UNITED STATES DEPARTMENT OF THE INTERIOR
Fish and Wildlife Service
Arnie J. Suomela, Commissioner

AN ANALYSIS OF PROBABLE EFFECTS ON FISH AND WILDLIFE RESOURCES OF THE WATERSHED PROTECTION PLAN, PRINCESS ANNE COUNTY WATERSHED, PRINCESS ANNE COUNTY, VIRGINIA, AND MEANS FOR THEIR CONSERVATION

BUREAU OF SPORT FISHERIES AND WILDLIFE
REGION 4

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Planning Agency: Soil Conservation Service, U. S. Department of Agriculture

Report Prepared: August 1958

Prepared by Branch of River Basin Studies
Raleigh, North Carolina

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE

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DA-Va. (Princess Anne)

August 28, 1958

Mr. Frank C. Edminster, State Conservationist
U. S. Soil Conservation Service
P. O. Box 5367
Richmond 20, Virginia

Dear Mr. Edminster:

The Bureau of Sport Fisheries and Wildlife has examined the area to be influenced by the proposed Princess Anne County Watershed Project, in cooperation with the Virginia Commission of Game and Inland Fisheries and the North Carolina Wildlife Resources Commission.

A detailed analysis of the probable effects of this project on fish and wildlife resources and means for their conservation, as prepared by our Raleigh field office, Branch of River Basins, is being submitted for your examination. Copies of this analysis also are being submitted to the Virginia Dare Soil Conservation District and the Princess Anne County Board of Supervisors, who are project sponsors, and to other interested agencies.

In concurrence with the findings of our reporting officer, we are of the opinion that fish and wildlife resources within the area under consideration are of national significance, and unless specific measures are included in your Work Plan, damages to these resources and trade dependent upon them will be irreparable.

Description of the Area

Princess Anne County Watershed is composed of the drainages of several small streams originating within Princess Anne County, Virginia, which empty either into North Landing River or Back Bay and thence into Currituck Sound, North Carolina.

The watershed as a whole lies in the Coastal Plain Physiographic Province, with elevations ranging from sea level to a maximum of about 20 feet above sea level. It comprises an area of 137,200 acres, of which 27,100 acres are water and marsh and 110,100 acres of upland.

Land and water uses consist chiefly of agriculture, military installations, and fish and wildlife developments. We are, of course, primarily interested in fish and wildlife development, and toward that end we are vigorously engaged.

Back Bay and Currituck Sound are the most important waterfowl hunting areas in Virginia and North Carolina and among the most important on the entire Atlantic Coast. Some of the hunting clubs have been active since 1870.

In recognition of the rôle which this watershed plays in providing wintering habitat for a large variety of waterfowl and hunting opportunity, the Back Bay National Wildlife Refuge, comprising 9,280 acres, was established in 1930. The management program in effect is dependent to a large degree upon maintaining favorable environmental conditions in Back Bay, Currituck Sound, and associated marshes. Of primary concern are water turbidity, salinity, circulation, and other ecological conditions necessary for the development of valuable aquatic vegetation.

Description of the Project

In the interest of more efficient use of agricultural lands within Princess Anne County Watershed, you have considered the construction of a system of major drainage outlets. Three major canals are proposed as an integral feature of your Work Plan. These are Seaside Neck Canal, which would drain the northeastern area of the watershed into Back Bay; and Oakum Creek Canal and Milldam Creek Canal, which drains into North Landing River. Three additional canals which shall be a part of the system are Nawney Creek Canal, draining into Back Bay, and Salem Creek Canal and West Neck Canal, which would drain into North Landing River. Nawney Creek Canal has been constructed under the Agricultural Conservation Program; West Neck Canal is under construction by the U. S. Navy; and Salem Creek Canal is reported to be under consideration by the Corps of Engineers in cooperation with your Service and the local people.

With the completion of these major outlets, it is expected that secondary drainage ditches will be constructed by local landowners with funds provided through the Agricultural Conservation Program. Subsequently, more intensive development of the drained lands for improved pasture and the production of corn, soybeans, and truck crops is expected.

Effects of the Project

With this development, a greatly increased discharge of suspended sediment into Back Bay and North Landing River will result,

followed by inevitable deterioration of fish and wildlife habitat and loss of its productivity.

To provide the basis for estimating the volume of suspended matter discharged from Seaside Neck and Nawney Creek subwatersheds under existing and with-the-project conditions, considerable data were obtained during the course of this examination. For example, it was estimated that a one and one-half inch rainfall in the Seaside Neck drainage during a 24-hour period discharges about 13 tons of suspended sediment into North Bay, which is an extension of Back Bay. With Seaside Neck Canal excavated, it is estimated that a comparable rain would deliver 175 tons of material. Moreover, on the basis of weather records for this vicinity, it may be assumed that following the normal occurence of ten such rains, the average annual discharge of suspended sediments would be approximately 1750 tons. This would constitute an increase of about 1250 percent in the amount of suspended sediment discharged into Back Bay as a direct result of drainage works. Actually, the volume of suspended material would probably be greater inasmuch as some existing woodlands will be cleared for agricultural purposes and additional canals dug by private landowners to accelerate drainage from their fields.

Similar experiences would accompany the construction of Oakum Creek and Milldam Creek Canals, which would discharge their silt loads into North Landing River.

Under these circumstances, the productive capacity of these coastal waters, already jeopardized by excessive turbidity, will be greatly reduced by the proposed drainage canals. The problem is further accentuated by the nature of the suspended matter of samples collected during our investigations; 50 percent of sediments were composed of colloidal particles of less than .002 millimeters in diameter. Moreover, according to reports received from the Geological Survey, these particles may carry electrical charges that would keep them suspended indefinitely unless neutralized.

Plan for Fish and Wildlife Conservation

With a view toward resolving these and related problems, consideration has been given a number of measures designed to prevent the discharge of excessive sediments into the open water areas. The following were found to be the most reasonable and constitute our plan for fish and wildlife conservation:

(1) Divert silt-laden waters originating within the Seaside Neck subwatershed away from North Bay into the Atlantic Ocean by way of Rudee Inlet. This would involve raising the crest elevation of

Sandbridge Road to form a dike across the marshlands which lie immediately north of North Bay; excavation of Seaside Neck Canal from Sandbridge Road to Fresh Pond along the planned alignment and thence into Rudee Inlet by way of Owl Creek or other feasible route; and erection of a tidal gate in the canal for salt water exclusion purposes. That segment of the proposed canal south of the Sandbridge Road should be deleted from the Work Plan or else it should be aligned along the edge of the adjacent upland, thereby protecting the marshes from drainage and spoil deposition.

(2) Delete the proposed Oakum Creek and Milldam Creek Canals from the Work Plan. Our studies have failed to reveal any feasible means of preventing discharge of silt-laden water into Back Bay and North Landing River if these canals are excavated.

(3) Align Seaside Neck Canal and any other canals constructed to avoid dissection of valuable marsh, swamp, and open waters; and provide for canal overflow into marsh and swamplands rather than directly into open water areas. Excessive drainage would accompany canalization of watershed wetlands, thereby reducing their fish and wildlife productivity. It has been variously estimated than canals through the swamps would remove surface water for a distance of from 500 to 1000 feet on each side of the canals. Detrimental effects therefore would be reduced in half if they were aligned to skirt the natural wetland areas. Anticipated damages to the productivity of the open waters of Back Bay-Currituck Sound could be further reduced by terminating outlet canals at the point of intersection with swamp or marshes. This would force silt-laden runoff from the uplands to flow as a sheet through dense vegetation before reaching open water. Not only would this retard the flow and thereby encourage deposition of suspended material, but the organic acids of the swamp and coastal marshes would aid in the precipitation of colloidal material.

(4) Canal excavation should be performed by bucket rather than by hydraulic dredging and spoil disposed in such manner that areas of particular value for fish and wildlife purposes may be preserved and developed. We realize that the initial cost of dredging a canal by hydraulic methods in marshy terrain is usually moreeconomical than other methods. From a long-range point of view, however, it is often the most expensive. Large areas are essential for containment of spoil; and even with such provision, escapement of large volumes of silt-laden waters is inevitable. The heavier particles settle rapidly, but the fine grained material, derived from muck, peat, and silt which composes much of the bottom soils of this area, is expected to flow or seep from the detention pools over extensive areas of marsh and open water. In this connection,

it is also important that spoil consisting mainly of fine clays, removed in ditching the agricultural lands, be covered with top soil or deposited in mounds so it will not be carried into the canals by surface drainage.

(5) Canal banks should be stabilized and runoff from agricultural land should be retarded by effective soil conservation practices. Experience on similar drainage projects reveals that much sediment carried by flood discharge is derived from erosion of canal banks. This is particularly true in the Coastal Plain Province. It is therefore important that the Work Plan not only provide for watershed treatment but that the soils of the canal bank be held in place by permanent plant cover, concrete aprons, or other engineering devices.

Discussion and Conclusions

The need for a balanced program of land and water use, involving both agricultural and fish and wildlife development to meet long-range needs, should be emphasized in your Work Plan.

The waterfowl resources of Back Bay have been an important source of revenue to the area for several generations. They will be of greater importance in the future.

The fishery resources, which are relatively undeveloped, have increased enormously in recent years. Moreover, with continued improvement of the production of aquatic habitat, largemouth bass, crappies, and other game fish will increase substantially. A conservative estimate of the potential sport fishery utilization under such conditions would be eight to ten times the current use. Financial income from this activity would increase even more.

Agriculture, of course, has been an important source of income to Princess Anne County since the first settlers arrived. However, consideration of recent land utilization trends in the county and appraisal of future prospects suggest that agriculture may be greatly reduced in importance in the revenue picture of the county in the next 25 to 50 years.

Recreational facilities, on the other hand, will greatly increase in use and demand in future years. Increasing human population, shorter working hours, and a decrease in good areas available for outdoor recreation, which have been forecast, are contributing to this trend. Princess Anne County is now within a few hours' drive of a major portion of the large population centers of the Eastern United States. The demand which will be made on the fish and wildlife resources is inestimable. Thus, it is imperative that adequate provision be made in your Work Plan for their preservation and development.

Recommendations

This Bureau therefore recommends that: (1) the fish and wildlife conservation measures, as described in this and the accompanying report, be made an integral part of your Work Plan for Princess Anne County Watershed, Virginia; moreover, that (2) following agreement as to general features of your development plan, we be given additional opportunity to assist in the preparation of design specifications.

Sincerely yours,

W. L. Towns

W. L. Towns
Acting Regional Director

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INTRODUCTION

The Bureau of Sport Fisheries and Wildlife has conducted a detailed study of the effects of the Princess Anne County Watershed Project, Virginia, on fish and wildlife resources of the area. The study was performed in accordance with the Memorandum of Understanding, dated May 12, 1955, between the Soil Conservation Service and the Fish and Wildlife Service, relative to works of improvement carried out pursuant to the Watershed Protection and Flood Prevention Act of August 9, 1954 (P.L.566, 83rd Congress, 2nd Session). The Bureau prepared a reconnaissance report on May 15, 1957 which determined that fish and wildlife resources of the area were of extremely high value and that a detailed study of the effects of the project on them should be made. The report, in accordance with Sections 5 and 6 of the Memorandum of Understanding, requested a transfer of funds from the Soil Conservation Service which was granted for the necessary studies.

The detailed study was carried out in cooperation with the Soil Conservation Service, the Virginia Commission of Game and Inland Fisheries, the North Carolina Wildlife Resources Commission and the U.S. Geological Survey. Fish and wildlife resources of both the project area and Currituck Sound were considered in the study since the North Landing River and Back Bay are but the headwaters of Currituck Sound and any effects on hydrological conditions of the headwaters will likely extend into the lower area.

This report presents the results of the detailed study. It discusses the probable effects of the proposed works of improvement on fish

and wildlife resources of the watershed and suggests alternate plans to minimize adverse effects of the project on these resources.

Discussions are also presented on certain theories and opinions which have been advanced by non-wildlife interests relative to the effects of the project on water quality in Back Bay and Currituck Sound.

Objectives of the Project

The primary objective of the project is to obtain better drainage of farm land in the watershed. Some of the area is so wet that its use is limited to pasture or woodland. Improved drainage would permit the more intensive utilization of these lands for the normal cash crops of the area.

Location of the Project

The watershed is located entirely in Princess Anne County, Virginia, and comprises approximately the southern two-thirds of the county. The City of Norfolk lies immediately to the northwest of the watershed.

Princess Anne County is bordered on the east by the Atlantic Ocean, on the north by Chesapeake Bay, on the west by Norfolk County, and on the south by Currituck County, North Carolina.

The northern third of the county, outside the watershed, contains the City of Virginia Beach and several other smaller communities. The area contains several major military installations, the Norfolk Municipal Airport and the 2710 acre Seashore State Park. Urbanization of this entire section of the county has developed rapidly since 1945. A majority of the agricultural land has been taken over for military installations, housing develop-

ments, industrial sites, roads, airports and other non-agricultural uses. This area contains substantial acreages of water in Little Creek, Lynnhaven Bay, Broad Bay and Linkhorn Bay, all of which drain north into Chesapeake Bay.

DESCRIPTION OF THE AREA

Physical Features

The watershed lies within the Atlantic Coastal Plain Physiographic Province. The area is very flat, lying between sea level on the ocean beach and an elevation of about 25 feet above m.s.l. [1/] Occasional sand dunes along the ocean beach reach elevations up to 54 feet. A majority of the watershed area lies below the 15 foot contour and much of it is less than 5 feet in elevation.

The Princess Anne County Watershed contains 137,216 acres. Of this 55,003 acres are cultivated, 2,192 acres are in pasture, 37,782 acres are in woodland, 3,131 acres are idle, 4,488 acres are in miscellaneous uses, 1,774 acres are in roads, 5,710 acres are in military installations and 27,136 acres are in marsh and water.

The watershed in general is poorly drained. Soils of the upland areas are predominately of the Bladen-Elkton-Fallsington group of light-colored soils and the Bayboro-Portsmouth-Hyde group of dark-colored soils. Both groups are poorly drained. There is also extensive acreage of various swamp and marsh soils. Restricted acreages of imperfectly drained soils of the Lenoir-Moyock-Dragston series also occur. The better drained soils of the Sassafras-Norfolk-Woodstown-Craven series are of limited occurrence in the watershed and account for only a small portion of the areas to be affected by the proposed works of improvement. A large expanse of dune sand extends the entire length of the watershed at the ocean edge.

1/ Hereafter in this report all elevations given, unless otherwise specified, are in relation to mean sea level.

The majority of the soils under cultivation in the area to be benefitted by the proposed drainage are of the Bladen and Bayboro groups. Some acreages of the Moyock group also occur but are limited in extent.

These first two groups have subsoils of a tough plastic clay, generally bluish gray in color and of very fine texture. In certain soil types there may be yellowish streaking in the subsoils. The clay layer generally extends from a few inches below the surface to a depth of two to four feet. This layer is in most cases virtually impervious to water.

Soils of the Moyock group in general have subsoils of clay, silt or of these materials mixed with sand. This layer provides better subsurface drainage than that found in Bladen and Bayboro group soils, but subsurface drainage is generally not good.

The swamp and marsh soils of the area are of varied texture ranging from peat and muck to sand and clay. These soils are generally all waterlogged and are not considered suitable for cultivation by virtue of their low elevation.

Save for an insignificant acreage in the northeast corner of the watershed, which drains into the ocean through Owl Creek and Rudee Inlet, the entire area drains generally southward into Currituck Sound through either North Landing River or Back Bay.

Back Bay[1] which in reality constitutes the northern tip of Currituck Sound, occupies the southeastern portion of the watershed, being separated from the ocean by a narrow barrier beach. It connects with Currituck Sound by way of Knotts Island Channel and Corey Ditch through Great Marsh. The ultimate outlet to the ocean of the drainage from the watershed is through Currituck Sound, Croatan and Roanoke Sounds, and Pamlico Sound at Oregon Inlet about 50 miles to the south.

Back Bay comprises an area of about 27,000 acres of open water and marsh. Several small streams flow into Back Bay. The larger of these are Nawney, Beggars Bridge and Asheville Bridge Creeks, however, there are no large streams. Some channelization work has been done on virtually all of the streams at some time in the distant past for either drainage or small boat navigation purposes but much of the work was not maintained.

Since 1947 most of the streams have been channelized, often with considerable enlargement and straightening. New drainage canals have been cut through the marsh to the Bay and many old canals have been enlarged.

Back Bay is quite shallow, nowhere exceeding about seven feet depth and averaging only about four feet in depth. Substantial acreages of marsh land surround the Bay on all sides, in nearly all instances

1/ Hereafter in this report, unless otherwise so specified, the use of the term "Back Bay" shall refer to Back Bay and its other open water areas to include North Bay, Shipps Bay, Redhead Bay, Sand Bay and all other open coves and embayments opening into them and lying north of the Virginia - North Carolina line.

separating high land areas from the open water. Numerous marsh islands occur in Back Bay and many small ponds occur in practically all the marsh areas.

Back Bay is essentially a fresh water area, being mildly brackish with a mean salinity of 1/2 percent of ocean water at the north end and about 2.2 percent at the south end. The entire Currituck Sound area, including both Back Bay and North Landing River, is influenced by wind tides. There is no recognizable effect of lunar tides. In general, winds from the north result in lowering of the water level of the area and winds from the south cause high tides.

Approximately the western half of the watershed is drained by the North Landing River. This stream originates in a large swamp area extending westward into Norfolk County, Virginia. Its major tributaries from the east are Salem Creek, West Neck Creek and Oakum Creek. Its major tributaries from the west are Pocaty Creek, Blackwater River and Milldam Creek. A portion of the drainage areas of the Blackwater River and Pocaty Creek lie outside the Princess Anne County Watershed boundaries in Norfolk County. The North Landing River flows southward into the head of Currituck Sound several miles below the Virginia - North Carolina State line. The North Landing River estuary widens to about 1 mile at the watershed boundary and about 3 miles at its mouth. The Northwest River and Tulls Creek join the North Landing River estuary about 3 miles below the line. The waters of the river are generally heavily stained by organic matter except when discolored somewhat by silt from heavy watershed runoff.

The water is virtually fresh except in the lower portion of the estuary where mild brackishness is encountered. The area is moderately deep.

The Intracoastal Waterway enters the North Landing River drainage through the Great Bridge Lock and Canal cut and follows the river to Currituck Sound, providing a 12 foot navigation channel.

Pocaty Creek and Blackwater River have been heavily channelized since 1947.

Average annual rainfall in the area is about 46 inches per year. Extremes of 34.66 and 63.91 inches were recorded in 1930 and 1924, respectively, at the Virginia Truck Experimental Station at Diamond Springs, just to the north of the watershed. Rainfall is fairly well distributed throughout the year, but with July and August usually the wettest months. Mean precipitation for these months is 6.61 and 6.47 inches, respectively, largely due to heavy rains associated with hurricanes. The driest months are generally October and November.

Rainfall with an intensity of 1.5 inches per hour can be expected with a frequency of every two years and an intensity of 2.2 inches per hour, every 5 years. Rainfall with an intensity of 1.5 inches in 24 hours can be expected with a frequency of 10 to 14 times per year.

Average mean temperature is about 60° F. Average July temperature is 78° F. and average January temperature is 43° F. The average frost free growing season at Diamond Springs is about 225 days.

Economic Features

The watershed has no large manufacturing plants of any kind. Most of the industry consists of several small sawmills. However, many residents of the watershed work in various manufacturing plants and military installations in the Norfolk area.

A large number of residents of the watershed secure all or a large part of their income from activities associated with fish and wildlife resources of Back Bay and the North Landing River. Many persons are employed as hunting guides during the waterfowl season and many serve as sport fishing guides throughout most of the rest of the year. Others find employment as fur trappers or commercial fishermen. There are several boat liveries, some of which also offer bait and other supplies to the fisherman. A small number of persons supplement their incomes by dressing game for hunters or by supplying food and lodging to hunters and fishermen.

A number of farmers in the area supplement their income by guiding, trapping or commercial fishing.

Agricultural Features

The major agricultural crops of the watershed are corn and soybeans, with some dairy and truck farms scattered throughout. Some swine and beef cattle are also produced.

Virtually all cultivated crops are row crops. In instances where truck crops are grown, two crops a year may be produced. Irish potatoes probably are the most common truck crop, and are usually followed with a late crop of soybeans or milo.

Some of the farms in the watershed probably have been under cultivation since the middle of the Seventeenth Century. Judging from the frequency of pure stands of loblolly pine in wooded upland areas of the watershed, and the presence of old ditches in various areas, virtually the entire upland has at sometime been cultivated.

The Soil Conservation Service has estimated that between 1947 and 1956 in excess of 100 miles of main canals and 700 miles of lateral ditches were dug in the watershed. These have, of course, contributed to the problem of sedimentation in the swamps and by dumping the water on the lower areas more rapidly have greatly aggravated the problem of flooding in these areas. Table 4 presents a record of the drainage performed in the watershed under the Agricultural Conservation Program of the U. S. Department of Agriculture between 1946 and 1957, as furnished by the Soil Conservation Service.

The ditching systems generally consist of two size classes of ditches. The smaller of these are the "Tap" ditches which first receive the waters from the fields and convey it to the "Lead" ditches which are the main arteries for carrying the water off the farm.

The standard design of the tap ditches as now recommended by the Soil Conservation Service usually consists of a bottom width of about 30 inches and a side slope of about 3/4 to 1 ratio. Depth is from three to five feet with an average of about four feet. Tap ditches are generally deep enough to cut through the layer of clay subsoil which usually extends from about two to four feet depth.

Lead ditches usually outlet into the nearest stream or main channel of water. In many instances where land elevation permits they empty into the swamp basin with no direct channel connection between field areas and the main run of the swamp. These ditches usually have bottom widths of from three to five feet and may range in depth to six or eight feet. Side slopes are usually cut with a one-half or three-quarter to one ratio.

Erosional Problems

Erosion in the watershed is not particularly evident. Gully erosion is almost totally absent due to the flat nature of the terrain. Sheet erosion is far more common but is not always easy to detect. Considerable erosion of ditch side slopes occurs on newly constructed ditches.

However, consideration of the degree of silting in the swamps and observations of the extreme turbidity of runoff water in ditches and streams clearly indicates that sheet erosion is widespread. It is probably not severe in comparison with that found on steeper sites, but considering the flat terrain, is probably of considerable magnitude. Some of it is rather insidious in nature consisting largely of the finer material of the topsoil which is carried away when downpours of rain pound the bare soil, leaving the heavier particles on the field surface. This results in something of a general trend toward sandier soil on the surface.

The Soil Conservation Service has estimated an average annual loss of 0.7 tons of soil per acre.

Virtually all cultivated crops in the watershed are cultivated in rows with clean tillage. Only nominal acreages of small grains or other broadcast crops are grown.

Winter cover crops for soil improvement or protection are grown on only nominal acreages. Recently some wheat has been grown, but generally as an extra crop since it could be planted in late fall following corn and harvested early enough to permit a crop of soybeans the following summer. Relatively minor acreages are planted to rye or other small grain for winter pasture. The majority of the crop land lies bare throughout the winter, and crop residue is generally not heavy enough to afford much protection to the soil.

Drainage Problems

Due to the flat nature of the terrain and in many areas the heavy, impervious nature of the subsoil, virtually all cultivated land in the watershed requires an extensive system of ditches.

With the advent of tractors and other farm machinery in the past 20 to 25 years it has become necessary to revise the ditch system of many of the farms. The old hand dug systems in many cases have not provided adequate drainage to permit operation of heavy farm machinery and others have not been adequately maintained. In many instances old ditches around fields of irregular shape have been filled and new ones dug to create a pattern of long narrow "cuts" of land to minimize turning of machinery .

The 3/4 to 1 side slope has been adopted because straight vertical sides result in too much caving. When a relatively flat slope is used, farmers tend to plow down on the slopes causing severe erosion and filling of the ditch.

During the past year the banks and side slopes of all ditches cut under the Agricultural Conservation Program have been seeded with serecia lespedeza. The seeds were furnished free of charge by the Virginia Commission of Game and Inland Fisheries. Ditch banks and side slopes normally become vegetated with various grasses and wild plants within one to five years after the ditch is constructed. The use of serecia lespedeza tends to accelerate the revegetation process by one or two years.

In cultivated areas, the spoil from the ditch is spread by bulldozer to form a slight ridge in the center of the cut between ditches and allow surface drainage directly into the ditch at all points. In wooded areas the spoil is usually piled on one bank with frequent breaks to permit drainage into the ditch.

Many of the drainage problems of the area are accentuated by the deposit of erosional silt in the channels which constituted the main drainage outlets through swamps and marshes of the area. It is these areas that the project is designed to provide outlets through. In many instances, deposition has progressed to the point that clearly defined channels no longer exist and the water must flow over the swamp bottom. The spread of the water out through the swamp has further

accentuated the problem through deposit of silt in these areas also. Some local residents estimate that this build-up may have exceeded two feet in the past 30 years.

The problem of drainage is further accentuated by the wind tides which tend to build up when strong southerly winds blow from the south for any long period of time. In contrast, northerly winds create low tides which help drainage. In general, southerly winds prevail more in summer and northerly winds in winter.

Tide range of Back Bay is between the extremes -1.7 and +2.1 feet M.S.L. Average water level in the Bay is about 0.58 feet M.S.L. A portion of the land in the watershed for which drainage improvement is needed lies below the 4.0 foot contour, some of it perhaps as low as 2.5 feet M.S.L. Prolonged tides of 1.0 to 2.0 feet are common to the area, sometimes persisting for days or weeks. These circumstances certainly pose the question of whether the land can ever be profitably farmed without dikes and pumps.

It is reported that the tides in Back Bay did not fluctuate to the present extent prior to the restoration of the Great Bridge Lock in 1932. Some believe that the open canal from 1917 to 1932 passed enough water to prevent a tidal buildup. It is theorized that prior to 1917 the abundant aquatic plants prevented wave buildup and therefore tidal buildup. It has been suggested that this abundance of plants would again reduce maximum tidal buildup.

An additional factor which is discounted by many is the apparent change in sea level. A letter from the Coast and Geodetic Survey to the Corps of Engineers, Norfolk District, dated March 15, 1956, has indicated that records from control tide stations covering 40 years or more, has indicated a long term rise in sea level along the Atlantic Coast at the rate of 0.011 feet per year. Data from Hampton Roads covering 29 years substantiate this long term trend. This would mean that in the 40 years since 1918 the average level of the ocean has risen by 0.44 feet, or about 5.28 inches. Since the average level of the ocean is after all a controlling factor in the average level of Back Bay - Currituck Sound, it certainly appears that the average level of these bodies would have risen by a like amount plus or minus the influence of other factors.

DESCRIPTION OF THE PROJECT

Structural Measures

The principal features of the project will be the construction of major drainage outlet canals.

Originally six such canals were proposed for the project (See Map No. 1). Specifications for these canals and the acreage of their individual subwatersheds are given in Table 1. Since the original proposal was made, one of these, Nawney Creek, has been constructed as a community drain under the Agricultural Conservation Program. The Bureau is now informed that two others, West Neck Creek and Salem Creek Canals will be constructed by the U. S. Navy and U. S. Army, respectively. The West Neck Canal would provide improved drainage for the Oceana Naval Air Station and the Salem Creek Canal would be dug to provide drainage for a small Nike installation near Kempsville. Correspondence from the Commanding Officer, Oceana Naval Air Station, indicated that construction of the West Neck Canal was to begin on June 15, 1958.

Informal conference with members of the Norfolk District Engineer's Office, Corps of Engineers, indicates that the Corps will pay for the Salem Creek work, but it will be performed under contracts let by the Soil Conservation Service, using this Service's plans and local personnel who will serve as consultants on the job.

While these three canals will no longer be a part of the watershed work plan, this report will include a discussion of them since their

effects on fish and wildlife resources of the area will be similar to and in addition to those of the three canals now proposed under the Watershed project.

The three canals to be constructed under the work plan are Seaside Neck, Oakum Creek and Milldam Creek. The Seaside Neck Canal is the only one of these which enters directly into Back Bay as does the already completed Nawney Creek Canal. Oakum and Milldam Creeks flow into the North Landing River.

The Seaside Neck Canal would, as planned, begin near Lovetts Marsh and extend southward, detouring around Fresh Pond through its marshy border at the west end. It would extend south through an existing canal to Salt Pond which it would also bypass through the marsh at the west end, and continue through a small existing canal to the head of Hell Point Creek which it would follow through the marsh, eventually taking a short cut to the head of North Bay.

At the bypasses of Fresh and Salt Ponds, the spoil material would be thrown up as a dike on the side next to the ponds. The canal would intersect the outlet of Fresh Pond and the inlet and outlet to Salt Pond a short distance from the open water of each. The floor of the outlets would not be lowered. At Fresh Pond a 36" culvert with a valve gate would be set in the dike near the west end to permit drainage of the pond if it was ever desired.

All excavation work will be by dragline except that approximately 1200 yards of canal at the south end of the Seaside Neck Canal

would be dug through the marsh and for a distance of several hundred feet into North Bay by hydraulic dredge. It is assumed that a portable dredge of 8 to 10 inch capacity with a rotary cutter head would be most practical to use there. Spoil disposal would be made at the western edge of the marsh adjacent to the high land. The material would be dumped on the marsh allowing it to drain back through the marsh vegetation. No provision has been made for any type of settling basin.

The Oakum Creek Canal would be approximately 2.3 miles long, extending from a point about 1 mile north of the town of Creeds to the estuary of Oakum Creek on the east side of the North Landing River.

Milldam Creek Canal would begin at a point about 1.9 miles above Virginia Highway No. 190 and extend generally northeastward to the bridge on Milldam Creek at Highway No. 190. This flows into the North Landing River from the west.

The Nawney Creek Canal, already constructed, begins at a point near the head of the Oakum Creek Canal and runs about 2 miles northward to join another recently channelized branch of Nawney Creek flowing from the north. These join and flow about 2 miles eastward to Back Bay. This portion of the stream has also been channelized in the past few years.

The West Neck Creek Canal, reported as under construction by the Navy Department, would begin at the Oceana Naval Air Station near the upper end of the watershed and proceed about 1.5 miles through a tributary stream to the main body of West Neck Swamp. This would be channelized about 3.85 miles to near Highway No. 603 west of the town of Pungo.

Below this point an open channel exists for about 4.0 miles to the junction of West Neck Creek with the North Landing River. Except for a short distance below the Oceana Station, virtually the entire course of the canal would be through a gum-cypress swamp. The portion of swamp lying upstream from the junction of the canal with the main body of West Neck Swamp would not be canalized by the current projects but it is reported that a canal would probably be dug at least as far as Mapleton Road as a community drain under the Agricultural Conservation Program, as soon as the Navy canal provides an outlet.

The current project on the Oceana Station will divert the runoff from 1420 acres of watershed now draining north into Lynnhaven Bay to the North Landing River by way of the West Neck Canal. In 1949 drainage operations at the Oceana Station diverted drainage from 1650 acres of the West Neck Watershed to Lynnhaven Bay to the north. The present diversion will therefore increase the Currituck Sound watershed by 1420 acres over that during the 1949-58 period but will leave a net loss of 230 acres from the original watershed as it existed prior to 1949.

The Salem Creek Canal will start at about the U. S. Army Nike site located just to the west of the run of North Landing River and about three miles southeast of the town of Kempsville. This canal would follow the general run or the swamp from this point about 7.3 miles to a junction with the Intracoastal Waterway Canal about two-thirds of a mile above North Landing Bridge. It is reported that the Salem Creek Canal might be extended about one mile above the Nike site as an Agricultural Conservation Program community drain.

Land Treatment Measures

Land Treatment measures which will be in practice in the subwatersheds at the completion of the project are given in Table 3. The first column provides a summary of land treatment measures proposed for all six of the originally proposed subwatersheds and the second column covers the three subwatersheds now considered for construction under the watershed work plan.

Table 2 presents the current and future estimated land utilization in the subwatersheds of the three canals proposed in the work plan. In these,it is noted that in general cultivated acreages will increase slightly and in Seaside Neck subwatershed, grassland acreage will decrease about one-third. No change in woodland or swamp and marsh areas is indicated.

The land treatment measures are to be applied by the land owners. The 358 miles of drainage ditch to be dug will probably be applied largely under the Agricultural Conservation Program. All ditch banks will be planted to serecia lespedeza or other plants to minimize erosion. No cover cropping of cultivated land is indicated.

HISTORY OF AQUATIC ENVIRONMENT CHANGES, BACK BAY-CURRITUCK SOUND

Prior to 1828 an inlet existed from the Atlantic Ocean into Currituck Sound at a point somewhat south of the present North Carolina - Virginia State line. Between 1828 and 1830 this inlet closed, presumably as a result of the construction of the Dismal Swamp Canal connecting the Elizabeth River to the north and Pasquotank River to the south. The canal diverted water from a large area of the Dismal Swamp away from the Northwest River and out through Pasquotank and Elizabeth Rivers. The inlet closed in the absence of enough outward flow to maintain it. In effect this created a long, narrow, shallow body of water, with a limited watershed which tended to buffer the ocean water from inlets far to the south. Relatively low, stable salinities resulted and conditions were ideal for the growth of submerged aquatic plants.

Sometime in the mid-nineteenth century, a navigation channel of about five to six feet depth was constructed from the head of the Elizabeth River to the head of North Landing River. A navigation lock at Great Bridge controlled currents detrimental to navigation interests. Presumably at about this time, a similar canal was cut from Coinjock Bay on Currituck Sound to North River at Coinjock, North Carolina.

In 1917, the locks at Great Bridge were removed. Approximately ten million cubic yards of spoil were dredged in the North Landing River, the Great Bridge Canal cut and Currituck Sound between 1914 and 1919 to deepen the Intracoastal Waterway. Some dredging occurred intermittently

through the 1920's in Currituck Sound and in 1925, 1.5 million yards of spoil were moved and in 1930, 2.5 million yards. The Great Bridge and Coinjock cuts were enlarged to provide 12 feet depth and a bottom width of at least 90 feet during this period. In February 1942, about 71,000 cubic yards of spoil ~~was~~ were dredged in Coinjock Bay and in May - June 1945, about 1,015,000 cubic yards of material ~~was~~ were dredged between the North Carolina - Virginia line and Coinjock Bay.

The spoil from all these operations was deposited on land adjacent to open channels or in open water areas near the channels. In either case it was deposited without regard for the destruction of aquatic plants by tremendous volume of fine material which was suspended in the water.

The removal of the Great Bridge Lock and enlargement of the canal permitted large volumes of salt water to flow into Upper Currituck Sound whenever north winds created high tides in Norfolk Harbor and low tides in Currituck Sound. When strong south winds prevailed this was reversed and fresh water was drawn through Currituck Sound from Albemarle Sound and North River. This resulted in relatively sharp fluctuations of salinity in various portions of Currituck Sound and Back Bay at various times.

During the dredging operations, the muddy waters were carried over virtually all of Currituck Sound and Back Bay by water currents. Aquatic plants suffered from light being shut out and from the settling of silt on the plants. This, plus perhaps the fluctuations in salinities,

resulted in the destruction of the aquatic plants over almost these entire areas. With the disappearance of the plants, wind action came into play. Severe turbidity resulted from wave action. This problem was probably aggravated by a thin layer of silt deposited over most of the bottom areas as a result of dredging.

As a result of biological studies and public demand, navigation locks were reinstalled at Great Bridge and placed in operation in 1932.

Subject to varying weather conditions and intermittent dredging during the 1930's and 40's, the plants began a slow recovery and by August 1955 were considered to be at least 50 percent, or more, as abundant over most of the area as during the 1900 - 1917 period.

In August and September 1955, three severe hurricanes struck the Back Bay-Currituck area causing major damage to aquatic plant resources. Damage was apparently both by physical destruction and by extreme turbidity and prolonged high tides which compounded the effects of the turbidity. The spring of 1956 was cold and windy, providing poor conditions for the recovery of the plants. Since that time, considerable recovery has been made under better conditions but in general, neither the thrift of the plants nor the extent of bottom coverage yet equals that of August 1955. This is particularly true of the deeper areas.

Among other factors which may have affected water conditions and plants in the Back Bay-Currituck Sound area is the construction of sand fences along the barrier beach to prevent salt water intrusion over the beach into these areas during high tides in the ocean during north-east storms. These were constructed mostly in the 1920's and 1930's. No

water crossed the beach from about 1936 to about 1950 - 53 when small volumes came through breaks in the fences which were soon repaired.

Very extensive ditching operations have been carried on in the watershed of both Back Bay and Currituck Sound since 1946. These have largely been in cultivated field areas but have also included construction of many large outlet canals through swamps and marshes of the area. Such operations have contributed large amounts of suspended matter to waters of Back Bay and Currituck Sound. Extremely severe turbidity conditions have occurred in many tributaries following major ditch construction. Such streams as Pocaty Creek and Blackwater River in the Princess Anne Watershed and Shingle Landing and Indiantown Creeks in the nearby Northwest River drainage have been converted from a condition of black stained, but otherwise clean and relatively clear water, to one of severe turbidity. Some of these streams are still very adversely affected after five to ten years. Further, new construction and subsequent ditch cleanouts, plus erosion from fields will probably prevent their ever recovering their former clean water condition. Sedimentation has been rather rapid in some instances.

Several other factors may have affected water quality in Back Bay and Currituck Sound to some minor extent. One of these was construction of Coreys Ditch from the North Landing River through Great Marsh to the south end of Back Bay in the early 1920's. Another was construction of a small tide gate near the Great Bridge Lock about 1954 to bypass a small volume of stained water from the North Landing River when tide conditions are favorable.

WILDLIFE RESOURCES WITHOUT THE PROJECT

Wildlife resources of the project area are extremely high in value.

Big Game

Big game is limited to white-tailed deer which occur in limited numbers along the southwestern portion of the watershed but they are apparently increasing both in numbers and range.

Black bear were frequently reported from areas adjoining the southwestern portion of the watershed until very recent years. These animals are probably now limited to rare stragglers, but such individuals may occasionally range into heavily wooded portions of the watershed.

Upland Game

Quail, doves, rabbits, and squirrels are common throughout the watershed. Dove hunting is generally rather limited but quail, rabbits, and squirrels are heavily hunted.

Fur Animals

Fur animal resources of the watershed are of high value. The marshes of the area produce substantial numbers of muskrats and raccoons while some otter and occasional mink are taken.

The deep, wooded, Cypress, and gum swamps of the watershed constitute high quality habitat for mink and raccoon, and otter are common along streams. Some muskrats also occur.

A number of persons secure a portion of their winter income by trapping in the marshes and swamps.

Waterfowl

The major wildlife resource of the watershed is the migratory waterfowl which utilize the area. Back Bay, together with Currituck Sound, is a major wintering ground for Canada geese, greater snow geese, whistling swan, coot and numerous species of ducks. This area is of National significance to waterfowl. It has been an important waterfowl hunting ground for almost a century. Some of the hunting clubs on Back Bay - Currituck Sound have been active since the 1870's.

In the market hunting era prior to 1935 this area was famous for the ducks (primarily redheads, canvasbacks and ruddy ducks) which were slaughtered by the thousands and shipped to northern markets.

The high value of this habitat to waterfowl is based upon the abundance of aquatic plants growing in the shallow waters of Back Bay and Currituck Sound. The most abundant species of plants are sago pondweed, redhead grass, wild celery, bushy pondweed, widgeon grass, and several species of muskgrasses. While a number of other species of aquatics, such as horned pondweed, have been recorded from the Bay and Sound, they are generally not abundant. It is of particular interest that all of the abundant species are rated as good to excellent waterfowl food plants and that none of the pest plants which have damaged so many other valuable waterfowl areas are found here.

As has been stated, three hurricanes in August and September 1955 wrought considerable damage to the aquatic plant resources of the Back Bay - Currituck Sound area. Poor growing conditions in the spring

of 1956 compounded this damage.

With somewhat better growing conditions in 1957 and early 1958 there has been substantial recovery by the plants, although in general neither the thrift of the plants nor the degree of bottom coverage is equal to that occurring before the hurricanes of 1955.

Aquatic plants are not abundant in the black water streams of the Back Bay - Currituck area except occasionally near the stream mouths. Where they do occur the species include bladderwort, coontail, northern naiad, white waterlily, American lotus, several species of pondweeds, and others. These as a whole are of low value as waterfowl foods, with the exception of bushy pondweed which generally is not abundant in these areas.

The wooded swamps of the Princess Anne watershed, when flooded, carry a substantial population of wintering ducks. Wood ducks, black ducks, and mallards are the major species involved. Many of these birds feed on waste corn, soybeans, and milo in nearby fields, coming out usually between sunset and dark or daylight and sunrise to feed. Most of their field feeding is before or after legal shooting hours. The birds are not usually heavily hunted in the swamps because of the difficulty of getting to them. The importance of the swamp-using blacks and mallards to the hunting on Back Bay is not clearly known but undoubtedly there is some interchange between these areas. This may contribute appreciably to the hunter's bag in certain portions of the watershed when hard freezes drive the birds from the swamp to open

"air holes" in the bays and streams.

The only species of waterfowl which breeds regularly in any numbers in the watershed is the wood duck. It is estimated that several hundred young are produced annually in the wooded swamps of the watershed.

The fluctuations of waterfowl populations have been considerable on the Back Bay - Currituck Sound area during recent years. This can be attributed to a number of factors which include fluctuations in the number of birds in the continental population, weather, local food conditions, and intensity of hunter activity.

Waterfowl hunting in the open waters and marshes of the Bay is done from blinds situated on piling in the open water or located at various points or coves on the marsh shore or pond margins. Float blinds are also used to a considerable extent in Currituck Sound.

In addition to the hunting clubs, there are a number of commercial lodges which provide hunters and fishermen with accommodations. Many individuals of the area act as hunting guides during the winter.

Back Bay and Currituck Sound constitute the most important waterfowl hunting areas in Virginia and North Carolina, respectively, and one of the most important on the entire Atlantic Coast. Hunting by local hunters is heavy but the major hunting pressure is from the large numbers of hunters from upstate and out-of-state who come to hunt waterfowl.

Back Bay National Wildlife Refuge

The Back Bay National Wildlife Refuge was established in 1938. It lies 13 miles south of Virginia Beach and entirely within the Back Bay

area. It comprises about 150 acres of upland, 4530 acres of marsh and barrier beach, and 4600 acres of open water, for a total of 9280 acres. About 48 acres of land are cultivated for production of waterfowl foods and much of the marsh area is also managed for food production. The major waterfowl food source is the abundance of aquatic plants in the open water and marsh ponds of the area.

Many thousands of waterfowl normally winter on this area and thousands of others use the area during spring and fall migration periods. The species include whistling swan, Canada geese, greater snow geese, coot, and the following species of ducks: Mallards, black duck, pintail, widgeon, gadwall, shoveller, green and blue-winged teal, canvasback, redhead, scaup, ringed-neck duck, ruddy duck, and bufflehead.

By providing feeding and resting areas for waterfowl at times when hunting pressure is heavy outside, the refuge makes a substantial contribution to the quality and consistency of waterfowl hunting in the Back Bay - Currituck Sound areas.

The refuge is an important link in the National system of wildlife refuges for the management of the continental waterfowl resource.

FISHERY RESOURCES WITHOUT THE PROJECT

Sport Fishery

The fishery resources of the Back Bay and Currituck Sound areas are of extremely high value. Together these bodies of water probably constitute one of the largest and most important recreational fishing grounds for fresh water fish on the Atlantic Coast of the United States. The major species of fish taken by the sport fishermen in the open bay and sound are the largemouth black bass and white perch. Other fish taken with less frequency are the common sunfish, yellow perch, chain pickerel, bowfin, catfish, and carp. Many black water streams flowing into the North Landing River itself, and certain of the tributaries of Back Bay and Currituck Sound, furnish excellent fishing for bluegill sunfish, largemouth black bass, black crappie, yellow perch, chain pickerel, and various rough fish.

Large numbers of local people fish these waters but the major fishing pressure is from the thousands of fishermen who flock to these areas annually from Upstate Virginia and North Carolina, and other areas as far distant as New York City.

The major basis for the productivity of the Back Bay - Currituck Sound fish habitat is again the aquatic plants of the area. These mats of plants are teeming with animal life. This life consists of amphipods and numerous other crustacea, insect larvae, worms, snails, numerous minnows and small fish and an abundance of microscopic animal life.

These animals feed upon each other and upon the algae, bacteria and other forms of life growing over the surface of the aquatic plants. They also feed upon plankton in the water.

So abundant are these animals that a single ball of "grass" the size of a basketball may contain hundreds of individuals.

The plant beds provide abundant cover for small fish which feed upon the abundance of animal life available there. The small fish in turn are eaten by larger fish or themselves escape to become the predators.

Back Bay and Currituck Sound are extremely productive of fish and are important recreational areas but they may also have further unidentified value to fisheries of a far larger area. It is probable that these areas are important breeding and nursery grounds for fish which are finally caught in other areas. At least one bass tagged in Back Bay has been recovered more than 100 miles away in the Chowan River System and many others were taken in upper Currituck Sound. The extent to which white perch, black bass, yellow perch, carp, catfish, and other species may move from Currituck to Albemarle Sound, Alligator River, or other areas is unknown. At times tremendous numbers of small spot, croakers and jumping mullets are in Currituck at least as far up as the mouth of Tulls Bay in late summer. These observations indicate possible unrecognized values to other areas.

Commercial Fishery

There is also a substantial commercial fishery in the Back Bay - Currituck Sound area. Normally this fishery functions from September

through April of each year. The primary fishing gear is long haul seines. In addition, gill nets are used rather extensively as are some catfish and eel pots. Species of importance in the commercial catch are carp, catfish, striped bass, white perch, yellow perch, jumping mullets and in the spring fairly large numbers of herring are taken. During the summer fairly large numbers of soft crabs are taken, both commercially and for local use.

EFFECTS OF THE PROJECT AND DISCUSSION OF FINDINGS

The conclusions and recommendations of this report are based partially upon data furnished by the Soil Conservation Service, the Virginia Commission of Game and Inland Fisheries, the North Carolina Wildlife Resources Commission, the U. S. Army Corps of Engineers, and from the files of the Bureau of Sport Fisheries and Wildlife.

Additional data were collected in the field by personnel of the Bureau of Sport Fisheries and Wildlife and opinions relative to specific problems were obtained from personnel of the U. S. Geological Survey and U. S. Army Corps of Engineers.

Other than that collected during the study, no measured data from the field were available on soil erosion losses, suspended matter content of runoff, nature and particle size of suspended matter, sedimentation rates, volume of runoff, flow currents, or discharge rates. In addition, very little is known about the currents and tides of Back Bay-Currituck Sound and about the effects of watershed runoff, wind, and other factors upon them. The cause of stained water, factors dissipating it, its effect upon non-organic suspended matter or even its chemical composition are all subjects about which little is known.

The interpretations of data, upon which conclusions in this report are based, are considered as conservative. While the short term data of necessity used in this report obviously did not cover the entire range of conditions which would occur under various combinations of climatic, hydrological and watershed conditions, the conclusions reached

are believed to be sound. Further data covering a longer period of time and wider variety of conditions is desirable. It is pointed out that the Bureau of Sport Fisheries and Wildlife, the Virginia Commission of Game and Inland Fisheries and the North Carolina Wildlife Resources Commission have recently initiated a cooperative long range detailed study of the aquatic resources of Back Bay-Currituck Sound. That study includes an investigation of all factors affecting water quality in these bodies of water and should provide a more adequate basis for further evaluation of the causes and effects of turbidity in the area.

Collection of Field Data

During the course of the detailed study, water samples were collected at 33 stations on Back Bay, North Landing River, and various tributaries of these which would be affected by the six canals originally proposed under the project. Sediment content of the samples was determined by the U. S. Geological Survey Water Quality Laboratory, Raleigh, North Carolina. Samples were taken on May 6 and 7 following approximately 2.5 inches of rain on May 4 and 5. Of the streams, ditches, and canals examined, every single one which drained cultivated land was extremely turbid, except for the lower end of major streams which the runoff water had not yet reached. Suspended matter content of the samples ranged from a low of 7 ppm at West Neck Creek on Highway 603 at the labor camp to 794 ppm at the Norfolk Farm Ditch on the road nearest its junction with North Landing Swamp. The runoff had not yet reached the West Neck Station and the Secchi disc was visible lying on the bottom in 27 inches of stained

water. The Secchi disc disappeared from view at a depth of 3/4 inch at the Norfolk Farm Ditch. Comparison of suspended matter weights is approximately 17 pounds of sediment per acre foot of water at the former station and 2156 pounds per acre foot at the latter.

In the Seaside Neck drainage area, samples from ditches and canals in cultivated areas showed suspended matter content ranging from over 1100 pounds per acre foot of water in Malban Swamp Canal at Dyer Road to 430 pounds per acre foot of water at a canal on Highway 615 just north of Dam Neck Corner. The Malban Swamp drainage area consists of about 625 acres of open land and 63 acres of woodland while the other watershed contains 99.7 acres of open land and 62.7 acres of woodland. Secchi disc readings were 1-3/4 inches at Malban Swamp and 3 inches at the other canal. The canals were near bankful capacity.

The basin of the Malban and James Swamps and the Fresh Pond into which they flow must have substantial storage capacity since this turbid water had not reached the Fresh Pond-Salt Pond Canal at the Dam Neck Naval Station Gate by noon on May 7, where suspended matter content was still at about 40 pounds per acre foot of water.

In the entire Princess Anne watershed, 22 canals, ditches, channelized streams, and swamps just below canal outlets were sampled for suspended matter content, most of them at or near the peak of discharge on May 6 and 7. The content ranged from the previously mentioned 2156 pounds per acre foot at Norfolk Farm Canal to 287 pounds and 322 pounds per acre foot at the two branches of Nawney Creek at Highways 603

and 622, respectively. Both of the latter samples were taken after almost all storm flow had passed and at the same time a sample of water taken about 300 yards above the creek mouth showed suspended matter content of 450 pounds per acre foot.

From the remainder of these, 8 sites yielded samples carrying more than 400 pounds per acre foot of water and 11 showed amounts ranging from 1000 to over 2100 pounds of suspended matter per acre foot.

Samples taken from streams and swamps, where cultivated land runoff had not yet reached or was a small part of the runoff, contained from 17 to 70 pounds of material per acre foot of water.

Samples of water taken off Murden's Dock in North Bay and at a point one-half mile northeast of Back Bay Warden's Headquarters showed a suspended matter content of about 70 to 130 pounds per acre foot respectively. These samples were taken under conditions of very severe wind action and there had been considerable runoff during preceding weeks which may have contributed to the turbidity.

At this same time the discharge of the previous several days formed a large muddy area at the mouth of Nawney Creek. It extended about 500 yards from the creek mouth covering almost the whole of the Bay between Warden's Headquarters and Drum Point. The division between this water and the Bay water was quite distinct. Suspended matter content of the Bay water was about 130 pounds per acre foot and that of the muddy water was about 444 pounds per acre foot. These samples were taken a few yards on each side of the muddy water division line.

All but two of the samples taken were analyzed to determine the proportion of organic matter in the suspended material. In virtually all samples having more than a negligible suspended matter content, the breakdown was about 5 to 20 percent organic matter and 80 to 95 percent mineral material.

Two of the water samples taken in the watershed were analyzed by the Geological Survey Laboratory for particle size of the suspended matter. The results of these tests are given in Table 5. These samples were from the West Neck and Salem Creek Canal Subwatersheds. The major soils of both areas are of the Bladen Series. Since most of the soils of the six subwatersheds are of the Bladen, Bayboro, or Lenoir series which are imperfectly drained and have a heavy gray or yellowish gray clay subsoil, it is believed that the samples analyzed would be representative for all of the areas.

Of particular importance in both samples, 50 percent of the suspended matter was finer than .002 millimeters; and 70 to 74 percent was finer than .004 millimeters. In both samples, 100 percent was finer than .125 millimeters and 97 to 98 percent finer than .031 millimeters.

All of the material less than .002 millimeters in diameter is either colloidal or near colloidal in size. The chemists of the Geological Survey reported that many of these particles may carry an electrical charge that will keep them suspended indefinitely unless neutralized. Under laboratory conditions, some of this material, even if not charged, would still remain suspended after one to two months.

Under field conditions which will always include water turbulence from wind, currents, temperature changes, man and animal disturbances, etc., the period required for these particles to fall out would probably be very much longer. The Geological Survey report indicated that hydrogen ion concentrations of the dark stained water and perhaps the mild salinity of the Bay would help to precipitate them.

Sediment Discharges

Based upon the engineering surveys and water samples taken, estimates were made of the tonnages of suspended matter now reaching Back Bay from the Seaside Neck subwatershed and those which would be discharged from Seaside Neck Canal, if constructed. The tonnage which is being discharged from Nawney Creek Canal was also estimated. It is believed that these estimates are very conservative and would represent the minimum changes to be expected.

It was estimated that under present conditions the Seaside Neck Drainage area now discharges about 13 tons of suspended matter into North Bay with the runoff from each one and one-half inch rain which falls within 24 hours. Weather records indicate such rains can be expected on an average of about 10 to 14 times per year. Assuming ten such rains, a discharge of about 130 tons per year would be indicated. With the Seaside Neck Canal constructed, it is estimated that a similar rain would deliver about 175 tons of material or around 1750 tons per year. These estimates take into account evidence that much of the silt now settles out in the swamp and marsh basins and in Fresh and Salt Ponds.

It was assumed that with the project 44 percent of this material would settle out in these areas due to overflows during high tide periods and the slow current in the canal. The finer material would be discharged into the Bay.

This would be an increase of about 1250 percent in the amount of suspended matter reaching North Bay from this subwatershed. Considering that Table 2 indicates an increase of about 6.5 percent in the cultivated acreage and Table 3 indicates construction of about 49 additional miles of ditches, it would appear that this is an extremely conservative estimate. It further seems extremely unlikely that the farmers will fail to clear at least some woodland for cultivation once drainage outlets are available, thus contributing still further to sediment loads.

One hundred seventy-five tons of sediment, if evenly distributed throughout the waters of North Bay from top to bottom (assuming an average depth of four feet), would be equal to a sediment load of about 87 pounds per acre foot over a 1000 acre area. This amount of this type material, plus severe turbidity from drainage on Muddy Creek, plus any turbidity remaining from earlier discharges or wave action, would probably produce a Secchi disc reading of not more than three to six inches over this area. A further spread of this water could affect a far larger area to a serious extent.

It is estimated that with the ditch as planned, virtually all of the runoff from a one and one-half inch rain would be in the Bay within 24 hours if normal tide levels prevailed. It is estimated that the discharge from Seaside Neck Canal would be only about 790 acre-feet of water

per day so the concentration of material would be extremely dense in the Bay near the outlet and would gradually spread out to achieve the density over a 1000 acre area referred to above.

It is estimated that the newly constructed Nawney Creek Canal discharges about 63.5 tons of silt with each one and one-half inch rain or about 635 tons per year. This would be enough to put 87 pounds of suspended matter per acre-foot over an area of 365 acres of water four feet deep with each one and one-half inch rain.

It is estimated that the Oakum Creek and Milldam Creek canals, if constructed, will deliver to their outlets about 352 and 636 tons of suspended material per year. This would be about 35 and 64 tons respectively per one and one-half inch rain. It is believed that this would equal an increase of 1000 percent or greater over present conditions.

Since the Salem Creek and West Neck Canals are not being considered in the present Soil Conservation Service work plans, very little data on them was obtained. Water samples from canals on the upper portion of these subwatersheds had some of the highest contents of suspended matter encountered. Samples taken at the lower ends of these proposed canal routes indicated a very high sedimentation rate in the swamps, particularly in West Neck Swamp. Based on the average cultivated acreage for the watershed and assuming the 0.7 tons per acre loss estimated by the Soil Conservation Service and a 44 percent sedimentation rate in the swamps, it is estimated that the West Neck Canal would discharge about 240 tons of suspended matter per one and one-half inch rain and Salem Creek

would discharge about 168 tons. Annual discharge would be at least 2400 tons and 1680 tons, respectively. In the case of West Neck, it is believed that the discharge of suspended matter would be increased by about 1000 to 1250 percent over present conditions. Since more of the Salem Creek silt seems to be getting through to the Inland Waterway Canal at this time, it is believed that this drainage will be increased by perhaps 1000 percent.

The Soil Conservation Service has estimated that soil loss in Princess Anne watershed is only about 0.7 tons of soil per acre of cultivated land per year. In Seaside Neck Subwatershed this would indicate a loss of about 2900 tons per year from the 4182 acres of cultivated and grass land under land utilization expected with the project. Assuming loss of 44 percent of this material before reaching the Bay would indicate more than 1625 tons reaching the Bay per year. This is not considered significantly different from the 1750 ton figure based on findings of this study.

Back Bay-Currituck Sound

In considering the effects of the project on aquatic plant resources of the Bay and Sound, it must be realized that one of the most important factors is water quality. This, of course, includes both physical and chemical quality. One of the most important physical factors is that of turbidity. The water must be sufficiently free of turbidity that sunlight can penetrate deep enough to reach the plants.

Turbidity of the Bay and Sound waters apparently arises from several sources. It consists of mineral and organic matter suspended in the water. Stain arising from organic matter in the soil of the swamps and marshes is in reality an organic color dissolved in the water and is not classed as turbidity.

A. Stained Water

It has been suggested that the black swamp water flowing in from the watershed was foul and stagnant and was a major cause of aquatic plant problems in this area.

It is true that heavily stained waters are not usually considered to be optimum habitat for most species of aquatic plants. This is partly because of somewhat reduced light penetration, but chiefly because of the acidity found in many stained waters.

Some stained waters are extremely acid, having a pH reading as low as 3.0 to 4.0, but such does not appear to be the case in the North Landing River and tributaries of Back Bay. Water tests made in May and July of 1958 at various points in the watershed gave pH readings from 6.3 to 7.0 in all stained waters and the majority were between 6.6 and 7.0. A series of tests made in August and September 1953 by the Virginia Commission of Game and Inland Fisheries in various stained waters of the North Landing River and Back Bay showed pH readings from 6.0 to 7.4, with the majority exceeding 6.4. The only exception in this series were two readings of 5.6 and 5.85 at the Labor Camp Bridge on West Neck Creek in August 1953. A similar

series in July 1956 showed pH of 6.0 and 7.0 at all these stations. Tests of Back Bay-Currituck Sound water usually are around 7.0 or slightly higher.

It is further pointed out here that prior to 1917, at which time Back Bay-Currituck Sound supported a wealth of aquatic plants which has not been duplicated since, the natural discharge of every stream of any size in the watershed carried a very high organic stain. Suspended matter from erosion undoubtedly occured then, but all reports indicate that it was rarely sufficient to be readily evident.

Examination of the stained water in several of the streams of the watershed has indicated that there is a great deal of misconception regarding these black waters. It is known that black water in this area, where draining from a swamp basin which receives no agricultural land runoff, may have a Secchi disc reading of as much as three to five feet. The addition of a comparatively small volume of the extremely muddy runoff from nearby fields may, when thoroughly mixed, have little effect on the color of the water but the Secchi reading may be cut to only a few inches. The general appearance of both bodies of water will still be black, but critical inspection will reveal the difference. During the study, a moderate content of suspended mineral matter and a very much smaller content of organic matter were found in all stained water samples which exhibited low Secchi disc readings.

It is known that severely stained, foul, stagnant water does occur in the swamps at times. Usually this is in connection with a hurricane, but possibly can result from an extremely high tide of long duration.

It must be remembered that hurricane conditions are quite different from ordinary conditions. To begin with, hurricanes usually are accompanied by very high winds and torrential rains. The wind creates considerable muddiness in open water through wave action, and extremely high tides are created which flood all swamps and low-lying areas. Tons of leaves, branches, limbs, and other green vegetation are blown into the swamps. The rains generally result in heavy runoff of very muddy water which also goes into the swamps. The runoff and tide together result in a relatively deep flooding of large masses of herbaceous plants growing in the low areas. When the tide remains high for several weeks, as occurred in 1955, the submerged nonaquatic plants could be expected to drown. It is logical that stagnancy and foulness would develop under these conditions. It seems highly probable that the ultimate discharge of this water into the Bay and Sound, following a return to normal tide level, would be detrimental to aquatic plants. It seems more probable that the major damage would have resulted before this, due to physical damage to the plants by waves, extreme turbidity coupled with an extra foot or two of water for the light to penetrate, settling of silt on the plants, and an abundant growth of bacteria, algae, and other organisms coating the plants while the light was shut off.

Under conditions of ordinary tides and rainfall, it appears that particularly poor quality water would develop in the swamps only in relatively small quantities. Evaporation and transpiration by plants remove large volumes of water during hot weather. Basins perched above tide level would undoubtedly go dry in a relatively short time unless maintained by frequent rainfall or stream flow which, except under unusual conditions, should tend to prevent severe stagnancy from developing. Basins at tide level would become stagnant only if the tide kept them flooded for a prolonged period.

It is believed that no benefit could be expected to occur to water quality at such times through further ditching in the swamps. The stained water develops as a result of extremely high tides holding the water there. The ditches would not prevent this but would only help to discharge the poor quality water into the Bay more quickly when the tide falls. If any appreciable drying of the swamps occurs, it may mean more herbaceous material present to decompose and contribute to the poor water quality, when it does flood.

The volume of these swamps is not large in comparison with that of Back Bay-Currituck Sound, so it would appear that the volume of stagnant water produced by other than an abnormal tide would not be great enough to cause major damage even if a heavy rain flushed the entire charge out at once. It is believed that the construction of ditches would not prevent flooding of the swamps by abnormal tides

and therefore would not prevent development of the stagnant conditions.

B. Turbidity

Turbidity of the waters of Back Bay-Currituck Sound seems to arise from two major sources. The first is from the bottom of the area and the second is through runoff from the watershed.

Human activities also cause some turbidity. Hydraulic dredging in particular can have severe effects, these being conditioned somewhat by the volume of material moved, the nature of it, where it is deposited, the season of activity, and the effects of wind and water upon distribution of the suspended matter. In general, any hydraulic dredging can be expected to have a substantial adverse effect on water quality over a large area.

Disturbances by motor boats, haul seining, and other human activities contribute to turbidity to some small extent.

Turbidity from the bottom is predominately caused by wave action, but may also arise from water currents and activities of fish such as carp. Both Back Bay and Currituck Sound are extremely shallow bodies of water, having large areas where depths are less than three or four feet. Much of the bottom of these areas is of fine mud or a mixture of mud and sand. When wave action develops, the bottom is agitated and much of the fine material becomes suspended in the water. Turbidity from this source is prevented, however, when beds of aquatic plants become established. The mats of plants

extending to the surface form "slicks" which effectively hold down wave action from any except storm winds. The roots of the plants also tend to bind the soil, protecting it from any moderate wave action. Since the finely divided particles on the bottom are already neutralized and no longer carry an electrical charge, they settle out much more rapidly when disturbed than freshly introduced silt, which frequently is electrically charged and must be neutralized before it will fall out.

When there has been damage to the plants over an extensive area, the recovery may be very slow. However, as the plants begin to bind the soil and retard the waves, plants develop in the shallowest areas where the sunlight can reach bottom. The more area covered by plants, the less turbidity there is from wave action. The clearer the water is, the deeper the sunlight penetrates and the deeper is the zone which the plants can occupy. In other words, the greater the area occupied by plants, the better conditions are for the plants to occupy more and deeper water.

There is, of course, usually a fair amount of turbidity in the very early spring, resulting from heavy winds and the fact that most of the plants have fallen back, broken off, or been cut up, or dug out by feeding waterfowl or carp. The rhizomes and tubers of most of the plants, where plant beds existed in water of moderate depth, seem to have sufficient stored energy to begin growth and, in the case of sago, redhead grass, widgeon grass, and wild celery,

to reach within a foot or two of the surface and ultimately to the sunlight zone. Once light is reached, the plants grow rapidly, soon forming dense mats which tend to reduce wave action.

Turbidity from carp can be fairly heavy at times, but there are also indications that these fish may migrate to some extent and therefore may spend part of their time in other waters. These fish are taken commercially, and in Back Bay this was encouraged in the spring of 1958 by an extension of the commercial season on carp.

Turbidity arising from watershed runoff is quite different than that arising from the bottom, since it is created whenever there is heavy rainfall. The density of the turbidity may vary according to the condition of the cultivated areas, the condition of the drainage system, and the force and intensity of the precipitation. Unlike wave-created turbidity which arises over a large area, runoff turbidity, as would be created by new outlets into the Bay, would be at its greatest intensity at the ditch outlet and would then spread over the area depending upon currents and tide conditions. While plants tend to prevent turbidity from rising from the bottom, runoff turbidity flows in over them.

It has been suggested that the runoff turbidity could be precipitated by increasing the salinity of the Bay water. This presumably would be accomplished by removing sand dunes and sand fences on the barrier beach so that northeast storm tides would push ocean water through the low breaks into the Bay.

Even if it is assumed that such a plan would produce a desirable amount of salt water, well distributed in the Bay, and that no inlet to the ocean would be opened by a storm, there are still problems to be solved. Northeast storms usually occur only in fall or early winter. In very wet years when there is substantial runoff, most of the salt water may have been carried out of the Bay and Sound by spring, when its effects would be most needed and in a year when runoff turbidity would be most severe.

Even if the turbidity could be precipitated soon after it reaches the Bay, it would result in the buildup of substantial deposits on the bottom of the Bay near the drain outlets, and in the course of 40 to 50 years would go far towards filling in areas such as North Bay. A more immediate effect would be the settling out of the material on top of plants, where they existed, weighting them down and depressing them from the surface where light is available. A thin coat of silt over the leaf surface would shut out the light just as effectively as extremely turbid water.

It has been suggested that the fine material would be flushed out of the Bay and eventually out of the Sound by water brought over the beach by northeast storms and by runoff. Any volume of sea water great enough to displace large volumes of silty water would also be great enough to raise salinities of the Bay and Sound above that which most of the plants can tolerate on sudden changes and probably would kill fresh water fish for the

same reason. Besides, under such conditions, salt water is supposed to ~~reper~~precipitate the silt. Undoubtedly a great deal of suspended material is transported from these areas by normal runoff discharge and, more especially, by wind tides which cause exchanges of large volumes of water from time to time. These tides can bring suspended matter into the Bay or Sound as readily as it is removed by them; so whether there is a net gain or loss may depend on many factors, such as frequency, force, duration and suspended matter content of the water, and may well vary from year to year.

The Corps of Engineers once estimated that total watershed runoff in Back Bay-Currituck Sound in an average year was probably about 90 percent of the volume of these bodies of water. This would mean that the volume of discharge from runoff would not be great and it could not be expected to carry large quantities of material out of the Bay and Sound. Furthermore, such material must be suspended for water to carry it. Hence, if any appreciable volume of silt is removed from the Sound by water, it will also have an appreciable effect on light penetration as long as it is suspended and over the entire area which it travels.

An important factor contributing to the problem of silt content of runoff waters in the watershed is the lack of vegetative soil cover during the winter period and at other times. The use of cover crops in the watershed is very limited. An additional factor is that virtually all cultivated land is in row crops with

very clean tillage. Also, some land is plowed and cultivated a double amount, since two crops are grown per year. The extensive use of winter cover crops throughout the watershed would reduce considerably the volume of sediment carried off during the winter and very early spring and might lengthen slightly the intervals between ditch cleanouts.

There are hundreds, and perhaps thousands, of miles of ditches in this watershed, of which an estimated 800 miles were dug new or reconstructed during the period 1946 to 1956. This activity has continued since then at at least an equal rate. The Soil Conservation Service has estimated that construction of the Seaside Neck, Milldam, and Oakum Creek Canals would result in construction of about 78 miles of tap and lead ditches in the next five years. Construction of Nawney, West Neck, and Salem Creek Canals would result in construction of another 280 miles of ditch.

One very damaging feature of the new ditches is the spreading of the spoil over the surface of the field. The fine clay subsoil, which probably equals from one-half to one yard of clay material per linear yard of ditch, is spread over the field surface. Under clean tillage, this is almost always subject to pounding by heavy rainfall which washes it out of the surface soil and into the ditch and away. This is the very fine material which is able to stay suspended for so long. In former years, this clay material was in a spoil-bank where it was soon overgrown and caused little damage.

The recently dug ditches are larger than most of the old ditches and therefore convey the muddy water away much faster. They are designed to convey the runoff from a one and one-half inch rain below the hydraulic gradient within 24 hours. This means that with construction of the main outlets proposed under the work plan, much of this muddy water would be in Back Bay or North Landing River within 24 to 48 hours. Thus the effect of settling out of suspended matter during the slow movement through the swamps would be lost.

It is pointed out that construction of new ditches or reconstruction of old ones by dragline results in leaving all parts of the ditch bare and with some loose soil. Furthermore, it is estimated that tap ditches must be cleaned at least every 10 years and lead ditches at least every 18 years. When performed by dragline or other machine, the ditch is, insofar as erosion potential goes, the same as a new ditch. In contrast, cleanout with hand shovels in bygone days usually disturbed only the bottom of the ditch and left the vegetation on the sides alone.

Observations indicate that in general at least three to five years are required for sufficient natural vegetation to become established on ditch side slopes to prevent bank erosion. Where planting of serecia lespedeza has been practiced, the process may be speeded up by one or two years. However, serecia often provides only limited protection during the first year or two, since it is slow to become established. By use of other plant species, the

period needed for revegetation of these ditchside slopes could be shortened. In particular, species are needed which can be planted to provide immediate cover, especially on ditches constructed in the fall and winter.

Assuming that 10 percent of tap ditches and 5.5 percent of lead ditches were cleaned each year and further assuming that good vegetative bank cover could be established by the end of the second growing season thereafter, it would mean that at any given time about 20 percent of taps and 11 percent of leads would be in a condition to suffer moderate to severe bank erosion.

Construction of the main canals by dragline will undoubtedly result in extreme turbidity in the canals throughout the construction period, much of which may be flushed into the Bay or River by heavy runoff. The construction period for Seaside Neck Canal is estimated at about one year. Turbidity reaching the outlets might be reduced somewhat by reversing the usual procedure and digging from the head of the canal down.

Because of the soft terrain, a hydraulic dredge would be required to dig the lower 1200 yards of the Seaside Neck Canal. This would involve about 40,000 cubic yards of spoil which would be deposited on the open marsh adjacent to the highland at the west edge. Discussion with dredging specialists indicated that a small 8- to 10-inch dredge with rotary cutterhead normally operates at less than 20 percent efficiency. This means that a volume of water

about four to five times as great as the spoil would be pumped. The specialists indicated that with the fine muck, peat, and silt occurring in this area, a major portion of the material would be expected to work through the marsh vegetation for distances of up to 5000 feet. Topographic maps of the area show that the proposed disposal site would not be more than 1000 feet from either the canal route or several small natural drain channels in the area. By diking a relatively large area to form a settling basin, perhaps most of this material could be prevented from reaching North Bay.

Therefore, it is concluded that the hydraulic dredging activity as planned would cause severe water turbidity in North Bay and other portions of the Back Bay area.

It is concluded that the large volume of silt which is being brought into the Bay by the recently completed Nawney Creek Canal and other drainage outlets constructed in the last 10 or 12 years contributes substantially to present turbidity problems which damage aquatic plants in Back Bay and portions of Currituck Sound. The construction of Seaside Neck Canal, which would increase sediment discharges from its watershed by an estimated 1250 percent, would create very severe turbidity conditions at times in North Bay and other areas of Back Bay, which would have additional severe adverse effect on aquatic plant resources of these areas.

The effects of the Seaside Neck drainage, in conjunction with the discharge of the other canals, would be most severe on the north and west sides of Back Bay where the discharge occurs. The greater depth of water there would increase the vulnerability of such areas. When plants are killed or prevented from developing in such areas, wave-created turbidity from the unprotected bottom is carried by currents into other areas, affecting plants there. During a poor growing season, which might involve severe turbidity from heavy runoff and persistent high winds, this could result in damage to plants over virtually all of Back Bay and probably into Upper Currituck Sound.

Waterfowl resources of the Back Bay area would be damaged proportionately with the damage to the aquatic plants which are the major element in this high quality habitat. Much public hunting opportunity would be lost in the decline of the area and many local residents would suffer loss of income.

The value for waterfowl of the Back Bay National Wildlife Refuge would be severely reduced by the damage and destruction of aquatic plants in the open waters of the refuge.

Damage and destruction of aquatic plant resources of Back Bay and Currituck Sound would also damage fishery resources of the area by at least a proportionate amount. Destruction of the plants would eliminate vast areas of cover for fish and also the tremendous volumes of small animal life which occur there and are sought as

food by fish. Increases in water turbidity which reduce penetration of sunlight into the water would also greatly reduce the growth of plankton and therefore would also reduce the productivity of the habitat for fish life.

Substantial reductions in fishery productivity of the area would reduce the tremendous aesthetic value of the Back Bay-Currituck Sound area as a fisherman's paradise. Increased muddiness of the water would also detract from its aesthetic value as a fishing area. The income of many watershed residents who serve as guides, operate boat liveries, or provide other services or supplies to fishermen would be substantially reduced. Commercial fishing income would also be reduced.

North Landing River

The construction of the Milldam and Oakum Creek Canals would result in the discharge of moderate volumes of silt into the North Landing River. Proportionate with the cultivated acreage in the watershed, it is believed that this discharge would be as severe as others in the watershed.

The construction of the Salem Creek and West Neck Canals would result in discharges of tremendous volumes of fine suspended material into the North Landing River.

Extensive drainage work has been performed in recent years in the North Landing River watershed. Many canals have been cut to the river through the swamp, and streams such as Blackwater and Pocaty

Rivers have had extensive drainage work. Pocaty swamp was channelized several years ago similar to the work proposed for the subwatersheds under the work plan. Examination of these streams gives a fair indication of the effects to be expected from the proposed works.

The combined effect of the discharge into North Landing River of the four canals, discussed in this report, plus that of the other works already existing would undoubtedly be a serious deterioration of water quality in this stream.

Some of the suspended material may settle out in the North Landing River estuary before reaching the plant beds in the lower estuary and Currituck Sound. The distribution of submerged aquatics in the river estuary is largely limited to the lower portion below the North Carolina-Virginia State line, and relatively large areas there, even in shallow water, have few or no plants. Should a considerable portion of the suspended matter settle out before reaching the aquatic plant area, then it would result in a need for more frequent maintenance dredging of the Intracoastal Waterway Channel. Such dredging is particularly destructive, since a large portion of the fine sediment is brought into suspension at one time and may be carried for long distances by water currents.

If the runoff material does not settle out in the estuary, then it can be expected to have severe adverse effects on aquatic plants as it is swept down into Upper Currituck Sound. Some of it may even reach Back Bay with incoming wind tides.

Therefore, it is concluded that the construction of any of the proposed canals draining into North Landing River would adversely affect water quality for the production of aquatic plants in Currituck Sound.

It is also concluded that construction of these canals would seriously damage the quality of the water of North Landing River and its tributaries as fish habitat and also its aesthetic values as a fishing area. Several streams which have suffered severe drainage activity, both in the watershed and in the nearby Northwest River Watershed, were inspected. These showed that for several years after construction, these streams usually are so muddy during the important spring fishing season and to a considerable extent in the summer, except during droughts, that fisherman utilization is cut drastically. The damaged stream not only produces fewer fish, but use of artificial lures is often impossible due to water turbidity. The feeling of fishing in a "mudhole" further lessens the aesthetic values of such areas.

Damage to the waters of North Landing River and its tributaries would result from silting of channels and holes, exclusion of sunlight which is essential to the growth of plankton, and perhaps also from the silting of spawning beds of certain species of fish. The destruction by turbidity of such plant beds as do exist would eliminate the animal life dwelling there, important items in the fish food chain. These effects would be particularly severe in the lower segments of the channelized streams.

Swamps and Marshes

It is estimated that about 2500 acres of low-lying gum-cypress swamp would be affected by the construction of the five remaining unconstructed canals. Most of this acreage lies in the North Landing and West Neck Swamps. Smaller acreages are in Milldam Creek Swamp and Malban and James Swamps.

It has variously been estimated that construction of the swamp canals would remove surface water for a distance of from 500 to 1000 feet on each side of the canals. In some of these areas, lead ditches would be cut through to the main canals at frequent intervals. Few of the swamp areas are wide enough to prevent drainage of most surface water under these circumstances.

In the lower portions of Salem, West Neck and Milldam Creeks considerable swamp areas may continue to be flooded by high wind tides. However, such flooding would be erratic in nature, and high tides usually prevail in summer and low tides in winter. The major use of waterfowl is of course during the winter. Erratic summer flooding would be less desirable from a wood duck breeding standpoint, since aquatic insect and other animal life sought as food would be affected. The erratic flooding would also reduce the quality of the area as fur animal habitat.

If spoil could be placed evenly, as a dike on one or both sides of the canals through the swamps and marshes, some of the flooding of these areas could be retained. In particular, this should be done where the swamp is wide and a relatively large area could be

flooded. This would permit continued utilization of these areas by waterfowl.

The cutting of the lead ditches through the swamps from the highland to the main channels would allow direct delivery of the turbid water to the main channel and also increase the effects of drainage on the swamps. Some settling out of silt and preservation of bottom land flooding could be secured by ending the leads at the swamp edge and forcing the discharge to flow over the bottom land to the main channel. This might be moderately effective if used in conjunction with the above referred to spoil placement.

Construction of the Seaside Neck Canal would result in drainage of surface water from a substantial area of marsh in the Fresh and Salt Ponds area. This habitat is rather heavily used by tipping ducks and coot, especially during the spring migration period. Although the canal would bypass Fresh and Salt Ponds, it is believed they would be lowered somewhat by the canal which would tap the present outlet and inlet canals a short distance from the ponds. The extent to which this would affect the ponds is not known. The diversion of muddy runoff from them should be of some benefit.

Long-Range Planning Needs

In conclusion, the need for long-range thinking and planning in the overall consideration of farm drainage problems and fish and wildlife problems in the Princess Anne County Watershed is deserving of emphasis.

To begin with, the waterfowl resources of Back Bay have been an important source of revenue to the area for several generations. There is every reason to believe that they will continue to be an important source of income in the future. With the recovery of the aquatic plant resources of this area to somewhere near their pre-1917 level of abundance, the financial return from the waterfowl resource may be increased considerably.

The great undeveloped resource of this region, however, is sport fishing. Within recent years the number of man-days spent in sport fishing on Back Bay has increased by leaps and bounds. The area can support many times as much sport fishing as is now carried on and still provide an average catch which would satisfy the fisherman. With return of the aquatic plants of the area to somewhere near their former abundance, the production of bass, white perch, and other sport fish may be expected to increase substantially. A conservative estimate of the potential sport fishery utilization under such conditions would be eight to ten times the current use. Financial income from this activity would increase even more.

Agriculture also has been an important source of income to Princess Anne County since the first settlers arrived. However, consideration of recent land utilization trends in the county and appraisal of future prospects suggest that agriculture may be greatly reduced in importance in the revenue picture of the county in the next 25 to 50 years.

It should be realized that within the past 10 to 15 years, a large portion of the agricultural land north of Virginia Beach Boulevard has shifted from agricultural use to other uses, such as housing developments, industrial sites, municipal or defense installations. When the remaining areas north of the boulevard are thus occupied, competition for sites south of the boulevard will increase. Small areas have already shifted from farming to other uses in the vicinity of Oceana and Kempsville. With the anticipated increase in the human population of the country and the location of this area near the major city of Norfolk, the demand for lands in the northern part of the watershed for other uses may displace agriculture within the foreseeable future. Demands for cottage sites and other recreational uses may take other shoreline acreages out of cultivation.

Increasing human population, shorter working hours, and a decrease in good areas available for outdoor recreation have all been forecast for the foreseeable future. Food, clothing, fuel, and many other needs of modern-day living can be transported to the human population. In contrast, the human population generally must be transported to its outdoor recreation. This requires money for travel, food, lodging, boats, motors, gasoline, guns, shells, tackle, bait, and a host of other goods and services used by the recreationist.

Princess Anne County is now within a few hours' drive of a major portion of the large population centers of the Eastern

United States. This area is important to many of the people who come to this section for recreation, and it will become vastly more important in the future.

Considering the tremendous aesthetic and economic potential which the fish and wildlife resources of this area hold, the effects of present-day developments upon them should be carefully analyzed. Long-range plans should be instituted for their preservation and enhancement.

A step in this direction has been made with the recent initiation of a cooperative long-range detailed study of the aquatic resources of Back Bay and Currituck Sound by the Bureau of Sport Fisheries and Wildlife, the Virginia Commission of Game and Inland Fisheries, and the North Carolina Wildlife Resources Commission. This study will ultimately provide solutions to the problems discussed in this report and should point out a way of preserving and enhancing these valuable resources.

ALTERNATE PLAN - SEASIDE NECK CANAL

An alternate plan for construction of the Seaside Neck Canal is offered for consideration. Its engineering and economic feasibility should be fully investigated.

It is suggested that the Sandbridge Road be raised as necessary at the Hellpoint Creek and Asheville Bridge Creek crossings to provide a dike and that these streams be blocked off at this point. The Seaside Neck Canal would be constructed to drain north from the Sandbridge Road dike through Owl Creek and Rudee Inlet into the Atlantic Ocean. The suggested routes are shown on map 2. If needed to prevent salt water intrusion during storms, a tide gate could be constructed in the vicinity of Camp Pendleton. It is believed that this outlet would provide drainage for agricultural land north of Sandbridge Road which would be superior to that obtainable to the south. Except for occasional periods of a few days, chiefly in the fall and winter, when storms might cause prolonged high tides at Rudee Inlet, drainage to near mean sea level or below would be available there at some time of every day. Prolonged wind tides in Back Bay often prevent drainage to below about 1.5 or 2.0 feet above mean sea level for periods of up to several weeks.

The added water to the Rudee Inlet area by the northward drainage of Seaside Neck Canal would provide much needed waterflow to assist in maintaining the navigational channel through Rudee Inlet.

Drainage of the area below Sandbridge Road should not be undertaken unless absolutely necessary. In which case, a small canal may be dug by dragline at the edge of the highland adjacent to the field. Data from the Soil Conservation Service indicate that the acreage here would be very small and lies entirely below the 4-foot contour.

Under this plan, drainage from about 11,000 acres would be diverted from the watershed of Back Bay-Currituck Sound to the Owl Creek-Rudee Inlet Watershed. 11,000 acres constitutes about 16 percent of the 67,000 acres in the Back Bay Watershed. It constitutes only about 2.5 percent of the 446,000-acre watershed of Currituck Sound. While it is not considered desirable to lose the runoff from this segment of the watershed, it is believed that potential damages are substantially less than those expected from the extremely turbid water under the proposed work plan.

TABLE NO. 1

CANAL SPECIFICATIONS AND WATERSHED AREAS OF THE SIX SUBWATERSHEDS ORIGINALLY PROPOSED

Watershed	Seaside Neck	Milldam Creek	Oakum Creek	Nawney Creek	Salem Creek	West Neck * Creek
Area (Acres)	12,003	2,566	1,498	4,006	8,080	11,507
Canal:						
Length (miles)						
Upper Seg.	0.7	--	--	--	2	--
Middle Seg.	3.5	--	--	--	1.3	--
Lower Seg.	3.5	--	--	--	4	--
Total	7.7	1.9	2.3	2	7.3	3.85
Bottom width (ft.)						
Upper Seg.	20	--	15	15	8	25
Middle Seg.	40	--	--	--	15	25
Lower Seg.	50-55	20	25	20	25	25
Avg. Depth (ft.)	6	4.5-5.0	4.5-5.0	4.5-5.0	4.5-5.0	-5.0 below m.s.l.

* U. S. Navy Specifications - Letter May 27, 1958, C. O., Oceana Naval Air Station

TABLE NO. 2

SUBWATERSHED LAND UTILIZATION, PRESENT AND FUTURE (IN ACRES)

	Seaside Neck		Milldam Creek		Oakum Creek	
	Present	With Proj.	Present	With Proj.	Present	With Proj.
Cropland	3,551	3,778	1,446	1,497	826	839
Grassland	631	404	93	93	43	43
Woodland	4,192	4,192	898	847	552	539
Swamp	3,629	3,629	129	129	77	77
Totals	12,003	12,003	2,566	2,566	1,498	1,498

TABLE NO. 3

LAND TREATMENT MEASURES WITH THE PROJECT

Practice	Total Acres Six Subwatersheds	Total Acres Three Subwatersheds in Work Plan
Pasture Seeding	694	151
Pasture Improvement	2,294	500
Conservation Crop Rotation	11,469	2,500
Crop Residue Utilization	6,882	1,500
Reforestation	200	---
Open Drain	358 (Miles)	78 (Miles)

TABLE NO. 4

MILEAGE OF DITCHES CONSTRUCTED IN PRINCESS ANNE COUNTY WATERSHED, VIRGINIA
UNDER ACP PROGRAM OF USDA - 1946 - 1957

	To North Landing River						To Back Bay					
Year	Old Leads	New Leads	Old Lat.	New Lat.	Cultivated Acreage Drained	Total Acreage Drained	Old Leads	New Leads	Old Lat.	New Lat.	Cultivated Acreage Drained	Total Acreage Drained
1946	--	--	--	--	--	--	--	--	--	--	--	--
1947) 1948)	4.3	--	4.3	--	545	779	4.4	--	--	--	378	540
1949	8.2	0.2	11.7	--	662	945	0.3	--	--	--	22	32
1950	10.9	--	8.8	--	835	1,193	3.5	--	3.5	--	518	740
1951	7.0	1.2	11.8	1.0	625	893	1.9	--	7.3	--	232	332
1952	3.7	1.2	3.7	--	200	287	2.3	--	3.2	--	169	242
1953	9.5	0.1	9.3	3.8	593	847	4.7	--	7.3	--	341	487
1954	4.8	0.5	12.3	--	268	383	2.1	1.5	10.9	--	382	545
1955	0.9	--	8.0	0.3	204	291	1.0	0.5	4.7	0.5	184	263
1956	1.9	0.4	2.3	1.0	116	166	4.1	1.1	1.8	0.6	690	986
1957	5.7	1.7	4.2	2.9	386	552	4.5	1.3	2.0	--	935	1,336
Totals	56.9	5.3	76.4	9.0	4,434	6,336	28.8	4.4	40.7	1.1	3,851	5,503

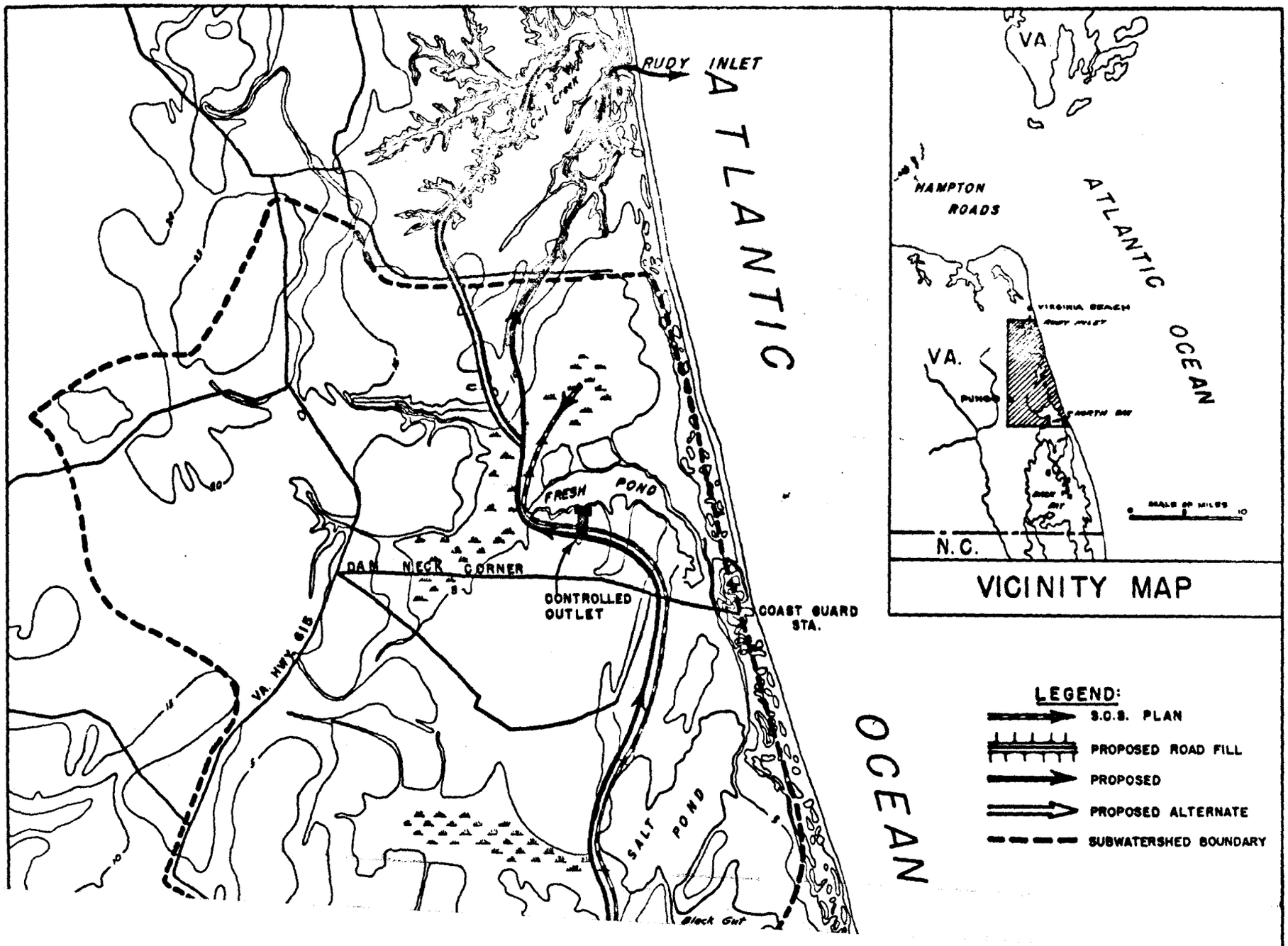
TABLE NO. 5

SIZE ANALYSES - SUSPENDED MATERIAL

WATER SAMPLES FROM PRINCESS ANNE COUNTY WATERSHED, VIRGINIA

Sample	Concentration of sample (ppm)	Concentration of tube * (ppm)	Percent finer than indicated size, in millimeters									
			1.000	.520	.250	.125	.062	.031	.016	.008	.004	.002
No. 3	404	414			100	100	99	97	96	87	70	50
No. 16	794	794				100	99	98	97	88	74	50

* Bottom withdrawal tube method used.


RUDY INLET
ATLANTIC
OCEAN
FRESH POND
DAM NECK CORNER
CONTROLLED OUTLET
COAST GUARD STA.
VA. HWY. 615
SALT POND
Black Gut
VA.
HAMPTON ROADS
ATLANTIC
OCEAN
VIRGINIA BEACH
RUDY INLET
VA.
NORTH BAY
N.C.
VICINITY MAP
LEGEND:
S.C.S. PLAN
PROPOSED ROAD FILL
PROPOSED
PROPOSED ALTERNATE
SUBWATERSHED BOUNDARY

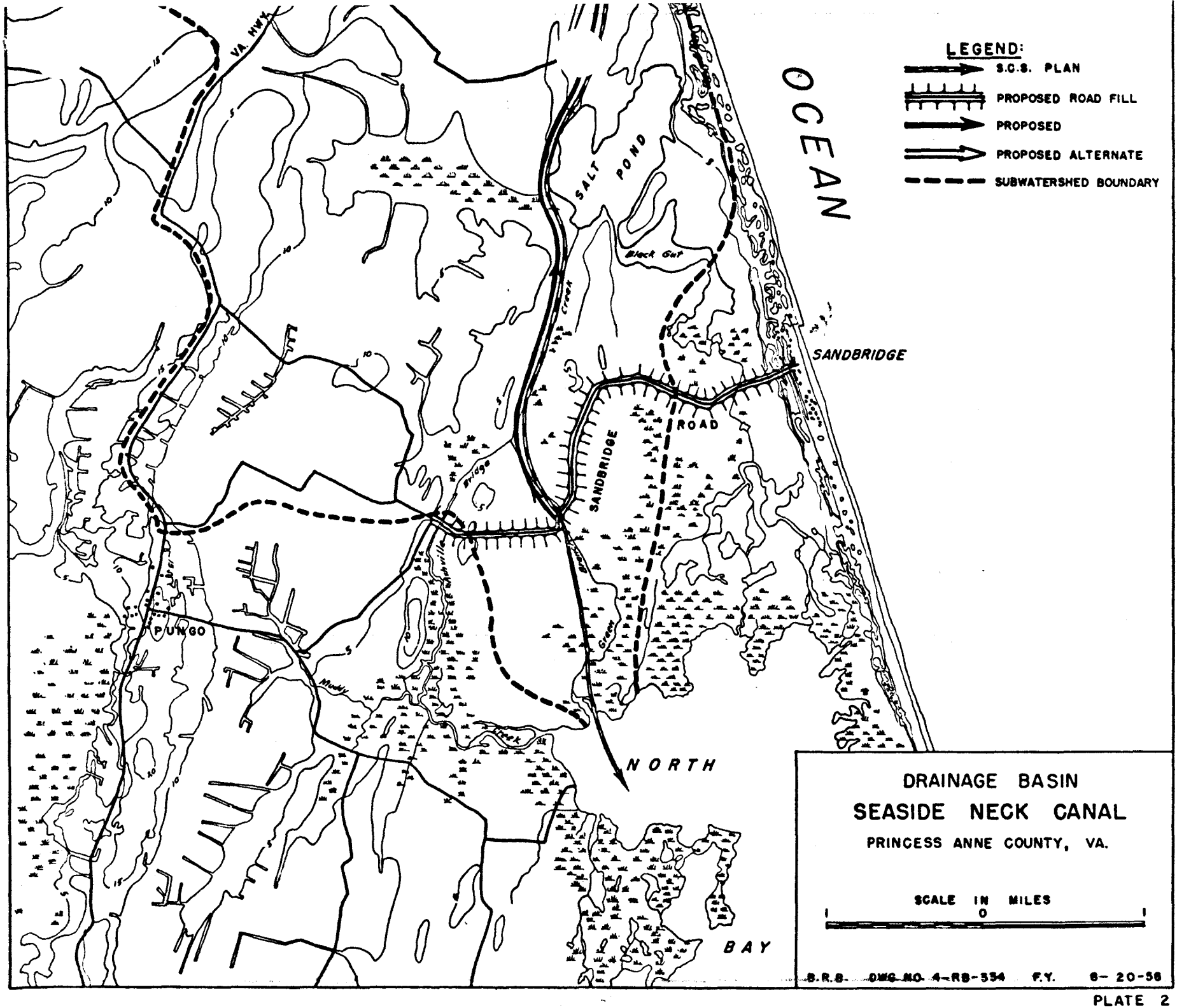
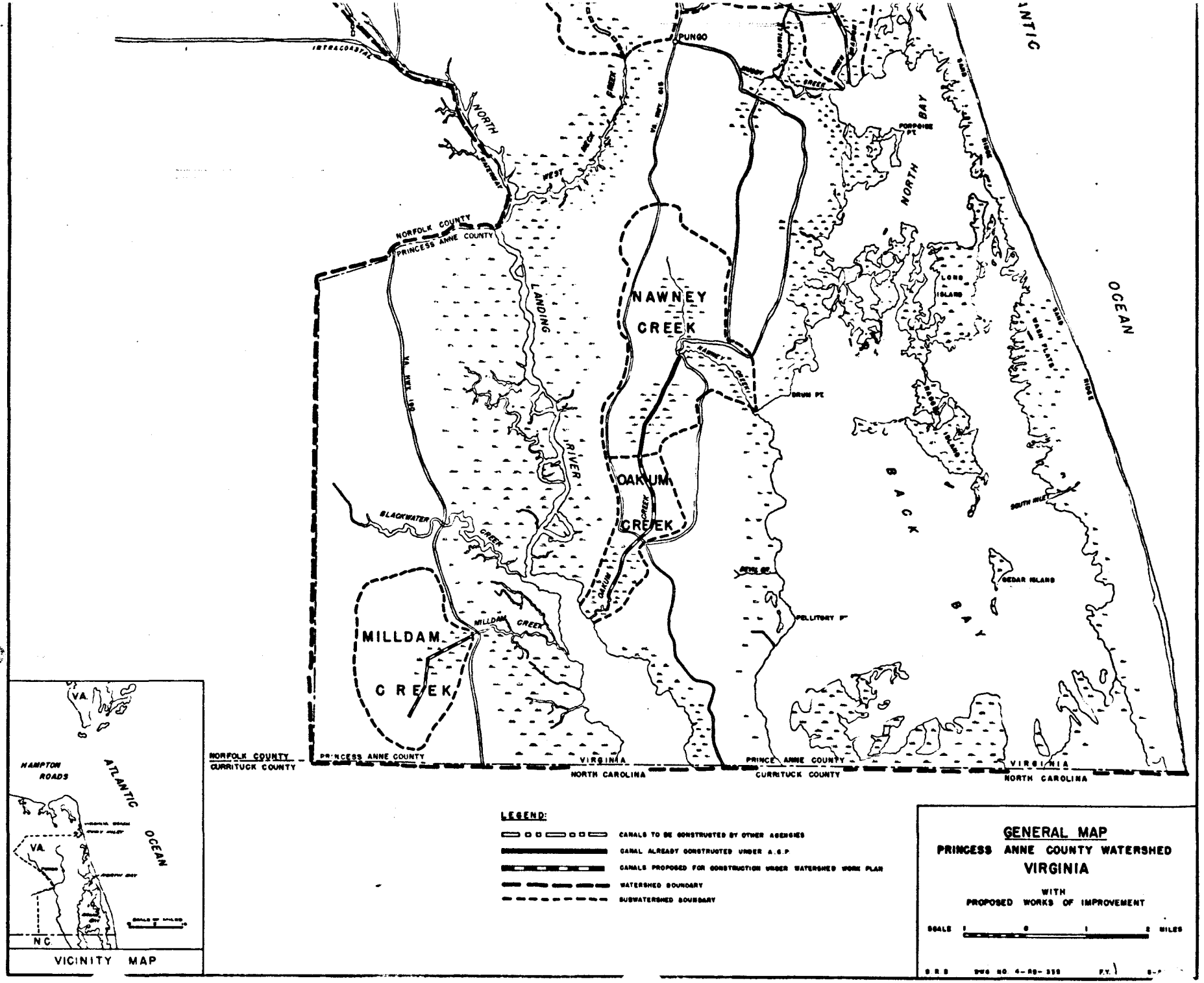
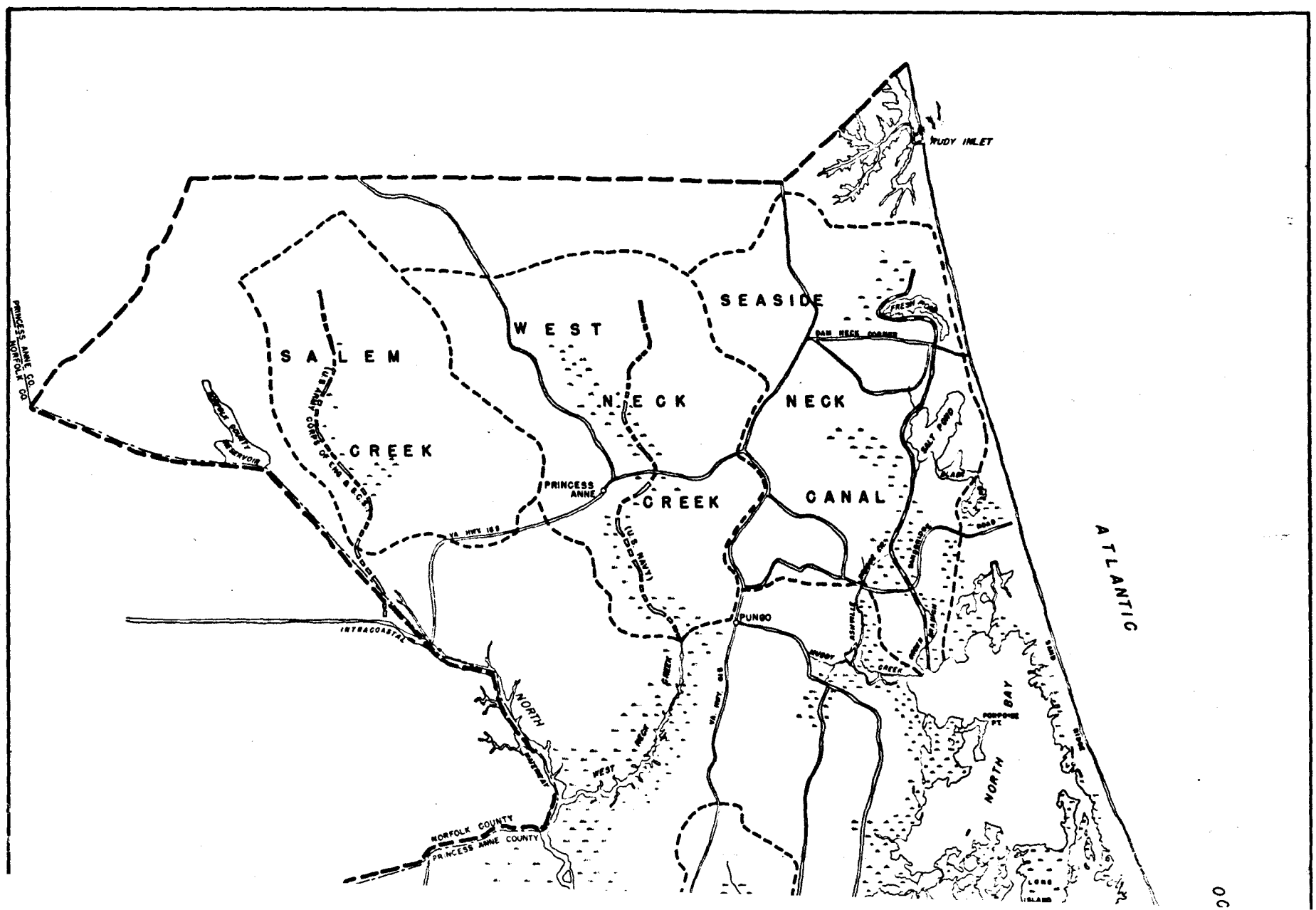

LEGEND:
S.C.S. PLAN
PROPOSED ROAD FILL
PROPOSED
PROPOSED ALTERNATE
SUBWATERSHED BOUNDARY
OCEAN
SALT POND
Black Gut
SANDBRIDGE
ROAD
SANDBRIDGE
PUNGO
VA. HWY.
NORTH
BAY
DRAINAGE BASIN
SEASIDE NECK CANAL
PRINCESS ANNE COUNTY, VA.
SCALE IN MILES
0
S.R.S. DWG. NO. 4-RB-534 F.Y. 6-20-56

PLATE 2


INTRACOASTAL
PUNGO
NORTH
WEST
NORFOLK COUNTY
PRINCESS ANNE COUNTY
LANDING
RIVER
NAWNEY
CREEK
OAKUM
CREEK
BLACKWATER
CREEK
MILLDAM
CREEK
MILLDAM
CREEK
NORTH
BAY
PORPOISE PT
DRUM PT
LONG ISLAND
BACK
BAY
CEDAR ISLAND
SOUTH BILL
OCEAN
NORFOLK COUNTY
CURRITUCK COUNTY
PRINCESS ANNE COUNTY
VIRGINIA
NORTH CAROLINA
PRINCE ANNE COUNTY
CURRITUCK COUNTY
VIRGINIA
NORTH CAROLINA
VA.
HAMPTON ROADS
ATLANTIC
OCEAN
VA.
NC.
VICINITY MAP
LEGEND:
CANALS TO BE CONSTRUCTED BY OTHER AGENCIES
CANAL ALREADY CONSTRUCTED UNDER A.C.P.
CANALS PROPOSED FOR CONSTRUCTION UNDER WATERSHED WORK PLAN
WATERSHED BOUNDARY
SUBWATERSHED BOUNDARY
GENERAL MAP
PRINCESS ANNE COUNTY WATERSHED
VIRGINIA
WITH
PROPOSED WORKS OF IMPROVEMENT
SCALE
MILES


MUDDY INLET
SEASIDE
WEST
NECK
NECK
SALEM
CREEK
CREEK
CANAL
PRINCESS ANNE
PUNGO
ATLANTIC
NORTH
BAY
INTRACOASTAL
NORFOLK COUNTY
PRINCESS ANNE COUNTY
PRINCESS ANNE CO.
NORFOLK CO.