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Alluvial stratigraphy of the Potomac River valley bottom near Petersburg and Moorefield, West Virginia

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Introduction

This report presents data and interpretations of stratigraphic investigations of valley-bottom alluvium at two sites along the South Branch Potomac River near Moorefield and Petersburg, W. Va. (fig. 1). These investigations were undertaken in cooperation with the Interstate Commission on the Potomac River Basin (ICPRB) and U.S. Army Corps of Engineers (CE).

Scope of the study

The alluvial stratigraphy of the Petersburg and Moorefield areas was investigated to provide a stratigraphic framework for subsequent archeological studies along proposed levee alignments, and to complement on-going Quaternary stratigraphic studies by the U. S. Geological Survey. The main stratigraphic questions addressed in this study are:

1) Do valley-bottom alluvial strata and alluvial terraces indicate paleoclimatically induced periods of aggradation or incision during the Quaternary?

2) Are deposits and erosional features similar to those produced by the large flood of November 1985 (Clark and others, 1987; Miller, 1987; McKoy, 1988) present in the valley-bottom stratigraphy? Do ages of such features indicate how often very large floods occur?

3) What does the distribution of valley-bottom sediment facies indicate about the processes of flood plain formation in high-energy, high-gradient environments like that of the South Branch Potomac River. Are valley bottoms formed dominantly by processes of rare, high-magnitude floods or do floods of lesser magnitude play an important role?

The stratigraphic framework presented here can be used to help archeological investigations by showing relative ages of deposits, depositional environments, thicknesses and depths of overbank sediments where cultural materials may be preserved, areas of repeated scour and erosion, and areas of incremental deposition where buried soils are likely to be preserved.

The geomorphic effects of an extremely large flood that affected the area in November 1985 can be used as models for some of the features found in the flood-plain strata. Descriptions and analyses of the geomorphic effects of the 1985 flood are based on personal observations directly following the flood, analysis and mapping of flood effects from air photos of the Petersburg and Moorefield areas taken immediately after the flood (plates 1, 2), and published and unpublished data including Clark and others (1987), Kite and Linton (in prep), Jacobson and others (in press), Miller (1987), McKoy (1988), and Scatena (1986).

Investigation of valley-bottom strata at Moorefield and Petersburg proceeded in three phases. The first phase consisted of inspection, description, and sampling of cut-bank exposures. Unfortunately, channel reconstruction activities following the 1985 flood had destroyed most cutbank exposures. Three locations, two at Moorefield and one at Petersburg, were chosen for detailed analysis and sampling because radiocarbon datable material was present at these sites (figs. 2, 3, 4, 5). Radiocarbon dates from these sites are reported here along with detailed soil profile descriptions. Laboratory analyses of the three soil profiles will be reported in a subsequent publication.

The second phase of investigation consisted of logging and interpretation of 30 US Army Corps of Engineers preliminary test borings (plates 3-14, figs. 6, 7). During test drilling in April and May, 1988, boreholes were logged by an experienced surficial geologist in addition to the CE drill inspector. These data are incorporated in this report.

The third phase of investigation consisted of drilling 53 additional shallow bore holes (figs. 8, 9) with a truck-mounted auger. These holes were planned to fill gaps in the CE coverage, to construct systematic cross sections, and to

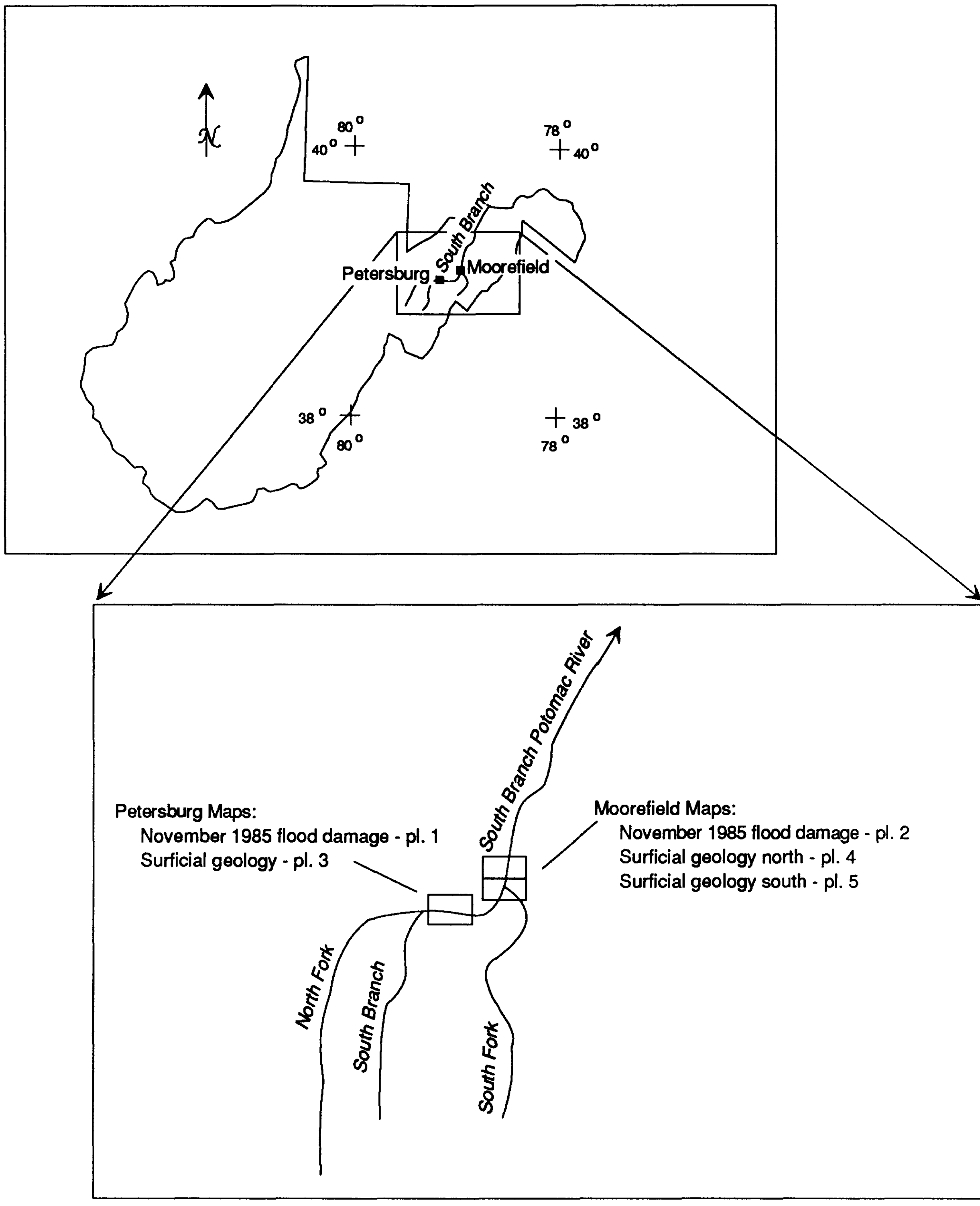

Figure 1. Location of Petersburg and Moorefield Study areas.

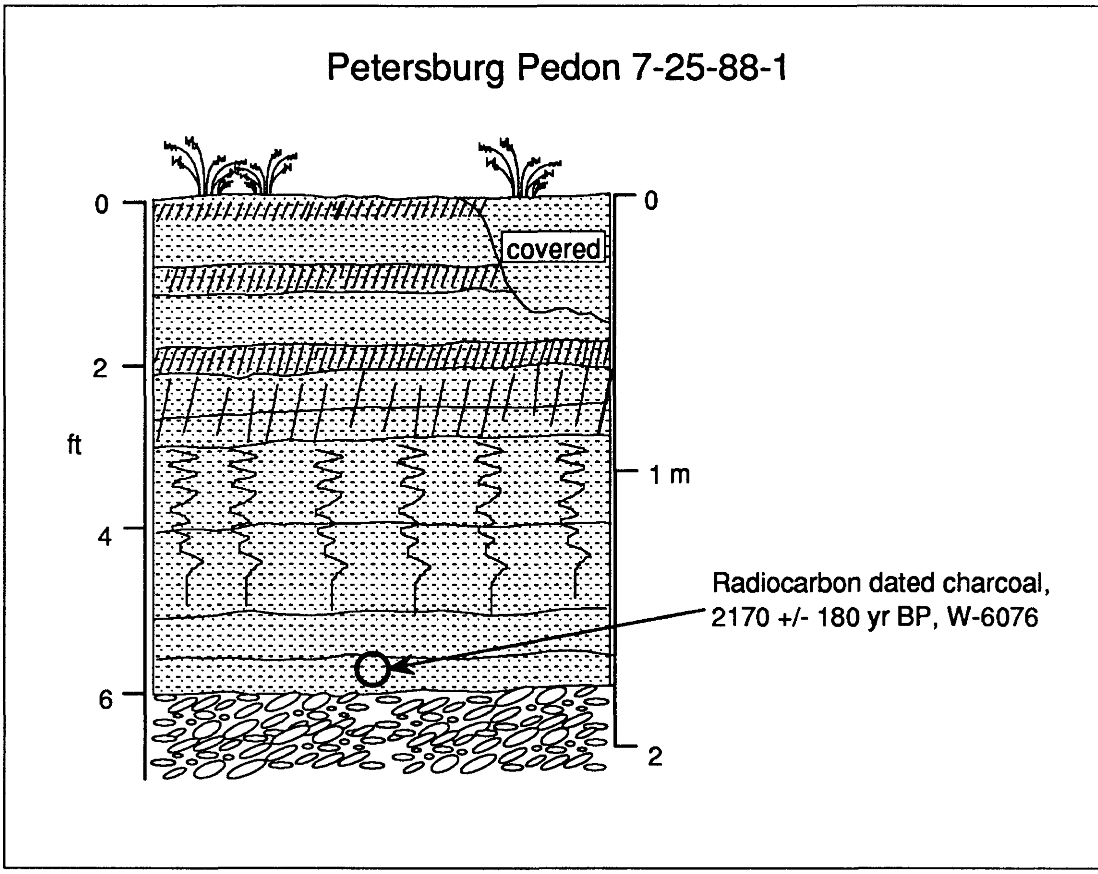

Figure 2. Pedon 7-25-88-1 at Petersburg, W. Va. and radiocarbon date location

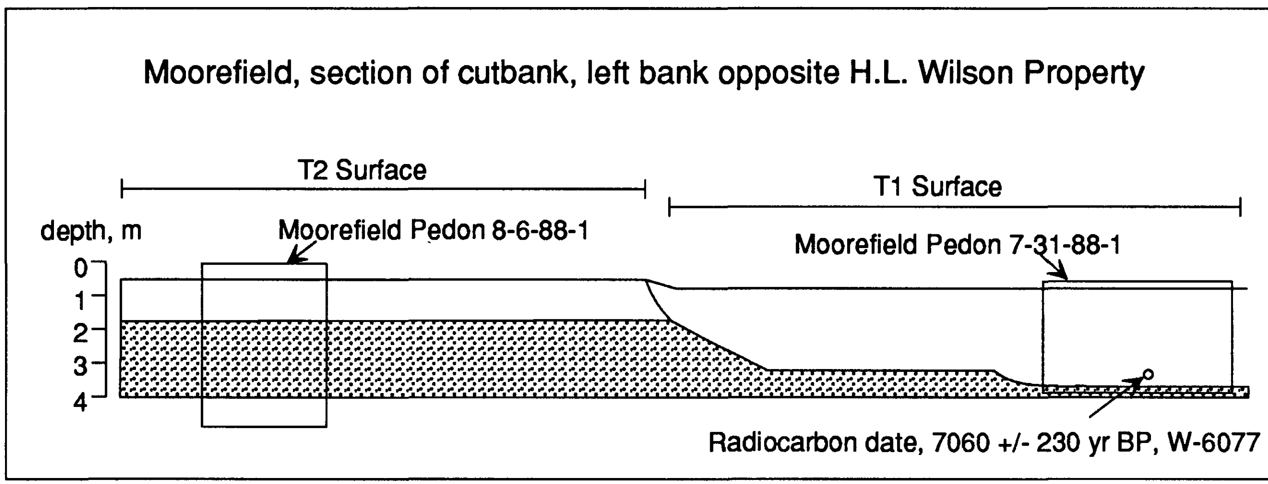

Figure 3. Sampled pedons and radiocarbon date location, Moorefield, W. Va.

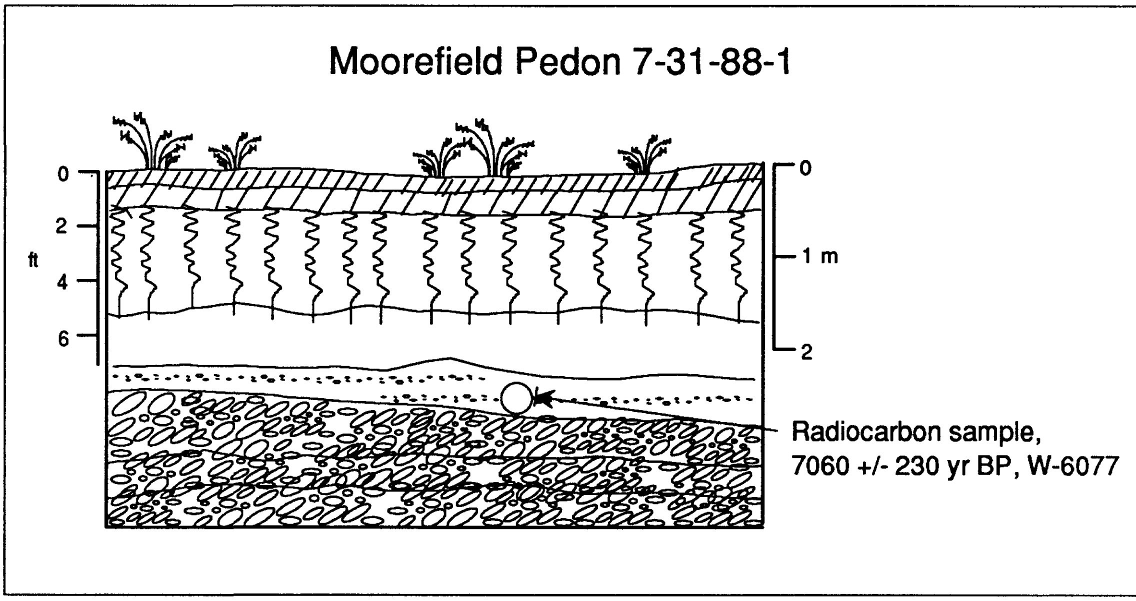

Figure 4. Pedon 7-31-88-1 at Moorefield, W. Va. and radiocarbon sample location.

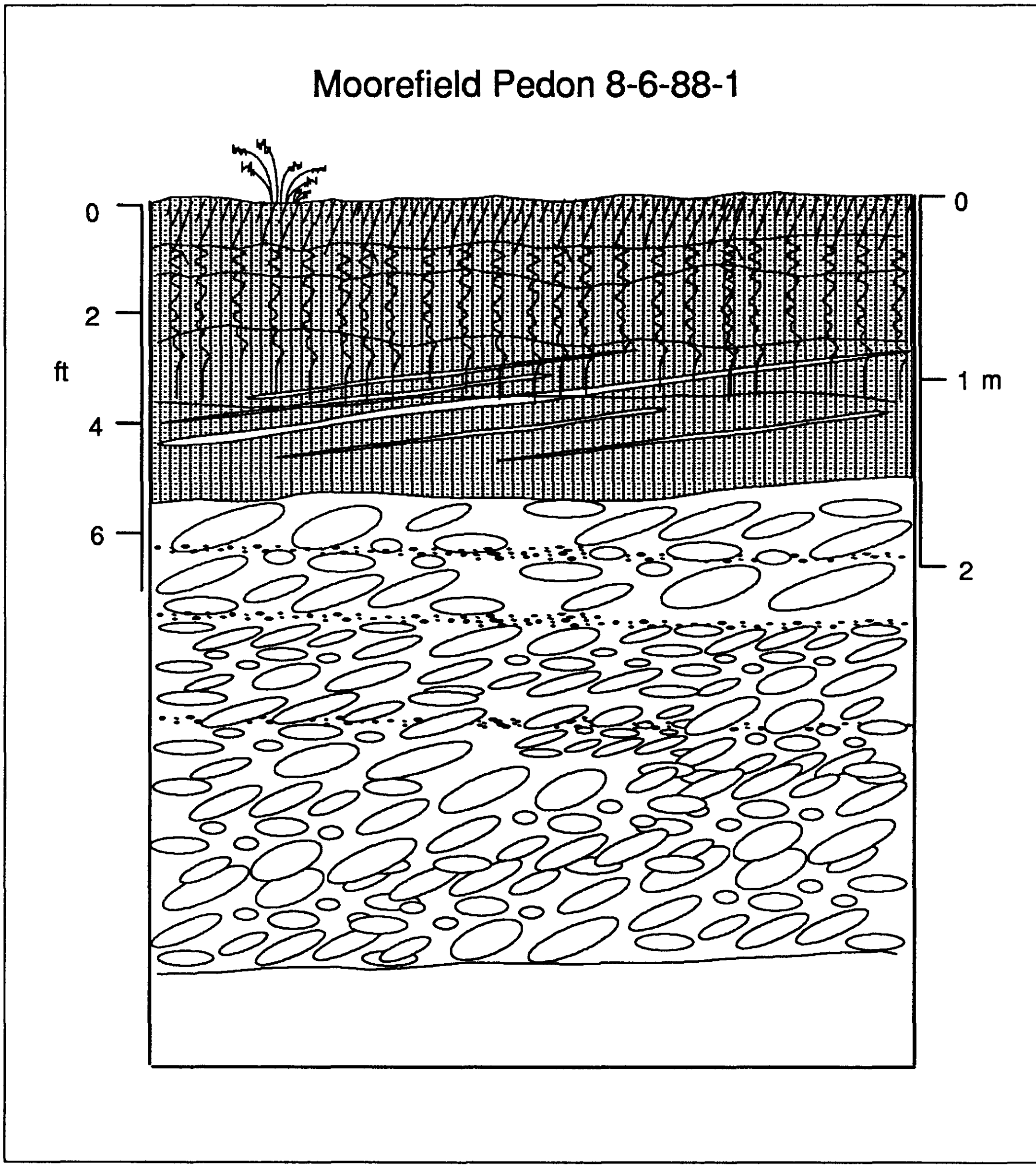

Figure 5. Pedon 8-6-88-1 at Moorefield, W. Va.

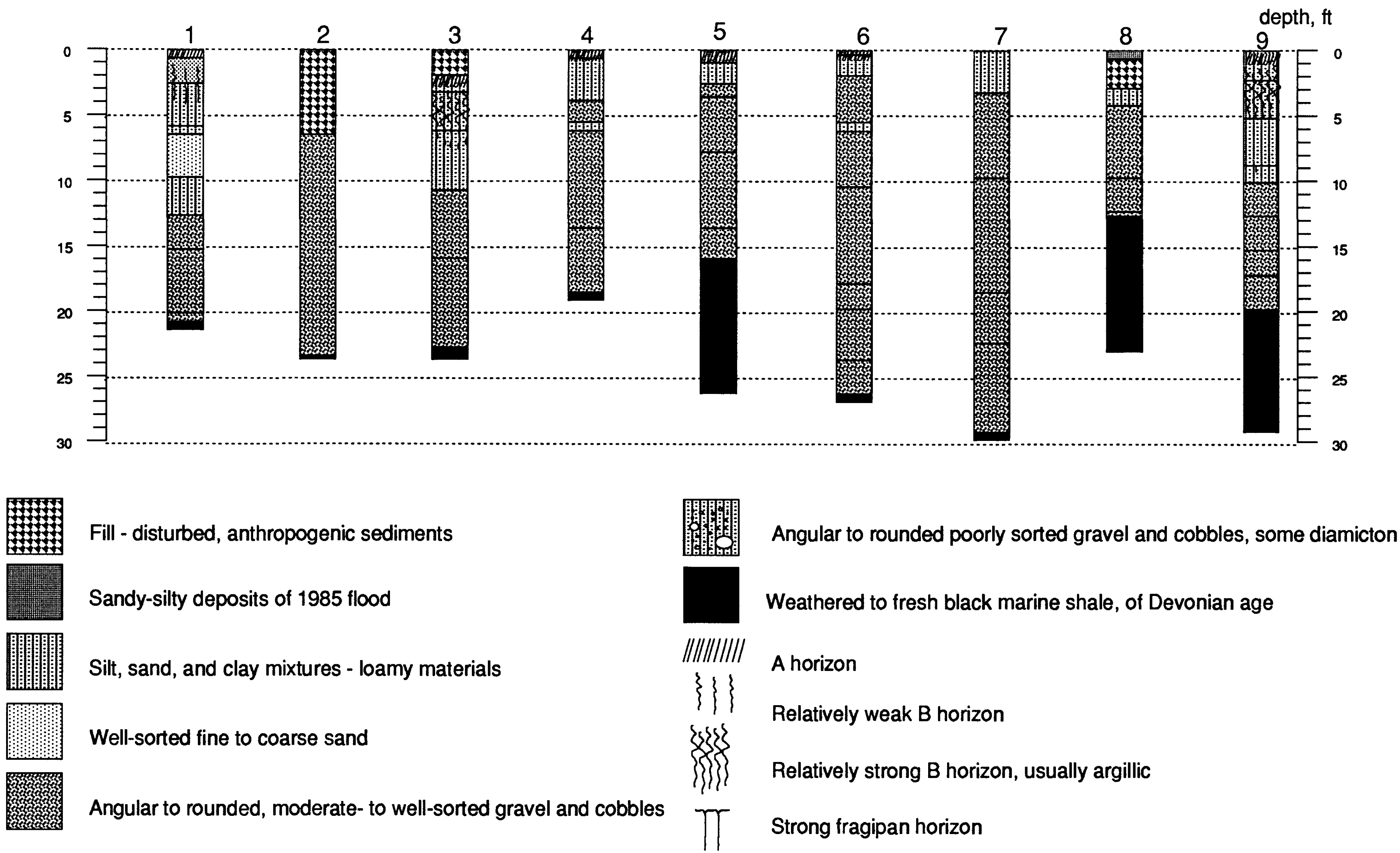

Figure 6. Graphic logs of US Army Corps of Engineer test drillholes, Petersburg, W. Va.

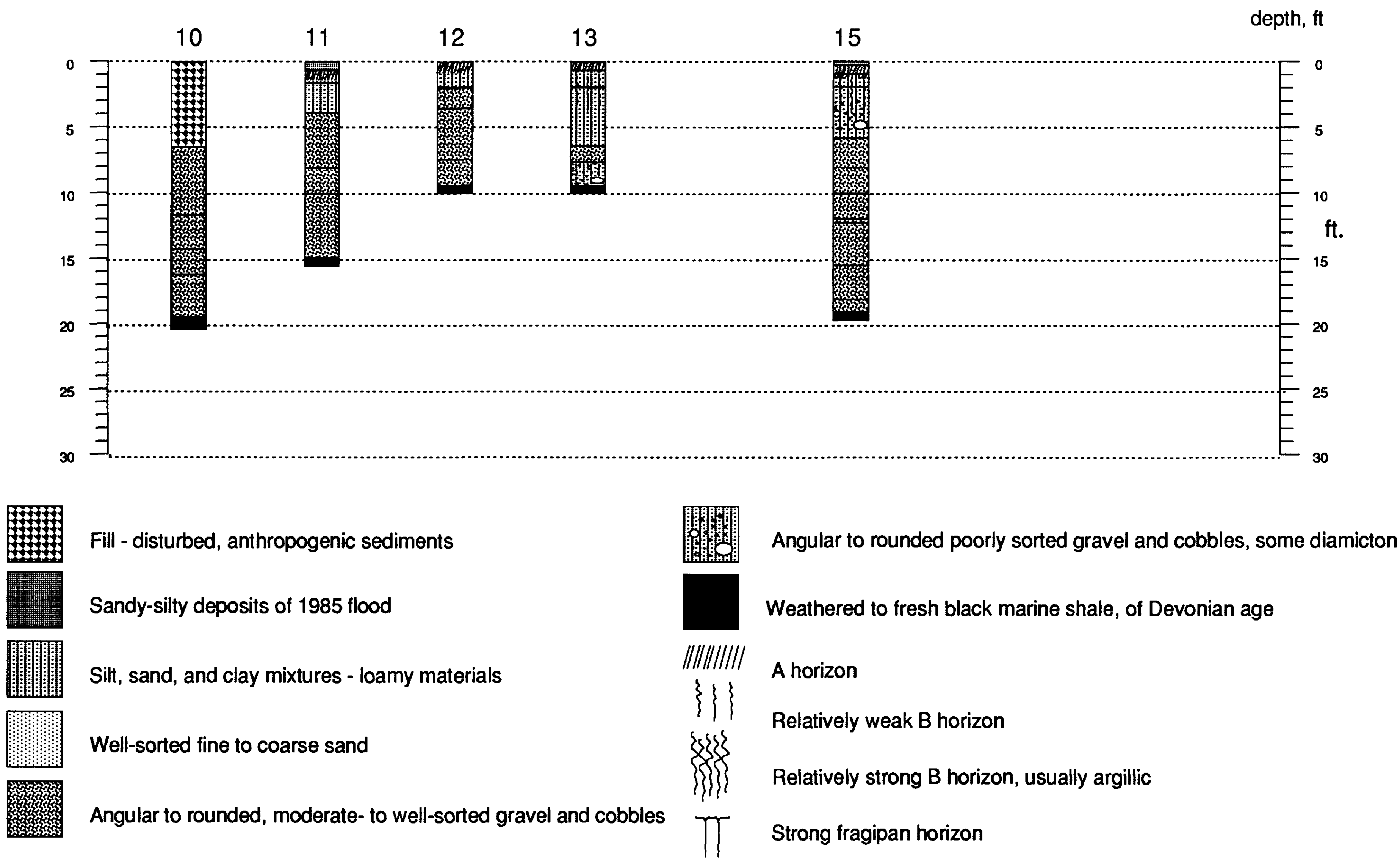

Figure 6 (cont.). Graphic logs of US Army Corps of Engineer test drillholes, Petersburg, W. Va.

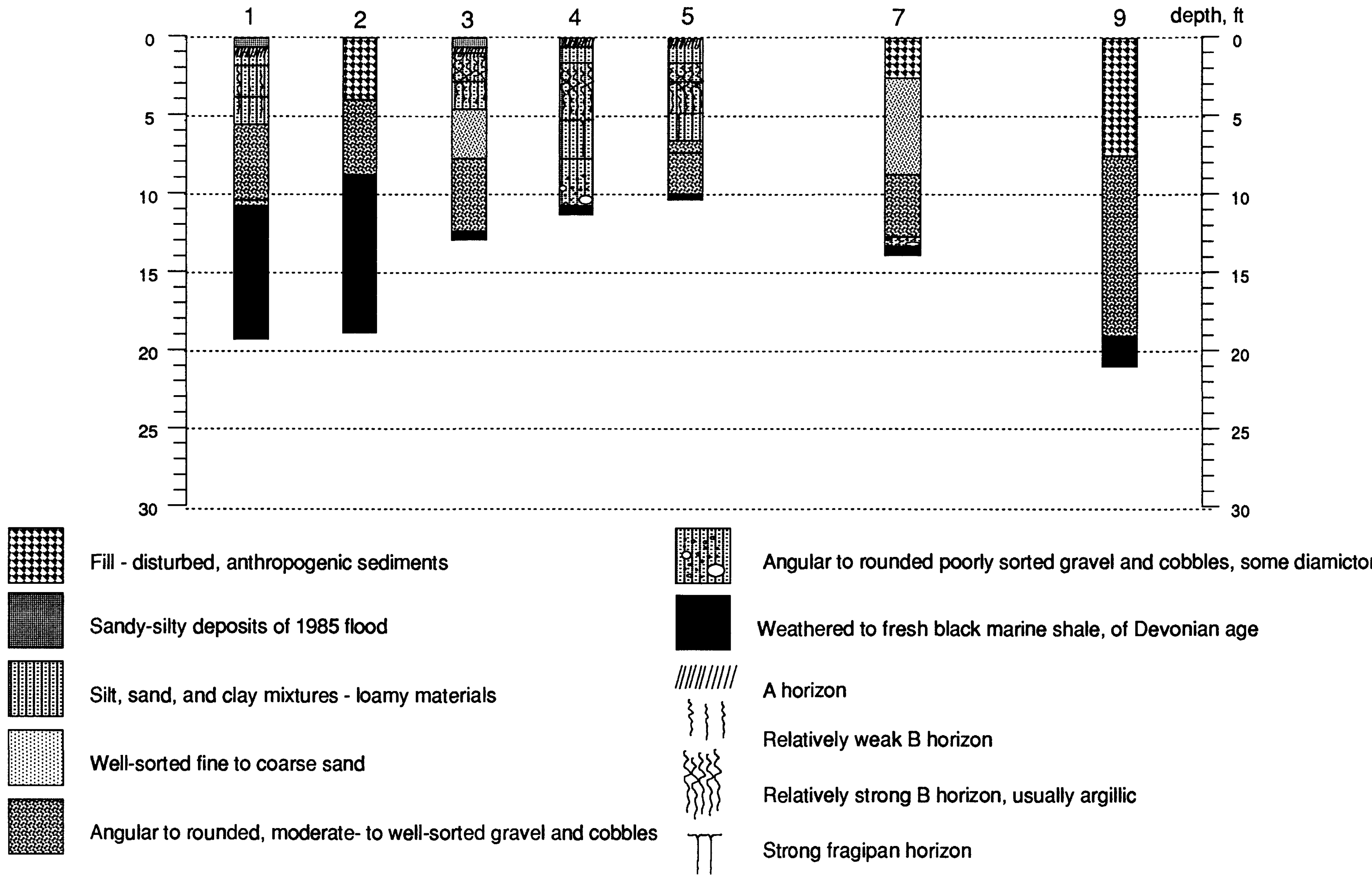

Figure 7. Graphic logs of US Army Corps of Engineer test drillholes, Moorefield, W. Va.

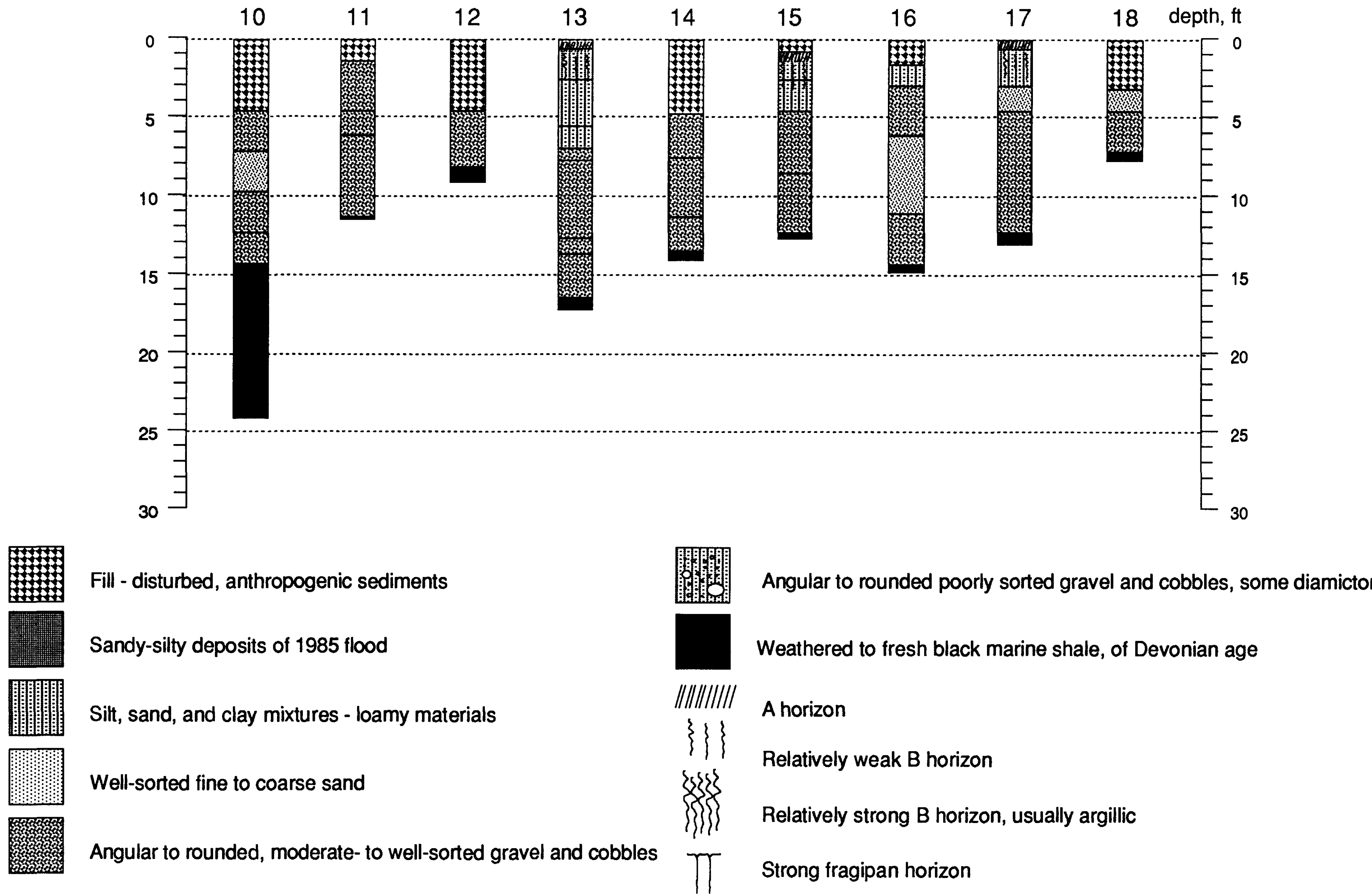

Figure 7 (cont.). Graphic logs of US Army Corps of Engineer test drillholes, Moorefield, W. Va.

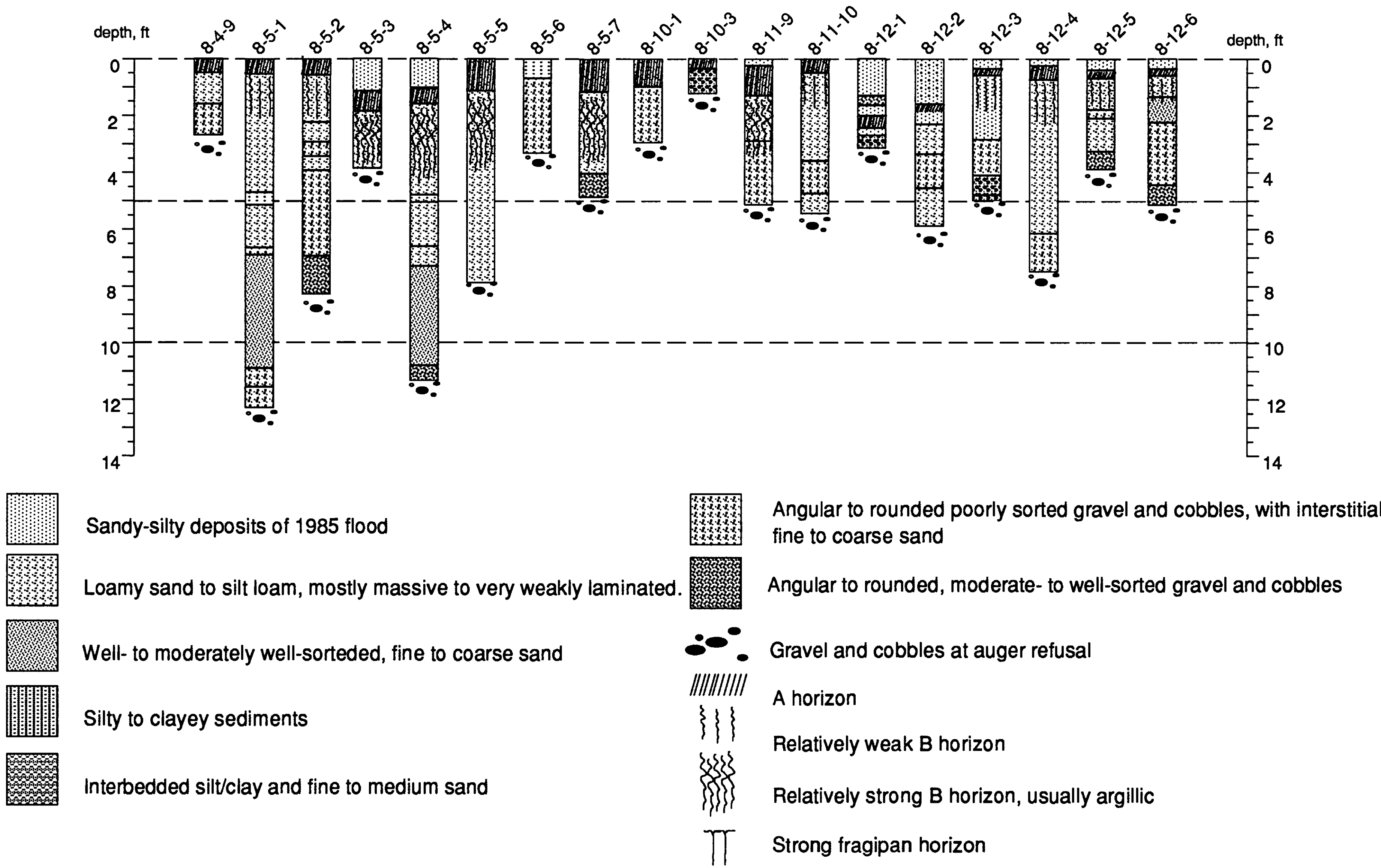

Figure 8. Graphic logs for USGS test drillholes at Petersburg, W. Va.

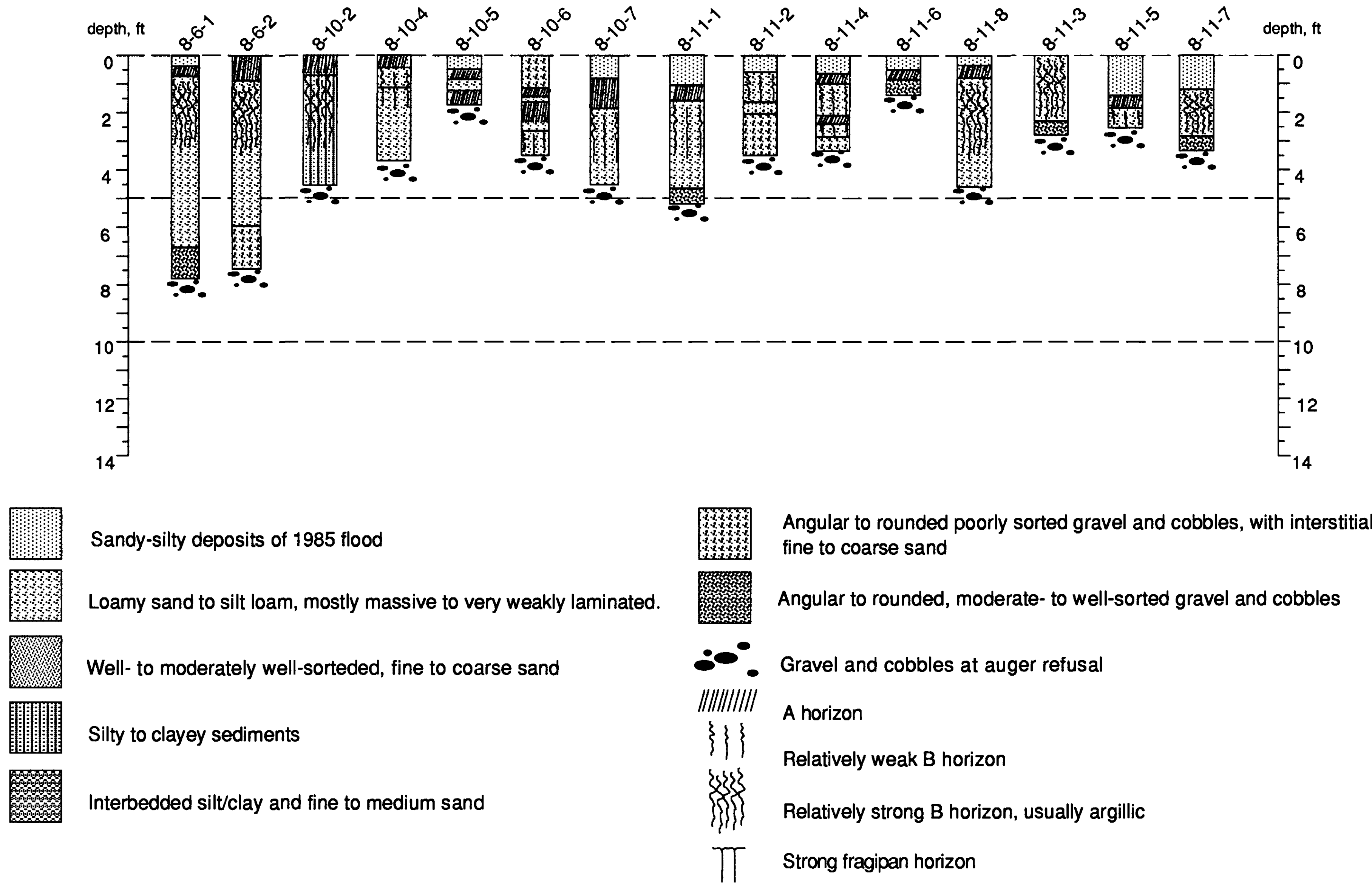

Figure 8 (cont.). Graphic logs for USGS test drillholes at Petersburg, W. Va.

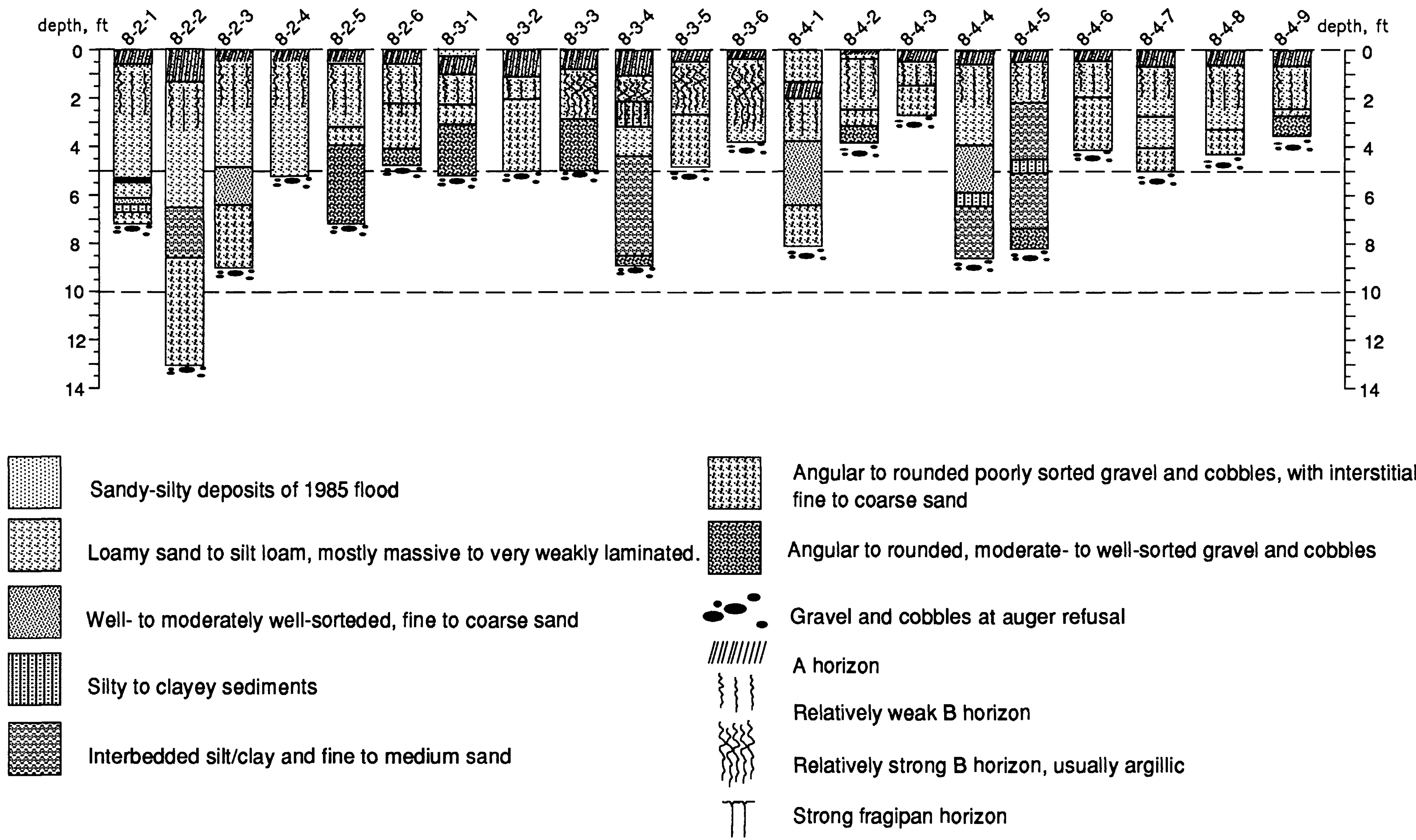

Figure 9. Graphic logs of USGS test drillholes at Moorefield, W. Va.

log and sample units for relative age determinations. The drill unit used was incapable of penetrating gravel more than approximately 1 m. Some of the borings were sampled by hydraulically driven split spoon but most were drilled and sampled with solid-stem flight augers due to the excessively dry and hard conditions of the soils during the testing period in mid-August, 1988.

These data are summarized in surficial geologic maps compiled on 2-foot contour interval topographic maps provided by the CE (plates 3-5), and on cross-section transects (plates 6-14). The cross-section transects combine topographic profiles compiled from the CE topographic maps, CE drill holes, USGS drill holes, and surveyed cross sections along selected USGS transects.

Effects of the 1985 flood

The flood of November 3-6, 1985 caused extensive erosion and deposition in both Petersburg and Moorefield (plates 1, 2). The most striking geomorphic effects were channel widening, erosion of deep channels where water flowed across the flood plains, and deposition of levee splays and sediment lobes. These geomorphic changes were relatively minor compared to more dramatic examples upstream in the Potomac drainage (Scatena, 1986; McKoy, 1988; Miller, 1987), but the patterns and processes were similar enough to draw on the conclusions of these other studies in developing a general model of the effects of rare floods.

Most flood-plain erosion caused by the 1985 flood involved widening of the stream channel by lateral erosion of fine sediments (fine gravel, sand, silt, and clay) overlying a coarse cobble and gravel layer. In some cases, portions of the coarse cobble/gravel layer were mobilized as well. In particular, erosive forces were capable of moving coarse cobbles in areas of scour around flood-plain obstructions, in chutes cutting across flood plains, and in areas of constricted and expanding flows (Miller, 1987). Widening was particularly severe on outsides of bends and downstream of channel expansions. Miller (1987) used the broad flood-plain area just downstream of the canyon section upstream of Petersburg as an example of extreme widening caused by movement of high-velocity discharge from a constricted reach into a broad flood plain with erodable sediments. In addition to widespread scour, flow emerging from the canyon jumped out of its banks and proceeded directly down-valley along Johnson Run, thereby localizing damage in the southern part of Petersburg.

In several places, channelized flow across flood plains was sufficient to erode deep, linear channels. More of these features (mapped as scours in plates 1, 2) were present in Petersburg than in Moorefield, and most of the scours in Petersburg occurred along Johnson Run. In most cases, some or all of the sediment eroded from the scours was redeposited in lobes at the downstream ends of the scours. Some scours clearly initiated in areas of flow around trees or other obstructions in the flood plain that caused turbulence and/or locally increased flow velocities. Drillhole data indicate that some of the scours were partially refilled with fresh flood sediment.

Maps of deposition caused by the flood are slightly biased by the methods used. On the black and white, low-altitude aerial photographs used to compile plates 1 and 2, sand and coarser sediments were easily identified by their high reflectivity. Finer sediments in the clay and silt ranges were not mappable because a) deposits were thin, b) the sediments tended to be dark and similar in reflectivity to pre-existing soils (especially because all were wet), and c) low areas where finer sediments were deposited were still ponded when the photos were taken. Subsequent test drilling has shown that even in ponded areas, however, most of the sediment deposited during the 1985 event was in the fine- to coarse-sand range. Importantly, no extensive deposits of finer clay and silt sediments were identified. Current velocities over almost the entire flood-plain surface of the study areas were therefore relatively high. Observations of subsequent sedimentation from seasonal high water in other parts of the South Branch basin indicate that floods of lesser magnitude than the 1985 flood have redeposited fine-medium sand-, silt-and clay-size sediments in areas where similar fine sediments were stripped by the 1985 flow.

Deposition during the 1985 flood was localized in four general types of areas: flow-separation zones downstream from flood-plain obstructions, levees and splays, lobes dowstream from scours, and ponded-water areas in pre-existing flood-plain depressions (McKoy, 1988; Miller, 1987; Miller, in press). Depositional areas in flow-separation zones downstream of fences and buildings were very common in Petersburg (plate 1). Mappable levee and splay sedimentation was less prevalent in Moorefield than in Petersburg. Both Moorefield and Petersburg experienced sedimentation in forested channel-margin areas where flow velocities slowed from increased flow resistance.

Types and distribution of sediments

Results of test drilling show that most of the flood plain is composed of a predictable sequence of fine sediments (clay to medium sand mixtures) over coarse sediments (coarse sand to cobbles). Fine sediments were usually less than 8 feet (2.75 m) thick. Coarse sediments (measured only in CE test holes) ranged from less than 5 ft (1.5 m) to over 25 ft (7.1 m). In some holes the transition from coarse cobbles to fine sediment is very abrupt, occurring over several cm, and in other holes the sequence changes upward gradually from cobbles to gravel to sandy gravel to interbedded sand and silt to loamy fine sand or silt.

The general fining-upward sequence is modified in places where fine to coarse sand deposited from the 1985 flood overlies pre-existing sediments. These sites are usually levees, splays that cut levees, lobes downstream of scours, and some channel areas. Some buried channel fills also have interbedded fine and coarse sediment.

Weathering of sediments (pedogenic development) varied from barely detectable A-and B-horizon structure to thick, heavily weathered argillic and fragipan horizons. Within the scope of this study, it was possible to discern four general stages of weathering based on pedogenic development. The youngest are sediments deposited during the 1985 flood. These have no pedogenic development and, except where disturbed by human activity, they usually retain primary sedimentary structures. The T0 surface was mapped where sediments with this degree of pedogenesis occur at the surface (plates 3-5).

The next older unit is composed of loamy and silty sediments that have accumulated recognizable amounts of organic carbon in their A horizons. These soils have B horizons characterized by incipient development of pedogenic structure; many have massive B horizons in which all primary sedimentary structures have been obliterated. No absolute ages are available for deposits with this degree of soil structure; however, they are inset against, and demonstrably younger than, soils associated with radiocarbon dates of 2170 +/- 180 yr BP (W-6076) and 7060 +/- 230 yr BP (W-6077). These are included in the T0 surface.

Soils with cambic B horizons (incipient reddening, weak to moderate structural development, but lacking definite clay accumulations) occur at the surface over much of the valley bottoms at both sites. This type of soil has developed on deposits that have two basal radiocarbon dates of 2170 +/- 180 yr BP (W-6076) and 7060 +/- 230 yr BP (W-6077), suggesting that soil development on this unit has occurred over (variable) time intervals since the middle to late Holocene. These soils are described in greater detail in the following section. Surfaces underlain dominantly by soils with this degree of pedogenesis are mapped as T1 on plates 3-5.

The oldest soils in the valley bottom have reddened (7.5YR4/4-5/6), argillic B horizons. Sediments underlying the T1 surface are entrenched into and inset laterally against these soils. Qualitative comparison with regional soil chronosequences suggests that they have been weathering since the late Wisconsin to early Holocene (approximately 9000-12,500 yr BP) with little additional sediment aggradation. Surfaces underlain by soils with this amount of pedogenesis are mapped as T2 on plates 3-5.

At Petersburg, CE hole #9 was completed in an even older terrace unit. Weathering features of this soil include a thick, red (5YR5/4-2.5YR5/4) argillic horizon and a well-developed fragipan. Qualitative comparison of this soil with regional chronosequences suggests a pre-late-Wisconsin age. Terrace surfaces with at least this degree of soil formation are mapped as T3, T4, and T5 on plates 3-5.

Sediments underlying each terrace surface are composed of a complex of strata formed by a series of flood events. Evidence of individual events would only be resolved with very detailed trench investigations that were beyond the scope of this study. The terrace surfaces identified and mapped in this report a second order of organization of alluvial strata. Episodic deposition of alluvial terraces is probably indicative of major changes in sediment supply and discharge over timescales of thousands of years. Successively higher numbers in terrace surface designations indicate relatively more-weathered sediments at successively higher elevations at each site. Surfaces T0-T2 are probably time-correlative between Moorefield and Petersburg within the broad age constraints given. Surfaces T3-T5 have not been traced between the two sites and correlations have not been attempted. Regional correlations of terrace units will require future work with emphasis on more relative and absolute dating of alluvial strata.

Cutbank sections

Two cutbank sections, one at Moorefield and one at Petersburg, provided good exposure of sediments underlying the T2 and T1 surfaces (figs. 2-5). At Petersburg (Pedon 7-25-88-1, fig. 2, plate 3), the cutbank exposes three sandy levee deposits, each separated by buried soil profiles, overlying a thicker overbank deposit. The top two cm is fine-medium sand deposited by the 1985 flood. The next two lower sedimentary units each have inicipient A and B horizon development, but are distinctly separable. This indicates that deposition has been episodic, with time intervals between deposition of sufficient duration to allow some pedogenesis but not enough to homogenize the profiles.

In contrast, the lowest unit has a thick (36 cm) complex of Ab and AB horizons, indicative of cumulative, slow sedimentation simultaneous with pedogenesis. The base of this unit has disseminated charcoalized wood fragments that were radiocarbon was dated at 2170 +/- 180 yr BP (W-6076).

In Moorefield, a long section of cutbank extending downstream from the duck pond and sewage lagoon exposes sediments that underlie the T2 and T1 surfaces (figs. 3, 4, 5). Pedon 7-31-88-1 is at the downstream end. Only 2 cm of 1985 flood deposit overlie a cumulative Ap/AB sequence. The sediments coarsen downward gradually through fine sandy loam, to interbedded sand and silt, to sandy gravel and gravel. The B horizon has incipient reddening and clay accumulation. At the base of the sequence, a peaty black unit interbedded with sand and silt yielded charcoalized wood fragments dated at 7060 +/- 230 yr BP (W-6077) yr BP.

Just upstream from the 7-31-88-1 site, the firm to very firm, mottled BC horizon crops out in the South Branch channel and forms a local riffle. In places, gravel and cobbles have been deposited over the BC horizon.

The section of T1 sediment represented by pedon 7-31-88-1 is inset against and lower than the T2 sediments described in pedon 8-6-88-1. The T2 package has a greater proportion of gravel and cobbles than the T1 and lacks an overthickened A horizon as would be expected if deposition was simultaneous with pedogenesis. These features suggest that the T2 sediments were deposited under a hydrologic regime characterized by greater transport capacity and faster deposition than has existed during the middle to late Holocene. Coupled with the presence of a well-developed argillic horizon, these features suggest deposition during a period of significantly different climate, probably during the late Wisconsin glacial epoch or early Holocene.

Results and Conclusions

Results are summarized in cross sections and maps (figs. 10-14, plates 3-14). The maps of surficial deposits separate alluvial sediments into a) those deposited in 1985 or very recently, characterized by zero or minimal pedogenic development (T0), b) early to middle Holocene, those with weak pedogenic development and dates of 2170 +/- 180 yr BP (W-6076) to 7060 +/- 230 yr BP (W-6077) (T1), c) probable late Wisconsin, those with moderate pedogenic structure and argillic horizon development (T2), and d) pre-late-Wisconsin terrace deposits. All mapped contacts on plates 3 and 4 are approximate because of the complex stratigraphic associations of these units.

Thick deposits of middle Holocene sediments suggest one or more major aggradational sequences may have occurred during the 2170 +/- 180 yr BP (W-6076) to 7060 +/- 230 yr BP (W-6077) time interval. Other studies of alluvial stratigraphy have delineated multiple episodes of accelerated flood-plain aggradation during this time interval elsewhere in North America (for example, Brakenridge, 1984; McDowell, 1983). Without additional subsurface data and radiocarbon dates, subdivision of the T1 surface sediments and correlations of subdivisions are not possible. More stratigraphic study will be necessary before concluding that Holocene climatic episodes are represented in the alluvial stratigraphy of high-gradient Appalachian rivers like the South Branch Potomac River.

As is evident from the County, Snell, and Liggett transects (figs. 10, 11, 14), multiple scour and fill events have produced a complex sequence of strata in the valley bottoms. Infilling of elongate scours and gradual onlapping of younger sediments over older sediment surfaces produces a complex alternation of strata across the flood plain. Some of these stratigraphic contacts are reflected in surface scarps and depressions; others, especially between older sediment packages, are not reflected in the surface topography at all. Surface-recognizable elongate scours (channel-like features) often had tens of cm of 1985 fine-sandy sediments deposited in them. In some cases, the 1985 sediment was deposited over a buried A horizon, but in many cases, lack of an underlying A horizon attests to scour before deposition. These observations suggest that elongate scours may collect only transient sediments with relatively short residence times.

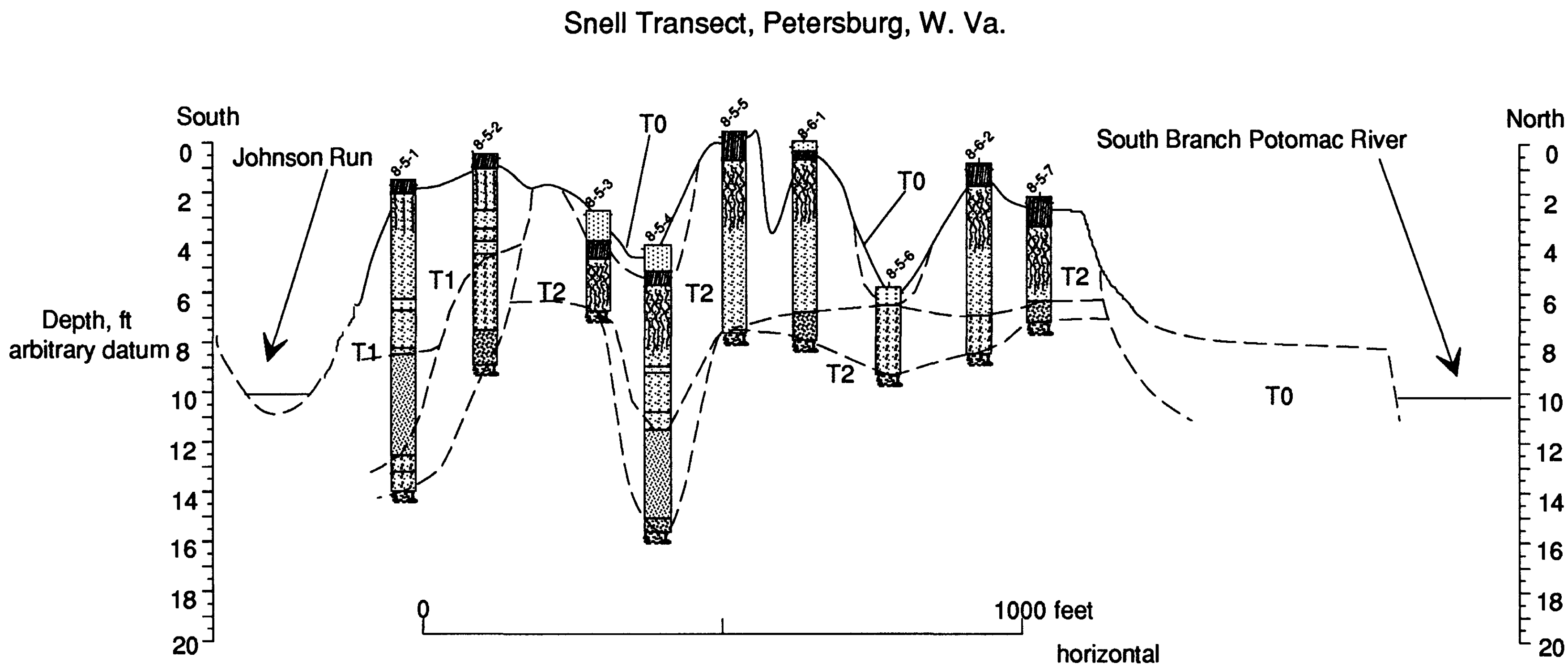

Figure 10. Cross section of drillholes on Snell property, Petersburg, W. Va. See section P1.
Symbols used are those shown in figures 8 and 9

County Transect, Petersburg, W. Va.

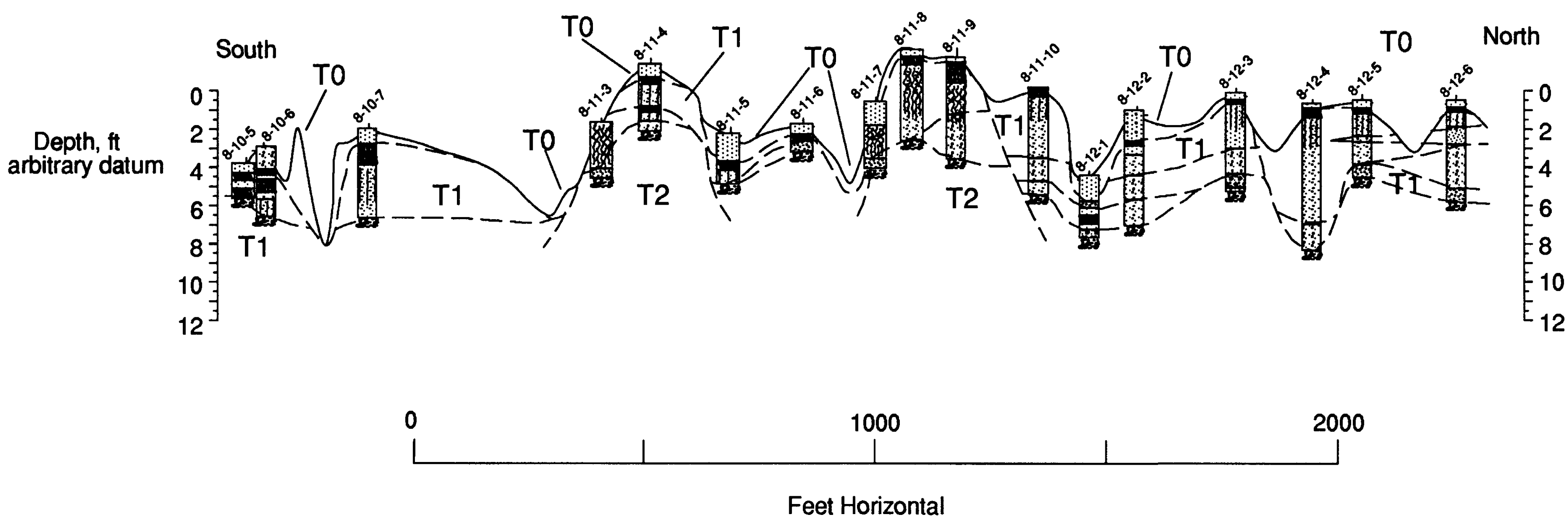

Figure 11. Cross section of drillholes on County property, Petersburg, W. Va. See section P4
Symbols used are those shown in figures 8 and 9.

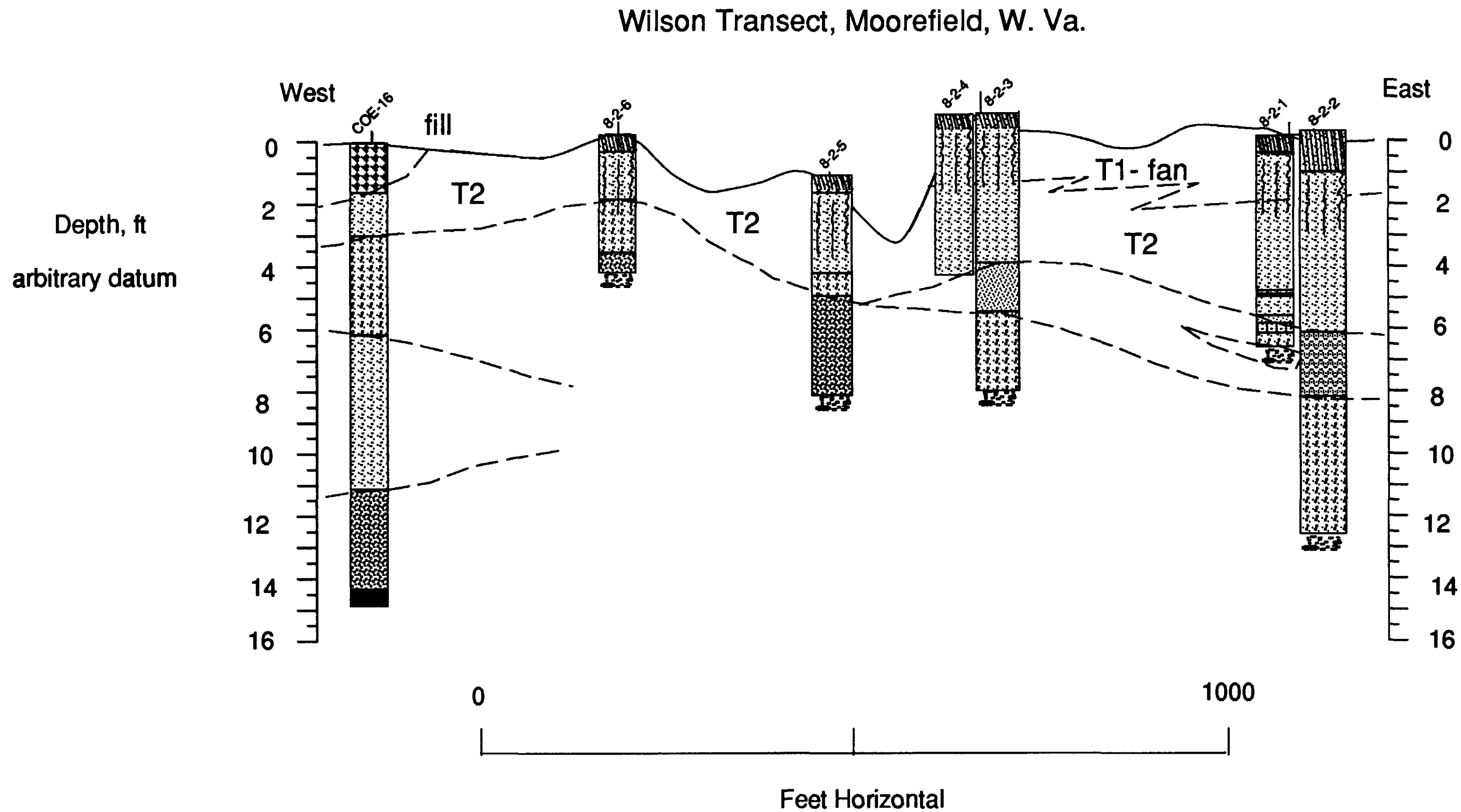

Figure 12. Cross section of drillholes on H.L. Wilson property, Moorefield, W. Va. See section M7
Symbols used are those shown in figures 8 and 9.

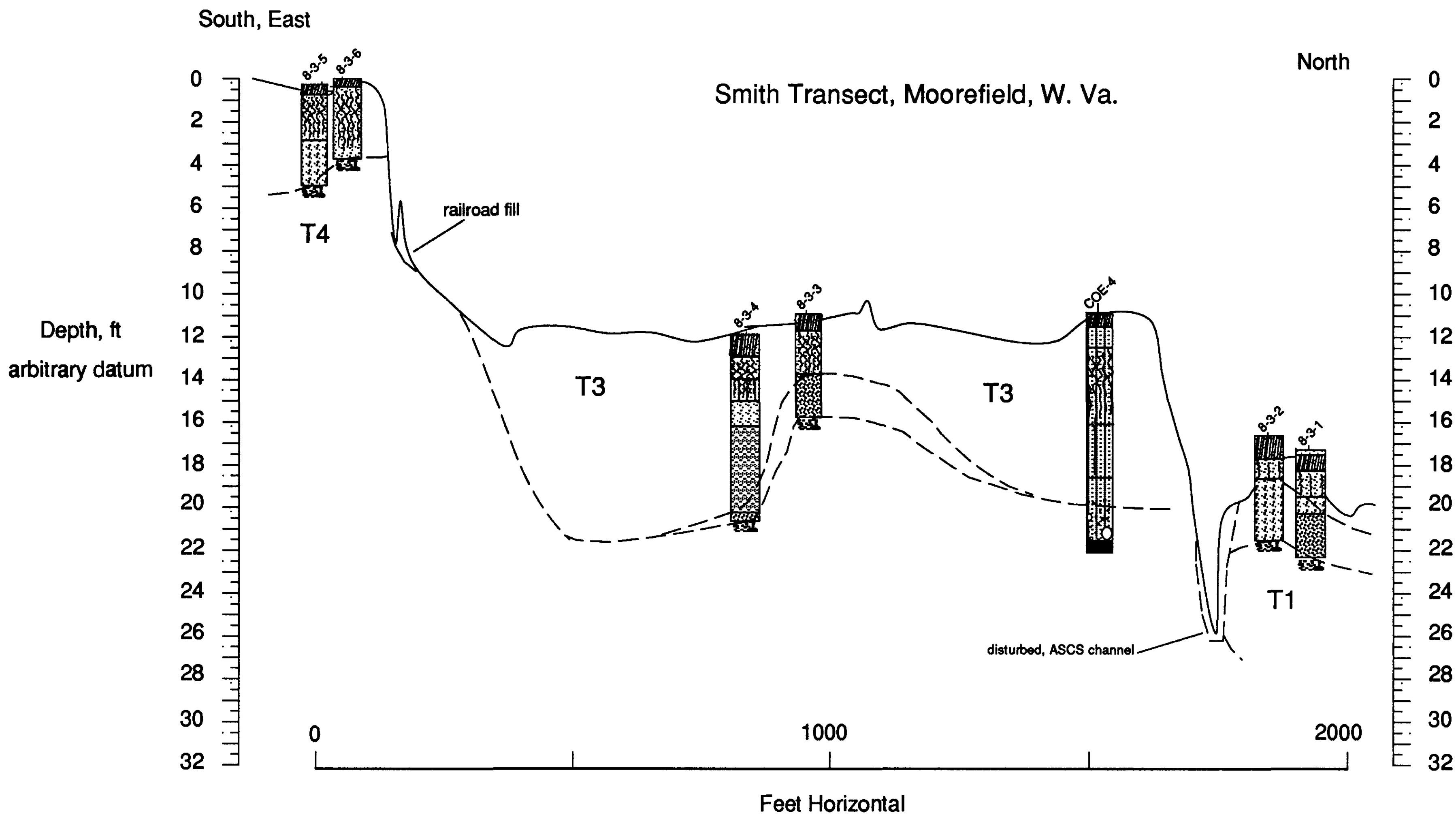

Figure 13. Cross section of drillholes on Smith property, Moorefield, W. Va. See section M3. Symbols used are those shown in figures 8 and 9

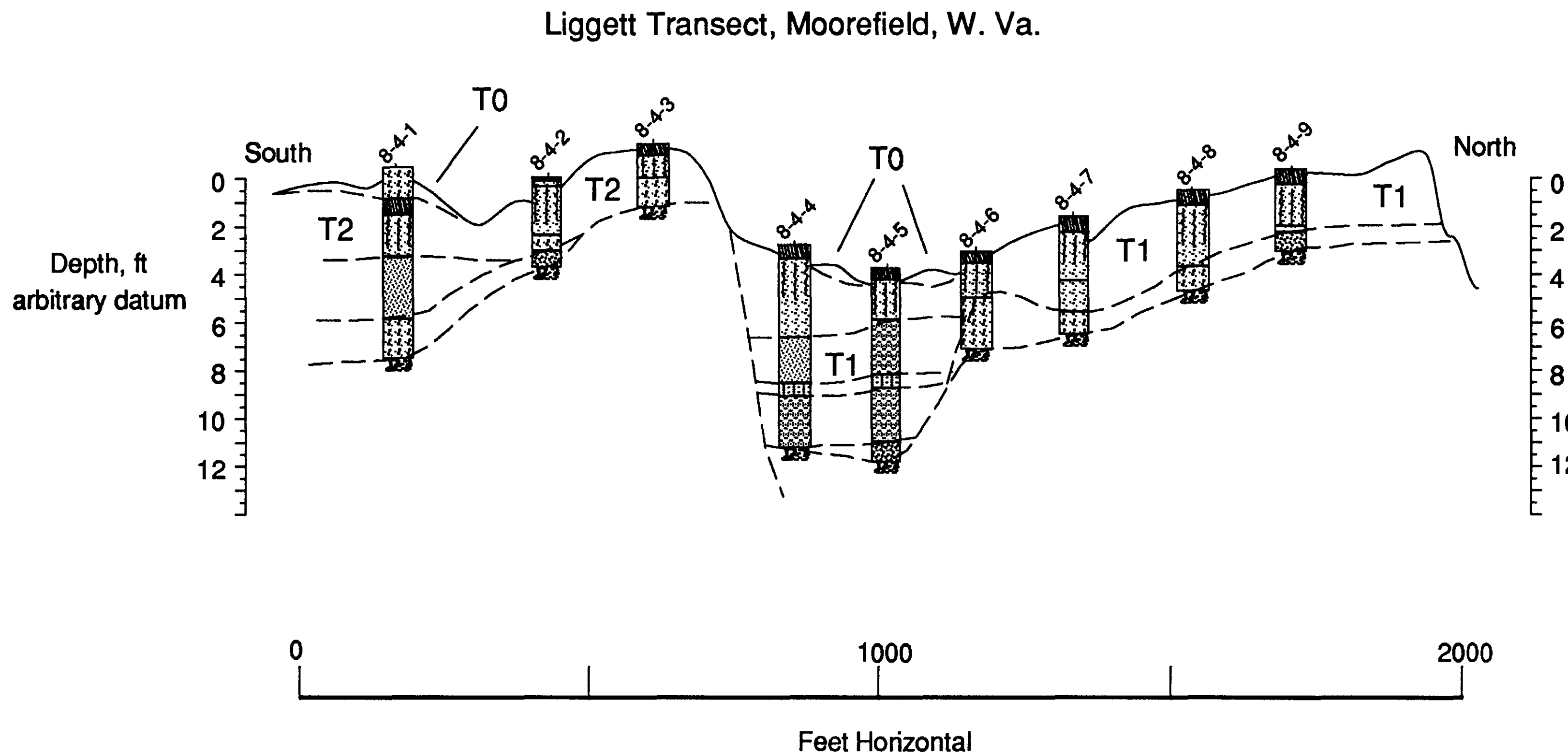

Figure 14. Cross section of drillholes on Liggett Bros. property, Moorefield W. Va. See section M1. Symbols used are those shown in figures 8 and 9.

In contrast to elongate scours, avulsion channels provide a more extensive, longer, and more-stable record. For example, the thick section of sediments at Moorefield where the 7060 +/- 230 yr BP (W-6077) radiocarbon date was obtained (figs. 3, 4, 5), was deposited in a steep-sided channel eroded into gravel and overbank sediments. This channel appears to be a discontinuous, cut-off channel that was abandoned due to channel avulsion perhaps caused by a major flood event. Although the same sediment is present in the Wilson sand borrow pit on the right bank, the sequence does not show up in any boreholes; much of it has been disturbed by the Moorefield Sewage Treatment Plant and the duck pond, and its upstream extent is unclear. Preserved sedimentary structures and lack of buried soil horizons attests to relatively rapid deposition. This aggradational sequence is also of interest because the 7060 +/- 230 yr BP (W-6077) radiocarbon date is located at its base, very close to the level of the low-water channel of the South Branch. Less than 100 m upstream, an eroded remnant of this unit has been covered by recently deposited channel gravel and cobbles. Hence, in this area, the South Branch channel has not incised appreciably for the last 7000 years.

Areas downstream from flood-plain obstructions, particularly fence lines, were preferred sites for flood sedimentation during the 1985 event. Over the time interval during which most of the valley bottom was formed, however, such concentrations of obstructions did not exist. The most common natural obstructions are trees, which would have distributed sediment more or less uniformly over the flood plain in pre-historic time. Therefore, sediment lobes nucleated by isolated obstructions in 1985 probably are not good analogs for the pre-historic stratigraphic record.

Channel margins experience sedimentation as stream channels erode laterally across a valley. These areas are scoured during rare events and recover by slow, gradual deposition of finer materials. This process has been observed following the 1985 flood which scoured extensive channel-margin areas; these areas have begun to reform by deposition from smaller, seasonal floods. Gradual, incremental deposition along channel margins produces massive sediments in which all primary sedimentary structures are destroyed by mixing by roots and fauna, thus producing massive, cumulative soils. The lower unit of the Petersburg radiocarbon site (fig. 2) appears to be this type of channel-margin deposit.

In contrast, less frequent overbank floods produce stratified sediments in natural levees. At natural levee sites, if deposited thicknesses and time between depositional events are great enough, buried soil horizons will be evident. At the Petersburg radiocarbon site three fine-sandy flood deposits at the top of the section are separated by buried A horizons. As shown in the cross section transect P7(plate 9), these units thin away from the channel margin. Levees may be relatively continuous, or they may be eroded into discontinuous segments by erosive flows (levee splays) that breech the levee. At Petersburg, natural levees exist along the right bank north of the airport, but much of the natural levee was destroyed in the process of building the old man-made levee that exists there.

Sediment deposited down-flow from levee splays (levee-splay lobes) also present possibilities for stratified sites. Levee-splay lobes were common in higher gradient parts of the South Branch basin and are evident as sand deposits mapped on the flood damage maps of both Petersburg and Moorefield (plates 1, 2).

Alluvial and debris fans also provide potential sites of deep deposits. In Petersburg, several small, high gradient debris fans occur on the south valley wall close to Johnson Run. These are composed mainly of gravelly and cobbly sediments. Many similar fans experienced active sedimentation and erosion during the 1985 storm; hence, these are active landforms under present-day climatic conditions. In Moorefield, several small to moderate debris and alluvial fans grade down to the T2 and T3 terrace surfaces. Because they have been protected from active lateral erosion from the main channels, these fans have grown to larger size relative to their upstream drainage area than those at Petersburg. The most dramatic fan is that formed by Dumpling Run in the northern part of Moorefield. Drillholes in the Wilson Transect indicated that younger, relatively unweathered fine sediment from Dumpling Run overlies older sediment of the T2 surface. This evidence of young deposits of alluvial sediment on the large fan carries two implications: a) fan sediments may preserve buried paleosurfaces and b) Dumpling Run may be a present-day flood hazard for northern Moorefield.

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Appendix

Petersburg: pedon 7-25-88-1, right cutbank, 2170 +/- 180 yr BP (W-6076) y BP

1AC 0-2 cm, yellowish-brown (10TYR5/4) fine-medium sand; loose; friable; remnant 2-5 mm sedimentary laminae; many fine roots; abrupt, smooth boundary.

2Ab 2-12 cm, very dark brown (10YR2/2) loamy fine sand; weak, medium crumb structure; friable; very weak remnant 2-5 cm sedimentary laminae; many fine roots; gradual, smooth boundary.

2Bwb 12-21 cm, very dark grayish-brown (10YR3/2), loamy fine sand; weak, medium, subangular blocky structure; slightly firm; many fine roots; gradual, smooth boundary.

2BCb 21-25 cm, brown (10YR5/3) silty fine sand; massive to weak, medium, angular blocky structure; slightly firm; common fine roots; abrupt, smooth boundary.

3Ab 25-35 cm, very dark grayish-brown (10YR3/2) loamy fine sand; moderate, medium crumb structure; slightly firm; few fine roots; few coarse roots; gradual, smooth boundary.

3Bb 35-62 cm, dark brown (10YR4/3) loamy fine sand; weak, medium, subangular blocky structure; slightly firm; few fine roots; clear-gradual (welded), smooth boundary.

4Ab 62-72 cm, very dark grayish brown (10YR3/2) fine sandy loam; moderate, medium crumb structure; slightly firm; few fine roots; gradual, smooth boundary.

4ABb1 72-86 cm, dark yellowish brown (10YR4/4) loamy fine sand; moderate, medium angular blocky structure; firm; few, fine roots; gradual, smooth boundary.

4ABb2 86-98 cm, dark yellowish brown (10YR4/4) loamy fine sand; moderate, medium subangular blocky structure; firm; few, fine roots; gradual, smooth boundary.

4Bwb 98-130 cm, dark brown to strong brown (7.5YR4/4-5/4) fine sandy loam; moderate, medium, subangular to angular blocky structure; firm; few fine roots; gradual, smooth boundary.

4BCb1 130-150 cm, dark yellowish brown (10YR4/4) loamy fine sand; weak, medium, subangular blocky structure; friable; clear, smooth boundary;

5BCb2 150-161 cm, dark yellowish brown (10YR4/4) silt loam; fine sand; weak, medium, subangular blocky structure; slightly firm to friable; abrupt, smooth boundary;

6C 161-175 cm, light yellowish brown to yellowish brown (10YR6/4-5/4) fine-medium sand; massive; loose; well-sorted; abrupt, smooth boundary. Charcoal sample layer

7C 175-200 cm, well-sorted, well-rounded pebbles and cobbles; clast supported; slightly imbricated; minor amounts of fine to coarse sand matrix.

Moorefield pedon 7-31-88-1; 7060 +/- 230 yr BP (W-6077) yr BP

1AC 0-2 cm, yellowish brown (10YR5/4) fine sandy loam, massive with remnants of 2-4 mm sedimentary ripple laminae; loose; few fine roots; abrupt, smooth boundary. 1985 flood sediment.

2Apb 2-15 cm, dark brown (10YR4/3) fine sandy loam; massive to weak, fine crumb structure (hints of remnant platey/sedimentary structure); firm; many fine roots; clear, smooth boundary.

2Ab 15-36 cm, very dark grayish brown (10YR3/2) fine sandy loam; weak, medium subangular blocky structure; firm; many fine roots; gradual, smooth boundary. Cumulative A.

2Bb 36-66 cm, dark brown (7.5YR3/2) fine sandy loam; moderate, medium angular to subangular blocky structure; firm; few fine roots; gradual, smooth boundary;

2Bt1b 66-130 cm, strong brown (7.5YR5/6-5/4) fine sandy loam; weak, medium prismatic breaking to moderate, medium angular to subangular blocky; firm; common, thin clay films on ped faces and pores; common fine roots; gradual, smooth boundary.

2BC1b 130-175 cm, dark brown (7.5YR4/2, ped interiors) and brown (7.5YR5/4, ped faces) loamy fine sand; weak, coarse prismatic structure; firm; few fine roots; gradual, smooth boundary.

2BC2b 175-211 cm, dark brown (7.5YR4/2, ped interiors) and yellowish brown (7.5YR5/4, ped faces) loamy fine sand; weak, coarse prismatic structure; firm to very firm; few fine roots; in places many, medium, faint to distinct, reticulate to rounded, gray (10YR5/1) mottles, gradual, smooth boundary.

3BC3b 211-275 cm, yellowish brown (7.5YR5/4) interbedded fine sandy silt and silty medium sand; weak, coarse prismatic structure; firm to very firm; many, medium, faint, reticulate gray (10YR5/1) mottles, gradual, smooth boundary.

3Cb 275-295 cm, brown (7.5YR5/4) and gray (10YR5/1) interbedded silty medium sand and silty coarse sand; firm; abrupt, smooth boundary. Radiocarbon sample layer.

4 295-334 cm, coarse sand and pebbles, friable, rounded.

5 334-400 cm, rounded and subrounded, imbricated, gravel and cobbles with fine to coarse sand matrix.

Moorefield pedon 8-6-88-1

1AC 0-1 cm, discontinuous loose, fine sand. 1985 flood deposit.

2Apb 1-12 cm, dark grayish brown (10YR4/2) silt loam; moderate, fine, crumb structure; friable; many fine roots; abrupt, smooth boundary.

2ABb 12-24 cm, dark brown (10YR4/3) silt loam; moderate, fine, subangular blocky structure; firm to very firm; few fine roots; gradual, smooth boundary.

2Eb 24-34 cm, yellowish brown (10YR5/4) silt loam; moderate to strong, medium, subangular blocky structure; very firm; few fine roots; gradual, smooth boundary.

2Bt1b 34-48 cm, yellowish brown (10YR5/4, stripped surfaces of ped faces) and strong brown (7.5YR5/8, ped interiors) silt loam; moderate, medium subangular blocky breaking to moderate, fine angular blocky; firm; common, moderately thick, patchy clay skins on pedfaces; few, fine roots; gradual, smooth boundary.

2Bt2b 48-60 cm, strong brown (7.5YR5/6 ped interiors) and yellowish red (5YR5/8, common, fine, distinct reticulate mottles) silty clay loam; strong, medium prismatic breaking to strong, medium, angular structure; firm; common, moderately thick clay skins on ped faces (grayish brown, 10YR5/2); gradual, smooth boundary.

2Bt3b 60-72 cm, strong brown (7.5YR5/6 ped interiors) and yellowish red (5YR5/8, common, fine, distinct reticulate mottles) silty clay loam; strong, medium prismatic breaking to moderate, medium, angular structure; indistinct remnants of planar sedimentary bedding; firm; common, moderately thick clay skins on ped faces (grayish brown, 10YR5/2); clear, smooth boundary.

2BC1b 72-90 cm, strong brown (7.5YR5/6) with 40% brownish yellow (10YR6/6) medium, distinct mottles, silt loam; weak to moderate, coarse prismatic structure; firm; many, moderately thick to thick clay skins on ped faces (very dark grayish brown, 10YR3/2); gradual, smooth boundary.

3BC2b 90-110 cm, polychrome, equally distributed medium, distinct mottles of strong brown (7.5YR5/6), brownish yellow (10 YR6/6), and gray (10YR6/2), interbedded silty clay and medium to coarse sand with scattered gravel (1.5 cm max. diameter); firm; weak, coarse prismatic structure; many, moderately thick to thick clay skins on ped faces (very dark grayish brown, 10YR3/2); gradual, smooth boundary.

4C 110-155 cm, strong brown (7.5YR5/6) fine to medium sand in 5-10 cm beds interbedded with brownish yellow (10 YR6/6) silt in 2-10 mm beds; massive; firm; abrupt, smooth boundary.

5 155-350 cm, 60% well-sorted, rounded to sub-rounded, imbricated gravel and cobbles with minor fine to coarse sand matrix, interbedded with (40%) variably sorted, fine to coarse sand.