

STATE OF DELAWARE  
UNIVERSITY OF DELAWARE  
DELAWARE GEOLOGICAL SURVEY

OPEN FILE REPORT No. 8

GUIDEBOOK: COLUMBIA DEPOSITS OF DELAWARE

BY  
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JOHN H. TALLEY

NEWARK, DELAWARE  
MAY, 1976

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## FRIENDS OF THE PLEISTOCENE

### 1976 REUNION

The Delaware Geological Survey welcomes you to the 1976 Reunion of the Friends of the Pleistocene at the University of Delaware. The DGS is pleased to provide participants with a guidebook to the Columbia Deposits of Delaware in the form of DGS Open File Report No. 8. This and other publications, maps, and guides to points of interest in the area are included in the packet that you will receive on arrival at Clayton Hall.

The materials that mantle the Coastal Plain of Delaware are of considerable scientific interest as well as of great practical importance. The Coastal Plain may contain portions of the geologic record helpful to our understanding of the critical transition between the continent and the ocean basin during a dynamic portion of earth history. We hope that all attendees will feel encouraged to participate in our discussions and to share their thoughts with the group.

Our itinerary is as follows:

#### Friday, June 4

- |                   |  |
|-------------------|--|
| 12 noon - 5:00 pm | Arrival and registration, Clayton Hall, University of Delaware. Personnel will be provided to answer questions and to show participants to the housing facilities at Christiana Towers West.   |
| 5:00 pm - 6:30 pm | Dinner on your own. Enclosed in the registration packet is a selection of restaurants in Newark and the surrounding area. Personnel at Clayton Hall will be glad to provide recommendations and directions to the restaurant of your choice. |
| 6:30 pm - 7:30 pm | Social hour, Clayton Hall.   |
| 7:30 pm - 9:30 pm | Discussion of the Columbia deposits of Delaware, Room 125, Clayton Hall.   |

Saturday, June 5

- 6:00 am - 7:00 am Breakfast, Room 101B, Clayton Hall.
- 7:30 am - 6:30 pm Field trip to central and southern Delaware. The road log to be followed is outlined on figure 3, page 16 of the Guidebook and on the State of Delaware Official Highway Map which is included in the packet. Beverages and a box lunch will be provided.
- 7:00 pm - 8:00 pm Social hour, Room 101B, Clayton Hall.
- 8:00 pm Annual Dinner, Room 101B, Clayton Hall.

Sunday, June 6

- 6:30 am - 7:30 am Breakfast, Room 101B, Clayton Hall.
- 8:00 am - 12 noon Field trip to northern Delaware. The road log to be followed is outlined on figure 3, page 16 of the Guidebook and on the State of Delaware Official Highway Map which is included in the packet.

Thomas E. Pickett, Richard N. Benson, and Josh T. Williams of the DGS and Daniel Belknap of the Department of Geology, University of Delaware provided support in the preparation and execution of the field trip. John C. Kraft and Chacko John of the Department of Geology, University of Delaware kindly provided figure 7 in the guidebook. Special thanks are given to the many private citizens who permitted access to their properties. Mr. Ronald Thomas, State Archaeologist, will be our host at the Island Field Archaeological Site.

Refreshments for the social hours were provided by the Energy and Materials Department of the E. I. duPont de Nemours and Company.

Arrangements for the 1976 Friends meeting were made by Mr. John Schoff, Conferences and Centers, University of Delaware.

Robert R. Jordan  
John H. Talley

June, 1976

## ERRATA

for  
DGS Open File Report No. 8, "Guidebook: Columbia Deposits  
of Delaware."

- 1 - Page 13, paragraph 1, line 2. "...deposition appears to lacking except along the present..." should read "...deposition appears to be lacking except along the present..."
- 2 - Page 14, paragraph 1, line 8, "...ling of sediments. This concept has been extended south of..." should read "...ling of sediments, this concept has been extended south of..."
- 3 - Page 19, mile 30.6, line 3. One mile should read 0.25 mile.
- 4 - Page 22, mile 59.8, line 1. Del. Rt. 35 should read Del. Rd. 35.
- 5 - Page 24, mile 76.5, line 2. (left) should read (right).
- 6 - Page 31, mile 121.4, line 2. 9 o'clock should read 3 o'clock.
- 7 - Page 33, mile 149.4, line 3. (left) should read (right).

## INTRODUCTION

The Columbia sediments of Delaware cover almost all of the surface of the Coastal Plain portion of the State. A major unconformity separates these predominantly sandy materials from the underlying rocks of the Coastal Plain. As it includes the materials closest to the surface in most places, the Columbia has great practical importance in Delaware. In addition to the morphology and soils which are largely dictated by the Columbia, it holds about 90 percent of the State's groundwater supplies, is the geologic foundation for most construction, and yields essentially all of the sand and gravel mined here.

The geologic importance of the Columbia lies in the fact that it represents one of the last major chapters in the history of the eastern margin of the North American continent. It is a great clastic wedge significantly different from the older units that comprise the Atlantic Coastal Plain and Continental Shelf. Many of the major events of geologic history are recorded in the sedimentary rocks of the continental margins and perhaps in the study of these deposits there lies an opportunity to correlate the history of the continents with that of the ocean basins.

The information in the guidebook has been compiled from several older sources which are referenced throughout. The road logs have been prepared for the 1976 meeting of the FRIENDS OF THE PLEISTOCENE, a group of scholars and researchers actively engaged in the study of the Pleistocene. It is hoped that their field conference in Delaware will add useful perspective to their efforts elsewhere; we know that we will benefit from their interest in the Columbia of Delaware.

## NOMENCLATURE

Many names have been used to designate the deposits which are the subject of this field conference. A review of the very early studies, none of which has had a lasting effect on the nomenclature, has been given by McGee (1888). Jordan (1962) has reviewed later stratigraphic terminology.

The materials in question are easier to distinguish in nature than they are in terms of stratigraphic nomenclature. They form a nearly continuous veneer over the Coastal Plain of Delaware. The lower contact is an angular unconformity on the beveled edges of the older Coastal Plain rocks, the youngest known of which are Miocene. The only superjacent beds are Holocene fill and alluvium. The possible stratigraphic interval for the age of the sediments studied is mid-Miocene to Recent. Pleistocene age may be demonstrated by fossils or by radiometric means at a few localities and the entire mass is generally considered to be Pleistocene. Evidence of this is found in correlation of the rare datable horizons, postulated conditions of deposition, and state of preservation. Accurate stratigraphic delineation within the interval will require painstaking efforts of long duration for few "bench marks" are available and much indirect study must be applied.

Names which have been used for all or a part of the deposits in this area include Columbia (McGee, 1886, 1887, 1888), Sunderland, Wicomico, and Talbot (Shattuck, 1901, 1906), Parsonsburg, Pamlico, Walston, and Beaverdam (Rasmussen et al., 1960), and Omar and Staytonville (Jordan, 1962, 1967). Also, although Delaware is north of their usual area of application, the names of the terraces of Cooke (1930, 1936, 1945) are sometimes used. Jordan (1962) suggested a return to McGee's use of Columbia as a possible clarification of the nomenclature. Columbia Formation would designate the undivided sequence in northern Delaware; this would be elevated to Columbia Group in the south where it includes at least the Beaverdam and Omar Formations.

A study by Jordan (1964) suggests that the material in Delaware may be divorced genetically, as well as geographically, from the type Columbia of Washington, D.C. and therein lies the writer's only objection to the term Columbia. In view of its introduction into Delaware by its author (McGee, 1887, 1888) it is retained here as representing the closest approximation to an accurate, convenient, inclusive, and legal term for the entire mass. Sirkin and Owens (1976) prefer "Pensauken Formation" for "Columbia Formation" of the

authors and consider much of the material discussed herein to be Miocene.

### LITHOLOGY

The Columbia consists mostly of fine-, medium-, and coarse-grained quartz sand. Gravel beds, cobbles, and even boulders are conspicuous in northern Delaware and silt beds are found both north and south but are thicker and more common to the south. The deposits are essentially unconsolidated although locally there may be considerable differences in the degree of induration due to interstitial clay and/or iron oxides. Heavy bands of limonite-cemented conglomerate are common, especially toward the north. Colors range from white through yellow, tan, and brown to reddish-brown. The thickness of the surficial sand is variable in the north, ranging up to a maximum of about 100 feet in features interpreted as former fluvial channels. The thickness becomes more constant at an average of about 125 feet to the south in Sussex County.

The dispersal pattern, deduced from foreset dip directions of cross-bedding, indicates that the sediment entered the study area from the northeast, i.e., from the direction of the valley of the Delaware River between Wilmington and Trenton, and spread south and southeast over Delaware. Median grain size, maximum particle size, and maximum grade size decrease, and sorting improves, in the down-paleocurrent direction.

The sands are subarkosic; the coarser fraction consists mainly of vein quartz, sandstone and quartzite, and chert. The heavy mineral suite is dominated by zircon, epidote, amphibole, sillimanite, and staurolite.

### COLUMBIA FORMATION

Except for the Piedmont Province of northernmost Delaware, the Columbia Formation covers the northern two-thirds of the State. The thickness of the Columbia Formation is variable; in a few places it is absent and its maximum known thickness is approximately 130 feet. Its irregular bottom contact represents intensive channeling into the older Coastal Plain deposits. Rasmussen *et al.* (1957) mapped and described a system of channels in New Castle County. Jordan (1964) mapped foreset dip directions as an indication of paleocurrent orientation and concluded that the direction

of flow was essentially from north to south. Spoljaric (1967) mapped the Pleistocene channel system in New Castle County and found that an eastern and a western channel could be defined north of the Chesapeake and Delaware Canal, and that south of the Canal the pattern of the channels indicates a complex braided stream system.

The average median grain size of the Columbia Formation is near 1.0 $\phi$ . There is a variable but significant admixture of gravel, and cobbles and boulders are not uncommon. The texture varies considerably from bed to bed, and, to a lesser degree, from outcrop to outcrop. It does, however, show a somewhat systematic decrease in the downcurrent (southerly) direction. Sorting is also somewhat variable but improves in the downcurrent direction due to attrition in the larger grade sizes. The grain size distributions are characteristically bimodal, with the secondary mode representing a coarse admixture as is reflected in the predominantly negative skewness values of these materials. Conspicuously large fragments are often present; some of these are of the angular type attributed to ice rafting.

The Columbia Formation is distinctly bedded. Pebbles tend to be segregated into bands of gravel. Cross-bedding is generally well developed and tends to be of the tabular type. Strong unidirectional current trends are deduced from measurements of the cross-bedding directions.

The Columbia Formation is of fluvial origin.

#### Staytonville Unit

The term Staytonville unit is used to informally designate a mass of sediment found in southwestern Kent and northwestern Sussex Counties. A rather flat area of approximately 100 square miles, mainly between 50 and 60 feet above sea level, is underlain by these distinctive sediments. Available well records suggest that the Staytonville is up to about 40 feet thick. The average thickness is closer to 20 feet.

The Staytonville unit consists predominantly of medium-grained sands, although fine and coarse sands as well as silts are abundant. The unit is distinguished by its irregular and indistinct bedding and abrupt lateral and vertical color changes. At many exposures it is mottled both in texture and in color. This mottling may be the result of reworking by bottom dwelling organisms.

Aside from one sample which yielded pollen, no fossils have been recovered from the Staytonville unit. The



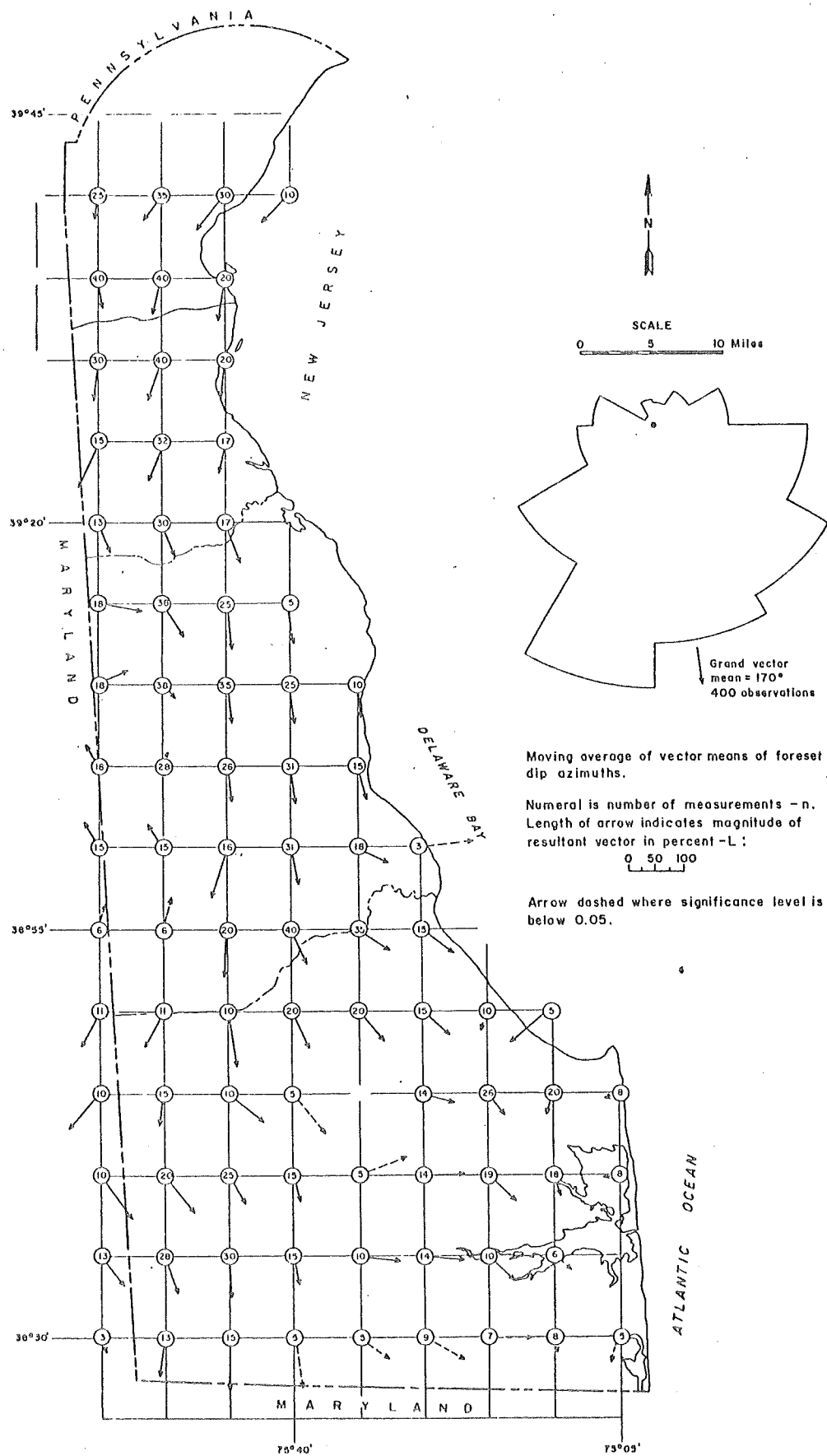


Figure 1. Moving average of vector means of foreset dip azimuths. (From Jordan, 1962).

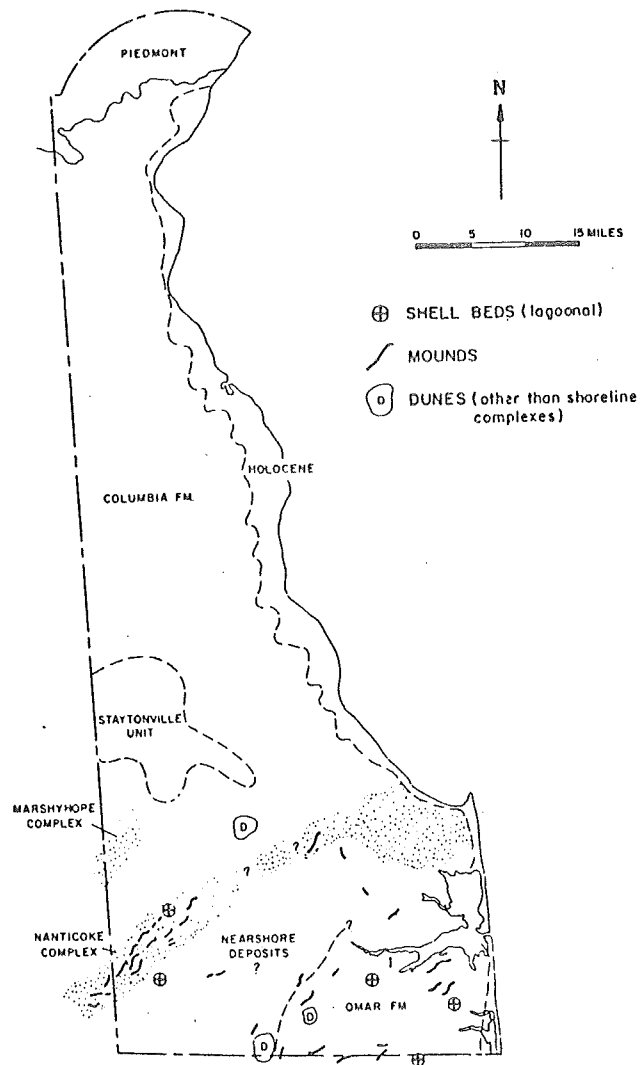


Figure 2. Generalized map of the surficial geology of Delaware. (From Jordan, 1974).

environment of deposition of the Staytonville was originally tentatively assigned to the estuarine category. It now seems more likely that it represents a fresh-water environment, possibly a swamp.

### Beaverdam Formation

The Beaverdam Formation was originally named by Rasmussen and Slaughter (1955) from near Salisbury, Maryland. Subsequently, the term Beaverdam was used in Delaware by Rasmussen *et al.* (1960) and Jordan (1962). According to the writer's interpretation the Beaverdam Formation is limited to the subsurface of the southern and southeastern portions of Delaware. Evidence from a few cored wells suggests that the Beaverdam is about 85 feet thick.

The Beaverdam in Delaware is a rather uniform, fairly well-sorted, medium sand. Small admixtures of gravel are present. Some interbedded lenses of silt are also found; however, they are minor. The average of 38 mechanical analyses from cores yields the following textural parameters based on the formulae of Inman (1952): Average median grain size ( $Md\phi$ ) 1.37 $\phi$ ; sorting coefficient ( $\sigma\phi$ ) 1.135; skewness values ( $\alpha\phi$ ) generally moderate and positive.

The Beaverdam fills channels, presumably of fluvial origin, cut into the Miocene sediments. Rasmussen *et al.* (1960) provide an interpretation of these channels and state that the Beaverdam is "a product of glacial meltwater floods, and of estuarine fill." Hansen (1966) suggests that the Beaverdam facies of nearby Maryland represents estuarine conditions. The writers interpret the Beaverdam Formation as the subsurface, downdip, extension of the Columbia Formation, and of fluvial origin.

### Omar Formation

Jordan (1962) proposed the name Omar Formation for deposits consisting of alternating beds of sand and silt found in southeastern Sussex County above the Beaverdam Formation. The Omar is the surficial unit over its area of occurrence except where it is locally overlain by sand dunes, or alluvium. The Omar averages about 45 feet thick.

A distinctive characteristic of the Omar Formation is its textural heterogeneity. Distinct beds of fine and medium sand of widely varying sorting characteristics are interbedded with silts and sandy silts. Individual beds average about 5 feet thick, although the sands tend to be thicker than the silts. The extreme range of median grain size based

on 36 core samples is from 0.75φ to 7.60φ.

Megafofossils dominated by Crassostrea virginica are found in abundance at several localities in the Omar Formation. In addition to the fauna, numerous plant fragments and plant microfossils have been recovered from the Omar. Pollen and spores indicate that the deposits originated under climatic conditions which included both moderate and cold temperatures (J. J. Groot, personal communication). Diatoms of probable brackish water affinity have been found.

The fauna of the Omar Formation indicates brackish water conditions. The environment of deposition is thought to reflect dominantly lagoonal conditions with elements of estuaries, marshes, and beaches (possibly bay or lagoonal beaches) also present. It is suggested that the Omar represents the highly irregular encroachment of the sea upon the land.

#### The Shoreline Complex

The term Shoreline Complex is used to designate all of the materials not otherwise designated, in southern Delaware, which reflect the environments of the shore including the beach proper, dunes, lagoons, bars, and inner neritic environments. These materials overlies and are younger than the units mentioned above, with a possible exception of at least part of the Omar Formation. Two distinct beach ridges have been identified in Sussex County, Delaware. These are best developed where they extend along the Nanticoke River and Marshyhope Creek in the southwestern portion of the State, and they are named for these streams.

The first suggestion of the presence of the Nanticoke Beach Ridge to appear in the literature is a reference by Booth (1841) to a dune field paralleling the Nanticoke River. Rasmussen et al. (1960) also noted this feature. Jordan (1964) identified a morphologic feature consisting of a beach ridge capped by dunes in the same area, and investigated the characteristics of the sediment which confirmed the presence of both beach and dune sands. The Nanticoke Beach Ridge consists of a broad, low, ridge capped by the hummocky topography of dunes, extending along the south bank of the Nanticoke River from at least the vicinity of Mardella Springs, Maryland to Concord, Delaware. It is continuous over this distance of approximately 20 miles. It is possible that the same feature extends to the northeast through the entire State of Delaware.

Where it is best developed near the town of Blades, the Nanticoke Beach Ridge rises from the level of the tidal

Nanticoke River to form a hill about 20 feet high and 0.5 miles across. The dunes on top of this hill reach a maximum altitude of about 40 feet. A relatively smooth plain at an altitude of between 20 and 30 feet continues toward the south and east.

The mechanical composition of the sands in the hummocks confirms their dune origin. At a few localities where the dunes have been stripped away by a combination of erosion and excavation, sands with mechanical composition, structures, and heavy mineral concentrations typical of beach sands may be observed.

The Marshyhope Ridge is analogous to the Nanticoke Beach Ridge but is less well-developed and investigated. It is best expressed in Delaware between the point where the Marshyhope Creek crosses the state line into Maryland in the south and passes through Woodenhawk to at least Adamsville, Delaware toward the north.

The term "elongate mounds" is selected to describe narrow, sharp, elongate hills found in southern Sussex County. Jordan (1964) described and mapped some of these features, referring to them as "bars(?)." It was conjectured that they originated as marine current-generated bars. Colleagues have suggested the use of a descriptive term until the origin is better understood. Also, later work has indicated that not all of these features share a similar origin, whatever that may be. The elongate mounds rise from 5 to 20 feet above surrounding areas and are 0.5 to more than three miles in length. The width is usually less than 0.1 miles. They tend to be moderately straight and are not to be confused with the elliptical rims of "basins" found in other parts of Delaware. Most of the known mounds are associated with the Nanticoke Beach Ridge, but they occur singly and in groups over the entire southern half of Sussex County. They display a variety of long axis orientations with a weak north-east-southwest preferred trend.

Most of the mounds are composed of fairly well-sorted medium sand, but others are finer grained and less well sorted. In the few outcrops exposing the material of the mounds, sedimentary structures are notably absent. A few mounds have been probed by auger holes which show that they are remarkably uniform internally. Augering to below the base of several mounds and in the surrounding plains has thus far indicated that the plains are composed of materials very similar to the mounds. The elongate mounds occur at all altitudes available in their occurrence, from a few feet above sea level to as high as 70 feet. Some of the mounds are found superimposed on the Nanticoke Beach Ridge and may be dunes. Most, however, are southeast of the ridge.

## Other Deposits

The sediments at the surface in southern Sussex County, other than those relegated to the deposits discussed above, are light tan or gray, fine-, medium-, and, more rarely, coarse-grained, sands which are unimodal, moderately well-sorted, and positively skewed. General homogeneity masks the sedimentary structures, but it appears that bedding is indistinct and structures are either absent or poorly developed. These materials are very tentatively considered to be of sublittoral origin. Possibly they were deposited seaward of the Nanticoke Beach Ridge.

## PROVENANCE

Evidence of the provenance of the Columbia deposits in Delaware is derived from three major sources of information: paleocurrents, coarse rock fragments, and heavy minerals.

The paleocurrents flowed essentially from north to south, apparently issuing from the valley of the Delaware River south of Wilmington. No evidence of contributions from the Susquehanna or other streams is apparent. The ultimate upstream source from Delaware River drainage could have included much of its present drainage basin and, possibly greatly exceeded that area in size, perhaps including some or much of the drainage of the Hudson River (Campbell and Bascom, 1933).

Gravel- and larger-sized fragments of orthoquartzite and conglomerate highly suggestive of the ridge-forming quartzites of the folded Appalachians are common in the Pleistocene sands. Some contain ripple marks, cross-bedding, and, rarely, poorly preserved Paleozoic fossils such as brachiopods. Metaquartzites of the Piedmont could well have yielded the less abundant cobbles composed of fine-grained welded quartz. Vein quartz, although common, provides little evidence of provenance; the Appalachian Piedmont is highly capable of yielding quantities of such material. Chert pebbles in Delaware commonly contain Paleozoic fossils suggesting an origin in the cherty limestones of the Appalachians. Shales, slate, and crystalline rock fragments are less common in the sediments. Such fragments could be derived from the Triassic basins and sedimentary and crystalline Appalachians.

The heavy mineral suite is varied, but has a marked metamorphic character and probably in large part originated

in the various metamorphic rocks of the Piedmont. Certain distinctive varieties may be assigned to the Wissahickon Schist and the Baltimore Gneiss (Dryden and Dryden, 1964). Worn grains of resistant minerals are probably of multi-cycle origin derived in Pleistocene time from Appalachian sedimentary rocks. The heavy mineral suite is compatible with that of the present Delaware River, which is largely engaged in reworking glacial detritus (MacDonald, 1961; Jordan and Groot, 1962). It appears that both the metamorphic and sedimentary rock areas of the Appalachians contributed material to the Pleistocene deposits of Delaware. Undoubtedly, some reworking of the older sediments of the Coastal Plain also occurred. Chloritoid found in the Pleistocene sands could have come from a limited area in the Wissahickon Schist (Dryden and Dryden, 1964), or from marine Cretaceous units (Groot, 1955). Some glauconite reworked from Coastal Plain greensands is found, but generally only very close to contacts with the source rocks. The feldspar content of the Pleistocene sand lends emphasis to its partial derivation from crystalline rock terrace as neither the Coastal Plain sedimentary rocks nor those of the Appalachians are feldspar-rich.

#### GEOLOGIC HISTORY

The basic framework of deposition of the Pleistocene sediments of Delaware involves the discharge of large quantities of water and detritus from streams originating within the glaciated area; the construction of a massive fluvial deposit from the distributary portions of this stream system; and the subsequent reworking of the upper, distal portion of the fluvial mass by near shore marine activity. Any history of these deposits must explain (1) channel cutting and deposition above and below present sea level; (2) the transportation and deposition of large volumes of coarse sediment by streams; (3) reworking by marine agencies to altitudes above present sea level; and (4) the incision of the present Delaware Bay channel system to below present sea level.

It seems a reasonable assumption that all these events transpired during the Pleistocene. There is not always direct evidence of this, but the complex events of the Pleistocene provide suitable mechanisms. Some or all of the major events may have occurred more than once; however, the deposits in Delaware seem to constitute a continuum. Stream channels cut below sea level previous to and during the deposition of the Columbia Formation are compelling evidence that the sea stood lower during part of its deposition. This

carries the corollary of a glacial advance. It is assumed that drainage from the source area of the Pleistocene sediments existed prior to the onset of glacial episodes. With glaciation and retreat of the sea these ancestral streams might be expected to downcut in the Coastal Plain. They may not have cut deep channels because of the gentle and uniform slope of the Coastal Plain and continental shelf. However, an increment in stream volume is postulated as the glaciers advanced into Atlantic drainage from the north.

This could be expected to increase competency and, perhaps downcutting, possibly flushing pre-existing channels of older detritus. Initial phases of glacial retreat would add additional meltwater and sediment resulting in high volume streams choked with sediment derived from the immediate vicinity of the glacier. As these streams debouched upon the gently sloping Coastal Plain the resulting reduction in gradient and competency triggered deposition and filling of the channels. Reduction of competency was later augmented by rising sea level and the drowning of the lower portions of the channels. Fluvial reworking undoubtedly continued wherever portions of the area were not flooded by the sea for drainage to the sea must have been maintained.

Marine and Rasmussen (1955), Ward and Groot (1957), Rasmussen et al. (1960) and Jordan (1964, 1965, 1967, 1974) subscribed to the major influence of lowered sea level and glacial meltwater on the fluvial deposits. It appears to be compatible with the glacial events in the upper Delaware River valley described by Ward (1938) and the distribution of fluvial deposits in northern Delaware described by Spoljaric (1967). The basic theory of deposition of the Columbia Formation fits well with the behavior of streams whose basins are partly occupied by glaciers and which drain into unglaciated coastal areas that has been postulated by Schumm (1965).

The superposition of shoreline deposits on the southern margin of the Columbia Formation indicates their younger age. The similar compositions are evidence that the materials of the Shoreline Complex were reworked from the older Pleistocene deposits. As the alluvial fan of glacial outwash is ascribed to a glacial episode, the shoreline deposits are relegated to a later interglacial when sea level would be sufficiently high to accomplish reworking to several tens of feet above present sea level.

During such an interglacial high stand (or stands) of the sea, the Omar Formation and the deposits forming the Shoreline Complex, including the Nanticoke Beach Ridge and, presumably, the Marshyhope Ridge, were superimposed upon the



Columbia and the Beaverdam. The relationship between the probable beaches and the lagoonal Omar is not clear. As the Omar is seaward of the ridges, it may be younger and associated with another barrier beach, possibly an extension of those thought to exist to the south. The relative age of the Staytonville unit is not at all clear. It is tempting to postulate that it is an estuarine-lagoonal deposit found behind the Nanticoke Beach Ridge (Klein, 1967). It is, however, about 30 feet higher than the stand of the sea suggested by the beach deposits.

It may be noted that Wisconsinan and Post-Wisconsinan deposition appears to be lacking except along the present coast. The Delaware Bay, which has a maximum present depth of about 150 feet, is formed on a system of partially filled stream channels cut well below sea level. Tributary streams in Delaware are tidal for several miles inland and occupy broad, marshy valleys. Drilling in several of these valleys has indicated that the thalwegs of the streams several miles from the bay are incised to -100 feet. These small streams were tributary to a deeply incised Delaware River and cross cut channels of Columbia age. It is suggested that the effect of the Wisconsin Epoch was primarily erosional in Delaware. The Delaware Estuary channel system is not filled with coarse sands as were those of the Columbia. Only fine-grained detritus is presently derived from the Delaware River (U.S.G.S., 1960, Jordan and Groot, 1962). This can be explained by postulating by-passing of the Wisconsinan sediments through the present land area and out onto the continental shelf. By-passing might be expected to occur, as the area of the Delmarva Peninsula had been built up in the form of an alluvial fan and stood relatively high so that subsequent streams went around it, not over it. Maintenance of the nearshore channels must have been a product of continuing stream reworking. If glacial and interglacial sea levels have progressively lowered, as is indicated by several sea level curves, the major Wisconsinan deposition might have been at a lower altitude than older accumulations, i.e. on the present continental shelf.

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#### DEPOSITIONAL MODEL

There appears to be a significant relationship between the distribution of the various types of Pleistocene sediments and the gross morphological elements of the entire Delmarva Peninsula (Jordan, 1966). Three morphological characteristics should be noted:

1. The general shape of the Delmarva Peninsula appears significant. It is about 185 miles long and about

65 miles wide at its widest point. Its axis is essentially north-south with a tendency to curve around to the south-southwest in its southern third. The eastern shore of the Peninsula is relatively straight and marshy along the Delaware Bay and is characterized by long, straight barrier bars along the Atlantic Coast. In contrast, the Chesapeake Bay shore is very irregular with intricate estuaries and many islands.

2. The major streams of the Delmarva Peninsula trend south-southwest. Those draining in this direction, to the Chesapeake Bay, are far longer than those draining eastward to the Delaware Bay and the Atlantic Ocean. The major streams occupy broad, marshy valleys generally a mile or more wide. The streams are tidal for an average of about 30 miles from the Chesapeake Bay. The drainage divide of the Peninsula is highly asymmetrical.
3. Low broad ridges parallel the southeastern shores of several of the major streams in the southern half of the Delmarva Peninsula. The Nanticoke Beach Ridge and the Marshyhope Ridge are two examples of these features. Others, in Maryland, include the Parsonsburg Divide Ridge, the "Berlin" Ridge along the Pocomoke River, and Sinepuxent Neck near the Atlantic Coast.

It is considered probable that during the Pleistocene prevailing southerly beach drift built a series of beach ridges enclosing chains of lagoons which, upon lowering of sea level, were converted into the long, broad, marshy, tidal valleys of the major streams of the southern half of the Peninsula. The writer has investigated the Nanticoke and Marshyhope Ridges; by analogy of topography and some sampling of sediments, <sup>(6)</sup> This concept has been extended south of Delaware in reconnaissance fashion. It is thought that the persistent removal of material from the eastern shore of the Peninsula and its redeposition toward the south-southwest by long-shore drift together with a conversion of barrier-lagoon associations into ridge-valley features provides explanations for the asymmetrical drainage and the basic shape of the Peninsula and the possible position of Pleistocene shorelines. Rasmussen and Slaughter (1955, p. 30) stated the essential elements of this scheme:

"The plains of Somerset, Wicomico, and Worcester Counties have numerous dunes and bar-like features with elongated swales alongside them, which have been given the name "barriers," and which are like the

barrier beach and barrier islands along the Atlantic Coast today... The broad lowlands behind the barriers form broad swales which are part of the major valley systems."

This reasoning suggests that there are at least five beach ridges in the southern Delmarva Peninsula. The overall sedimentary model for the Peninsula during the Pleistocene calls for a very large scale alluvial fan-like mass reworked at southern portions and redistributed toward the south in a manner not unlike a large compound spit.

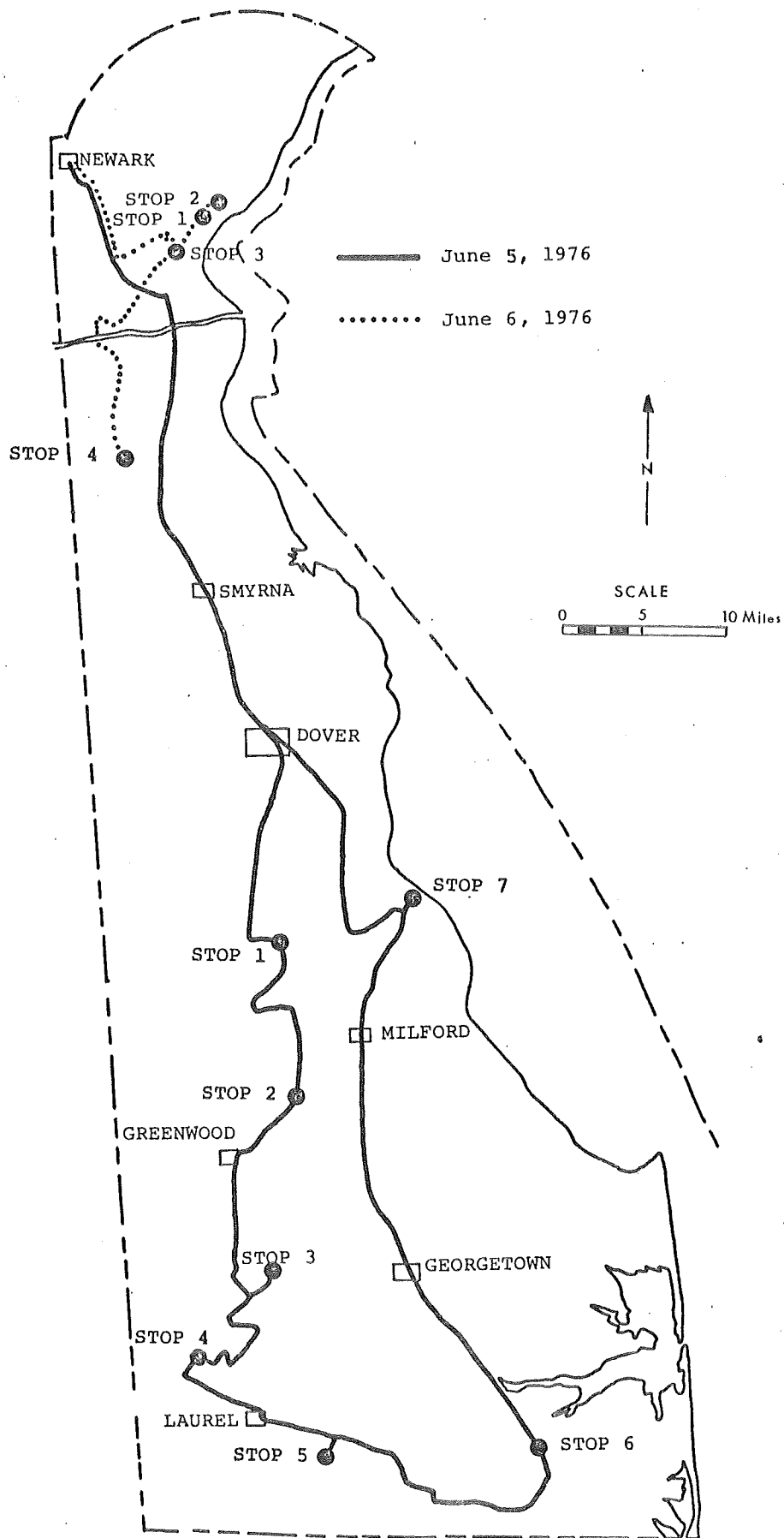


Figure 3. Road log with stops.

# ROAD LOG

June 5, 1976

Leave from main entrance of Clayton Hall, North Campus, University of Delaware, Newark. Distances are given to nearest tenths of miles as measured by automobile odometer.

Distance	Cumulative Distance	Notes
0.0	0.0	Leave Clayton Hall bearing south (right) on main drive from North Campus.
0.1	0.1	Jct. Del. Rt. 896, New London Road. Turn south (left) onto Del. Rt. 896. Altitude 160 feet.
0.3	0.4	Jct. New London Road and Cleveland Avenue. Turn west (right) following Del. Rt. 896.
0.1	0.5	Jct. Cleveland Ave. and West Main St. Turn east (left) following Del. Rts. 896 and 273.
		Descend Fall Zone from Piedmont Province to Atlantic Coastal Plain. Cross ConRail R.R. Bear south (right) following Del. Rts. 896 and 273.
0.1	0.6	Enter Atlantic Coastal Plain (Alt. 125').
0.1	0.7	Jct. Elkton Road and Delaware Ave. Turn east (left) following Del. Rts. 896 and 273.
0.2	0.9	Jct. Delaware Ave. and South College Ave. Continue east (straight) following Del. Rt. 2 (Delaware Ave.).
0.1	1.0	Pass through main quadrangle, University of Delaware Campus.
0.2	1.2	Jct. Delaware Ave. (Del. Rt. 2) and Academy St. Turn south (right) on Academy St.
0.3	1.5	Pass Penny Hall housing Delaware Geological Survey and Department of Geology - to the east (left) of road.
0.2	1.7	Jct. Academy St. and Courtney St. Turn east (left) on Courtney St.
0.2	1.9	Jct. Courtney St. and Ashley Rd. Bear east (left) on Ashley Rd.
0.2	2.1	Jct. Ashley Rd. and Del. Rt. 72 (Chapel St.). Turn south (right) on Del. Rt. 72.

0.3	2.4	Cross ConRail R.R., formerly Penn Central, and continue south through University of Delaware Farms, reclaimed landfill, and waste transfer station. (Alt. 99').
1.0	3.4	Jct. Del. Rt. 72 and Del. Rt. 4. Continue south (straight) on Del. Rt. 72.
0.2	3.6	Pass City of Newark's South Basin Wellfield - to east (left) of road.
1.5	5.1	Cross Christina River. Telemetered stream gage to east (left) of road. Battle of Coochs Bridge fought 0.5 miles to the west in 1777.
0.7	5.8	Pass ditches and road cut exposing Potomac Formation (Cretaceous). Cover of Columbia Formation is absent at this point.
1.4	7.2	Jct. Del. Rt. 72 and U.S. Rt. 40. Continue south (straight) on Del. Rt. 72. (Alt. 72').
2.0	9.2	Cross Delmarva Line of ConRail R.R.
1.3	10.5	Pass Getty Oil Company, Delaware City Refinery well (water) to north (left) of road. Wells in the Potomac Formation provide about 2 mgd to the refinery. Refinery and associated industries and power plant visible at 11 o'clock.
0.7	11.2	Wrangle Hill. Jct. Del. Rt. 72 and U.S. Rt. 13. Turn south (right) on U.S. Rt. 13. (Alt. 62').
1.4-2.4	12.6-13.6	St. Georges Bridge over Chesapeake and Delaware Canal (tidal). Exposures in banks of C & D Canal are of marine Upper Cretaceous units, at this point primarily the Mt. Laurel Formation. The Salem Nuclear Power Plant is visible across Delaware Bay at 10 o'clock at a distance of 8 miles.
0.8	14.4	Pass borrow pit in Columbia Formation - to west (right) of road.
0.7	15.1	Pass Delaware Bay rangelight - to east of road at distance of 0.5 miles.
0.6	15.7	Pass Del. Rd. 413, site of testwell to basement. Formation log of well Ec41-10; Alt. 50 feet:

		Depth (feet)	Group or Formation	Systems or Series
		0-34	Columbia Formation	Pleistocene
		34-52	Marshalltown - Mt. Laurel Fms. ?	Upper Cretaceous
		52-230	Matawan Formation	Upper Cretaceous
		230-246	Magothy Formation	Upper Cretaceous
		246-1130	Potomac Formation	Upper and Lower Cretaceous
		1130-1260	weathered crystalline rock	Precambrian
3.1	18.8		Cross Drawyers Creek (tidal). Exposures in stream cuts are of the Hornerstown Formation (Paleocene) a few tens of feet stratigraphically above the Cretaceous-Tertiary boundary.	
			Thalweg of stream is at about - 80 feet. The tidal streams of eastern Delaware are incised toward an ancient master drainage system under the present Delaware Bay.	
0.3	19.1		Pass Drawyers Chapel. Founded 1711; present building 1773 - to west (right) of road.	
0.6	19.7		Enter Odessa (pop. 547). Site of the Indian village Appoquinimi. Named Cantwell's Bridge in 1731. Because of prominence as a grain port it was renamed Odessa in 1855. Odessa contains the Corbit-Sharp House (1774) and other buildings of historic interest.	
0.2	19.9		Jct. U.S. Rt. 13 and U.S. Rt. 301/Del. Rt. 299. Continue south (straight) on U.S. Rt. 13. (Alt. 65').	
0.9	20.8		Cross Appoquinimink River (tidal).	
4.5	25.3		Jct. U.S. Rt. 13 and Del. Rt. 896. Continue south (straight) on U.S. Rt. 13.	
0.6	25.9		Cross Blackbird Creek.	
0.2	26.1		Blackbird. Enter area of undrained depressions ("bay-basin" or "Carolina bay" topography). For next 2 miles several small but well-developed examples are present on either side of road.	
4.5	30.6		North of Smyrna. Much silicified wood is found in the Columbia Formation in this area. In a pit 1/2 mile to the west	

0.25

0.6	31.2	(right) a silicified cypress trunk 52 feet long has been recorded. Cross Duck Creek (Smyrna River) (tidal). Leave New Castle County; enter Kent County. Enter Smyrna (pop. 4243).
0.9	32.1	Pass main water well of City of Smyrna - to west (right) of road. The location of very large capacity, relatively shallow water wells is dependent on the location of channels filled with the Columbia Formation cut into the beveled edges of the older Coastal Plain units. The channels have no surface expression and are very difficult to detect by geophysical means. The Smyrna well is an example of an excellent well located by geologic investigation for a channel.

Log of well Hc34-22; Alt. 24 feet.

Depth (feet)	Description
0-7	Top soil and sandy clay.
7-58	Sand, brown, medium to coarse.
58-81.5	Sand, brown, coarse.
81.5-88	Clay, gray, silty.
88-97	Sand, brown and gray, coarse. Below: silt, gray (Chesapeake Group, Miocene).

#### Well Construction:

Depth - 97'  
Diameter - 20"  
gravel packed, 12" casing  
Screen - 12" Everdur, slot #110, 55-83' and 88-96'.  
Pump - turbine; rated 1100 gpm.

#### Performance:

Production - 1000 to 1200 gpm. Specific Capacity - Approx. 55 gpm/ft.

3.9	36.0
-----	------

Cross Garrisons Lake. In a 5-mile wide band across Delaware in this vicinity ground water supplies are limited due to thin Columbia sands and facies



		changes in the deeper Cretaceous and Tertiary units.
1.5	37.5	Cheswold (pop. 286), (Alt. 42').
1.7	39.2	Pass Delaware Technical and Community College, Kent Co. Campus - to west (right) of road.
1.5	40.7	Pass Delaware State College - to west (right) of road.
1.0	41.7	Enter Dover (pop. 17,488). Capitol of the First State since 1777. Dover has many sites of historic interest.
1.6	43.3	Jct. U.S. Rt. 13 and U.S. Rt. 113. Bear southwest (right) following U.S. Rt. 13. (Alt. 30').
0.8	44.1	Cross St. Jones River (tidal).
2.8	46.9	Camden-Wyoming (pop. 1,200-each).
		Cross Del. Rt. 10. (Alt. 41').
3.0	49.9	Woodside (pop. 223). Cross Del. Rt. 30. (Alt. 54').
1.9	51.8	Canterbury. Note gently rolling topography in this area. (Alt. 57').
2.7	54.5	Felton (pop. 495). Cross Del. Rt. 12. (Alt. 62').
1.5	56.0	Jct. U.S. Rt. 13 and Del. Rd. 384.
1.2	57.2	Turn east (left) on Del. Rd. 384.
		Pass entrance to Killen Pond State Park.
1.1	58.3	<u>STOP 1.</u> Killen Pond Gravel Pit.

*photo #3*

Section: Columbia Formation (undisturbed land surface alt. 30').

0-2 feet	Sand, brown, gravel and silt; soil.
2-4	Sand, brown, coarse.
4-5	Gravel and coarse sand, brown.
5-11	Sand, brown, coarse, and very fine gravel; cross-bedded.
11-11.5	Gravel, brown, with very coarse sand.
11.5-13.5	Sand, yellow, medium to coarse; cross-bedded.
13.5-15	Sand, brown, coarse; cross-bedded.
15-15.5	Gravel, brown, with very coarse sand.
15.5-20	Sand, brown, coarse, with fine gravel; cross-bedded.

Mean of foreset dip azimuths: 203°.

Textural parameters (Inman):  $Md\phi = 0.81$ ;  
 $\sigma\phi = 1.275$ ;  $\alpha\phi = -0.1058$ . Primary mode 1-2 $\phi$ ;  
 secondary mode -4 - -3 $\phi$ .

*Mio/plio  
 medium -  
 small mollusc  
 molds.*

At some points the floor of this pit has penetrated the angular unconformity between the Columbia Fm. and the underlying Chesapeake Group. Silts of the Chesapeake here contain fossils suggestive of the Choptank Formation. (T.E. Pickett, personal communication).

	58.3	Leave Stop 1. Turn south (left) on Del. Rd. 384.
0.2	58.5	Cross Killen Pond Outlet, Murderkill River.
1.3	59.8	Jct. Del. Rd. 384 and Del. Rt. 35. (Vehicles not subject to 12-ton limit of bridge ahead may proceed south on Del. Rd. 384).
		Note rolling topography.
3.2	63.0	Harrington (pop. 2407). Jct. Del. Rt. 35 and U.S. Rt. 13. Turn south (left) on U.S. Rt. 13.
0.7	63.7	Jct. U.S. Rt. 13 and Del. Rt. 14. Turn east (left) on Del. Rt. 14. (Alt. 53').
2.8	66.5	Marvels Crossroad. Jct. Del. Rt. 14 and Del. Rd. 384. Turn south (right) on Del. Rd. 384.
0.7	67.2	Houston (pop. 317). Cross ConRail R.R.
0.8	68.0	Cross Beaverdam Branch. Stream gage to west (left) of road.

The hydrology of the Columbia is critical to water supply in Delaware. Most ground water is unconfined and related to stream-flow. Johnston (1976) has studied the hydrology of Beaverdam Branch (and others) basin and reports the following estimated budget for the 10-year period, 1959-68:

Budget Factors:	Inches per year	Gallons per day per mi <sup>2</sup>
Overland runoff	4	190,000
Ground-water runoff	<u>13</u>	<u>610,000</u>
Total Runoff	17 17	800,000
Soil moisture and surface water evapotranspiration	20	960,000
Ground-water evapotranspiration	<u>3</u>	<u>140,000</u>
Total Evapotranspiration	23 <u>23</u>	<u>1,100,000</u>
Total Budget (Precipitation)	40	1,900,000

NOTE: Ground-water recharge (16 in/yr) is the sum of ground-water runoff (13 in/yr) and ground-water evapotranspiration (3 in/yr).

In summary, about 50 percent of the precipitation is evaporated and transpired from the unsaturated zone and the stream and approximately 10 percent of the precipitation runs off directly to the stream. Forty percent of the rainfall reaches the water table as recharge, and 33 percent ultimately discharges to Beaverdam Branch as base flow. About 7 percent of the precipitation is evaporated and transpired directly from the shallow ground-water reservoir.

- |     |      |   |
|-----|------|---|
| 0.8 | 68.8 | Williamsville. Jct. Del. Rd. 384 and Del. Rd. 443. Continue south (straight) on Del. Rd. 384. |
| 0.9 | 69.7 | Note chicken houses. About 125,000,000 chickens are raised annually in Sussex County.         |
| 0.8 | 70.5 | Note ditches reflecting poor drainage in area underlain by the Staytonville unit.             |
| 0.6 | 71.1 | Leave Kent County; enter Sussex County. Del. Rd. 384 becomes Del. Rd. 613.                    |
|     |      | Note mottled brown, gray, and black soil developed on Staytonville unit.                      |
| 1.0 | 72.1 | Staytonville, Jct. Del. Rd. 613 and Del. Rd. 629. Continue south (straight) on Del. Rd. 613.  |
| 0.1 | 72.2 | Jct. Del. Rd. 613 and Del. Rt. 36. Turn southwest (right) on Del. Rt. 36.                     |
| 0.3 | 72.5 | <u>STOP 2.</u> Staytonville. (Alt. 57')'  |

The Staytonville unit is informally named from exposures in drainage ditches in this area. It underlies over 100 square miles in southwestern Kent and northwestern Sussex counties.

The Staytonville consists of (mostly) medium-grained, poorly sorted, silty sands which are distinguished by their irregular and indistinct bedding and abrupt lateral and vertical color changes; it includes some beds of clayey silt. Mottling is common and generally applies to both lithology and the tan, brown, yellow, and gray colors of the unit. Some of the mottling may have been produced by burrowing organisms; however, no fossils are known except for the following pollen reported by J. J. Groot (in Jordan, 1967):

*Bob - believed to overlie Columbia - but to S - contact w/ Nantuxoke fm. Chris sees it as a facies of Colum, not overlapping*

Investigation of a very polleniferous sample from the Staytonville unit collected near Greenwood gave the following results:

<u>Arboreal Pollen</u>	<u>%</u>	<u>Non-Arboreal Pollen and Spores</u>	<u>Approx. %</u>
<u>Alnus</u> (alder)	60	Caryophyllaceae	5
<u>Betula</u> (birch)	2	Compositae (composites)	28
<u>Carya</u> (hickory)	<1	Gramineae (grasses)	27
<u>Quercus</u> (oak)	<1	Cyperaceae (sedges)	6
		<u>Typha latifolia</u>	2
<u>Pinus</u> (pine; several species)	34	Other herbs	25
<u>Picea</u> (spruce)	4	Polypodiaceae	2
		<u>Lycopodium</u>	5
		<u>Sphagnum</u>	<1
	100%		100%

A few grains of Salix  
(willow) are probably  
also present.

% NAP: 55

72.5 Leave Stop 2, Continue southwest on  
Del. Rt. 36.  
4.0 76.5 Jct. Del. Rt. 36 and Del. Rt. 16. Turn  
west (left) on Del. Rt. 16.  
0.6 77.1 Greenwood (pop. 700). Jct. Del. Rt. 16.  
and U.S. Rt. 13. Turn south (left) on  
U.S. Rt. 13.

The route follows the section from  
Talley (1975) shown as Fig. 4.  
3.5 80.6 Enter outskirts of Bridgeville (pop.  
1500).

From 1934 to 1940 the area to the south-  
east of Bridgeville was explored for oil  
by the Cleveland and Sun Oil companies.  
During the exploration period the deep-  
est testwell in Delaware was drilled  
to a depth of 3012 feet in 1935.

2.2 82.8 Jct. U.S. Rt. 13 and Del. Rt. 404.  
Continue south (straight) on U.S. Rt. 13.  
(Alt. 45').

2.6 85.4 Jct. U.S. Rt. 13 and Del. Rd. 46. Turn  
southeast (left) on Del. Rd. 46.

1.5 86.9 Enter Middleford.

0.3 87.2 Jct. Del. Rd. 46 and Del. Rd. 535.  
Continue southeast (straight) on Del.  
Rd. 46.

0.1 87.3 Cross Nanticoke River.

0.3 87.6 Jct. Del. Rd. 46 and Del. Rd. 526. Turn  
north (left) on Del. Rd. 526.

Note hummocky topography of dunes and  
elongate mounds for next 1.0 mile.

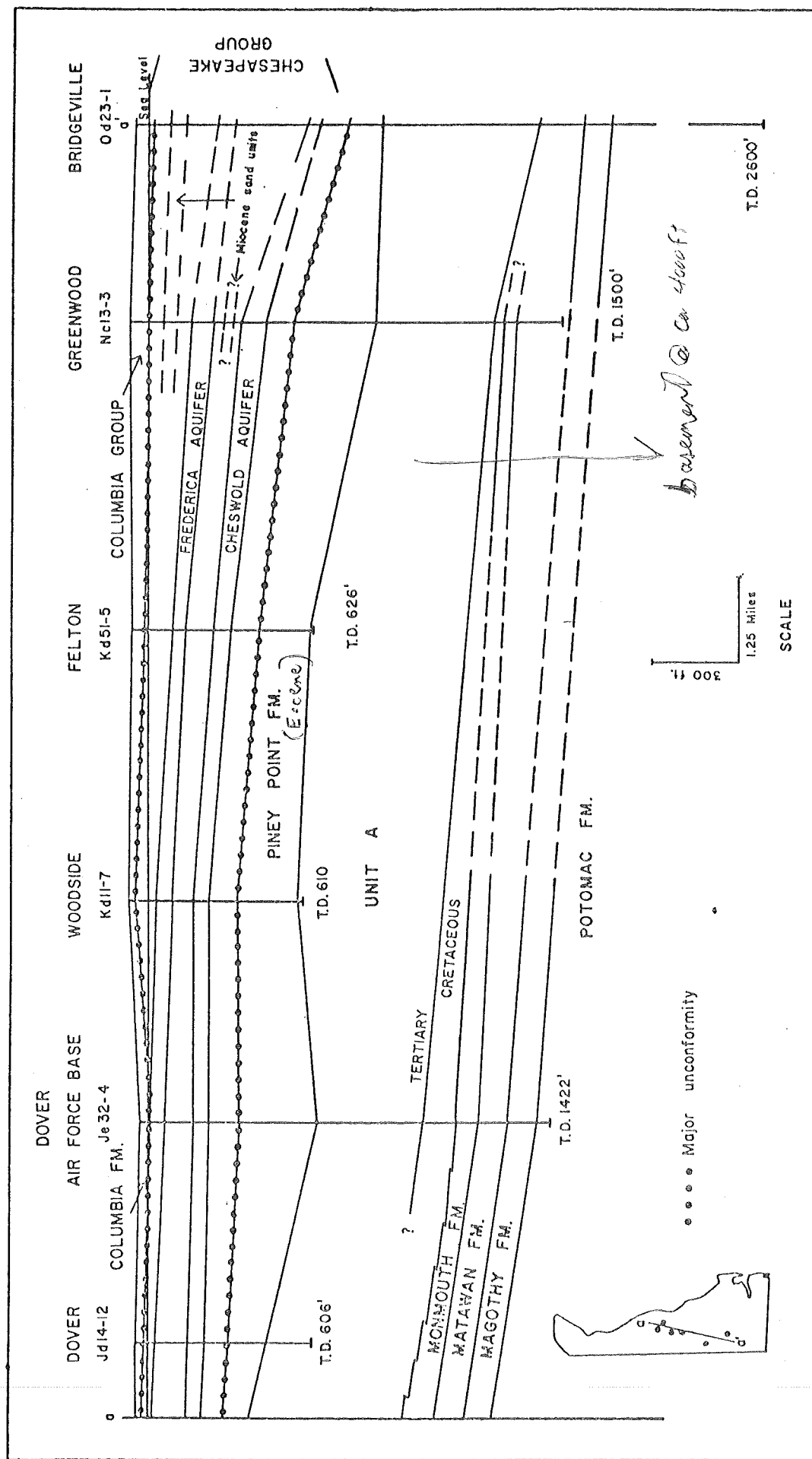


Figure 4. Geologic cross section of central and southwestern Delaware. (Talley, 1975).

1.0      88.6      Jct. Del. Rd. 526 and Del. Rd. 525.  
Turn north (left) on Del. Rd. 525.

0.3      88.9      STOP 3.      "Middleford" Borrow Pit.

This large pit provides at the top of the eastern face, a rare cross section of an "elongate mound." These features are distinguished from both the hummocks of the known dunes in this area and the rims of undrained depressions. They are considered by some to be dunes but their origin (s?) is considered to be unresolved.

Beneath the sands of the mound is a partially indurated sand. Below that lies the beach sand of the Nanticoke shoreline.

88.9      Leave Stop 3. Turn south (left)  
on Del. Rd. 525.  
0.3      89.2      Jct. Del. Rd. 525 and Del. Rd. 526.  
Turn southwest on Del. Rd. 526.  
1.0      90.2      Jct. Del. Rd. 526 and Del. Rd. 46.  
Turn west (right) on Del. Rd. 46.  
0.2      90.4      Cross Nanticoke River.  
0.2      90.6      Jct. Del. Rd. 46 and Del. Rd. 535.  
Turn southwest (left) on Del. Rd. 535.  
1.9      92.5      Seaford (pop. 5537). Jct. Del. Rd.  
535 and U.S. Rt. 13. Turn south (left)  
on U.S. Rt. 13.  
0.3      92.8      Cross Nanticoke River (tidal).  
0.2      93.0      Jct. U.S. Rt. 13 and Del. Rt. 20. Turn  
east (left) on Del. Rt. 20.

Route ahead lies generally on axis of Nanticoke shoreline. Note hummocky topography of dunes.  
1.7      94.7      Concord. Jct. Del. Rt. 20 and Del. Rd.  
485. Turn southwest (right) on Del.  
Rd. 485.

0.8      95.5      Pass site of borrow pit described in  
INQUA Guidebook (1965).

Section: 0-1 feet	Disturbed soil,
1-6	Sand, tan and brown laminated, medium, silty where brown.
6-15	Sand, white, medium, well- sorted.

Small-scale cross-bedding and other structures present throughout section. Textural parameters (Inman) are:

$Md\phi=1.72; \sigma\phi = 0.505; \alpha\phi = -0.2673.$

		Heavy mineral concentrations prominent. The sand is interpreted as a beach sand.
0.3	95.8	Note eastern end of Easter Hill, a large elongate mound, showing as a 10-foot rise at 10 o'clock at a distance of 0.5 miles. The road will approach and cross Easter Hill ahead.
0.3	96.1	Approaching Easter Hill; 0.25 miles at 10 o'clock.
0.5	96.6	Sand pit in Easter Hill at 9 o'clock.
0.2	96.8	Cross axis of Easter Hill.
0.2	97.0	Jct. Del. Rd. 485 and U.S. Rt. 13. Continue southwest (straight) on Del. Rd. 485.
0.2	97.2	Note Easter Hill at 3 o'clock.
0.4	97.6	Jct. Del. Rd. 485 and U.S. Rt. 13A. Turn north (right) on U.S. Rt. 13A.
0.4	98.0	Cross axis of Easter Hill.
0.8	98.8	Cross smaller elongate mound.
0.3	99.1	Jct. U.S. Rt. 13A and Del. Rd. 488. Turn southwest on Del. Rd. 488.
0.1	99.2	Cross ConRail R.R.
1.1	100.3	Jct. Del. Rd. 488 and Del. Rd. 490. Bear northwest (right) on Del. Rd. 490. Road approaches the Nanticoke beach ridge from the south.
0.7	101.0	Jct. Del. Rd. 490 and Del. Rd. 490A. Turn southwest (left) on Del. Rd. 490A. Route ahead lies along axis of Nanticoke beach ridge. Note hummocky topography of dunes.
0.3	101.3	<u>STOP 4.</u> "Blades" Sand Pit.

This location illustrates the dune sands found for a distance of about 30 miles along the southeast banks of the Nanticoke River. Analogous deposits occur along the other long, tidal, southwest-flowing streams of the Delmarva Peninsula. Just below the floor of the pit is the contact of the aeolian sands with the beach sand which is also present along the southeast side of the Nanticoke River. A cross section perpendicular to the Nanticoke River 1.4 miles southwest of Stop 4 is shown in figure 5. The nature and relationships of the units together with limited occurrences of peaty sands and

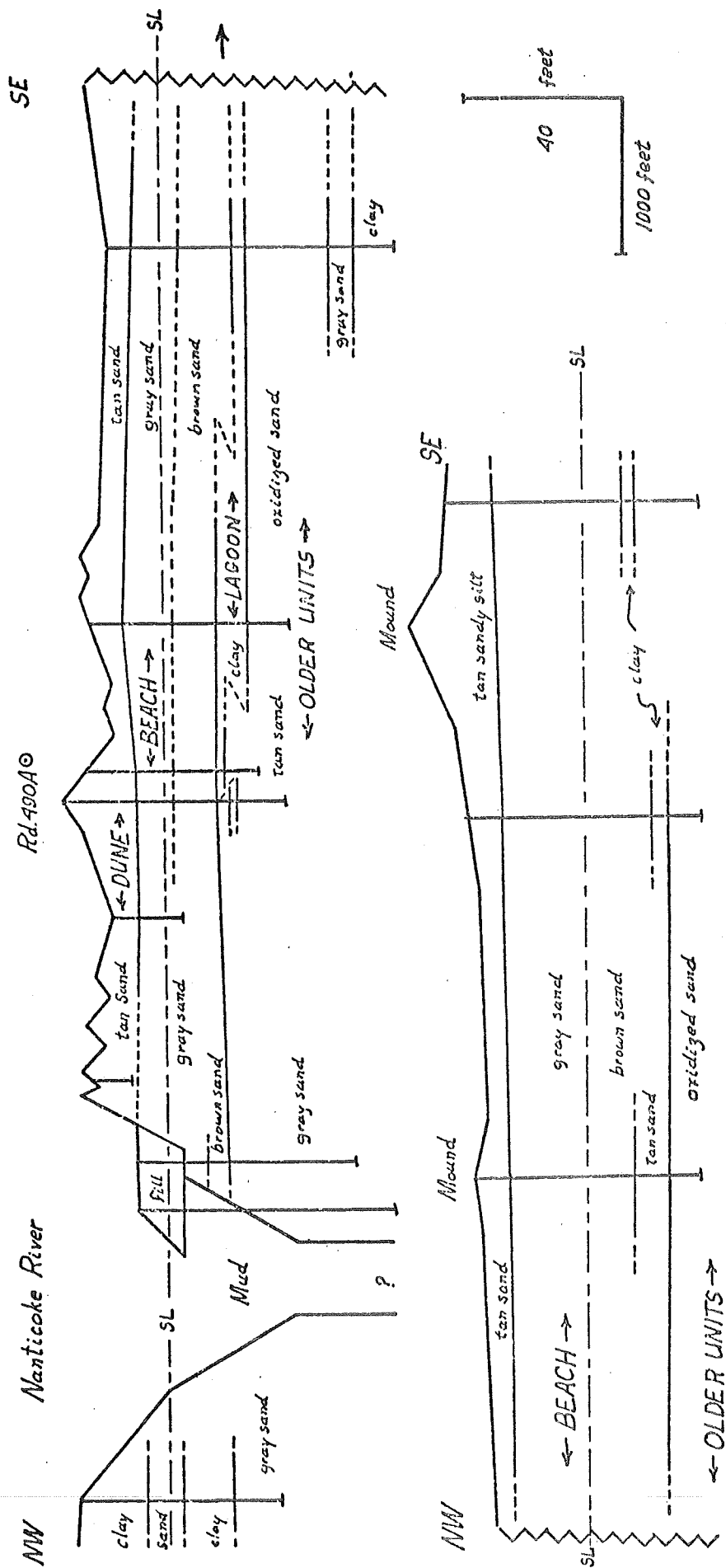


Figure 5. Cross section of Nanticoke Shoreline along Delaware Road 78 from Woodland Ferry toward Laurel, Sussex County. Lithologic units are shown as determined by test holes together with interpretations of environments of deposition.



shelly silts indicate a transgressive sequence in which sea level reached + 15 to + 20 feet.

The textural parameters (Inman) of the dune sand at this site are:  
 $Md\phi = 1.71$ ;  $\sigma\phi = 0.464$ ;  $\alpha\phi = 0.0442$ .

	101.3	Leave Stop 4. Continue southwest on Del. Rd. 490A.
		Note hummocky topography of dunefield which is continuous along the south bank of the Nanticoke River for about 20 miles.
0.9	102.2	Cross Patricks Pond (tidal).
0.5	102.7	Jct. Del. Rd. 490A and Del. Rd. 78. Turn southeast (left) on Del. Rd. 78.
		The route ahead lies normal to the trend of the Nanticoke beach ridge. A cross section developed by drilling along Del. Rd. 78 is shown as figure 5.
1.2	103.9	Cross elongate mound.
0.7	104.6	Cross elongate mound.
0.2	104.8	Jct. Del. Rd. 78 and Del. Rd. 493. Continue southeast (straight) on Del. Rd. 78.
2.5	107.3	Jct. Del. Rd. 78 and U.S. Rt. 13. Turn south (right) on U.S. Rt. 13. Enter Laurel (pop. 2408).
0.5	107.8	Cross Broad Creek (tidal).
0.2	108.0	Jct. U.S. Rt. 13 and Del. Rt. 24. Turn east (left) on Del. Rt. 24.
4.7	112.7	Pepper. Jct. Del. Rt. 24 and Del. Rd. 449. Turn south (right) on Del. Rd. 449.
0.8	113.5	Enter Trap Pond State Park.
		Note northernmost stand of cypress trees.
0.4	113.9	Turn left into parking area.
0.2	114.1	<u>STOP 5.</u> Trap Pond State Park. LUNCH

The log of a testwell drilled in exploration for a water supply for the park is given below. The Columbia sediments are rather thick in this area and may be related to the "Salisbury paleochannel" found in nearby Maryland.

Well No. Qe42-2; Alt. 40 feet:

Depth (feet)	Description
0.0-0.5	Soil (disturbed).
0.5-1.5	Sand, brown, fine, sorting fair, some silt; grades to:

1.5-8	Sand, tan, fine, well sorted.
8-24	Sand, white, fine to medium, sorting fair to good, with granules of chert.
24-26	Clay, light gray.
26-44	Sand, white, medium to coarse, with granules and gravel; coarser below 37 feet.
44-50	Sand, brown, coarse, sorting fair.
50-64	Sand, brown, very coarse, much gravel; first appearance of lignite.
64-67	Clay (electric log).
67-105	Sand, brown, very coarse, much gravel; grades to:
105-115	Sand, light gray, medium, some granules; grades to:
115-138	Sand, light gray, fine, well sorted; grades to:
138-144	Sand, light gray, fine to very fine, well sorted; lignitic.
144-148	Clay, gray, silty.
148-165	Sand, gray, fine to very fine, well sorted.
165-170	Sand, gray, very fine; alterna- ting with clay, gray; grades to:
170-185	Silt, gray; alternating with sand, very fine; lignitic; grades to:
185-210	Sand, gray, very fine; alterna- ting with clay, gray; grades to:
210-226	Silt, gray; alternating with sand, very fine; lignitic.
226-235	Clay, dark gray.
235-270	Clay, brownish-gray; alternating with sand, gray, very fine; grades to:
270-283	Clay, dark blue-gray.
283-284	Clay, with shell.
284-300	Clay, blue-gray.
300-304	Sand (driller).
304-320	Clay, blue-gray; alternating with sand, very fine.
320-329	Clay, blue-gray; alternating with sand, very fine, some glauconite and shell fragments.
T.D.	

114.1      Leave Stop 5 on drive to main entrance of  
Trap Pond State Park.

0.2	114.3	Turn north (right) on Del. Rd. 449.
1.3	115.6	Pepper. Jct. Del. Rd. 449 and Del. Rt. 24. Turn east (right) on Del. Rt. 24.
0.7	116.3	Note small elongate mound in field to north (left) of road at distance of 200 yards.
1.6	117.9	Cross elongate mound.
1.5	119.4	Lowes Crossroads. Jct. Del. Rt. 24 and Del. Rd. 61. Turn southeast (right) on Del. Rd. 61. (Alt. 50').
2.0	121.4	Cross elongate mound; note expression in cemetery at 3 o'clock.
1.8	123.2	Jct. Del. Rd. 61 and Del. Rt. 26. Turn south (right) on Del. Rt. 26.
0.4	123.6	Enter Gumboro. (Alt. 50').
0.1	123.7	Jct. Del. Rt. 26 and Del. Rd. 417. Turn east (left) on Del. Rd. 417. (Turn is on north side of Gumboro School.)
0.2	123.9	Jog right and left following Del. Rd. 417.
1.3	125.2	Cross Cypress Branch Ditch. Headwaters of Pocomoke River.
1.1	126.3	Jct. Del. Rd. 417 and Del. Rt. 54. Continue east (straight) on Del. Rt. 54. Enter Cypress Swamp (Alt. 40').
0.9	127.2	Location of western testhole in cross section shown as figure 6.
2.7	129.9	Jct. Del. Rd. 60 and Del. Rd. 380A. Turn northeast (left) on Del. Rd. 380A.
0.2	130.1	Jct. Del. Rd. 380A and Del. Rd. 380. Turn northeast (left) on Del. Rd. 380.
2.0	132.1	Jct. Del. Rd. 380 and U.S. Rt. 113. Turn north (left) on U.S. Rt. 113.
0.8	132.9	Enter Frankford (pop. 635).
0.9	133.8	<u>STOP 6.</u> Pepper Creek Ditch (Alt. 19').

The outcrop of the Omar Formation in Pepper Creek ditch east of U.S. Rt. 113 is one of only three localities known in Delaware where the unit is fossiliferous. However, fragments of fossils and microfossils are known to be common in the Omar from wells in the area.

The altitude of the top of the fossiliferous horizon at this location is +18 feet. The fauna, here and from the subsurface, indicates brackish-water deposition. The alternating sands and

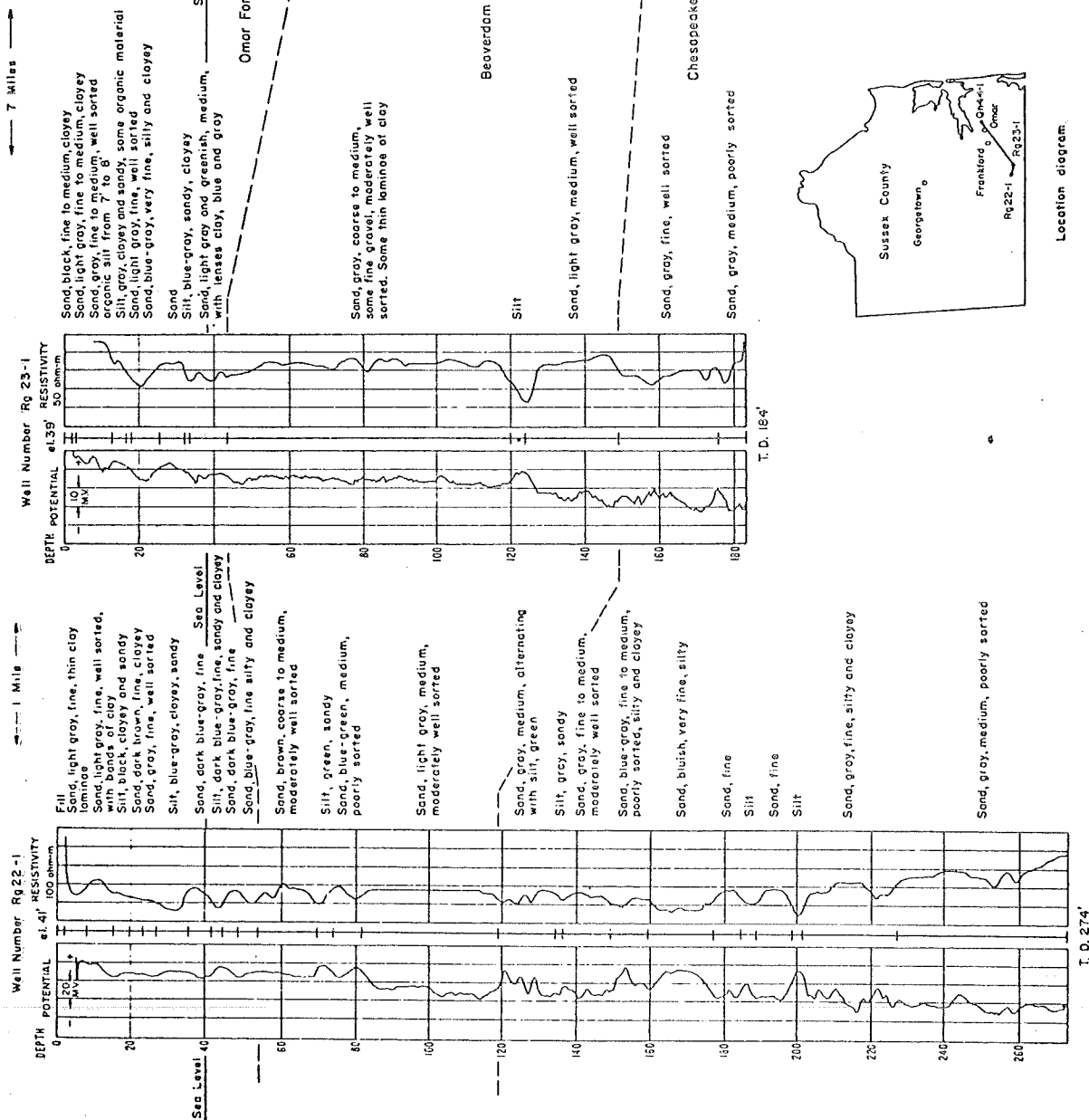


Figure 6. Logs of some cored wells in Sussex County, Delaware, showing the nature and relationships of the Omar and Beaverdam Formations. No horizontal scale. Well Qh44-1 provides the type section of the Omar Formation. (From Jordan, 1962).

silts of the Omar are interpreted as an intertonguing of beach and lagoonal environments.

The first radiocarbon date on shell from the site gave an age of 34,000<sup>±</sup> 2,000 years BP. However subsequent dates have given 37,000-or 38,000-plus years.

The fauna from Pepper Creek Ditch as identified by Horace G. Richards includes:

#### Pelecypoda

Arca transversa Say  
Merceneria mercenaria L.  
Corbula contracta Say  
Cumingia tellinoides Conrad  
Crassostrea virginica Gmelin  
Noetia ponderosa (Say)

#### Gastropoda

Odostomia dianthophila H. W. Wells  
O. impressa Say  
O. trifida Totten?  
O. sp.  
O. sp.  
Cerithiopsis greeni C. B. Adams  
Urosalpinx cinerea Say  
Nassarius obsoletus Say  
Crepidula plana Say  
Columbella lunata Say  
Busycon canaliculatum L. juv.

#### Foraminifera (R. R. Jordan)

Elphidium clavatum Cushman  
E. florentinea Shupack  
Rotalia beccarii tepeda Cushman

good oysters  
 John Weymiller  
 or 40 ka?  
 or 60-80 ka?  
 53 also get  
 similar rare

- |       |  |
|-------|--|
| 133.8 | Leave Stop 6. Continue north on U.S. Rt. 113.  |
| 1.2   | 135.0 Enter Dagsboro (pop. 375).   |
| 3.1   | 138.1 Enter Millsboro (pop. 1073).   |
| 2.3   | 140.4 Cross elongate mound.  |
| 7.0   | 147.4 Enter Georgetown, county seat of Sussex County (pop. 1844; alt. 50').  |
| 2.0   | 149.4 Start of hummocky topography; best expressed in Redden State Forest off the road to the east (left). It has been conjectured that this area of dune-like topography, which continues to the Delaware Bay north of Lewes, may be a continuation of the Nanticoke Shoreline Complex. |
| 4.3   | 153.7 Enter Ellendale State Forest.  |

right

6.3	160.0	Note rolling topography for next 2 miles.																												
2.1	162.1	Enter Milford (pop. 5314).																												
1.9	164.0	Cross Mispillion River (Haven Lake). Leave Sussex County; enter Kent County.																												
1.2	165.2	Pass site of testdrilling for City of Milford water supply. Ground water supply problems exist in the Milford area because the Columbia Fm. is relatively thin, the deeper aquifers of the Miocene series are somewhat overpumped, and deeper units contain brackish water.																												
		Log of well Le54-2; Alt. 38 feet:																												
		<table><tr><th>Depth (feet)</th><th>Description</th></tr><tr><td>0-0.8</td><td>Topsoil.</td></tr><tr><td>0.8-3</td><td>Clay, brown.</td></tr><tr><td>3-10</td><td>Clay, brown, and sand, fine.</td></tr><tr><td>10-27</td><td>Sand, brown, medium to coarse with layers of clay.</td></tr><tr><td>27-43</td><td>Sand, yellow, medium to coarse.</td></tr><tr><td>43-46</td><td>Clay, gray and orange.</td></tr><tr><td>46-51</td><td>Clay, gray and orange, with layers of sand, blue, fine.</td></tr><tr><td>51-61</td><td>Clay, blue, with layers of sand.</td></tr><tr><td>61-65</td><td>Clay, brown, sandy, with some layers of sand, fine, soft.</td></tr><tr><td>65-80</td><td>Sand, brown, fine, and soft.</td></tr><tr><td>80-90</td><td>Clay, blue; sand; layers of cemented iron ore.</td></tr><tr><td>90-113</td><td>Clay, blue, with layers of sand, blue, fine.</td></tr><tr><td>113-145</td><td>Clay, blue, with layers of sand; shells.</td></tr></table>	Depth (feet)	Description	0-0.8	Topsoil.	0.8-3	Clay, brown.	3-10	Clay, brown, and sand, fine.	10-27	Sand, brown, medium to coarse with layers of clay.	27-43	Sand, yellow, medium to coarse.	43-46	Clay, gray and orange.	46-51	Clay, gray and orange, with layers of sand, blue, fine.	51-61	Clay, blue, with layers of sand.	61-65	Clay, brown, sandy, with some layers of sand, fine, soft.	65-80	Sand, brown, fine, and soft.	80-90	Clay, blue; sand; layers of cemented iron ore.	90-113	Clay, blue, with layers of sand, blue, fine.	113-145	Clay, blue, with layers of sand; shells.
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90-113	Clay, blue, with layers of sand, blue, fine.																													
113-145	Clay, blue, with layers of sand; shells.																													
0.9	166.1	Jct. U.S. Rt. 113 and Del. Rt. 1. Continue north (straight) on U.S. Rt. 113. Del. Rt. 1 leads to Delaware's Atlantic Coast resorts.																												
1.3	167.4	Jct. U.S. Rt. 113 and Del. Rd. 19. Turn northeast (right) on Del. Rd. 19.																												
3.4	170.8	Thompsonville. Del. Rd. 19 becomes Del. Rd. 121. Continue straight on Del. Rd. 121.																												
2.7	173.5	Note undrained depressions ("bay-basin" topography or "Carolina bays").																												
0.9	174.4	Enter tidal marsh of Murderkill River. Turn east (right) into Island Field Archaeological Museum.																												

0.2      174.6      STOP 7.      Island Field Archaeological  
Museum.

Island Field is a site used as a cemetery by the people of the Webb Phase. During three centuries between 600 and 900 A.D., they practiced elaborate mortuary rites at this location on the Murderkill River. This advanced society which existed in the Delmarva Peninsula during the period known as Middle Woodland engaged in hunting, fishing, gathering, and probably horticulture, as well as in a widespread trading system.

This section also illustrates the effects of rising sea level along the Delaware shore. The rate of rise for the past several thousand years has been estimated at 0.5 to 1 foot per century. This has profound effects on the low coast of the Atlantic Coastal Plain and on the shores of its estuaries. Typically, as at Island Field, thin sandy beaches migrate landward over marsh deposits. Kraft and John (1976) have studied this situation in the vicinity of Stop 7 (see Figure 7).

	174.6	Leave Stop 7.
0.2	174.8	Turn southwest (left) on Del. Rd. 121.
2.2	177.0	Jct. Del. Rd. 121 and Del. Rd. 419.
		Turn west (right) on Del. Rd. 419.
1.9	178.9	Jct. Del. Rd. 419 and Del. Rd. 120.
		Turn northwest (right) on Del. Rd. 120.
2.0	180.9	Jct. Del. Rd. 120 and U.S. Rt. 113.
		Turn north (right) on U.S. Rt. 113.
1.6	182.5	Cross Murderkill River (tidal).
		Thalweg of stream at this point lies at - 110 feet.
1.0	183.5	Pass Barratt's Chapel, 1780, the "Cradle of Methodism in America," to the east (right) of road.
1.6	185.1	Enter Little Heaven.
2.8	187.9	Cross St. Jones River. Note tidal marshes.
1.8	189.7	Pass Dover Air Force Base.
1.8	191.5	Pass site of Dover Air Force Base Testwell.

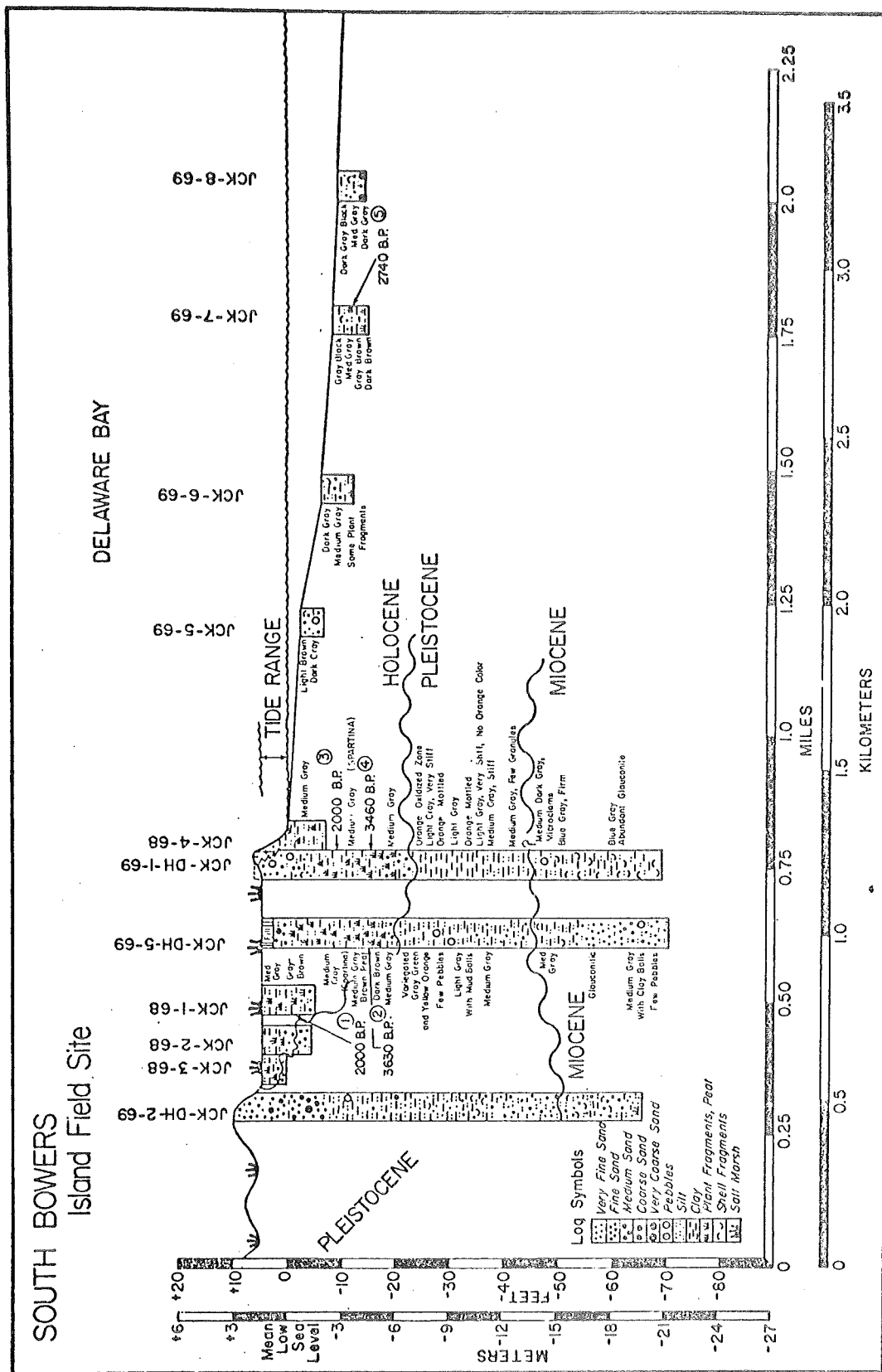


Figure 7. Cross section east from Island Field into Delaware Bay  
(From Kraft and John, 1976).



Formation log of well Je32-4; Alt. 40 feet:

Depth (feet)	Unit	Systems or Series
0-44	Columbia	Pleistocene
44-340	Chesapeake Group	Miocene
340-615	Piney Point Formation	Eocene
615-1090	Unit A	Eocene- Paleocene- Upper Cretaceous
1090-1170	Monmouth Formation	Upper Cretaceous
1170-1275	Matawan Formation	Upper Cretaceous
1275-1369	Magothy Formation	Upper Cretaceous
1369-1422	Potomac T.D. Formation	Upper and Lower Cretaceous

(From Jordan, 1962)

2.2	193.7	Enter Dover.
0.6	194.3	Jct. U.S. Rt. 113 and U.S. Rt. 13. Continue north (straight) on U.S. Rt. 13. From this point the route will be retraced to the University of Delaware at Newark. Those wishing to follow the log may reverse the southbound log from mile 0.0 to mile 43.0.
43.0	237.3	Clayton Hall, North Campus, University of Delaware, Newark.

# ROAD LOG

June 6, 1976

Leave from main entrance of Clayton Hall, North Campus, University of Delaware, Newark. Distances are given to nearest tenths of miles as measured by automobile odometer.

Distance	Cumulative Distance	Notes
	0.0	Leave Clayton Hall bearing south (right) on main drive from North Campus.
0.1	0.1	Jct. Del. Rt. 896, New London Road. Turn south (left) on Del. Rt. 896. Altitude 160 feet.
0.3	0.4	Jct. New London Road and Cleveland Ave. Turn west (right) following Del. Rt. 896.
0.1	0.5	Jct. Cleveland Ave. and West Main St. Turn east (left) following Del. Rts. 896 and 273. Descend Fall Zone from Piedmont Province to Atlantic Coastal Plain.
0.1	0.6	Cross ConRail R.R. Bear south (right) following Del. Rts. 896 and 273.
0.1	0.7	Jct. Elkton Rd. and Delaware Ave. Turn east (left) following Del. Rts. 896 and 273.
0.2	0.9	Jct. Delaware Ave. and South College Ave. Continue east (straight) following Del. Rt. 2 (Delaware Ave.).
0.1	1.0	Pass through main quadrangle, University of Delaware Campus. To the north (left) are men's dormitories. To the south (right) are major academic buildings housing the Departments of Physics, Chemistry, and Biology. The University's theater and administration building are also in this group. At the end of the quadrangle is Memorial Hall which is dedicated to Delawareans who have died in military Service.
0.2	1.2	Jct. Delaware Ave. (Del. Rt. 2) and Academy St. Turn south (right) on Academy St.
0.3	1.5	Pass Penny Hall (to the east; left) which houses the Delaware Geological Survey and the Department of Geology.

0.2	1.7	Jct. Academy St. and Courtney St. Turn east (left) on Courtney St.
0.2	1.9	Jct. Courtney St. and Ashley Rd. Bear east (left) on Ashley Rd.
0.2	2.1	Jct. Ashley Rd. and Del. Rt. 72 (Chapel St.) Turn south (right) on Del. Rt. 72.
0.3	2.4	Cross ConRail R.R., formerly Penn Central R.R., the route of the Metroliner high-speed trains. Continue south through the University of Delaware Farms.

Solid waste disposal is a major environmental problem in many areas. In Delaware it is complicated by the high permeability of the Columbia sands which combined with relatively high rainfall permits leachate to migrate rapidly into ground water. Three generations of solid waste disposal facilities are present in this area:

1. The old town dump which occupied an abandoned borrow pit has been covered and is now part of the pasture to the east (left) of the road.
2. A completed, capped, and reclaimed landfill lies under the mound to the west (right) about 0.3 miles from the road. It was discontinued when its leachate was found to be threatening a nearby city wellfield.
3. Also to the west (right) lies the present solid waste transfer facility of the City of Newark and the University of Delaware. Solid waste is transferred to large trucks and taken across the county to the location of a large landfill where a pioneering reclamation plant will soon be built. The waste is intended to become "urban ore."

1.0	3.4	Jct. Del. Rt. 72 and Del. Rt. 4. Continue south (straight) on Del. Rt. 72.
0.2	3.6	Pass City of Newark's South Basin Wellfield. This channel of thick Columbia sand and gravel was discovered and developed during the 1950's. The community's sprawl has now resulted in much pavement which intercepts recharge and has decreased the efficiency of the wellfield.
1.5	5.1	Cross Christina River. The telemetered stream gage operated in cooperation by the Delaware Geological Survey and the U. S.

Geological Survey is a major link in the flood alert and evaluation system in New Castle County.

0.7      5.8      Pass ditches and road cuts exposing Potomac Formation (Cretaceous) lying below the Columbia Formation and separated from it by a major angular unconformity. The thickness of the Columbia changes abruptly due to its channelled contact with underlying Coastal Plain units.

1.4      7.2      Jct. Del. Rt. 72 and U.S. Rt. 40. Turn east (left) on U.S. Rt. 40.

0.4      7.6      Cross ConRail Delmarva R. R. Line.

1.1      8.7      Pass large sand and gravel borrow pits in Columbia Formation south (right) of road.

1.2      9.9      Bear. Jct. U.S. Rt. 40 and Del. Rt. 7. Turn south (right) on Del. Rt. 7.

In the area southwest of this intersection is a major wellfield. Typical log:

Well Dc31-19; Alt. 70'.

Depth (feet)	Description
0-1	Top soil.
1-15	Clay, sandy and gravel.
15-20	Sand, brown, coarse, and gravel.
20-40	Sand, fine to medium, and gravel.
40-55	Sand, fine to medium, and much gravel.
55-58	Clay, yellow.
58-62	Sand with stringers of clay, yellow.
62-80	Gravel and sand, brown and white, fine to coarse.

0.3      10.2      Cross railroad spur line. Jct. Del. Rt. 7 and Del. Rd. 381. Turn east (left) on Del. Rd. 381.

1.2      11.4      Jct. Del. Rd. 381 and U.S. Rt. 13. Turn north (left) on U.S. Rt. 13.

1.0      12.4      Pass Buena Vista (to the west, left, of road). Home built in 1845 by John M. Clayton, U.S. Senator from Delaware and Secretary of State in President Taylor's cabinet. His name is given to the building at the University of Delaware from which this trip departed.

1.4      13.8      STOP 1.      Army Creek Landfill, Llangollen.

This major landfill, closed since 1968, is producing leachate that has con-

taminated ground water in the Columbia and Potomac Formations over a wide area. Wellfields once producing about 6 million gallons per day have been affected. A number of domestic wells have been shut down and Army Creek has been contaminated. This area illustrates clearly the competing uses for major Columbia channels for sand and gravel production, ground water, and waste disposal. (Fig. 8).

- 13.8 Leave Stop 1. Continue north on U.S. Rt. 13.
- 0.2 14.0 Jct. U.S. Rt. 13 and U.S. Rt. 40. Continue north (straight) on U.S. Rt. 13/40.
- 1.1 15.1 Jct. U.S. Rt. 13/40 and Del. Rt. 273. Turn east (right) on Del. Rt. 273.
- 0.3 15.4 Jct. Del. Rt. 273 and Quigley Blvd. Turn south (right) on Quigley Blvd.
- 0.1 15.5 STOP 2. "Hares Corner."

Large borrow pits are concentrated in the coarse fluvial facies of the Columbia Formation in this area. This pit has been essentially mined out to the Potomac Formation and is being reclaimed as an industrial park. This is the northernmost exposure of the Columbia to be visited. Sedimentary textures and structures are of the same types seen to the south, but are coarser and of larger scale indicative of its relatively upstream location. The section as measured in 1963 is:

(feet)	
0-2	Soil, stripped or disturbed.
2-7	Gravel, dark brown, with medium sand and cobbles.
7-8.5	Sand, dark brown, medium, with gravel and cobbles.
8.5-9.2	Sand, dark brown, medium with gravel.
9.2-11.2	Gravel, brown, with coarse sand and cobbles.
11.2-15.5	Sand, tan, coarse, with gravel and cobbles.
15.5-17.5	Gravel, tan, with cobbles and coarse sand.
17.5-18.5	Gravel, black (manganese stained), with cobbles and coarse sand.

P hole 13  
beach (d)

Artesian Water Co. only  
in 1 mi. away

ext. yield  
4.5 to 7.5 mgpd  
(15% of county supply)  
from same channel

(Columbia) that was mined  
for gravel.

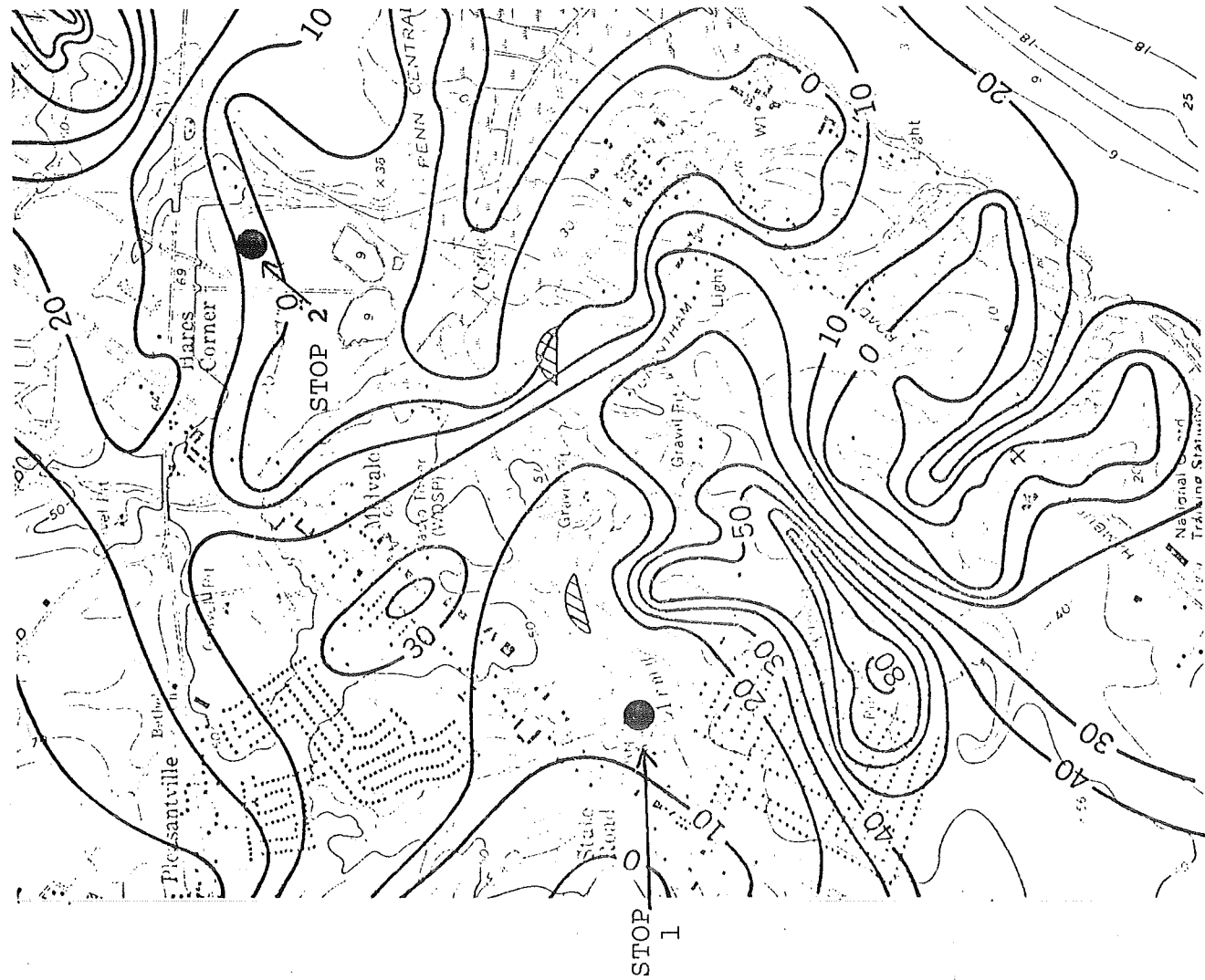
intercepts Test.

Potomac, Swagnum. beach (d)

area S @ ~500 ft/y.

Section is asphalt sea  
@ 18" - or remove it  
all to a prepared pit

drove  
through



# SYMBOLS

Quaternary isopach

30

Landfill, active or abandoned.



Quarry, gravel or clay pit, active or abandoned.



Wetlands (Holocene marsh).



SCALE 1:24000

1 MILE

1 KILOMETER

CONTOUR INTERVAL 10 FEET

Figure 8. Area of STOPS 1 and 2.

(From Woodruff and Thompson, 1975)

18.5-20.5	Sand, brown, medium, with gravel.
20.5-26.5	Sand, yellow, medium.
26.5-27.5	Sand, black (manganese stained), coarse, with gravel.
27.5-30.5	Sand, yellow, medium.
30.5-31.5	Bench-covered.
31.5-35.5	Sand, yellow, medium, with limonite ledges.
35.5-36.5	Gravel, brown, partly limonite-cemented.
36.5-42.5	Sand, yellow and gray, medium, silty.
42.5-47.0	Slump; sand, gravelly.

Textural parameters (Inman):  $Md\phi = 0.30$ ;  $\sigma\phi = 3.575$ ;  $\alpha\phi = -0.6223$ ; polymodal.

Mean foreset dip azimuth for area:  $214^{\circ}$ .

Pebble count for 1 to 2" gravel:

vein quartz	- 50%
sandstone	- 34
chert	- 11
crystalline	
rocks	- 3
shale	- 2

	15.5	Leave Stop 2. Continue south and west on Quigley Blvd.
0.8	16.3	Jct. Quigley Blvd. and U.S. Rt. 13/40. Turn south (left) on U.S. Rt. 13/40.
0.8	17.1	Jct. U.S. Rt. 13 and U.S. Rt. 40. Continue south (straight) on U.S. Rt. 13.
1.7	18.8	Pass Buena Vista - to west (right) of road.
1.0	19.8	Tybouts Corner. Jct. U.S. Rt. 13 and U.S. Rt. 301-Del. Rt. 71. Turn southwest on U.S. Rt. 301-Del. Rt. 71.
0.6	20.4	Turn east (left) at entrance to landfill-borrow pit.
0.2	20.6	<u>STOP 3.</u> Tybouts Corner Landfill and sand and gravel pit.

This pit served as a landfill from 1968 to 1971. Sand and gravel mining continued until 1975. The landfill is producing leachate that is affecting ground and surface waters. The sorted gravel offers evidence of the provenance of the Columbia Formation.

20.6 Leave Stop 3 on former haul road.

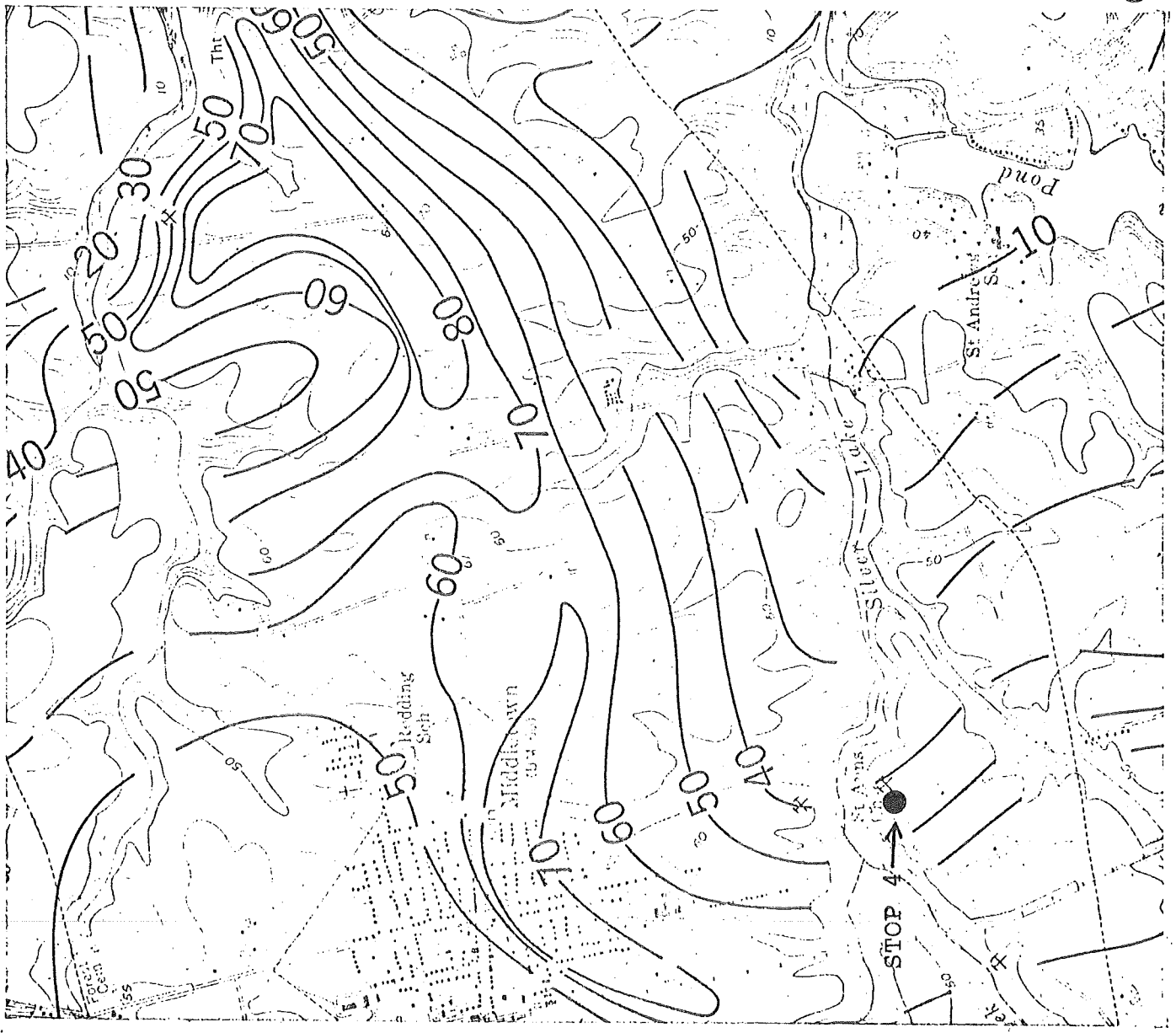
0.2	20.8	Turn southwest (left) on U.S. Rt. 301-Del. Rt. 71.
0.5	21.3	Enter Red Lion.
0.7	22.0	Pass road cuts and ditches in Potomac Formation. The Columbia is absent at this point.
2.1	24.1	Enter Kirkwood.
0.3	24.4	Cross ConRail Delmarva Line R.R.
1.3	25.7	Note spoil banks of Chesapeake and Delaware Canal south (left) of road.
2.5	28.2	Jct. U.S. Rt. 301-Del. Rt. 71 and Del. Rt. 896. Turn south (left) on Del. Rt. 896.
0.9	29.1	Summit Bridge, Chesapeake and Delaware Canal.
		Note view of Coastal Plain ahead and Piedmont 10 miles behind. The bridge crosses the Canal in the section of the Deep Cut where the channel has been cut to -35 feet from a general land surface altitude of 70 feet. The banks of the Canal contain the marine Cretaceous rocks of the Merchantville, Englishtown, Marshalltown and Mt. Laurel formations.
3.3	32.4	Enter Mount Pleasant.
2.0	34.4	Enter Armstrong.
1.2	35.6	Jct. Del. Rt. 896 and U.S. Rt. 301-Del. Rt. 71. Bear south (left) on Del. Rt. 896.
0.5	36.1	Enter Middletown (pop. 2644).
0.6	36.7	Jct. Del. Rt. 896 and Del. Rt. 299. Continue south (straight) on Del. Rt. 896.
0.9	37.6	Cross Deep Creek.
0.1	37.7	Turn east (left) enter Delaware Division of Highways borrow pit.
0.3	38.0	<u>STOP 4.</u> "Middletown" Gravel Pit.

This location illustrates the fluvial nature of the Columbia Formation. It lies near the western edge of the channel shown in figure 9. Several studies of the sedimentary textures and structures and the hydrology of the Columbia have been conducted in this area. Some plant fragments have been recovered here. The section and measured properties as measured in 1963 are:

(feet)

0-1	Disturbed
1-3	Sand, tan, coarse, clayey, soil.
3-9.2	Gravel, tan, with very coarse sand.
9.2-16	Sand, yellow (with some black manganese staining), medium,





# SYMBOLS

30- Pleistocene thickness in feet.

Marsh (small, undrained depressions are Carolina Bays).

Approximate boundary of marsh.

x Sand or gravel pit.

SCALE 1:24 000

0 1 MILE

0 1 KILOMETER

CONTOUR INTERVAL 10 FEET

Figure 9. Area of STOP 4.

(From Pickett and Spoljaric, 1971)

with fine gravel; cross-bedded.  
 16-21 Sand, yellow, medium; cross-bedded.  
 21-23 Slump; floor of pit.

Textural parameters (Inman):  $Md \phi = 0.28$ ;  
 $\sigma\phi = 1.860$ ;  $\alpha\phi = -0.3333$ ; bimodal.

Mean foreset dip azimuth for area:  $207^{\circ}$ .

	38.0	Leave Stop 4.
0.3	38.3	Turn north (right) on Del. Rt. 896.
1.0	39.3	Center of Middletown.
1.1	40.4	Jct. Del. Rt. 896 and U.S. Rt. 301-Del. Rt. 71. Continue north (straight) following Del. Rt. 896 (road bears all above route numbers).
6.2	46.6	Cross Summit Bridge, Chesapeake and Delaware Canal.
1.3	47.9	Jct. U.S. Rt. 301-Del. Rts. 71/896. Continue north (straight) on Del. Rt. 896.
3.0	50.9	Glasgow, Jct. Del. Rt. 896 and U.S. Rt. 40. Continue north (straight) on Del. Rt. 896.
2.3	53.2	Jct. Del. Rt. 896 and Old Baltimore Pike. To the east (right) is the site of the Battle of Coochs Bridge (1777), the only Revolutionary War Battle in Delaware. Rt. 896 ahead rises over the eastern flank of Iron Hill which was the location of major encampments during this campaign. Iron Hill is composed of gabbroic and ultramafic rocks and is an outlier of the Piedmont surrounded by Coastal Plain sediments.
0.8	54.0	Cross I-95.
0.1	54.1	Cross Christina River; enter Newark.
0.7	54.8	Pass, to the east (right) University of Delaware Farms, Stadium, and Fieldhouse.
0.3	55.5	Cross ConRail (Penn Central) R.R.
0.2	55.7	Enter area of main campus of University of Delaware.
0.7	56.4	Jct. South College Ave. and Main St. (Del. Rt. 2). Turn west (left) following Del. Rt. 896 (Main St.). Building north of this intersection is Old College (1834).
0.1	56.5	Bear north (right) following Del. Rt. 896 (New London Rd.). Cross ConRail (B & O) R.R.
0.5	57.0	North Campus, University of Delaware. Turn east (right) on Pencader Dr.
0.1	57.1	Clayton Hall.

End of Field Conference

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