COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES
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GEOLOGY OF THE NORFOLK SOUTH QUADRANGLE, VIRGINIA

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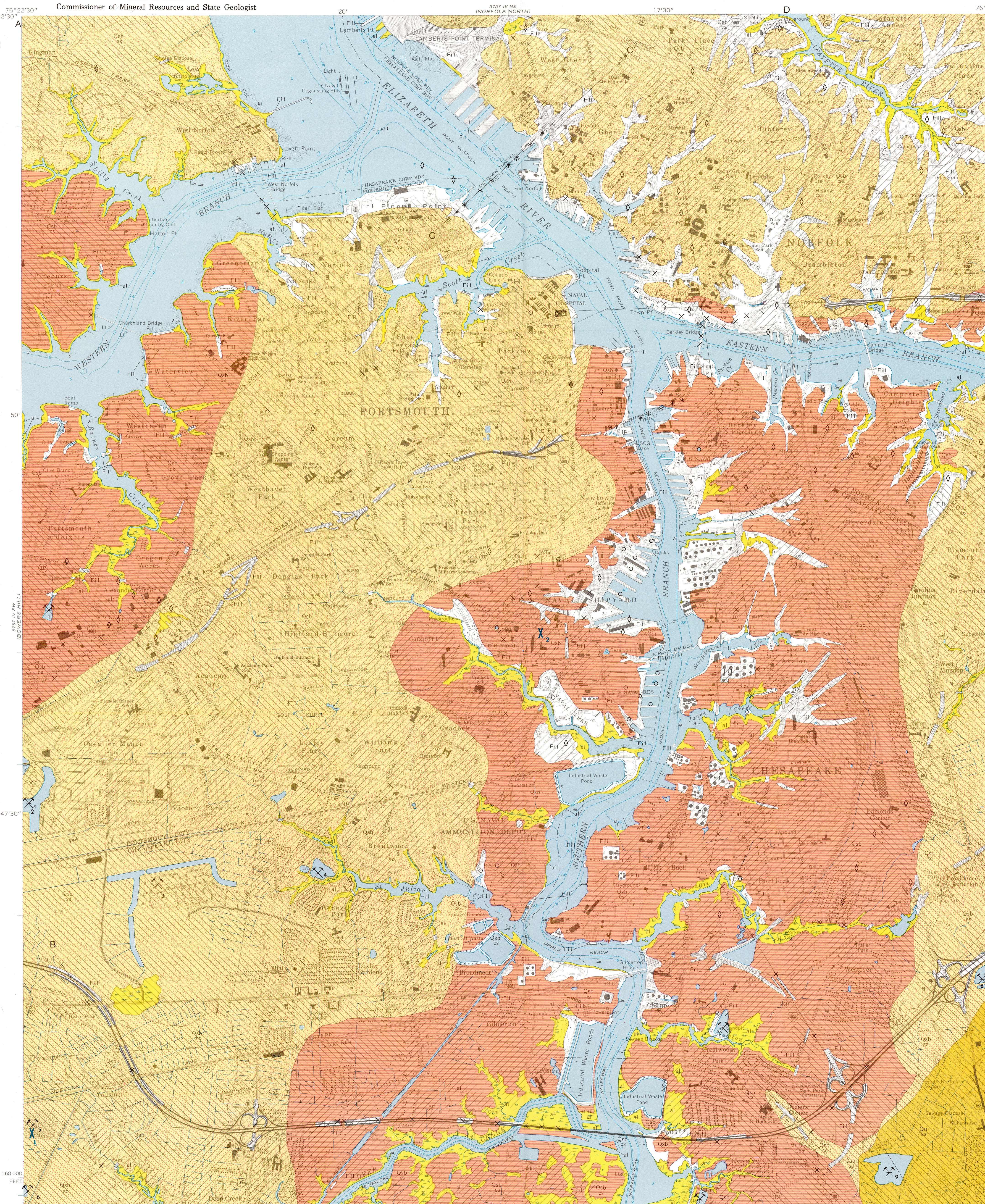

Interpretive cross sections with 20x vertical exaggeration; subsurface structure interpreted from surface measurements and borehole data.

1978

EXPLANATION

UNIT CHARACTERISTICS / GEOLOGIC AND ECONOMIC FACTORS AFFECTING LAND MODIFICATION

Age	Symbol	Unit characteristics	Geologic and economic factors affecting land modification
Quaternary — Holocene	al	Alluvium, sand, and marsh sediment: *Estuarine-beach, tidal marsh, and fluvial silt, sand, and clay with organic material (peat) abundant in tidal marshes.*	Marsh deposits have good potential as a source of silt; potential development of sand deposits limited due to small areal extent and urban location of deposits. Marsh deposits: plasticity/sensitivity high, bearing capacity low, permeability poor, erosion resistance poor, slope stability poor, aquifer recharge poor. Sand deposits: permeability good, slope stability good, bearing capacity poor to good, erosion resistance fair, aquifer recharge good.
Quaternary — Pleistocene	Qsb (cs, ss, sc)	Sand Bridge Formation: *Upper member; facies—cs, tidal channel, clayey sand; ss, shoal lagoonal, silty sand; and sc, lagoonal, silty clay. (Lower member included with upper member.)*	All facies have potential as a source sand and silt. cs: plasticity/sensitivity low to high, bearing capacity good, permeability poor to good, erosion resistance good, slope stability fair, aquifer recharge fair to good. ss: plasticity/sensitivity low to moderate, bearing capacity poor to good, permeability good, erosion resistance good, slope stability good, aquifer recharge fair. sc: plasticity/sensitivity high, bearing capacity poor to good, permeability poor to good, erosion resistance poor to fair, slope stability poor, aquifer recharge poor to good.
Quaternary — Pleistocene	Qn (ss)	Norfolk Formation: *Upper member; facies—ss, brackish marine silty sand and fluvial-estuarine silty sand; lower member included with upper member.*	Good potential as a source of sand and silt; plasticity/sensitivity moderate to high, bearing capacity poor to good, permeability poor to fair, erosion resistance fair, slope stability fair, aquifer recharge poor to fair.
Tertiary — Pliocene	Ty	Yorktown Formation (in sections A—A′, B—B′, C—C′, and D—D′ only): *Nearshore marine fossiliferous, silty, coarse sand and coquina.*	Yorktown sediments exposed only in the floor of the Chesapeake Development Company borrow pit (abandoned quarry number 5). Depth below the surface makes it presently uneconomic to mine the Yorktown. Bearing capacity good.

GENERAL LOAD BEARING CAPACITY

- Good: 1,500 to 3,000 pounds per square foot (6,341 to 12,682 kg per sq m)
- Fair: 500 to 1,500 pounds per square foot (2,114 to 6,341 kg per sq m)
- Poor: up to 500 pounds per square foot (up to 2,114 kg per sq m)

QUARRY

Abandoned Quarry

1 Sand
2 Sand
3 Sand
4 Sand
5 Chesapeake Development Co. (sand)
6 Sand
7 Sand
8 Sand
9 Sand
10 Higgerson and Buchanan (sand)

CONTACTS

Exposed, approximate, and inferred

STRATIGRAPHIC CONTROL

- Depth of test boring on or elevation to a section
- ◊ Location of test or auger boring by Herbert and Associates, Ltd., Virginia Beach
- × Location of Virginia Department of Highways and Transportation boring
- ○ Location of Soil Engineering Division, 5th Naval District Command boring
- * Location of Elizabeth River Tunnel Commission boring
- X_2 Stratigraphic section (borehole)

DISCUSSION

The Norfolk South 7.5-minute quadrangle area is approximately 60 square miles, about one-eighth of which is covered with water. Portions of the cities of Norfolk, Portsmouth, and Chesapeake compose the political subdivisions. Cities were examined to establish the stratigraphic framework, the distribution of geologic units, morphology, and geologic and economic factors affecting land modification.

The area is highly industrialized near the principle waterways and includes part of the largest naval facility in the world. The three branches of the Elizabeth River, the main drainages, flow north through Hampton Roads into the Chesapeake Bay. There is a well-developed transportation network. The area is served by the Norfolk and Western Railway which maintains a large coal-loading facility at Lamberts Point; the Norfolk, Franklin, and Danville Railway; and the Norfolk and Portsmouth Belt Line Railway.

Field work was done between November 1973 and February 1974. Over 200 test-boring and hand-auger logs were obtained from Herbert and Associates, Ltd., Virginia Beach. Additional boring logs were obtained from the Virginia Department of Highways and Transportation, the Elizabeth River Tunnel Commission, and the 5th Naval District Command. All drilling consisted of conventional core borings with samples obtained at least every 5 feet of depth, using standard split-spoons driven with 140-pound (63-kg) hammers having a 30-inch (76-cm) fall. Subsurface data were supplemented by natural and man-made exposures. Physical analyses, including sieve analyses, Atterburg limits, specific gravity, hydrometer, relative density, California Bearing Ratio, and confined consolidation tests, have been performed on samples from the Sand Bridge and Norfolk formations.

MORPHOLOGY

Three prominent geomorphic features are present in the Norfolk South quadrangle: the Churchland flat; the Deep Creek swale; and the Fentress rise. The Deep Creek swale has a north-south trend in the central portion of the map. The Southern Branch of the Elizabeth River is near the middle of the swale. The swale gradually widens in a southerly direction and reaches its maximum east-west width of 5.9 miles (9.5 km) near the confluence of Deep Creek and Southern Branch. The 15-foot contour line generally coincides with the eastern and western boundaries of the swale. The average trough elevation is about 5 feet (2 m). The Deep Creek swale is underlain by sand of the Sand Bridge Formation except for alluvial sand and organic silt of Holocene age that occur in tidal basins along the Elizabeth River.

Abutting the Deep Creek swale on the west is the Churchland flat. This feature has a maximum elevation of 19 feet (6 m) along U. S. Highway 13 northwest of Yadkin and has slopes to the northeast less than 1.0 foot per mile (0.2 m/km). The Churchland flat is underlain by sands of the Sand Bridge Formation. The Fentress rise, which has a maximum elevation in excess of 20 feet (6 m), bounds the Deep Creek swale on the east. The rise is underlain principally by a thin layer of the silty-clay facies of the Sand Bridge Formation above a thick clayey silty sand facies of the Norfolk Formation.

STRUCTURE

The area investigated lies south of the crest of the eastward-trending Fort Monroe high (Richards, 1974, p. 12, Figures 1, 2). According to Teifke (1973) the "basement" surface upon which the late Mesozoic sediments were deposited has a regional easterly dip of 40 to 50 feet per mile (8 to 10 m/km). "Basement" rock was penetrated at a depth of 2,243 feet (684 m) at Fort Monroe (Cederstrom, 1945). Costain and Robinson (1972) indicated considerable structural relief on the "basement" surface based on magnetic and gravity surveys. Increasingly stable tectonic conditions are reflected in the upward decrease in dip of the Cretaceous and younger sediments (Brown and others, 1972; Teifke, 1973).

STRATIGRAPHY

The stratigraphic framework of the Outer Coastal Plain has been established by Coch (1968, 1971), Oaks and Coch (1973), Johnson (1972, 1976), and Oaks and others (1974). In the Norfolk South quadrangle the Pleistocene Norfolk and Sand Bridge formations are exposed at the surface in addition to sediment of Holocene age. The Yorktown Formation occurs in the shallow subsurface and is exposed in the wall of abandoned quarry number 5.

Pliocene Series
Yorktown Formation

The Yorktown Formation occurs in the subsurface except for a small exposure in a vertical wall in the Chesapeake Corporation Pit (abandoned quarry number 5). The depth to the top increases toward the Southern Branch of the Elizabeth River (Figure 1). Its top has a maximum depth of about 100 feet (30 m) under the Elizabeth River near Lamberts Point Terminal. Between Scott Creek and Deep Creek there is a large area where the depth to the top of the Yorktown is less than 20 feet (6 m).

The distinctive molluscan fauna, highly compact nature of the sediments, and a greenish-gray color are the major characteristics used to identify the formation from boring samples. Most of the formation is a massively bedded, compact, greenish-gray, *fossiliferous, fine sand. Locally the upper* Yorktown may be reddish orange. This coloration is believed to be the result of pre-Norfolk weathering (personal communication, B. L. Sutphin). Quartz comprises the bulk of the sand; enough glauconite, however is present to impart a greenish-gray coloration to the formation. Layers of shelly material composed of snails (*Crepidula fornicata*) and attached barnacles (*Balanus*) and bryozoans (Cheilstomata), and thin silty clay layers are present (Stratigraphic Section 1).

Johnson (1976, p. 21-22) interprets the silty-sand facies as " . . . deposited on the continental shelf in warm waters about 75 to 150 feet (23 to 46 m) deep. The bottom was swept by gentle waves or currents and the bottom waters were well oxygenated and supplied with nutrients."

Pleistocene Series
Norfolk Formation

The Norfolk Formation crops out only in the southeastern corner of the mapped area. Locally it is absent and the Sand Bridge Formation lies directly on the Yorktown Formation or recent channel alluvium overlies the Yorktown (Sections A—A′, B—B′). Where the Norfolk overlies the Yorktown the contact is very distinctive. A sharp color change from gray to greenish gray commonly marks the contact although the greenish-gray Yorktown may be reddish orange locally. Degree of consolidation changes across the contact, with the Norfolk being less compact. The Norfolk is sparsely fossiliferous. Over highs in the Yorktown Formation, the Norfolk is absent to only a few inches thick. The Norfolk may be as much as 50 feet (15 m) thick where deposited in channels cut into the Yorktown.

The Norfolk Formation is composed of a lower member and an upper member. Only one facies of the upper member—the clayey silty sand—is present in the mapped area. The lower member, which is composed of clean, coarse quartz sand and fine gravel, is included with the upper member as shown in the cross sections. The lower member ranges from 0 to about 8 feet (0-2 m) in thickness. Oaks and Coch (1973, p. 43) interpret the lower member as a beach sand.

The clayey silty sand facies of the upper member is composed of cross bedded fine to medium sand with isolated gravel and sand layers containing varying concentrations of silt and silty clay (Stratigraphic Sections 1 and 2). Macrofossils are considerably leached. Under the Churchland flat the facies averages 18.5 feet (5.6 m) in thickness and locally is within 4 feet (1 m) of the surface. In channels cut into the Yorktown Formation the facies is characterized by excessively soft, moist clayey silt and clayey sand. The depositional environment is interpreted to have been fluvial estuarine and brackish marine.

Sand Bridge Formation

The Sand Bridge Formation as defined by Oaks and Coch (1963) is divided into a homogeneous lower member overlying the Norfolk Formation and an upper member consisting of four mappable facies of which three crop out in the mapped area. The lower member is composed of massively bedded, tan to light-gray, fine to medium sand with a small amount of pebbles. The member is a blanket deposit of variable thickness because of erosion and reworking during the deposition of the upper member. Locally the lower member has been removed by erosion and various facies of the upper member overlie the Norfolk Formation. The upper and lower members are illustrated as one unit in the cross sections.

Silty-sand facies: The silty-sand facies occurs in the northern and eastern parts of the quadrangle and west of Southern Branch. It is dissected by channels filled with alluvium. The facies is a clean, homogeneous, fine to medium sand, having silt concentrations of 10 to 35 percent. The maximum thickness is slightly greater than 25 feet (8 m) and averages 12 to 14 feet (4 m). Oaks and Coch (1973) interpret this facies to represent river-influenced lagoonal deposits.

Clayey-sand facies: This facies is exposed in the Churchland flat and in the Deep Creek swale. It is relatively thin in the western part of the area, averaging 10 to 15 feet (3 to 5 m) thick. Near the branches of the Elizabeth River the facies thickens to about 40 feet (12 m). The clayey-sand facies grades laterally into both the silty-sand and silty-clay facies. Lithologically the clayey-sand facies ranges from clayey sand, silt, and clay to well sorted, fine to medium sand (Stratigraphic Section 2). This facies is interpreted as tidal channel deposits (Oaks and Coch, 1973).

Silty-clay facies: The silty-clay facies crops out in the southwestern corner of the mapped area and along the Fentress rise in the southeastern area. Much of this area is composed of recently drained marshes (personal communication, B. L. Sutphin). Massive cohesive clay and silt with approximately 20 percent fine sand comprise the facies (Stratigraphic Section 1). The silty clay is thin, being only about 15 feet (5 m) thick when combined with the lower member of the Sand Bridge Formation. The depositional environment is interpreted as one having lagoonal conditions (Oaks and Coch, 1973).

Holocene Series
Alluvium, Sand, and Marsh Sediments

Holocene surficial deposits have a sporatic distribution and range from low-energy organic silt to higher energy clean sand. These sediments unconformably overlie older stratigraphic units and range from only a few inches to over 100 feet (30 m) in thickness.

All the smaller tidal tributaries in the area are underlain by organic silt and silty sand. In some areas these fine sediments occur as much as 5 feet (2 m) above sea level and can be recognized by the occurrence of a number of species of marsh grass (*Spartina*).

Holocene sediments within the larger, deeper waterways are more variable. Clean, fine to medium sand is deposited along the shores of the Elizabeth River. The presence of thick channel fills is evidenced from test borings that penetrated the Holocene sediments. The separation of these sediments from those of underlying Pleistocene is often difficult. A maximum thickness of Holocene sediments is about 100 feet (30 m). The sediment composition is variable with alternating silt and sand layers reflecting minor changes in sea level. Some thick sections of clayey and organic silts are present indicating rapid siltation.

GEOLOGIC AND ECONOMIC FACTORS AFFECTING LAND MODIFICATION

Several geologic factors must be considered when the land's surface is modified. Two factors are of prime importance in the Norfolk area: load-bearing capacity and flood potential. Load-bearing capacity is based on analysis of samples obtained by using a standard split-spoon driven with a 140-pound (63-kg) hammer having a 30-inch (76-cm) fall. Analysis of bearing capacity has resulted in three groups of measurements: good, 1,500 to 3,000 pounds per square foot (6,341 to 12,682 kg/sq m); fair, 500 to 1,500 pounds per square foot (2,114 to 6,341 kg/sq m); and poor, 0 to 500 pounds per square foot (0 to 2,114 kg/sq m).

Flood-prone areas are those that may be initially affected during extremely high water before runoff or subsidence takes place. In the study area elevations below 10 feet (3 m) are classified as flood prone. The Ash Wednesday storm of the early 1960's is an example of a severe storm that flooded areas in excess of 8.0 feet (2.4 m) elevation above mean sea level.

Extensive areas of fill were developed along the branches of the Elizabeth River. Essentially all the shoreline change between 1887 and 1973 is due to the accumulation of fill. Fill material used to claim land comes from dredging operations in the Elizabeth and Lafayette rivers and Chesapeake Bay. Poorly designed fill may lead to the following problems: (1) displacement and erosion of adjoining land, (2) surface water contamination from runoff, (3) ground-water contamination from drain fields or spills that enter the ground-water system, (4) an increase in the mosquito population, and (5) the loss of biologically productive resources, such as, oyster beds and grasses (Marcellus, Dawes, and Silbehorn, 1973). Well-designed fill and shoreline structures have a positive effect in some areas, stabilizing the shoreline and slowing the filling of navigable channels.

Abandoned quarries numbers 1, 2, 3, and 4, are good examples of sequential land use. Shallow depressions were formed from the mining of sand and gravel. When activity ceased the shallow depression became filled with water (Abandoned quarry numbers 1, 2, and 4). Some of these lakes are used for recreational activities and urbanization around the lakes has increased the land value. Because the lakes are runoff catchment basins, soil treatment, stability of slopes and sewage disposal should be carefully considered during the planning stage. These lakes are also a potential water supply. Abandoned quarry number 3 has been regraded for a housing development.

The following definitions refer to terms used in the Explanation column headed "Geologic and Economic Factors Affecting Land Modification":

aquifer recharge—capacity of a formation to be recharged with ground water either by lateral or downward percolation of ground water.

erosion resistance—ability to resist erosion primarily through the internal strength of the stratum regardless of vegetation cover.

permeability—relative rate at which ground water or induced water will move through a formation.

plasticity—ability of a soil to deform plastically under external loading; the plasticity of a soil is directly proportional to and varies with its moisture content.

sensitivity—relative change in physical characteristics of a soil stratum when the stratum undergoes reworking, remolding, or is subjected to unusual external forces.

slope stability—ability of a slope to retain its gradient. This is directly proportional to the angle of repose of the material comprising the slope.

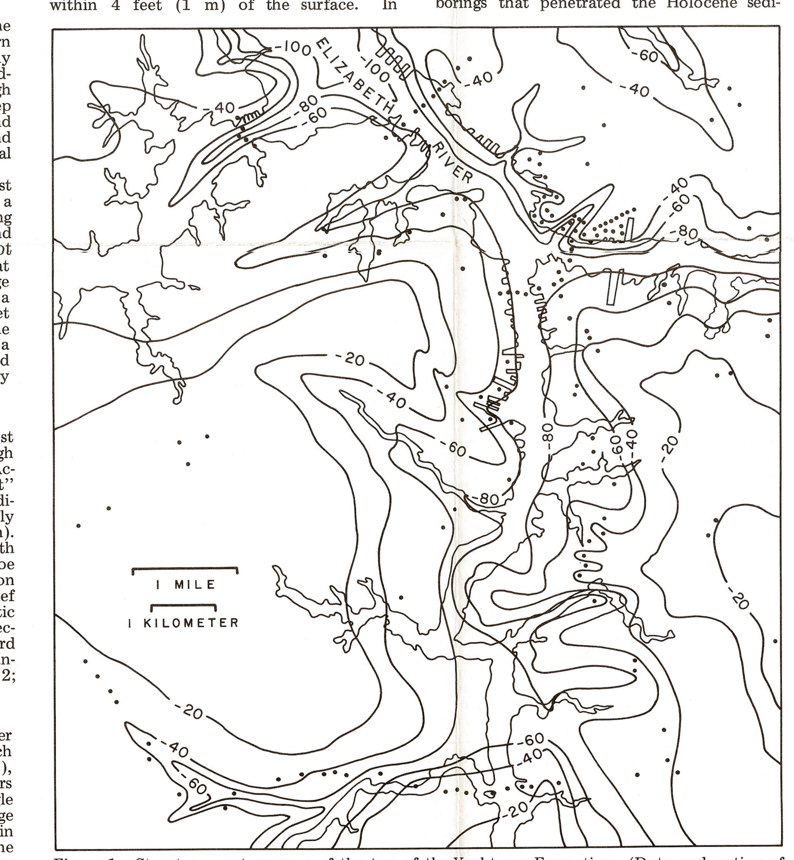

Figure 1. Structure contour map of the top of the Yorktown Formation. (Dots are location of subsurface control, heavy lines are structure contours with numbers representing elevations in feet, thinner line is shoreline.)

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STRATIGRAPHIC SECTIONS

Section 1: Yorktown Formation (coquina facies); Norfolk Formation (clayey-silty sand facies); and Sand Bridge Formation (silty-clay facies

Exposure in borrow pit of Chesapeake Development Company about 0.5 mile (0.8 km) southwest of Yadkin and 0.4 mile (0.6 km) west of the end of Dowdy Lane in Chesapeake. Elevation at the top of the section is approximately 19 feet (6 m).

	Thickness Feet (Meters)
Sand Bridge Formation	
Silty-clay facies	
Sand, tan to buff, fine to medium, slightly silty, trace of very fine heavy minerals, homogeneous	4.0 (1.2)
Norfolk Formation	
Clayey silty sand facies	
Sand, gray to brownish-gray, fine to medium silty, sparsely fossiliferous; fossils leached; homogeneous except occasional cobbles near base	18.0 (5.5)
Sand, brown, medium to coarse	0.5 (0.2)
Sand, bluish-gray, fine to medium, slightly silty to clayey, iron-stained, locally abundant *Mercenaria* and poorly preserved *Enis directus*	3.0 (0.9)
Yorktown Formation	
Coquina facies	
Coquina, red to orangish-brown, silty to clayey; shelly sand, hematitic nodules; hardened siltballs, abundant *Pectin*, *Crepidula*, and *Ostrea*	2.5 (0.8)
Coquina, gray, silty to clayey; shelly sand, abundant *Pecten*, *Crepidula*, and *Ostrea*	4.0 (1.2)

Section 2: Norfolk Formation (clayey-silty sand facies) and Sand Bridge Formation (clayey sand facies)

Test boring B—1, job no. 74-458, Herbert and Associates, Ltd., 3850 Elm Avenue, Portsmouth; adjacent to U. S. Naval Shipyard, approximately 1,000 feet (305 m) west of the intersection of Elm Avenue and the Norfolk and Portsmouth Belt Line Railway. Elevation at top of boring is 9 feet (3 m).

	Thickness Feet (Meters)
Fill, rubble, and orangish-brown, silty to clayey, fine to coarse, subangular sand and rounded gravel	1.0 (0.3)
Sand Bridge Formation	
Clayey sand facies	
Sand, gray, mottled yellowish-brown to orange, mottled light-gray, clayey to silty, fine to medium, medium plastic	10.0 (3.0)
Sand, grayish-orange, clayey to silty, fine to medium, moist, soft	2.5 (0.8)
Norfolk Formation	
Clayey silty sand facies	
Sand, brownish-gray mottled light bluish, gray, fine-grained, silty to slightly clayey, moist, very soft to loose	5.5 (1.7)
Sand, gray, mottled bluish-gray, fine, fossiliferous, trace of coarse sand to fine gravel	3.0 (0.9)

REFERENCE NOTE

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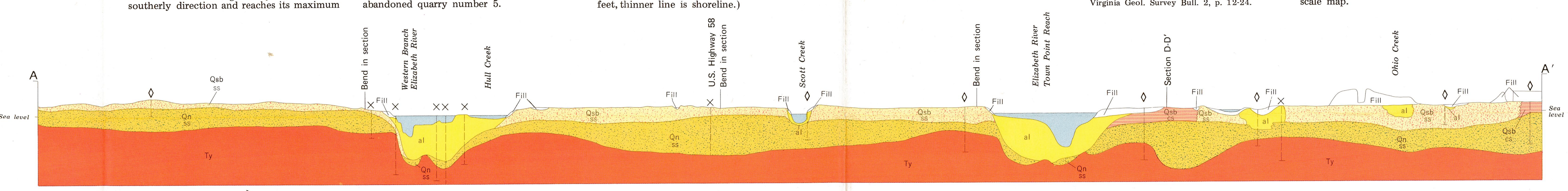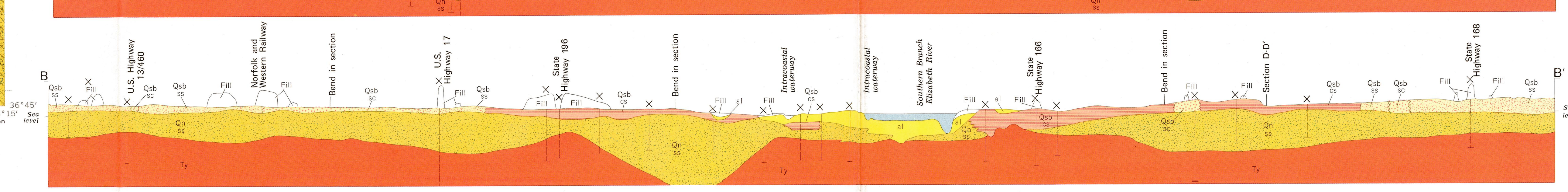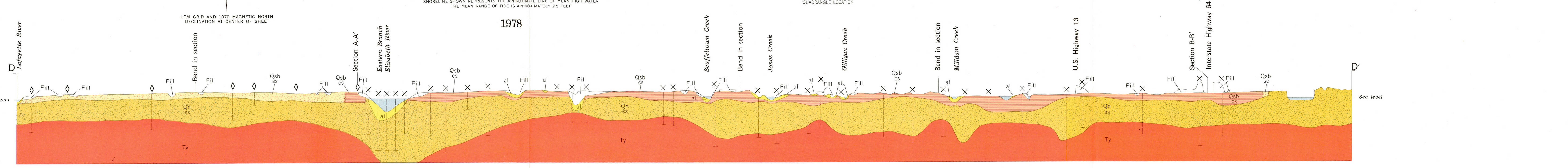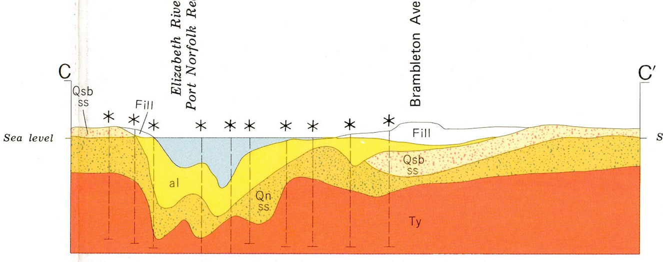
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