PRELIMINARY ENGINEERING REPORT

[redacted]

(PHASE I) REGIONAL WATER SYSTEM

AND

(PHASE II) REGIONAL WASTEWATER COLLECTION AND TREATMENT

[redacted]

DARE BEACHES WATER AND SEWER AUTHORITY

DARE COUNTY, NORTH CAROLINA

SEPTEMBER 1973

HENRY VON OESEN AND ASSOCIATES, INC.
Consulting Engineers & Planners
Wilmington, North Carolina

TABLE OF CONTENTS

DARE BEACHES WATER AND SEWER AUTHORITY

PRELIMINARY ENGINEERING REPORT
for
WATER AND SEWERAGE SERVICES

PART I INTRODUCTION

ORGANIZATION AND AUTHORITY

This report has been prepared at the direction of the Dare Beaches Water and Sewer Authority (hereinafter referred to as the "Authority"). This organization was constituted under the provisions of Chapter 162A, General Statutes of North Carolina, which authorized creation of such a body stating that, "...each authority created...shall be deemed to be a public instrumentality exercising public and essential governmental functions to provide for the public health and welfare..." In accordance with said statute the Authority was formed by the combined actions of the Dare County Commissioners and the Town Councils of the incorporated communities of Nags Head and Kill Devil Hills. This initative was taken after joint studies of the rapidly growing water supply and sewerage disposal problems in the area indicated the need for a cooperative effort to resolve the problem on a regional basis.

This study was made possible by planning assistance grants from the North Carolina Department of Health (Sanitary Engineering Division) and the Department of Natural and Economic Resources (Office of Water and Air Resources), and the Coastal Plains Regional Commission. The State grants were authorized by North Carolina General Assembly legislative actions in 1971 which included two separate acts to "...encourage and promote regional water supply systems [Chapter 892, SB168] and Regional Sewerage Disposal Systems [Chapter 870, SB802]." The Coastal Plains Regional Commission has

provided additional funds to facilitate construction of water supply test wells and collection of other technical engineering field and test data essential to the technical and economic feasibility analysis of the proposed projects.

PROBLEM AND PURPOSE

During the past few years the Dare County beach areas have experienced a phenomenal rate of growth and development. The problem of water supply throughout the region to meet the demands resulting from the rapid growth has taxed the existing small municipal and private water supply systems beyond their existing or expandable capacity. Correspondingly, this growth and development has created health and sanitation problems related to sanitary waste (sewage) disposal. The purpose of this report is to analyze the technical and economic feasibility of providing both regional water supply and sewerage services to the Dare Beaches area and to propose plans and methods to accomplish this objective.

PART II PRELIMINARY ENGINEERING REPORT - REGIONAL WATER SUPPLY SYSTEM

I. GENERAL

A. Historical Background

Dare County was formed in 1870 from portions of Currituck, Tyrell, and Hyde Counties. The present area is 388 square miles. It was named in honor of Virginia Dare, the first child born of English parents in America. It is the most easterly of the North Carolina counties, and is bounded by Pamlico, Croatan and Albemarle Sounds, Hyde and Tyrell Counties, and by the Atlantic Ocean on the east. There are three incorporated towns in the county. Manteo, the county seat, was settled in 1865 and incorporated in 1899. The town was named for an indian taken to England by Amandas and Barlow in 1584. Nags Head was settled in 1820 and incorporated in 1923. The Town of Kill Devil Hills was incorporated in 1953.

B. Physiography

Dare County is divided by broad sounds into two distinct parts; a low-lying forested mainland, and a sand barrier reef called the "Outer Banks" (including Roanoke Island). The sound waters comprise the greater part of the county and vary considerably in depth and salinity. To the north, the Albemarle and Currituck Sounds, with no direct outlets to the ocean, are essentially fresh water and have an average depth of eighteen and seven feet respectively. Pamlico Sound, to the south, has three outlets (generally referred to as "inlets" on maps and navigation charts) through which the waters from four major rivers flow. Salinity varies directly with rainfall and wind. It is higher at the inlets and decreases gradually northward and westward.

Although the average depth is about 20 feet, there are broad shoals along the back of the Outer Banks and west from Ocracoke Inlet. Connecting Pamlico with the northern sounds are the Roanoke and Croatan Sounds. The former, shallow and narrow, averages little more than three feet deep. Croatan Sound is about five feet deeper and provides the main outlet for water from Albemarle Sound.

Except for a limited area close to the inlets there are no lunar tides within the large sound areas and the mean range is less than six inches. Currents are produced by the interactions of wind, river discharge, evaporation, tide and rainfall. However, wind tides are predominant, and can raise the water level several feet above or below the mean. Ocean tidal ranges vary from a mean of 3.4 feet to 4.1 feet during the spring tide.

As previously mentioned, the land areas are generally low lying with elevations averaging from just above sea level in the marshlands to about ten feet above mean sea level. The exception is the dune areas on the Outer Banks which range between fifteen and twenty feet, with some unique dune formations (Jockey Ridge, Engagement Hill and Nags Head Woods) exceeding 150 feet in elevation.

C. Climate

The Dare Beaches area enjoys a maritime climate with cooler summers and warmer winters than are to be found on the mainland. The average annual precipitation within the study area ranges between forty-five and forty-seven inches. The average annual temperature is about sixty-one degrees Fahrenheit.

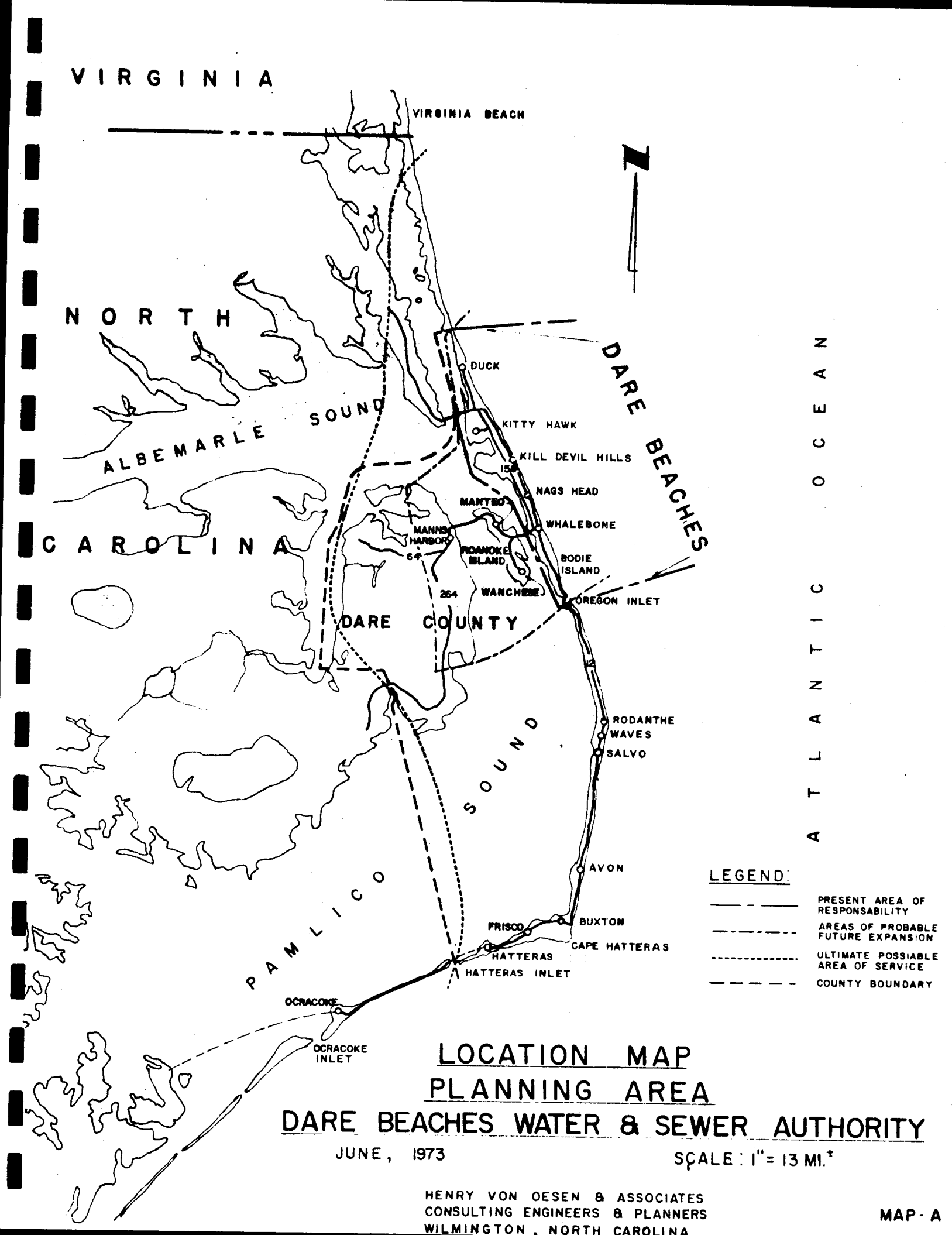
D. Study Area

As previously stated, the Authority has been designated as the agent for planning and operation of regional water and sewer systems for the Dare Beaches area by the County and the incorporated communities of Nags Head and Kill Devil Hills. The Authority's area of responsibility has been designated as that area in the beach margin of Dare County extending from Oregon Inlet on the south to the Currituck County line on the north. All developed areas within this designated region are considered in the development plan. A map outlining this initial area of responsibility follows this page.

While planning is confined to this designated area initially, it is recognized that to be truly regional in scope the Authority may eventually be called upon to provide utilities services to other developed areas contiguous to the initial service area. Additional areas considered for future possible expansion are also outlined on Map A. It is not unreasonable to assume that future service could be extended even beyond these boundaries into all developed areas within Dare County and to limited portions of Currituck County if requested by the local people and approved by the sponsoring governing authorities. Such expansions would also have to be provided to be economically feasible and shown to be compatible with overall regional planning in the larger area.

E. Geology and Groundwater

Information on the subsurface geology of Dare County is primarily limited to the study of well cuttings made throughout the area. It is generally accepted that the area was submerged during the Tertiary and early Pleistocene periods. Generally sandy materials of the Pleistocene-



LOCATION MAP
PLANNING AREA
DARE BEACHES WATER & SEWER AUTHORITY

JUNE, 1973

SCALE: 1" = 13 MI.±

HENRY VON OESEN & ASSOCIATES
CONSULTING ENGINEERS & PLANNERS
WILMINGTON, NORTH CAROLINA

MAP-A

Pliocene Period are encountered to varying depths of approximately 180 feet. These materials are underlain by sediments from the Miocene Period to depths of about 1600 feet. Lithologic units below this depth have been identified but are not discussed in that they do not bear directly on this report.

Water bearing formations are found in both the surficial sands and deeper units such as the Yorktown formation found in the upper Miocene sediments. Non-artesian aquifers have been the principal source of water supply in Dare County. Most wells on the mainland yield water from this source at depths ranging from ten to sixty feet. These wells are of the dug or driven type and yield five to fifteen gallons per minute from fine to medium grained sands.

On Roanoke Island, the non-artesian aquifer consists of fine to medium grained sands, levels of coarse grained sands and fairly disseminated shell materials approximately 100 feet thick. The aquifer is recharged directly by local precipitation and provides yields to domestic and municipal wells ranging from five to seventy-five gallons per minute. A bed of sandy clay, about twenty-five feet thick, lies beneath the non-artesian aquifer. The top of the Yorktown formation ranges in depth from 125 to 150 feet below the land surface on Roanoke Island. This aquifer is comprised of fine to coarse grained sand in the upper part and generally has yielded fifteen to twenty-five gallons per minute to domestic wells. Water levels in the artesian aquifer range from one to three feet above mean sea level. It appears that water to supply the Dare Beaches area must come primarily from this source.

2. POPULATION, GROWTH AND WATER SUPPLY DEMAND

As previously mentioned the rate of growth and development of the Dare County Beach areas over the past few years has been tremendous. Because of its location within easy driving range of the major urban centers of the northeastern Seaboard, and because of its rich, scarcely tapped recreational potential, the Dare Beaches region is in an excellent position to serve the recreational needs of the northeastern megalopolis and the central Atlantic coastal states. The region's combination of historical, physiographic, climatic attributes and sheer natural beauty attract thousands of visitors to the area each year, plus other thousands seeking recreational developments and permanent retirement homesites. The recent rate of growth and expansion can be expected to continue and even accelerate in the next two decades that lie ahead.

A "Sketch Development Plan" for the Dare Beaches area has been prepared by the coastal area office of the North Carolina Department of Natural and Economic Resources. This plan includes an analysis of the growth potential of the area, identification of various limiting factors and development guidelines and an excellent land use planning guide to be used as a basis for more detailed land use planning and growth management procedures for implementation by the local government entities involved. The study also projects population growth rates and suggests how and where various density growth rates might be expected and controlled to insure a desirable pattern of development.

A corresponding socio-economic study entitled Economic Study of the Dare Beaches was prepared by Stephens and Associates of Raleigh, North Carolina to demonstrate the economic viability and potential of the area. This report presents a myriad of economic indicators that reflect this

historical growth pattern of the region as compared to the almost explosive growth experiences of the past few years. The report effectively demonstrates the economic growth potential of the area in employment potentials and income expectations that will benefit the region. This report also includes an excellent analysis of population projections and "peak loads" of seasonal residents and visitors that may be expected to inhabit the area during certain seasons.

Both of these studies were prepared at the request of the Authority to complement and provide a basis for this preliminary engineering report; therefore no attempt is made here to include the detailed information, findings and conclusions reached in these excellent studies in this report. However, the information contained in these studies have been used extensively in the analysis and design of the regional water and sewer systems proposed in this report.

It is noteworthy to mention that these two independently prepared studies, using different methods of analysis, reflect high degrees of uniformity in their projections of population growth rates and peak population holding capacities for the area under study. This becomes important in view of the fact that both water and sewer service systems must be designed and constructed to meet projected peak load requirements.

A summary of pertinent portions of these average demographic projections contained in the above referenced reports is shown on Table I following Page 9. The water supply requirements to meet these growth projections are also shown on the table. Careful consideration has been given to the growth centers indicated in the land use planning guidelines, and provisions are made for future expansion of water and sewer systems to meet the phased growth projections depicted in that plan.

The population and water supply requirement projections depicted on Table I are further portrayed graphically on Figures 1 and 2. These graphs clearly depict the wide range in water supply requirements that result from the tremendous influx of seasonal residents or visitors to the area. While the permanent residents in the area represent a fairly moderate water supply requirement, the high seasonal peak loads must be accommodated, and any water supply system must be designed and modulated to meet both the peak and variable load demands. This factor becomes even more critical in design of the sanitary wastewater (sewerage) system requirements covered later in this report.

Beach Unit/Planning Area	1970[2]	1972[3]	1975	1980	1985	1990	1995	2000	2010	2020[4]
Nags Head (South)	414	464/16,000	650/21,000	863/26,000	1450/45,000	2200/67,000	4600/78,500	7000/90,000	18,000/98,000	115,000
Kill Devil Hills - Collington Island	357	400/14,000	525/19,000	900/23,000	1150/40,000	1900/59,000	3950/69,500	6000/80,000	15,000/86,000	95,000
Kitty Hawk (North)	784	878/7,000	1250/10,000	1650/14,250	2670/20,000	4200/24,000	8600/27,000	13,000/30,000	34,000/40,000	40,000
Totals	1555	1742/37,000	2425/50,000	3413/63,250	5270/105,000	8300/150,000	17,150/175,000	26,000/200,000	67,000/224,000	80,000/250,000
Estimated number of permanent resident units[5]		500	700	975	1505	2370	4900	7430	19,150	22,850
Water supply requirements to meet peak demands (in MGD):										
Permanent residents[6]		0.2	0.24	0.34	0.53	0.83	1.7	2.6	6.7	8.0
Seasonal residents[7]		2.1	2.86	3.59	5.98	8.5	10.5	10.4	9.4	10.2
Total water demand (MGD)		2.3	3.1	3.9	6.5	8.4	11.2	13.0	16.1	18.2

Notes: (1) Beach unit planning areas and population estimates correspond to planning area segments and median population projections prescribed in Dare Beaches Sketch Development Plan prepared by the Northeastern Field Office, Community Services Division, N. C. Department of Natural and Economic Resources.

(2) Permanent population only.

(3) Figures depict: (permanent population)464/16,000(peak seasonal residents)

(4) Peak seasonal population only.

(5) Based on individual housing unit occupancy rate of 3.5 people per household.

(6) MGD = Million Gallons per Day. Daily water supply estimates are based on 100 gallons per person per day for permanent residents.

(7) Daily water supply estimates for seasonal residents are based on an anticipated average daily consumption of 60 gallons per person per day for motel guests, campers, cottage dwellers, "day visitors", etc. Experience factors for recreationally oriented areas such as the Dare Beaches indicate that the per capita water consumption is generally below the 100 gallons per day applied to permanent residents. Therefore, an average of 60 gallons per person per day was selected for non-permanent residents for planning and forecasting purposes.

Population & Water Use Projections[1]

Dare Beaches Region
North Carolina

TABLE 1

POPULATION GROWTH PROJECTIONS

COMBINED PERMANENT & SEASONAL POPULATION

(PROJECTED PERMANENT POPULATION SHOWN IN PARENTHESIS)

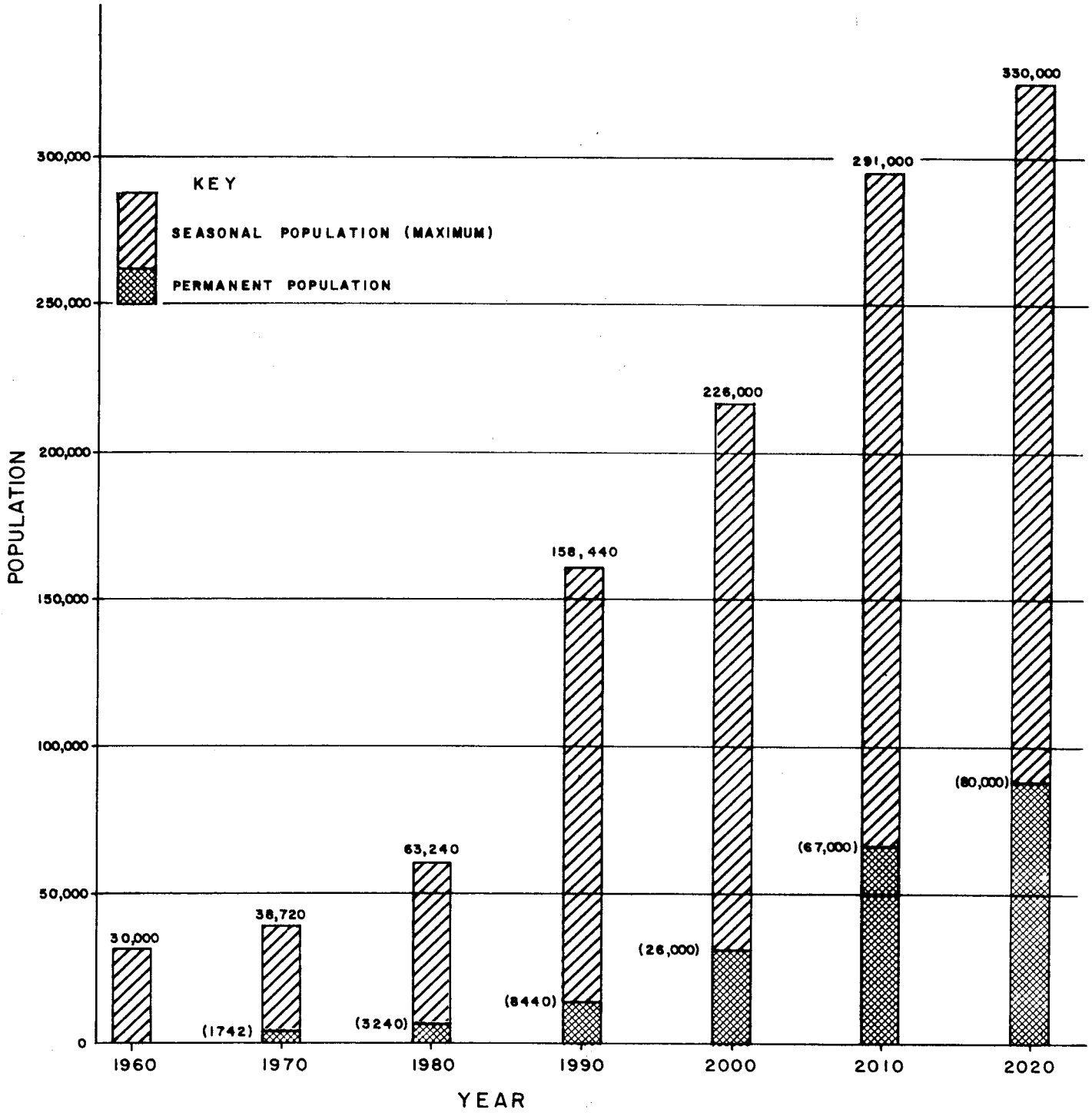


FIGURE - 1

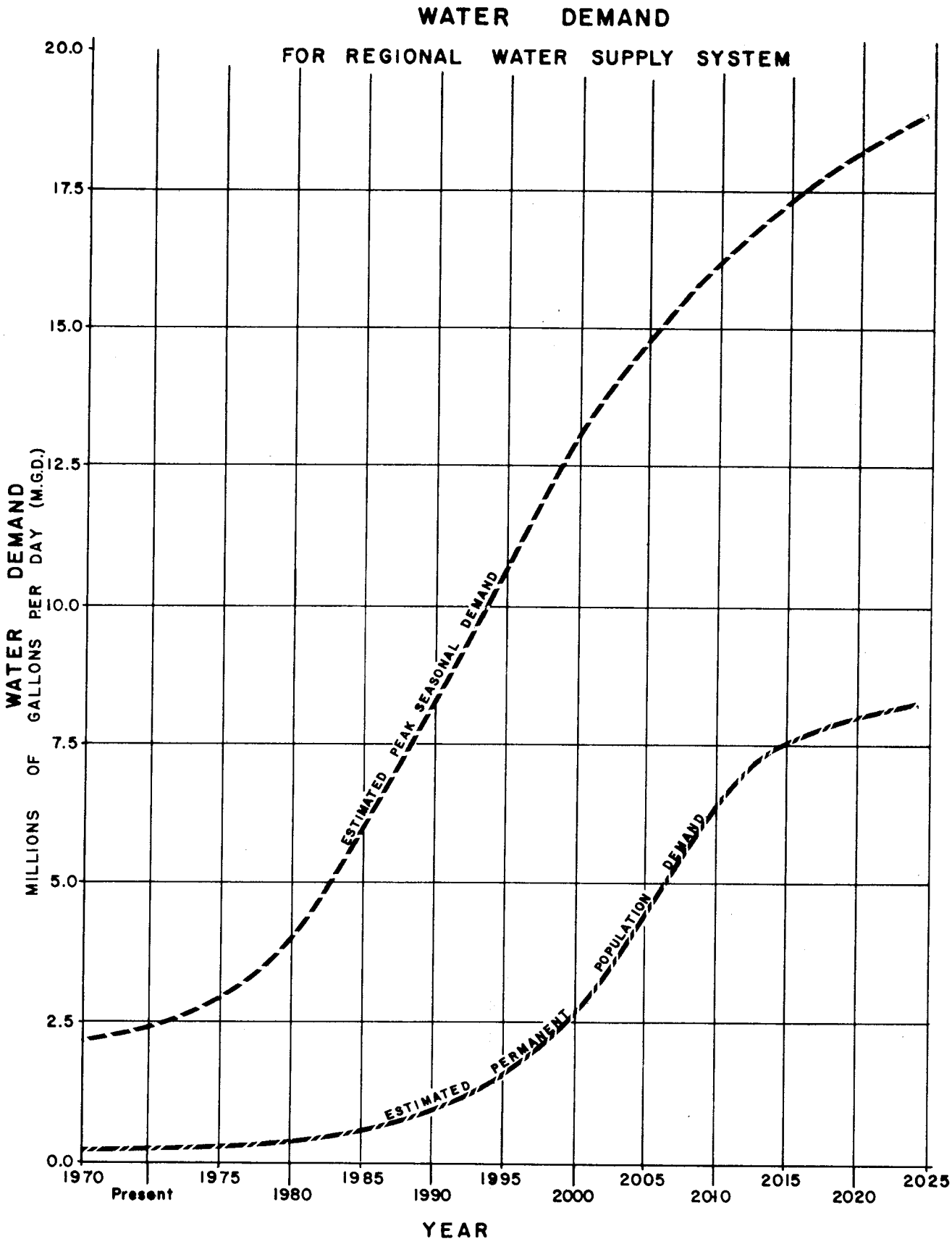

WATER DEMAND
FOR REGIONAL WATER SUPPLY SYSTEM
WATER DEMAND
MILLIONS OF GALLONS PER DAY (M.G.D.)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
ESTIMATED PEAK SEASONAL DEMAND
POPULATION DEMAND
ESTIMATED PERMANENT
1970
Present
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
YEAR

FIGURE - 2

3. SUMMARY OF PRIOR ENGINEERING AND GROUNDWATER STUDIES

During the past decade numerous studies and reports related to the geology and groundwater resources in the project area have been made. Identified references are listed in the bibliography at the end of this report. Unfortunately, most of these reports were prepared for a specific purpose and are limited in scope and detail. However, a great deal of useful information is provided and certain conclusions may be drawn from them.

These studies indicate that reasonable quantities of moderately good quality water can be obtained from surface sources and surficial sands or relatively shallow groundwater aquifers in the beach areas. The Moore, Gardner and Associates report (September 1969) on raw water supply for the Towns of Nags Head and Kill Devil Hills indicates that approximately 359,000,000 gallons of water can be drafted annually from the fresh water pond and adjacent area in the vicinity of Nags Head Woods (without risking salt water intrusion under normal circumstances). This is the prime source of water supply for the existing systems for the two towns. Thus it can be concluded that the maximum yield capacity of surface water in that area would be slightly less than one million gallons per day on an average.

Kimrey's investigation of Ground Water Supply for the Dare Beaches Sanitary District (1961), indicates that shallow wells in the upper aquifer (twenty-five to seventy feet, averaging forty-five to fifty feet in thickness), should yield approximately twenty-five gallons per minute (gpm). He also suggests that a "safe" yield of 650 gpm might be withdrawn from the upper aquifer in the same Nags Head Woods supply area if a well field is installed on two parallel lines 1500 feet apart with individual wells spaced 1000 feet apart on each line. This would indicate a maximum theoretical yield in

excess of two million gallons per day; however, he cautions against the possibility of salt water intrusion from overpumping and surface contamination during severe weather events. His report also concluded that the lower aquifer was not considered as a suitable source of ground water, primarily due to variable and unpredictable saline content in various locations and the high probability of saline encroachment under conditions of high withdrawals.

Since the Nags Head Woods area is considered to be the most potentially productive area in the entire study region it is assumed that the productive capacity of the balance of the varrier island offers a much lesser capability to meet the growing water supply demands of the region. Also, in view of the fact that the combined productive capacity from surface and subsurface sources in the prime Nags Head Woods area has a maximum productive capacity that will be exceeded by the regional demands within the next five years, it is concluded that further costly expenditures to exploit this source are unwarranted. This factor, combined with the constant risk of periodic or partial failure of the system due to salt water intrusion or contamination has led to the conclusion that water supply to meet the long range water supply needs of the region must come from other sources.

The most recent investigation of potential sources of fresh water supplies for the Dare Beaches area was conducted by the Ground Water Division of the North Carolina Office of Water and Air Resources (OW&AR) in 1972. The study was made in cooperation with the Dare Beaches Water and Sewer Authority and is to be incorporated into the Division's capacity use investigation of that area. The results of this investigation have been published in a report entitled Potential Ground Water Supplies for Roanoke Island and the Dare Beaches, North Carolina.

After careful examination of all available data, a system of exploratory test wells was patterned throughout the study area. Eight test wells were drilled to a depth of 500 feet, collecting formation samples at ten-foot depth intervals. Geophysical logs were made in each borehole and lithologic logs were prepared from examination of the formation samples. On the basis of hydrologic information obtained, zones in the principal water bearing units were selected for collecting water samples, making water level measurements and determining water quality. After collection of the water samples, permanent observation wells were constructed at all but one of the sites in the principal artesian aquifer and pumping tests were made.

No attempt is made here to repeat the excellent detailed information contained in this report, but the "principal aquifer" was identified and plotted throughout the study area. It was found generally that the quality and quantity of this principal aquifer improved as you moved southward and westward from the beach area through the southern half of Roanoke Island and to the mainland south and west of Manns Harbor. The configuration of the contours for this water source shows that recharge to the principal aquifer occurs on Roanoke Island and the mainland.

Thus, a detailed analysis of this report reveals that a reliable, long-term source of water supply can be obtained from the principal aquifer underlying the southern half of Roanoke Island that will meet the present and projected water supply needs of the Dare Beaches area.

A map showing the suggested well field locations identifying potential water supply areas follows this page. Also shown are the location of test wells.

ATLANTIC OCEAN

BODIE ISLAND

SOUND

N.C. 12

Wanchese

TEST WELL (Proposed)

SITE No. 4

PRIMARY SUGGESTED SUPPLY SOURCE

TEST WELL (Proposed)

SITE No. 3

ROANOKE ISLAND

US 64-264

SITE No. 6

SITE No. 5

LOCATION OF POSSIBLE SUPPLY SOURCES OF LIMITED YIELD.

Nags Head

Manteo

SITE No. 2

ROANOKE SOUND

SECONDARY SUGGESTED SUPPLY SOURCE

CROATAN

Manns Harbor

S

U.S 64-264

Fort Raleigh City

N

SITE No. 9

SITE No. 11

Collington

COLLINGTON ISLAND

U.S. 158

Kill Devil Hills

LEGEND:

WATER SUPPLY AREAS

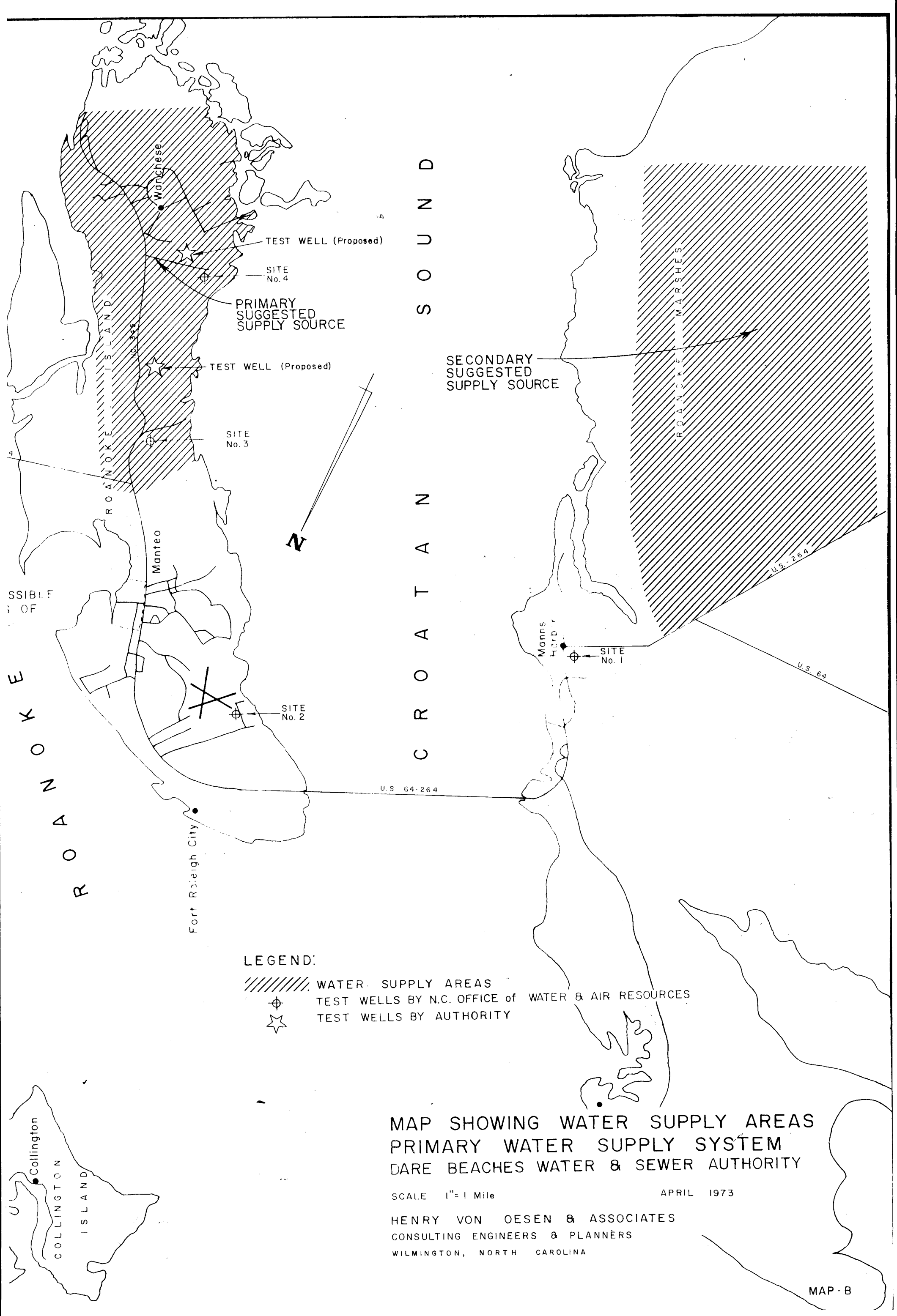
TEST WELLS BY N.C. OFFICE of WATER & AIR

TEST WELLS BY AUTHORITY

MAP SHOWING WATE
PRIMARY WATER S
DARE BEACHES WATER

SCALE 1"= 1 Mile

HENRY VON OESEN & AS
CONSULTING ENGINEERS & PLANN
WILMINGTON, NORTH CAROLINA



MAP SHOWING WATER SUPPLY AREAS PRIMARY WATER SUPPLY SYSTEM DARE BEACHES WATER & SEWER AUTHORITY

SCALE 1"= 1 Mile

APRIL 1973

HENRY VON OESEN & ASSOCIATES
CONSULTING ENGINEERS & PLANNERS
WILMINGTON, NORTH CAROLINA

MAP - B

4. WATER SUPPLY

A. Existing Systems and Sources

Two municipalities in the Dare Beaches area have existing modern water distribution systems. The Towns of Nags Head and Kill Devil Hills both constructed and began operation of their systems in 1964. The Nags Head system began operation with approximately 555 customers and currently has around 850 customers. The Kill Devil Hills system went into operation with about 500 customers and currently serves slightly over 1000 customers. This total of approximately 1850 customers represents service to slightly less than fifty percent of the potential customers in the service area, not including another 1100 or more trailer park and campground sites that are not being served.

The source of supply for these systems is a fresh water lake which is located on the boundary between the towns about 3200 feet westward of the ocean and which is surrounded on the southwest and north by vacant lands owned by the municipalities. This lake is recharged by rainfall in the area and has provided ample supply until 1969 when an apparent drop in the lake water level indicated the rate of withdrawal was greater than the area's recharge capacity. Since that time a growing demand for water has caused greater water level drops and increasing concern. Studies by consulting engineers for the towns have recommended the use of shallow well fields to supplement the lake supply. A portion of these wells have been installed and are in operation. This first group of shallow wells has increased the supply by about 110,000 gallons per day. A second group of wells was recommended and is now being contemplated that would increase this augmentation supply to 300,000 gpd.

Subsequent investigation and test well construction under the Dare Beaches study and report have indicated the possibility of obtaining supplementary water supply from a deep well source. The towns have undertaken construction of one or more deep wells to explore this possibility. These would be used as a temporary supplement to their present supply source until the Authority can provide a supply source.

Both town systems have treatment plants, ground storage of finished water and pumping capacity for high service. Both systems have elevated storage and the systems are capable of interconnection although they are normally operated separately.

There are no other known public water distribution systems now being operated within the Dare Beaches area.

B. Ground Water Sources

As previously stated, early studies and reports have indicated that no suitable source of ground water has been found in the beach areas other than from shallow wells. However, these early explorations had been limited to a depth of around 100 feet except in several instances where depths of several hundred feet were reported. The geological formation in this region is similar to those in other coastal areas of the state where ground water supplies do exist and are used as a source of supply for water systems.

Also, as previously discussed, the southern half of Roanoke Island is indicated as the most adequate and available area to develop a regional water supply source of no less than eight to ten mgd which is required to meet the area's initial and short-term needs (to 1990). It will probably be necessary to augment this with additional supply from the mainland (Manns Harbor area) at some time in the future to

attain the projected eighteen to twenty mgd ultimate water supply needs of the region.

It is planned to construct one or more test wells on Roanoke Island with funds provided by the Coastal Plains Regional Commission to test the quantity and quality of an identified aquifer to verify the productive capability of this selected water supply source. Information obtained from these test wells will be used to confirm the capability of obtaining sufficient water from this area to meet the initial requirements of the proposed system. (The results of this testing program will be published as a supplement to this report as soon as the tests are completed.) Meanwhile, it appears that a suitable and sufficient quantity of water can be obtained to meet the demands of the region from the ground water aquifers on Roanoke Island and the mainland, as indicated in the aforementioned ground water investigation and report prepared by the Ground Water Division of the North Carolina Office of Water and Air Resources.

WATER ANALYSIS

A typical analysis of water taken from the principal aquifer on Roanoke Island is as follows:

Color	(000)	5 units	Ph	(00.0)	7.7

Results in Parts Per Million

Alkalinity $CaCO_3$	(000)	205	Fluoride	(0.00)	.2
Total Hardness	(000)	132	Aluminum		.067
Iron	(00.00)	.000	Calcium		43
Manganese	(00.00)	.052	Magnesium		5.8
Turbidity SiO_2	(000)	21	Carbonate		0.0
Chloride	(000)	44	Bicarbonate		250
Sodium	(000)	56	Calcium		43
Potassium	(00.0)	7.5	Magnesium		.052

C. Surface Water Sources

The present municipal systems on Dare Beaches obtain their water supply from a surface source locally referred to as the "fresh water pond." This lake is about thirty-five acres in size and has been estimated to contain about ninety million gallons of water at normal stages. It is resupplied by rainfall which falls in a recharge area of about 1100 acres. From past history and records it has been estimated that an average safe daily yield from this source of about 1.0 mgd is possible if the full water supply potential of the lake catchment areas were exploited.

Some other small ponds are located on the western edge of the beach island where dunes were formed in past ages and forests have since covered the dunes. Consideration was given the possibility of using water from these small ponds and pumping to a central treatment point. Many of these ponds are close to the tidal waters of the sounds and might be subject to recharge from these waters. Few of the ponds are deep enough to provide a daily supply sufficient to justify the expense of land acquisition and facilities to obtain and transport the water. Many of the ponds are full of algae and aqua dill weed which would require extreme treatment and all of the ponds are a natural habitat of fish and water foul which inhabit this area. It does not appear to be feasible to try to develop a supplementary water supply source from these ponds and this alternative was abandoned.

There is a large area on the mainland to the west of Manns Harbor which lies generally between Croatan Sound and the Alligator River which has been dyked and is pumped continually to lower the water table to facilitate the cultivation and harvesting of trees. For the

most part these lands belong to the one private owner. Map C showing this potential surface water supply area follows this page. We have studied this area as a possible source for a surface supply. Analysis of the water was made and is shown below. Although this water is potable, it lacks the requirements set out for domestic supply by the U. S. Public Health Service.

WATER ANALYSIS

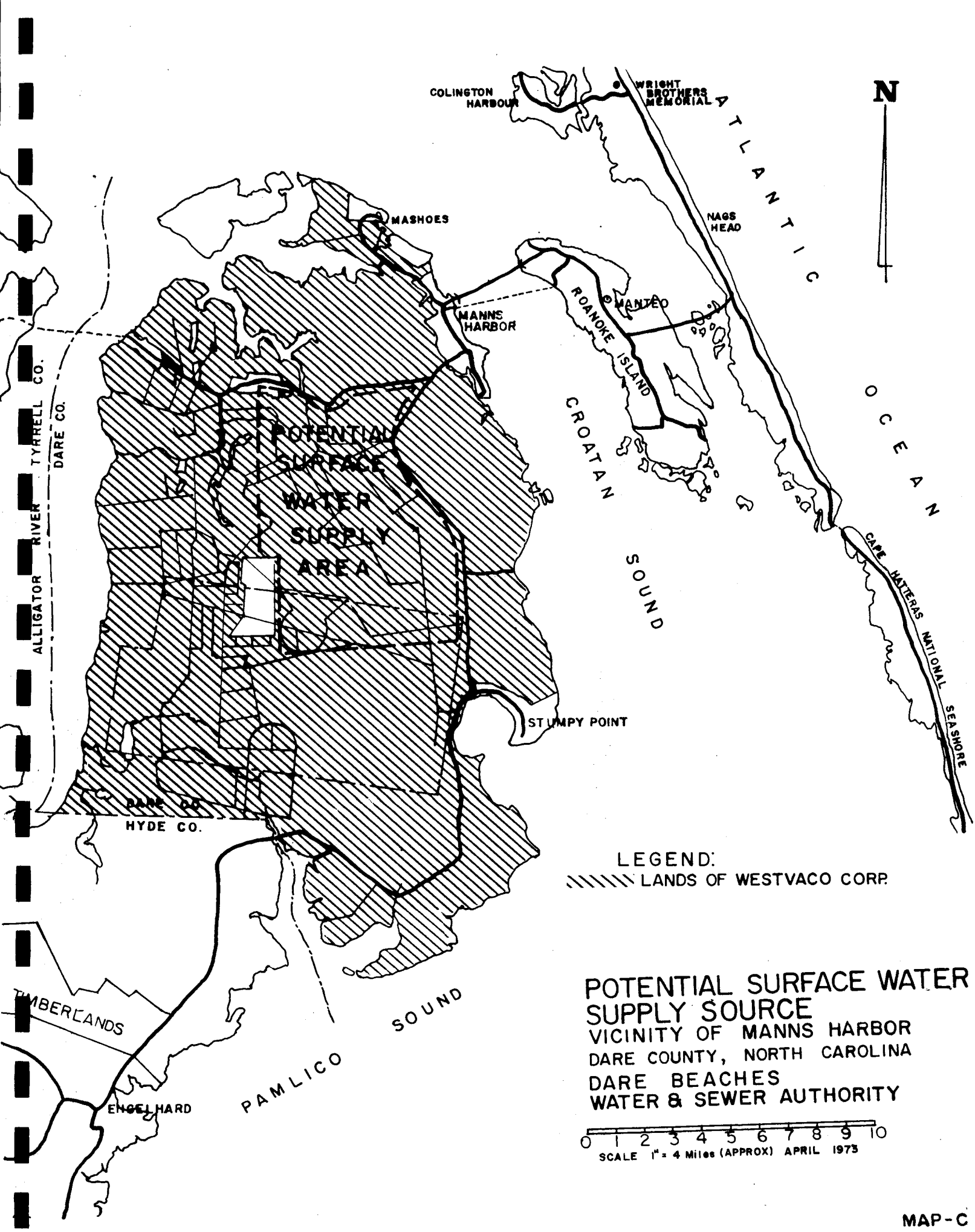
Source: Surface (swamp water) taken from WESTVACO pumping station on U. S. Highway 64 approximately ten miles west of Manns Harbor.

Color	(000)	400	units	Ph	(00.0)	3.9

Results in Parts Per Million

Alkalinity $CaCO_3$	(000)	0	Fluoride	(0.00)	0.10
Total Hardness	(000)	23	Arsenic	(0.00)	0.01
Iron	(00.00)	1.13	Cadmium	(0.00)	0.01
Manganese	(00.00)	0.03	Chromium +6	(0.00)	0.05
Turbidity SiO_2	(000)	1.5	Copper	(00.00)	0.05
Acidity $CaCO_3$	(000)	37	Lead	(0.00)	0.05
Chloride	(000)	16	Zinc	(00.00)	0.05
Sodium	(000)	10	Calcium		1.7
Potassium	(00.0)	0.8	Magnesium		2.3

The major items of concern from this analysis are the color, pH and iron. The iron may be removed fairly easily by aeration and filtration and the pH corrected by addition of proper chemicals. However, removal of color in the magnitude of 400 units would be very difficult. It can probably be accomplished by careful study, design, and operation, although we know of no plant where this much color is being removed at this time. The plant would be expensive and operation would be very critical.


COLINGTON HARBOUR
WRIGHT BROTHERS MEMORIAL
N
ATLANTIC OCEAN
NAGS HEAD
MASHOES
MANNS HARBOR
ROANOKE ISLAND
MANTEO
CROATAN SOUND
POTENTIAL SURFACE WATER SUPPLY AREA
ALLIGATOR RIVER
TYRRELL CO.
DARE CO.
CAPE HATTERAS NATIONAL SEASHORE
STUMPY POINT
DARE CO.
HYDE CO.
TIMBERLANDS
ENGELHARD
PAMLICO SOUND
LEGEND:
LANDS OF WESTVACO CORP.
POTENTIAL SURFACE WATER SUPPLY SOURCE
VICINITY OF MANNS HARBOR
DARE COUNTY, NORTH CAROLINA
DARE BEACHES
WATER & SEWER AUTHORITY
0 1 2 3 4 5 6 7 8 9 10
SCALE 1" = 4 Miles (APPROX) APRIL 1973

MAP-C

Pumping systems employed by the Westvaco Company indicate that at least thirty mgd are removed from the area on a seasonal basis. With proper treatment it is believed that an adequate source of supply might be found from the development of this area; however, the cost of treatment and cost of a pipeline across Croatan Sound are unfavorable when compared economically with development of the ground water source on Roanoke Island.

The recharge of this area which would provide surface supply is believed to be the same recharge area which feeds the ground water aquifers from which water can be obtained on Roanoke Island. The quality of ground supply indicates little or no treatment requirements while the surface supply will require extensive chemical treatment and filtration to be usable.

It is roughly estimated that the initial construction requirements to develop the surface supply west of Manns Harbor will cost not less than twice as much as to develop the ground water supply on Roanoke Island.

D. Water Supply from Desalinization Processes

In view of the extensive availability of salt or brackish surface water in the study area, the possibility of obtaining a fresh water supply by desalinization processes to meet current and projected needs has been investigated. While much progress has been made in the art of desalinization of water, the cost of such operations have been substantially higher than other water source development where other supplies are present. Undoubtedly, as the art is refined and new equipment is developed the cost will be reduced.

There are various methods of desalting brackish or salt water. These are described briefly as follows:

(1) Heat processes; which are well established for salt water; accepted techniques employed are:

a. Multi-Stage Flash Distillation (MSF). This is a conventional method in which heated salt water is introduced into a low pressure chamber causing the water to flash into steam. A series of chambers (called "effects") are used, each having a lower pressure and brine temperature.

b. Vertical Tube Evaporation (VTE). As salt water falls through a series of tubes, it is heated by steam. The heat exchange operation converts some of the salt water to steam and condenses some of the surrounding steam into fresh water. The process is repeated in a series of effects to obtain high efficiency.

c. MSF - VTE. This is a combination of the above two processes and is the most advanced process to date.

(2) Membrane processes, which include:

a. Reverse Osmosis (RO). This process is used primarily for brackish water. Pressure on the salt solution forces the pure water through a membrane. Once the proper equipment is installed, only pumps are needed to make the system operate.

b. Electro-Dialysis. Anodes and cathodes on either side of membranes draw off positive sodium ions, negative chloride ions, leaving fresh water between the membranes.

(3) Freezing processes. Two freezing processes have been developed. One is known as "Vacuum Freezing" and the other is called

"Secondary Refrigerant Freezing." Both methods have been plagued with problems, mainly in separating salt from the ice.

All of the above systems have been developed and applied with differing degrees of success since the Department of the Interior's Office of Saline Water first began research on desalinization processes over twenty years ago. Although there have been varying degrees of technical success with the various processes, the cost of desalting water has been extremely high. During the twenty years mentioned above, the cost of desalting seawater has been reduced from $8 per 1000 gallons to about 80¢ per 1000 gallons. Recent developments in membrane processes have demonstrated a capability to produce fresh water from moderately saline sources for about 40¢ per 1000 gallons under ideal circumstances. This is still above the normal cost for water from conventional sources. This cost reflects only the operating cost of the equipment itself, but does not include the cost of ancillary equipment for processes that may be required to make the system work. Current data indicates that the total costs range from as low as 60¢ up to $1.80 per thousand gallons.

Recent reports indicate that the greatest technological advances have been made in the Reverse Osmosis process. The first drop of salt water was forced through a membrane in 1955 and the first system was developed in 1961. At that time, ten gallons per square foot per day was a nominal membrane capacity. Most units today produce thirty gallons per square foot per day. However, recent development of hollow tube fiber membranes has greatly increased the productivity of RO units. Although these membranes produce 1.5 gallons per square foot per day, a high flux rate is not needed because an acre of fiber can

be fitted into a small area.

Some of the drawbacks of heating systems are not present in RO. No heat energy is required. . .only pumps to keep the water under pressure. RO membranes have a 97 to 99.5 percent salt rejection rate. While heat systems have problems with scale and corrosion accounting for low life on many parts, RO is not bothered by scale. Advances in membrane technology do not necessarily make an installed RO system obsolete. As future improvements are made in membranes it is anticipated that these filter units may be exchanged for the units in existing operating systems. Membrane life is presently limited to five years or less and RO systems can be used only on brackish or wastewater. Because of the high salinity of seawater, it would take two effects (units) to obtain potable water, making the process approximately twice as expensive.

In light of the above, it was concluded that the Reverse Osmosis Process had the greatest potential application to the Dare Beaches water supply problem. Brackish water is available from deep wells or possibly even from Currituck Sound, although suspended solids could represent a considerable problem if the latter source were used. A number of companies have developed and are producing Reverse Osmosis process equipment. A recognized leading manufacturer of hollow fiber RO equipment was invited to Dare County to discuss and demonstrate the equipment capability to the Authority members and other interested parties. This was done by use of a small individual residence reverse osmosis plant. The unit effectively demonstrated the processing of saline water containing approximately 3000 parts per million of chlorides to a product water residual which contained approximately

200 parts per million chlorides which is within the State Health Department limitation of 250 ppm for acceptable, potable water. It was noted during the demonstration that larger plants producing 150,000 to 300,000 gallons per day have been placed in operation in various parts of the country.

A proposal to provide a supplementary temporary supply to Nags Head and Kill Devil Hills based on this demonstration was then discussed. It was proposed to construct a well into brackish waters under the beach areas. This was to be pumped into a portable battery of reverse osmosis units to be supplied and operated by the manufacturer. The produced water would then be pumped into the towns' systems. The capacity of the proposed supplement was to be 200,000 gallons per day. Further detailed discussions concerning total cost factors revealed that this would result in a water cost of not less than $2.15 per 1000 gallons to the towns. This represented a daily cost of $430 and a monthly cost of $12,900.

It is believed that with current knowledge and methods that the Reverse Osmosis method is the most promising desalinization method presently available; however, the indicated costs are too great where other more economical water sources are available.

Although the present day operating costs of desalinization appear to be high for immediate application of the RO process to the Dare Beaches water supply problem, rapid strides in development are being made and it is estimated that within the next ten years or so, desalinization processes may offer an extremely competitive method for primary or supplementary water supply to the beach areas. We recommend that technological advances in this field be watched carefully

as a possible means of supplementing the water supply needs of the area in the next ten to twenty-year time frame.

E. Economic Evaluation and Conclusions as to Source of Supply

Several factors are of importance in the economic evaluation of the previously described water supply sources available: First Cost, Operating and Maintenance Cost, and Final Product Cost. A comparison of these costs is set out as follows:

Source	Estimated First Cost	Est. O&M Cost (per 1000 gallons)	Est. Product Cost (per 1000 gallons)
Ground Water	$3.8 million	$ .02 per 1000	$ .25 per 1000
Surface Water	$10 million	$ .05 per 1000	$ .60 per 1000
Desalinized Water	$1 million	$2.00+ per 1000*	$2.15 per 1000

* Estimated cost to pump two MGD from wells. Other capital cost would be by saline equipment owner. Item is shown for comparison only as two to five million gallons initial requirements is too great for any currently available proven equipment.

From this comparison it is clear that the most economical source appears to be from ground water.

5. PROPOSED WATER SUPPLY SYSTEM

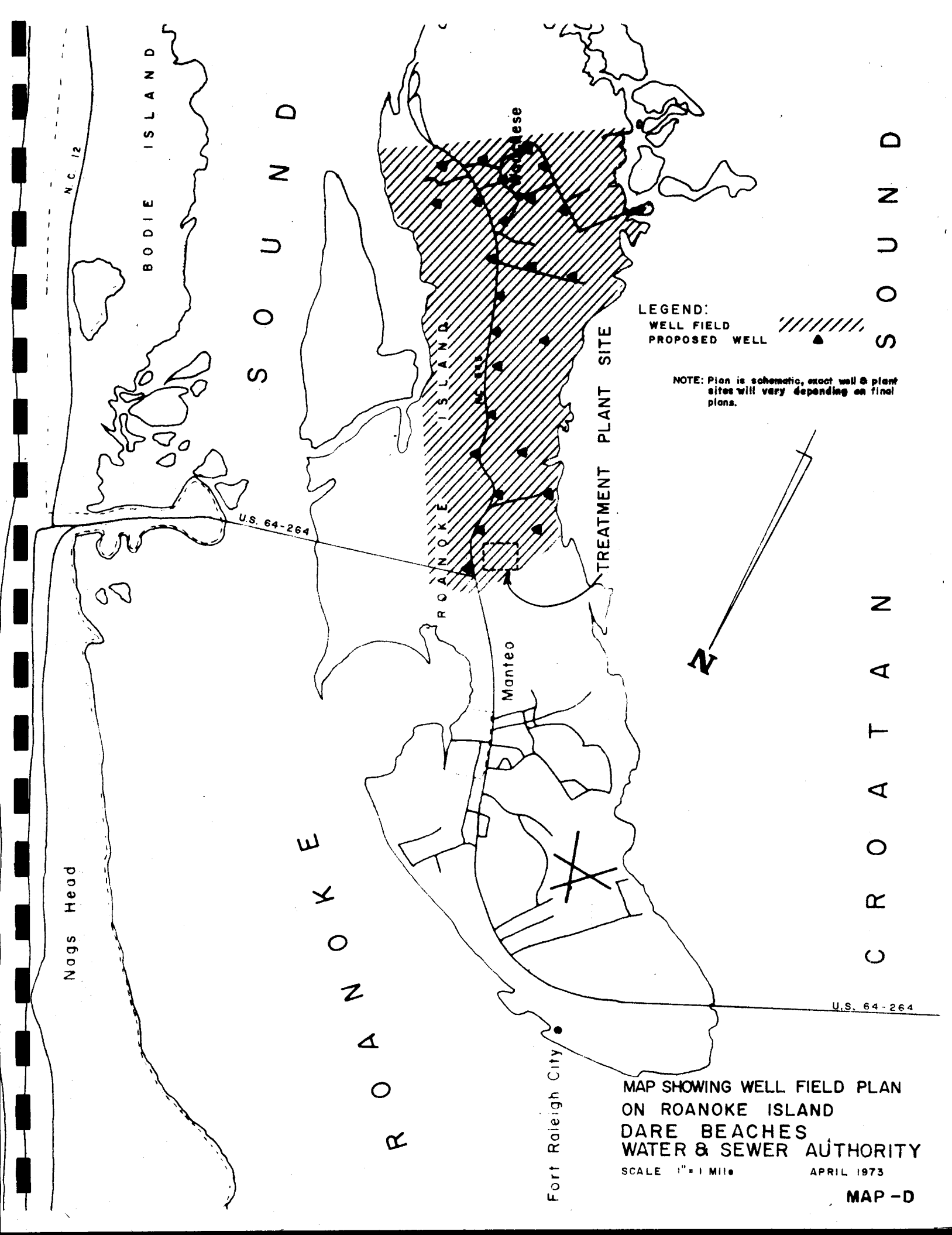
A. Source of Supply

As stated earlier in this report, the State Ground Water investigation of the area indicates that the best and most economical source of water to meet the initial requirements of the system is from the southern half of Roanoke Island. This will be confirmed by the Authority's demonstration (test) well program to be constructed in the near future. For purposes of this report we are assuming that each well will produce at least 500 gallons per minute. (The aforementioned tests will reveal whether or not this rate can be increased.) Based on this assumption it is recommended that approximately forteen wells be constructed initially in a well field as set out on Map D following this page. One-half of the wells will be equipped with a standby engine to provide power to the pump in the event of an electric power stoppage or interruption.

As water supply demands increase additional wells will be constructed to increase this supply. Based on the growth and demand indications set out in Section 2, we estimate that wells will be required according to the following schedule:

Year	Total Demand	Wells Required
1974-80	3.9 MGD (5.0 MGD capacity)	14
1985	6.5	18
1990	8.4	23
2000	13.0	36
2020	18.2	50

Obviously, as water supply demands continue to increase and the need for additional wells is demonstrated, it probably will become necessary to establish a supplementary well field on the mainland


BODIE ISLAND
N.C. 12
SOUND
ROANOKE ISLAND
Roanoke
TREATMENT PLANT SITE
SOUND
CROATAN
LEGEND:
WELL FIELD
PROPOSED WELL
NOTE: Plan is schematic, exact well & plant sites will very depending on final plans.
N
U.S. 64-264
Manteo
Nags Head
ROANOKE
U.S. 64-264
Fort Raleigh City
MAP SHOWING WELL FIELD PLAN
ON ROANOKE ISLAND
DARE BEACHES
WATER & SEWER AUTHORITY
SCALE 1" = 1 Mile
APRIL 1973
MAP-D

in the vicinity of Manns Harbor. When this occurs, consideration might be given to extending the system south and westward into other parts of the county in addition to transporting some of the water to Roanoke Island and the beach areas.

B. Treatment and Storage

Coastal ground water supplies usually require some treatment for iron, sulphur, and carbon dioxide removal and for softening. The analysis of test wells accomplished by the State Department of Water and Air Resources indicates a water which is low in iron but somewhat hard. There also is some manganese present but this is generally less than the allowable Public Health Service maximum.

The water will be pumped from the wells through raw water lines to a ground reservoir at the treatment plant site. The water will be aerated and chlorinated as it enters the reservoir. This will remove any dissolved gases such as hydrogen sulfide or carbon dioxide, oxidize any iron or manganese that may be present, and sterilize the water. The water will be pumped from the reservoir into the main supply line to the area being served and an elevated tank will be provided at the treatment plant site. Provision may be made for other chemical feeds such as fluoride, phosphate or pH adjustment as necessary. The hardness of the water (about 150 ppm) is in a range where softening may be desirable but is not absolutely necessary. The site will be planned to provide space for softening equipment which may be provided at any time. The character of the water makes it suitable for either cold lime or zeolite softening, and the selection of the type process would be made on the basis of prescribed health standards and economic considerations.

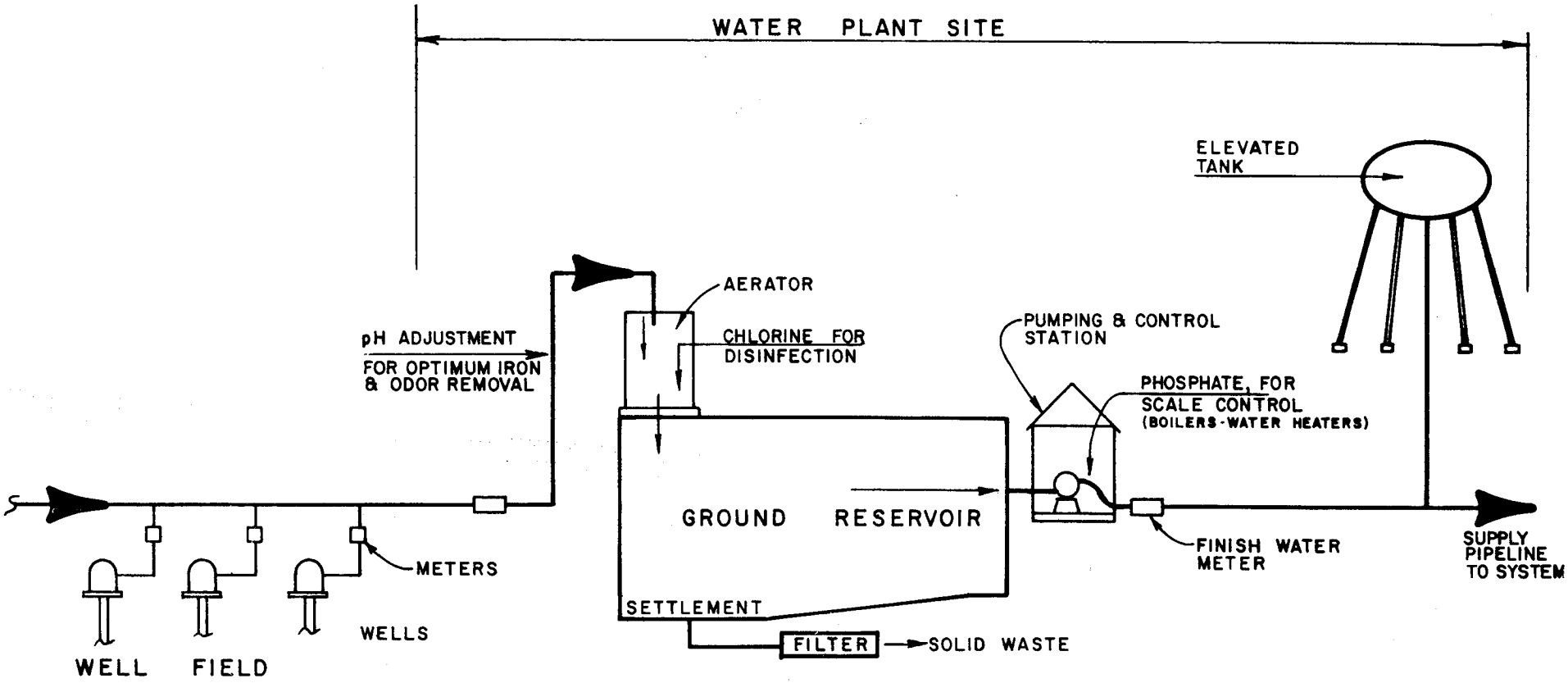
Storage of water will be in an elevated tank and ground storage tank at the treatment plant site. Initial elevated storage size is suggested at one-half of an average day's demand. We propose to construct a 1,000,000 gallon elevated tank, plus a 1,000,000 gallon ground reservoir at the treatment plant site. Additional elevated storage will be constructed as the supply increases on the beach, and ground storage will also be provided by this project or by others when separate systems connect.

These reservoirs will serve as a point of delivery for the various separate systems as required for proper operation and coordination of the Authority's supply system with customers' systems. The reservoirs will also provide storage for emergencies such as fire fighting demands, supply system breakdowns, or interruptions for maintenance and repair.

A schematic flow diagram for the water supply source and primary treatment plant follows this page. The regional distribution and storage system is further expanded upon in the following paragraphs.

C. Supply Pipeline

It is proposed to construct a 24" pressure pipeline along Highway U. S. 64-264 and 158 By-Pass from the reservoir and pumping plant on Roanoke Island to the joint town limits of Nags Head and Kill Devil Hills on By-Pass U. S. 153. An 18" pipeline branch will extend from the 24" pipe on Highway 158 By-Pass to the water plants. Direct connections will be made to the ground storage reservoir of the towns at their water plants. Each connection will have a meter to measure flows into the reservoir and will also have a rate of flow control and valve. It is anticipated that flows can be controlled by the



SCHEMATIC FLOW DIAGRAM

WATER SUPPLY AND STORAGE

DARE BEACHES WATER & SEWER AUTHORITY

FIGURE - 3

water level in the reservoir, or manually by the town's plant operator. A 16" pipeline extension from the junction of the 24" and 18" line at Nags Head - Kill Devil Hills town limits to the north will be made to provide a water supply for the Kitty Hawk - Southern Shores district system. This line will terminate just north of the northern town limit of Kill Devil Hills at the site of a ground storage reservoir to be constructed by the service district system. Rate of flow and valving control here will be the same as outlined for the two towns above.

Two routes have been studied for the pipeline from Roanoke Island to the beach area. The first (Route A) is generally along U. S. Highway 64-264 from Roanoke Island to the vicinity of Whalebone Junction and thence along the U. S. 158 By-Pass to the common boundary of the two towns, and a branch pipeline constructed westwardly to the two treatment plants.

An alternate route (Route B) has been studied which would extend from the Roanoke Island reservoir and pumping plant site, northward along U. S. Highway 64-264 through the edge of Manteo to the northeastern portion of the island, thence directly across the sound to the vicinity of Nags Head Woods and thence to the two water plants and water storage tanks. Supply service would be provided to the towns as set out for the previous route, with a branch line extended out to Highway 158 By-Pass and northward along the by-pass to the site of the district reservoir.

A map showing both routes is provided on the following page.

T L A N T I C O C E A N

PIPELINE SUPPLIES EXISTING PLANTS

U.S. 158

16"

Kill Devil Hills

16"

Nags Head

24"

N.C. 12

BODIE ISLAND

ALTERNATE 24" ROUTE

S O U N D.

U.S. 64-264

24"

Collington

COLLINGTON ISLAND

R O A N O K E

ROANOKE ISLAND

DEEP WELL FIELD

N.C. 345

Manteo

24"

Wanchese

Fort Raleigh City

ELEVATED STORAGE & GROUND STORAGE PUMPING PLANT

LEGEND:

- PRIMARY WATER SUPPLY PIPELINE
- ALTERNATE ROUTE FOR PIPELINE
- GROUND STORAGE RESERVOIR
- EXISTING MUNICIPAL TREATMENT PLANTS
- ELEVATED TANK PRIMARY SUPPLY
- EXISTING & PROPOSED DISTRIBUTION SYSTEM TANKS

C R O A T A N S O U N D

U.S. 64 264

MAP SHOWING ALTERNATE PIPELINE ROUTES

FROM ROANOKE ISLAND TO DARE BEACHES

DARE BEACHES WATER & SEWER AUTHORITY

APRIL 1973 SCALE 1"= 1 Mile

HENRY VON OESEN & ASSOCIATES

CONSULTING ENGINEER'S & PLANNERS

MAP-E

COMPARISON OF TWO PIPELINE ROUTES
(See Map "E")

Item	Route A Along 64-264 and By-Pass	Route B Across Roanoke Sound
Length of route (pumping station to town plants)	58,240'	45,200'
Length of subaqueous pipeline	600'	15,850'
Construction problems	4,500' pipe on pile bents above sound	Open sound crossing hazardous; silt bottom requires deep trench for bedding
Estimated cost of pipeline only	$1,858,000	$4,168,100
Future maintenance	Normal except pile which is accessible by normal methods	Normal except open sound crossing will require divers and underwater work
Future expansion	Right of way will accommodate added pipelines; pile structure will carry two additional pipelines	Land route will accommodate added pipelines; sound crossing will require new trench and line.
	This route is recommended.	

D. Ground Storage and Pumping

At the points where water is delivered to the various customers and distribution systems differentials in operating pressures and systems characteristics prevent a direct flow through connection from the supply main into the users' system; therefore, some type of ground storage tank will be required. At each point of delivery, the two towns presently have existing reservoirs that are usable for this purpose. A ground storage tank will be needed at any service take-off of the supply pipeline on the beach.

Ground storage tanks would normally be constructed of concrete and would be substantially above ground and above the highest flood level of record. They would be covered and would have a pump house to provide service pumps and chlorine treatment equipment.

E. System Control

It is proposed to provide an automatic control system to operate the supply well field (all wells) to control the water level in the elevated storage tank and ground storage reservoirs at the end of the system. This control system would be comprised of the following principal components and capacities:

(1) The control system would program when each well operates, turning it on and off and providing an alarm to indicate any malfunction of the well.

(2) The elevated tank and ground storage reservoir water levels would be indicated on system control boards.

(3) Rate of flow control units at the two municipal service points would record this information on control boards.

(4) A rate of flow (Venturi) meter would be placed on the supply pipelines at the supply field storage and treatment plant site to provide immediate indication of the flow at that point.

(5) A central control board would be located at the supply field and treatment plant site which would provide overall control of the system. A pre-programmed well operation sequence could be used to automatically operate sufficient well units to accommodate the supply demand. If conditions indicated that manual operation is preferred for testing or other purposes, the control console would provide such options.

(6) All wells would be provided with an in-line meter to record the discharge of the well into the system. Each meter would have a totalizing dial to record cumulative flows.

(7) All services to users would be metered and the total flows would be recorded. It is not contemplated that meter readings would be transmitted, as this is an expensive procedure and it is not believed to be necessary or desired for this system. Regular visits for inspection and meter reading four to six times per year is a necessary operating procedure and discipline.

It is planned that the site acquired as a part of the initial project to contain elevated and ground storage on Roanoke Island would also contain the control and operations facilities as well as pumps for ground water storage. This site will also accommodate treatment facilities when needed, storage yard, and equipment housing. Space for Authority offices can also be provided in the facility if deemed desirable.

F. Cost Estimate for Initial Construction of Supply System

(1) WATER SUPPLY FACILITIES

a. Water Supply Wells

[1]	10" deep well with auxiliary power	7 @ $17,800	$ 124,600
[2]	10" deep well with electric motor only	7 @ $16,600	116,200
	TOTAL AMOUNT - Wells		$ 240,800

b. Water Supply Field Pipelines

[1]	24" water pipeline	8000'	@ $20.00	$ 160,000
[2]	20" water pipeline	4400'	17.00	74,800
[3]	18" water pipeline	3300'	15.00	49,500
[4]	12" water pipeline	3600'	10.00	36,000
[5]	8" water pipeline	7400'	6.00	44,400

[6]	Pipeline valves	Lump Sum	$ 12,60.
[7]	Fittings, pavement repair, etc.	Lump Sum	20,860
	TOTAL AMOUNT - Pipeline		$ 400,000

(2) WATER STORAGE AND CONTROL FACILITIES

a.	1 Million gallon elevated tank	$ 250,000
b.	1 Million gallon ground reservoir	100,000
c.	Pump house, controls, pumps, etc.	100,000
	TOTAL AMOUNT - Storage & Pumping	$ 450,000

(3) PIPELINE TO SERVICE AREAS

a. Pipeline to Nags Head and Kill Devil Hills plants and Kitty Hawk District

[1]	24" pipeline ground	51,500'	@ $20.00	$1,030,000
[2]	24" pile bents	4500'	66.00	297,000
[3]	24" subaqueous	600'	200.00	120,000
[4]	18" pipeline ground	1640'	15.00	24,600
[5]	16" pipeline ground	25,500'	13.00	331,500
[6]	Valves and fittings	Lump Sum		25,000
[7]	Meters (rate control, etc.)	Lump Sum		30,000
	TOTAL AMOUNT - Pipeline to S. Areas			$1,858,100

(4) SUMMARY OF FACILITIES AND OTHER COSTS

a.	Supply facilities	$ 240,800
b.	Supply field pipelines	400,000
c.	Elevated and ground storage	450,000
d.	Service area pipeline	1,858,000
	Total Construction Cost	$2,948,800
	Administrative and legal	59,000
	Engineering, inspection, etc.	236,000
	Land and right of way	100,000
	Interest during construction	70,000
	Contingency 10%	386,200
	TOTAL SUPPLY SYSTEM PROJECT COST	$3,800,000

G. Estimated Annual Operation and Maintenance Costs for Water Supply System

		1st Year	2nd Year	3rd Year
(1)	Administrative and operating personnel	$ 33,000	$ 35,500	$ 37,500
(2)	Office equipment and supplies	4,500	5,000	5,500
(3)	Records and billing)	1,500	1,600	1,700
(4)	Equipment and parts	5,000	5,000	7,500
(5)	Repairs to system	1,000	2,500	3,500
(6)	Chemical and supplies	2,000	2,000	2,200
(7)	Power (electricity)	9,000	9,000	9,500
(8)	Automotive equipment rental	2,000	2,500	3,000
(9)	Fuel	2,500	3,000	3,300
(10)	Travel and perdiem	1,000	1,000	1,200
(11)	Miscellaneous expense	500	750	1,000
		$ 62,000	$ 67,850	$ 75,900

Subsequent increases after the third year will generally follow the cost of living index and will also be changed by system expansion. Past experience has indicated that operation and maintenance unit costs (per one million gallons of water pumped) change very slowly and are not a source of sudden and unexpected acceleration in costs.

6. WATER DISTRIBUTION SYSTEM

As indicated in the previous section, the main distribution system will deliver treated water to the two existing systems of the Towns of Nags Head and Kill Devil Hills. In the case of these two systems, water will be delivered directly to the existing storage reservoirs owned by the two towns. As their systems demand water, the valve control systems at the town reservoirs will "call for water" when needed which will activate supply from the Authority's supply pipeline system. These flows will continue until the required storage capacity of the town systems is satisfied. This supply will be "automatic" and the Authority's supply system will respond to the demands placed upon it.

In county areas where there are no existing water systems it will be necessary to establish new distribution systems if such systems are desired. It is felt that this can be best accomplished by the establishment of Service Districts to serve this need. These potential "County District Systems" are discussed in the following subparagraphs.

A. Kitty Hawk (North): Service District System Analysis

(1) General

Water supply service to the Kitty Hawk (North) area is important for a number of reasons. First, there is a large number of residences and structures in this area that are presently without a central water supply and fire protection system. In turn, this lack of an adequate water supply system represents a potential health hazard in that existing individual water supplies are obtained from shallow well sources that are generally located in close proximity to adjacent septic tank sewerage disposal systems with the ever-present potential threat of contamination therefrom.

Recently, there have also been numerous reports of poor water quality and well failures in this particular area. Also, an adequate central water system must be installed before it is technically and economically feasible to construct a sewerage system for the area.

Lastly, but of considerable importance, is the fact that the economic viability of the Dare Beaches regional water supply project is heavily dependent upon the revenues that will be obtained from this important segment of the system. This last point is effectively demonstrated and discussed in detail in the economic feasibility analysis of the entire regional system that follows in the next section of the report.

In view of the fact that there is no existing water system in the Kitty Hawk (North) area, this section undertakes to analyze the various alternatives for establishing such a system, including a general distribution system description, costs and methods of financing the project.

(2) Service District Concept

It is suggested that consideration be given to establishing a Service District under the provisions of N. C. General Statute 153-300 ("The County Service District Act of 1973"). In turn, the county can delegate the administration and operation of the service district to the Dare Beaches Water and Sewer Authority under the provisions of GS 162A(4) and (14). General Statute 153 authorizes the County Board of Commissioners to create such a service district to "...finance, provide or maintain for the district...facilities and functions in addition to or to a greater

extent than those financed, provided or maintained for the entire county." These services include water supply and distribution systems and sewerage collection and disposal systems. The law stipulates procedures and requires public hearings, a referendum, and approval by a majority of the voters residing in the entire county. The county may also issue general obligation bonds to finance services, facilities and functions provided within the service district. Such a bond issue must also be submitted to and approved by a majority of the voters of the county. If increased tax revenues are required to help finance the systems, the county is authorized to levy property taxes within the defined service district in addition to those levied throughout the entire county. The statute also stipulates that a county may allocate to a service district any other revenues whose use is not otherwise restricted by law.

(3) Proposed Service District System

It is proposed to construct a water supply system in the Kitty Hawk (North) service district to provide for domestic water supply and fire protection for that area. This system would be supplied from the branch pipelines described in Paragraph 5C. A 500,000 gallon ground storage reservoir would be constructed at the terminus of the Authority's sixteen-inch trunk main at the northern town limits of Kill Devil Hills. Sufficient pumping capacity would be provided at this point to service the distribution system and an elevated storage tank that would be centrally located in the general vicinity of the U. S. Highway 158 and 158-Business road junction near Southern Shores. This tank would be constructed

to maintain pressure at optimum levels and stabilize the distribution system.

The distribution system would be designed so as to provide a trunk loop system satisfactory for the initial years of operation. Addition of mains in the distribution system would be made when demands for water service justify these extensions. Adequate valving and fire hydrants would be provided to assure system control and proper fire protection coverage for the area served. Lateral distribution lines would initially be installed throughout the system to service all areas and dwellings where they can be economically justified. In a limited number of cases it may be necessary for an isolated property owner to pay the cost of installation of a temporary service line if said owner is the sole user of this service. A plan of the main trunk distribution system is shown on Map "F" following Page 43.

(4) Estimated Cost for Construction

Cost estimates for construction of the proposed Kitty Hawk (North) distribution system have been prepared and are tabulated as follows:

12" mains	25,000 lf @	$ 7.50	$ 187,500
8" mains	99,700 lf	4.00	398,800
6" mains	64,600 lf	2.50	161,500
12" mains	12 ea	325.00	3,900
8" valves	52 ea	200.00	10,400
6" valves	60 ea	150.00	8,400
Hydrants	136 ea	300.00	40,800
Services	1,310 ea	115.00	150,700
Miscellaneous pavement repairs, casings, etc.			50,000
Contingencies			100,000
Total Distribution System			$1,112,000

500,000 Gallon reservoir	$ 76,000
Pumping Station	100,000
500,000 Gallon elevated tank	175,000
Total Construction Cost	$1,463,000
Technical services	117,000
Legal and administrative	15,000
Land, easements and rights of way	50,000
Total Cost	$1,645,000

(5) Assumed Costs for Estimating Purposes

A detailed analysis of the economic feasibility of the Dare Beaches Water and Sewer Authority regional water supply project is set forth in Paragraph 7 following this analysis of the Kitty Hawk (North) distribution system. As previously stated, the economic viability of the Authority's project is partially dependent upon revenues produced by the Kitty Hawk (North) system. The balance of this section of the report is designed to demonstrate that the Kitty Hawk (North) system can be economically self-sufficient, and at the same time, contribute its proportionate share of support to the Authority's regional system which will supply it with water.

The Kitty Hawk (North) system cost estimate can be reasonably adjusted by the assumption that a grant may be obtained from the State under the provisions of the Clean Water Bond Act of 1972. The Act authorizes grants of up to twenty-five percent to support projects of this nature. Therefore, assuming a twenty-five percent State grant, the total project cost requiring bond support would be as follows:

Total Cost	$1,645,000
State Grant (25%)	410,000
Net	$1,235,000
Two years' borrowed interest	137,000
Total bond issue requirement	$1,372,000

(6) Annual Operating Costs

As will be shown in Section (7), the Authority's regional water supply project from the Kitty Hawk (North) area requires revenues initially in the amount of about $46,000 annually. The estimated quantity of water that will be used by the 1300 present potential customers in the Kitty Hawk (North) area will only generate about $25,000 in annual revenues to the Authority at the suggested bulk rate of $0.25 per 1000 gallons. For the purposes of this study, it is assumed that the Authority's rate for this area will be $0.25 per 1000 gallons, with a monthly minimum charge to the service district of $4,000. It appears that it will be to the mutual advantage of the service districts and the Authority for the Authority to provide the personnel and facilities to maintain and operate this system. However, the figures indicated below would be applicable whether the Authority or the service district operated the system.

Salaries	$ 10,000
Utilities (power)	3,000
Repairs and maintenance	5,000
Office expense	2,000
Miscellaneous	2,500
Water purchase contract (with DBW&SA)	48,000
Total operating expenses	$ 70,500
Debt retirement (on G. O. Bonds)	81,000
Total Annual Cost	$ 151,500

(7) Proposed Water Rate and Estimated Revenues

Normally the water rate must be set so as to generate the revenue required to pay the owning and operating cost of the system. However, there are limitations on the amount that can be reasonably charged for water. The maximum water rates that will be tolerated by customers on a system vary widely in different locations. These rates are influenced by the availability of water, type of development, and other factors. Experience in similar coastal areas in eastern North Carolina indicates that the maximum rates that can be suggested in this area are as follows:

Monthly Usage	Charge
First 3,000 gallons	$6.00 (minimum)
Next 7,000 gallons	$1.00 per 1000 gallons
Next 40,000 gallons	$0.75 per 1000 gallons
Next 50,000 gallons	$0.60 per 1000 gallons
Next 100,000 gallons	$0.50 per 1000 gallons
All over 200,000 gallons	$0.40 per 1000 gallons

There are presently 1,307 potential customers in the Kitty Hawk (North) area that can reasonably be served by the water system. This is based on an actual house count conducted in June 1973. Although it is obvious that this number of potential customers will increase as the area develops, the initial feasibility must be based on the existing customers. Mandatory hook-up by all potential customers must be required under the provisions of N. C. GS 153. With the rate proposed above, the estimated revenues that the system will produce are summarized as follows:

Residential and Small Commercial Users:

600 ea @	72.00	$ 43,200
400 ea	90.00	36,000
150 ea	100.00	15,000
50 ea	120.00	6,000

Motels/Hotels

20 small	@	100.00	2,000
30 medium		200.00	6,000
20 large		500.00	10,000

Commercial

5 medium	@	120.00	600
5 large		200.00	1,000

Public and Institutional

5 small	@	72.00	360
10 medium		120.00	1,200
10 large		200.00	2,000

Industrial

2 ea @ 1,000	2,000
Total Annual Revenue	$125,360

The revenue from water sales at the proposed rate is about $26,000 less than the expenses. This additional amount could be provided by increasing the minimum water charge to about $7.50 per month, or by creating other sources of revenue from assessments or advalorem taxes. This is discussed in greater detail in the following paragraphs.

(8) Economic Feasibility

From the above, it may be seen that it would be desirable to obtain additional revenues to reduce the total bonded indebtedness, or to allow for the accumulation of a reserve fund that

would finance the inevitably required future expansions of the system without further increasing the bonded indebtedness. This may be accomplished in a number of ways. First, water rates may be increased to produce additional revenues as previously discussed. Secondly, property taxes may be increased to help pay some of the costs for the system. It would be desirable not to exercise this option of tax increases if the system can be financed by other means.

Another alternative would be to assess property owners serviced by the distribution system under the provisions of N. C. GS 153-296.1. This assessment may be based on the actual cost of the work, or on a fixed fee basis established by the County Commissioners. Assessments would be charged only against properties serviced by mains that would provide service and fire protection. As mains are added to the system, properties not assessed initially would be assessed as service is provided at a later date. Assessments would cover the cost of pipelines, fittings, valves and hydrants, plus overhead costs (administrative, legal, engineering and interest). Assessments would be the same regardless of service main sizing as long as adequate service and fire protection was provided. Pipelines through easements for system convenience would not be assessable to owners granting such easements. At corner lots assessments would be based on one frontage only, that frontage where service is provided as provided in GS 153-294.3.

Based on current costs, it appears that an assessment of $1.50 per front foot of property could be levied on all individual lots of privately owned properties. It is estimated that this assessment would produce revenue in the amount of $425,000. Although

some property owners would pay the entire assessment initially these funds would normally be collected over a period of two to ten years. Six percent annual interest will be charged on unpaid portions of this assessment. If this is done, a number of financial arrangements are possible. One possibility is shown on the schedule following this analysis. This would consist of paying the excess funds received from assessments over the first ten years of the forty-year bond life into a reserve fund to be used over the last thirty years to make up any deficit during those years and to provide funds for expansion. It can be seen that the accumulative balance after ten years is $592,587 in the reserve fund. Therefore, the project is easily feasible on this basis. It is suggested that the surplus funds generated by this method be used for capital improvements to the system as required. It can also be seen from the schedule that income from water sales alone will exceed total expenses after about eight years of normal growth.

This analysis considers assessments only on the basis of properties fronting on water service mains. Obviously, as public utilities' services are made available in the area other undeveloped areas will require service. These areas can be assessed at the time such development occurs, as a direct cost to the developer. He in turn would pass such costs to purchasers as a part of their lot cost. County subdivision ordinances should require water (and sewerage) system extensions when available. If, as proposed elsewhere in this report, a developer expects to install his own water distribution system, it should be up to service district standards to be allowed to connect to this system. Where such

private systems are not turned over to the County or Authority to operate, a "tap-on fee" should be charged.

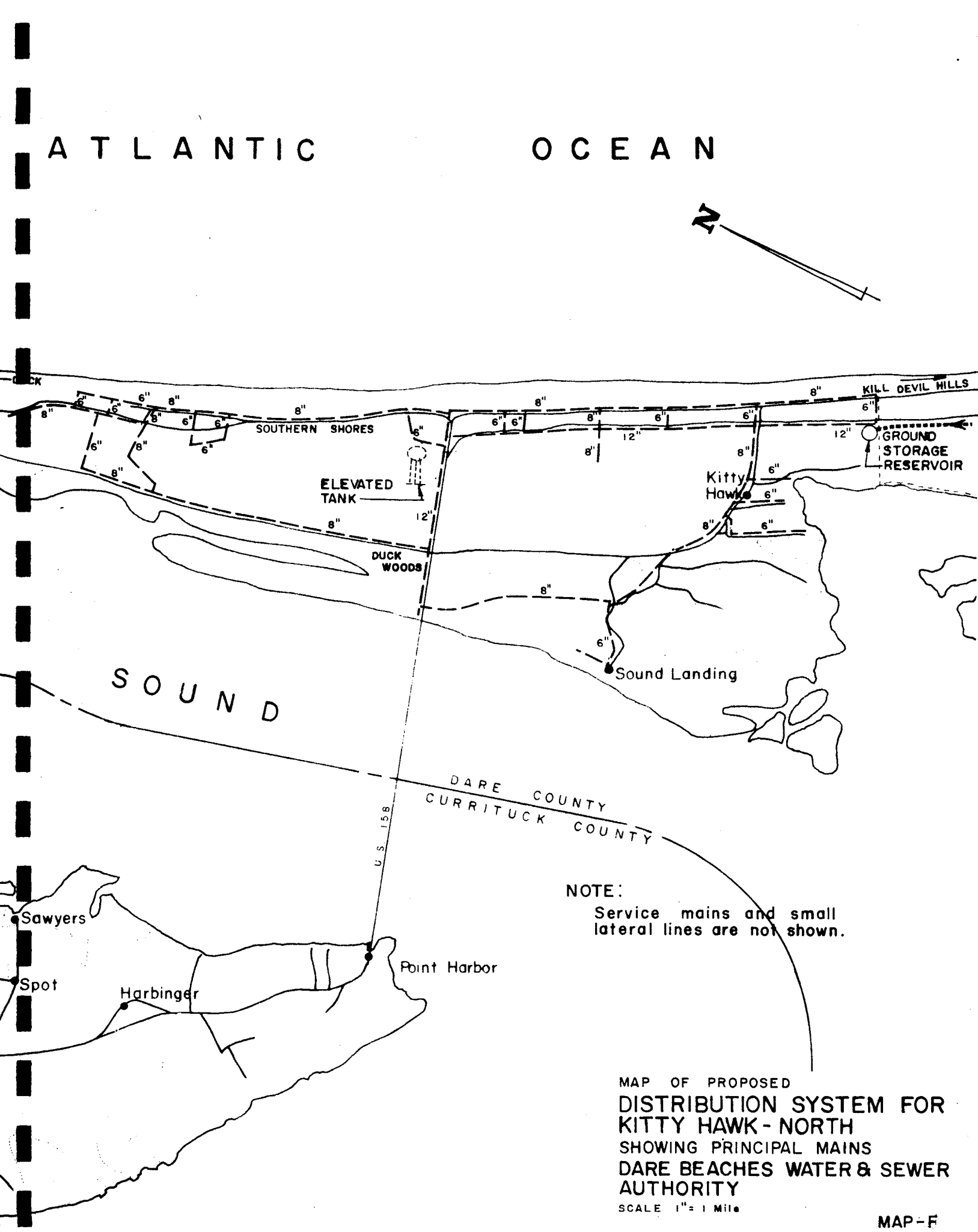
This analysis shows that the Kitty Hawk (North) service district system is economically feasible based on charging reasonable rates for water, plus a reasonable assessment against property owners to help reduce the capital costs of the system and pay off the bonded indebtedness. As additional customers are added to the system, thereby producing additional revenues, it may be possible to reduce the water rates at some future date. The schedule presented on the following page demonstrates the economic viability of the proposed Kitty Hawk (North) Service District System.

SCHEDULE OF ECONOMIC FEASIBILITY

Kitty Hawk (North) Service District System

Year	Operation & Maintenance	Debt Service	Reserve	Total Expenses	Water Sales Income	Assessment Income	Total Income	Cumulative Surplus for Debt & Expansion*
1	70,500	68,600	8,000	147,100	125,360	57,750	183,110	36,010
2	72,600	68,600	8,000	149,200	131,600	57,750	189,350	78,320
3	74,800	81,000	8,000	163,800	138,200	57,750	195,950	115,169
4	77,000	81,000	8,000	166,000	145,100	57,750	202,850	158,930
5	79,300	81,000	8,000	168,300	152,300	57,750	210,050	210,215
6	81,700	81,000	8,000	170,700	159,900	57,750	217,650	257,165
7	84,200	81,000	8,000	173,200	167,900	57,750	225,650	325,045
8	86,700	81,000	8,000	175,700	176,400	57,750	234,150	402,997
9	89,300	81,000	8,000	178,300	185,200	57,750	242,950	491,827
10	91,900	81,000	8,000	180,900	194,400	57,750	252,150	592,587
15	101,200	81,000	8,000	190,200	223,600	-	223,600	-
20	111,300	81,000	8,000	200,300	257,000	-	257,000	-

*Including 6% interest



MAP OF PROPOSED

DISTRIBUTION SYSTEM FOR KITTY HAWK - NORTH

SHOWING PRINCIPAL MAINS

DARE BEACHES WATER & SEWER AUTHORITY

SCALE 1" = 1 Mile

MAP - F

B. Collington Island

Present population densities on Collington Island are low. Structures are generally along the shore of the island and along the access roadway. The new development, "Collington Harbor", has a few structures and will experience an increasing rate of building. The provision of water from a central system is sure to accelerate the building process.

Two alternative methods of accomplishing this are possible:

(1) Creation of a service district in the same manner as described for the Kitty Hawk area. This does not appear to be economically feasible until a greater density or demand can be developed.

(2) Extension of the Kill Devil Hills distribution system to the Collington Harbor development with service mains in the development. This could be done by an agreement between the developers and the town. To do this it would normally be required that the developer provide the funds to construct the lines. The town would operate this new system, putting in services and selling water. The new system would become the town's property in fee at some early period. The developer should be refunded some part of his capital costs at opportune intervals as the system is loaded with customers and when other developments connect to the line extending out from the town's present system. Consideration should be given to some form of annexation of the entire development and the island to the town as the demand for public utility services increases.

C. Roanoke Island

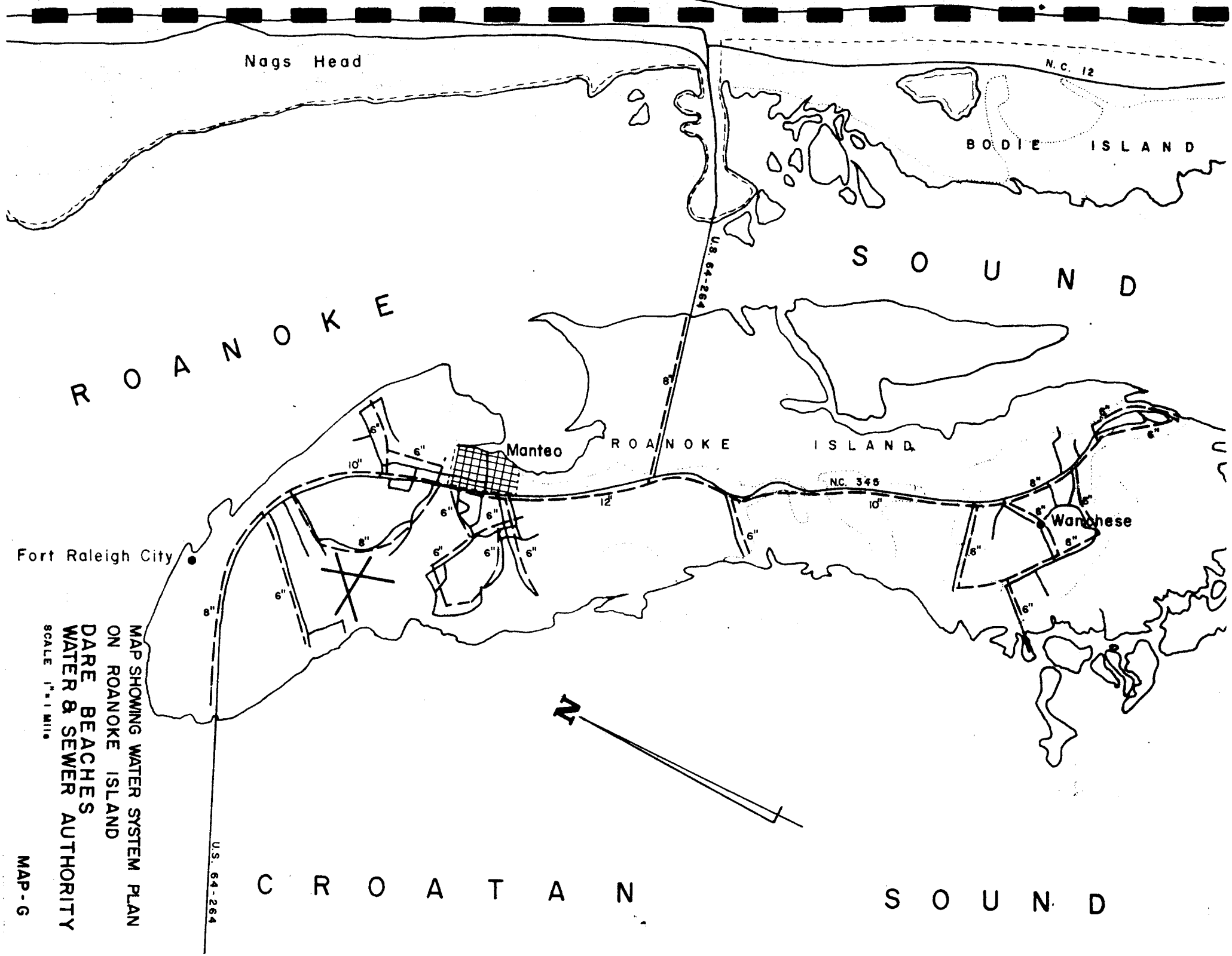
The existing water system in the Town of Manteo provides service to only a small percentage of the total population of Roanoke Island. If water service is desired throughout the island it is suggested that a service district be created for the remainder of the island and that a distribution system be constructed to provide service to those requesting same. Adequate fire protection should also be provided to the area served by the system.

This system can be supplied from the trunk pipeline before it leaves the island, utilizing the elevated tank at the reservoir pumping station. Domestic service cannot be provided directly from the well supply pipeline, however.

The system would be constructed as two lateral projections off of the trunk main, one extending south and the other into the northern portion of the island providing service to the recreational and historic areas and facilities. This area would be looped by an eight-inch main with distribution mains in presently developed and occupied areas.

A second lateral eight-inch main would be extended southwardly throughout the southern portions of the island with a loop in the Wanchese Community.

Service would be provided at the same fee basis and conditions as set out for the Kitty Hawk (North) system described above. A plan of the proposed initial system for this area follows this page.


Nags Head
N. C. 12
BODIE ISLAND
SOUND
ROANOKE
U.S. 64-264
Manteo
ROANOKE ISLAND
N.C. 345
Wanchese
Fort Raleigh City
CROATAN
SOUND
U.S. 64-264
N
MAP SHOWING WATER SYSTEM PLAN
ON ROANOKE ISLAND
DARE BEACHES
WATER & SEWER AUTHORITY
SCALE 1" = 1 Mile
MAP-G

D. Town of Manteo

The Town of Manteo currently has three deep wells producing not less than 100,000 gpd. Their average daily usage is 90,000 gpd and the town's increased demand is estimated to be about 130,000 gpd by 1975. The town's system provides complete coverage within the town limits and has sufficient capacity to provide the demands of its domestic users at the present time. The town should consider the advantages of a connection to the Authority's system as a primary source and maintaining its existing wells as a backup in the event of a large fire or major power outage. The Authority could provide a supply to the Town of Manteo in the same manner as they will supply Nags Head and Kill Devil Hills.

E. Other County Areas

If the community of Mann's Harbor desires to have a water system the county can establish a service district in this area and the Authority could construct a small separate water system there. This system would be supplied from deep wells at Mann's Harbor and would operate on a hydro-pneumatic tank until enough demand (customers) is developed to afford an elevated tank. A density study should be completed to assure enough customers to support such a system.

For those areas of Dare Beaches extending northward of Duck Woods, Southern Shores and the community of Duck, it is contemplated that the branch pipeline running in this direction be further extended as water demand justifies to cover all of this northeastern portion of the county.

The U. S. Park Service Seashore area south of Nags Head would be provided water service at the park boundary if such is desired. Initially no pipeline is contemplated by the Authority south of Whalebone Junction other than existing lines in the Nags Head municipal system. If the Park Service desires water they can either extend a main to this point or purchase water from the Town of Nags Head system to the south.

No provision is made to provide water for the Dare Beaches area south of Oregon Inlet. With proper planning and population control it would appear that these areas could utilize the shallow fresh water source available in the Banks, and with proper treatment, provide their supply needs.

7. ECONOMIC FEASIBILITY OF PROPOSED AUTHORITY WATER SYSTEM

For purposes of this report and future consideration we must assume certain logical rates of water demand (consumption) and anticipated costs to meet these demands based on the analyses presented in the foregoing portions of this report. We must then establish reasonable rates to insure the economic viability of the proposed project. Lastly, we must assume a source of capital funds to support this analysis. This analysis is summarized in the following paragraphs.

A. Summary of Anticipated Costs

From information previously set out in Sections 5F and 5G the following schedule of costs is proposed. Expansion to cover ten years is made for potential comparison purposes.

SCHEDULE OF ANNUAL ESTIMATED COSTS

	First Year	Second	Third	Fourth	Fifth	Tenth
Operation & Maintenance Costs	$ 62,000	67,850	75,900	84,000	95,000	120,000
Bond Repayment	50,000	50,000	60,000	60,000	60,000	60,000
Debt Reserve	3,000	3,000	3,000	3,000	3,000	3,000
Operation Reserve	-	2,500	3,000	3,500	3,750	5,000
Total Estimated Cost	$115,000	123,350	141,900	150,500	161,750	188,000

B. Summary of Anticipated Revenues

Based on present usage of water by towns and the anticipated demand by growing population within the service area of the distribution systems the following revenue estimates have been developed based on what appears to be the minimum feasible rate of $250 per million gallons (25 cents per thousand gallons). See Figure 4 (chart showing revenue cost comparison following Page 49). This rate is for finished, quality water ready for domestic use.

SCHEDULE OF USERS
FOR FIRST YEAR OF OPERATION
(Quantities shown in number of gallons per day)

User	Minimum	Maximum	Average
Nags Head	87,840	1,134,600	549,000
Kill Devil Hills	71,040	917,600	444,000
Kitty Hawk (North) service district	81,120	1,047,800	507,000
Totals	240,000	3,100,000	1,500,000

As information, the anticipated sources of revenue for the first, third, sixth and tenth years is set out below on estimated usage:

SCHEDULE OF ESTIMATED ANNUAL USAGE AND SOURCES OF REVENUES - FIRST YEAR

User	Annual (in millions of gallons)	Rate	Annual Revenue	Average Monthly Revenue
Nags Head	200.385	250.00/mg	50,096.25	4,174.69
Kill Devil Hills	162.060	250.00/mg	40,515.00	3,376.25
Kitty Hawk & So. Shores	185.055	250.00/mg	46,263.75	3,855.31
Totals	547.5 mg/yr		136,875.00	11,406.25

SCHEDULE OF ESTIMATED ANNUAL USAGE AND SOURCES OF REVENUES - THIRD YEAR

User	Annual (in millions of gallons)	Rate	Annual Revenue	Average Monthly Revenue
Nags Head	221.759	250.00/mg	55,439.75	4,619.98
Kill Devil Hills	179.346	250.00/mg	44,836.50	3,736.38
Kitty Hawk & So. Shores	204.794	250.00/mg	51,198.50	4,266.54
Totals	605.899 mg/yr		151,474.75	12,622.90

SCHEDULE OF ESTIMATED ANNUAL USAGE AND SOURCES OF REVENUES - SIXTH YEAR

User	Annual (in millions of gallons)	Rate	Annual Revenue	Average Monthly Revenue
Nags Head	253.821	250.00/mg	63,455.25	5,287.94
Kill Devil Hills	205.276	250.00/mg	51,319.00	4,276.58
Kitty Hawk & So. Shores	234.403	250.00/mg	58,600.75	4,883.40
Totals	693.500 mg/yr		173,375.00	14,447.92

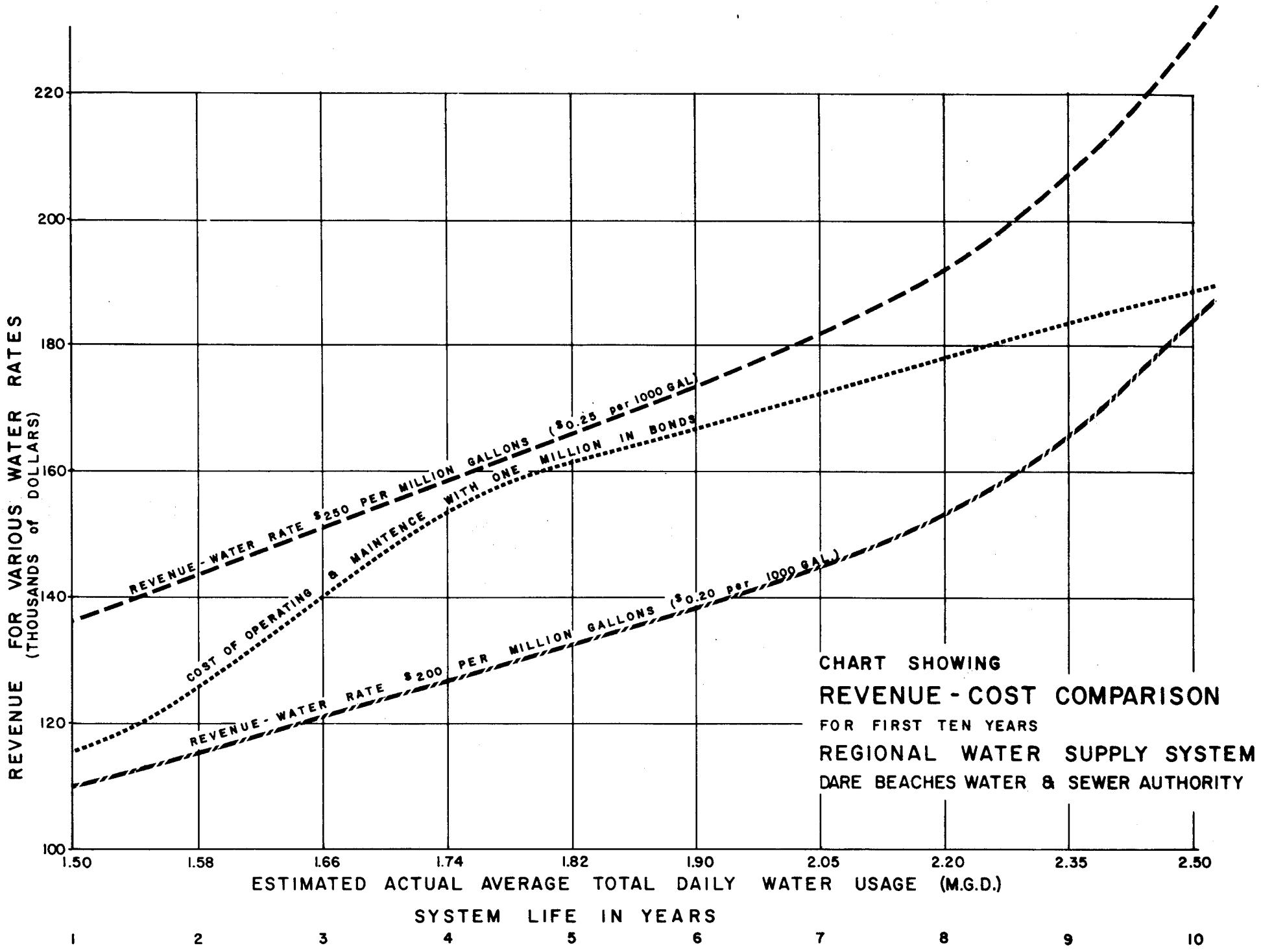

REVENUE FOR VARIOUS WATER RATES
(THOUSANDS of DOLLARS)
220
200
180
160
140
120
100
REVENUE - WATER RATE $250 PER MILLION GALLONS ($0.25 per 1000 GAL)
COST OF OPERATING & MAINTENCE WITH ONE MILLION IN BONDS
REVENUE - WATER RATE $200 PER MILLION GALLONS ($0.20 per 1000 GAL)
1.50
1.58
1.66
1.74
1.82
1.90
2.05
2.20
2.35
2.50
ESTIMATED ACTUAL AVERAGE TOTAL DAILY WATER USAGE (M.G.D.)
SYSTEM LIFE IN YEARS
1
2
3
4
5
6
7
8
9
10
CHART SHOWING
REVENUE - COST COMPARISON
FOR FIRST TEN YEARS
REGIONAL WATER SUPPLY SYSTEM
DARE BEACHES WATER & SEWER AUTHORITY

FIGURE - 4

SCHEDULE OF ESTIMATED ANNUAL USAGE AND SOURCE OF REVENUES - TENTH YEAR

User	Annual (in millions of gallons)	Rate	Annual Revenue	Average Monthly Revenue
Nags Head	295.650	250.00/mg	73,912.50	6,159.38
Kill Devil Hills	228.125	250.00/mg	57,031.25	4,752.60
Kitty Hawk & So. Shores	292.000	250.00/mg	73,000.00	6,083.34
Other Users	96.725	250.00/mg	35,304.65	2,942.05
Totals	912.500 mg/yr		239,248.40	19,937.37

C. Source of Capital Funds

Based on the cost estimate for the regional water system found in Section 5F it is recommended that the Authority seek its capital funds from the following sources:

Federal Grant Programs	$ 1,900,000
State of North Carolina (Clean Water Bond Act)	900,000
Federal Loan Programs	1,000,000
Project Total	$ 3,800,000

D. Loan (Revenue Bond) Repayment Requirements

From the source of funds schedule we will assume a bond amount of $1,000,000. Computed on a basis of forty-year term at five percent annual interest, and having the repayment of principal deferred for the first two years, the repayment requirements are as follows:

SCHEDULE OF BOND REPAYMENTS

Repayment - First two years	$ 50,000
Annual Repayment - Next 38 years	60,000
Annual Deposit in Debt Reserve	3,000

E. Comparative Economic Feasibility

The following schedule reflects the operating condition of the Authority's funds through the first ten years of operation.

SCHEDULE SHOWING ECONOMIC FEASIBILITY

Item	First Year	Second	Third	Fourth	Fifth	Tenth
Annual Revenues	$ 136,875	143,300	151,475	159,350	166,050	239,248
Annual Costs	115,000	123,350	141,900	150,500	161,750	188,000
Annual Surplus Balance	21,875	19,950	9,575	8,750	4,300	51,248
Cumulative Reserves (Debt and Operations)		3,000	8,500	14,500	21,000	54,750

It clearly appears that the system is economically feasible at a rate of $250 per million gallons ($0.25 per 1,000 gallons).

PART III PRELIMINARY ENGINEERING REPORT - REGIONAL WASTEWATER SYSTEM

I. ALTERNATIVES FOR MANAGING WASTEWATER

For any wastewater system to be complete, it must have three basic features; collection, treatment and disposal. An associated feature which is very desirable but one not absolutely essential is the re-use potential of the renovated water and those products separated from the water during the treatment phase. The major differences in these alternatives are in the treatment features. One way, and the most commonly known, is to continue to use rather sophisticated "man-made" processes, utilizing biological or chemical techniques. The second way, just beginning to be practiced in the country, is to provide limited chemical and/or biological treatment, and then to apply the wastewater to land areas utilizing the natural assimilative capacity of the soil, the vegetative cover and the soil micro-organisms to treat the waste. The end result of using this soil system as a "living filter" is two-fold: The soil purifies the matter which can be collected if desired and re-used; and the materials contained in the water applied to the land have the potential for stimulating plant growth as well as acting as soil conditioners.

These alternatives may be grouped under three management strategies; one using advanced waste treatment techniques termed "water disposal", one using land as the predominant treatment mechanism termed "land disposal", and finally, combinations of these two techniques. The water disposal system assumes a relatively high degree of treatment (depending on the water quality standards which must be maintained in the receiving waters) with discharge of the treated effluent into a free flowing stream or other body of water. On the other hand, the land disposal method assumes basic water treatment either by chemical-biological treatment systems or lagoon treat-

ment systems with ultimate disposal of the treated effluent through spray irrigation or other dispersed discharge systems. While the latter technique has not seen wide-spread application to date, generally the sandy and porous character of the soils in the area lend themselves well to this economical and effective process and must be considered as an alternative until an adequate water disposal method can be economically justified.

The explicit goal of any adopted system or technique is to achieve "maximum feasible purity" or removal of all pollutants and contaminants that technology can treat in order to achieve the highest water quality standards capabilities of techniques already available. First, basic water treatment - primary and secondary processes - can remove 85% of bio-degradable wastes, 85% of suspended solids, and 99.9% of harmful bacteria. These techniques, including treatment lagoons and the activated sludge process are well established, widely understood and can provide a measure of receiving water cleanliness which represents an impressive improvement over present water quality in many cases.

To control the full range of pollutants effectively, advanced treatment techniques must be applied. These are tertiary, physical, chemical and land renovation systems that use processes which take up where basic (secondary biological) treatment leaves off. Coagulation-sedimentation, carbon absorption, filtration, and ion exchange, all attach the remaining concentrations of common pollutants left after basic treatment and additional sophisticated substances which basic treatment does not affect. With a complimentary series of basic and advanced water treatment processes, color, odor and bad taste are eliminated and the esthetic appeal of water can be fully restored. Land application uses the vegetative cover and soils beneath to trap constituant pollutants in overland flow and infil-

tration areas. Whatever techniques or systems are employed in the planning region, steps must be taken to insure maximum cost effectiveness, assurance of compatibility with desired regional concepts and plant design and operating efficiency to insure maintenance or upgrading of water quality standards.

In the case of the project under study it appears most desirable to employ the water disposal method for treated waste effluent in view of the large quantities of sewerage which ultimately must be treated; however, initially it may be necessary to employ land disposal methods as an interim measure until the quantity of waste effluent generated will economically support the water disposal method. This point is discussed in greater detail in the following sections of this report.

2. EXISTING SEWERAGE AND WASTEWATER SYSTEMS

A sewerage collection system and secondary treatment plant is owned and operated in the Town of Manteo. Several small treatment systems are existing or under construction elsewhere in the county.

All other sewerage and wastewater disposal is by septic tank and drain field, or direct discharge into the sound estuary. Because of many problems including concentrations of structures and high population densities in certain areas, high ground water conditions, improper construction and overloading of existing sewerage treatment systems, many areas of the county's shallow ground water and surface areas are becoming polluted.

In many cases ditches extending through areas where drain fields have overcharged the ground are full of the effluent of septic tanks and discharge this polluted water into the surrounding sounds and lakes.

Some septic tanks and drain fields are undoubtedly doing a better job than those described above. These are in less densely developed areas and are of sufficient capacity to accommodate their loadings. However, all subsurface discharge of sewerage will eventually contaminate the ground water around the discharge which, for many dwellings outside the two beach municipalities, is the source of their present water supply.

Generally, it has been the experience of this firm in examining existing wastewater disposal systems (septic tanks - drain fields) in beach areas that they function well only if they are installed in land areas above elevation 8 MSL, and when the ground water table is at least three feet below the surface. Such tanks should not be constructed at a greater density than two per acre. Land mass should be principally sand with no shell lenses to "pipe" drain field discharges. Coarse uniform sands are better for drain fields than fine well-graded sands which are formed in aeolian (wind-formed) sand dunes.

3. FORECAST AND DEMAND FOR SEWER COLLECTION, WASTEWATER TREATMENT AND DISCHARGE

Based on information provided in the previously mentioned Sketch Development Plan and Economic Study, and the analysis made in this report, sewerage loadings have been forecast. These estimates are summarized in the table and graph that follow Page 57.

It should be pointed out that these population and wastewater demand projections correspond closely to the figures presented in the water supply section of this report. The differences in both numbers of people that will be served and quantities of sewerage generated are less than the numbers shown for water supply during the first ten to fifteen years of the sewerage project in that it is not anticipated that 100% service can be achieved throughout the entire area until about 1990. The notes on the table and the graph summarize and further explain this point.

It is also pointed out that the table reflects maximum or peak seasonal loadings, whereas the graph shows the wide variances in loading requirements that occur between the winter and summer seasons. While the system must be designed to accommodate the peak seasonal loadings it must also be constructed and modulated so that it can function and operate efficiently under the low, off-season loads.

Our estimates of wastewater flows and demands are also based upon several other factors which are listed as follows:

A. The requirement that all future commercial, hotel and motel, and business facilities be served by a collection system.

B. That initially most residential units not having functioning problems with their existing disposal systems will be reluctant to connect to a sewerage collection system. This will ultimately be

overridden by ordinances requiring all such units to connect where service is available.

C. The construction of residential units will be concentrated in newer development areas where utility lines are put in. When existing areas have utility lines installed normal economic and environmental controls will regulate the location of new construction.

D. New development will tend to concentrate on the more desirable land and where good quality construction exists nearby. Comparable land costs have become a lesser factor as all land prices are now high and the cost of development exceeds land cost in most instances.

E. Beach development will generally begin close to available water vistas (ocean, sound or artificially created canals), and many pond areas previously considered undesirable for development would be made desirable by improvement and beautification. These newly developed areas will definitely require a sewerage collection system.

It is estimated that there are presently approximately 2500 permanent private dwellings on Dare Beaches from the Park Service Boundary on the south to Duck on the north. In addition there are about 3000 motel type units and 1200 trailer park and camp sites scattered throughout the area. It is estimated these combined waste producing units and facilities discharge into well over 3000 septic tanks or other small treatment systems. Population and water consumption studies and projections indicate that there is a maximum daily discharge of wastewater in the area of between 2.5 and 3.0 MGD.

DARE BEACHES WATER AND SEWER AUTHORITY

WASTEWATER (SEWERAGE) LOADING PROJECTIONS
(Figures reflect estimated population to be served)

Beach Planning Unit	1975[1]	1980[2]	1985[3]	1990[4]	1995	2010	2020
Nags Head (South)[5]	11,088	18,550	36,000	67,000	78,500	98,000	115,000
Kill Devil Hills - Collington Island[6]	9,800	16,100	40,120	59,000	69,500	86,000	95,000
Kitty Hawk (North)[7]		6,075	17,000	24,000	27,000	40,000	40,000
Total Estimated Population Densities which will be Served	20,888	40,725	93,120	150,000	175,000	224,000	250,000
Estimated Peak Daily Sewerage Loadings in MGD	1.3	2.5	5.6	8.4	11.2	16.1	18.2

Notes:

(1) Assumes that approximately 60% of the available loading will be available to sewerage systems by 1975.

(2) Assumes sewerage service to 70% of the population by 1980.

(3) Assumes sewerage service to 85% of the population by 1985.

(4) Assumes sewerage service to 100% of the population by 1990.

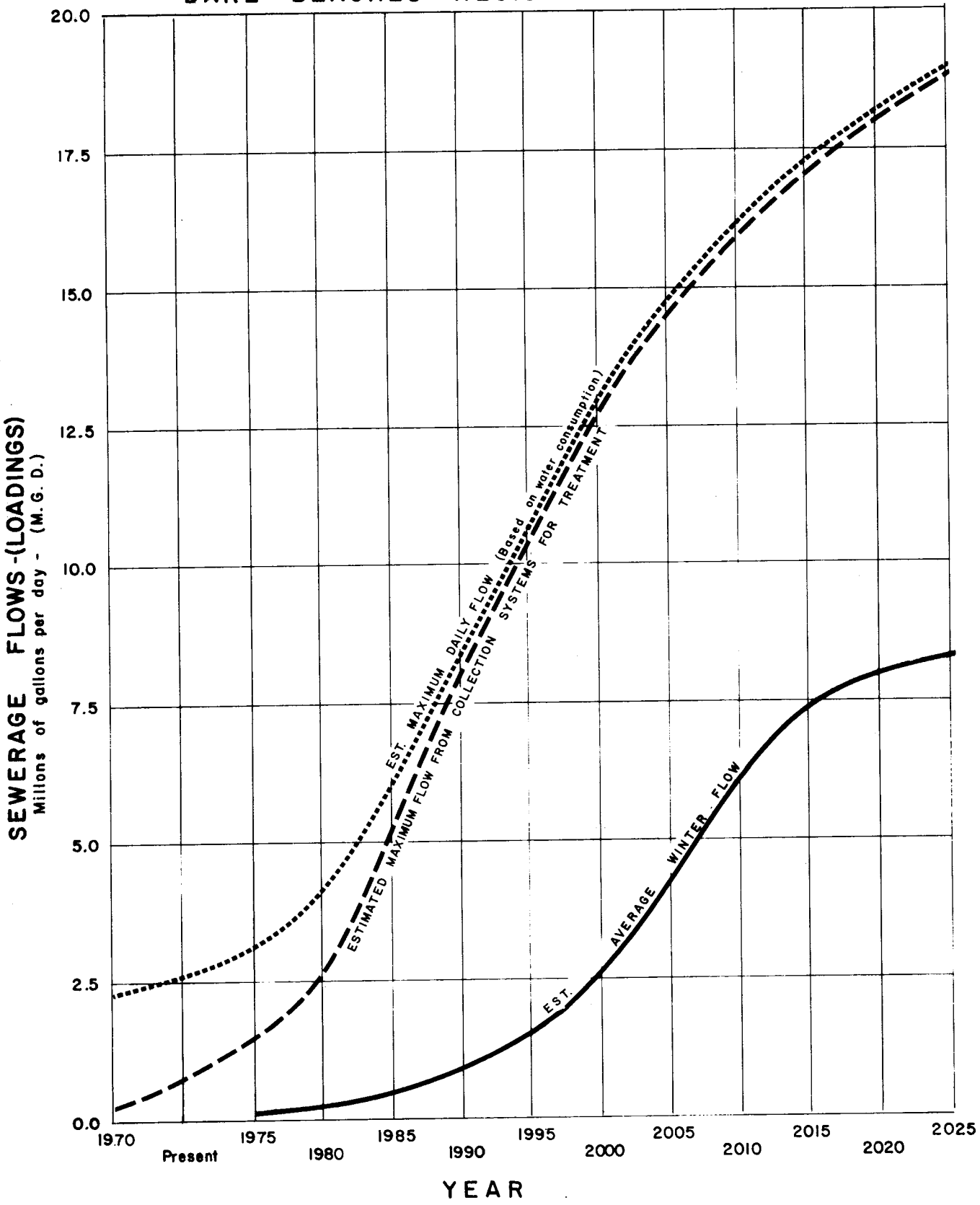
(5) Assumes initial sewerage service to cover all of Nags Head area between north city limits and Whalebone Junction by 1975 and to balance the area within town limits by 1980.

(6) Assumes initial sewerage service to most of the area within Kill Devil Hills town limits by 1975 and to all of the town and Collington Island by 1980.

(7) Assumes initial sewerage service to most of the Kitty Hawk area between U. S. Highway 158 and Kill Devil Hills town limit by 1980 and to all of the area extending through Southern Shores to the Duck community by 1985.

TABLE 2

WASTEWATER (SEWERAGE) LOADINGS
FOR
DARE BEACHES REGIONAL SEWERAGE SYSTEM



NOTE:
Estimated sewerage loadings taken from table

FIGURE - 5

(1) Sizing and Stage Construction

Based upon the estimated sewerage flow schedule it is anticipated that the initial plant sizing should be for 5.0 MGD. This would initially consist of four parallel treatment sections, each having a normal capacity of 1.25 MGD. The screen and grit removal unit for this initial plant would be sized for a flow of 10 MGD and would distribute to the sectional units. The chlorination treatment unit would also be sized for 10 MGD. Other plant facilities and flow patterns can be examined more closely on the flow plan, Plate D, following Page 67.

This phased staging of the plant enables the Authority to construct for near future loadings, thereby avoiding investment of capital funds for treatment plant capacity not needed until some later years. The use of sectional treatment arrangements will also enable adjustment of treatment plant operations so as to efficiently handle the seasonal load fluctuations as they occur.

This stage construction and sectional components concept of construction of the plant would also facilitate the acceptance of any variable sequence of loadings in an initial interim plant that could handle special commercial loadings from shopping centers, large housing developments, and highrise group housing developments that would generate unanticipated loading demands on the facility.

In view of the high degree of flexibility of this regional plant concept, and the avoidance of loss of investments in smaller interim or sectional plants, we feel that the single plant concept for the Dare Beaches subregion is clearly the optimum cost - effective solution to the problem.

4. PROPOSED SEWERAGE COLLECTION SYSTEMS

A. Municipal Systems

It was suggested previously that towns having existing water systems construct their own sewerage collection systems. This is in the interest of uniformity of control, operations, and billing. This also gives the community a voice, by vote, as to when such systems are to be constructed and as to how it will be paid for. Provision will be made by the Authority in its wastewater collection and treatment system to accept the gravity flows of the towns' sewerage collection and properly dispose of it.

The municipal systems would consist of a network to collectors and lines and laterals extending to all developed areas which will discharge into a lift station owned by the Authority. The municipal systems will require some small pumping stations where gravity flows become critical. Lines would generally be located in the street rights of way with service laterals extending to a point within five feet of the lot line being served. All extensions of services on private property would be at the owner's expense and direction.

Care should be exercised in the construction of these gravity lines to assure little or no ground water infiltration into the lines. Charges by the towns for sewerage service would normally be based upon the amount of water consumed by the customer. Generally the rates for domestic sewage service would be 100% added to the water bill. This cost will be influenced somewhat by the method of financing which the town adopts.

Municipal collection systems will normally be financed from General Obligation Bonds authorized by a bond referendum. The annual debt repayment requirements, together with the operating and maintenance cost of the sewerage collection system (usually about 60% added to existing water system operation and maintenance), will require substantial revenues

to pay these costs. In many communities the use of a pipe frontage assessment against the lands on both sides of a street provided with a sewer line is used to reduce the debt repayment figure, thereby lessening the annual cost of the system and allowing a reduction in service charges. This generally assures that advalorem tax funds will not be necessary to pay off bonds.

B. District Systems

The creation of a service district under the provisions of GS 153 by the Board of County Commissioners will enable the inhabitants of the district to have a sewerage collection system provided for them as well as a water distribution system. The Board of County Commissioners, or some duly appointed agency, would normally operate these systems. In this instance, it would appear that the Authority could act in this capacity. The creation of a service district enables the issuance of General Obligation Bonds in the same manner as a municipality and facilitates the construction of a system when authorized by referendum.

C. Private Development Systems

Where developments exist or are proposed outside of municipalities or districts, the developer having an acceptable and approved plan or system will be able to contract with the Authority to discharge its collected wastewater into the Authority's system for pumping to its treatment plant for treatment and proper disposal.

Where private developers do plan a collection system as a part of their program, care and coordination should be exercised to assure the adequacy of lines and the physical characteristics of the system. Care must be taken to provide line sizes and depths which will cover all areas which might ultimately be served from such a system. This is particularly true

where adjacent land parcels not owned by the developer must depend on the developed land for utility access or service. Planning must take this future need into consideration.

While there are some higher areas and dune (hill) topographic variations throughout the project area, most areas to be served are without a developed drainage flow pattern and provide little opportunity for long gravity flows. Therefore, it will be necessary to develop reasonably small gravity flow areas which empty into a pumping station. These stations will then pump the collected wastewater to the ultimate treatment facility.

In the interest of uniformity for such treatment facilities it is necessary to establish certain specifications and performance standards which must be met if the system discharges into the Authority's treatment facilities or is ever to be turned over to the Authority. Systems which are not so constructed would not be acceptable to the Authority. All collection systems should be well constructed so as to have an absolute minimum amount of infiltration. Pumping stations should contain adequate storage capacity for good cycles of operation, both initially and when completely loaded. Pretreatment by trash and grit removal and even pre-aeration, together with good quality pumps, electrical systems, standby power, and flood-proof structures is an absolute necessity. Pumping stations should be sized so as to accommodate the ultimate flows anticipated for the system even though initial flows dictate smaller pumps when first constructed. Such stations must ultimately be capable of being a part of the permanent system with housing compartments which are conveniently maintained and provide for ease in system repairs and replacements.

D. Potential Service Districts

There are areas which now have fair densities of residential units and which are not incorporated as a municipality or are under development by private interests. Where such areas wish to be provided with sewerage service this can best be done by petition to the Board of County Commissioners requesting such service. The best currently indicated procedure would be for the County Commission to form a service district (see Paragraph 4B to include the area desiring service. The Water Authority, as the agency to develop the district, would accomplish planning, development of a program, project construction and provision of service to the area.

A system developed under this method would follow the same requirements as outlined in the preceeding paragraphs. Sewerage would be collected in gravity area systems and delivered to the Authority's facilities.

5. WASTEWATER (SEWERAGE) TREATMENT SYSTEM

A. General Plan

It is proposed that the most efficient and effective treatment facility for the entire Dare Beaches area would be a single regional facility. This point is elaborated upon below. Sewerage collected by the various methods previously discussed would be pumped into a system of pumping stations and force mains extending up and down the island. A wastewater treatment plant would be located in the approximate center of the current loading (vicinity of Wright Monument). All flows would go to this regional plant.

There would be two types of pumping stations; one having screening and grit removal capability and pumping capacity; and the other having the additional capacity of pretreatment (aeration) to accommodate and control such problems as odor, anaerobic development, and the formation of undesirable gases or substances in the wastewater. A system of force mains would be constructed from the pumping stations to the regional wastewater treatment plant.

The regional wastewater treatment plant would provide secondary treatment using a modified activated sludge method with clarification, sludge digestion and disposal (probably incineration) and chlorination.

Treated wastewater effluent would be discharged into the Atlantic Ocean sufficiently offshore to assure no diliterious effect to the bathing beach or to the environment, in accordance with Federal and State regulations.

A map showing the regional wastewater collection and treatment plan is attached at the end of this report.

B. Regional Treatment Plant

Several different plans were considered to accomplish treatment.

(1) The location of several treatment plants in various segments of the island was considered. The use of three plants (Plan A as shown on Plate A following) was considered. Three plants were to be constructed initially, with a fourth in the vicinity of Duck when the need would justify its construction.

(2) Another method of installing a series of small plants was considered. This appears to afford early coverage where demands exist but includes the continuing penalty of much higher capital cost and operating cost. The reclassification of the waters of Currituck, Roanoke and Albemarle Sounds to shellfish waters removes these water areas in the future from being points of discharge for plant effluents. See Plate B for the multi-plant concept.

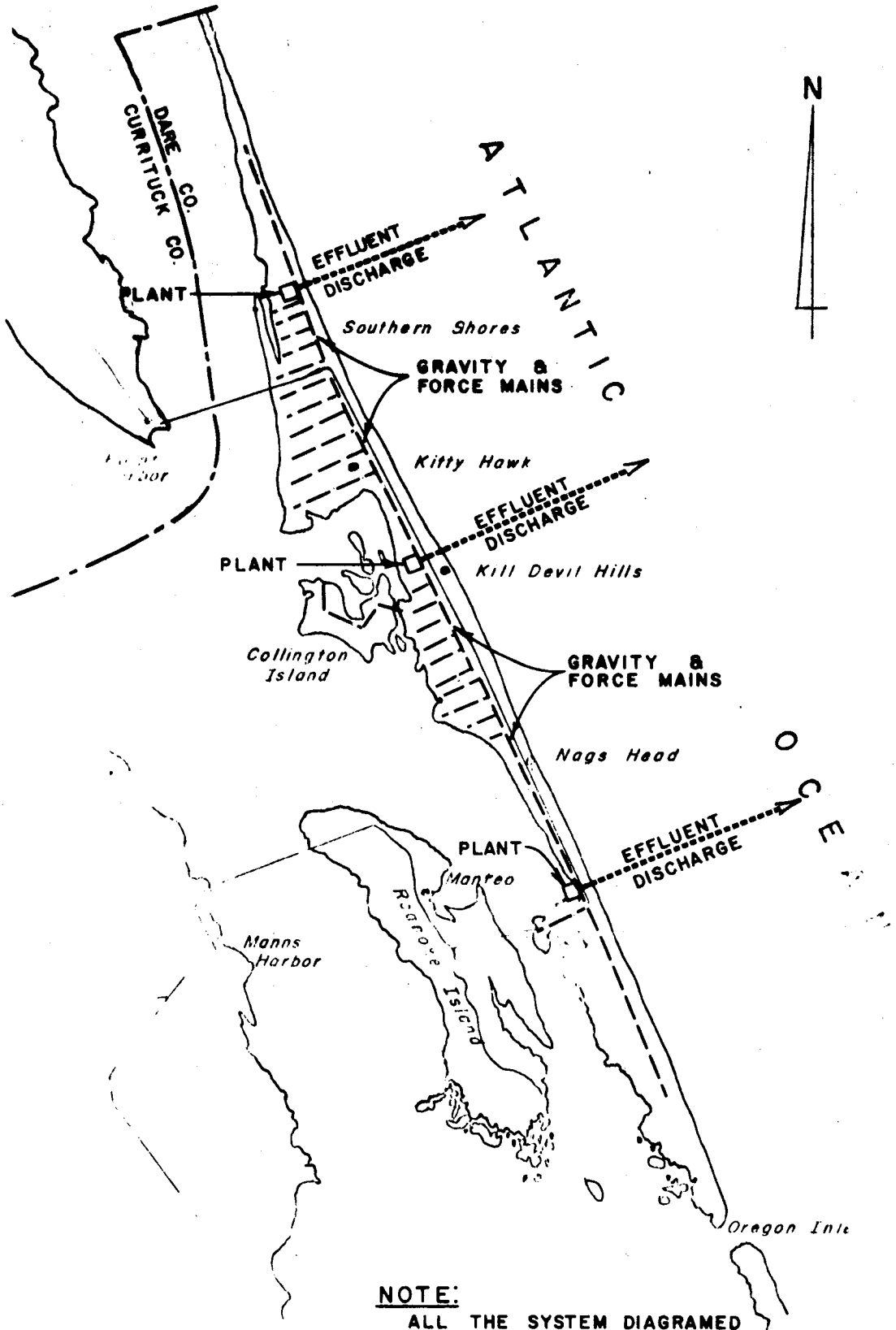
(3) A method of using only one plant was considered. This concept which would actually more nearly conform to the regional plan has been selected as the best plan and is recommended as the regional concept for the study area. This plan is shown on Plate C.

A schedule showing the aforementioned plant concepts follows this page.

C. Regional Wastewater Treatment Plant

(1) General

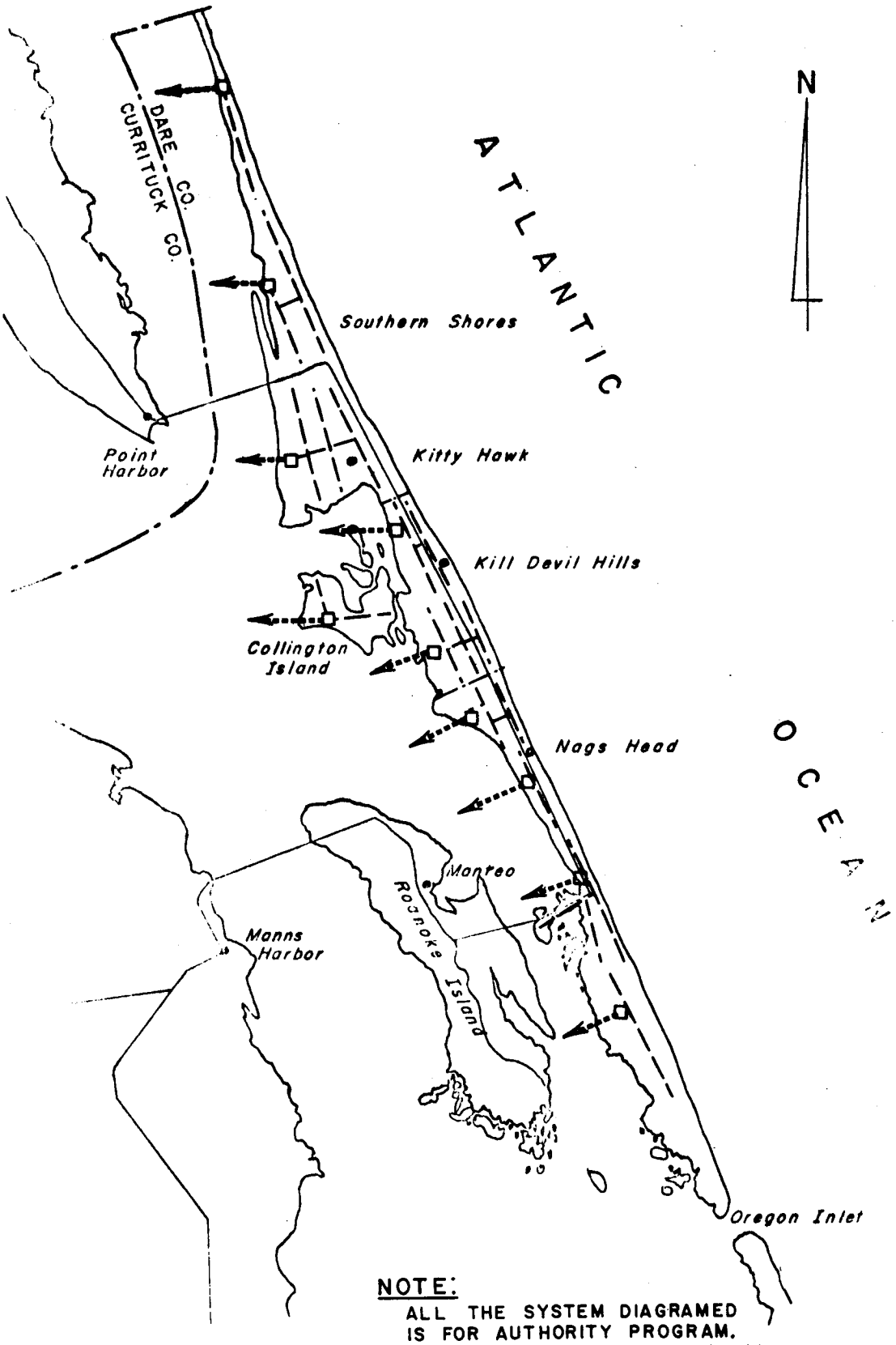
The cost of adequate facilities (capital first costs) together with the ultimate operating cost must be a major consideration in the development of any system. It would appear that the capital cost in waste treatment facilities on Dare Beaches will be influenced largely



NOTE:
ALL THE SYSTEM DIAGRAMED IS FOR AUTHORITY PROGRAM. COLLECTION SYSTEMS NOT SHOWN.

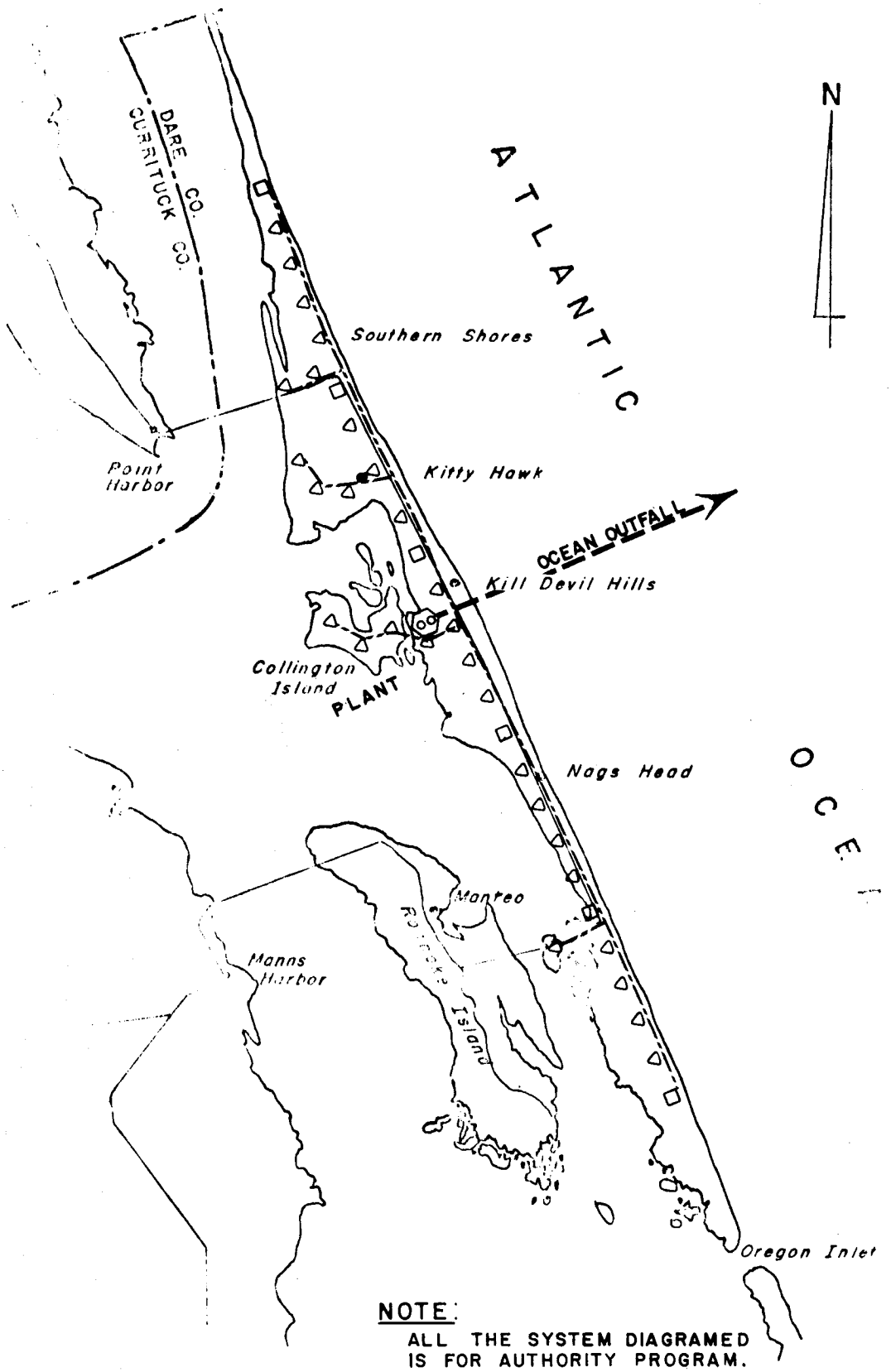
MAP SHOWING PLANT LOCATIONS (THREE PLANTS)

PLATE - A



NOTE:
ALL THE SYSTEM DIAGRAMED IS FOR AUTHORITY PROGRAM. COLLECTION SYSTEMS NOT SHOWN.

MAP SHOWING PLANT LOCATIONS (SMALL PLANTS CONCEPT)



KEY

- △ LIFT STATION
- □ PRIMARY LIFT STATION
- ⬡ REGIONAL SEWERAGE TREATMENT PLANT.

NOTE:
ALL THE SYSTEM DIAGRAMED IS FOR AUTHORITY PROGRAM. COLLECTION SYSTEMS NOT SHOWN.

MAP SHOWING PLANT LOCATIONS
(SINGLE PLANT CONCEPT)

PLATE - C

Plant/Plan	Type of Treatment Required	Land Purchase Required	Discharge of Treated Effluent	Estimated Cost of Pumping Sta. & Force Main	Estimated Cost of Treatment Plants	Estimated Cost of Outfall Discharges	Total Estimated Capital Cost for 5 MGD System	Estimated Annual O&M Costs of System
"A" (Three plants with fourth later)	Initially tertiary with nutrient removal and chlorination; secondary and chlorination to ocean discharge.	10 acres per plant; approximately 100 acres for irrigation; line right of way.	Irrigation initially; ocean outfalls for 1 MGD or greater.	32 Stations $4,100,000	Three $4,100,000	Three ocean $1,800,000	$12,000,000	$265,500
"B" (Approximately ten plants; build as needed)	Tertiary with nutrient removal and chlorination; carbon filtration to 98% for sound discharge.	5 acres per plant; approximately 100 acres for irrigation; 25-50 acres for subsurface disposal; line right of way.	Irrigation initially; sound discharge.	32 Stations $3,600,000	Ten $7,750,000	Ten sound $1,750,000	$15,700,000	$347,000
"C" (One plant; constructed in modulars)	Secondary with clorination for 90% to ocean discharge; if irrigation issued initially, possible tertiary with nutrient removal	25 acres for plant; approximately 75 acres for temporary irrigation; line right of way.	Irrigation initially; ocean outfall for 1 MGD or greater.	34 Stations $4,500,000	One $3,000,000	One ocean $830,000	$11,100,000	$220,000

Note: This comparison is based on a capacity of 5 MGD which will accommodate until about 1985. Plan "C" will allow increase of loading with minimal cost to increase plant capacity. Plans "A" and "B" will require much larger capital costs to accommodate larger flows.

Comparative Schedule of Plant Concepts

Dare Beaches Region

North Carolina

by the problem of effluent discharge. Discharge disposal by irrigation or subsurface methods has a limitation in that it requires use of large areas of valuable land. Irrigation of golf courses or parks is a good solution but has definite limitations in volumes which such areas can tolerate, and in this location, the additional problem of a large differential in flows. Discharge into the large sounds would require a high degree of treatment which would be impossible to afford. In addition, extension of discharge pipelines out to suitable depths would be expensive and of questionable ecological effect. Discharge by outfall into the ocean appears to be the most desirable method. Although the cost of such construction is high the future assurance of the adequacy of the receiving waters and the minimum effect of the effluent on the receiving environment are more clearly predictable. When sufficient loadings are present to justify the construction of an outfall into the ocean this facility can be sized and constructed to accommodate the regional plant, probably until the year 2000 when additional outfall capacity may be required.

(2) Plant Site

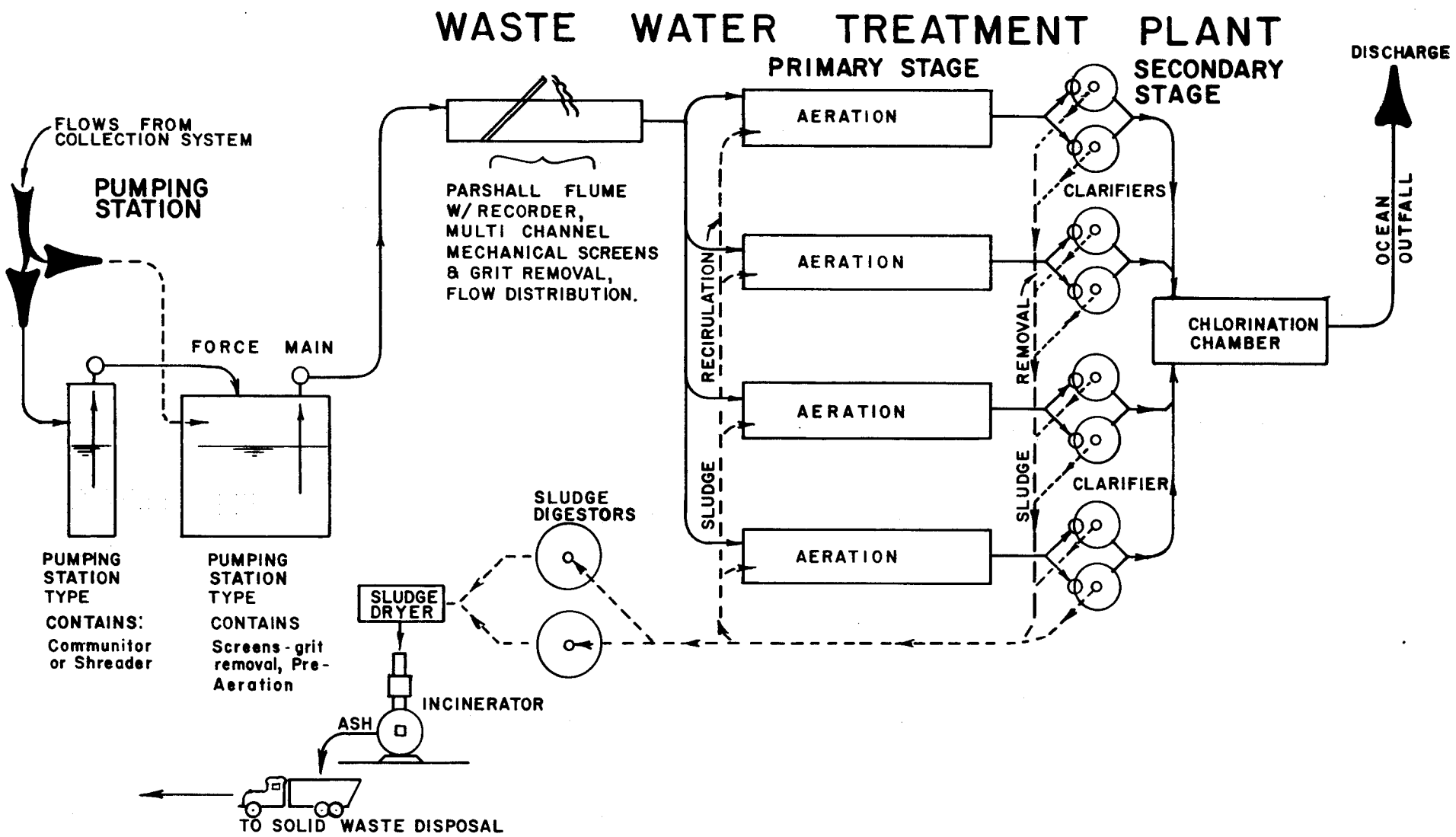
A plant site in the general vicinity of the Wright Memorial is suggested. Lands just inland from the sound shore appear to be less valuable for other uses and would be suitable for a wastewater treatment facility. It is suggested that about 25 acres in a near-square configuration be acquired. If this land could be located adjacent to the government tract which contains the memorial, this would be desirable but not mandatory. The site should have access by roadway eastward to the U. S. Highway 158 By-Pass. The site should be fenced on its perimeter with identifying signs for public information. The original plant should not be located within 1200 to 1500 feet of any existing residence. Future development should be

discouraged within 600 to 700 feet in the interest of avoiding any odor problem which sometimes occurs during periods of rapid weather and temperature changes. The site should be cleared only where required for plant facilities and the remaining areas seeded in rapid growing sea pine or similar evergreen. If initial loadings are not sufficient to justify the construction of an ocean outfall as set out in Paragraph C(3) below it is suggested that an additional seventy-five acres of land be leased for a three to five-year period for use as a spray irrigation or nitrification field area in which to discharge the plant effluent. When the effluent discharge into this area is discontinued the land can be released and will have no loss in value. The irrigation piping or drain field tile can be easily removed and there will be no foreseeable problem from the use of the land. By this time, it will probably have an excellent growth of young trees and grasses which should enhance its use as proposed in the long-term land use plan.

(3) Suggested Method of Treatment

Some degree of pretreatment will have occurred prior to the wastewater influent reaching the treatment facility. The general scheme of treatment is found on the diagram (Plate D) following Page 67. The method of treatment is broadly described as a sequence of secondary grit removal and screening, aeration, clarification, sludge recirculation, aerated sludge digestion, thickening, drying and incineration, chlorination of the clarifier discharge, and discharge into the ocean or to land irrigation. Solids removed by sludge drying and incineration would be a very desirable solution in this plant location. Some sludge drying beds are to be included as a standby emergency backup. Screenings and grit are to be disposed of as solid waste in the process used in the area. The plant will be planned to avoid flooding during storm periods and will be provided

with standby power and auxiliary units to assure continued operation even during power outage periods. While initial discharge of the effluent in an ocean outfall may be by gravity, future loadings will require a pumped discharge and space will be provided for this future addition.



SCHEME OF

REGIONAL SEWERAGE TREATMENT SYSTEM

DARE BEACHES WATER & SEWER AUTHORITY

PLATE-D

PLATE-D

6. TREATED WASTEWATER DISCHARGE

Of the three methods suggested previously, a more detailed discussion of each will assist in their evaluation and reflect the basis for the recommended solution.

A. Discharge into the Sound Areas

Present requirements where discharge is approved into Class S-B waters which have been opened as shellfish waters would require essentially that all BOD and bacteria be removed before discharge. The cost of such treatment is estimated to be from 2-1/2 to 5 times as costly as that of secondary treatment which is proposed in the regional plant described in Paragraph C(3) above.

Where Class S-B waters are not open to shellfish and are shallow near shore the degree of treatment will have to be upgraded to tertiary and will also require nutrient reduction or removal. The treated waste will have to conform to a very low BOD loading and have no bacteria. Such treatment will have a cost of approximately 60% more than for the system proposed. Further, the point of discharge would have to be in water having both a reasonable depth and continuous movement, generally a flow channel.

It is therefore clear that with the higher costs and the possible ecological damage which will occur to the processes of the sound, including fish and shellfish, that this method is neither the most economical or most desirable.

B. Land Discharge

Two methods of land discharge present themselves. Subsurface drain fields and underground filtration and irrigation (spray) discharge

on the surface of the ground using organic growth to accomplish complete oxidation and the soil to filter during the percolation of the effluent into the ground. Either process will require some additional treatment above normal secondary treatment under current practice methods. Either method is effective if not overloaded and is suggested for use with any interim or early plant construction having sizes which do not afford the recommended discharge method as set out below. Subsurface discharge requires the use of reasonably uniform surface land having a low water table, good percolative characteristics and adequately controlled surface drainage. Generally this type of discharge is made at the rate of up to 90,000 gallons per acre per day; however, recently published State guidelines restrict this method of effluent disposal to 24,300 gallons per acre per day.

Spray irrigation requires the use of reasonably uniform surface land which has excellent surface drainage carefully controlled, and which will be suitable for the development of an acceptable organically grown cover growth and which has a reasonable growth of trees. Access for mowing and cultivation are desirable. The wastewater discharge is pumped into the area under pressure through a pipe network and is discharged through standing sprinkler heads which rotate several feet above the ground. Discharge using irrigation is normally at the rate of up to 80,000 gallons per acre per day. Again, the new State guidelines restrict effluent disposal by spray irrigation to 6,789 gallons per acre per day.

Either method utilizes period applications of discharge with absorption or recovery periods between. A perimeter fence must be placed around such facilities and there should be no water supply sources within several hundred feet of the facility.

C. Ocean Discharge

A very critical consideration in the selection of a location for the discharge from a waste treatment facility is the ability of the receiving waters or area to accept the discharge with no degrading effect. The laws regulating discharge require that the discharge shall not contravene the quality of the receiving waters. Most small streams have little capacity to accept such discharges without a high degree of treatment. There is concern and doubt that the shallow sound areas west of the beaches have the capacity to accept the waste which would be discharged at present. Thus, it is not likely that the sounds will have the capacity to accommodate future loads.

The ocean, however, does afford a great capacity to accommodate properly treated effluent from sanitary wastewater treatment plants. The high oxygen content available presents an environment sufficiently aerated to quickly reduce any small oxygen demand in the effluent. Continuous movement and current patterns assure a dilution ratio which is so large that any suspended solids in the effluent do not measurably increase the content of suspended solids in the ocean waters. The high chlorides present present a very hostile environment to any bacteria which may drag out in small floc or small solids in suspension.

More detailed study of the ocean area where the outfall discharge line would be located would be made during the design phase to measure currents, beach profiles, water depths, water quality, and other physical characteristics of the area. For purposes of this report it has been assumed that an outfall about 2500 feet long seaward of the surf zone and located in water deeper than -25 MLW will accommodate the health and sanitation requirements which we feel will be established for this area.

The outfall pipeline would be buried on land and through the beach area to about the ten-foot depth (MLW). It would then be placed in a shallow trench or anchored to the bottom throughout its remaining length to the discharge area.

One or more diffusing outlets would be installed about three to five feet above the bottom to assure good mixing and dilution of the effluent. This diffusion head would be secured with rubble stone placed around the diffuser to protect it from damage by trawlers.

7. ESTIMATED COST FOR REGIONAL COLLECTION SYSTEM AND TREATMENT FACILITIES

Assuming construction of initial 5 MGD sewerage treatment plant, trunk main collector system with all required lift stations and ocean outfall for treated waste effluent, the estimated cost is summarized as follows:

(1)	Pumping stations (34 stations)	$ 2,197,000
(2)	Force mains, valves and fittings	2,209,000
(3)	Pavement and encasements	65,000
(4)	Air release valves	20,000
(5)	Waste Treatment Plant (5 MGD)	3,000,000
(6)	Ocean outfall	831,000
	Total Construction	$ 8,322,000
(7)	Administrative and legal costs	166,000
(8)	Engineering, inspection, testing	665,000
(9)	Land Purchase and right of way	300,000
(10)	Interest during construction	600,000
(11)	Project contingency	1,047,000
	Total Estimated Project Cost	$ 11,100,000

The above cost estimate does not include the individual collection systems that would be required for the towns or other service districts. (These are discussed in the following section). It should also be pointed out that scaling the system down (ie: not constructing the entire system initially), and/or use of land disposal methods at the outset of the project will change this total cost estimate considerably. These various alternatives can be costed when some indication is given as to how extensive the first phase sewerage collection and treatment project will be.

8. COLLECTION SYSTEMS

A. General

Sewerage originates in the dwellings and structures throughout the area and is carried via the structures' plumbing systems to a service pipe extending to a collection system which is usually located in the street adjacent to the structure. The collection system is comprised of a series of gravity flow pipelines which discharge into a trunk collection pipeline, and these discharge into small pumping stations or the Authority's pumping station. The Authority's pumping stations then pump the sewerage to the regional treatment plant.

It is anticipated that incorporated towns will prefer to construct and operate collection systems within their limits. These can be paid for and operated from sewerage fees collected, along with water service accounts at little additional administrative and overhead costs. This also simplifies the control and decision process in utility matters and places utility control in a responsive position to the citizens of the municipality.

It is becoming increasingly apparent that almost all of the unoccupied land in the beach areas will be considered unsuitable for septic tank disposal in the future because of increasing health and sanitation problems. The alternative to completely halting new building construction of all types is to construct a sewerage collection system to service the new areas as well as existing developed areas which are presently served by septic tank systems. Some of these existing septic tank systems are known to operate poorly and all are very costly to maintain.

Where areas are not incorporated but development exists, collection systems will have to be constructed either as a part of a county owned

system or under the Service District concept. This is similar to the procedure set out for water systems on Page 33. These districts are organized by the County government and are managed by an agency appointed by the Commissioners. It is assumed this Authority will be the designated agency to operate such a district.

It is reasonable to state that a sewerage collection system is necessary and should be required in all areas where water distribution systems extend. It is also desirable and recommended that all structures within areas so served be required to connect to both utilities when available within a reasonable period. This period should not be longer than twelve months.

B. Existing Collection Systems (Private)

Where developers or other private interests own and operate a collection system such systems could continue under private ownership for operation and maintenance. When permit requirements require upgrading or stipulate termination of treatment plant operation where the regional treatment system becomes operational, these plants should be removed and the sewerage (wastewater) pumped into the regional system. Where developers or other private owners desire to divest themselves of the collection system it should be conveyed to the Town or Service District in which it is located. However, such systems must be of good quality construction with conventional equipment and be in good condition. When systems are not up to required standards, replacement or upgrading will be required in order to turn over such systems. Systems having ground water infiltration at rates higher than that required under current Environmental Protection Agency (EPA) criteria cannot be accepted without elimination of such infiltration.

C. New Collection System

No planning has been included in this report for collection systems other than to provide some indication of the estimated cost at today's prices to construct a collection system in the towns and service districts listed in Section E below. These estimates are based on populations and construction existing in the last quarter of 1972 and should be esculated about 15% per year cumulative for normal single and duplex housing construction, plus the new group housing projects, such as highrise, townhouse condominiums or apartment complexes. This information is provided for use in discussion by governing boards and residents of areas considering construction of sewerage collection systems in evaluating the economics of such a system.

D. Future Collection and Regional Discharge

Roanoke Island(other than Manteo) is not yet of a sufficient population density (except in the fringes of Manteo) to justify a sewerage collection system. Coverage of adjacent areas to Manteo by the expansion of their system is suggested either by corporate expansion or without such by agreement. When Roanoke Island, including the Town of Manteo, finds the treatment of sewerage and its discharge into the adjacent sound areas has become too expensive to continue it is suggested that their waste be pumped to the regional system on the beaches for final treatment and discharge into the ocean. Croatan and East Lake Townships do not presently have sufficient densities to justify a collection or central treatment system. No study has been made of Kinnakeet or Hatteras Townships. The continued use of high standards of construction of residential septic tanks and the possible future use of small community collection systems at Buxton and Hatteras with high treatment levels should provide the most

economical and desirable solution for waste treatment in these areas.

E. Collection System Costs

As previously mentioned, individual collection systems will have to be funded independently of the Authority's regional trunk main collection system and treatment facilities. The estimated cost for the collection systems that are initially anticipated to become integral parts of the regional system are shown as follows:

Town or Service District	Estimated Project Cost
Nags Head - South	$ 3,000,000
Kill Devil Hills	3,600,000
Kitty Hawk - North	3,150,000
Collington Island	2,050,000

9. ECONOMIC FEASIBILITY

A. General

Previous sections have outlined various wastewater collection alternatives and have indicated the costs associated with what might be termed a "complete initial regional sewerage system" for the Dare Beaches area **(beach communities only).** Until it is determined how many of the initial segments of the system are to be constructed it will not be possible to establish an economic feasibility analysis. The citizens of the towns and other potential service districts will first have to determine whether or not they desire the sewerage service, and how they intend to finance the costs of such systems. When the extent of the service requirements are known it will then be possible to size and cost the Authority's trunk collector system and treatment facilities to accommodate the extent and loadings of the system. In summary, this economic feasibility analysis must await a firm differentiation of the scope and requirements of the project desired by the citizens of the region.

B. Sources of Funds

As far as the Authority's regional system is concerned there are two primary sources of funding assistance available. These are:

(1) Federal grants from the Environmental Protection Agency (EPA). Authorized grants of up to 75% for primary collection systems (force mains, lift stations, etc.), treatment facilities and outfall systems may be obtained.

(2) State grants based on the State Clean Water Bond Act. The Act authorizes 25% grants; however, this was predicated on 50% to 55% Federal grant assistance. In view of the 75% Federal grant (EPA) authorization, the State has adopted the policy of applying an additional

maximum percentage of 12-1/2% (to eligible project items) in State grants if the full Federal grant is obtained.

In addition to the above, the Farmers Home Administration (FHA) is authorized to participate in low cost loans on approved sewerage projects.

C. Interim System Financing

For some time now, the question has been asked as to how an interim sewerage system might be constructed to relieve the sewerage disposal problem in the most critical areas to allow continued orderly development of the Dare Beaches area without creation of additional health and sanitation problems. In view of the time required to plan, finance and construct a complete regional system following normal grant procedures, it has been determined that an increment of the regional system (a portion of the trunk main collection system and the first module of the treatment facility) could be constructed and financed entirely by private capital. These funds would be provided by those developers desiring to continue their planned or proposed development projects, with such facilities constructed and operated by the Authority. The cost to each developer would be determined on a prorata share basis and the completed works would be dedicated to the Authority without incumbrances. Any such system constructed initially would be designed and sized to be entirely compatible with the initial regional system plan. Details on scope, coverage and costs related to this possibility can be determined when there is a firm definition of the collective project requirements by the prospective developers concerned.

PART IV CONCLUSIONS AND RECOMMENDATIONS

I. CONCLUSIONS

A. Phase I - Water Supply Project

Based on the foregoing study and analysis concerning the Phase I Water Supply Project it is concluded that:

(1) The Dare Beaches area is growing and developing at an exceptionally rapid rate. Studies indicate that this growth trend may be expected to continue and even accelerate during the next ten to thirty years.

(2) The present and projected future demand for water supply in the Dare Beaches Area far exceeds the present capacity of existing systems or identified sources of water supply in the immediate barrier beach island vicinity to meet these demands.

(3) Exploration for other sources of water indicate that the most economical source of water supply for the Dare Beaches Area would be from ground water reserves in the southern half of Roanoke Island. These investigations also indicate that additional ground water supplies are available just west of the Manns' Harbor area.

(4) Testing of water samples from these ground water sources (as of the date of this report) do not indicate any need to treat this water, except for possible aeration and chlorination. Hardness is above the desired median standards, but does not appear to be excessive. Further testing is required to determine the quality and quantity (productive capability) of this identified source of supply.

(5) The most efficient and cost effective system for water supply to the Dare Beaches area would be to construct deep wells which would discharge directly into the system with some portion of this discharge being held in ground storage for standby purposes. Elevated storage throughout the system would assure good operating characteristics and accommodate emergency requirements.

(6) Supply to individual distribution systems would be through service pipelines from the source of supply into ground storage reservoirs provided by the users (Towns or Service Districts as appropriate), for further distribution through these systems.

(7) The existing systems in Nags Head and Kill Devil Hills should continue to operate as independent municipal systems for the present time. Areas where no distribution systems exist but are desired should petition the Dare County Board of Commissioners to form a Service District in the area to be served. Authorizing referendums and bond issues will be required to finance these systems. Action should be taken to create the Kitty Hawk (North) service district at the earliest practicable date.

(8) The proposed regional water supply project is technically and economically feasible.

(9) Grant application and loan requests must be submitted to the appropriate State and Federal agencies to finance the proposed regional water supply project.

B. Sewerage Collection and Treatment System Project

Based on that portion of this report related to sewerage collection and treatment it is concluded that:

(1) The concept of one central treatment plant, to which all subregional sewage is pumped and which plant discharges through a single effluent discharge is the most economical, efficient, and ecologically beneficial method of disposing of collected sewerage wastewaters.

(2) The use of an ocean outfall to discharge effluent from the plant is the most desirable and least harmful method of discharge and will not contravene any water classifications in existence or anticipated.

(3) The construction of a sewerage (wastewater) treatment plant to accommodate a wide variation in sewerage flow volumes will result in the most economical and well controlled treatment of sewerage.

(4) Control and ownership of collection systems by towns or service districts will assure justification of need and willingness to afford such service by the town or district concerned.

(5) This proposed regional system will accommodate new construction of high density housing developments such as highrise or town house condominiums, apartments, hotels, motels, or large communal facilities by incremental construction of parts of the regional system.

(6) It would be possible to begin immediate construction of an interim system which would become an integral part of the regional system if such a system could be entirely financed by private capital. Such a project undertaking would require the cooperative, collective sponsorship of interested developers in the Dare Beaches area.

DARE BEACHES WATER AND SEWER AUTHORITY

WEST EIGHTH STREET
NAGS HEAD, NORTH CAROLINA 27959

P. O. BOX 273

TELEPHONE 919-441-5949

REGULAR MEETING

NOVEMBER 5, 1973

AGENDA

I. Call to Order. Quorum.

II. Approval of Minutes

III. Treasurer's Report and Approval of Bills

IV. Old Business

1. Test Wells

2. Engineering Data-Agreement for Professional Engineering Services with Henry von Oesen and Associates

3. Briefings:

a. Manteo Town Council, October 10, 1973

b. Community Leaders, October 11, 1973

4. IRS Protest

5. Fidelity Bond

V. New Business

1. Consideration of Future Actions

2. Amendments to By Laws

3. Election of officers for period November 26, 1973 - November 26, 1974.

VI. Adjournment

Piling

DARE BEACHES WATER & SEWER AUTHORITY
WEST EIGHTH STREET
NAGS HEAD, NORTH CAROLINA

REGULAR MEETING

The regular monthly Board meeting of the Dare Beaches Water & Sewer Authority was held on Monday, October 8, 1973, at the offices of the Authority, West Eighth Street, Nags Head, North Carolina, at 8:00 p.m. with the following members present constituting a quorum:

Arthur V. Peterson, Chairman
Alva F. Rollins, Vice Chairman
Carl P. Nunemaker, Secretary and Treasurer
Ben F. Hill, III

Also present were Mr. Robert G. Byrne, General Manager and Vi Evans of the Coastland Times.

With only a few minor editorial changes, the minutes of the September meeting were approved by a motion made by Mr. Rollins and seconded by Mr. Hill.

The Treasurer's report was presented and approved as follows:

Balance September 10, 1973, after payment of bills $17,263.89

Bills presented for payment:

M. S. Raper & Associates	$ 3.00
Haskett Mobile Homes	150.00
Times Printing Co. (Furniture)	60.00
Norfolk & Carolina Tel & Tel	66.64
VEPCO	23.15
Roanoke Oil & Gas Co., Inc.	19.52
A. V. Peterson, Mileage & Meals	125.10
Federal Tax & FICA	474.70
R. G. Byrne, Salary	504.76
Nancy Snyder, Salary	73.49
A. F. Rollins, Travel, Meals, Lodging	85.11
Total Bills	$ 1,585.47

Deposits:

9/14/73 -	Sale of 2 Economic Studies and 2 Sketch Dev. Plans	28.00
9/21/73 -	Sale of 2 Economic Studies	20.00
9/26/73 -	Nags Head contribution to Dare Beaches W & S Authority for 1st & 2nd quarters FY74	4,450.00
10/5/73 -	Dare County contribution to Dare Beaches W & S Authority for 1st & 2nd quarters FY74	4,450.00
	Total Deposits	$8,948.00

Balance due after payment of bills and depositing of monies (October 8, 1973) $24,626.42

PETTY CASH SUMMARY:

Balance, September 10, 1973	$22.44
50 stamps @ 8¢ each	4.00
2 rolls of paper towels	.34
1 ream of onion skin paper	4.58
Balance as of 8, October 1973	$13.52

Mr. Byrne stated that the employees FICA withholding should not have been deposited with Planters National Bank for forwarding along with the federal tax, but should have been sent to the state separately. This will be corrected in the future, a refund has been requested from The Federal Government and a check has been sent to the state with the FICA withholding.

He also gave a brief report on the Administrative Budget and explained the Authority was staying well within the budget except in one area, the telephone and postage. In this area, we have on the average, been a little over the budget on telephone.

Mr. Nunemaker moved that the above Treasurer's report be approved and the bills paid, seconded by Mr. Rollins and unanimously carried.

Mr. Peterson suggested the Authority setup a record showing the cumulative balance of each item in the administrative budget. Mr. Byrne stated Mr. Johnson, the Authority CPA will assist him in October when the Authority's accounts are audited.

Under Old Business, the test wells were discussed. Mr. Peterson announced that it is essential that the Authority get another site immediately. He reported that he and Mr. Byrne found many sites, but for variable reasons, they were not obtainable. He urgently requested the help of all of the Authority members in the search for a suitable test well site at the earliest possible date. He noted that we are in grave danger of having the Carolina Well & Pump Company leave for other drilling operations in South Carolina if we don't have a second site ready in the very near future.

Mr. Byrne gave a report on the present test well. He stated it is down about 200 feet and has pumped as high as 700 gallons per minute. The water is good tasting, clear and appears to be in great quantity. Test pumping should begin on October 10th and be completed by October 12th.

Mr. Byrne reported that he had heard nothing further from the CPA, Speight Burrus, regarding the status of the Authority's request for relief from payment of federal income tax.

Mr. Rollins indicated that he had reviewed the file on this matter and it was his belief that the authority filed its request for relief under the wrong criteria.

The Vice Chairman volunteered to look into the matter with the IRS during his forthcoming trip to Washington. He stated it is possible that the IRS might allow the Authority to withdraw its request for tax exemption after he shows them the clear cut definition of the Authority's statutory status. He noted that this would pave the way for the Authority to reopen the matter under the proper criteria.

Mr. Peterson expressed the Board's appreciation for Mr. Rollins' offer to go to Washington to settle this matter.

Mr. Byrne gave a brief report on the submission of the "Test Well Progress Report to the CPRC." The Authority hopes to have a final report on the first test well by the end of October.

Under New Business, the Chairman discussed the results of the meeting held in Raleigh with the Local Government Commission on October 2, 1973, which Mr. Rollins, Mr. Byrne and he attended. A Memorandum for Record of this meeting, prepared by Mr. Peterson, was given to the members to read and discuss.

Pertinent extracts of Mr. Peterson's Memorandum for Record which were discussed with board members are as follows:

The Water supply system will be designed to meet the projected 10 year peak capacity requirements, i.e. 5mgd. A small supply system will neither be financially feasible nor practical for the Dare Beaches area.

Financing the water supply system will involve the following sources of funding is possible:

Federal grants
State grants
General Obligation Bonds (issued by Dare County)

Financing Distribution Systems will involve the following sources of funding:

State grants
General Obligation Bonds (issued by Dare County)

Separate General Obligation Bonds will be issued by Dare County for:

The Water Supply System
Distribution Systems

Service Districts will be established by the County, as required, to facilitate the provision of the water supply system and distribution systems. Establishment of such Service Districts will make it possible for the County to issue General Obligation Bonds for the supply and distribution systems and to tax the Districts if necessary, and as may be appropriate, for the payment of obligations, separately from the remainder of the County.

Dare County has the authority to require mandatory hook-up to water distribution systems of all users in the Dare Beaches area. Such authority makes it possible to firm up demand for water and so facilitate the sale of bonds.

In considering future actions to be taken by the Authority the board discussed the need to find out where the Authority stands in obtaining grant funds from EDA. All agreed that in order to determine how much additional money must be obtained by issuance of general obligation bonds, assessments, or taxes it is necessary that the Authority know whether or not it may still expect an EDA grant.

Mr. Peterson also discussed possible future contacts with State officials and State and U. S. Congressional personages in order to determine the availability of EDA grant money. In this regard Mr. Peterson stated he would prepare a background memorandum concerning the Authority's objectives so that it could be hand carried by the County Commissioners and presented to the Governor on their next visit to Raleigh.

The purpose of the memorandum would be to ensure that the Governor would be aware of the Authority's project in the event he were to be contacted by either State or U. S. Congressmen concerning the matter.

Mr. Byrne announced the briefing to be given by Mr. Paul Denison of Henry von Oesen & Associates on October 10, 1973 to the Manteo Town Council. Mr. Denison's briefing will be generally the same briefing previously given the leaders from Kitty Hawk last August.

Mr. Byrne also announced a briefing that is to be given in Manteo by Mr. Denison for the Dare County Commissioners and Community Leaders from the three towns. Mr. Denison will give an updated briefing based on the Authority's meeting with the Local Government Commission in Raleigh on October 2nd.

Mr. Peterson informed the Board that it appeared that it would be beneficial to re-distribute funds for certain items in the budget. He noted that the estimated cost of $15,000 for "Water Supply Production Test Wells" was too low and that in other areas our estimates had been a little high. At this time Mr. Peterson asked Mr. Byrne to explain the situation to the Board. Mr. Byrne by means of charts informed the Board that the revised estimated cost of the two test wells was now $19,910 an increase of $4,910 over the original estimate of $15,000. He stated that it now appeared the two test wells would cost $17,760 plus an estimated $2,150 for site preparation, land survey, and options taken on the sites. Mr. Byrne further pointed out that in two budget items funded by the State we apparently had a surplus, the two areas being $2,800 for engineering and consulting services and $2,110 that was left over after payment of the Stephens and Associates' bill.

After Mr. Byrne concluded his talk, Mr. Peterson recommended to the Board that the budget be amended by transferring $2,800 provided by the State for engineering consulting services and $2,110 provided by the State for the Economic Feasibility Study to Water Supply Production Test Wells.

Mr. Nunemaker moved that the Chairman's recommendation for transfer of funds be approved. The motion was seconded by Mr. Hill and unanimously carried.

The Chairman further reported that the Authority's attorney, Mr. Tom White again spoke to Mr. Balfour Baum with reference to obtaining a well site from him. Mr. Peterson indicated that it was possible that we may be able to work out a satisfactory boundary line by establishing a line, measuring off an extra 50 feet and then marking off the 200 feet by 200 feet site. The additional 50 feet would be acquired to off-set any error in the questionable boundary as it now exists.

Mr. Rollins moved the meeting be adjourned, his motion was seconded by Mr. Hill, and unanimously carried. The meeting was adjourned at approximately 10:00 p.m.

_____
Secretary

Attest

_____
Chairman

DARE BEACHES WATER AND SEWER AUTHORITY
EXPENDITURES COMPARED WITH BUDGET
JULY 1, 1973 - OCTOBER 31, 1973

FISHER-HARRISON PRINTING CO., GREENSBORO, N. C.

	BUDGET	ACTUAL EXPENDITURES	REMAINING BUDGET
SALARY AND WAGES	16 800 00	2 583 96	14 216 04
PROFESSIONAL SERVICES:			
ACCOUNTING	600 00	-	600 00
LEGAL	600 00	-	600 00
SECRETARIAL	300 00	292 88	7 12
FICA	1 000 00	107 25	892 75
TELEPHONE & POSTAGE	1 200 00	221 81	978 19
PRINTING & COPYING	1 000 00	40 05	959 95
UTILITIES	400 00	93 21	306 79
TRAVEL	1 500 00	433 34	1066 66
MAINTENANCE & REPAIR	300 00	-	300 00
BUILDING & EQUIP. RENT	3 100 00	908 50	2 191 50
SUPPLIES & MATERIALS	600 60	240	597 60
INSURANCE AND BONDS	100 00	-	100 00
MISCELLANEOUS	1 000 00	917	990 83
	28 500 00	4 692 57	23 807 43

2. RECOMMENDATIONS

Based on the findings and conclusions of this report it is recommended that:

A. The Dare Beaches Water and Sewer Authority approve this preliminary engineering report and take the necessary steps to initiate the Phase I Regional Water Supply Project.

B. The Authority obtain the necessary concurrances of the sponsoring governmental bodies to proceed with the proposed project.

C. Notices of intent and grant and loan applications be submitted to the appropriate State and Federal Agencies to obtain the required financial support for the project.

D. An immediate program be launched to determine the desires of the citizens of the towns and other potential service districts for both water and sewer projects.

E. Based on the results obtained from D above, actions should be initiated by the towns, citizens of the prospective service districts, and private developers to implement their respective projects in conjunction with the proposed regional systems.

Respectfully submitted,

HENRY VON OESEN AND ASSOCIATES, INC.
Consulting Engineers & Planners

By_____
Henry M. von Oesen, P. E.

BIBLIOGRAPHY

MOORE, GARDNER & ASSOCIATES, INC.; Comprehensive Water and Sewer Study, Dare County, N. C.

N. C. DEPARTMENT OF NATURAL & ECONOMIC RESOURCES, Community Service Division, Northeastern Field Office; Dare Beaches Sketch Development Plan; March 1973.

N. C. DEPARTMENT OF NATURAL & ECONOMIC RESOURCES, Office of Water & Air Resources (Ground Water Division); Potential Ground Water Supplies for Roanoke Island and the Dare County Beaches (Report of Investigations No. 9); 1972.

N. C. DEPARTMENT OF WATER RESOURCES, Division of Ground Water; Report of Investigations No. 3, Ground Water Supply for the Dare Beaches Sanitary District; Jack O. Kimery, 1961.

N. C. DEPARTMENT OF WATER RESOURCES, Division of Stream Sanitation and Hydrology; Bulletin 2, Chemical and Physical Character of Municipal Water Supplies in North Carolina; 1961.

N. C. STATE UNIVERSITY, Department of Economics; An Economic Study of Dare County, North Carolina; Hayes & Swanson, April 67.

STEPHENS ASSOCIATES; Economic Study of the Dare Beaches; March 1973.

U. S. DEPARTMENT OF COMMERCE, National Technical Information Service (NTIS), National Water Commission (PB-209942); Desalting; May 1972.

WATER RESOURCES RESEARCH INSTITUTE, University of North Carolina; Analog Modeling to Determine the Fresh Water Availability on the Outer Banks of North Carolina; George J. Kriz, (Report No. 64), April 1972.

WATER RESOURCES RESEARCH INSTITUTE, University of North Carolina; Regional Development of Public Water Supply System; by John M. Higgins and Daniel A. Okum (Report No. 72), September 1972.

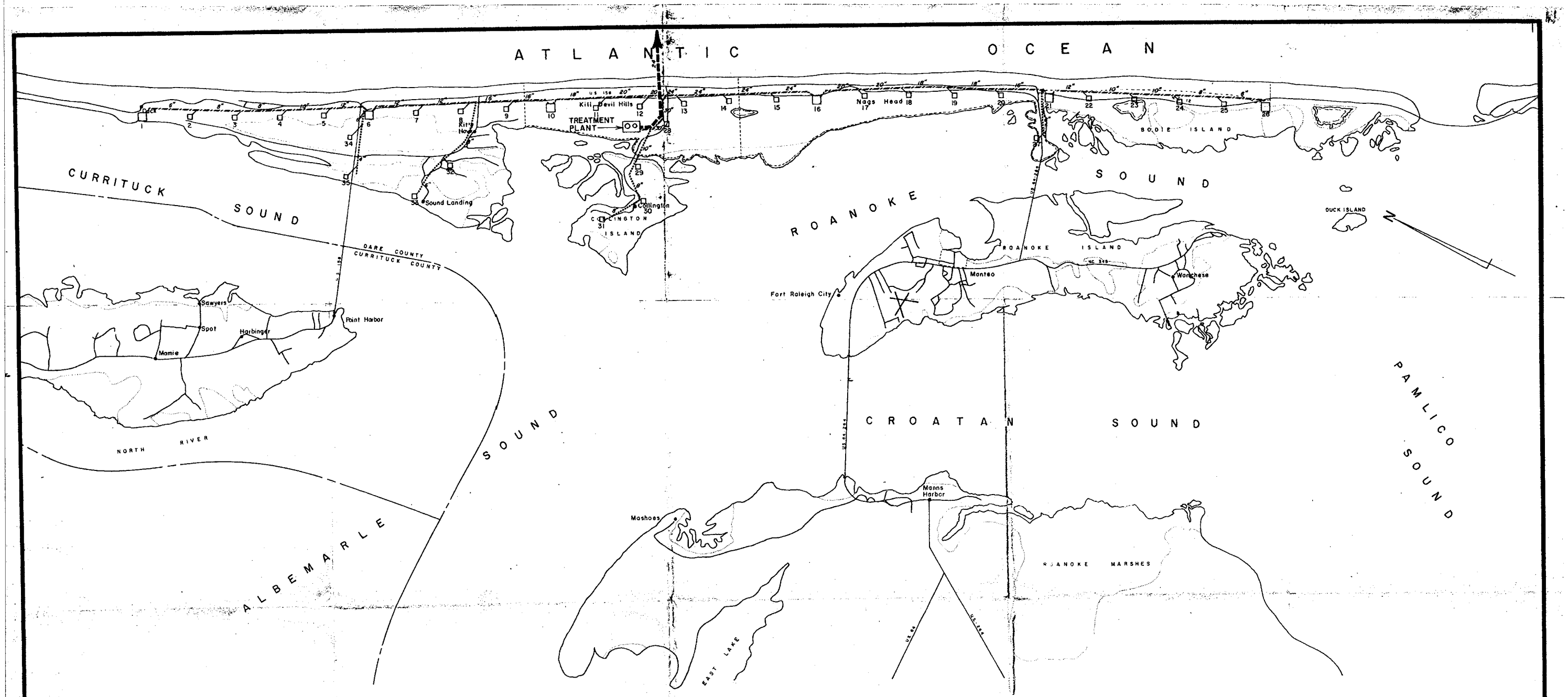
METCALF AND EDDY, INC. "Wastewater Engineering", 1972 (McGraw-Hill)

BIBLIOGRAPHY (CONT'D)

N. C. STATE BOARD OF HEALTH; Standards and Criteria for Design and Construction of Public Water Supply Systems to Serve Residential Communities; 1972.

N. C. DEPARTMENT OF WATER AND AIR RESOURCES; Laws of North Carolina Relating to Water and Air Resources; 1971.

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE, Public Health Service; Manual of Septic Tank Practice; 1967 Revision.



LEGEND:

- PRIMARY LIFT STATION (With Pre-treatment)
- SECONDARY LIFT STATION
- TRUNK FORCE MAIN
- SECONDARY FORCE MAIN
- TREATMENT PLANT
- OCEAN OUTFALL

SYMBOL	DATE	DESCRIPTION	BY
REVISIONS			

DARE BEACHES WATER & SEWERAGE AUTHORITY
DARE COUNTY, N. C.

REGIONAL WASTE WATER COLLECTION & TREATMENT PLAN

HENRY VON OESEN & ASSOCIATES
CONSULTING ENGINEERS
WILMINGTON, N. C.

SEAL	DES.	FILE NO. 1726
	DRWN.	
	CHK.	SHEET
	DATE	OF