have significant affects on vegetation patterns, groundwater levels, and river discharge. These factors, in turn, influence geological processes, human subsistence patterns, and ultimately, the archaeological record.

The goal of this study was to use an interdisciplinary approach to examine the postglacial development of the central Penobscot River Valley, and to use that information as the basis of an environmental context of archaeological sites in the central Penobscot Valley. The result was a wide-ranging set of conclusions that address the presence and absence of sites relating to specific time periods, linked alluvial depositional histories exposed in archaeological excavations with climatic and geological processes, and lead to and understanding of archaeological site formation and preservation in the region. The importance of understanding the geological, climatic, and paleoenvironmental setting of archaeological sites in postglacial rivers valleys was established. While this work marks the end of a long and complicated endeavor, it also lays the groundwork for investigations

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BIOGRAPHY OF THE AUTHOR

Alice Repsher Kelley was born in Fountain Hill, Pennsylvania, on June 30, 1953. She grew up in Passer, Pennsylvania, a small community near Coopersburg, Pennsylvania. She graduated from Palisades High School in 1971. Following graduation, she attended West Chester State University in West Chester, Pennsylvania, and earned a B.S. in Earth Science Education in 1975. After graduation, she worked as an exploration geologist for Bethlehem Steel Corporation, Bethlehem, Pennsylvania, in a variety of locations, including Mexico and the southern Appalachian coalfields. While in Bethlehem, she married her husband, Joseph T. Kelley, on Halloween of 1976. She left Bethlehem Steel in 1978 to complete her M.S. in Geology at Lehigh University, Bethlehem, Pennsylvania. After graduation, she worked as an exploration geologist/geophysicist for Chevron USA in New Orleans, Louisiana. In 1982, Alice moved to Maine with her husband, where she currently resides. She holds an Instructor's position in the Department of Geological Sciences at the University of Maine, in Orono, Maine. She also works as a consulting geologist and geoarchaeologist. She is the mother of three children: Samuel Edward, Anna Katherine (Kate), and Taylor Forrest. Alice is a candidate for the Doctor of Philosophy degree Interdisciplinary in Archaeological Geology from The University of Maine in December 2006.