COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION
AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES

GEOLOGY OF THE NEWPORT NEWS SOUTH AND BOWERS HILL QUADRANGLES, VIRGINIA

NICHOLAS K. COCH

REPORT OF INVESTIGATIONS 28

VIRGINIA DIVISION OF MINERAL RESOURCES
James L. Calver
Commissioner of Mineral Resources and State Geologist

CHARLOTTESVILLE, VIRGINIA
1971

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION
AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES

GEOLOGY OF THE NEWPORT NEWS SOUTH AND BOWERS HILL QUADRANGLES, VIRGINIA

NICHOLAS K. COCH

REPORT OF INVESTIGATIONS 28

VIRGINIA DIVISION OF MINERAL RESOURCES
James L. Calver
Commissioner of Mineral Resources and State Geologist

CHARLOTTESVILLE, VIRGINIA
1971

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF PURCHASES AND SUPPLY
RICHMOND
1971

Portions of this publication may be quoted if credit is given to the Virginia Division of Mineral Resources. It is recommended that reference to this report be made in the following form:

Coch, Nicholas K., 1971, Geology of the Newport News South and Bowers Hill quadrangles, Virginia: Virginia Division of Mineral Resources Rept. Inv. 28, 26 p.

DEPARTMENT OF CONSERVATION AND
ECONOMIC DEVELOPMENT

Richmond, Virginia

MARVIN M. SUTHERLAND, *Director*
CHARLES A. CHRISTOPHERSEN, *Deputy Director*
A. S. RACHAL, JR., *Executive Assistant*

BOARD

WILLIAM H. KING, Burkeville, *Chairman*
WILLIAM H. STANHAGEN, Alexandria, *Vice Chairman*
D. HENRY ALMOND, Richmond
MAJOR T. BENTON, Suffolk
JOSEPH C. CARTER, JR., Richmond
ADOLF U. HONKALA, Richmond
CLAUDE A. JESSUP, Charlottesville
GERALD L. LAVENSTEIN, Virginia Beach
GEORGE C. MCGHEE, Middleburg
ROBERT PATTERSON, Charlottesville
COLLINS SNYDER, Accomac
FREDERICK W. WALKER, Roanoke

CONTENTS

PAGE

Abstract 1

Introduction 2

Morphology 3

Stratigraphy 5

Miocene Series 5

Yorktown Formation 5

Pleistocene Series 8

Norfolk Formation 8

Sand Bridge formation 13

Holocene Series 14

Dismal Swamp peat 14

Estuarine sediments 14

Geologic history 15

Engineering properties 17

References 19

Appendix I: Reference sections 20

Appendix II: Faunal lists 23

Appendix III: Summary of data from test borings 24

Index 25

ILLUSTRATIONS

PLATE PAGE

1. Geologic map of the Newport News South quadrangle, Virginia In pocket

2. Geologic map of the Bowers Hill quadrangle, Virginia.....In pocket

FIGURE

1. Index map showing location of the Newport News South and Bowers Hill quadrangles 2

2. Index map of lower part of the James River Basin 4

3. Areal variation in sediment size of the Yorktown Formation 6

4. Paleotopography of top of Yorktown Formation 7

5. Stratigraphic sections in the Newport News South quadrangle 8

6. Paleogeography of the lower part of the James River Basin in Norfolk time 10

7. Geologic section across Bennett Creek Army Reservation 12

TABLE

PAGE

1. Test characteristics of formations studied 18

GEOLOGY OF THE NEWPORT NEWS SOUTH AND BOWERS HILL QUADRANGLES, VIRGINIA

By

NICHOLAS K. COCH[1]

ABSTRACT

The Newport News South and Bowers Hill 7.5-minute quadrangles, covering an area of about 119 square miles, are located in the southeastern Virginia portion of the Coastal Plain and include portions of Nansemond and Isle of Wight counties and the cities of Chesapeake, Hampton, Portsmouth, and Newport News. Stratigraphic units exposed in the quadrangles range in age from late Miocene to Recent and consist of the Miocene Yorktown Formation, the Pleistocene Norfolk and Sand Bridge formations, and the Holocene Dismal Swamp peat and estuarine sediments. The oldest unit exposed is the fossiliferous Yorktown Formation, which was deposited in shallow water of less than 20 feet in a coastal-marine environment in the western portion of the mapped area and in a nearshore environment having water depths of 30 to 60 feet in the eastern part. The fossiliferous Norfolk Formation unconformably overlies the Yorktown Formation. The Norfolk Formation was deposited when late Pleistocene (Sangamon?) sea level rose to about 50 feet above present sea level and the shoreline was at the Suffolk scarp. Fossil assemblages of specific associations in the Norfolk Formation indicate that estuarine conditions prevailed in the northwestern and northern part of the mapped area and nearshore-marine conditions were present in the southern and southeastern parts during Norfolk time. The Pleistocene Sand Bridge formation overlies the Norfolk Formation in the interfluvial areas and fills channels cut through the Norfolk Formation into the Yorktown Formation in the vicinity of present streams. Sediments of the Sand Bridge formation were deposited during the last Pleistocene rise of sea level on the Virginia Coastal Plain to 17 feet above present sea level. At maximum submergence estuarine conditions prevailed and the shoreline lay east of the area of study. The flat, upper surface in the quadrangles is an emerged estuarine depositional one underlain by complexly interfingering sediment facies of the Sand Bridge formation.

[1] Department of Earth and Environmental Sciences, Queens College of City University of New York, Flushing, New York 11367.

INTRODUCTION

The Newport News South (Plate 1) and Bowers Hill (Plate 2) 7.5-minute quadrangles are located on the Coastal Plain of southeastern Virginia and include portions of Nansemond and Isle of Wight counties and the cities of Chesapeake, Portsmouth, Hampton, and Newport News (Figure 1). The quadrangles encompass an area of 119 square miles and are bounded by parallels 36°45′ and 37°00′ north latitude and by meridians 76°22′30″ and 76°30′ west longitude. The area on the right bank of the James River is drained by northward-flowing tributaries, such as Chuckatuck Creek, Nansemond River, Bennett Creek, and the Western Branch of the Elizabeth River. Salters Creek drains the area on the left bank of the James River.

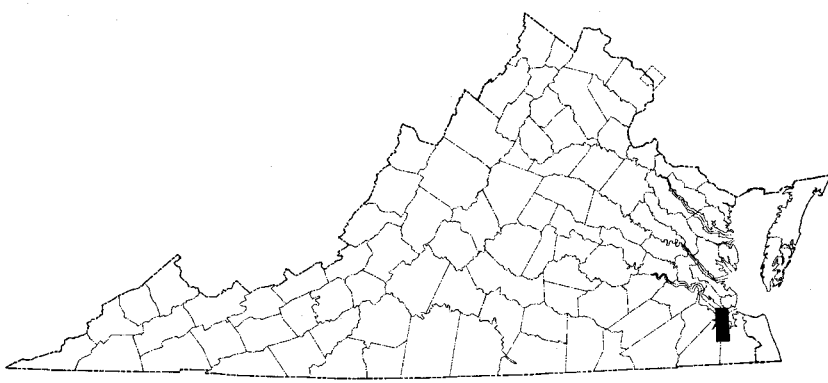


Figure 1. Index map showing location of the Newport News South and Bowers Hill quadrangles.

The writer made a regional study of post-Miocene stratigraphy and morphology in southeastern Virginia with Robert Q. Oaks for the Geography Branch, U. S. Office of Naval Research during the early 1960's (Coch, 1965; Oaks, 1965). Field work for the present report was carried out for a total of 19 weeks during the summers of 1962, 1963, 1969, and 1970. Stratigraphic relationships were studied by examination of 93 exposures; supplemental shallow hand-auger borings were made. In 1969 the Virginia Division of Mineral Resources contracted to have 32 test borings made to determine

stratigraphic contacts in densely populated areas and under interfluves, and to obtain samples for sedimentologic and faunal analyses (Appendix III). Two-foot split-spoon samples were taken at 5-foot intervals. All holes were cased and were washed out prior to the taking of the next sample. The writer accompanied the drillers in order to keep drilling logs, observe the character of the washed intervals, and to take penetrometer readings so as to characterize the engineering properties of the sediments sampled. Numbers preceded by "W" in parentheses (W-2505) correspond to test-boring localities on Plates 1 and 2.

The writer gratefully acknowledges the financial and technical aid of the Virginia Division of Mineral Resources and especially Dr. James L. Calver, who authorized the project. Several individuals graciously provided access to subsurface data for the area. Chief among these were Randall Spencer, Old Dominion University; E. F. Caldwell, Carpenter Construction Company; Page Herbert, Herbert Associates; T. E. Rodgers, Virginia Electric and Power Company; Ray Eure, George T. McLean Corporation; Gene Groshong, Forest Coile & Associates; William Vogelsang, Froehling & Robertson, Inc.; and the Virginia Department of Highways, Suffolk office.

Robert Q. Oaks, Jr. kindly provided supplementary data for the Bowers Hill quadrangle and adjacent areas to the east and south. In addition, he worked jointly with the writer for 11 days in 1963 to establish the general stratigraphic relations in the Bowers Hill area. Rolf Sohn drafted several of the figures for the report. E. S. Gaffney and J. E. White, Jr. assisted the writer in making shallow borings and test borings in 1963. E. F. Caldwell provided laboratory and shop facilities and gave freely of his detailed knowledge of the subsurface geology of Tidewater Virginia. Special thanks to Gerald H. Johnson, College of William and Mary, for many stimulating discussions on mutual stratigraphic problems and for his aid in the field in working out the stratigraphic relations on the lower York-James Peninsula.

The Sand Bridge and Norfolk formations are being mined in the Bowers Hill area (Plate 2) for use as general fill for highway embankments by the E. V. Williams Company.

MORPHOLOGY

South of the James River, all of the study area lies within the broad, very gently sloping Churchland flat (Figure 2) that has

maximum elevations of 24 feet in the western part and 20 feet in the eastern part. The Churchland flat is underlain by facies of the Sand Bridge formation.

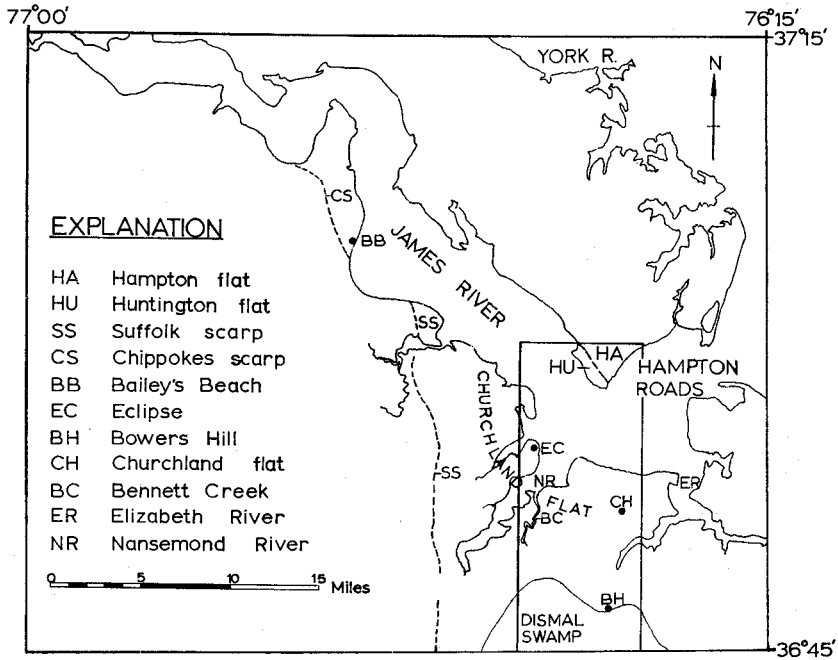


Figure 2. Index map of lower part of the James River Basin showing location of area studied, morphologic features, and localities mentioned in text. (Mapped area encompassed by outline.)

North of the James River, the study area is divided into two morphologic subdivisions, the Huntington flat and the Hampton flat (Figure 2). The Huntington flat is a narrow (0.5-mile wide), northwest-southeast feature occupying the western part of the land portion of the area of study north of the James River. It has a general elevation of 25 to 30 feet, with highs as much as 35 feet or more in the northern part. Along the west side, the flat is being eroded by the James River and the sediments underlying it are exposed in steep bluffs along the river, where the cliffs have not been covered or modified by construction of buildings and docks. Exposures in the cliffs along the James River show the Huntington

flat is underlain by the sand facies of the Norfolk Formation. On the west side, the flat slopes westward at about 6 feet per mile and is a prominent morphologic feature when viewed from the adjacent Hampton flat. The scarp on the east side of the Huntington flat can be traced discontinuously northward where it is believed to be correlative with the Harpersville scarp (personal communication, G. H. Johnson).

The Hampton flat extends northeastward from the Huntington flat. It ranges in maximum elevation from 18 feet in the western part to 15 feet in the eastern part bordering Hampton Roads. The flat is relatively undissected; it is underlain by the clayey-sand facies of the Norfolk Formation.

STRATIGRAPHY

MIOCENE SERIES

Yorktown Formation

The Yorktown Formation at Chuckatuck, about 4 miles west of the Bowers Hill quadrangle, was deposited as a series of biofragmental bars in shallow, marine water less than 20 feet deep (Johnson and Coch, 1969). Using a combination of sedimentary structures, biofacies, and sediment facies changes, it was determined that the coquina facies became finer eastward into the area of study where the water was deeper (Figure 3). Only the uppermost part of the Yorktown Formation is exposed above sea level; its area of outcrop is solely south of the James River and along Bennett Creek, Deanes Branch and their tributaries, and Nansemond River (Plate 2). It is characterized by a 2- to 5-foot, orangish-red, indurated saprolite that commonly contains imprints of fossils present in the unweathered Yorktown sediments. A concentrate of coarse pebble-gravel and cobble-gravel commonly overlies the weathered Yorktown Formation in exposures along the Nansemond River.

The Yorktown Formation occurs in the subsurface over most of the area and is recognized by character and abundance of fauna and by the compact nature of the sediments (Table 1). The upper surface of the Yorktown decreases in elevation toward the northeast and east. South of the James River, this surface has a maximum elevation of 10 feet along the Nansemond River, is above sea level in the Dismal Swamp, and occurs below sea level east of Bennett Creek (Plate 2).

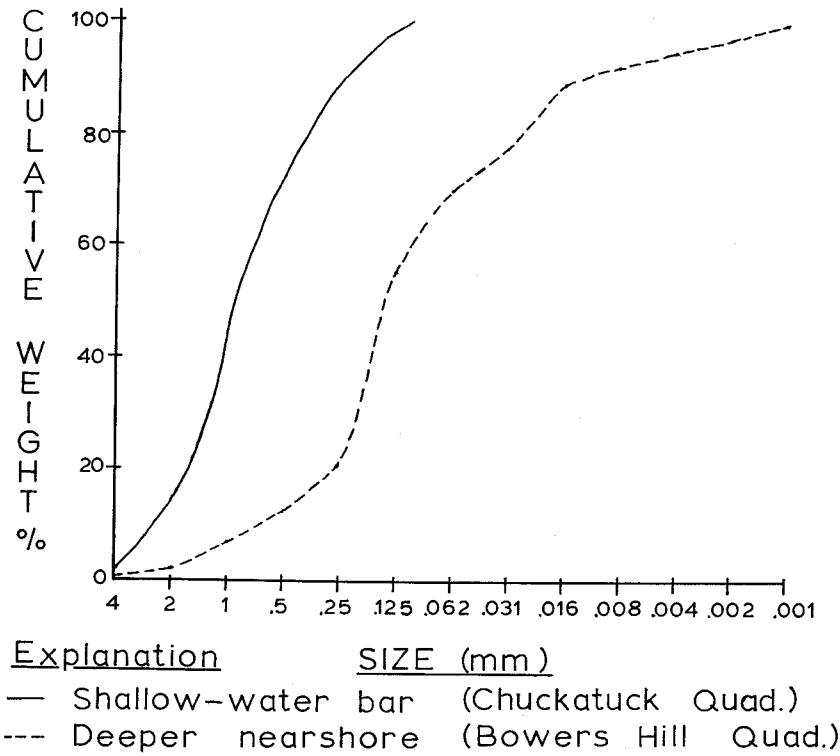


Figure 3. Areal variation in sediment size of the Yorktown Formation from the adjacent Chuckatuck quadrangle (littoral environment) eastward to area of study (shallow nearshore environment).

Contours drawn on the upper surface of the Yorktown (Figure 4) reveal deep channels cut into the formation. These channels are sometimes reflected at the ground surface, but many deep channels, such as the ones near Churchland, are not apparent. Similar relationships are present north of the James River where the Yorktown is characterized by deep channels now lying below sea level at elevations of –30 to –45 feet (Figure 5). The irregular topography on the upper Yorktown surface is significant because it controlled, to a large degree, the depositional patterns of the overlying Pleistocene sediments.

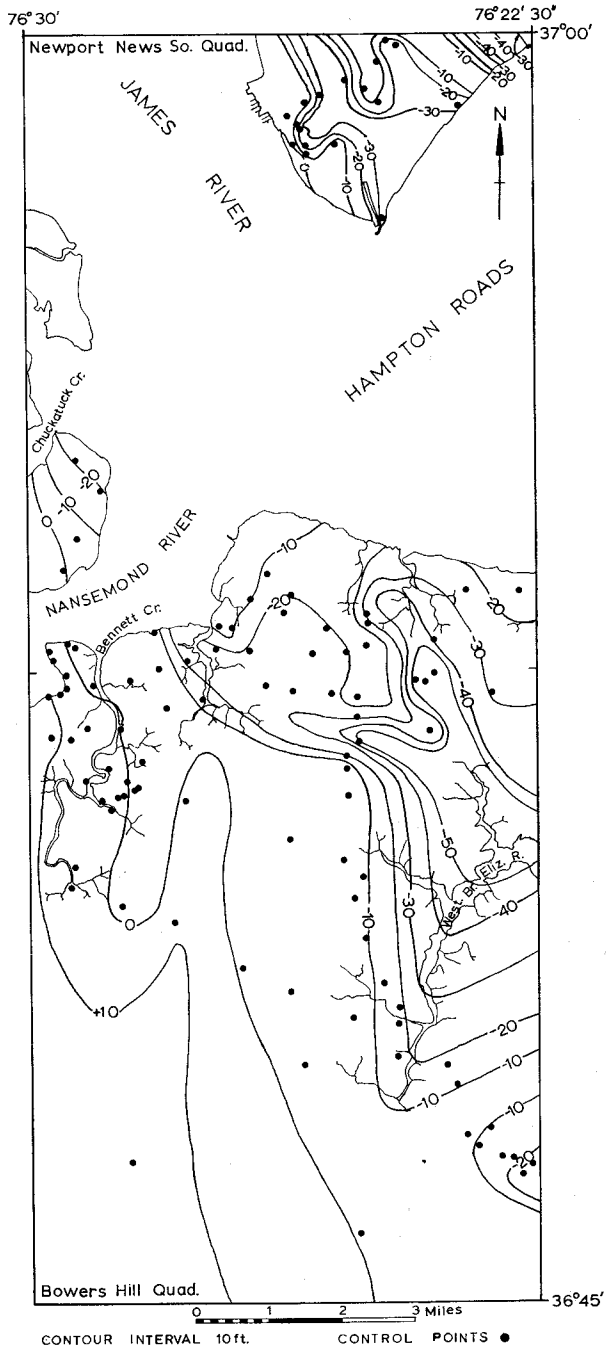


Figure 4. Paleotopography of top of Yorktown Formation in mapped area.

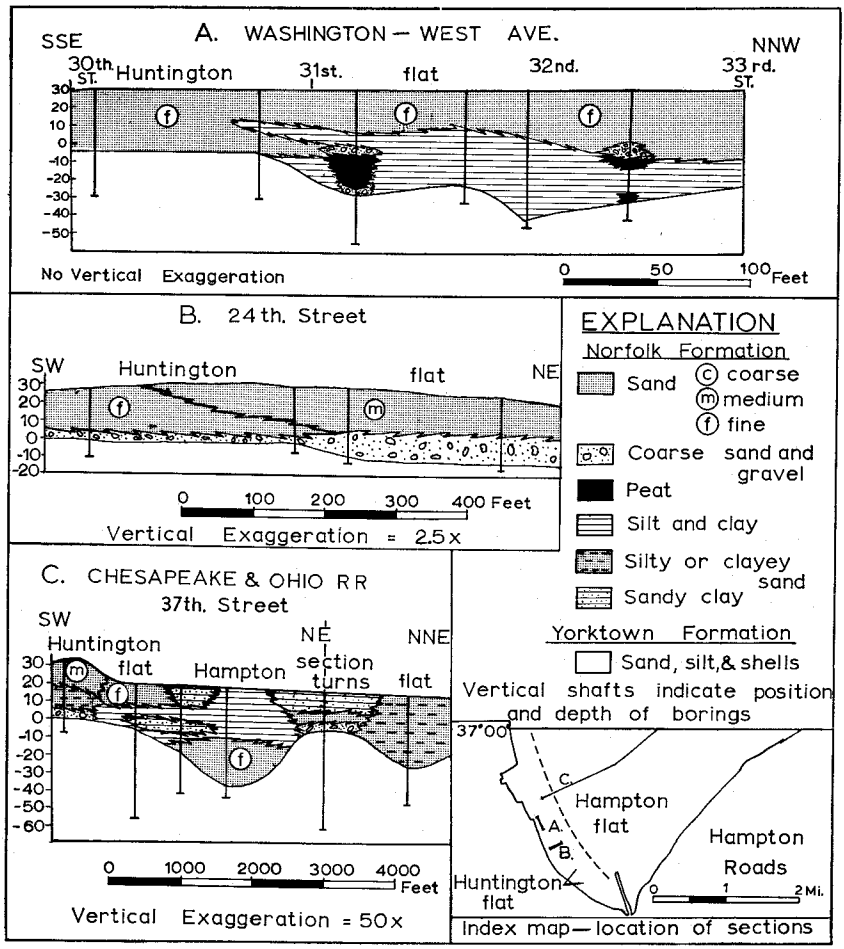


Figure 5. Stratigraphic sections in the Newport News South quadrangle north of the James River.

PLEISTOCENE SERIES

Norfolk Formation

Good exposures of the Norfolk Formation are present in the James River bluffs at Eclipse (Plate 1), at Newport News (Plate 1), and in numerous borrow pits in the vicinity of Bowers Hill

(Plate 2). The Norfolk Formation unconformably overlies the Yorktown Formation except where the Norfolk was removed during erosion prior to the deposition of the overlying Sand Bridge formation. South of the James River, the Norfolk is overlain by the Sand Bridge formation; north of the James it is the surficial unit. The Norfolk has an average thickness of 20 feet and is more than 40 feet thick in the central parts of channel-fill sequences both north (Figure 5) and south of the James River. The formation is subdivided into a sand facies under the Huntington flat and a clayey-sand facies under the Hampton flat north of the James River (Plate 1; Figure 2), and a silty-sand facies under the Churchland flat south of the James (Plate 2; Figure 2).

The contact between the silty-sand facies of the Norfolk and the underlying Yorktown, observed only in test borings in the area of study, is marked by a medium to coarse, silty sand with pea-sized gravel, which overlies decomposed coquina. A marked increase in compaction occurs at this contact (Table 1). The silty-sand facies crops out east of Bennett Creek (Plate 2), is encountered in borings beneath interfluvial areas, and is commonly eroded away and replaced by the clayey-sand facies of the upper member of the Sand Bridge formation near present streams. In exposures under the Churchland flat, the Norfolk Formation is easily distinguished by its bluish-gray color, in contrast to the yellow and yellowish-brown colors of the overlying Sand Bridge formation. In borings, the contact between these formations is generally sharp and marked by a decrease in grain size, change in sediment color, and reduction in compaction below the contact (Table 1).

The silty-sand facies is composed of fairly uniform silty sand and sandy silt on level or high areas on the surface of the underlying Yorktown Formation (Appendix I, Section C). Where the silty-sand facies is thick and fills channels cut into the underlying Yorktown Formation, it is less homogeneous and is composed of three vertical lithologic zones. The basal zone contains coarse sand and pea-gravel overlain by organic sands, silts, and woody peats, which grade upward into fossiliferous silty sands.

The lower part of the silty-sand facies consists of fine sands and silty sands and beds of organic rich sand, silt, and peat above the basal coarse zone at elevations of –7 to –20 feet. Average organic content, as based on oxidation with 15 percent H_2O_2, for a 13-foot thick organic interval near the Western Branch of the Elizabeth River was 25 percent (W-3516, 4 samples, Plate 2) and

for an 11-foot section at Eclipse it was 8 percent (W-2531, 3 samples, Plate 2). A test boring taken at the site of the South Street Baptist Church in Churchland contained a layer of fossil tree remains from an elevation of –33 to –28 feet in the lower part of the silty-sand facies. A *Taxodium* wood sample from this stratum gave a C^{14} date of greater than 47,000 years B.P. (Y-1047).

The upper part of the silty-sand facies contains Pleistocene marine and estuarine fossils that indicate environmental conditions varied in the area. Fossils in the Norfolk Formation at Baileys Beach (Figure 6) included *Mulina lateralis* Say and are indicative of brackish-water conditions (Bick and Coch, 1969). Fossils that were collected at Eclipse (Figure 6) included Pleistocene marine forms characteristic of less brackish water (Appendix II, A) and some characteristic of warmer waters than the present water off the Virginia coast. Fossils at Bowers Hill (Figure 6) included Pleistocene forms indicative of more open-marine conditions. East of the

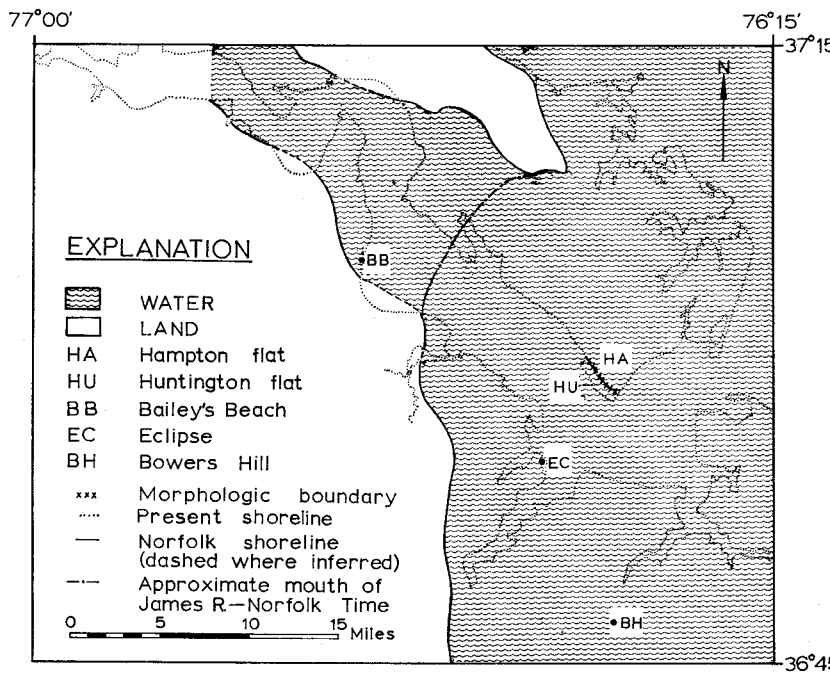


Figure 6. Paleogeography of the lower part of the James River Basin in Norfolk time.

area of study normal- or open-marine fossils have been found in other facies of the Norfolk Formation (Oaks, 1965). The fossil evidence and the distinct increase in grain size of the Norfolk Formation from northwest to southeast suggest a gradation from estuarine to open-marine conditions.

The clayey-sand facies of the Norfolk Formation occurs under the Hampton flat north of the James River. Exposures of the facies are few and no thicker than 6 feet. The facies grades from coarse- to fine-grained sediments eastward in its upper part (Appendix I, Section B). Under the Hampton flat, it occurs in deep fills (Figure 4) that were cut into the underlying Yorktown Formation. The lower part of the clayey-sand facies is composed of thick sequences of fine sand, silty sand, silt, and clay in subsurface topographic lows of the Yorktown surface, with coarser sediments occurring above subsurface topographic highs of the underlying Yorktown (Figure 5, C). The upper part of the facies becomes more coarse grained westward where it interfingers with the sand facies under the Huntington flat.

The sand facies of the Norfolk lies under the Huntington flat north of the James River. It is well exposed in the James River cliffs north of 57th Street (Appendix I, Section A) and in shallow exposures as far west as Terminal Avenue and 6th Street in Newport News. The facies consists of 20 to 30 feet of mostly sand, generally grading from coarse sand and gravel at the base to fine sand at the top. The sand sequences are unusually free of any silt or clay beds except near the outer parts of the Huntington flat. In the area from 22nd Street to 30th Street, the sand facies directly overlies a subsurface topographic high of the Yorktown surface (Figure 5, B) and has a maximum thickness of 35 feet. In the area between 30th and 33rd streets, the sand facies is decreased in thickness to less than 20 feet and grades into silts and peats that fill channels cut into the underlying Yorktown Formation (Figure 5, A). These silts and peats may be traced eastward in the subsurface into similar lithologies of the clayey-sand facies under the Hampton flat.

The sand facies interfingers with the clayey-sand facies to the northeast. Additionally, the sand facies probably becomes finer westward, as based on test borings along the western edge of the Huntington flat, between 35th and 36th streets, and Washington and West avenues. Exposures along the James River, north of the area of study, have increased thicknesses of finer-grained sediments

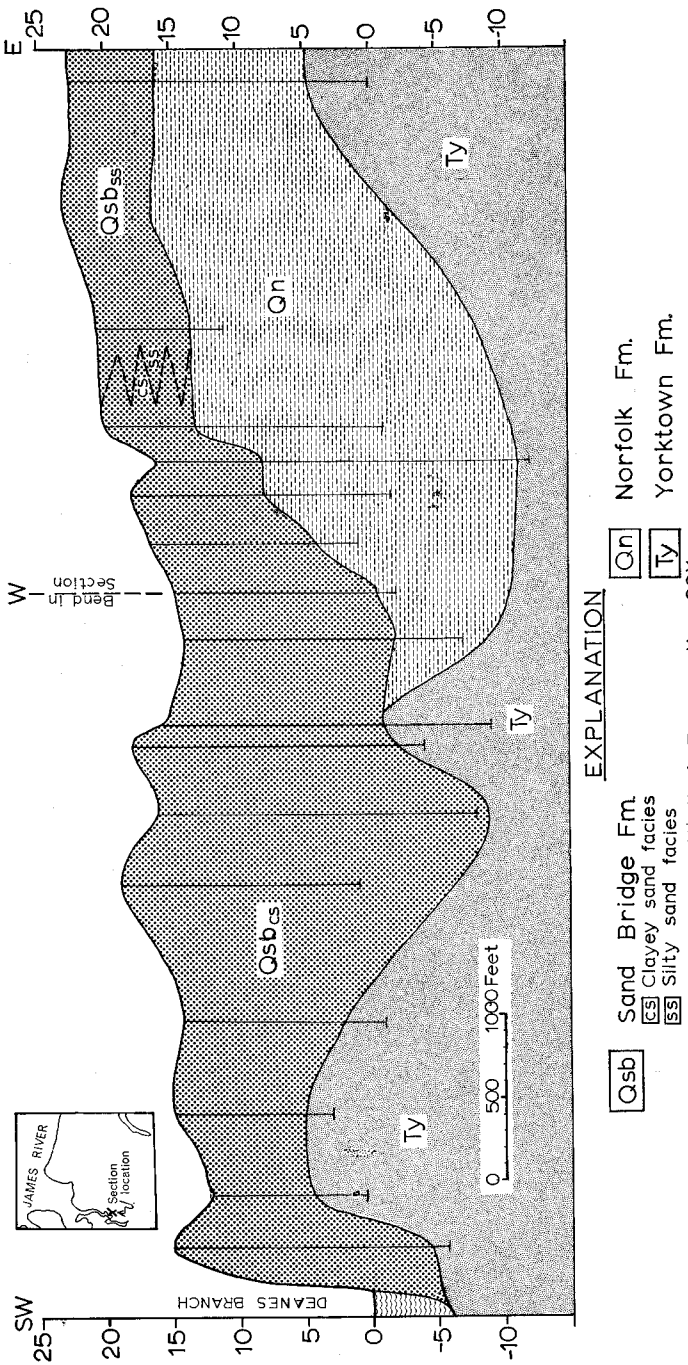


Figure 7. Geologic section across Bennett Creek Army Reservation, Bowers Hill quadrangle, showing detailed stratigraphic relations between facies of the Sand Bridge formation and erosional contact of the Sand Bridge and the underlying Norfolk and Yorktown formations.

northwestward (Appendix I, Section A). At the James River Bridge (Newport News North Quadrangle, north of the mapped area), cliff exposures are composed almost entirely of silty sands and silts of the clayey-sand facies.

Sand Bridge Formation

The Sand Bridge formation was informally named by Oaks and Coch (1963), who divided it into a homogeneous lower member and an upper member composed of several mappable facies. The lower member, 3 to 5 feet thick, occurs only under relatively undissected parts of the Churchland flat. It consists of unstratified, well-sorted, fine- to medium-grained sand and has a sharp contact with the underlying Norfolk Formation. The lower member has been omitted on the geologic maps and sections because of its discontinuous nature and thinness. The upper member is divided into three facies which crop out on the Churchland flat south of the James River (Figure 2).

The clayey-sand facies crops out on both sides of major streams, but is absent over interfluvial areas (Plate 2). The base of the facies was deposited on a very irregular, eroded surface cut into older stratigraphic units and decreasing in elevation toward present streams (Plate 2, cross sections; Figure 7). It is heterogeneous and composed of cross-bedded sands, massive sands, silty sands, silts, and clayey sands. Along the Nansemond River and Bennett Creek the clayey-sand facies is typically composed of massive, gray, clayey sands mottled with yellow that overlie a pebble- and cobble-gravel zone. It is highly variable texturally, both laterally and vertically, with upstream sections having considerably coarser sediments than downstream ones. There is also a general decrease in grain size vertically in a given exposure. The facies is more than 30 feet thick and averages about 20 feet. Thicker sections of the Sand Bridge clayey-sand facies generally directly overlie the Yorktown Formation with the intervening Norfolk Formation having been eroded away prior to and perhaps during deposition of the Sand Bridge clayey-sand facies (Appendix I, Section E).

The silty-sand facies underlies the interfluvial areas north and east of the Dismal Swamp (Plate 2). It is homogeneous, unstratified, and is composed of medium sand with 15 to 20 percent silt (Appendix I, Section D). The facies is about 10 feet thick except in the area of Churchland (Plate 2), where it fills channels that were cut through the Norfolk Formation into the underlying

Yorktown Formation (Plate 1, Cross Section A-A′). It typically ranges from tan at the base, where it is in sharp contact with the Norfolk Formation, to brownish gray in the upper part. The silty-sand facies grades into the silty-clay facies in the southern and southwestern parts of the area and into the clayey-sand facies in the northeastern and northwestern parts.

The silty-clay facies crops out north and east of the Dismal Swamp (Plate 2). In the southern part of the area it is overlain by the Dismal Swamp peat. It is composed of massive, cohesive clay and silt with about 20 percent fine- to medium-grained sand. The sand percentage increases near gradational contacts with the clayey-sand and silty-sand facies. The silty-clay facies is typically light to medium gray in color with yellowish-orange mottling.

HOLOCENE SERIES

Dismal Swamp Peat

The Dismal Swamp peat was informally named by Oaks and Coch (1963). The peat overlies the Sand Bridge formation in the southern and southwestern part of the mapped area. The peat, less than 5 feet thick, consists of a dark-brown, soft, wet, sponge-like mass of decaying organic materials, chiefly leaves, twigs, rooted stumps, and fallen logs (Oaks, 1965).

Estuarine Sediments

Tidal streams in the area are underlain by fine silt and silty sand; they are bordered by exposures of coarser silty sand and fine sand that are as much as five feet above sea level in elevation. Wide creeks and portions of creeks bordering the James River commonly have narrow beaches of fine sand.

The Ragged Island Marsh on the James River has a distinctive ridge and swale topography which is outlined by the linear arrangement of trees on the ridges and marsh grasses in the swales. The ridges are 100 to 200 feet wide, 120 to 1500 feet long, and about 5 to 8 feet above sea level in elevation. The ridges have a preferred northwest-southeast orientation, which parallels the direction of flow of the James River in that area. The ridges are underlain by thin sands resting on finer sediments. Swales are underlain by fine silts and organic sands similar to those observed in other marshes in the area. In places the marsh is underlain by gray, silty clays

that grade upwards into very thick sandy clays (personal communication, E. F. Caldwell). The deepest test boring in the marsh terminated in gray, medium to coarse sand and fine, pebble-gravel at an elevation of –90 feet. This coarse layer may represent the basal part of a Holocene estuarine-fill sequence which is at least 95 feet thick.

GEOLOGIC HISTORY

From Late Cretaceous to Miocene time the area was part of the shallow continental shelf and was the site of extensive offshore and nearshore marine sedimentation. During the late Miocene, it was covered by the warm, shallow Yorktown sea and only fine silt, sand, and shells were deposited. Uniform conditions prevailed for a long time as indicated by the 150 to 200 foot thick Yorktown Formation (Clark and Miller, 1912). The shoreline retreated from the Fall line area to a position west of Chuckatuck (Coch, 1968). Along this new shoreline a series of coalescing longshore coquina bars were deposited in water less than 20 feet deep across the bars. The coalescing bars were composed of shells living *in situ* and fragments of locally derived shells (Johnson and Coch, 1969). This late Yorktown longshore-bar complex extended from south of Chuckatuck northward at least to Yorktown (personal communication, G. H. Johnson, 1971). In the western part of the area of study, fine-grained coquina was deposited, grading eastward into finer grained, biofragmental, silty sand. When the area emerged from the sea, drainage systems were formed and the area began to be dissected.

The area studied contains no sediments of Pliocene and early Pleistocene age, as they were removed by fluvial, tidal, and coastal erosion during fluctuations of sea level in the early Pleistocene (Coch, 1968; Bick and Coch, 1969). The first Pleistocene event recorded in the area is the cutting of deep channels into the Yorktown Formation, which are presently below sea level at more than –80 feet elevation. A major tributary stream of the pre-Norfolk James River apparently flowed southeasterly through the area during this time (Figure 5).

The Great Bridge formation (Oaks and Coch, 1963) was then subsequently deposited as sea level rose from –80 feet to between –10 feet and its present elevation (Oaks, 1965, p. 211), probably during the Sangamon Interglaciation. The sands and freshwater

peats that were deposited in topographic lows on the upper surface of the Yorktown Formation in the area of study are probably of Great Bridge age but have been mapped as part of the Norfolk Formation because of their sporadic subcrop pattern.

The Norfolk Formation was deposited in the latter part of the Great Bridge-Norfolk submergence as the Great Bridge barrier was drowned by rapid submergence during a rise of sea level, which took place in early Norfolk time (Oaks, 1965). The Norfolk shoreline migrated westward, removing portions of older stratigraphic units that had not been eroded in the post-Windsor, pre-Great Bridge emergence. At maximum submergence, the Norfolk sea reached an elevation of 45 or 50 feet above present sea level and the shoreline position was at the Suffolk scarp (Figure 6). As sea level rose in the James River channel, finer grained silts were deposited in the topographic lows on the Yorktown surface whereas coarser grained sediments were deposited in the shallower waters over the topographic highs. In the vicinity of the southwestern part of the Hampton-Newport News area a group of estuarine sand bodies formed on topographic highs of the Yorktown Formation, interfingering with finer estuarine silts, clays, and silty sands as sea level rose. Faunal evidence suggests that at maximum submergence, the Norfolk Formation in the northeastern part of the area was deposited in brackish water whereas the southern and southeastern parts of the water was open marine, with only minor brackish-water influence (Figure 6).

The Norfolk submergence was followed by several fluctuations of sea level described by Oaks (1965) in which the Kempsville, Londonbridge, and Sand Bridge formations were deposited. Stratigraphic evidence for the Kempsville and Londonbridge submergences is not present in the area of study.

Evidence for post-Norfolk history of the area north of the James River is very limited, but available evidence (personal communication, G. H. Johnson, 1971) suggests the following sequence of events. After Norfolk submergence, sea level dropped to about 30 feet of present elevation and the bar-like Norfolk sand facies of the Huntington flat was exposed. The clayey-sand facies on the Hampton flat was eroded by waves and a scarp was cut into the Huntington flat. Sea level continued to drop, thus cutting into and removing the upper part of the Norfolk Formation under the Hampton flat and reducing its level to the present elevation.

South of the James River, the area of study was part of an estuarine complex extending eastward from the Sand Bridge shoreline barrier at Pungo Ridge (Oaks, 1965). The clayey-sand facies was deposited in the extensive tidal channels draining the estuarine complex. Channel erosion by tidal action during Sand Bridge time removed parts of the underlying Norfolk Formation and in some cases cut into the Yorktown Formation (Figure 7). The silty-sand facies was deposited under shoal-lagoon conditions in areas bordering the James River and on the broad interfluves between tidal channels. The silty-clay facies was deposited in higher, marshy areas located away from tidal channels in the southwestern and southern parts of the area.

Sand Bridge time was followed by an emergence in which streams cut deep valleys through younger sediments into the Yorktown Formation. Test borings taken in the Ballard Marsh (Plate 2) are indicative of dissection in areas near the James River to a depth below –90 feet elevation. In the mouth of Chesapeake Bay (Harrison, 1962) indicates Holocene sediments as deep as –180 feet.

Postglacial rise in sea level relative to the land is documented by a series of radiocarbon dates reported by Oaks (1965). The Dismal Swamp peat began to accumulate about 8900 ± 160 years B. P. (Y-1320). This rise in sea level is also evident in other parts of the area by the thick estuarine fills underlying all creeks and rivers.

ENGINEERING PROPERTIES

Differences in standard penetration and unconfined compressive strength among several formations may be used along with other data for correlation purposes. Standard penetration, measured in blows-per-foot, is defined as the number of blows, from a 140-pound hammer dropped 30 inches, needed to advance a split-spoon sampler 1 foot (American Society of Testing Materials, 1964, p. 50-52). The standard penetration value for each 2-foot sample interval was determined from blow counts recorded during drilling operations. A Soiltest penetrometer was used to determine the unconfined compressive strength, a measure of consistency, of each sample interval. The tip of the penetrometer was inserted 0.25 inch into a flat surface cut on one end of a 5-inch long and 1.5-inch diameter core that was representative of the interval sampled. The compressive strength, in tons/ft^2, was read from the gauge. Samples

were taken from 32 test borings made in the summer of 1969. A summary of the characteristics for each of the formations in the area is given in the table below.

Table 1.—Test characteristics of formations studied.

	STANDARD PENETRATION			UNCONFINED COMPRESSIVE STRENGTH		
Formation	Number of test borings	Number of determinations	Average blows/ft.	Number of test borings	Number of determinations	Average U.C.S. tons/ft.^{2}
Sand Bridge	32	98	10.9	29	55	1.42
Norfolk	26	85	8.0	20	45	1.05
Yorktown	31	43	23.3	20	27	1.87

Significant differences exist in engineering properties among the different formations and may be used, along with other data, to distinguish between the stratigraphic units. It should be realized that these values are averages and that many properties such as grain size, water content, grain shape, sorting, mineralogy, weathering, age, stratigraphic position, and fluctuation of the ground water table will determine the compaction and consistency of a particular sample.

REFERENCES

American Society for Testing Materials, 1964, Tentative method for penetration and split-barrel sampling of soils: Am. Soc. Testing Materials, Philadelphia, p. 50-52.

Bick, K. F., and Coch, N. K., 1969, Geology of the Williamsburg, Hog Island, and Bacons Castle quadrangles, Virginia: Virginia Division of Mineral Resources Rept. Inv. 18, 28 p.

Clark, W. B., and Miller, B. L., 1912, The physiography and geology of the Coastal Plain province of Virginia: Virginia Geol. Survey Bull. 4, 222 p.

Coch, N. K., 1965, Post-Miocene stratigraphy and morphology, inner Coastal Plain, southeastern Virginia: Office of Naval Research, Geography Branch, Tech. Rept. No. 6 (Ph.D. dissertation, Yale University), 97 p.

——— 1968, Geology of the Benns Church, Smithfield, Windsor, and Chuckatuck quadrangles, Virginia: Virginia Division of Mineral Resources Rept. Inv. 17, 39 p.

Harrison, P. W., 1962, Pleistocene record in the subsurface of the Norfolk area, Virginia: Virginia Acad. Sci. Guidebook for Field Trips, Norfolk Mtg, p. 35-61.

Johnson, G. H., and Coch, N. K., 1969, A coquina facies in the Yorktown Formation near Chuckatuck, Virginia and its geological implications *in* Abstracts for 1968: Geol. Soc. America, Special Paper 121, p. 448.

Oaks, R. Q., Jr., 1965, Post-Miocene stratigraphy and morphology, outer Coastal Plain, southeastern Virginia: Geography Branch, U. S. Office of Naval Research, Tech. Rept. No. 5 (Ph.D. dissertation, Yale Univ.), 240 p.

Oaks, R. Q., Jr., and Coch, N. K., 1963, Pleistocene sea levels, southeastern Virginia: Science, vol. 140, p. 970-983.

APPENDIX I

REFERENCE SECTIONS

SECTION A: NORFOLK FORMATION (SAND FACIES)

Exposure in James River cliff at River Road and Belvedere, City of Newport News. Section measured by N. K. Coch and G. H. Johnson on October 23, 1970. Elevation of top of section is 35.0 feet.

	Thickness Feet
Spoil, rubble, and oyster shells	1.5
Norfolk Formation, sand facies (31.5 feet)	
Sand, reddish-brown, fine; cohesive at top, grades downward into underlying sand	7.0
Sand, tan, fine; small-scale cross bedding; laminae of dark minerals	12.0
Sand, tan, medium; contains thin clay laminae	7.0
Sand, purplish-gray, fine to medium; contains scattered fine pebble-gravel and locally thin, gray clay beds	2.5
Sand, grayish-white, medium to coarse; large scale trough-type cross bedding; scattered quartz and feldspar pebbles	3.0
	(exposed)

This exposure, just north of the area of study, is the only uncovered complete section of the sand facies. There is an upward decrease in grain size and generally a lateral gradation northward into the clayey-sand facies.

SECTION B: NORFOLK FORMATION (CLAYEY-SAND FACIES)

Exposure in drainage ditch at Roanoke Avenue and 46th Street, just south of Virginia Electric Power Company substation, City of Newport News (Plate 2). Section measured by N. K. Coch and G. H. Johnson on October 27, 1970. Elevation of top of section is 17.0 feet.

	Thickness Feet
Fill	1.1
Norfolk Formation, clayey-sand facies (5.1 feet)	
Sand, pale purplish-gray, silty; some pea-size gravel concentrated at the base; grades downward into underlying sand	2.1
Sand, greenish-gray with orange mottling, coarse; silty at top, grades downward to finer silty sand at base; grades downward into underlyng unit	2.0
Clay, dark-gray, massively bedded; trace of fine sand; some orange mottling	1.0
	(exposed)

This exposure is typical of the fine-grained material underlying the Hampton flat in the cities of Newport News and Hampton. The uppermost sandy unit, consisting of pea-size gravel concentrations overlying fine-grained material, may represent post-depositional erosion of this facies.

SECTION C: NORFOLK FORMATION (SILTY-SAND FACIES)

Test boring W-2518 (Plate 2) on east side of State Road 658 at intersection with farm road leading west along drainage ditch, about 0.45 mile north of U. S. Highway 17, Nansemond County. Elevation at top of boring is 20 feet.

	Thickness Feet
Sand Bridge formation, silty-sand facies	
Sand, brownish-gray, fine to medium, silty; grades downward to gray with orange mottling	8.0
Norfolk Formation, silty-sand facies (40.0 feet)	
Sand, blue, fine to medium, silty, laminated and bluish-gray silt; trace of fine laminated sand	11.0
Sand, dark bluish-gray, medium to coarse; trace of fine pebble-gravel	5.0
Sand, greenish-gray, coarse; grades downward into very coarse sand; locally contains green, silty sand	10.0
Sand, gray, medium; some thin layers of greenish-gray silt	14.0
Yorktown Formation	
Coquina, greenish-gray, fine, soft, crumbly	2.0 (exposed)

Under the Churchland flat, the Norfolk Formation grades upward from coarse sand to fine sand and interlaminated soft silt. In some parts of the Churchland flat, near Churchland and at Eclipse (Plate 2), the lower sand section is interbedded or replaced by thick peat and organic sand with fossil wood.

SECTION D: SAND BRIDGE FORMATION (SILTY-SAND FACIES)

Test boring W-2515 (Plate 2) at northeast corner of intersection of Gum Road and Norfolk, Franklin, and Danville Railroad, 0.15 mile south of State Road 659. Elevation of top of boring is 20 feet.

	Thickness Feet
Sand Bridge formation, silty-sand facies	
Sand, dark-gray, fine to medium, silty; tan streaks; possibly faintly laminated	8.0
Norfolk Formation, silty-sand facies (12.0 feet)	
Sand, dark bluish-gray, silty; interlaminated with silt, dark bluish-gray, soft	6.0
Sand, dark bluish-green, homogeneous, trace of pea-size gravel	6.0
Yorktown Formation	
Coquina, dark-gray; mostly shell fragments	3.0 (exposed)

This boring shows the characteristic homogeneity of the silty-sand facies.

SECTION E: SAND BRIDGE FORMATION (CLAYEY-SAND FACIES)

Test boring W-2507 (Plate 2) at northwest side of intersection of Woodland Drive and Dock Landing Road, City of Chesapeake. Elevation of top of boring is 10 feet.

	Thickness Feet
Sand Bridge formation, clayey-sand facies (18.0 feet)	
Sand, dark-orange, fine to medium, homogeneous	4.0
Sand, orange, fine, silty, homogeneous	5.0
Sand, orangish-tan, medium to coarse	5.0
Sand, orange, medium to coarse; streaks and chunks of soft, light gray silt	4.0
Norfolk Formation, silty-sand facies	
Sand, dark-blue; very-fine brown; wood fragments	3.5
Yorktown Formation	
Coquina, dark-gray, very-fine; some very small shells	3.5
	(exposed)

This boring has variations in textural characteristics of the clayey-sand facies. The clayey-sand facies occupies a channel cut into the silty-sand facies of the underlying Norfolk Formation, the upper part of which has been removed by erosion (Compare with Section C).

APPENDIX II

FAUNAL LISTS: NORFOLK FORMATION (SILTY-SAND FACIES)

A. Exposure along James River at termination of State Road 1506, Eclipse, Nansemond County. Elevation of exposed fossiliferous bed is 4.0-7.5 feet. Samples collected by N. K. Coch and H. G. Richards in August and September 1963. Faunal identifications by H. G. Richards.

Gastropoda:

Busycon caricum (Gmelin)
Nassarius trivittatus (Say)
Polinices duplicatus (Say)
Busycon canaliculatum (Linné)
Prunum roscidum (Redfield)
Eupleura caudata (Say)
Olivella mutica (Say)

Pelecypoda:

Barnea costata (Linné)
Arca transversa (Say)
Mulinia lateralis (Say)
Ensis directus (Conrad)
Tellina agilia Stimpson
Abra aequalis (Say)
Mactra soladissima Dillwyn
Crassostrea virginica (Gmelin)
Mercenaria campechiensis (Gmelin)
Venericardia borealis (Conrad)
Brachidontes recurvus (Rafinesque)
Rangie cuneata (Gray)
Mercenaria mercenaria (Linné)

The specimens are probably no older than Pleistocene and are indicative of shallow water in bays and estuaries. Shallow water is definitely suggested; all species are known to be presently living in Virginia waters (personal communication, H. G. Richards, 1963).

B. Samples from spoil heap and plastic-tube boring. Collected by R. Q. Oaks, Jr. and H. G. Richards in borrow pit on north side of Norfolk and Western Railroad 0.4 mile northeast of U. S. Highway 460, Bowers Hill, City of Chesapeake. Faunal identifications by H. G. Richards.

Gastropoda:

Polinices duplicatus (Say)
Nassarius obsoletus (Say)
Busycon canaliculatum (Linné)
Eupleura caudata (Say)
Nassarius trivittatus (Say)
Busycon carica (Gmelin)
Crepidula convexa Say

Pelecypoda:

Corbula contracta Say
Nuculana acuta (Conrad)
Pitar morrhuanna (Linsley)
Anadara transversa (Say)
Mercenaria mercenaria (Linné)

APPENDIX III

SUMMARY OF DATA FROM TEST BORINGS

Repository Number	Elevation at top of hole in feet	Total depth in feet	Formations* Penetrated
W-2505	18	30	Qsb, Qn, Ty
W-2506	13	25	Qsb, Qn, Ty
W-2507	10	25	Qsb, Qn, Ty
W-2508	15	30	Qsb, Qn, Ty
W-2509	22	45	Qsb, Qn, Ty
W-2510	23	25	Qsb, Qn, Ty
W-2511	20	25	Qsb, Ty
W-2512	23	25	Qsb, Qn, Ty
W-2513	20	25	Qsb, Ty
W-2514	20	25	Qsb, Qn, Ty
W-2515	20	25	Qsb, Qn, Ty
W-2516	15	45	Qsb, Qn, Ty
W-2517	21	30	Qsb, Qn, Ty
W-2518	20	25	Qsb, Qn, Ty
W-2519	19	45	Qsb, Qn, Ty
W-2520	22	45	Qsb, Qn, Ty
W-2521	18	30	Qsb, Qn, Ty
W-2522	17	35	Qsb, Qn, Ty
W-2523	14	40	Qsb, Ty
W-2524	17	45	Qsb, Ty
W-2525	19	45	Qsb, Qn, Ty
W-2526	20	45	Osb, Ty
W-2527	22	30	Qsb, Qn, Ty
W-2528	20	30	Qsb, Qn, Ty
W-2529	19	40	Qsb, Qn, Ty
W-2530	20	40	Qsb, Qn, Ty
W-2531	20	50	Qsb, Qn, Ty
W-2532	17	40	Qsb, Ty
W-2533	14	50	Qsb, Qn, Ty
W-2534	15	40	Qsb, Qn, Ty
W-2535	15	25	Qsb, Ty
W-2536	15	30	Qsb, Qn, Ty

* Formations are Qsb, Sand Bridge Formation; Qn, Norfolk Formation; Ty, Yorktown Formation.

INDEX

PAGE

Baileys Beach 10
Bennett Creek 2, 5, 9, 13
Bennett Creek Army Reservation 12
Biofragmental bars 5
Bowers Hill 8, 10
Bowers Hill quadrangle 2
Chesapeake 2
Chuckatuck 15
Chuckatuck Creek 2
Chuckatuck quadrangle 6
Churchland 6, 10
Churchland flat 3, 9
Cobble-gravel 5
Coquina bars 15
Dismal Swamp 5, 13
Dismal Swamp peat 14
Eclipse 8, 10
Elizabeth River, Western Branch 2, 9
Estuarine 11, 14
Fossils, marine 1, 10
    estuarine 10
Great Bridge formation 15
Great Bridge—Norfolk submergence 16
Hampton 2
Hampton flat 4, 10, 11
Harpersville scarp 5
Holocene estuarine-fill 15
Huntington flat 4, 10, 11
James River 2, 4, 11, 14
Nansemond River 2, 5, 13
Newport News 2, 8
Newport News South quadrangle 2

PAGE

Norfolk Formation
- clayey-sand facies 9, 11
- silty-sand facies 9, 10
- sand facies 9, 11

Open-marine 11
Paleogeography, Norfolk time 10
Paleotopography, top of Yorktown Formation 6, 7
Postglacial sea level 17
Portsmouth 2
Penetrometer 17
Pebble-gravel 5
Ragged Island Marsh 14
Sangamon Interglaciation 16
Salters Creek 2
Sand Bridge formation 13, 16
- clayey-sand facies 13
- silty-sand facies 13

Saprolite 5
Split-spoon samples 3
Suffolk scarp 16
Taxodium 10
Yorktown Formation 5, 9
Tidal streams 14
Test borings 2, 3, 15

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES
James L. Calver
Commissioner of Mineral Resources and State Geologist

Base map from U. S. Geological Survey 1968,
Newport News South Quadrangle, 7½ Minute Series

Williams & Heintz Map Corporation

Copyright 1971
Commonwealth of Virginia

GEOLOGIC MAP OF THE NEWPORT NEWS SOUTH QUADRANGLE, VIRGINIA

Geology by Nicholas K. Coch

1968 MAGNETIC DECLINATION

SCALE 1:24 000

CONTOUR INTERVAL 5 FEET

QUADRANGLE LOCATION

1971

EXPLANATION

QUATERNARY — HOLOCENE

al — Alluvium
Estuarine-beach sediments, estuarine fill, peat in Dismal Swamp.

Unconformity

QUATERNARY — PLEISTOCENE

Qsb (cs, ss) — Sand Bridge formation
Upper member: facies-cs, tidal channel, clayey sand; and ss, shoal lagoon, silty sand. Lower member not designated on map.

Unconformity

Qn (cs, s, ss) — Norfolk Formation
Upper member: facies-cs, estuarine clay and fine-grained sand; s, estuarine sand; ss, brackish marine, silty sand. Lower member not designated on map.

Unconformity

TERTIARY — MIOCENE

Ty — Yorktown Formation
Nearshore, marine coquina; fossiliferous, silty sand.

CONTACTS

exposed

approximate

covered or inferred

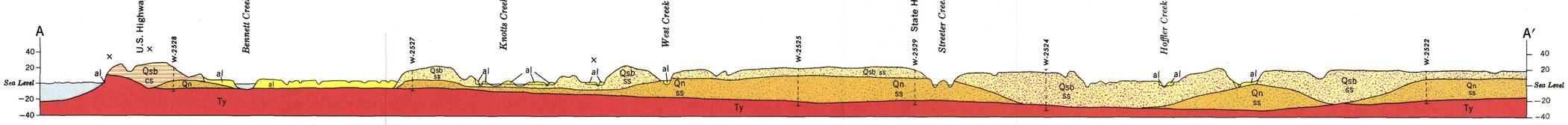
STRATIGRAPHIC CONTROL

W-2504 18′ — Location of test boring with elevation at top of hole.

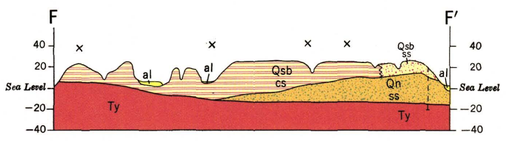
Depth of test boring on or elevation to a cross-section.

× — Location at which sample was examined to determine formation and facies contact, includes some auger borings. In cross-section × denotes location on or projection to the line of section.

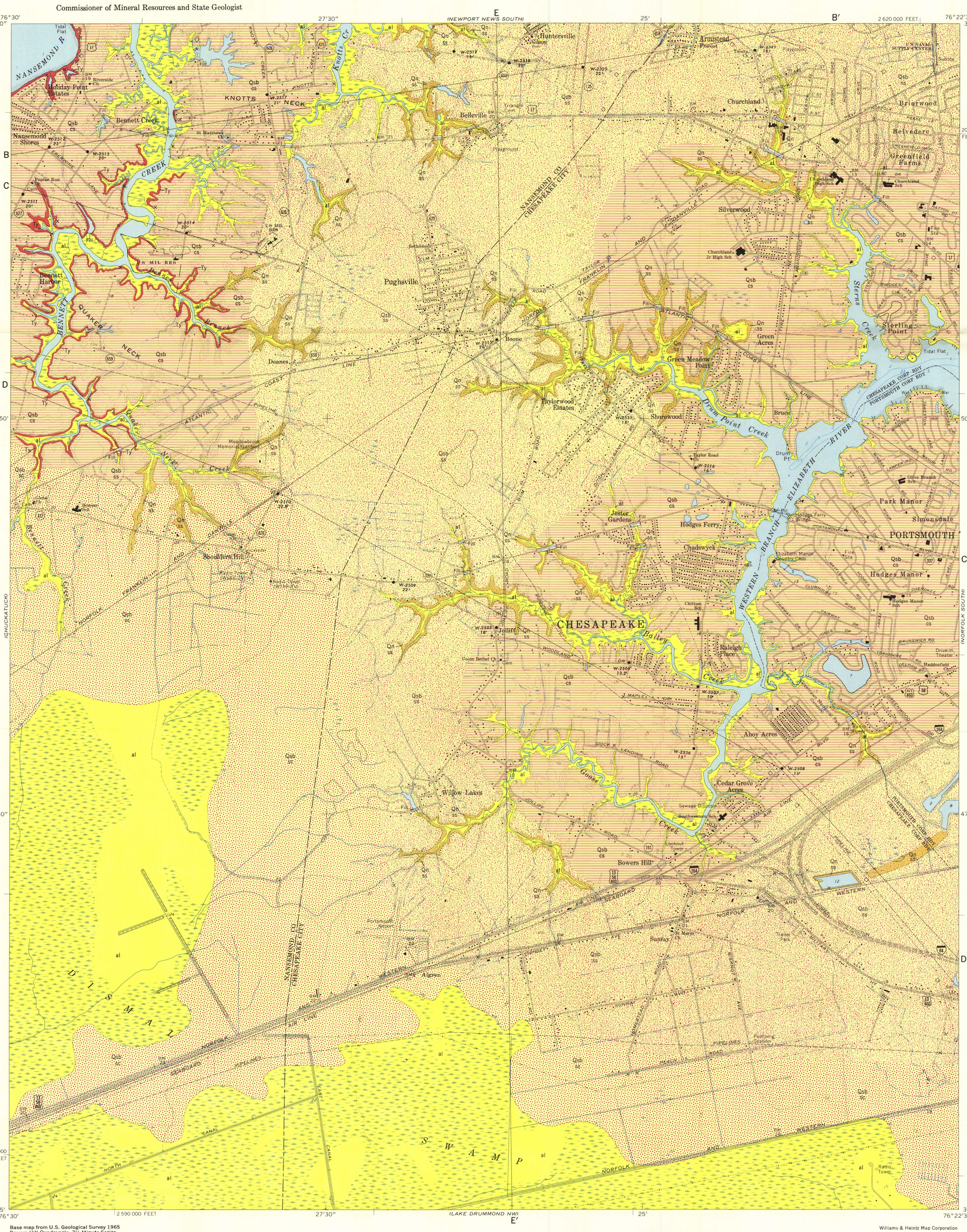
◇ — Record of company test boring or well.



Interpretive cross section
with 20X vertical exaggeration



COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES
James L. Calver
Commissioner of Mineral Resources and State Geologist



Base map from U.S. Geological Survey 1965
Bowers Hill Quadrangle, 7½ Minute Series

Williams & Heintz Map Corporation

Copyright 1971
Commonwealth of Virginia

GEOLOGIC MAP OF THE BOWERS HILL QUADRANGLE, VIRGINIA

Geology by Nicholas K. Coch

6½° Magnetic North True North

1965 MAGNETIC DECLINATION

SCALE 1:24 000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 5 FEET

VIRGINIA

QUADRANGLE LOCATION

1971

EXPLANATION

QUATERNARY — HOLOCENE

al — Alluvium
Estuarine-beach sediments, estuarine fill, peat in Dismal Swamp.

Unconformity

QUATERNARY — PLEISTOCENE

Qsb (sc, cs, ss) — Sand Bridge formation
Upper member: facies-sc, marsh and tidal flat, silty clay; cs, tidal channel, clayey sand; and ss, shoal lagoon, silty sand. Lower member not designated on map.

Unconformity

Qn (ss) — Norfolk Formation
Upper member: facies-ss, brackish marine, silty sand. Lower member not designated on map.

Unconformity

TERTIARY — MIOCENE

Ty — Yorktown Formation
Nearshore, marine coquina; fossiliferous, silty sand.

CONTACTS

exposed

approximate

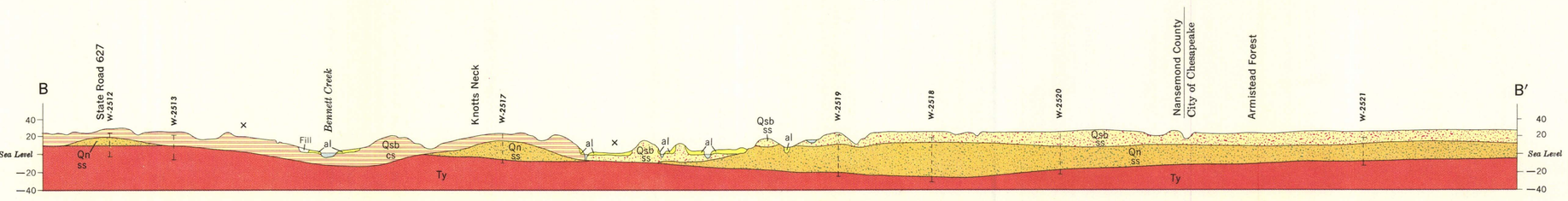
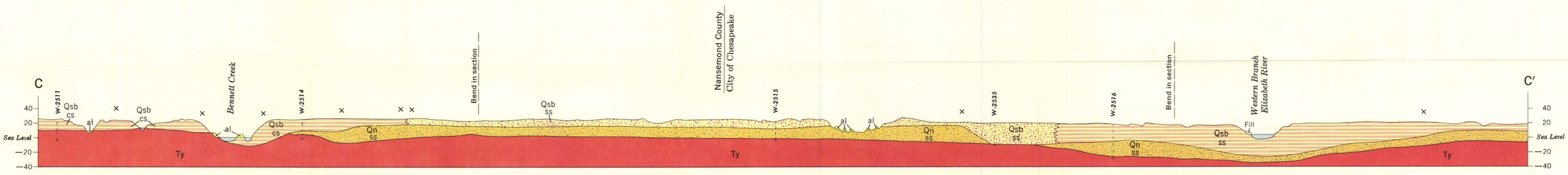
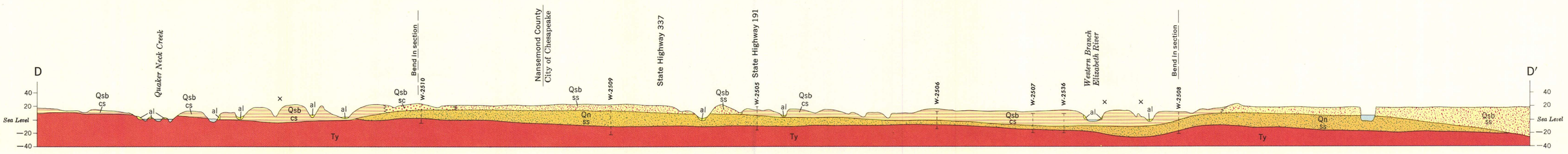
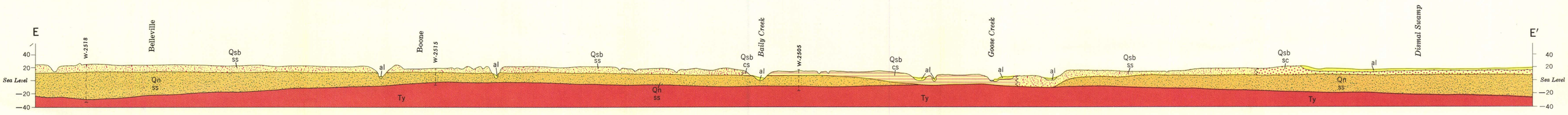
covered or inferred

STRATIGRAPHIC CONTROL

● W-2515 18' — Location of test boring on or projected to a cross-section.

Depth of test boring on or elevation to across-section.

× Location at which sample was examined to determine formation and facies contact, includes some auger borings. In cross-section × denotes location on or projection to the line of section.

◇ Record of company test boring or well.

Interpretive cross sections
with 20X vertical exaggeration