*POTABLE WATER FEASIBILITY REPORT*
*FOR*
*RODANTHE-WAVES-SALVO*
*DARE COUNTY, NORTH CAROLINA*

*BOARD OF COMMISSIONERS*

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*Revised June 1993*

*B&V Project 23578*

I HEREBY CERTIFY THAT THIS REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION.

SIGNED, SEALED, AND DATED THIS 2nd DAY OF JUNE 1993.

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# 1.0 SUMMARY, CONCLUSIONS, AND RECOMMENDATION

## 1.1 PROJECT COST

The overall project cost opinion is $6,000,000 or $7,060 per connection based on all of the potential users connecting to the water system. A contingency of approximately 10 percent has been added to the construction and development costs. Also, $700,000 has been included in the overall project cost opinion for interest during the construction and development period. These factors provide a conservative cost opinion.

## 1.2 PROJECT FINANCING

It is suggested that the initial tap fees be in accordance with the present Dare County policy, and that these funds be used in the initial years to help defray the debt requirements. The cost of taps for 761 connections ($280,750) is included in the overall initial capital cost budget. Additionally, it is suggested that each lot be assessed $1,000 to cover the cost of the water distribution system. Once the system is operational new connections will come under the County's policy for payment of the $2,000 impact fee plus the cost of service tap. The $1,000 assessment per lot will be set up so that the property owner may pay it over a five-year period at a reasonable interest rate - something in the range of 6 percent.

Annual lease-purchase payments will average approximately $510,000 per year for twenty years based on an overall project cost of $6,000,000.

## 1.3 USER COST

Revenues have been projected on an average annual daily water usage of 135,000 gallons, while the O&M cost for treatment of water has been based on an average annual daily water usage of 310,000 gallons. This difference in volume is due to the question of just how much water will be used by the tourists and seasonal inhabitants over a twelve month period. This will cover the higher use of O&M and the lower use for revenue. Water rates used in calculating revenues are the same as currently used on the Dare County Water System - $15.00 minimum for 3,000 gallons and $4.00 per 1,000 gallons for all over 3,000 gallons per month. Revenues have been figured low purposefully in order to be conservative.

Average water bill is based on approximately $21.00/month for annual revenue projection - this includes restaurants, motels, campground, as well as residential.

## 1.4 WATER SYSTEM DESIGN

It is proposed to use deep wells for the water supply with reverse osmosis treatment to remove the chlorides and dissolved solids. The plant will have an initial RO capacity of 1,000,000 gallons per day, with the ability to be expanded.

Storage will be provided by means of 200,000 gallons in an elevated tank and 1,000,000 gallons in a ground level tank.

The distribution system will be comprised of a basic 12-inch diameter line along Highway 12 through the three villages, with other lines being 2 inches through 8 inches in diameter. Fire hydrants will be placed an average of 500 feet apart along all lines 6 inches and larger in diameter. As proposed, the distribution system can deliver 1,800 gallons per minute of water with a minimum pressure of 35 pounds per square inch. This translates into the ability to meet the peak day demand and deliver 500 gallons per minute fire flow at the same time. Based on the population projections set out in the Carrying Capacity Report, the system as proposed would be adequate to the year 2010.

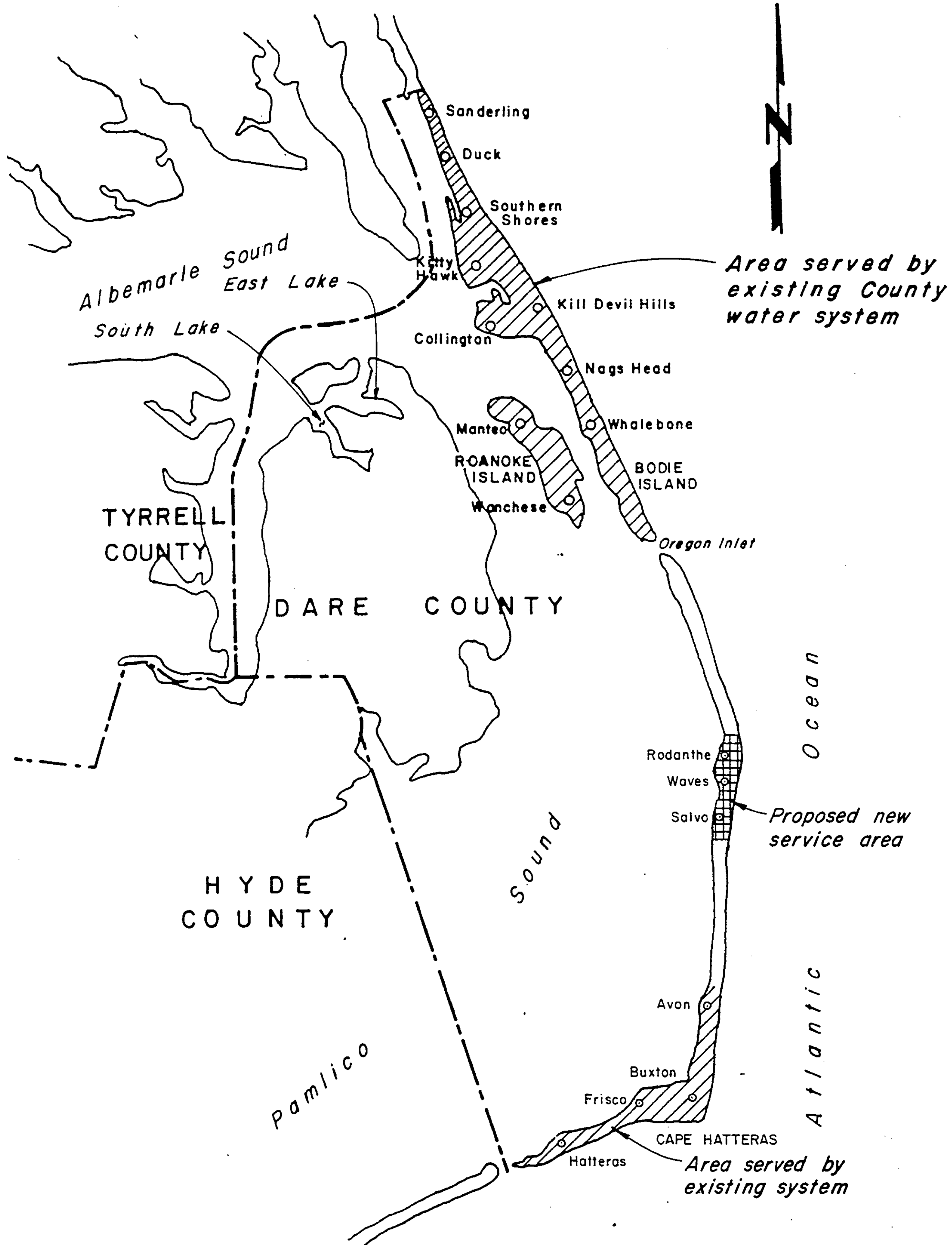



Figure I-1: STUDY AREA

# 2.0 INTRODUCTION

## 2.1 PURPOSE AND SCOPE

In 1982, Dare County initiated a study to investigate the water supply and treatment alternatives available to serve Rodanthe, Waves, and Salvo. This report is based on the alternative Dare County selected to supply the area's water needs.

This alternative was selected because it would supply the area's water needs beyond the foreseeable future and use new technology for treating the water supply.

The scope of this study includes (1) population projection, (2) water requirements, (3) water facilities needs and cost analysis, and (4) the project financing.

The study period covers the years through 2010.

## 2.2 RELATED REPORTS

Reports reviewed and considered under this study or related this study are as follows:

- Comprehensive Engineer Report, Black & Veatch, Inc., Asheboro, North Carolina, 1984.
- Water Supply and Treatment Alternatives, Black & Veatch, Inc., Asheboro, North Carolina, 1987.
- Well Test Analysis Report, Groundwater Management, Inc., Kansas City, Kansas, 1986.
- The Carrying Capacity Study, Booz, Allen & Hamilton, Inc., Bethesda, Maryland, 1986.
- Water Supply and Treatment Alternatives - Rodanthe-Waves-Salvo, Moore, Gardner & Associates, Asheboro, North Carolina, 1982.

# 3.0 POPULATION PROJECTION AND WATER REQUIREMENTS

## 3.1 POPULATION PROJECTION

The population of the study area was taken from the Comprehensive Engineering Report, (Black & Veatch, Inc., Engineers-Architects, Asheboro, North Carolina, 1984) and The Carrying Capacity study, (Booz, Allen and Hamilton, 1986). Both reports projected the permanent and seasonal population as illustrated in Table 3.0. The population projections are relatively close in both reports.

The area is experiencing moderate growth and this trend is expected to continue. Therefore, the medium growth projection in Table 3.0 will be used to determine the water requirement of the area.

## 3.2 WATER REQUIREMENT

Water usage rates vary during different times of the day and periods of the year. Demand rates are defined by the following terms:

Annual Average Day. Computed by dividing the total annual water production by 365. This value id useful in determining annual operation and maintenance cost, and long-range water resource requirements.

Maximum Day. The maximum amount of water used in any 24-hour period. This number is used to determine treatment plant capacity. A water system would be capable of supplying the maximum day demand without depleting storage. Also, raw water supply facilities must be capable of delivering the maximum day demand.

Maximum Hour. The average amount of water used in a peak period during a maximum day (or near maximum day). Typically, it occurs during late afternoon and early evening for a duration of 3 or 4 hours. Although it occurs for only a few hours, this demand is usually expressed in the same units (mgd) as maximum day and annual average day. This number is used to size distribution mains, and pumping and storage, since storage reservoirs are used to supply the difference between maximum day and maximum hour rates.

Average Off-Season Day. Computed by dividing the total water production from October through March by 182 days. This value is used to determine water requirements and the approximate system needs during off-peak periods.

Average Peak-Season Day. Computed by dividing the total water produced from June through Labor Day by 97 days. This value is used to determine sustained peak usage, which is useful in determining staffing, treatment chemical inventories, and preventive maintenance schedules.

Ratios. The ratios of Maximum Day, Maximum Hour, Average Off-Season Day, and Average Peak-Season Day to Annual Average Day (MD/AAD, MH/AAD, AOSD/AAD, and APSD/AAD) are all useful for projecting future water requirements and for recognizing changes in water use patterns. These ratios will fluctuate from year to year, but, in a stable water system, will remain fairly constant. A consistent change (up or down) in any of these ratios indicates a change in water use patterns, often caused by changing water system socio-economic status or by changes in industrial or commercial water users. Thus, these ratios can be used to improve the accuracy of future water requirements projections.

The projected future water requirement is shown in Table 3-1. The projections for maximum day are based on 105 gallons per capita per day and the medium population projection of The Carrying Capacity study of Section 3.0.

TABLE 3.0
POPULATION PROJECTION, PERMANENT AND SEASONAL

| | 1985 | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|---|
| Comprehensive Engineering Report (1984) | 4,123 | 5,876 | 6,000 | | 6,1607,339 |
| Carrying Capacity Study (1986) | | | | | |
| Low Growth | 5,555 | 5,813 | 6,151 | 6,514 | ---- |
| Medium Growth | 5,555 | 6,116 | 6,850 | 7,806 | ---- |
| Rapid Growth | 5,555 | 6,963 | 9,028 | 11,942 | ---- |

TABLE 3-1
WATER REQUIREMENTS (mgd)

| | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| Maximum Day (1) | 0.72 | 0.82 | 0.92 | 1.02 |
| Maximum Hour (2) | 1.44 | 1.64 | 1.84 | 2.04 |
| Annual Average (3) | 0.22 | 0.25 | 0.28 | 0.31 |

(1) 105 gpcd

(2) 2 times Maximum Day

(3) 0.30 times Maximum Day

# 4.0 WATER FACILITIES DESIGN

## 4.1 WATER SUPPLY

The existing water supply in the Rodanthe, Waves, and Salvo area consists of individual shallow wells of the upper water table aquifer that are mainly captured rainfall. A previous study estimates that approximately 25 percent of the annual rainfall (45 inches) is retained in this aquifer as a potential water supply.

Previous studies have also identified a need in this area for a safe and dependable potable water supply that would serve current and future development.

Within the past several years, Dare County has initiated an extensive study of the groundwater resources on the Outer Banks. The study is being conducted now on the northern section of the Outer Banks near Kill Devil Hills. The data already collected will be used in this study to determine the needs in the Rodanthe, Waves, and Salvo area. This data would typically represent the general condition of all of the Outer Banks and should be sufficient for the planning purposes described in this report.

### 4.1.1 Groundwater Exploration

In order to determine whether any groundwater exists which can be treated by desalination, a testing project was undertaken. A test well was drilled in Rodanthe approximately 300 feet south of the Chicamacomico Lifesaving Station. The well drilling anticipated finding the same aquifers that were found in the test well drilled in Kill Devil Hills for the northern Dare County desalination project, although the aquifers were expected to be deeper due to the general slope of the geological plates. The drilling located the following aquifers.

- Upper Aquifer. This is a watertable aquifer, located approximately 8 to 30 feet deep. This contains fresh water, and is currently used as the primary water source for private wells in the three villages.

- Lower Aquifer. This is a confined aquifer of loose sand, located approximately 200 to 250 feet deep. The water, as tested at a depth of 211 to 216 feet, has the same salinity as seawater. Apparently there is a direct connection between this water and the Atlantic Ocean.

- o <u>Yorktown Aquifer</u>. The Yorktown aquifer was found at elevations 330 to 600 feet, or about the same depths as in Kill Devil Hills. The water is of varying quality, from moderately brackish at the top to half seawater strength at the bottom.

- o <u>Castle Hayne Aquifer</u>. The Castle Hayne aquifer was not found, although drilling continued to a depth of 1,400 feet. Further drilling was not done since, in all likelihood, the water would be highly saline and deep well drilling costs would be too great.

The Yorktown aquifer at the test well consists mainly of confined sand. Driller's observation of the aquifer indicates that the well could yield in excess of 1,000 gpm, not considering the effect on water quality. Water samples were taken from 332 to 342 feet deep and 507 to 517 feet deep. These samples were analyzed both at the well head and in the laboratory, and the results of these analyses are shown in Table 4-6.

The characteristics of the aquifer were further studied by setting an 8-inch well screen at a depth of 300 feet to 450 feet, and conducting pump tests. An 8-inch diameter stainless steel casing increased to 12-inch diameter to accommodate the pump. The pump tests conducted were step drawdown, 24-hour pumping and recovery, and a long-duration pumping test. The latter test was performed to assess the potential for salt water intrusion and hydrologic connections between aquifers. The pumping rate for the 24-hour and long-duration tests was 450 gpm, or less than half of the driller's estimate of well capacity. This pumping rate and the screen setting depth were selected to attempt to draw only from the top part of the aquifer and limit the TDS of the potential supply to 2,500 mg/l or less. The long-duration pump test was terminated after 11 days due to equipment problems, although it was originally intended to pump for 15 to 20 days.

### 4.1.2 <u>Quality</u>

Table 4-7 shows the results of analyses of water samples from the test well during the long-duration pump test. Analysis consisted of tests at the well head for silt density index, temperature, pH, turbidity, and iron concentration. These tests were made each weekday during the test. Samples were also collected and sent to the laboratory at approximately weekly intervals, to be analyzed for a broad range of constituents which are factors in desalination process design.

The analyses show that the water is slightly brackish, high in alkalinity and TOC, and relatively high in silica and fluoride. Iron concentration is relatively low, and no problems are anticipated with iron scaling of reverse osmosis membranes. The high level of alkalinity, when combined with the low calcium concentration, does pose a problem. The finished water will be corrosive due to the excellent removal by membranes of calcium and alkalinity but not carbon dioxide. To compensate, the treated water will require post treatment of degasification for carbon dioxide reduction, followed by the addition of lime or caustic soda to raise pH to stabilize the water. Blending of raw water with RO permeate will also help to stabilize the treated water, but blending may be limited by other factors.

Additional aspects of water quality which require careful consideration are the relatively high levels of TOC and turbidity. It is possible that rapid sand filtration will be required to remove these constituents ahead of the RO membranes in order to protect the membranes. The possibility of blending some untreated raw water with RO permeate might be limited due to the TOC and turbidity. A pilot plant study would be helpful to determine the effect of these constraints, but is not essential.

The evaluation of the water quality of the Yorktown aquifer in Rodanthe shows that treatment of this water by a desalination process is feasible. There are no constituents in the water which would prohibit its use as a feedwater for desalting. However, the plant design should carefully consider all factors listed above to make certain that the plant can successfully treat this water.

#### 4.1.3 Quantity

The quantity of water which can be withdrawn from the Yorktown aquifer for treatment in the area of the three villages, from either a single well or from a well field depends on the geological characteristics of the formation, the amount of water stored in the aquifer, and preservation of water quality. As mentioned previously, the physical characteristics of the formation will allow high yielding wells, in excess of 1,000 gpm, and perhaps as high as 2,000 gpm. This is confirmed by drawdown measurements during pump testing.

The apparent specific capacity of the completed well is 20 gpm/foot. At a well yield of 1,000 gpm, the drawdown is 50 feet. This is within usual well design parameters.

Due to the relatively small raw water requirements for this area, a detailed study of overall aquifer characteristics was not made. Comparison of this part of the aquifer with the detailed information about the aquifer obtained from the test well in Kill Devil Hills indicates that the raw water requirements of Rodanthe-Waves-Salvo can be met from the Yorktown aquifer. However, as a part of any well field design associated with implementation of a desalination plant, further evaluation of aquifer yield, well spacing, and well design should be made from data gathered during the well test.

4.1.4 Facilities Required

4.1.4.1 Wells. The projected wells required for the design period are shown in Table 4-1.

As illustrated, two wells will be sufficient to supply the area's needs through 2010. However, this is based on an average well production of 450 gpm. A test well has been constructed on a four-acre site at the north edge of Rodanthe in order to verify both quantity and quality of water supply for reverse osmosis treatment.

It is also projected that one additional well be provided to serve as a back-up for emergencies. This well could be delayed until sufficient data is available to determine when it actually will be needed. GMI, a groundwater consulting firm, analyzed the data of the test well near Kill Devil Hills. GMI's typical well construction design is shown in Figure 3. This typical well design was used to determine the probable well construction cost shown in Table 4.3.

4.1.4.2 Raw Water Transmission Main. No significant raw water transmission main will be required, since only two wells are required. Raw water piping should be of inert material, preferably PVC or fiberglass.

4.1.4.3 Pretreatment. The pretreatment normally required for a groundwater desalination plant is less stringent than for desalination of surface water.

TABLE 4-1
PRODUCTION WELLS REQUIRED

| Design Year | Water Demand (mgd) | Well Capacity (mgd) | No of Wells* |
|---|---|---|---|
| 1995 | 0.72 | 1.29 | 2.00 |
| 2000 | 0.82 | 1.29 | 2.00 |
| 2005 | 0.92 | 1.29 | 2.00 |
| 2010 | 1.02 | 1.29 | 2.00 |

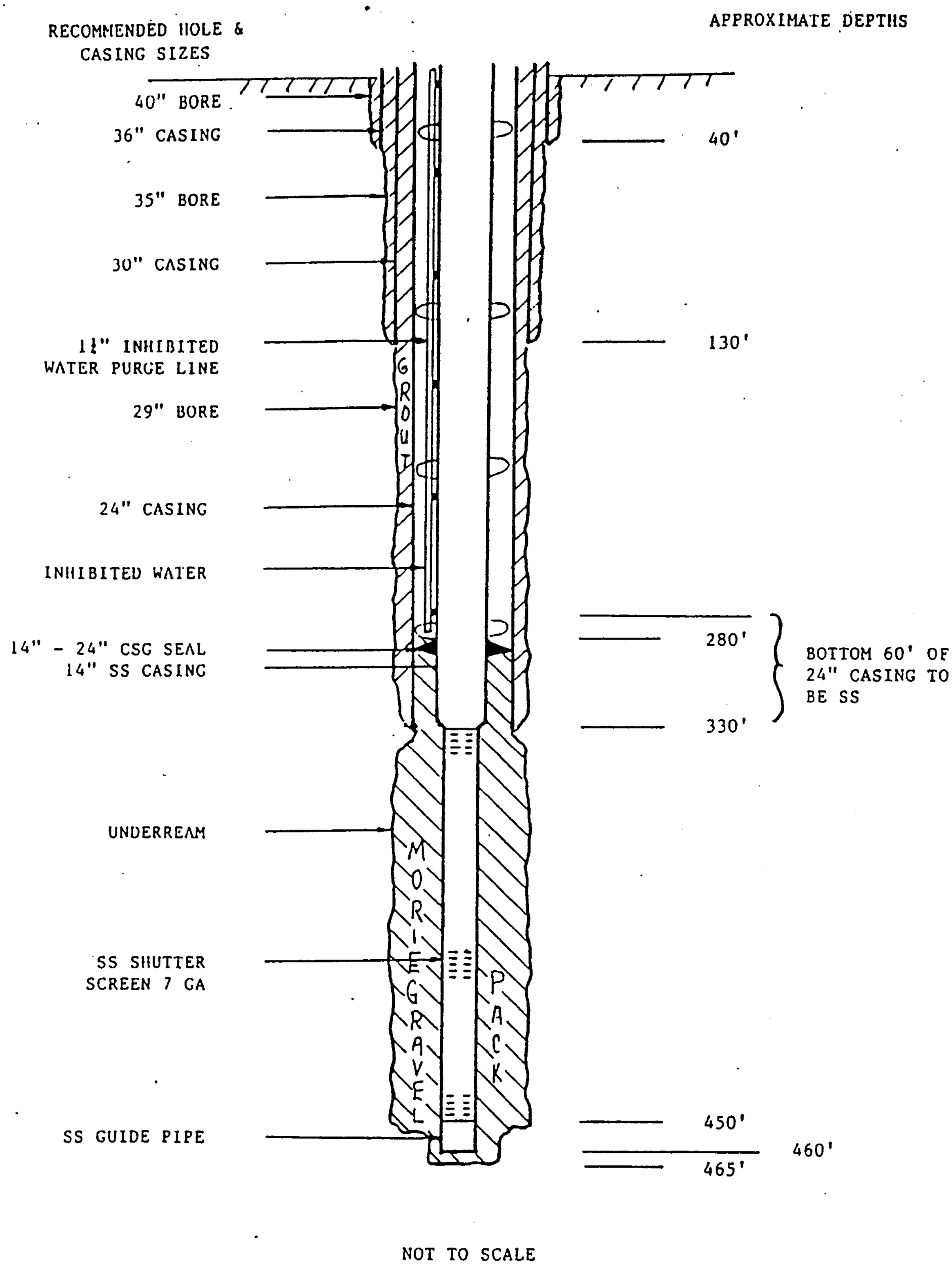
* A total of two wells will be required for 1995, as well as 2010.

TABLE 4-2
WATER TREATMENT OPERATION AND MAINTENANCE COST

| Year | Annual Average gallons/day | Annual O&M Cost ($) | Cost/1,000 Gallons ($) |
|---|---|---|---|
| 1995 | 220,000 | 258,000 | 3.21 |
| 2000 | 259,000 | 309,000 | 3.39 |
| 2005 | 280,000 | 370,000 | 3.62 |
| 2010 | 310,000 | 440,000 | 3.89 |

TABLE 4-3
REQUIRED STORAGE VOLUME

| | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| Maximum Hour & Emergency | 240,000 | 273,000 | 306,000 | 340,000 |
| State Regulation | 720,000 | 820,000 | 920,000 | 1,020,000 |




GROUNDWATER MANAGEMENT, INC.

FIGURE 3

PROPOSED WELL CONSTRUCTION DESIGN

JOB NO: HY-0147 DATE: SEPT. 8, 1986

TABLE 4-4
PROBABLE CONSTRUCTION COST - WELLS

| Item | Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| 1. | Mobilization | | | | $ 5,000.00 |
| 2. | Observation Well Drilling and Construction | 465 | ver ft | $ 25.00 | 11,625.00 |
| 3. | Permanent Well Drilling and Construction | 465 | ver ft | 50.00 | 23,250.00 |
| 4. | 36-inch diameter Outer Casing | 40 | ver ft | 75.00 | 3,000.00 |
| 5. | 30-inch diameter Inner Casing | 130 | ver ft | 65.00 | 8,450.00 |
| 6. | 24-inch diameter Inner Casing | 280 | ver ft | 60.00 | 16,800.00 |
| 7. | 24-inch diameter Inner Casing SS | 60 | ver ft | 150.00 | 9,000.00 |
| 8. | 14 inch Well Screen | 150 | ver ft | 50.00 | 7,500.00 |
| 9. | Testing & Development | --- | Lump sum | --- | 5,000.00 |
| 10. | Pump - 40 hp | 2 | Lump sum | 20,000.00 | 40,000.00 |
| 11. | 12 inch Piping | 2,000 | lin ft | 12.00 | 24,000.00 |
| 12. | 6-inch Turbine Meter | 2 | each | 5,000.00 | 10,000.00 |
| 13. | 12-inch Butterfly Valve | 4 | each | 1,200.00 | 4,800.00 |
| 14. | 12-inch Check Valve | 2 | each | 1,500.00 | 3,000.00 |
| 15. | Piping Accessories | 2 | Lump sum | 5,000.00 | 10,000.00 |
| 16. | Pumphouse | 2 | Lump sum | 20,000.00 | 40,000.00 |
| 17. | Pumping Test | --- | Lump sum | --- | 12,000.00 |
| 18. | Geophysical Logging | --- | Lump sum | --- | 1,000.00 |
| 19. | Ocean Side Monitoring Wells | 2 | Lump sum | 10,000.00 | 20,000.00 |
| 20. | Shallow Observation Well | 1 | Lump sum | 2,500.00 | 2,500.00 |
| 21. | Access Road | 1 | Lump sum | 20,000.00 | 20,000.00 |
| 22. | Electrical | 1 | Lump sum | 75,000.00 | 75,000.00 |
| 23. | Standby Generators | 2 | Lump sum | 40,000.00 | 80,000.00 |
| | | Probable Construction Cost | | | $431,925.00 |

Note: One well has been constructed.

TABLE 4-5
PROBABLE CONSTRUCTION COST
DISTRIBUTION SYSTEM

| Item | Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| 1. | Mobilization | | | | $ 35,000.00 |
| 2. | 12-inch Water Main SDR 21 | 22,400 | lin ft | $ 7.50 | 257,600.00 |
| 3. | 8-inch Water Main SDR 21 | 4,200 | lin ft | 7.50 | 31,500.00 |
| 4. | 6-inch Water Main SDR 21 | 12,400 | lin ft | 6.25 | 77,500.00 |
| 5. | 4-inch Water Main SDR 21 | 31,200 | lin ft | 4.25 | 132,600.00 |
| 6. | 2-inch Water Main SDR 21 | 17,800 | lin ft | 3.00 | 53,400.00 |
| 7. | 4-inch DIP Bored and Jacked | 60 | lin ft | 25.00 | 1,500.00 |
| 8. | 2-inch DIP Bored and Jacked | 400 | lin ft | 15.00 | 6,000.00 |
| 9. | Fittings | 8,000 | lbs | 1.50 | 12,000.00 |
| 10. | 12-inch Gate Valve and Box | 10 | each | 1,000.00 | 10,000.00 |
| 11. | 8-inch Gate Valve and Box | 3 | each | 500.00 | 1,500.00 |
| 12. | 6-inch Gate Valve and Box | 8 | each | 400.00 | 3,200.00 |
| 13. | 4-inch Gate Valve and Box | 34 | each | 300.00 | 10,200.00 |
| 14. | 2-inch Gate Valve and Box | 47 | each | 250.00 | 11,750.00 |
| 15. | Fire Hydrant and Assembly | 78 | each | 1,000.00 | 78,000.00 |
| 16. | 2-inch Blowoff Assembly | 45 | each | 350.00 | 15,750.00 |
| 17. | 2-inch Service Connection | 2 | each | 2,000.00 | 4,000.00 |
| 18. | 1-inch Service Connection | 10 | each | 500.00 | 5,000.00 |
| 19. | 1-inch Service Connection, Bored | 4 | each | 1,000.00 | 4,000.00 |
| 20. | 3/4-inch Service Connection | 675 | each | 350.00 | 236,250.00 |

| Item | Description | Quantity | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| 21. | 3/4-inch Service Connection, Bored | 70 | each | 450.00 | 31,500.00 |
| 22. | Driveway & Pavement Repair | 1 | --- | Lump sum | 50,000.00 |
| 23. | Miscellaneous Concrete | 1 | --- | Lump sum | 15,000.00 |
| 24. | 0.20 MG Elevated Tank | 1 | --- | Lump sum | 360,000.00 |
| | | Probable Construction Cost | | | $1,443,250.00 |

For desalination by reverse osmosis of the water as previously sampled and analyzed, the pretreatment required is acid addition for pH adjustment, scale inhibitor chemical addition to increase recovery, and 5 micron cartridge filtration to protect the membranes from suspended matter. This level of pretreatment is typical of a majority of RO plants. Additional pretreatment that may be required for this plant is rapid sand filtration to reduce turbidity and TOC. The cost opinion for plant construction includes funds for these filters; however, successful results from a pilot plant may indicate that pre-filtration is not required.

4.1.4.4 Desalination. Available processes for desalination are covered in greater depth in Section 4.2 of this report. The apparent least costly option is reverse osmosis, using low pressure membranes.

4.1.4.5 Post Treatment. As stated above, post treatment will be required to produce a stable finished water. The cost opinion in Table 5-0 includes a degasifier for carbon dioxide removal and chemical addition for pH adjustment. Also included is chlorine addition for disinfection.

4.1.4.6 Other Facilities. Other facilities will be required at the plant, such as a clearwell, ground storage reservoir, and high service pumping. The cost opinion for these facilities is included in Section 5.0.

## 4.2 WATER TREATMENT

Previous studies have evaluated all alternatives for the area's water supply and treatment. The most effective method to supply the long-range needs is desalination by the reverse osmosis process using the brackish groundwater of the Yorktown aquifer.

Desalination processes are used when water contains dissolved solids that cannot be removed by conventional treatment or when total dissolved solids are present in sufficient quantity to make desalination processes cost effective. Typical dissolved solids which, when present in sufficient quantity, can require the use of a desalination process include sodium, calcium, magnesium, sulfate, chloride, and bicarbonate. Saline water is a term given to any

TABLE 4-6

YORKTOWN AQUIFER WATER ANALYSIS

| | DEPTH OF SAMPLE | |
|---|---|---|
| | 332-342 ft. | 507-517 ft. |
| $BOD_5$ (mg/l) | <1.5 | <1.5 |
| Alkalinity, as $CaCO_3$ (mg/l) | 603 | 528 |
| Chloride (mg/l) | 439 | 4,920 |
| Color (PCU) | 35 | 10 |
| Conductivity @ 25 C (umhos/cm $^2$) | 2,250 | 14,000 |
| Fluoride (mg/l) | 1.58 | 1.56 |
| Total Hardness (mg/l) | 94 | 890 |
| Nitrate-Nitrogen (mg/l) | 0.055 | 0.062 |
| Nitrite-Nitrogen (mg/l) | <0.002 | <0.002 |
| pH (units) | 8.0 | 7.5 |
| Total Phosphorus (mg/l) | 0.074 | 0.048 |
| Total Solids (mg/l) | 1,430 | 9,480 |
| Total Volatile Solids (mg/l) | 177 | 468 |
| Total Suspended Solids (mg/l) | 10 | 19 |
| Total Dissolved Solids (mg/l) | 1,410 | 9,430 |
| Sulfate (mg/l) | <2 | 530 |
| Turbidity (NTU) | 1.3 | 7.3 |
| TOC (mg/l) | 151 | 134 |
| Free Chlorine (mg/l) | <0.1 | <0.1 |
| Silica (mg/l) | 28.8 | 18.6 |
| Strontium (mg/l) | 0.63 | 0.44 |
| Silver (mg/l) | <0.005 | <0.005 |
| Aluminum (mg/l) | <0.5 | <0.5 |
| Arsenic (mg/l) | 0.0005 | 0.0077 |
| Barium (mg/l) | 0.20 | <0.05 |
| Calcium (mg/l) | 11.51 | 93.6 |
| Cadmium (mg/l) | <0.005 | <0.005 |
| Total Chromium (mg/l) | <0.005 | <0.005 |
| Hexavalent Chromium (mg/l) | <0.01 | <0.01 |
| Copper (mg/l) | 0.009 | <0.005 |
| Iron (mg/l) | 0.635 | 1.236 |
| Mercury (mg/l) | <0.0005 | <0.0005 |
| Potassium (mg/l) | 33.5 | 142 |
| Magnesium (mg/l) | 36.2 | 187 |
| Manganese (mg/l) | 0.014 | 0.028 |
| Sodium (mg/l) | 540 | 3,330 |
| Lead (mg/l) | <0.05 | 0.032 |
| Selenium (mg/l) | <0.0005 | <0.001 |
| Zinc (mg/l) | 0.03 | 0.087 |
| SDI (units) | Void | 7 |
| Temperature (deg F) | 74 | 72 |

water with chloride concentration greater than 250 mg/l and total dissolved solids (TDS) concentrations greater than 500 mg/l. Saline waters include salt water, which is undiluted seawater typically containing 35,000 mg/l TDS, and brackish water, containing up to 10,000 mg/l TDS. Brackish waters include highly mineralized groundwater and diluted seawater.

Dare County has an abundance of saline waters which are potential drinking water supplies if desalination can be economically employed. Sources of saline water near Rodanthe, Waves, and Salvo include:

- The Atlantic Ocean.
- Pamlico Sound.
- Outer Banks groundwater, found in several aquifers of both brackish and salt water at depths exceeding 100 feet.

Water treatment costs, both capital and operating and maintenance, are considerably less for brackish water than for salt water. Since brackish water is available, salt water will not be considered further. Pamlico Sound has TDS concentration of 14,000 to 18,000 near the project area, which would require seawater desalination processes. Therefore, it is not considered further in this report.

Typical processes used for removing dissolved solids from brackish water are reverse osmosis (RO) electrodialysis (ED), and ion exchange (IE). Distillation can also be used for more concentrated brackish waters although it is more typically used for salt water desalting. Several other desalination processes are being developed, but are not yet commercially feasible and will not be discussed herein.

A brief description of the RO process mentioned above follows. The cost of RO, as the selected process, is discussed more fully in Section 4.3.

TABLE 4-7

YORKTOWN AQUIFER BLENDED WATER ANALYSIS

| | DAY OF SAMPLE | |
|---|---|---|
| | 2 | 7 |
| $BOD_5$ (mg/l) | <0.2 | 0.3 |
| Alkalinity, as $CaCO_3$ (mg/l) | 597 | 601 |
| Chloride (mg/l) | 435 | 435 |
| Color (PCU) | 30 | 30 |
| Conductivity @ 25 C (umhos/cm $^2$) | 2,200 | 2,350 |
| Fluoride (mg/l) | 1.96 | 1.95 |
| Total Hardness (mg/l) | 98 | 100 |
| Nitrate-Nitrogen (mg/l) | 0.054 | 0.025 |
| Nitrite-Nitrogen (mg/l) | <0.002 | <0.002 |
| pH (units) | 7.8 | 7.9 |
| Total Phosphorus (mg/l) | 0.086 | 0.05 |
| Total Solids (mg/l) | 1,480 | 1,470 |
| Total Volatile Solids (mg/l) | 271 | 221 |
| Total Suspended Solids (mg/l) | 4 | 7 |
| Total Dissolved Solids (mg/l) | 1,460 | 1,467 |
| Settleable Solids (mg/l) | <0.1 | <0.1 |
| Sulfate (mg/l) | <2 | 44 |
| Turbidity (NTU) | 0.3 | 3.0 |
| TOC (mg/l) | 115 | 117 |
| Free Chlorine (mg/l) | <0.1 | <0.1 |
| Silica (mg/l) | 6.1 | 27 |
| Strontium (mg/l) | 0.75 | 0.72 |
| Silver (mg/l) | <0.01 | <0.01 |
| Aluminum (mg/l) | <0.2 | <0.2 |
| Arsenic (mg/l) | <0.002 | <0.002 |
| Barium (mg/l) | <0.1 | <0.11 |
| Calcium (mg/l) | 9.48 | 9.40 |
| Cadmium (mg/l) | <0.005 | <0.005 |
| Total Chromium (mg/l) | <0.02 | <0.02 |
| Hexavalent Chromium (mg/l) | <0.02 | <0.02 |
| Copper (mg/l) | <0.02 | <0.02 |
| Iron (mg/l) | 0.052 | 0.048 |
| Mercury (mg/l) | <0.0005 | <0.0005 |
| Potassium (mg/l) | 38.5 | 35.8 |
| Magnesium (mg/l) | 20.6 | 19.9 |
| Manganese (mg/l) | <0.01 | <0.01 |
| Sodium (mg/l) | 588 | 527 |
| Lead (mg/l) | <0.05 | <0.09 |
| Selenium (mg/l) | 0.0023 | 0.0025 |
| Zinc (mg/l) | 0.024 | 0.026 |
| SDI (units) | 0.8 | 0.6 |
| Temperature (deg F) | 70 | 70 |

TABLE 4-8
PROBABLE FEEDWATER ANALYSIS
FOR COST COMPARISON

| Parameters | Pretreated Water |
|---|---|
| Alkalinity (mg/l) | 600 |
| Chloride (mg/l) | 435 |
| Fluoride (mg/l) | 1.96 |
| Hardness, Total (mg/l) | 100 |
| pH (units) | 7.8 |
| Total Dissolved Solids (mg/l) | 1470 |
| Sulfate (mg/l) | 44 |
| Turbidity (NTU) | 3.0 |
| Calcium (mg/l) | 9.5 |
| Iron (mg/l) | 0.05 |
| Potassium (mg/l) | 38.5 |
| Magnesium (mg/l) | 20.6 |
| Manganese (mg/l) | <0.01 |
| Sodium (mg/l) | 588 |
| Silica (mg/l) | 27 |

4.2.1 <u>Reverse Osmosis</u>

Reverse osmosis is a physical process that takes advantage of the natural tendency of water to dilute a concentrated solution. When salt water and fresh water are on opposite sides of a membrane that is permeable to water but not to solids dissolved in the water, dilution of the salt water occurs as water molecules pass through the membrane. When an external pressure is applied to the salt water, the water flow across the membrane can be reversed and pure water is removed from the more concentrated salt solution. This is the process of reverse osmosis.

Figure 1 shows the reverse osmosis process in simplified form. Pressure is continuously applied to the feed stream by a high pressure pump, while product and brine are continuously withdrawn. Dissolved solids rejected by the membrane are continuously flushed from the system in the brine. The brine contains a high level of dissolved solids while the product contains a low level. A flow regulating valve on the brine discharge line controls the percentage of feedwater that is converted to product.

Currently available RO devices are either hollow fiber membrane permeators or spiral wound membrane permeators. The design and manufacture of these devices and of process systems incorporating these devices is highly specialized. Performance of the process depends upon feedwater quality, applied pressure, and the presence of potential fouling or scaling ions which can harm membranes. RO is typically cost-effective at feedwater TDS concentrations of 1,000-6,000 mg/l. The primary operating costs include electric power for the high pressure pumps and membrane replacement.

RO is used mainly for treating groundwater. Surface waters usually require extensive pretreatment for removal of suspended solids and turbidity. Groundwater requires cartridge filtration for removal of fine suspended solids and possibly chemical addition. Other pretreatment requirements are specific to membrane materials and configuration.

RO is a viable process for treating brackish groundwater in the three village area.

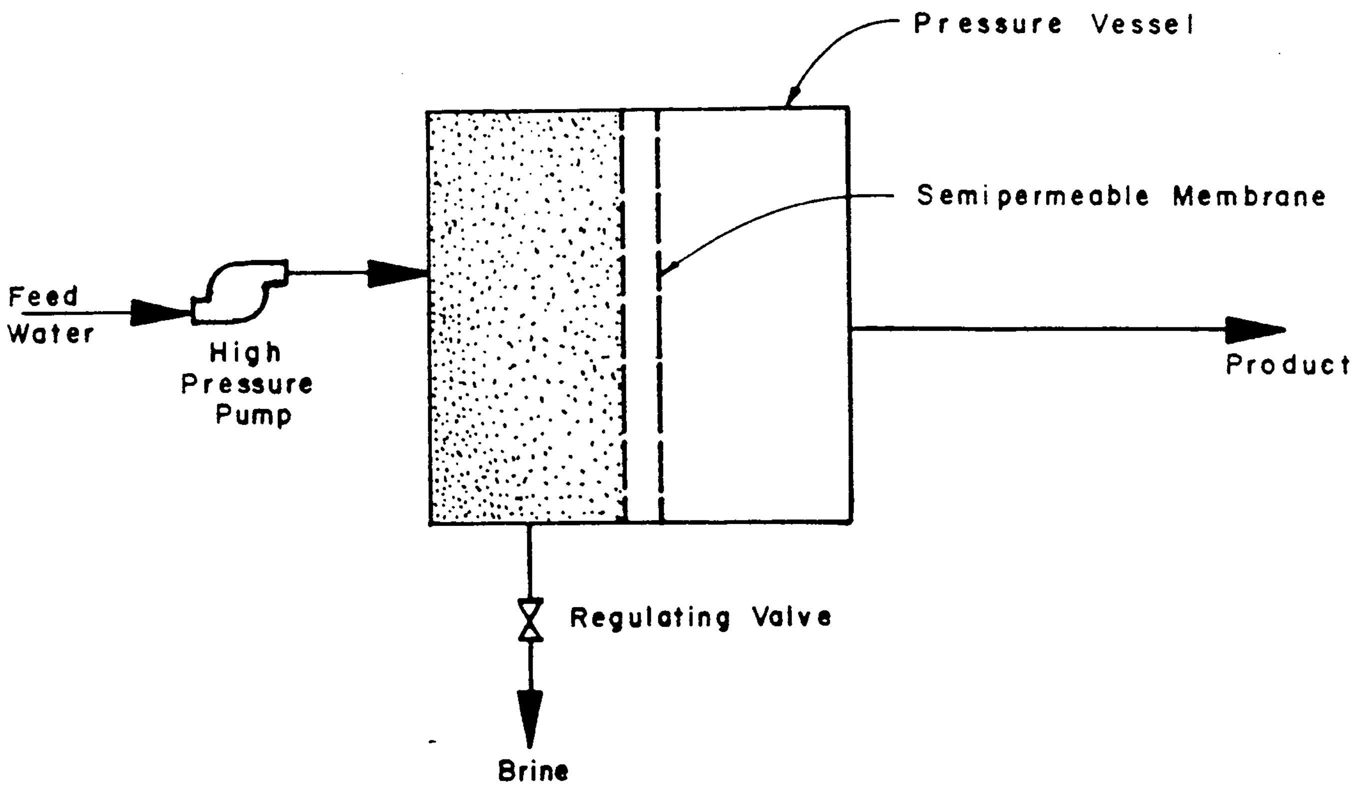



FIGURE 1 – REVERSE OSMOSIS SCHEMATIC

## 4.3 RO FACILITY REQUIREMENTS

### 4.3.1 RO Process Performance

Previous discussions of reverse osmosis in this report have been brief, without giving any thought to describing performance characteristics, or to factors affecting performance. Typical measures of performance are salt rejection, membrane flux (flow through the membrane per unit time), percent recovery, and time between membrane cleanings. Factors which affect performance are operating pressure, and ionic constituents in the water. Several of these characteristics and factors are discussed below.

4.3.1.1 Feedwater Concentration and Recovery. The concentration of dissolved solids in the feedwater is of prime importance in planning RO systems. The higher the concentration, the higher the feed pressure must be to overcome the feedwater's osmotic pressure. At constant pressure, the percent recovery will decrease as TDS concentration increases. Recovery is the percentage of feedwater which passes through the membranes to become product water. This is a critical parameter in determining RO feasibility since higher recoveries reduce the raw water requirements and the amount of RO membranes to be used, and minimize pretreatment costs and the amount of brine to be handled. Usual design is intended to utilize as high a recovery as possible without causing damaging scale formation.

A change in feedwater concentration may adversely affect RO performance. In the Yorktown aquifer in Dare County, there is potential for movement of higher TDS concentration water into the well field. Such movement would gradually increase feedwater TDS, resulting in higher osmotic pressures and lower recovery. With time, the plant capacity would be reduced. Proper well field design and operation can minimize salt water migration in the aquifer, but some increase in feedwater salinity can be anticipated with time. It is recommended that this increase be considered in the plant design.

4.3.1.2 Salt Rejection. Salt rejection is a percentage measure of how much salt is removed from (i.e., TDS retained by the membrane) the feedwater. Each ion is rejected to a different extent, and the overall rejection will be a weighted average of the rejection of each constituent. Salt rejection is relatively constant with the age of the membrane, but is reduced if the net operating pressure across the membranes is reduced.

Most RO membranes available today have excellent rejection characteristics for ionic constituents typically found in brackish water.

Rejections greater than 90 percent are easily achieved, and 95 percent is possible, depending upon the feed pressure and ionic constituents. Greater salt rejection results in a purer product water. If the feedwater TDS is not too high, the product water will have TDS well below the statutory limits, and blending of some feedwater with product water may be possible. This will reduce both the amount of raw water and the number of RO membranes required.

For Yorktown aquifer water having a nominal TDS of 2,000 mg/l, the product water could be expected to have a concentration of 100 mg/l with 95 percent salt rejection. Bypassing and blending of approximately 20 percent of the raw water flow would be possible, which may be economical.

4.3.1.3 Ionic Constituents. Certain ions which are commonly dissolved in water are either difficult to remove or potentially harmful to the membranes. There is a saturation point for ions in solution after which precipitation of the ion occurs. If this occurs in an RO vessel, the precipitate will scale on the membrane, reducing the water flux across the membrane. The most common scalants are calcium carbonate ($CaCO_3$) and calcium sulfate ($CaSO_4$). Other possible scalants are barium sulfate ($BaSO_4$), strontium sulfate ($SrSO_4$), calcium fluoride ($CaF_2$), and silica ($SiO_2$). The critical location of scaling is on the brine side of the membrane, where concentrations are greatest. Dissolved iron and aluminum compounds can also be a source of scaling.

Scaling can be controlled by:

(1) Reducing recovery to avoid exceeding solubility limits.
(2) Removing the calcium ion (or other scaling ion) by pretreatment.
(3) Removing the carbonate/bicarbonate ion by adding acid.
(4) Adding a scale-inhibiting chemical.

The analysis of Yorktown aquifer water at the project area indicates that silica will be as potential scaling compound. Although fluoride in the water is relatively high, it is not high enough to cause a scaling problem. The design should consider pH adjustment and chemical addition for scaling control, as is done at most RO plants.

4.3.2 RO Equipment Requirements

An RO plant to produce water for a water system for Rodanthe, Waves, and Salvo would consist of many RO membranes assembled in vessels and groups of vessels and staged. The major options to choose between on the RO process are as follows.

- Spiral wound permeators, consisting of sheets of membranes and spacers wound around a collection tube. Usually, several permeators are placed in series in a single pressure tube.

- Hollow fiber permeators, consisting of many hair like fibers in a bundle, located inside a pressure tube.

- Parallel single-staged systems, consisting of many permeators connected in parallel.

- Brine-staged systems, wherein the brine from the first stage becomes the feedwater for the second stage. This approach both maximizes recovery and minimizes brine volumes.

- Product-staged systems, where the products from the first stage are passed through a second stage to provide higher quality product water.

All of these options have much in common. Permeators are mounted on racks and connected by manifolds. Recovery is controlled by a valve on the brine manifold. Provisions must be made to sample and replace permeators individually and to clean permeator racks. RO systems usually have parallel racks of permeators that can be operated independently to increase or decrease plant flow. Several on-line instruments are needed to provide performance data for operating decisions.

Materials of construction must be carefully chosen for all parts of the RO system due to the potential for corrosion. Non-metallic materials should be used for all wetted parts wherever practical and economical. The high operating pressures also must be considered in material selection.

Pretreatment and other appurtenant systems are also required.

- Cartridge filtering system, to remove suspended particles down to 5 microns.

- Chemical feed systems as required by detailed process design. The most likely chemicals that will be needed are acid for pH control and a scale inhibitor.

#### 4.3.3. Other Plant Facilities

Other equipment and facilities will be required at the RO water treatment plant. Facilities located at the plant are listed as follows.

- Treatment Plant Building. This building will house all the RO equipment, pretreatment equipment, chemical feed and storage systems, and transmission and transfer pumps. The building will also house mechanical and electrical equipment, and include personnel facilities such as operations room, laboratory, offices, conference rooms, locker rooms, etc.

- Clearwell. A clearwell will be required for collection of product water, for degasifier discharge, and as a source of water for various in-plant uses.

- Storage Reservoir. A ground storage reservoir will be needed to provide a buffer between plant production rate and pumping rate and for times when the treatment plant is shut down. The size of the reservoir should be based on total water demand, and available storage facilities. Since each distribution system has adequate storage facilities, the amount of storage required at the water treatment plant need not be excessive. A storage reservoir is recommended.

- High Service Pumps. High service pumps will supply treated water to the distribution system. Studies should be made during the plant design to determine the correct discharge pressure of the pumps.

- Operations Room. There should be one room in the plant for centralized controls where operating decisions are made. This room would have all display instruments for monitoring plant processes, and contain control instruments for implementing process control decisions. The control system will include some microprocessor-based controls.

The plant should be arranged on-site to accommodate future expansion. The initial capacity will be 1.0 mgd, with a building capacity to house 1.0 mgd or process units. The plant site will be arranged for a greater plant capacity. The potential site purchased by the Company will have more than adequate space.

### 4.3.4. Plant Operations

An RO plant composed of several parallel treatment modules can be operated at various flow rates simply by starting or stopping modules. Proper shutdown procedures must be followed to prevent damage to the membranes while inactive. Thus, varying the flow rate should be done in increments and not to match water demands required for short durations. The plant flow rate should be selected and set and maintained for as long as possible. During the off-peak season, the RO plant should be run at a reduced capacity, rotating the modules daily.

Achieving a good balance between ease of operation and minimizing the total cost of producing water will not come automatically. There will be a period of trial and error during which time plant operations must work with various flow rates, during both peak and off-peak seasons, to achieve the best possible performance.

## 4.4 WATER DISTRIBUTION

The distribution system was designed using computer modeling performed by hydraulic analysis. The hydraulic analysis is an analytical method of predicting the hydraulic gradient pattern (pressure) that may occur over a system network based on a given set of water demands.

The distribution mains were sized based on 100 percent participation in the area and the design flow of 400 gallons per residential connection plus a 500 gpm fire flow demand on the system. The distribution system is designed to deliver a maximum flow of 2.6 mgd while maintaining a minimum pressure of 35 psi throughout the system. The system would have sufficient capacity to supply the projected 2010 maximum hour demand of 2.04 mgd.

The water distribution system would consist of a 12-inch diameter transmission main along Highway 12, from the elevated tank at the north side of Rodanthe, to the south side of Salvo. This size main is needed due to the elevated storage tank's location on the edge of the system. If the tank was located nearer the center of the overall distribution system, the transmission main could be reduced in size to an 8 inch diameter. This would reduce the probable construction cost; however, this cost saving would need to be weighed against the cost of acquiring a centrally located tank site. With an 8-inch transmission main, pressure would also drop below 20 psi at the north and south ends of the distribution system during the maximum day demand, plus a fire flow of 500 gallons per minute.

The distribution system analyses and system layout are listed in Appendix A.

## 4.5 STORAGE

Storage is provided in a distribution system to alleviate heavy demand periods, supplying the difference between maximum day and maximum hour demands, and other emergency flow conditions. Normally, one-half of the total storage volume should satisfy maximum hour demand and the other half should be reserved for emergencies and fire fighting purposes. Using the above criteria and a 4-hour maximum hour duration, the area would need 340,000 gallons of storage to supply the maximum hour condition plus emergency reserve for the design period 2010. State regulations impose the additional requirement that sufficient storage be available to supply the annual average demand for 24 hours.

The required storage volume based on both of the criteria listed above are shown in Table 4-4.

Based on the state regulation, approximately 1.0 MG of storage volume would be needed by 2010. This storage can be provided in any combination, ground storage, and/or elevated storage. The tentative plan is for the wells, treatment plant and storage to be located at the same site which is presently owned by Dare County. Based on the location for these facilities it would be most feasible to provide the majority of the storage required as ground storage.

It is recommended that 200,000 gallons of elevated storage and 1,000,000 gallons of ground storage be provided for a combined storage of 1,200,000 gallons. This would be sufficient to meet the need of the area through 2010.

# 5.0 ESTIMATED PROJECT COST

The construction cost opinion was presented in the previous section. This section includes the additional cost for the project. Table 5-0 shows the overall estimated project cost. Also included in this section is a tabulation of capital costs, O&M costs, and revenues applicable to the project.

TABLE 5-0
ESTIMATED PROJECT COST

| | |
|---|---|
| (1) Wells and Pumphouses | $ 431,925.00 |
| (2) Water Treatment Plant, 1.0 MG Ground Storage, High Service Pumps, and Standby Generator | 2,000,000.00 |
| (3) Water Distribution System | 1,443,250.00 |
| TOTAL PROBABLE CONSTRUCTION COST | $3,875,175.00 |
| Legal & Administration | 35,825.00 |
| Land & Right-of-Way | 200,000.00 |
| Technical Service | |
| Engineering | 350,000.00 |
| Construction | 200,000.00 |
| Pilot Testing & Hydro-Geological | 100,000.00 |
| Interest During Construction | 700,000.00 |
| Contingencies (10%) | 539,000.00 |
| TOTAL PROBABLE PROJECT COST | $6,000,000.00 |

## 6.0 PROJECT FINANCING

There are 852 potential users within the Rodanthe-Waves-Salvo area. The cost and revenue estimates are based on providing service to each potential user. These potential users are based on an actual on-the-ground count, and they are shown schematically on the maps of proposed distribution system. Additionally, there are 957 vacant lots for a total of 1,809 lots overall in the three villages.

Revenue estimates have been developed using the existing water rate schedule for the Kitty Hawk-Southern Shores-Duck area of the County. These schedules will generate in the range of $216,000 annually from water sales.

Dare County currently operates water systems on Roanoke Island, and the Outer Banks area north of Kill Devil Hills to the Currituck County line. These service areas comprise a customer base of approximately 4,800 services. It is only logical that the County expand its water system operation to include the villages of Rodanthe, Salvo, and Waves. It will be much more economical to add this water service area to those the County already operates, because the added cost of operation would be minimized by this approach.

Financing of the initial capital cost of this system may be handled in a number of ways. One is through the use of revenue bonds, which require a trustee to administer the revenues and expenses. Another is through the sale of Certificates of Participation (G.S.160A-20). There is a third option which is through privatization whereby a private entity designs, finances, builds, and operates the facilities. In lieu of the private entity operating the facility, it may be leased to the County for operating and maintaining.

A financial summary of the integrated County system follows. The financing is based upon a lease purchase approach, with the County becoming the owner of the facilities after twenty years.

## TABLE 6-0

## DARE COUNTY WATER SYSTEM COMBINED

| | | | |
|---|---|---|---|
| Revenues | (Water Sales North) | $ 1,800,000 | |
| | (Water Sales South) | 216,000 | |
| | (Assessments) | 427,000 | (for 5 years) |
| | (Impact Fees) | 50,000 | |
| | (Tap Fees) | 85,000 | |
| | Total | $ 2,578,000 | |
| Expenses | (North) | $ 1,446,500 | |
| | (South) | 258,000 | |
| | (Debt Service) | 510,000 | |
| | Total | $ 2,214,500 | |
| | Difference | $ 363,500 | |

Note: Difference may be applied to accelerating the lease payments, thereby reducing the debt service or lease payments by $1,500,000 over the five-year period in which the assessments are paid to the County. Adjust rates at end of five years to make up for loss of assessment revenue. Debt service or lease payments will be reduced by $135,000 per year at end of five years.

# SUPPLEMENT TO PRELIMINARY ENGINEERING REPORT (WATER FACILITY)

## CONSTRUCTION COST ESTIMATES
(List All Major Items)

**WATER SYSTEM:**

**Supply and Treatment:**

| | | | |
|---|---|---|---|
| ______ | Wells | @ | ______ |
| ______ | Pumphouses | @ | ______ |
| ______ | Treatment Plant | @ | ______ |

**Distribution System:**

| | | | |
|---|---|---|---|
| LF 8" ______ | Pipe | @ | ______ |
| LF 6" ______ | " | @ | ______ |
| LF 2" ______ | " | @ | ______ |
| Ea. 8" Valves | | @ | ______ |
| Ea. 6" " | | @ | ______ |
| Lbs. Fittings | | @ | ______ |
| Ea. Fire Hydrants | | @ | ______ |
| Ea. Meter Connection | | @ | ______ |

**Storage:**

| | | |
|---|---|---|
| ______ gallon elevated tank | @ | ______ |
| Tank Foundation | @ LS | ______ |

TOTAL CONSTRUCTION COST (Round to nearest thousand dollars) See Table 5.0

Above prices are current through December 1993.

## PROJECT COST ESTIMATE

| | |
|---|---|
| Construction | $3,875,175.00 |
| Land & Rights | $ 200,000.00 |
| Legal & Administrative | $ 35,825.00 |
| Engineering & Hydro-geological | $ 650,000.00 |
| Interest | $ 700,000.00 |
| Equipment | $ 0 |
| Contingencies | $ 539,000.00 |
| TOTAL PROJECT COST | $6,000,000.00 |

## PROJECT FINANCING PLAN

| Cash Contrib. by Appl. | Clean Wat. Bond Grant | Other Grant* | Bonds | Total |
|---|---|---|---|---|
| | | | | 6,000,000.00 |

## Existing Indebtedness:
(This facility only)

| Purpose | Amount Owed | Amortization Period | Amount of Installment |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

## FLOOD PLAIN INFORMATION

Is any part of project located in a flood plain area? If project is in flood area, is applicant eligible for National Flood Insurance?

## EXISTING RATE SCHEDULE

| | | | | |
|---|---|---|---|---|
| First | 3,000 | gallons @ | 15.00 | Min. |
| Next | | gallons @ | | Per 1,000 gal. |
| " | | gallons @ | | " " " |
| " | | gallons @ | | " " " |
| All Over | 3,000 | gallons @ | 4.00 | " " " |

## PROPOSED RATE SCHEDULE

| | | | | |
|---|---|---|---|---|
| First | 3,000 | gallons @ | 15.00 | Min. |
| Next | | gallons @ | | Per 1,000 gal. |
| " | | gallons @ | | " " " |
| " | | gallons @ | | " " " |
| All Over | 3,000 | gallons @ | 4.00 | " " " |

## USE AND INCOME ESTIMATES
(According to proposed rate schedule)

**WATER:**

Benefited Users (All users with 3/4 x 5/8 meters)

| | Existing | New | Total | | | | |
|---|---|---|---|---|---|---|---|
| (3/4") | | 300 | 300 | users @ | 3,000 | gal. | $ 4,500.00 |
| (3/4") | | 284 | 284 | users @ | 5,000 | gal. | $ 6,532.00 |
| (3/4") | | 250 | 250 | users @ | 7,000 | gal. | $ 7,750.00 |
| | | | | users @ | | gal. | $ |
| | | | | users @ | | gal. | $ |
| | | | | users @ | | gal. | $ |
| | | | | users @ | | gal. | $ |
| TOTAL | | 834 | 834 | users @ | 4,070,000 | gal. | $ 18,782.00 |

Non Benefited Users (All users with larger than 3/4 x 5/8 meters)

| | Existing | New | Total | | | | |
|---|---|---|---|---|---|---|---|
| (1") | | 14 | 14 | users @ | 15,000 | gal. | $ 882.00 |
| (2") | | 2 | 2 | users @ | 50,000 | gal. | $ 406.00 |
| | | | | users @ | | gal. | $ |
| | | | | users @ | | gal. | $ |
| TOTAL | | 850 | 850 | users @ | 310,000 | gal. | $ 1,288.00 |

TOTAL = $ 20,070.00 x 12 = $ 240,840.00 Annually

For operating budget purposes 90% of projected annual revenue is used - $216,000.00.

## BUDGET FOR COMPLETED FACILITY

| | Actual (Fiscal Year Ending 19 ) | Estimated (Completed Facility) | |
|---|---|---|---|
| **Income:** | | | |
| Water Sales (R-S-W) | NA | 216,000 | |
| Impact Fees (RSW) | NA | 50,000 | |
| Assessments (RSW) | NA | 427,000 | (for 5 years) |
| Revenue from Tap Fees | | 85,000 | (for 3 years) |
| TOTAL | | 778,000 | |
| **EXPENSES:** | | | |
| Salaries | | | |
| Supt. & Clerk | NA | | |
| Labor | NA | 127,900 | (Incremental Cost) |
| Soc. Security Tax | NA | 14,000 | (Incremental Cost) |
| Office Exp. (Supplies, Postage, Heat, Electricity, Telephone, Equipment, etc.) | NA | 5,000 | (Incremental Cost) |
| Bond & Insurance | NA | 20,000 | |
| Audit | NA | 1,000 | |
| Testing-St. Reg. Agy. | NA | 12,000 | |
| Chemicals | NA | 12,000 | |
| Transportation | NA | 6,000 | |
| Electricity | NA | 32,000 | |
| Supplies | NA | 10,000 | |
| Maint. & Repairs | NA | 10,000 | |
| Miscellaneous | NA | 18,000 | (Mebrane Replacement) |
| Bulk Water Purchase | NA | | |
| Debt Service | | | |
| Existing | NA | | |
| Proposed Addition | NA | 510,000 | |
| TOTAL | NA | 778,000 | |
| BALANCE AVAILABLE | NA | 0 | |

## MODELED CONDITION

Analysis #1. This model illustrates the condition of 8-inch maximum distribution mains with the elevated storage tank centrally located on the system. As illustrated the system would supply the maximum day demand maintaining a minimum pressure of 52 psi and a maximum line velocity of 4.2 fps.

Analysis #2. This analysis is the same as Analysis #1 with the exception of adding 500 gpm fire flow to the system. The results shows the system would not supply the maximum day demand plus fire flow. Pressure at the fringes of the system would drop below 20 psi. Some pressures would actually be negative.

Analysis #3. In this model, the system was changed, locating the storage tank at the treatment plant site and increasing the major trunk main to 12-inch. The model shows that the maximum day can be supplied maintaining a minimum pressure of 57 psi and a maximum velocity of 2.8 fps.

Analysis #4. This analysis is the same as Analysis #3 with the exception of adding 500 gpm fire flow. The model shows the system would supply this demand maintaining a minimum pressure of 45 psi.

Analysis #5. This model illustrates the condition of increasing the flow to a projected maximum hour demand of 2.6 mgd. The results indicated the system would supply this demand maintaining a minimum pressure of 39 psi. This flow rate takes into account 400 gpm fire flow in addition to the maximum hour of 2.04 mgd.