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The Surficial Geologic Maps of Connecticut Illustrated by a Field Trip in Central Connecticut

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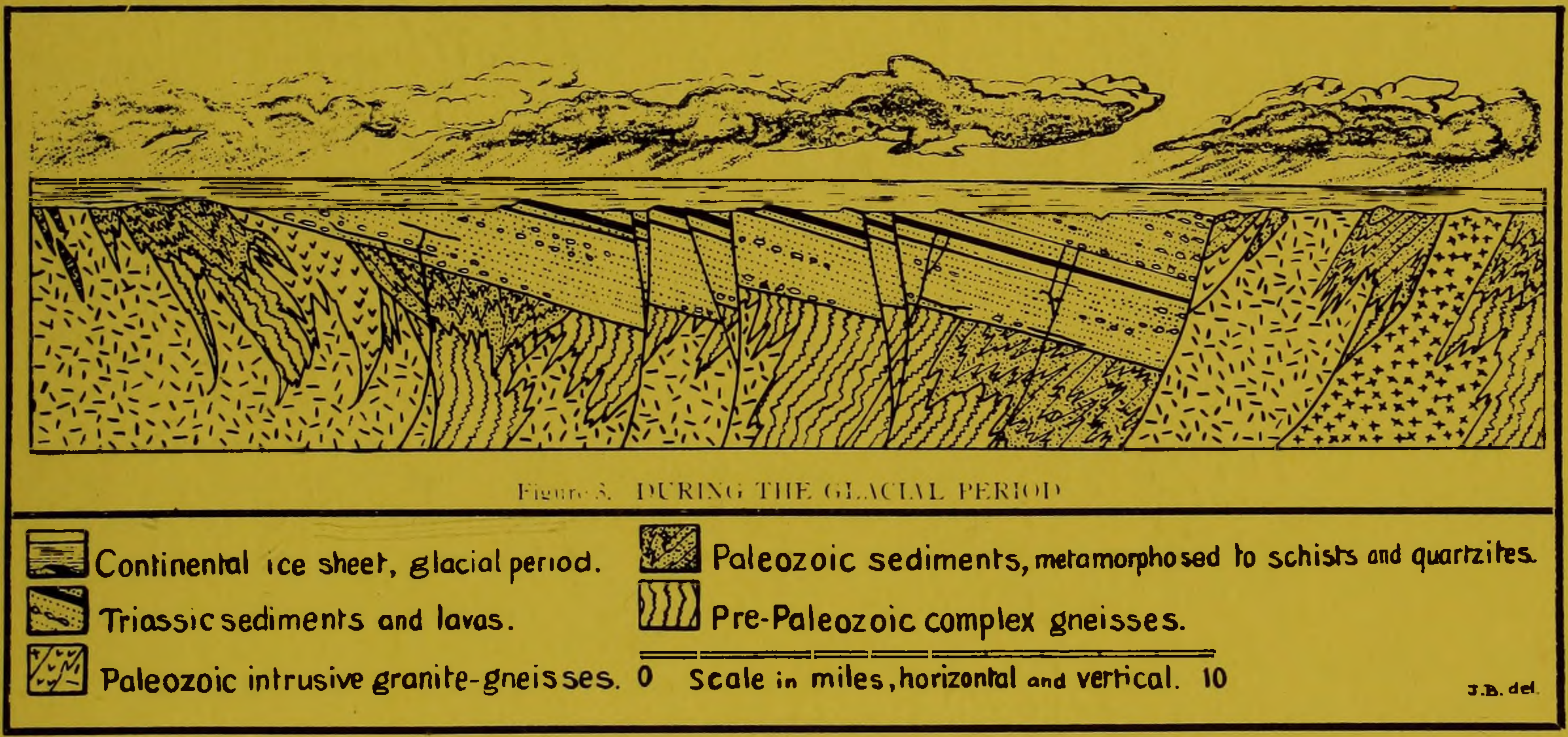
Quaternary Geology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THE SURFICIAL GEOLOGIC MAPS OF CONNECTICUT ILLUSTRATED BY A FIELD TRIP IN CENTRAL CONNECTICUT

by

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INTRODUCTION

Two maps of the surficial deposits of Connecticut have been compiled by the authors and Woodrow B. Thompson (Maine Geological Survey). Both maps show glacial till, stratified glacial deposits, and postglacial deposits, but the main difference between the maps is in the ways that the stratified glacial deposits (glaciolacustrine and glaciofluvial) are shown. The surficial materials map emphasizes the areal and vertical distribution of different textures relative to depositional environment. The Quaternary geologic map emphasizes the history of those deposits and the information they provide about the retreat of the last ice sheet. Figure 1 shows a preliminary version of this map for part of central Connecticut.

Connecticut is covered by 75 full or nearly full U.S. Geological Survey topographic quadrangle maps (7 1/2', 1:24,000), and 42 partial ones. Of these, 68 were covered by U.S. Geological Survey published or open-filed maps of surficial geology, 16 by Connecticut Geological and Natural History Survey maps, and 14 by unpublished data from various authors. All the quadrangle maps were reviewed by us, and a few quadrangles were extensively remapped; reconnaissance mapping was performed in the remaining quadrangles. In the course of compiling this large body of data into two coherent State maps, based on a consistent interpretive rationale, we have taken greater or lesser liberties with the original studies.

Measurements are given either in metric or in both metric and U.S. customary units, except that altitudes taken from topographic maps are given only in feet.

GLACIAL TILL

On both maps, areas of "thick till" (more than about 5 m thick) are distinguished from the areas of thin, discontinuous till in which bedrock crops out extensively. The surface relief of thin till is controlled mostly by the irregularities of the bedrock surface. Thick till is much smoother; it commonly forms drumlins, and also drumlin heads and tails banked against bedrock hills. Till is commonly 30 m thick or more in drumlins, and reaches a maximum thickness of about 60 m.

Drumlins and glacial grooves trend south-southeast in most of Connecticut. They generally trend southwest to west-southwest on the west side of the Connecticut Valley, and southeast on the east side of the valley; these diverging trends reflect the major lobation of the relatively thick ice in the valley during retreat. In a few places on the west side of the valley, grooves trending west of south cross older grooves trending east of south, or reddish-brown till derived from the Mesozoic sedimentary rocks of the valley overlies gray till derived from the crystalline rocks of the western uplands. These relationships result from changing directions of ice movement caused by lobation during retreat of the last ice sheet.

The two-till stratigraphy previously described for Connecticut (Pessl and Schafer, 1968; Pessl, 1971) has been strengthened by identification of the lower, older till beneath the upper till in almost all parts of the State. The till in most drumlins and other thick-till areas is believed to be mostly lower till, mantled by thin and discontinuous upper till. Not only the materials but also the general orientations of drumlins appear to have survived from the earlier glaciation. We still lack adequate evidence to decide whether the earlier glaciation in which the lower till was deposited was of early Wisconsinan or Illinoian age.

STRATIFIED GLACIAL DEPOSITS AS SHOWN ON THE SURFICIAL MATERIALS MAP

The surficial materials map portrays the texture of surface and subsurface stratified deposits, based on surface observations and subsurface data, and extended by inference from depositional models. Thicknesses of textural units are shown by selected point data from wells and test holes. Map units in which coarse-grained material overlies fine-grained material, shown as stack units such as sg/s and sg/s/f (fig. 2), indicate the pervasive deltaic bodies of sediment. Map units in which finer grained materials overlie coarser grained sediments are shown as stack units such as f/sg, s/sg, and s/f/sg; the general interpretation of these is that slightly older, coarser grained sediments deposited near an ice margin are overlain by younger distal sediments laid down when the ice margin had retreated farther away. Thus, the surficial materials map not only provides textural information useful to planners and engineers interested in the development of unconsolidated materials and ground-water aquifers, but also is a companion to and enhances the Quaternary geologic map by supporting such inferences about depositional environment.

STRATIFIED GLACIAL DEPOSITS AS SHOWN ON THE QUATERNARY GEOLOGIC MAP

The stratified glacial deposits of Connecticut result mainly from the interaction of three factors: 1) the form of the landscape across which the ice was retreating; 2) the form of the margin of the retreating ice; and 3) the locations of the principal meltwater streams emerging from the ice. These factors are not independent of one another; the form of the landscape influences the other two to a considerable extent.

We believe that the character of these deposits in all parts of Connecticut fully supports their interpretation through two closely related concepts: stagnation-zone retreat and morphosequence deposition (Currier, 1941; Jahns, 1941; Koteff, 1974; Koteff and Pessl, 1981). These concepts have roots more than a century old, were articulated in present form four decades ago, and have since been exemplified in many quadrangle studies.

Stagnation-zone retreat means that the retreating margin of active ice is fringed by a continuous zone of dead ice, too thin to transmit forward motion. The dead ice encroaches on the active ice by retreat of the shear zone that separates them. The dead ice disappears very irregularly because of differences in such factors as ice thickness, topographic position, thickness of mantling debris, and flow of meltwater through the ice. Therefore, detached ice masses of various sizes and shapes persist well beyond the fringe of continuous dead ice.

The systematic and predictable ponding of large and small glacial lakes in north-draining valleys at high and low altitudes is clear evidence of generally northward retreat of the ice. The available evidence indicates that the direction of retreat in most places was approximately opposite to the direction of ice advance as shown by drumlins and glacial grooves. Retreat was to the north-northwest in most of the eastern and western parts of the State, but was in other directions, such as northeast or northwest, where controlled by lobation.

Morphosequence deposition occurs in contact with or in front of dead ice. A morphosequence is the basic mappable chronologic unit of stratified glacial deposits. It is the body of sediment formed in a particular valley during a particular time (perhaps in the range of 10 to 150 years), as meltwater streams aggraded their beds, filled proglacial ponds and lakes, and built up to a maximum level, commonly controlled by a spillway or by other deposits or remnant ice downstream. The heads of many morphosequences probably extended well up into the dead-ice zone and perhaps as far as the active ice, but melting of adjacent and subjacent ice generally destroyed such headward parts, or caused them to be collapsed downward and later buried; the part of a deposit containing evidence of presence of active ice is not likely to have been preserved. The ice-marginal or ice-contact position at the head of an ideal morphosequence is taken as the scarp between the severely collapsed headmost part of the deposit and the part that retains some of the flattish top at or close to the original level of deposition. That scarp defines the outer margin of the fringe of continuous dead ice. A minimum measure of the width of the fringe is given by the extent of the collapsed deposits headward of the ice contact, especially by the length of esker segments. Such data, together with inferences made from the topographic setting and texture of deposits about the proximity of continuous high-standing ice, indicate likely widths of 0.5 to 2 km in most places for the fringe of continuous dead ice. Few morphosequences extend downstream more than 10 to 15 km, and most are shorter; evidently the regime of meltwater streams changed downstream from aggradational to balanced or degradational. The ending of deposition of one morphosequence and beginning of another occurred because of such events as opening of a new and lower spillway, retreat of the margin of the source ice, or shifting of position of meltwater flow within the ice.

Most units for the Quaternary geologic map are groups of 2 to 12 or more morphosequences of common depositional setting, formed along the same or related paths of flow of meltwater. These units are inherently chronologic, because retreat of the ice generally resulted in changes from one path of flow to another, and thus from one group of deposits to another. Where drainage divides are transverse or oblique to the direction of ice retreat, paths of escape of meltwater were first held to higher positions against or through uplands, and then gradually lowered as lower paths were uncovered in valleys. Of the very large number of morphosequences (several to 25 per 7 1/2' quadrangle, probably close to 1000 total in Connecticut), only a small number of particularly large or significant ones are shown individually on the State map. The composite units, of course, represent longer time intervals than do single morphosequences.

Four main depositional settings have emerged from the process of compilation, and are used for broader categories of the map units. These four settings embrace almost all the meltwater deposits, regardless of the great variety of local detail. The distinctions depend on glaciolacustrine versus glaciofluvial deposition, occurrence in south-draining versus north-draining valley, and upland versus lowland position. The four depositional categories are: 1) major glacial lakes in lowlands; 2) ice-marginal ponding in north-draining valleys in uplands; 3) glaciolacustrine-glaciofluvial systems in south-draining valleys; and 4) glaciofluvial systems. Of course these categories grade into one another, and placement of some map units in one of the categories can be somewhat arbitrary. The four categories, each of which is described below, are distinguished on the State map by contrasting groups of colors.

Major glacial lakes in lowlands occupied areas shown in greens and blues on the State map. The map units include not only deltas and lake-bottom deposits, but also glaciofluvial feeder deposits graded to deltas. Formal glacial-lake names have been given only to those lakes in which sizable bodies of open water existed. Estimates of postdepositional crustal tilting can be obtained from the deposits only of lakes that had long-lasting stable levels that were controlled by spillways over glacial till or bedrock.

Some of the major lakes were impounded in north-draining valleys by the retreating ice; such lakes commonly show successively lower stages related to the exposure of successively lower spillways. (North-draining streams are tributary to the main streams of Connecticut, which all drain south to Long Island Sound.) Examples include Lake Danbury in the Still River valley of west-central Connecticut, and Lakes Winsted and Norfolk in the Still River and Blackberry River valleys of northwestern Connecticut.

Lakes of this type grade by decrease in size into those of the second category, ice-marginal ponding in north-draining valleys in uplands.

Some glacial lakes came into existence in south-draining valleys as a result of temporary blocking by bulky bodies of stratified drift. The longest lived of such lakes were those whose outlets were established over spillways floored by glacial till or bedrock rather than over easily eroded drift dams. Examples are Lake Hitchcock in the Connecticut Valley, and Lakes Southington (Stops 8 and 9) and Farmington (Stop 13) in the narrow valley on the west side of Talcott Mountain. Even though Lake Middletown (Stops 4, 5, and 6) did overflow over its drift dam in the valley of the lower Connecticut River, this lake survived for a considerable time, perhaps because the dam extended far downstream.

Other drift-dammed lakes in south-draining valleys persisted not as large water bodies that lengthened as the ice retreated, but as successive small, somewhat overlapping lakes. The dams of such lakes may be renewed by deposition of additional morphosequences or "shingles" at successive retreatal positions of the ice margin; each such deposit is a delta built behind the previous one, and may fill the space forward to the ice-contact scarp of the preceding delta. Lacustrine deposits of this kind occur in the Shetucket River valley in the Willimantic quadrangle, and along the Quinebaug River valley. Such deposits grade by decrease in size and continuity into deposits of the third category, glaciolacustrine-glaciofluvial systems in south-draining valleys.

Ice-marginal ponding in north-draining valleys in uplands occurred where the ice was retreating from drainage divides that were transverse or oblique to the direction of ice retreat. The deposits of the ponds and small lakes are shown on the State map in shades of purple. All these deposits are deltaic, and many of the deltas filled the small basins in which they were built. These lake deposits include isolated single deltaic morphosequences that are perched against sags in east-west divides, groups of nearby but separated deposits related to spillways at different altitudes, and series of contiguous deltas in single valleys. Deposits of the last type may approach those of some major lakes in size and character. Map units in this category occur throughout the State. Good examples occur on the north slope of the Hanging Hills, Meriden quadrangle (unit hh, fig. 1; Stop 10); in the central and north-central part of the Mount Carmel quadrangle; and in the northeast part of the Haddam quadrangle.

Glaciolacustrine-glaciofluvial systems in south-draining valleys are the results of temporary blocking of valleys by combinations of stratified drift and masses of dead ice. Their deposits are shown on the State map in shades of brown. Glaciofluvial gravel and sand, including topset beds, are at the surface in almost all places, and many of these deposits look like glaciofluvial terraces at first glance. However, deeper exposures generally reach lacustrine foreset or bottomset beds, and logs of wells and test holes very commonly record thick subsurface bodies of fine-grained sediments.

Some of these deposits consist of series of deltaic "shingles" like those of the last-described type of major glacial lakes. Commonly, however, the shingled character is not obvious, because of lack of topographic differentiation between successive deltas, perhaps because the upper glaciofluvial beds overlap from one segment to another. Glaciofluvial beds lie directly on bottomset beds at some places where shallow lakes drained or filled up completely before deltas built forward. Coarse glaciofluvial materials extend to the till/bedrock floors of these valleys in other places, particularly where the floors are shallow.

The deposits of this category are abundant in south-draining valleys of all parts of the State except those occupied by major glacial lakes. A good example is map unit lc (fig. 1; Stop 1) along the lower Connecticut River below Middletown. The conclusion is clear that, even in valleys nominally open for free southward drainage, the incidents of deposition around the disappearing ice generally resulted in at least local ponding.

Glaciofluvial systems, unaccompanied by ponding, occurred in remarkably few places in Connecticut. Their deposits are shown on the State map in orange. Most of them produced sand and gravel terrace deposits that erosionally overlie other valley deposits (commonly glaciolacustrine), and that we call meltwater terrace deposits. The largest and best known is the Quinnipiac valley terrace (unit qt, fig. 1; Stop 7). Glaciofluvial deposits also occur in south-draining valleys that were too open and steep for ponding to take place; however, many such deposits are too small and isolated to be shown as separate map units, and have been included in an undifferentiated category. The glaciofluvial category, as we have used it, does not include the glaciofluvial components of other categories: delta topset beds, glaciofluvial feeders graded to deltas, and the various glaciofluvial components of the glaciolacustrine-glaciofluvial systems category.

SPECIAL TOPICS

Dominance of glaciolacustrine deposition. A major conclusion we have drawn from our compilation of the glacial geology of Connecticut is that most of the meltwater sediments were deposited in or graded to glacial lakes, both large and small. On R. F. Flint's 1930 "Map showing the glacial geology of Connecticut", most of the stratified drift is mapped as "sand and gravel deposits in local temporary lakes (dammed by ice and controlled by spillways)" (Flint, 1930). The new Quaternary geologic map of Connecticut reflects our concurrence with Flint's early observation of pervasive deltaic bedding in these deposits as well as our strong disagreement with his regional-stagnation model, which he later retracted (Flint, 1932). The "ubiquitous gravel cap", the recurrence of sg/s textural stacking in many well and test-hole logs, and the multitude of pits exposing flat-lying gravelly beds overlying dipping sand beds all demonstrate the deltaic nature of most meltwater deposits.

The glacial lake in Long Island Sound. Regional compilation supports the existence of a major glacial lake in Long Island Sound at about present sea level, as has long been suggested. Because of the interaction between postglacial tilt of the water plane of the former lake and the northward convexity of the present shoreline, deltas built into this lake are exposed above present sea level only between Westport and Clinton. Topset/foreset contacts in the New Haven delta plain, illustrated by Lougee (1938, pl. IIA), occur at about 22 ft in altitude. At Fairfield, in the Mill River delta, the topset/foreset contact is estimated from well logs to occur at present sea level. If lake level was stable, these deltas have been tilted upward to the north-northwest at about 3 ft/mi (0.6 m/km) by postglacial rebound. Deltas south of the zero isobase of the inferred water plane (i.e., east of Clinton and west of Westport) probably exist below present sea level. Recent work by Williams (1981) shows foreset stratification in bodies of sand offshore from Norwalk and from Saybrook at the mouth of the Connecticut River.

Glacial Lake Middletown is the name we propose for a lake that first developed along the Connecticut River and in the Mattabesset River basin. It was impounded by a long mass of slightly earlier deposits (unit lc, fig. 1) in the lower Connecticut River valley at and south of The Straits, and the spillway of the lake was over these deposits. Accordant delta levels, basin geometry resulting in ice-margin positions trending northwest-southeast, and the extent of the Berlin clays all indicate that Lake Middletown occupied both the Middletown and the Berlin-New Britain basins. Delta surfaces in Cromwell (lmr) and in the Newington (lmn) and New Britain (lmw) areas all stand at altitudes of about 150 ft, and topset/foreset contacts are at approximately 135 ft. Deltas in Rocky Hill (lmd) that were graded to the Dividend Brook spillway were temporarily ponded to a higher level than Lake Middletown; this spillway over delta sand and gravel (lmr) was not eroded lower than its level of 129 ft because of the presence of the water of Lake Middletown at its mouth. Erosional lowering of the dam of Lake Middletown evidently was very slow. When the ice uncovered the low part of the Mattabesset-Connecticut divide where the New Britain spillway of Lake Hitchcock would later exist Lake Middletown persisted at a level high enough to spread across the divide into the upper Connecticut River basin; when the ice retreated from the north end of Cedar Mountain, this water body spread east into the south end of the basin later occupied by Lake Hitchcock. Deltaic deposits in Glastonbury and Manchester, lake-bottom deposits in Glastonbury and East Hartford, and deltaic and lake-bottom deposits in West Hartford all occur at altitudes accordant with Lake Middletown but too high to have been controlled by any possible early level of the New Britain spillway. Not until Lake Middletown had dropped to below 110 ft could the New Britain spillway come into use as the control for Lake Hitchcock. This drop did not happen until the ice had retreated north of West Hartford and Manchester, and quite possibly not until it had retreated to Windsor and Windsorville.

The Cromwell-Rocky Hill delta complex (controlled by Lake Middletown), which became the dam for Lake Hitchcock, was built higher than the place on the Mattabesset-Connecticut divide at which the New Britain spillway later was established. Had Lake Hitchcock overflowed across the deltaic dam, erosion would have been rapid. Instead, the dam failed probably by ground-water sapping, powered by the head of water in the lake, at a time when Lake Middletown already had drained.

Glacial Lake Hitchcock, the large and long-lived lake in the Connecticut Valley, has been extensively described by previous workers (Hartshorn and Colton, 1967; Hartshorn and Koteff, 1968; and many earlier references). Highlights emphasized by regional compilation are: 1) The New Britain spillway started out at about 110 ft in altitude and was not eroded down to its present altitude of about 70 ft until sometime after the ice margin had retreated into Massachusetts. 2) When the gap through Talcott Mountain at Tariffville was uncovered, the water level in the Farmington River-Salmon Brook valley west of the gap dropped, probably to the level of Lake Hitchcock; large bodies of deltaic sediment were deposited in this glacial Lake Tariffville. 3) The extensive Farmington delta is actually three deltaic deposits built into Lake Hitchcock at three different levels. The southern part has an ice-contact head and was built into the highest level of Lake Hitchcock (Hartshorn and Colton, 1967). Plane-table leveling of a topset/foreset contact in the Bloomfield town landfill gave an altitude of 178.6 ft; adjusted for postglacial tilt, the altitude indicates an early level for the New Britain spillway of about 110 ft. When the lake level had dropped somewhat, the Farmington River, flowing through the Tariffville gap, entrenched the ice-contact delta and built another delta northeastward into the lake in the Bradley Field area. As the lowest levels of the lake were reached, the Farmington River again entrenched, and deposited deltaic material southeastward into the lake. 4) On the east side of the Hitchcock basin, a complex series of deposits occurs in which high-level ice-contact and non-ice-contact deltas were entrenched by slightly later meltwater and meteoric water flowing down tributary valleys such as the Hockanum and Scantic. Low-level deltas occur at the mouths of these valleys. 5) Postglacial tilt of about 4.2 ft/mi (0.8 m/km) upward to the north in the Lake Hitchcock basin, established in Massachusetts by Jahns and Willard (1942) and extended to Connecticut by Koteff (1967), has been corroborated by the present study. Extrapolation of this amount of tilt across the State has aided in reasonable interpretation of many deposits.

The Middletown readvance? Till or ice-contact stratified deposits overlying glaciolacustrine clay in the Middletown-Berlin-New Britain area were described by Flint in 1933 (p. 969), and were suggested to be evidence that the clays predated the last ice advance in the area. Flint in 1953 (p. 899) attributed this overriding of the clays to a late-glacial readvance of more than 16 mi from north to south. Other occurrences of stratified deposits under till were described by Simpson (1959) and Deane (1967). The term "Middletown readvance", which had come into informal use, was first used in print by Schafer and Hartshorn (1965, p. 121).

Descriptions of other localities of readvance in the Connecticut Valley (for instance, Larsen and Hartshorn, 1982) indicate that minor fluctuations of the ice margin occurred several times, and that no basis exists for correlation of such fluctuations with events near Boston, not to mention with glacial substages in New York and the Midwest (Flint, 1953). Furthermore, we are now uncertain that any late-glacial readvance took place in the Middletown area. Probably many of the occurrences of till over stratified deposits represent the main advance of late-Wisconsinan ice, or even the activity of the earlier ice sheet believed to have deposited much of the thick till (cf. Stop 3). The exposures of a disturbed zone ("till equivalent") on top of clay in Berlin and Middletown listed by Flint and Cushman (1953) have long since vanished; however, similar features in the present Kane pit (Stop 5) may be explained as load and ice-rafting structures. We believe that the Middletown-Berlin clays, across which the ice allegedly readvanced, and the Cromwell deltas, which show no sign of having been overridden, all were deposited in glacial Lake Middletown within the same general period of time. Postulating a readvance event between them would require the existence of two glacial lakes, an earlier one having bottom deposits but no deltas, and a later one having deltas but no bottom deposits. Finally, we wish to mention that there is no feature that could be referred to as a Middletown moraine (Sirkin, 1967), and that the pollen-diagram features once thought to record cooling at the time of a Middletown readvance (Leopold, 1956) are now believed to be artifacts of relative pollen statistics (Davis, 1965).

Minor end moraines. We have shown the small moraines of southeastern Connecticut (Goldsmith, 1982) on our maps. We have shown those of south-central Connecticut (Flint and Gebert, 1976) with considerable modification, as they were seriously overmapped. We agree in general with the extension of the moraines west-southwestward into Long Island Sound (Flint and Gebert, 1976; Williams, 1981). Black (1982) rejected the interpretation of the mapped moraines as features formed at an active ice margin. Much of Black's criticism was anticipated by Goldsmith (1982), and much was based on setting up too narrow a definition of a moraine.

We have identified a few moraines north of the coastal moraine belt; they are in the central part of the Colchester quadrangle, in Meshomasic State Forest in the Middle Haddam quadrangle, and in the northwest part of the South Coventry quadrangle. These moraines reflect a more irregular ice margin than do the ones in southeastern Connecticut.

Regional stagnation? Dissent from State-wide use of the twin concepts of stagnation-zone retreat and morphosequence deposition has recently been expressed by Black (1977, 1979, 1982). Using as his main example the Shetucket-Willimantic basin, he has urged the alternative of basin-wide regional stagnation. Space does not permit a detailed rebuttal of his arguments here. We commonly disagree with both his descriptions and his interpretations of field situations (as he presumably would with ours). We believe that many of his conclusions either are incorrect or do not indicate what is claimed. The net result is our conviction that the hypothesis of basin-wide stagnation is in contradiction to the great bulk of the evidence. In fact, the Shetucket-Willimantic basin seems to us to contain one of the best portrayals of stagnation-zone retreat and morphosequence deposition in eastern Connecticut, and our depiction of the area on the State maps reflects our belief.

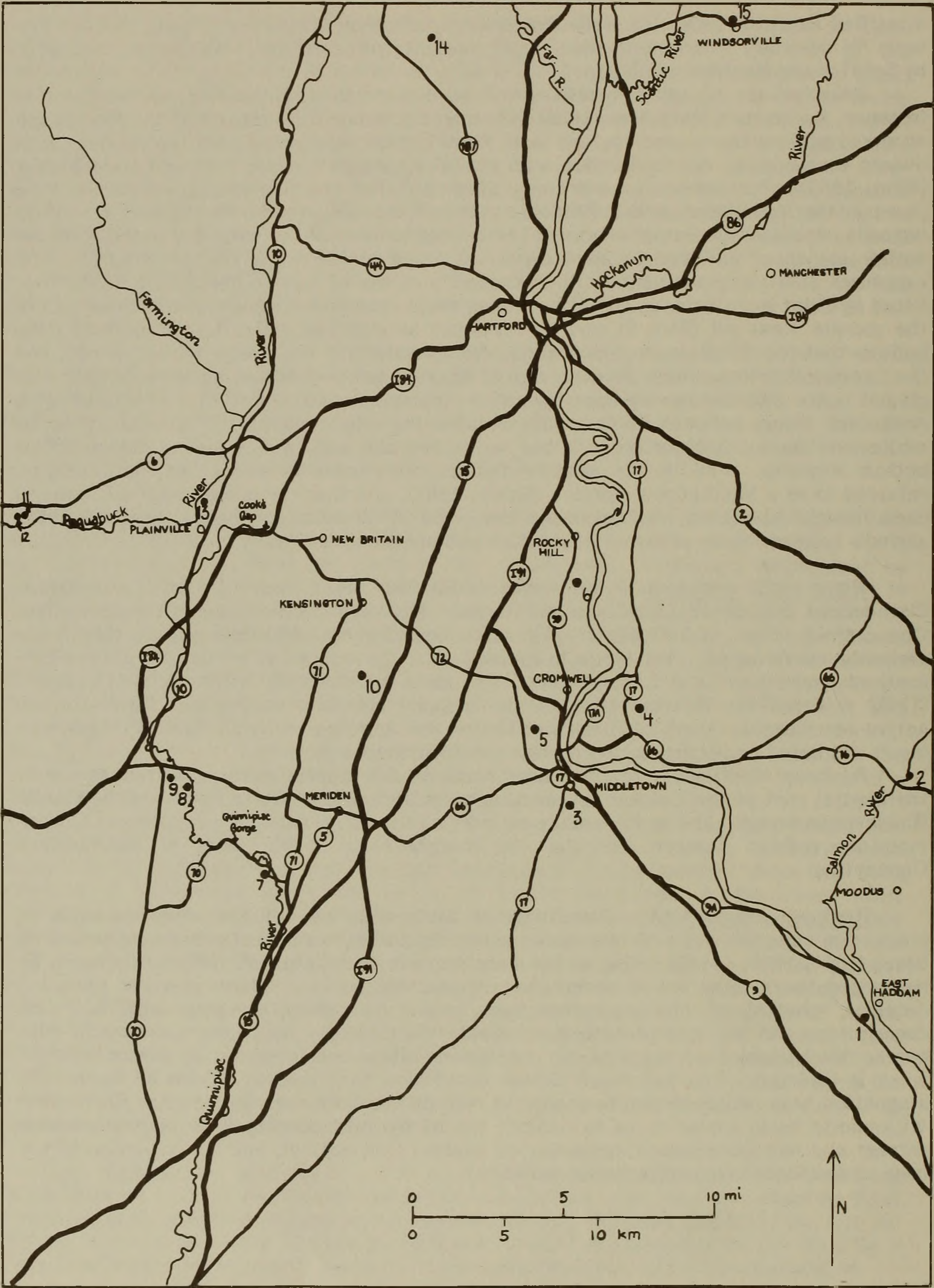

Figure 3. Map showing locations of field trip stops.

FIELD TRIP STOPS

The stops on this trip (fig. 3) have been chosen both to demonstrate the units shown on the Quaternary geologic and surficial materials maps of Connecticut and to illustrate some of the particular glacial geologic features of central Connecticut. Almost all the stops are on private property, and permission should be obtained before visiting them. Stops occur in the following quadrangles, which all are covered by U.S. Geological Survey topographic maps (scale 1:24,000, contour interval 10 ft): Bristol, Broad Brook, Deep River, Hartford South, Meriden, Middle Haddam, Middletown, Moodus, New Britain, Southington, and Windsor Locks. Other quadrangles useful for travel between stops are Haddam, Hartford North, and Manchester.

STOP 1. State Highway Dept. pit at Tylerville, town of Haddam, Deep River quadrangle. Entrance is east off Connecticut Route 9A, 0.15 mi (0.25 km) south of junction with Route 82.

The delta topset and foreset bedding exposed in this pit is an example of that seen in deposits along the lower Connecticut River valley. These deposits have previously been described as "outwash valley train" (Flint, 1953, 1975, 1978). O'Leary (1977) recognized that these deposits were not one outwash body but a series of ice-contact morphosequences built as the ice retreated northward up the valley. Our work indicates that the lower Connecticut River deposits (unit lc, fig. 1) are a succession of ice-contact deltaic sequences, each one ponded behind the last (see discussion above under heading "Glaciolacustrine-glaciofluvial systems in south-draining valleys"). Subsurface data from logs of wells and test holes as well as deep pit exposures indicate that deltaic deposition was extensive. Surface textures in these sediments grade from coarser to finer within individual sequences. The profile of deposits along the Connecticut River in the Deep River quadrangle (O'Leary, 1977, C-C') shows the "shingled" surface gradients of four morphosequences.

STOP 2. Salmon River till cut, town of Colchester, Moodus quadrangle. Cut on east side of Salmon River, about 750 m east of Connecticut Route 16 bridge.

The base of this natural exposure of many years standing was cleaned off by the June 1982 flood, which exposed about 1 m of dirty gravel beneath the lower till. When visited in July 1982, the cut was being "stabilized" under direction of the U.S. Army Corps of Engineers. The July exposure:

5-7 m	upper till, sandy, light yellowish gray; no inclusions of lower till except a few "schlieren".
4-6 m	upper till containing numerous inclusions of lower till. Inclusions mostly subhorizontal slabs, 0.3-1.5 m long; some having obscure borders; some having sharp borders and having stained joints inside.
6 m	lower till, sandy, yellowish brown to brown. Considerable groundwater flow at contact; till only moderately compact where wet. Jointed zone removed by erosion?

STOP 3. Marino Crane Service cut, in Middletown, Middletown quadrangle. Cut is adjacent to Marino building, on south side of Mill Street, which runs between South Main Street (Connecticut Route 17) and Ridge Road.

The locality is a long, discontinuously exposed cut in the thick till unit (fig. 1). The cut exposes till and laminated fine-grained sediments (laminites) in the north and east sides of a drumlin. Laminites are fairly common in drumlins in central Connecticut. In these drumlins, laminites occur as cores, as ice-thrust wedges, and as interbeds with till; some of them evidently predate the last glaciation because they are associated with the older till.

The major units exposed at Marino are a body of laminites and two tills (fig. 4). The laminites are between the tills; the lower contact is a surface of unconformity, and the upper contact, as exposed in the north cut, is a shear zone. Other units, less well exposed, are a small lens of sand at the top of the southeast end of the cut and a body of sand and pebble gravel beneath the till near the base of the cut. The lower, compact, fine-grained till contains sandy lenses and a relatively small percentage of clasts, chiefly subangular pebbles, cobbles, and small boulders. The matrix of the till contains streaks of silt and clay that may be deformed laminae.

The laminites include two facies that grade vertically into one another. One facies is pebbly and contains diamicton lenses; the other is relatively free of diamicton and stones, but contains concentrations of granules along bedding planes. Laminae in the pebbly facies are generally thicker and coarser grained than their less stony counterparts, which are composed chiefly of silt and clay. The laminites are broadly warped, dip south-southeast, and are deformed around stones and diamicton lenses; convolute structures, probably formed by loading, are common.

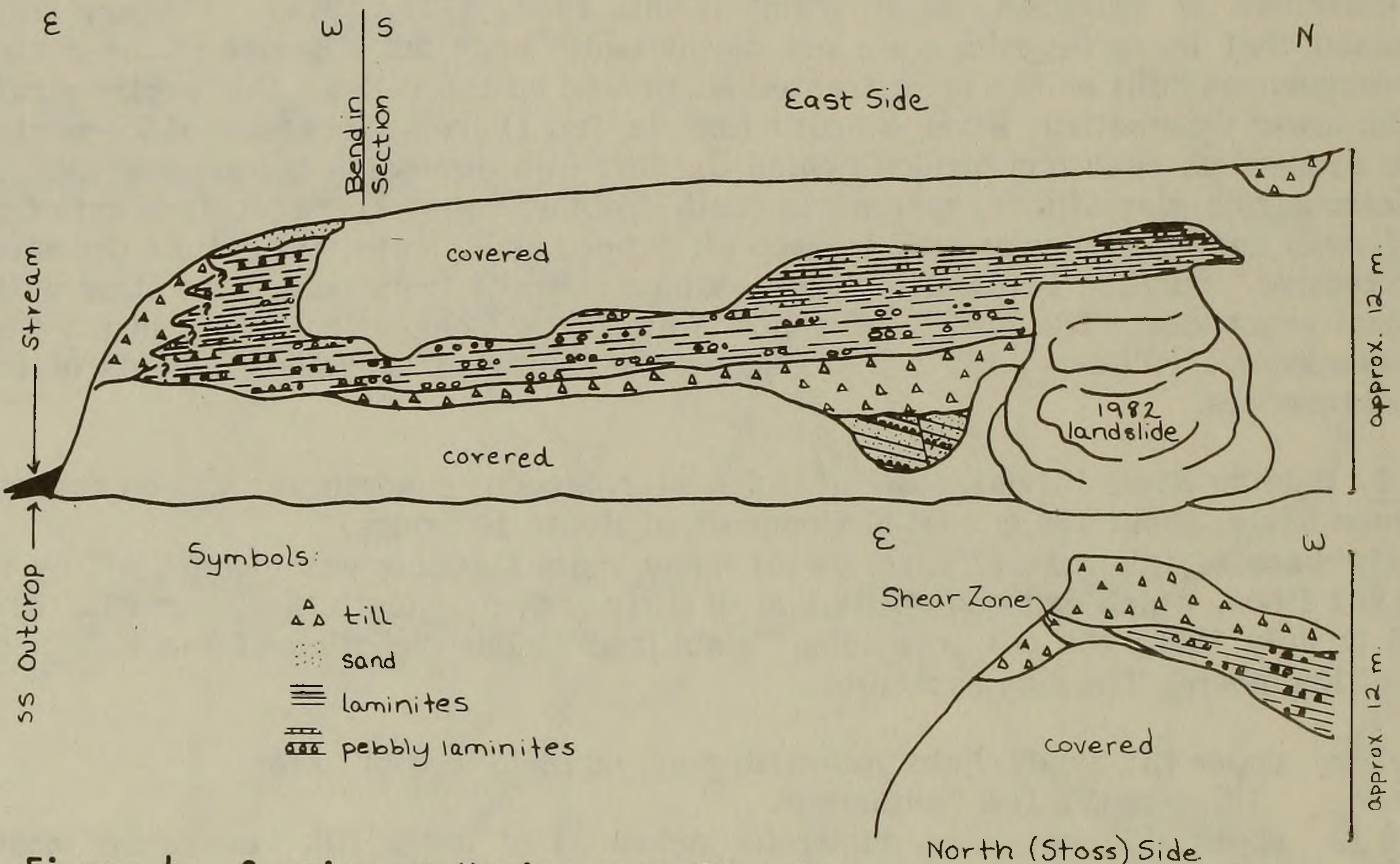

Figure 4. Section at Marino cut, Stop 3.

The overlying till is exposed at the north and southeast ends of the locality. In the north cut, till and laminites interpenetrate along folds and faults. Detached slabs of laminated fine-grained sediments appear to have been interthrust from the northwest with till. The till in this cut is compact, sandy, and stony. The clasts include many well-rounded pebbles and cobbles. At the southeast end, the upper till either is draped over the laminites or grades into them; this contact has not been well exposed.

An ice sheet apparently overrode the deposits of a proglacial lake at this locality. The lake may have been impounded in Sumner Brook valley when an advancing ice sheet encroached upon the north-sloping terrain. Lacustrine sedimentation took place close to the ice margin; this proximity is indicated by the abundance of small stones and diamicton in the laminated fine-grained sediments. The diamicton may have been shed from an ice shelf or from icebergs, or it may have been injected into the lake at the base of the glacier by subaqueous mass flows.

STOP 4. Pit behind Portland Burying Ground, town of Portland, Middle Haddam quadrangle. Pit is on south side of cemetery on Bartlett Street, which turns east off Connecticut Route 17, about 1.2 mi (2 km) north of junction of Connecticut Routes 17 and 66.

The main cut in this pit exposes 7.5 m of west- to northwest-dipping foreset beds composed of plane-bedded and ripple-bedded medium to fine sand. The top of the main face is at about 140 ft in altitude. Small cuts above it show 2 m of topset beds composed of pebble gravel and sand; thus a topset/foreset contact altitude of approximately 140 ft is inferred. Bottomset beds of very fine sand are exposed in the lower south slope of the delta. The form of the delta and its westerly foreset dip directions indicate that it was built by meltwater from the east, between the stagnant ice margin to the north and a probable detached ice block to the south.

The Portland Burying Ground delta is part of a stratified drift complex that fills a buried channel of the Connecticut River. The bottom of the channel is from 100 to more than 200 ft below sea level; the deposits in this channel contain a chain of deep kettles including Jobs Pond. The Jobs Pond deposits, which have been treated as one entity by previous investigators, were considered by Flint (1953) to be part of one glaciofluvial outwash body that filled the Connecticut River channel from Rocky Hill to Long Island Sound. More recently, Hartshorn and Colton (1967) differentiated them from the deposits at Rocky Hill. We have divided the Jobs Pond deposits into two units; one is continuous with deposits in the Connecticut River channel to the south (unit lc, fig. 1), which now are thought to be largely deltaic; the other is graded to glacial Lake Middletown (lmj) and is also deltaic. Unit lc deposits were laid down before the ice margin retreated from Straits Hill; glacial Lake Middletown opened after the ice margin retreated from Straits Hill. The Portland Burying Ground delta was one of the first deposits that was graded to glacial Lake Middletown.

STOP 5. Michael Kane Brick Co. pit, Middletown, Middletown quadrangle. Entrance is on east side of Connecticut Route 72, 0.8 mi (1.3 km) north of the intersection of Route 72 and Westfield Street.

The pit exposes lake-bottom deposits of glacial Lake Middletown (unit l, fig. 1). These deposits, called the Berlin clay by Deane (1967), consist of reddish-brown silt and clay in couplets that are commonly 5 cm thick. The Berlin clay supposedly was overridden by the so-called Middletown readvance (see discussion above). Part of the evidence for this event was what Flint called "till equivalent" (Flint and Cushman, 1953; Simpson, 1959). Although that term was not formally defined, it evidently refers to features observed on the Berlin clay in some exposures: a zone of contorted varves, or a layer of homogeneous silt and clay that includes remnants of deformed varves and/or pebbles and cobbles. The Kane pit (actually a pit 0.3 km south of the present active pit) was included in the itinerary for a 1953 field trip (Flint and Cushman, 1953) and listed as "till equivalent on varved clay"; the stop was omitted on the actual trip, but J. P. Schafer noted that Flint described the locality as showing "upper 18 inches of clay contorted, with scattered stones." That is the only cited evidence in Middletown itself for what has come to be called the Middletown readvance. The following section is exposed in the southeast corner of the active pit:

0.8 m	spoil
1.4 m	thinly to very thinly bedded, fine to very fine sand in which bedding is contorted.
0.15 m	stratified medium to very coarse sand, containing some small pebble gravel.
0.3 m	massive very fine sand and silt; bed contains a detached block of the same sediments. Embedded stones have been seen in this stratum in exposures nearby.
0.15 m	stratified medium to very coarse sand, granule gravel, and small pebble gravel, containing a trace of silt; poorly sorted.
———	erosional contact ———
0.45 m	rhythmically bedded, very fine sand, silt, and clay; total of three couplets with weak convolutions. Uppermost bed is greasy clay, which is thickened and thinned where penetrated by overlying sand and gravel bed. Each lamina consists of many microlaminations; contacts are gradational within and between couplets.
9.0 m	varved silt and clay. The varves are thinner and slightly finer grained than the rhythmites above them, and are undisturbed except for broad warping. An additional 3 m of clay is reported from test holes in this pit that do not reach bedrock.

The deposits above the rhythmites are shown as a stream terrace unit (st) on the map in figure 1, and appear to be continuous with 3 m of sand and pebble gravel that is exposed in excavations about 200 m east-southeast of this section. We believe that these sediments were deposited soon after the lake was drained, when Lake Hitchcock overflow water was still coming down the Mattabesset drainage.

The deformed structures shown by some beds in this section are interpreted by us as syndepositional load structures. The occurrence of stones scattered through a silt and sand stratum, not shown in the measured section but seen in several nearby sections, is attributed by us to such processes as foundering of thin gravel layers or rafting by river or lake ice. These two types of features possibly were interpreted by Flint as "till equivalent", especially if they occurred at a place where the postlake alluvial sediments were thinner and their character less obvious than at the present pit. Of course, what Flint saw more than three decades ago may have been something quite different from what we see here now.

We question the occurrence of a readvance at Middletown because of stratigraphic relationships in the basin. The massive Cromwell delta complex 3 km north (Stop 6) was deposited in glacial Lake Middletown occupying this basin. Because these deltas were not overridden by ice, any readvance must have preceded their deposition, and the lake-bottom facies associated with the deltas would of necessity overlie the readvance stratum. No lake-bottom sediments overlie the "till equivalent" zones as described by Flint and others. We suggest, therefore, that the lake-bottom facies of the Cromwell deltas is the varved sequence exposed here at Kane pit, and that any "glacially contorted material" may have resulted from such processes as load deformation, ice rafting of stones into shallow lake-bottom sediments, or thrust or drag caused by grounded icebergs.

STOP 6. Pit northeast of Mustard Bowl, town of Rocky Hill, Hartford South quadrangle. Turn east from Main Street (Connecticut Route 99), 0.1 mi (0.15 km) north of Brook Street, onto new street, and travel 0.75 mi (1.2 km); pit entrance on right at intersection with Dividend Road.

The Cromwell-Rocky Hill delta complex consists of a southern part in Cromwell that was built into open waters of glacial Lake Middletown, and a northern part in Rocky Hill that was controlled in altitude by the Dividend Brook spillway (fig. 5). The pit is in the first delta to be controlled by that spillway, which started out at about 150 ft; the altitude of the topset/foreset contact in the pit is estimated to be at 149 ft. The spillway was fairly rapidly cut down to its present 129-ft level; no further deepening took place because glacial Lake Middletown stood near this level at the spillway mouth. On the map (fig. 1), all these deltas are part of the glacial Lake Middletown map unit, but the more southerly ones controlled by the open lake are subunit lmr and the more northerly ones controlled by the Dividend Brook spillway are subunit lmd. Previous workers (Hartshorn and Koteff, 1968; Hartshorn and Colton, 1967; Langer, 1977) considered the Dividend Brook spillway to be an early high-level control for glacial Lake Hitchcock (see above discussion of the lake).

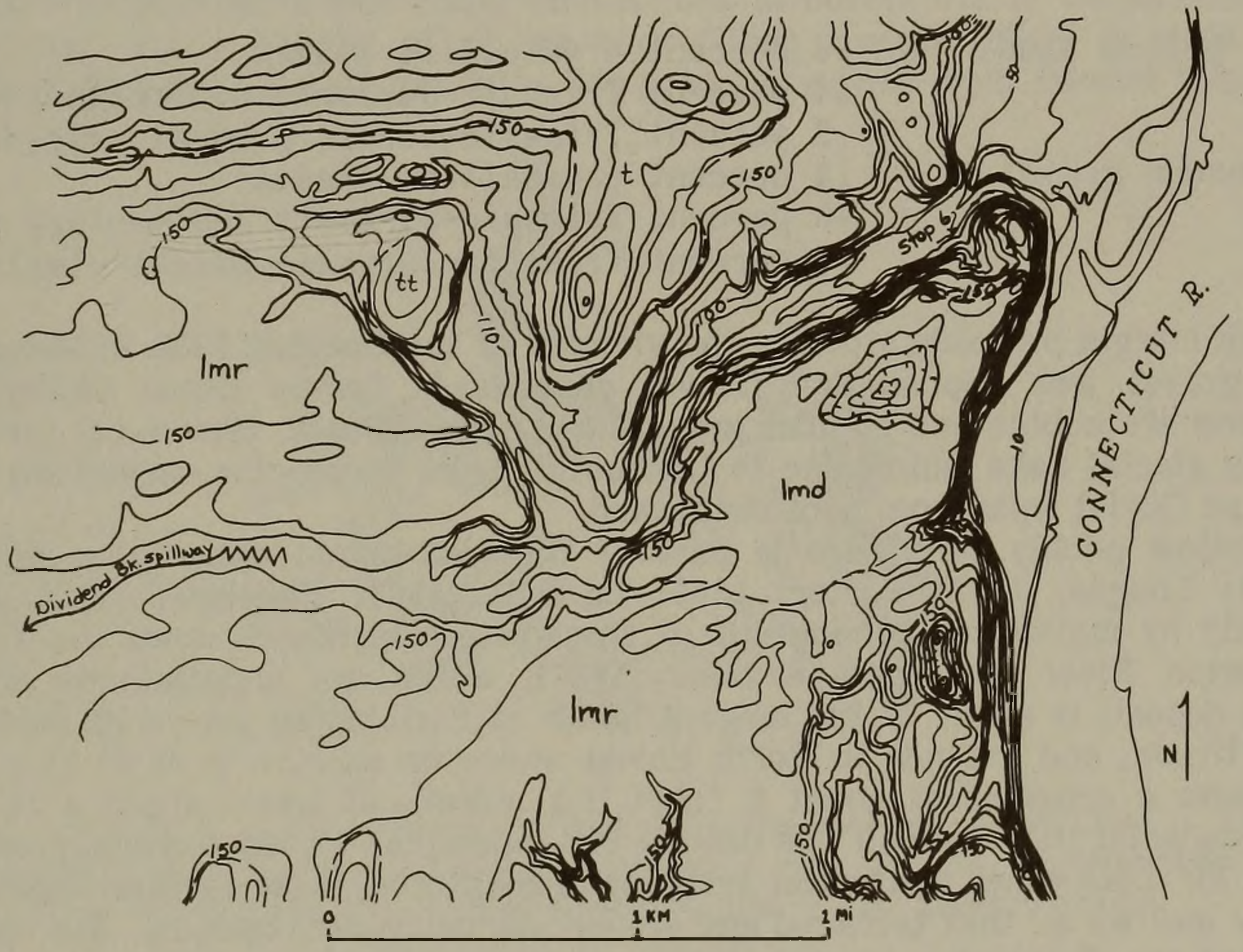

Figure 5. Topography of the Dividend Brook spillway and adjacent deposits from the U.S. Geological Survey topographic map of the Hartford South 7 1/2' quadrangle, 1952 edition. See Stop 6 for description.

The pit exposes about 30 m of ice-contact and deltaic sediments. The northeastern part shows highly collapsed fluvial topset beds composed of coarse gravel. Toward the distal end of the collapsed zone, these beds are collapsed 4-5 m (measured from the uncollapsed topset level), yet show little evidence for intrastratal deformation. The southwestern part of the pit exposes noncollapsed deltaic topset and foreset beds. In the lower foresets, fine to medium sand occurs in ripple-drift cross-laminated units, interbedded with planar beds and festoon crossbeds. In the middle to upper foreset beds, pebbly sand, pebble gravel, medium to coarse sand and silty sand beds dipping 10 to 15° toward the southwest show planar beds and tangential crossbeds. Topset beds are composed of approximately 3 m of pebble-cobble gravel and sand in fluvial planar beds.

Just southwest of this pit, collapse of topset and foreset beds toward the Mustard Bowl kettle was shown in a former pit centered on the kettle. The surface of the isolated ice block that produced the kettle was at least partly below lake level, perhaps weighed down by deposits. At the end of deposition, the ice block was mostly or completely buried by delta sediments derived from meltwater streams issuing from the main ice mass to the northeast.

STOP 7. Pit on west side of Meriden-Markham Municipal Airport, town of Wallingford, Meriden quadrangle. Access is by dirt road that turns west off Hanover Street near power line, 1.3 mi (2 km) south of junction (as Evansville Avenue) with Main Street (Connecticut Route 70) in South Meriden. Pit is just west of the landing strip and north of a small stream.

The pit exposes two glaciofluvial units. The lower unit is reddish-brown pebble-cobble gravel, mostly in horizontal planar beds 10-20 cm thick. Stones are imbricated; crossbeds occur in 30 cm sets. The upper unit consists of 1.5 m of yellowish-gray pebbly coarse sand containing tangential crossbeds in 10-20-cm sets. Stone counts in these units showed:

yellow sand	-	64 percent crystalline clasts
		34 percent Triassic-Jurassic sedimentary clasts
		2 percent Triassic-Jurassic basalt clasts
red-brown gravel	-	14 percent crystalline clasts
		48 percent Triassic-Jurassic sedimentary clasts
		38 percent Triassic-Jurassic basalt clasts

The ice margin probably stood in the vicinity of the Hanging Hills in Meriden when the lower gravel was deposited. Gravel deposits in Sodom Brook valley coarsen northward and are cobble and boulder gravel near Beaver Pond. Base level for this unit was probably glacial Lake Quinnipiac to the south. Lake Quinnipiac varved silt and clay underlie these fluvial units from here southward.

The yellow pebbly sand here is part of the well-known Quinnipiac valley train (Flint, 1934; Lougee, 1938; Porter, 1960; La Sala, 1961; Hanshaw, 1962) deposited predominantly by meltwater coming out of the western highlands down the Pequabuck and Farmington River drainages (Krynine, 1937), which are underlain by crystalline rocks. This deposit is about 47 km long; it heads at Farmington where its surface is at 210 ft in altitude, and extends to North Haven where its surface is at 35 ft. It slopes southward with a gradient of about 6 ft/mi (1.1 m/km), of which about 4 ft/mi (0.75 m/km) is postglacial tilt. We call this deposit the Quinnipiac Valley terrace, glaciofluvial unit qt (fig. 1). Like other meltwater terraces in the State, these terrace deposits were laid down by meltwater that terraced and eroded slightly older deposits. The meltwater that deposited the Quinnipiac terrace sediments first eroded into deltaic and lacustrine deposits of glacial Lake Southington, the water level of glacial Lake Southington having slowly dropped as the barrier at the Quinnipiac Gorge was eroded. The meltwater, which came mostly from the spillway of glacial Lake Farmington to the north, must have carried the material eroded from the Southington deposits through the gorge and out onto the surface of the glacial Lake Quinnipiac sediments in the lower Quinnipiac River valley. No crystalline-derived material could be carried southward, however, until the waters of glacial Lake Farmington (unit lf, fig. 1) had also dropped. Ice-contact deltas graded to this lake occur as far north as Avon. Therefore, the crystalline-derived yellow sand and fine gravel of the Quinnipiac terrace must have been laid down during the time of ice retreat from Avon to Tariffville. When the Tariffville gap was opened, water levels in the valley dropped from approximately 300 ft down to about 200 ft in altitude, causing the Farmington River joined by the Pequabuck River to turn northward, thereby ending the supply of meltwater and sediment to the Quinnipiac valley.

STOP 8. County Wide Construction Co. pit, town of Cheshire, Southington and Meriden quadrangles. Entrance is north from East Johnson Avenue 0.3 mi (0.5 km) west of junction with Cheshire Street.

This pit and that at Stop 9 expose the internal structure of ice-contact deltaic morphosequence 2 (fig. 2), which is an esker-fed delta (fig. 6) built into glacial Lake Southington (unit ls, fig. 1). When the ice margin retreated north of the Mill River-Quinnipiac River drainage divide, ponded deposits (unit md), graded to local spillways over that divide, were laid down in four north-draining valleys. The easternmost of the these deposits in the Broad Brook valley appears to have blocked the Quinnipiac Gorge and impounded the waters of glacial Lake Southington, which expanded to the north as retreat of the ice margin continued.

The exposure shows an excellent oblique view of foreset beds dipping southwesterly. The northeast end of the pit shows foresets of pebble-cobble gravel and sand in crosscutting planar beds that dip 25-30°. In the middle face, a 1.5-m-thick bed of fining-upward boulder-cobble gravel occurs; this gravel may be the result of a subaqueous gravity flow down the foreset slope. The southwest end of the face shows finer grained foresets dipping 10-20°; the fine to medium sand and silty sand beds consist of characteristic ripple-drift and drape laminations in cosets 0.3 m thick; coarse sand to granule gravel layers consist of planar beds filling troughs 10-20 m wide and 2-5 m thick. The southwest slope of the delta was probably a free-front foreset slope.

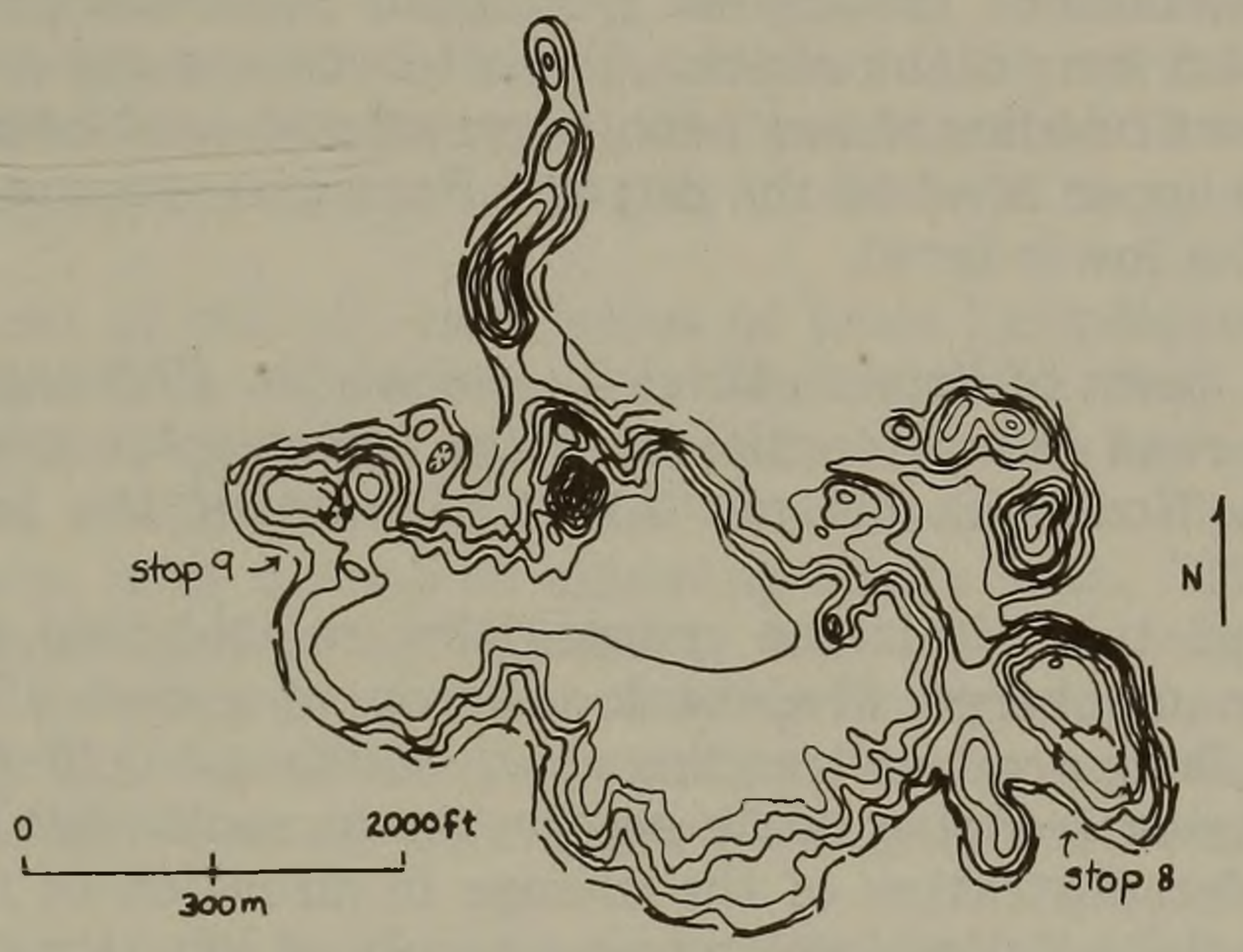

Figure 6. Topography of the "Lougee delta" from the U.S. Geological Survey topographic map of the Southington 7 1/2' quadrangle. See Stops 8 and 9 for description.

STOP 9. Pipeline pit, town of Cheshire, Southington quadrangle. Entrance is east off Connecticut Route 10, 0.2 mi (0.3 km) north of junction with East Johnson Avenue.

The stop is at the "Lougee delta" (fig. 6). R. J. Lougee made a plane-table map of this delta, using a 5-ft contour interval, and published it in his 1938 monograph "Physiography of the Quinnipiac-Farmington Lowland in Connecticut". Most of his observations and interpretations in this early work are supported by our current compilation.

From the corner of the field immediately south of the pit area, the flat surface of the delta can be viewed; looking northeast from this point, a section of the esker that fed the delta can be seen. This landform is an excellent example of an ice-contact delta fed by an ice-channel stream. The esker, which may or may not have been built in a tunnel, extends from the proximal edge of the delta where its altitude is 200 ft, northward for approximately 1 km; at its northern tip, it is at 150 ft. An excavation in the esker several years ago revealed reddish-brown cobble-pebble gravel.

The pit, which is on the west edge of the delta, shows minor collapse. The fluvial topset beds exposed in the westernmost part of the pit are pebble-cobble gravel and sand in slightly collapsed horizontal beds. The eastern part of the pit shows foreset beds cut by high-angle faults.

STOP 10. Swede Pond pit, town of Berlin, Meriden quadrangle. Entrance is at the end of a new development road which runs east off Elton Road, 0.25 mi (0.4 km) south of the junction with Kensington Road.

On the way to Stop 10, climb from Meriden on Route 71 (Capitol Avenue) toward the scarp of the Hanging Hills, and into a fault-controlled notch where steep active basalt talus slopes are present below the cliffs. Cross the divide, emerge into Hatchery Brook valley, and descend over successively lower delta surfaces. This valley and Belcher Brook valley to the east, where the stop is located, are two of several valleys that drain the north slope of the Hanging Hills. In each of these valleys, meltwater was ponded between the retreating ice margin and local cols, and deltas were deposited at successively lower altitudes as progressively lower outlets from the valleys were uncovered. The result was the deposition of a large deltaic complex on the north slope of the Hanging Hills; these deltas are mapped collectively as one unit (hh, fig. 1). At least 12 ice-contact deltaic morphosequences can be differentiated within these deposits.

At the Swede Pond pit, the typical deltaic nature of such deposits can be seen. The pit is cut into the 195-ft surface of the lowest (youngest) sequence graded to a 165-ft spillway across the divide, 4.5 km to the south. Topset beds are not now visible in the pit; a good exposure of foreset bedding shows pebble-gravel and sand beds dipping steeply toward the southwest in the upper level of the pit; and finer grained, more gently dipping toeset beds are exposed in the lower level.

STOP 11. Barnum Road pit, town of Bristol, Bristol quadrangle. Entrance to pit is at the end of Barnum Road. This road is not identified on the topographic map; it turns south off Terryville Avenue (U.S. Route 6), 0.1 mi (0.15 km) west of the junction with Hill Street.

The main attraction at this pit is the crosscutting relationship of striations and grooves seen on a recently uncovered whaleback outcrop of gneiss of the Collinsville Formation. Large, straight, long grooves trending south-southeast (160-164°) are crossed by short and less regular striae trending south-southwest to southwest (195-229°). The striations are an excellent demonstration of the change in direction of ice movement on the west side of the Connecticut Valley lowland as a result of lobation of the ice margin during retreat. During the maximum of glaciation, when ice movement was generally south-southeast, the large grooves were produced. During retreat, when ice of the Connecticut Valley lobe impinged on the edge of the western highlands, direction of ice movement was southwest; hence, the smaller southwest-trending striae cross the slightly older south-southeast-trending grooves.

In the pit to the east of this outcrop, most of the faces are slumped, but topset and foreset bedding can be seen. This deposit is part of the same delta exposed at the next stop. Unusually abundant and large flakes of muscovite, derived from The Straits Schist which crops out nearby, occur in the foreset beds in this pit.

STOP 12. Scalia Brothers pit, town of Bristol, Bristol quadrangle. Entrance to pit is east off Barlow Street which turns south off Terryville Avenue (U.S. Route 6), 0.3 mi (0.5 km) west of junction with Hill Street.

This pit and the one at Stop 11 are in a flat-topped delta at an altitude of 640-650 ft. The delta is part of an extensive complex of primarily deltaic sediments (unit br, fig. 1) deposited in high-level lakes impounded against the upland in the Pequabuck River valley by the Connecticut Valley ice lobe. Deposits in the southern part of this complex were graded to a spillway at 625 ft across the Pequabuck-Naugatuck divide. In this pit 3 m of topset beds composed of cobble-pebble gravel and sand disconformably overlies 8 m of coarse sand, pebbly sand, and silty sand beds. The sand beds consist of 20-50-cm sets of tangential crossbeds alternating with subhorizontal planar beds; current directions are westerly. Little readily apparent dip of these beds can be seen, but the morphology and structure of the surrounding deposit and the basin geometry indicate that the sand must have been deposited below a water plane. These lacustrine beds in which current structures predominate may have been deposited subaqueously under constricted flow conditions, or they may actually be proximal bottomset beds. Pebbly sand foreset beds dipping gently to the southwest that are about 4 m thick are exposed at the north end of the main face, stratigraphically below the other sand. Collapse structures are visible in the north part of the pit. Our interpretation at this pit is an example of the way in which regional relationships of ice-margin and basin geometry impose constraints on the interpretation of sedimentary structures.

STOP 13. Russack Brothers sand and gravel pit, town of Plainville, New Britain quadrangle. The pit is bounded by the Farmington-Plainville town line, the railroad, and the Pequabuck River. The entrance is off Hyde Road, which is now the main artery of an industrial park. The new road layout is different from that shown on the topographic map. We will visit the southern section of the pit.

The pit shows lacustrine sediments of glacial Lake Farmington (unit lf, fig. 1) overlain by glaciofluvial deposits of the Quinnipiac valley terrace (unit qt). Terrace sand and gravel 3-4 m thick have been removed from most of the area, but a few patches remain. The Quinnipiac terrace is at 205 ft in altitude here, 4 km south of its head at Farmington.

In the south part of the pit, two facies of Lake Farmington sediments are exposed. In the upper facies, 1-2 m of moderate-brown, massive very fine sand and silt grade downward into laminated very fine sand, silt and clay. The lower facies consists of 1-2 m of light-gray fine to medium sand in distal bottomset beds dipping gently to the north; planar beds alternate with 0.3-0.5-m climbing-ripple sets. The climbing ripples show northerly paleocurrent directions indicating that the source of these sands was the Pequabuck drainage to the south. The overlying fine-grained sediments were most likely laid down as slightly later lake-bottom sediments during deposition of ice-contact deltas to the north; those lake-bottom sediments pinch out southward and are absent at the south end of the pit.

During the time of ice retreat through Plainville and Farmington and northward to Avon, glacial Lake Farmington occupied the Farmington-Quinnipiac valley. The valley was blocked to the south by deposits of glacial Lake Southington; the spillway for the lake was over till and bedrock at about 190 ft in altitude, 2.4 km northwest of Southington center. Interstate Route 84 now goes through this spillway. Deltaic sediments graded to this lake occur as far north as Avon; as much as 80 m of lake-bottom silt and clay underlies the deltaic and terrace sediments.

STOP 14. The "red and white" pit, town of Windsor, Windsor Locks quadrangle. Turn north off Prospect Hill Road, 0.15 mi (0.2 km) east of junction with Blue Hills Avenue (Connecticut Route 187). Travel 0.5 mi (0.8 km) to tobacco barns; continue on dirt road past barns to pit.

The red and white pit is so named for the contrasting colors of the gravel and sand beds. The contrast seems to be texturally controlled and has been observed in other exposures of sediments presumably derived from Triassic-Jurassic rocks. Gravel beds and fine-grained layers are red-brown; medium to fine sand layers are light gray to almost white. Establishing the provenance of the "white" sand would make a good thesis topic for someone.

The deposits here also are deltaic; the channeled surface cut into the foreset sands by the streams depositing the topset gravels displays as much as a meter of relief. The surface here stands at 205 ft in altitude; the deposit extends southward for approximately 2 km and stands 10-20 ft higher than the high-level Lake Hitchcock deltaic sediments that surround it. The 190-195-ft water level indicated by the topset/foreset contact here, adjusted for postglacial tilt, projects to the New Britain spillway at 135-140 ft in altitude, too high for Lake Hitchcock. This delta possibly was deposited in an exceptionally large hole in stagnant ice; however, we suggest that it may have been controlled instead by the glacial Lake Middletown water plane still persisting in the Hitchcock basin. Deposits at about the same altitude, which are probably deltaic (no cuts seen), occur on the east side of the basin, near the moraine of Stop 15.

STOP 15. Windsorville moraine(?) pit, town of East Windsor, Broad Brook quadrangle. From Windsorville intersection (Thrall Road, by Ketch Brook), go northwest 0.45 mi (0.75 km) to V intersection, at which bear right; Boutin pit is on right in 0.2 mi (0.3 km).

The narrow ridge (fig. 7) just north of Windsorville is about 1.2 km long, trends north-northeast, and has a sharp ice-contact slope on its north side. The front slope of the ridge overlooks a sand plain having a conspicuous southeast slope of about 6.5 m/km (35 ft/mi), which may be seen along Thrall Road. The ridge lacks exposures; whatever its composition, it stands 3-15 m above surrounding deposits, and presumably marks an ice-contact position on the east side of the Connecticut Valley lobe. The position may be correlative with that represented by the ice-contact delta at Stop 14.

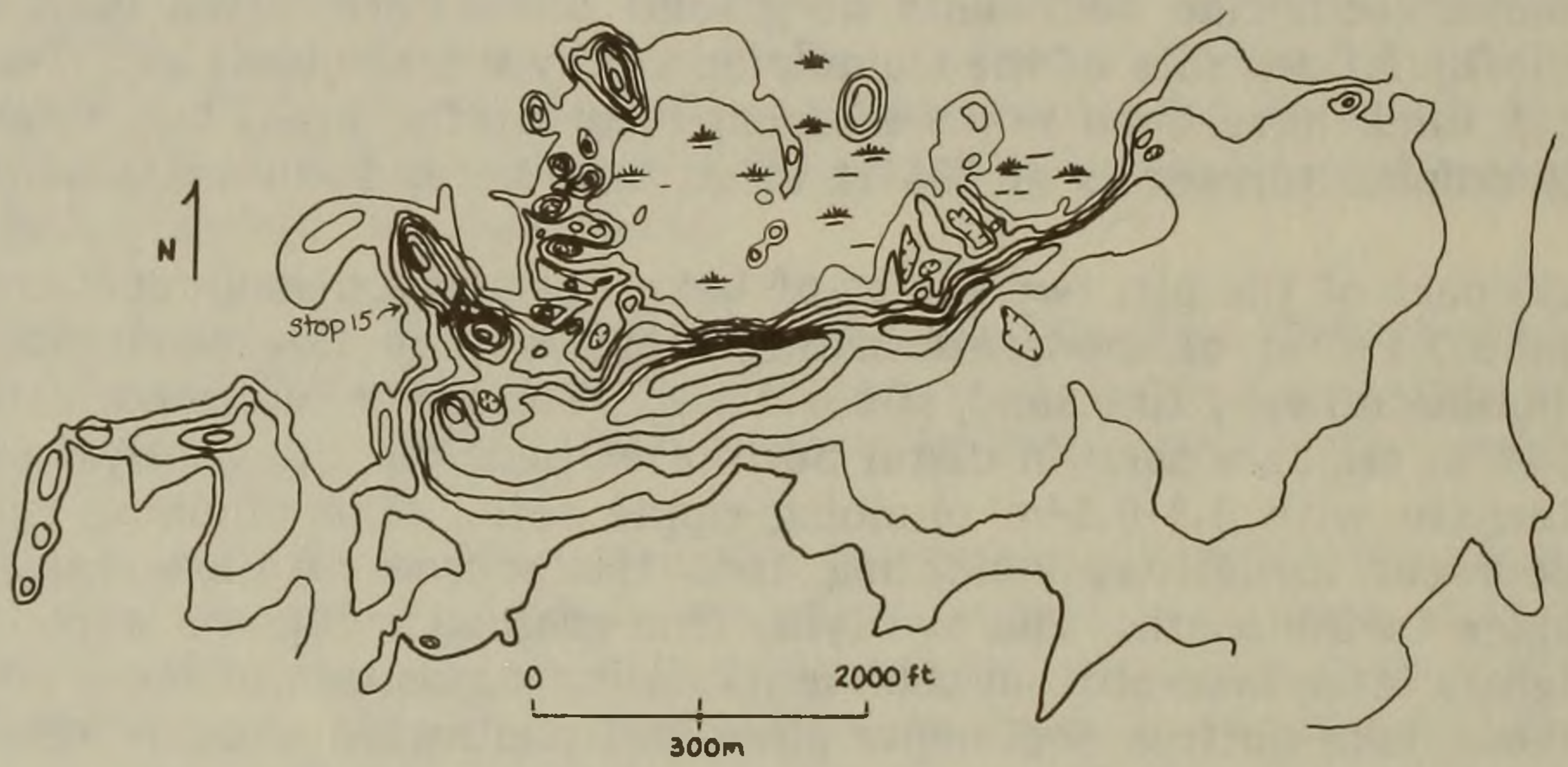

Figure 7. Topography of the Windsorville "moraine" from U.S. Geological Survey topographic map of the Broad Brook 7 1/2' quadrangle. See Stop 15 for description.

The pit is in collapsed deposits just north of the west end of the ridge. A slumped cut at the north side is at least partly in till. A slumped cut at the south side is in collapsed sand and gravel. The main active face, in the bottom of the south part of the pit, exposes sand deposited in a small lake and an interbedded layer of reddish-brown till. The till is at least 1 m thick to the east, and thins to the west in a way that is suggestive of a flowtill. However, the sand is deformed beneath the till, in one place by a 1-m-thick zone of recumbent folds and flat faults, and the deformation is more indicative of overriding than of flowtill deposition.

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ROAD LOG FOR TRIP Q1

Distances were measured from topographic maps, and will be slightly different from (generally less than) distances recorded on the road.

MILES	
0.0	Meeting place: Tylerville (town of Haddam, Deep River quadrangle), intersection of Conn. 9A and 82; parking area for stores at SE angle of intersection. Go SE on Conn. 9A.
0.15	Turn left (NE) at entrance to pit.
0.35	STOP 1. Return to pit entrance.
0.6	Turn right (NW) on Conn. 9A.
0.75	Turn right (NE) on Conn. 82. Cross Connecticut River.
1.7	East Haddam village; turn left (N) on Conn. 149. Enter Moodus quadrangle at 5.4 mi.
7.2	Turn left (N) on Trowbridge Road, which becomes Water Hole Road.
9.7	Turn left (NW) on Conn. 16. Cross Salmon River.
10.2	Turn right (NE) on River Road.
10.7	Park and wade river to STOP 2. (Alternatively, park at covered bridge near Conn. 16 bridge, and walk up E bank.) Return SW on River Road.
11.2	Turn right (NW) on Conn. 16. Pit in complexly collapsed gravel and sand on right at 11.3 mi. Enter Middle Haddam quadrangle at 14.1 mi.
16.3	Turn left (W) on Conn. 66; old pit in delta on left. Another old pit in delta (unit 1c, fig. 1) on left at Axelrod Tire at 18.4 mi.
20.1	Turn right (N) on Conn. 17. Cross from crystalline rocks of eastern highlands onto Jurassic redbeds.
21.2	Turn right (E) on Bartlett Street. Turn right at pit entrance road by house at 21.3 mi. or walk in from back of Portland Burying Ground just to E.
21.55	STOP 4. Return on Bartlett Street and Conn. 17 to Conn. 66.
23.0	Turn right (W) on Conn. 66. Enter Middletown quadrangle at 24.1 mi. Go through Portland and cross Connecticut River to Middletown.
26.2	Continue straight ahead (S) on Main Street (where Conn. 66 turns right on Washington Street).
27.15	Bear right (S) on Ridge Road.
27.2	Turn right (W) on Mill Street.
27.35	STOP 3. Marino Crane Service site on left; park near street. Return to Conn. 66.
28.5	Turn left (W) on Conn. 66 (Washington Street).
28.9	Turn right (NW) on Conn. 72.
30.4	Turn right (E) at Michael Kane Brick Co. entrance. Cross railroad on dirt track, then turn left (N) to clay pit.
30.9	STOP 5.

Alternative route from Stop 1 if Stop 2 is omitted:

(0.6	Turn left (SE)on Conn. 9A.
(0.8	Turn right (SW) on Conn. 82.
(3.0	Turn right (NW) on entrance ramp for northbound Conn. 9. Enter Haddam quadrangle at 3.5 mi, Middle Haddam quadrangle at 10.3 mi, and Middletown quadrangle at 14.1 mi.
(14.6	Exit from Conn. 9 at Interchange 12.
(14.7	Turn left (W) on Bow Lane.
(14.9	Bear right (NW) on Saybrook Road.
(15.2	Turn left (W) on Mill Street.

(15.55 STOP 3. Marino Crane Service site on left; park near street. From here to STOP 4 (21.4 mi), reverse the route described above. Then return to Middletown and continue on Conn. 66 to Conn. 72 (26.5 mi), and turn rt to STOP 5 (28.5 mi) as described above.

From STOP 5 (30.9 mi), return to entrance.

31.4 Turn right (N) on Conn. 72.

32.9 Bear right (N) on Conn. 3.

33.8 Turn right (E) on Evergreen Road.

35.1 Turn left (N) on Conn. 99 (Main Street). Enter Hartford South quadrangle at 36.0 mi.

37.5 Turn right (E) on new divided street.

38.3 At intersection with Dividend Road, turn right into pit entrance.

38.6 STOP 6. Return to Conn. 99.

39.7 Turn right (N) on Conn. 99.

40.3 Turn left (W) on West Street. Dinosaur State Park on left at 41.1 mi.

42.0 Turn left (S) on entrance ramp for southbound Interstate 91. Enter Middletown quadrangle at 44.0 mi and Meriden quadrangle at 50.3 mi.

51.6 Bear right (SW) on exit ramp from Interstate 91 to Conn. 15 (Wilbur Cross Parkway). Enter Wallingford quadrangle at 54.5 mi.

55.2 Exit from Connecticut 15 at Interchange 66.

55.3 Turn left on U.S. 5.

55.6 Turn right (W).

55.7 Turn right (NW) on Church Street.

56.4 Yalesville; turn right on Hanover Street. Enter Meriden quadrangle at 57.0 mi.

57.1 Turn left (W) on dirt track that bends N, goes under power lines, past a small pit, across a little stream, and turns E to pit on W side of airstrip.

58.0 STOP 7. Return to Hanover Street.

58.9 Turn left (N) on Hanover Street, which becomes Evansville Avenue.

60.2 South Meriden; turn left (W) on Conn. 70 (Main Street). This highway enters Quinnipiac Gorge at 60.6 mi; weathered New Haven Arkose (Triassic) at left.

62.2 Bear right (NW) from Conn. 70.

62.4 Turn right (N) on Cheshire St.

64.0 Turn left (W) on East Johnson Avenue.

64.3 Turn right (N) at pit entrance (2nd track).

64.4 STOP 8. Return to East Johnson Avenue.

64.5 Turn right (W) on East Johnson Avenue. Enter Southington quadrangle at 64.55 mi. Road climbs over front of delta; old pit in foreset slope on left at 64.8 mi.

65.4 Turn right (N) on Conn. 10.

65.6 Turn right at pit entrance, along pipeline.

65.75 STOP 9. Return to Conn. 10.

65.9 Turn right (N) on Conn. 10.

66.6 Turn right (E) on Conn. 66. Enter Meriden quadrangle at 67.4 mi. Dinosaurs in back yard on left at 68.7 mi. Turn right on ramp to new part of Conn. 66 at 68.95 mi.

71.0 Exit from Conn. 66.

71.1 Turn left (N) on Conn. 71 (Capitol Avenue). Active talus slopes on right below Holyoke Basalt cliffs, at 71.6-72.1 mi. Beginning at 72.5 mi, road is on ponded meltwater deposits that are discussed under Stop 10.

74.1 Turn right (E) on Orchard Road.

75.1	Turn left (N) on Kensington Road.
76.4	Turn right (S) on Elton Road.
76.65	Turn left (E) on new street to pit.
76.8	STOP 10. Return to Kensington Road.
77.2	Turn right (E) on Kensington Road, then N. Enter New Britain quadrangle at 78.7 mi.
79.5	Kensington; turn left (NW); becomes Corbin Avenue.
82.4	Turn left (W) on ramp to westbound expressway.
83.6	Expressway joins westbound Interstate 84 and passes through the Cooks Gap wind gap (a segment of a Tertiary stream course?); quarries in Holyoke Basalt on both sides.
83.9	Exit from Interstate 84 at Interchange 34.
84.1	Turn right (NE).
84.3	Turn left (NW) on Conn. 72. Enter Bristol quadrangle at 86.4 mi.
90.4	Turn right (N) onConn. 69. Cross onto crystalline rocks of western highlands at 88.5 mi.
91.1	Turn left (W) on U.S. 6.
92.4	Turn left (S) on Barnum Road; enter pit across small stream.
92.6	STOP 11. Return to U.S. 6.
92.8	Turn left (W) on U.S. 6.
93.0	Turn left (S) on Barlow Street.
93.35	Turn left (E) into pit.
93.45	STOP 12. Two more pits 0.25 and 0.5 mi SE of this one. Return to U.S. 6.
93.9	Turn right (E) on U.S. 6.
100.6	Turn right (S) on New Britain Avenue.
100.9	Turn right on Hyde Road.
101.2	Turn left (SE) into large pit area. (Road location uncertain because Hyde Road has been relocated.) Go S to S part of pit area.
101.9	STOP 13. Return to U.S. 6.
103.2	Turn right (E) on U.S. 6. Cross basalt ridge.
107.3	Turn left (NE) on ramp to eastbound Interstate 84. Enter Hartford South quadrangle at 109.8 and Hartford North quadrangle at 112.6 mi.
115.1	Exit from Interstate 84 to northbound Interstate 91. Enter Windsor Locks quadrangle at 122.8 mi.
122.8	Exit from Interstate 91 at Interchange 38.
123.0	Turn right (NW) on Conn. 75.
123.2	Turn left (SW) on Day Hill Road.
125.8	Turn left (SW) on Prospect Hill Road.
126.8	Turn right (N) on paved road.
127.3	Continue to N on dirt track beside row of tobacco barns, to pit.
127.6	STOP 14. Return to Interstate 91.
132.2	Turn left (N) from Conn. 75 onto ramp to northbound Interstate 91. Cross Connecticut River and enter Broad Brook quadrangle at 135.9 mi.
136.5	Exit from Interstate 91 at Interchange 44 to southbound U.S. 5.
137.8	Turn left (E) on Tromley Road. Road bends left and crosses Scantic River at 140.0 mi, bends right and crosses Broad Brook Road at 140.7 mi. Moraine of Stop 15 behind St. Catherines Cemetery on left at 141.9 mi.
142.2	Windsorville; turn left (NE) on Thrall Road. Moraine ridge just to left, exceptionally steep sand plain on right (fig. 7). Bear left on Thrall Road, turn right on Chamberlain Road, East Road , and Clark Rd.
144.3	Windsorville; turn right (W). Bear right (N) at 144.8 mi.

144.55 Turn right (E) into pit.

144.65 STOP 15. Return to Windsorville.

145.0 Windsorville; turn right (SW) on Wapping Road.

145.1 To reach Storrs, turn left (SE) on Rockville Road, which becomes Windsorville Road; then by Conn. 74 and 195.

To reach southbound Interstate 84, continue SW on Wapping Road, bear left on Miller Road and right on Graham Road, and join Conn. 194. At Wapping (South Windsor), go S on Buckland Road, then right (W) on Burnham Street and left (SE) on Windsor Street to Interstate 84 at Interchange 93.