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Introduction

The Great Bend site (36SQ17) is a deeply buried, multi-component archeological site along the Upper Susquehanna River near the town of Great Bend, Susquehanna County, Pennsylvania (Figure 1). Initial (Phase I) archeological and geomorphological investigations (Pan Cultural Associates 1998) for the Hallstead/Great Bend Bridge replacement suggested that the T-0 landform flanking the bridge on the northeast had potential for preserving buried archeological deposits at depths 2-2.5 meters beneath the surface. The T-0 was defined at an elevation of ca. 261-262 masl. The McDonald's Restaurant, the key landmark for the site, was considered to be a built up extension of the T-1 surface (elevation ca. 269 asl) and subsurface disturbance rendered it insensitive for preservation of prehistoric cultural resources.

In 1999, Geoarcheology Research Associates (GRA) was contracted by CHRS to undertake subsurface testing attendant to the Phase I recommendations. Field relations and initial trenching verified the presence of an intermediate terrace between the T-0 and the formerly designated T-1. This extensive landform was reclassified T-1 at an elevation of 265 masl. The former T-1 landform (supporting McDonald's) was reclassified T-2.

Over the course of subsurface testing, it was discovered that the T-1 capped a sequence of four discrete stratigraphic units. These units are unconformably stratified and are traceable, with lateral variability, across the T-1 landform in the site vicinity. Unit designations were developed on the basis of an allostratigraphic sequence, one which considers the individual unit to be “a mappable stratiform body of sedimentary rock that is defined and identified on the basis of its bounding discontinuity” (NASCN 1983: 865). The advantage of this type of sequence for archeology is that it recognizes the contemporaneity of different types of stratigraphic components—artifacts, soils, sediments—as the ordering principle for vertical succession. Thus, for example, a set of potsherds of clear Middle Woodland association preserved in a sandy flood deposit can be assigned to the same allostratigraphic unit as a buried soil that has been radiocarbon dated to the same period but contains no artifacts whatsoever.

At 36SQ17 the four (4) allostratigraphic units are briefly summarized below:

- ASU IV; historic fill (0-1.0 m);
• ASU III; prehistoric deposits overlying/interdigitated with early historic fill; cultural sediments articulate with renewed high energy accretion deposits (0.6-1.0 m);
• ASU II; overbank alluvium and well developed soil horizon of Middle Holocene age (2.0-2.4 m);
• ASU I; laterally accreted Early-Middle alluvium with thin to thick soils and a preserved prehistoric component of (probable) Middle Archaic age (2.4->3.2 m).

The lowermost prehistoric component did not contain diagnostic artifacts but yielded dates in the range of 8500-7000 B.P. The uppermost archeological deposits are of Late Woodland (Owasco culture) affinity. The reclassified T-1 landform which houses the prehistoric components is of Holocene age and occurs intermittently throughout the Susquehanna River valley (Schuldenrein 2002; Thieme and Schuldenrein 1998; Vento et al. 1999). An unconformable contact with upper Pleistocene outwash occurs at the base of the terrace, approximately 4.5 m below the land surface. Radiocarbon dates for the basal Holocene sediments range from 8320±50 B.P. to 11,160±40 B.P., with the younger dates representing charred material directly associated with an assemblage of early Middle Archaic lithic artifacts.

The excavations described in the present report were within the area of potential effect (APE) of construction activities for replacement of the S.R. 11 bridge over the Susquehanna River (see Figure 1). The report begins with the regional geology and what is known about the Quaternary geologic history of this part of the Susquehanna River valley. The history of geomorphological investigations in this part of Pennsylvania and adjacent New York State is then briefly summarized.

The master stratigraphy of site 36SQ17 was developed on the strength of identifications of 30 soil horizons or discrete fill deposits, which were traced by careful hand excavation. The excavation block within the APE had final dimensions of 9 m x 5 m at the top. As noted, there are four basic packages of sediment, or allostratigraphic units (Autin 1992; NACSN 1983) in the terrace, of which only two contained \textit{in situ} prehistoric archeological contexts within the excavation block. Following a description of the master profile from top to bottom of the site, sedimentological and geochemical characteristics are discussed in detail based on laboratory results for a total of 36 soil sediment samples. Because this is such a deep and well-characterized stratigraphic profile, these details should prove
relevant to archeological reconnaissance and predictive modeling in alluvial settings throughout eastern and central Pennsylvania and adjacent south central New York.

It is noted that the uppermost package (Allostratigraphic Unit IV) at site 36SQ17 consists of a series of late-19th through 20th century fill deposits. The sedimentology of these deposits is discussed in some detail in a final section, and they are compared with the deposits which housed the prehistoric contexts. Once again, these data should prove useful for interpretation of sites where similar stratigraphy occurs but the analytical budget is less robust.

The final sections of this report explore some possible correlations between the stratigraphic framework developed for site 36SQ17 and other alluvial landscapes in the immediate vicinity. In particular, a recently developed geoarcheological sequence at site 36SQ111 is examined for landform succession and subsurface stratigraphy. The latter site underscores the difficulties in unraveling complex alluvial chronologies where landform morphologies have been variously altered by land development and upper stratigraphies have been destroyed by large scale stripping and filling.
Regional Physiography, Bedrock Geology, and Quaternary Stratigraphy

Susquehanna County is in the glaciated portion of the Appalachian Plateaus physiographic province (Berg et al. 1989; Briggs 1999). Relief of approximately 300 meters occurs between the local elevation of ca. 261(?) m MSL at river grade and ridge summits visible to the south and north. The bedrock is slightly folded siltstone and fine-grained sandstone of Upper Devonian age. Formerly this was known as the Chemung formation (Stevenson 1891; White 1881; Willard 1934; Willard et al. 1939), and the term Chemung is still used by some geologists working in New York State for a tidally-influenced facies with abundant silt and clay (Isachsen et al. 2000: 122-126; Woodrow 1963). The term Lockhaven is currently favored in Pennsylvania (Berg et al. 1980) for the nearly flat-lying beds of gray or greenish gray rock, which are extracted for flagstone at many nearby quarries.

The prevalence of sedimentary lithologies throughout the Susquehanna River valley makes many glacial deposits immediately identifiable based on the occurrence of erratic clasts from metamorphic and igneous lithologies. Great Bend is approximately 120 km north of the terminal moraine for the late Wisconsinan glacial advance, which is just upstream of Berwick in the North Branch of the Susquehanna River valley (Braun 1988, 1994; Crowl and Sevon 1980, 1999). The Wisconsinan terminal moraine is estimated to be approximately 18,000 years old by Cotter et al. (1986) while a slightly older age may be indicated by 29 radiocarbon dates greater than 20 ka obtained from outwash deposits at Port Washington on Long Island by Sirkin (Sirkin 1986; Sirkin and Stuckenrath 1980).

The rate of retreat of the Laurentide ice sheet from its terminal moraine is not well constrained since glacial deposits contain few organic materials dateable using radiocarbon techniques. Pennsylvania was definitely free of glacial ice by 14,000 years ago, the age assigned to the “Valley Heads” margin at the southern tip of the Finger Lakes in New York State (Braun 1994, Muller and Calkin 1993). Meltwater floods lasted until at least this late in the Chemung and Chenango River valleys north and west of Binghamton, where the valley train has a “bright” appearance due to common clasts of limestone scoured from the Finger Lakes glacial troughs (Denny 1956; Denny and Lyford 1963; MacClintock and Apfel 1944).

Upstream of Binghamton at least as far as Great Bend, a proglacial lake filled the Susquehanna River valley and extended south up Salt Lick Creek valley (Braun 1999; Braun et al. 1999). The spillpoint for glacial lake Great Bend was the divide between Salt Lick Creek and a south-flowing tributary of Tunkhannock Creek. Gravel terraces in the Tunkhannock Creek valley are in part the result of
catastrophic discharges across the divide. Stratigraphic evidence of glacial lake Great Bend in the immediate vicinity of site 36SQ17 includes well-sorted sand sheets in the lower reaches of Salt Lick Creek and ice-contact deltas on the valley walls. Once the outlet to the west was unblocked, multiple channels were incised into the proglacial lake sediments. Most of these appear to have been considerably to the north of the present river channel at Great Bend. Streams north of Penny Hill such as Trowbridge Creek may have carried much larger flows and transported more sediment at this point, and at least one relict channel can be discerned running approximately parallel to S.R. 171 east of interstate highway I-81.

Gravelly to coarse sandy textures in the upper Pleistocene deposits, contrasting with fine sandy to silty textures in the Holocene alluvium, make it possible to map much of the Quaternary geomorphology of northeastern Pennsylvania on the basis of the U.S.D.A. county soil surveys. Within the Susquehanna River valley, the Chenango and Wyoming series typically occur on outwash terraces (T-2 and higher) while the Barbour and Basher series occur on the T-1 terrace or in the active floodplain (Reber 1973). The T-2 at Hallstead, on the left bank of the river within the S.R. 11 bridge replacement area, is thus identifiable as a glacial landform based on the occurrence of the gravelly Chenango series. The T-1 which housed the Great Bend archeological site (36SQ17) is mapped with the Barber series. The floodplain (T-0) surface less than a meter above river grade cannot be distinguished using the mapped soils, however, and urban disturbance makes many of the geomorphic relationships unclear without subsurface investigations.
History of Geomorphological Investigations

Great Bend, Pennsylvania is closer to Binghamton, New York than it is to any of the cities in Pennsylvania. This fact has affected what little previous research has been conducted on these reaches of the Susquehanna River valley. An early reconnaissance was conducted by H. L. Fairchild (1925), financed by the New York State Science and Museum Service. In order to account for the ice-contact deltas and outwash plains he observed, Fairchild proposed an immense glacial lake extending all the way from Towanda, Pennsylvania upstream past Binghamton to Great Bend, a distance of over 120 km. The recent glacial lake Great Bend reconstruction (Braun 1999; Braun et al. 1999) is considerably more modest and more or less independent of the ice-recessional history in the valleys now occupied by the Chenango and the Chemung Rivers.

MacClintock and Apfel (1944) described Pleistocene glacial drift in the Salamanca Reentrant and extended the units observed throughout south central New York. They proposed a still-stand or discrete recessional position in the Binghamton area, but this has been disputed by subsequent stratigraphers working with the Binghamton deposits (Coates 1963; Denny and Lyford 1963; Moss and Ritter 1962). Randall (1972) compiled boring logs throughout the Susquehanna River valley between Oneonta and Binghamton. While up to 120 m of gravelly outwash occur in some locations, less than 30 m were found to occur at Great Bend.

The concavo-convex form of hill-slopes immediately north of Great Bend was described by Coates (1974: 225-226) as a feature inherited from the recession of the ice sheet. Solufluction was caused by the heavy load of till on slopes inadequately stabilized by vegetation. Coates further linked the downslope convexity to concave depressions on adjacent uplands. Water moves between these features by through-flow, increasing the pore water pressure of sediments on the lower hill-slope segments. The resulting upper Pleistocene through Holocene colluvium was shown to extend downslope into the channels of the southwest trending Trowbridge Creek drainage.

A pioneering investigation of Holocene alluvial stratigraphy was conducted in the upper Susquehanna River Basin by Scully and Arnold (1979, 1981) with the objective of evaluating the relationship between soil properties and terrace age. One of the study sites was along the Susquehanna River downstream of its confluence with the Unadilla River while the other site was along the Unadilla upstream of the confluence. The T-1 was recognized as a Holocene alluvial terrace distinct from the active floodplain (T-0), and individual packages of alluvium were identified on the basis of the soils
which formed at their upper bounding surface. Unfortunately, the study site is over 50 km upstream of Great Bend and the T-1 exposures have yet to be examined for most of the intervening reaches.

Maps of surficial geology for the entire state of New York at a scale of 1:250,000 were published beginning in 1986, and the Susquehanna River originates on the Hudson-Mohawk sheet (Cadwell and Dineen 1987) and continues across the Finger Lakes sheet (Cadwell and Dineen 1987). Holocene alluvium (al) is distinguished from glacial outwash sand and gravel (og) on both sheets but greater detail on the youngest deposits can often be obtained from the county soil surveys.

A particularly fruitful collaboration between Quaternary geologists and archeologists was initiated by Robert Funk during the 1970’s in his investigations in the Upper Susquehanna Valley (Funk 1993, 1997; Funk and Rippeteau 1977). Funk’s project studied archaeological sites along the Susquehanna River upstream of its juncture with the Unadilla River. Kirkland and Funk (1979) linked postglacial alluvial change with prehistoric settlement patterns, noting a low terrace formed by lateral migration ca. 4200-4500 B.P coinciding with the Lamoka and Vestal phases of prehistoric culture. Subsequently, Dineen (1993) identified at least three Holocene terraces in the vicinity of several of the archeological sites. Less than a meter of relief marks most of the terraces mapped by Dineen, however, and they have yet to be traced beyond the reaches of the initial study.

Geomorphological studies in conjunction with archeological fieldwork in the Hallstead-Great Bend area began in the early 1990’s when the SUNY-Binghamton Public Archeology Facility identified and tested the sites which were impacted by the Pennsylvania American Water Company pipeline (Versaggi et al. 1993; Wurst and Lain 1996). Vento undertook most of the deep testing efforts for these projects and proposed a total of five (5) terraces for these valley reaches. Interpretations were modeled after the description by Peltier (1949) and projected between three and five terraces in the reaches between Athens, Pennsylvania and the terminal moraine.

Kame or ice-contact delta deposits occur over 30 m above river grade, and Vento followed the stratigraphic terminology proposed by Crowl and Sevon (1980) in referring to such active ice deposition as “Olean” as opposed to “Binghamton.” Peltier, on the other hand, used the term Binghamton extensively and identified what he considered to be a recessional moraine for the Binghamton ice in the vicinity of Milan, Pennsylvania (Peltier 1949: 89-91). A higher percentage of far-traveled clasts derived from igneous and metamorphic lithologies of the Mohawk Valley and the Adirondack Mountains.
is commonly considered to be characteristic of the Binghamton deposits (Coates 1976: 65; Peltier 1949: 18).

At Great Bend, Vento proposed an Olean outwash terrace (T-4) at 18 m above river grade and a Binghamton terrace (T-3) at 14 m above river grade, which seems inconsistent since the study location is upvalley of both proposed moraines. The proposed Valley Heads terrace (T-2) at 7.6 m and Port Huron terrace (T-1) at 3.5-6 m above river grade are characterized as having a “veneer” of Holocene alluvium, and have generally been found in previous studies to be more veneer than gravel. The actual discharges from heads of outwash north of the Valley Heads recessional moraine are as yet poorly understood and were probably greatest in the Chemung and Chenango River valleys.

A simpler approach has been taken in the present report, grouping all of the outwash surfaces into a single T-2 from 8-14 m above river grade and proposing a Holocene T-1 surface from 3-5 m above river grade which correlates upriver with surfaces previously mapped by Scully and Arnold (1979, 1981) and Dineen (1993). Upper Pleistocene deposits found at elevations above that proposed for T-2 show evidence of deposition in very close proximity to active ice rather than from meltwater floods.

Frank Vento also reported on an initial phase of investigations for replacement of the S.R. 11 bridge (Pan Cultural Associates 1998). In that study, the T-1 landform housing site 36SQ17 was referred to as a T0 terrace, while the floodplain in the southeast quadrant upstream of the mouth of Salt Lick Creek was referred to as T00. The present studies in the southwest and southeast quadrants of the S.R. 11 bridge replacement have been reported previously under separate cover (Thieme et al. 1999a, 1999b). Vento’s general model of the project area was confirmed in that there was little or no potential for preservation of prehistoric archeological contexts in the active floodplain (T-0) at elevations less than three meters above river grade. Significantly, the limited field investigations conducted at the Hallstead Park Site (36SQ31) (Wurst and Lain 1996) provided a more complete stratigraphic and geomorphic context for this multi-component prehistoric site on the T-2 surface.
Initial Testing of the Great Bend site (36SQ17)

The present investigations of the Great Bend site (36SQ17) began with a series of three backhoe trenches, two of which were excavated as close as possible to locations previously tested by Pan Cultural Associates (1998). All of these trench locations were outside the APE which was eventually defined by project engineers, but the exposures were used to preview the stratigraphy subsequently encountered in the larger block excavation. The fieldwork was conducted in very cold weather early in 1999, and frozen ground limited profile exposures, detailed mapping, and interpretation of the deposits. There were also some problems relocating the original trenches in spite of a site visit by personnel from Pan Cultural Associates.

Trench 99-2 reopened Pan Cultural’s Trench 2 (Figure 2). A prehistoric charcoal concentration, probably a hearth, was encountered in the west wall profile (Plate 1) at a depth of approximately a meter below surface (264 m MSL). The profile was described and a hand auger was used to core in the floor of the trench. As shown in Figure 2, a hearth was exposed in section at the interface of ASU III and ASU IV. While the cultural affiliation of the hearth feature is unknown, it occurs at the base of a 2Ab horizon which appears to correlate stratigraphically with deposits dated to $4780\pm40$ B.P. (Beta-128115) within the excavation block. A sample of bulk sediment from the 4Ab soil horizon (ASU-I) approximately two meters below surface (263 m MSL) was subsequently radiocarbon dated to $7360\pm80$ B.P. (Beta-128117). Unfortunately, there were no archeological contexts associated with this stratigraphic package in the APE excavation block. Significantly, however, the projected feature date and the dated bulk sediments are in stratigraphic order and their respective dates are consistent with the absolute chronology of other portions of the site.
Figure 2
Plate 1. Trench 99-2, view across west wall toward the APE perimeter fence. (photograph GRA).
Trench 99-3 reopened Pan Cultural’s Trench 1 at the extreme west end of the T-1. A composite 2 m deep stratigraphy is presented in Figure 3. The sequence appears to extend through units ASU-IV and ASU-III. A possible prehistoric feature was encountered at the base of the A1 soil horizon. At approximately 50-70 cmbs, a buried surface (2Ab horizon) was encountered which sloped steeply toward the river channel. No prehistoric artifacts were observed, but a sample of bulk sediment was collected from this horizon for possible radiocarbon dating. The underlying sediments were coarse textured and may correlate with massively bedded sand found in the APE excavation block approximately two meters below the land surface (263.5 m MSL).
Trench 99-1 was downslope from the eventual location of the APE excavation block, on the T-0 landform (Plate 2). The surface elevation was approximately 264 m MSL, compared to 265 m MSL at Trenches 99-2 and 99-3. The area had recently been used as a dumping ground, and approximately 50 cm of historic fill occurred at the north end of the trench, thickening to upwards of a meter toward the river (see Figure 4). A much older fill deposit (2Ab-2C horizons) containing abundant redware ceramic fragments was found approximately 1.3-1.8 mbs (262.8-263.3 m MSL). Beneath that were a series of sandy fills (3AC-3C horizons) resting on an intact stratum of very gleyed alluvium, probably late Holocene in age (4Ab-4Bg-4C horizons). Despite the number of buried soil horizons (through 4Cg), the weak degree of soil development and the presence of historic debris until at least the top of horizon 3AC indicates that only ASU-IV and ASU-III were exposed to depths of 2.5 m at Trench 99-1; the exposed sequence represents a succession of the last 3000 years or less.

Plate 2. View of backhoe excavating Trench 99-1 and the existing Susquehanna River bridge. (photograph GRA).
Figure 4
Of the three trenches excavated, Trenches 99-1 and 99-2 were the closest to the APE defined by the project engineers. The Trench 99-1 profile represents a portion of the river floodplain (T-0) that had been artificially built up to within a meter of the T-1 surface which houses the prehistoric archeological contexts. Trench 99-2 was on an intact portion of the original T-1 and therefore served as a better model to use in planning the block excavation within the APE. Four allostratigraphic units were numbered sequentially beginning at the basal deposits described from a core in the floor of the trench (see Figure 5). These same units were also identified in Core 99-11, taken within the APE excavation block at grid coordinates N58/E52.

Trenches 99-2 and 99-3 illustrated the variable depth and complexity of historic occupation (ASU-IV) as well as the waning phases of dominant overbanking near the end of the prehistoric (Late Archaic and Woodland) period (ASU-III).

When Core 99-11 was taken, excavation had begun within an initial 5 m x 5 m block. The upper levels were difficult to interpret because of thick accumulations of historic fill, which typically included much organic-rich sediment from the underlying A horizon. Prehistoric artifacts from various periods were found in these upper deposits, many of which probably washed downslope from the portion of the site which has been paved over by the McDonald’s parking lot. The allostratigraphic framework correlating Core 99-11 with Trench 99-2 suggested the depth at which intact, archeologically sensitive deposits would be found.

Two radiocarbon dates were obtained on samples from Core 99-11 in March, 1999. A date of 4780±40 B.P. (Beta-128115) was obtained for a sample from the 2Ab horizon at 263.85 m MSL, and a date of 7630±100 B.P. (Beta-128116) was obtained for a sample from the 4Ab horizon at 263.15 m MSL. As discussed in the following sections on the stratigraphy of the excavation block, these dates agree quite well with all of the other available age estimates from the site.
Great Bend Site Master Stratigraphy

There are a total of 30 soil horizons or discrete fill deposits in the master stratigraphy of site 36SQ17 (Table 1). Because most of the T-1 alluvium consists of relatively flat-lying, conformable beds, it was possible to trace all four of the allostratigraphic units through the excavation block (Plate 3). ASU-I was found to be considerably thicker and more archeologically sensitive than was suspected based on the channel and point bar sands sampled in the core at the base of Trench 99-2. It was extremely difficult to devise an appropriate “window” for investigation of the deepest ASU-1 deposits due to safety considerations. Only the upper portion of ASU-1, designated ASU-1c on Plate 3, was exposed within the maximum depth of three meters attained by stepping of the initial 5 x 5 m excavation block.

Plate 3. View of the initial 5 m x 5 m excavation block looking southeast. (photograph GRA).
The majority of the sediment excavated from the block belonged to ASU-IV, which was not initially expected to be significant from an archaeological standpoint. However, several large Woodland (Owasco culture) pit features were found at the top of the C1 horizon, from 50 to 90 cm below the original land surface. The 5 m x 5 m block was stepped in to 3 m x 3 m approximately 30 cm above the 2Ab horizon at the top of ASU-III (Figure 5). The 2Ab horizon was initially expected to contain relatively dense concentrations of Late Archaic midden or pit features. No features were found and the artifact density appeared to have declined. While the stratigraphy correlated quite closely with Trench 99-2, it was difficult to use it to predict the relatively small and discrete cultural activity areas on site 36SQ17.

The final step in the initial excavation block occurred at the top of the 3Bw horizon, a very compact subsoil discolored by oxidized iron. The 3Bw represents an entire sediment package, ASU-II, on both sedimentological and pedological grounds. It was truncated by a scour episode and unconformably overlain by the much coarser flood sands of the 2C horizon. Its firm consistence made it a convenient place at which to step the excavation down to a 1 m x 1 m unit. Radiocarbon ages of 7,630±100 B.P. (Beta-128116) for the 4Ab horizon at the top of ASU-Ic and 4,780±40 B.P. for the 2Ab horizon (or 2C) at the top of ASU-III indicate a mid-Holocene age for this strongly oxidized Bw horizon scoured by a relatively high energy flood event.

A column of sixteen soil sediment samples, Column 1, was collected from the east wall profiles of each step in the initial block excavation (Table 2). Soil monoliths were collected across horizon boundaries in ASU-I and ASU-II for soil micromorphology (Courty et al. 1989). Specifically, a block was collected from the 2C/3Bw contact, the 3Bw/4AB contact, and the 4AB/4Bt contact. Micromorphological study is in progress, both to corroborate the general stratigraphic framework and to compare the degree of soil development with samples from soils of similar age.
No prehistoric cultural material was recovered from ASU-I in this initial excavation, but a core taken in the floor of the 1 m x 1 m unit indicated that at least another meter of sandy sediment was present above the upper Pleistocene outwash gravel. The entire excavation block was consequently expanded at this point into a 9 m x 5 m block, within which it was possible to attain a total depth of slightly over four meters. Wooden shoring was used to make the excavation safe (Plate 4).

![Plate 4. View of the 9 m x 5 m shored excavation block. (photograph GRA).](image)

The basic framework of four allostratigraphic units was also valid for the much larger block, although many of the beds were less flat-lying and there had been considerably more disturbance of this area during the late-19th through 20th centuries. The undisturbed C horizon which contained the Late Woodland contexts could not be traced more than a meter or two west of the E46 line. ASU-IV extended as deep as 160 cm below surface (263.5 m MSL) in the southwest corner of the block (N54/E43). Interstratified muddy fills (Fills Ia, Ib, II, III, IV, and V) and coarser sandy fills (Sands I and II) represent a combination of dumping episodes and natural colluviation. A deep trench had been excavated running north-south, and organic refuse pushed into this depression gave the appearance of an intact buried soil on the alluvial terrace.
A column of twenty soil sediment samples, Column 2, was collected from the west wall profiles of the entire block excavation (Table 2). Fills IB, II, IV, and V as well as what appeared to be intact C2 alluvium representing ASU-IV were sampled from a profile at N58/E44. Samples of the 2AB, 2BC, and 2C horizons of ASU-III were also collected from this profile. The 3Bw (ASU-II) and 4AB, 4Bt1, 4Bt2, and 4Bt3 horizons of ASU-Ic were sampled at N56/E44. The scaffolding-supported large block excavation afforded an opportunity to photograph the moderate medium prismatic soil structure of the argillic horizon, shown in Plate 5.

Plate 5. 4Btx horizon showing moderate medium prismatic ped structure and continuous clay films. (photograph GRA).

The subdivision of ASU-I has been done to reflect two relatively thin (~ 50 cm) packages of sandy alluvium at the base of the excavation. The lower of these two packages, ASU-Ia was found to contain an assemblage of early Middle Archaic lithic artifacts. Most of the artifacts were in the 6AC soil horizon, a brown (7.5YR4/4-5/4) fine to medium sand which appeared to have been deposited by lateral accretion. Some of the artifacts may also come from the top (?) of the underlying 6BC horizon, which exhibited slightly more evidence of soil development. The basal gravelly sand (6C horizon) of
ASU-Ia is probably upper Pleistocene outwash and consistent with the radiocarbon date of 11,180±40 B.P. (Beta-133919). Unfortunately, however, that date was obtained on a sample out of stratigraphic sequence, from the 5AC horizon in ASU-Ib.

The basal 6C gravels at 259.5 m MSL are typically below river grade. Fortunately, limited stratigraphic inspections were undertaken in the drier summer and fall months when the excavation was completed. Samples representing ASU-Ia and ASU-Ib were collected in cramped conditions from the west wall profile at approximately N54.5/E44. The 6AC, 6BC, and 6C samples in Column 2 represent ASU-Ia while the 5AC and 5C samples represent ASU-Ib. Two more samples from ASU-Ic, from the 4C2a and 4C2b horizons, were also collected from this profile.

The field nomenclature for soil horizons in the above master stratigraphy has been corroborated with laboratory analyses of particle size and soil chemistry. The test of the allostratigraphic framework in many ways was the fact that contacts occurred at predictable depths within the excavation block. Some modifications were made during the course of the excavation. It should also be noted that secure dating of the cultural horizons is also impeded by the lack of diagnostic archeological material.
Table 1. Great Bend Site (36SQ17) Master Soil Stratigraphy
Sedimentological and Geochemical Characteristics of the Composite Profile

The two columns of soil sediment collected from the site 36SQ17 APE excavation block overlap from ASU-Ic up-section to the top of ASU-III. A composite stratigraphic column of 23 samples was assembled from the two columns, running from the base of the excavation at 259.80 m MSL (6C horizon) up to the A/C horizon at 264.40 m MSL. The nine samples at the base of the composite profile were collected from the west wall profiles (N56/E44, N54.5/E44, or N55/E46) while the fourteen samples at the top were collected from the east wall profile of the initial 5 m x 5 m block (N53.5/E40, N56/E41, or N55/E42).

Vertical trends in particle size, organic matter, pH, available phosphorous, exchangeable calcium, magnesium, and potassium, and extractable iron and manganese are plotted in Figure 6. The clay bulge in the 4Bt1, 4Bt2, and 4Bt3 horizons is the most obvious feature of ASU-1c. Small clay increases of five percent or less in ASU-1a and ASU-1b may also be due to soil development. The most clay-rich horizon in the profile, however, is the 3Bw horizon (ASU-II). The 3Bw is also enriched in Decreasing organic matter from the 3Bw (0.8%) down through the 4Bt1 (0.9%) indicates that ASU-II has been to some extent “welded” onto ASU-1c by soil development (Birkeland 1999: 27-28; Ruhe and Olson 1980). However, the peak in citrate-dithionite extractable Fe (0.99%) and Mn (0.07%) as well as P, Ca, Mg, and K corroborates the inference that the 3Bw represents a distinct depositional and soil forming episode.

In general, ASU-1c and ASU-II were silty overbank deposits with well-developed cambic to argillic soil development. ASU-III, however, begins a new cycle of vertical accretion. There is an abrupt coarsening in the profile at the 2C(b)/3Bw contact which is evident in all of the laboratory results. The 2Cb horizon is 84% sand compared to only 41% for the 3Bw horizon. The mean grain size for the 2Cb, 2.9 (0.15 mm), is actually fine sand. Nonetheless, this is considerably coarser than the mean of 6.8 (0.008 mm) for the 3Bw horizon.

Increases in silt from the 4C2b (43%) to the 4Bt3 (64%), and from the 2Cb (13%) to the 2Ab (51%) typify fining-upward trends of vertical accretion on point bars of meandering streams (Allen 1970: 140-143; Nichols 1999: 116-118; Reineck and Singh 1986: 267-274). Overbank deposition appears to have been much less common after the deposition of ASU-III, with both slope wash and refuse disposal contributing significantly to the uppermost 50-70 cm of the T-1 (ASU-IV). Sediment texture only differed subtly from the top of ASU-III upward in the profile, a probable function of the
heterogeneous composition of slope deposits and a variety of clastic components from multiple sources. The laboratory results for percent organic matter and sediment chemistry register the most significant changes in the upper part of the composite profile. Many of these changes are clearly related to either historic or late prehistoric human activities in the immediate vicinity of the APE excavation block at site 36SQ17.

Perhaps the most problematic and compelling transition registered in the composite profile is at the interface between ASU II and ASU III. The sedimentology indicates initiation of a new depositional cycle signaled by renewed coarse sediment (i.e. sand-size) aggradation. An upward fining trend is continuous for 0.7 meter (between 2.0 and 1.3 mbs). Typically this would be considered an indicator of a change in channel morphology, except that in the attenuated Upper Susquehanna Valley the last obvious evidence of lateral channel migration would appear to be signaled by the argillic soil profile (Bt) in ASU-I. Presumably the T-1 surface would have stabilized across the valley by then and the durable and well-weathered early Holocene soil would be ample evidence of this. A renewed cycle of coarse sediment accretion might be related to climatic forcing and high periodicity of flooding events at during the Middle Holocene. The radiometric dates would suggest that this would have occurred around 6000-5000 B.P. (interpolated between known dates for 2Ab and 6BC in Figure 6). This is consistent with evidence for some climatic change around the time of Early to Middle Holocene transition. However, the possibility of a change in channel geometry and dynamism at that time cannot be discounted.
figure 6
The Composite Sequence at Site 36SQ17

Figure 7 is a synthetic profile establishing landform and subsurface relations at 36SQ17. The landform relations have been extensively revised from initial interpretations for the site (Pan Cultural Associates 1998). Summarily, the T-0 is considered to occupy surfaces at ca. 263 m and are underlain by fills demonstrated to date to the historic period.

The T-1 surface is within an elevational belt of 265-267 m and is demonstrably the landform of prehistoric sensitivity. There is radiometric, soil, and depositional (formally lithostratigraphic) evidence confirming that the T-1 emerged following the stabilization of a braided to meandering stream with meta-stable surfaces sometime during the Early Holocene (ca. 10,000 B.P.). As the braided stream geometry gave way to a meandering stream pattern, the earliest occupations took place. These are preserved in thin soils overlying the parent sands of ASU-I. The prehistoric evidence of a preserved horizon is unequivocal, even though the age of the occupation is more problematic. Placing it in the Middle Archaic is consistent with the range of the radiocarbon determinations, the lithic inventory (undiagnostic as it is) and more regional evidence suggestive of recurrent Early to Middle Archaic habitations preserved along select reaches of Pennsylvania’s trunk streams (i.e. the Delaware, Susquehanna, and Ohio) and within coarser grained sediments accumulated 1-2 m above terminal Pleistocene gravel beds.

ASU II preserves thin overbank deposits and a critical soil of the lower Middle Holocene. The soil and sediment packages date to the interval 7500-6000 B.P. This would appear to have been a period of relative floodplain stasis and environmental stability. Prehistoric information is lacking. The dearth of archeological material may be due either to the thinness of the accumulation or, more possibly, to the initiation of the subsequent cycle of high frequency flooding that may have eroded the shallow accumulation of ASU II sediments.

ASU III represents renewed alluviation on the T-1 as depicted in the central portion of the sequence on the T-1 (Mid Holocene flood sands). The upward-fining sequence terminates around 5000-4000 B.P. where an extensive soil—the 2Ab—registers the most pervasive archeological horizons in the sequence. This soil may have endured over 2000 years and would have spanned the Late Archaic through Woodland periods. Several variants have been identified at several segments of the project area, both within and beyond the block excavation. Occupation would have occurred at the end of the aggradation cycle, when flood discharge frequencies and volumes waned.
Finally ASU IV witnessed renewed high level flooding as well as increased sedimentation through colluvial activity and accelerated soil erosion in the surrounding terrain. Slope stripping during the historic period coupled with high runoff and deforestation, perhaps on a regional scale accounts for higher sand sedimentation at the base of the unit that continues up the sequence.

The present study suggests that the T-2 represents the lowest level of the Pleistocene aggradational terrace sequence. This is most accurately considered a Valley Heads surface, although, as noted earlier it may represent the local morpho-stratigraphic variant of terminal Pleistocene outwash deposition. The T-1 would be the earliest manifestation of the early Holocene landform, regionally referred to as the Port Huron terrace. Alternatively, the Port Huron may also have been formed from sedimentation by tributaries and slope wash as well as flooding by the trunk stream.
Comparisons with Stratified Site 36SQ111

The landform chronology and stratigraphy at the Great Bend site (36SQ17) invites comparisons with the sequence at the recently investigated prehistoric site of 36SQ111, one quarter of a mile to the north (Schuldenrein 2002). That location underscored the problems of correlating land surfaces and dateable terraces because of the creation of artificial landscapes associated with industrial development along the banks and terraces of the Susquehanna. Site 36SQ17 would appear to facilitate correlation by linking T-0 and T-1 topographies northward, but the Great Bend excavations also verified that the uppermost land surface is covered by variable depths of historic fill. 36SQ17 established that surface to be a second terrace (T-2; elevation 268 m.) (Schuldenrein et al. 2000). Supportive evidence consisted of the Phase I work showing the depth of fill underneath the McDonald’s restaurant (Pan Cultural Associates 1998) as well as landform topographies formally mapped in advance of the present investigations. It is therefore instructive to link the terrace morphologies and the detailed observations at both 36SQ17 and 36SQ111 using that elevation and landform as a baseline. Collectively, the two sequences have critical implications for synthesizing regional landform, stratigraphic, and archeological relationships.

Figure 8 and Table 2 establish correlations between the two sites, accounting, as much as possible, for the massive realignments to landforms by re-landscaping. Reconstructions must begin by examining the “pre-fill” sequences and comparing the deposits across equivalent landforms in Figure 8. It is noted that for 36SQ111 the T-1a and T-1b were established to offset the 2-3 ft. difference in elevation between the proximal and distal segments of the first terrace flanking a former abandoned (or overflow) channel of the Susquehanna River. Current topographic differences between the two landforms is a function of historic filling associated with road improvements (at T-1b) and modifications to the lowlying wetlands (T-1a). Based on “pre-industrial” landform configurations, the T-1b is typically 2-3 ft. higher than the T-1a but is continuous across the landform extending from the river’s edge (at Great Bend) to the uplands at 36SQ111.

Thus, on a regional scale, the central landform for developing chrono-stratigraphies is the distal segment of the first terrace, the T-1b. This is the intact Port Huron surface at 36SQ17. At that site 4-5 ft. thick historic archeological deposits cap the prehistoric (i.e. Woodland/Late Archaic) surfaces, depressing the elevation of the late Holocene T-1b to a range of 263-264 m. The depth of fill of the “upper landform” at Bart-Rich extends to 3.4 m., or an absolute elevation of 262.5 m. A date of
2640±40 B.P. (Beta-162025) was obtained near the top of the intact sequence and this is equivalent to the age range of the uppermost prehistoric deposits of the T-1b. For these reasons it is provisionally proposed that the T-1b at 36SQ17 and 36SQ111 are time-equivalent surfaces of the late prehistoric Port Huron terrace.

The T-1a represents the proximal portion of the Port Huron terrace. It is only preserved at 36SQ111 where, as noted, it is on the order of 1 m lower in elevation than the T-1b. Locally, the T-1a may be considered a separate and distinct landform from the T-1b on stratigraphic grounds; the former preserved a well formed Cambic profile, while the latter did not contain a weathering sequence. The determination of 4030±40 B.P. (Beta-162027) obtained from the upper portion of the B-horizon on T-1a, is consistent with dates from the T-1b at 36SQ17, suggesting penecontemporaneity with that landform as well. The preservation of analogous archeological components—Woodland and Late Archaic—bolsters the case for equivalence between the T-1 landscapes across both sites. Again, however, at 36SQ111 the site's lower position on the landscape argues for a separate morpho-stratigraphic designation.

There remains some uncertainty about the regional significance of the T-2 at 36SQ17. As noted earlier, fills capping that surface grade downward to the north in the vicinity of the “upper landform” at 36SQ111. There remains the possibility that the T-1b here may merge with the T-2, especially given that dense concentrations of outwash gravels form the “upper fill” capping the landform; these would probably have come from a local source before being mobilized during regrading activities. This scenario is partially refuted by the radiocarbon determination of 2640±40 B.P. which would then have to be considered anomalous. Only further deep testing across the extensive “upper landform” can resolve this question.

Finally, Figure 8 underscores the dominance of the T-1 (“a” and “b”), and the Port Huron surface generally, across the project area. The terrace’s extensive distribution reflects classic point bar migration as the channel geometry of the Holocene Susquehanna River migrated steadily southward, creating a series of aquatic and widely differentiated eco-tones and subsistence environments in the back channel areas of the evolving Susquehanna Valley. This particular portion of the river was extremely attractive to prehistoric peoples since at least Early Holocene times. Subdivisions of the T-1 notwithstanding, chrono-stratigraphic, pedogenic, and archeological relations converge around the significance of the T-1 as an indicator for prehistoric site preservation.
In sum, the T-1 occupies a specific geomorphic position within the Susquehanna River valley. At Great Bend, both an upper Pleistocene outwash terrace (T-2) and an active floodplain (T-0) are present as well (Figure 8). Hence the relative age of T-1 is immediately obvious from a schematic showing the valley cross-section. To date, site 36SQ111 provides the only comparative geoarcheological context. It presents a situation fairly typical of distal T-1 settings within the valley. Only additional field and laboratory analysis will facilitate differentiation between T-1 “a” and “b” sequences, both of which have significant archeological sensitivity.
Conclusion

The objectives of the geoarchaeological effort at 36SQ17 were to develop a baseline sequence for human occupation and floodplain development for the Upper Susquehanna drainage. The following key points emerged from the study:

1. Site 36SQ17 preserved continuous evidence of varied and complex floodplain sedimentation spanning over 11,000 years to a depth of 4.5 m. The alluvial sequence is interdigitated with two discrete sets of prehistoric deposits, one at the base of the sequence (depth 4.0 m) and a second within the upper portion of the succession (depth 1.0-1.8 m). The upper portion of the sequence is mantled by various contributions of slopewash, historic debris, and sub-recent alluvium.

2. The only landform containing the evidence for the linked alluvial-prehistoric sequences has been reclassified a first-terrace (T-1). That designation supercedes its earlier classification as the active floodplain surface (T-0).

3. A total of thirty (30) stratigraphic bodies were recognized in the course of the investigation. To systematize observations, an “allostratigraphic sequence” was overlaid on the composite T-1 sequence. The advantage of this type of sequence for archeology is that it recognizes the contemporaneity of different types of stratigraphic components—artifacts, soils, sediments—as the ordering principle for vertical succession. Four allostratigraphic units accommodated all deposits recognized in the succession. These are (bottom to top):

- ASU-I laterally accreted sandy alluvium with shallow soils (11,000-8000 B.P.)
- ASU-II overbank alluvium and well developed soil horizon (7500-6000 B.P.)
- ASU III Late Archaic to Woodland deposits overlying/interdigited with early historic fill; prehistoric sediments articulate with renewed high energy accretion deposits (6000 B.P-1000 B.P.)
- ASU IV historic debris, slopewash and high discharge alluvium (<1900 AD)
4. Evidence for prehistoric activity is preserved in two separate contexts: first, a discrete occupation horizon within a meta-stable surface of the active Early-Middle Holocene floodplain dated to ca. 8500 B.P. (ASU-I); second a more diffuse series of disparate features concentrated between 4000-2000 B.P. at depths of 1.3-1.8 m.

5. The alluvial history and soil formation chronology of the T-1 is characterized as follows:
   • Braiding, point bar deposition and lateral migration of post-glacial channel (11,000-8000 B.P.);
   • Overbanking and stabilization of the Early and Middle Holocene channel, long-term environmental stability (Bt soil profile) and emergence of the T-1 landform (8000-6000 B.P.);
   • Renewed high energy discharge and frequent flooding of the T-1; short term soil forming intervals (3Bw) (5500-4000 B.P.)
   • Lower energy pulses of sandy discharge with limited soil formation (sequence of AB-BC profiles) (4000-1000 B.P.
   • Slopewash, episodic flooding, and historic landscape modification (1000 B.P.-present)

6. The T-1 at 36Sq17 is correlated with a similar landform at prehistoric site 36Sq111. Both preserve Late Archaic and Woodland features within the upper 1.5 m of alluvial sediment; the signature soil is either a Cambic (Bw) or BC horizon

7. The T-1 is a complex landform containing a T-1a (proximal) and T-1b (distal) segment; these are separated by <1 m of relief and are not always differentiated. The T-1b has been tentatively correlated with the regional Port Huron Terrace, the initial Holocene terrace landform for the Susquehanna Valley.

8. Preliminary indications are that archeological deposits of at least Middle Archaic age can be expected at depths of 3-5 m bmsl for T-1 surfaces of the upper Susquehanna.
9. More commonly, laterally to vertically stratified occupations of Late Archaic to Late Woodland age are likely to be encountered within the upper 1.5 m of undisturbed T-1 terrace fill. This is a signature archeo-stratigraphic context for the Upper Susquehanna Valley.

10. Additional geoarcheological investigations are critical to determine the upstream to downstream extents of these linked depositional, pedogenic, and archeological packages.
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