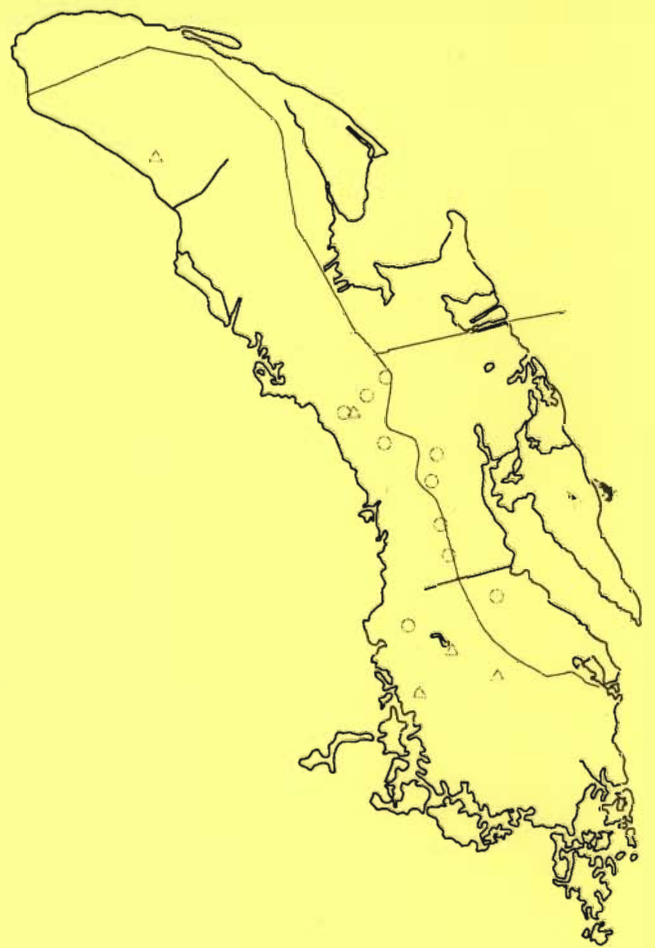


Roanoke Island
Ground Water Monitoring Report
for 1994

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Division of Water Resources



May 1995

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INTRODUCTION

This second report on ground water level conditions beneath Roanoke Island is a follow-up study to the 1993 report. In that first report the Division of Water Resources (DWR) documented Dare County's successful establishment of a monitoring well network and their commitment to protection of the water resources. The 1994 monitoring report is similar in format to the first report.

Background

The Town of Manteo developed a list of ground water management concerns in Resolution #11-92 dated August 5, 1992. Among other issues, the Resolution identified possible over-pumping of the aquifer beneath Roanoke Island, which supplies ground water to private residents in Wanchese and to the Dare Regional Water Supply System, saltwater intrusion potential, loss of Reverse Osmosis (RO) facility production capacity, and the lack of safe yield estimates for the aquifer beneath Roanoke Island. Manteo asked the Environmental Management Commission (EMC) to investigate.

At the request of the EMC the Division of Water Resources prepared a report, dated October 7, 1992, with recommendations to the EMC and to the water users. One of those recommendations was to monitor the effects of ground water withdrawals beneath Roanoke Island using a well network. During a November 24, 1992 work session, attendees acknowledged that annual reporting of ground water levels and chloride concentrations was needed to give the public and local governments accurate information about this critical resource. Without reliable data upon which to base opinions or decisions, false impressions about the state of ground water resources can develop.

Monitoring Report

In 1993, Dare Regional Water System staff began collecting data from a series of monitoring wells on Roanoke Island. They continued to collect water levels and chloride concentrations through 1994 from monitoring wells that were constructed in the early 1970s and early 1980s to help determine the appropriate site for the Dare County system and to monitor effects produced by those supply wells. Beginning in the early 1980s the County received reports of pump and water level problems from residents of Wanchese. There was a two-year hiatus from 1989-1991, when the RO water plant came on-line, and problems reappeared in 1992 when the RO plant slowed production of water.

The DWR report in 1992 showed that many Wanchese residents use well and pump systems that are not compatible. Their wells tap the upper Yorktown aquifer at depths of 130-200 feet below

land surface. Water is drawn from the well using a shallow-well pump capable of drawing water from about 20-30 feet down. As ground water levels are drawn down in the upper Yorktown aquifer by the County system (especially during the summer months), the levels in the Wanchese wells drop below the ability of the shallow-well pump to draw water. If a deep-well pump system is used in the private wells, then the lowered water levels caused by the County pumping would not affect Wanchese residents.

DWR research of Division of Environmental Management (DEM) and County records showed that the reported problems continue to occur because of inadequate water pumps and plumbing. These problems, in combination with drawdowns resulting from water production at the Skyco water plant, illustrated the need for a monitoring network, methods of analyzing the data produced, and a reporting procedure.

This report analyzes the ground water situation in the vicinity of the Skyco water plant. Skyco production is highly dependent upon volumes of water generated through the two other sources in the Dare Regional System. As an overview of the Dare County Regional System was included in the 1993 report, only major changes to that system are reported here.

Changes to the Dare Regional Water Supply System

The one significant change to the Dare Regional Water Supply System was the addition of two more supply wells to the Reverse Osmosis water plant. These wells are located south of the original eight supply wells and also tap the middle Yorktown aquifer. These additional wells seem to have lessened the dependence on withdrawals from the Skyco wells.

DATA COLLECTION AND INTERPRETATION

Data Collection

Dare County employees continue to measure water levels and collect water samples from five pairs of wells located on Roanoke Island in April of 1993 (Table 1). Each pair of wells was constructed in the early 1970s or early 1980s to analyze the aquifer framework and to measure the water level drawdown caused by the Skyco water plant withdrawals from the upper Yorktown aquifer. One well in each group is screened in the surficial aquifer and the other is screened in the upper Yorktown aquifer. During the 1994 sampling year these wells were sounded (see Table 1). Discrepancies between actual and constructed depths are probably due to collapse of the well screens or insufficient development. In either case each well needs to be purged of sediment and to have its integrity checked. One group of wells is located north of the Skyco well field, another in the well field, and three pairs of wells are located south of the well field in Wanchese (see Figure 1).

A portion of the aquifer framework based on data from these monitoring wells is shown in Figure 2. Cross-section A-A' illustrates the relationship between the surficial, upper Yorktown, and middle Yorktown aquifers along a north-south traverse of the island. Typical well depths, locations, and correlation to the Skyco well field are also shown on Figure 2.

Water samples from many of the monitoring wells were analyzed for their chloride content. Besides drawdown effects from the County well field, chloride analysis of water samples might

help quantify the stress on the aquifer system. For example, a rise in chloride concentrations at a particular monitoring well during higher water use months may indicate that pumping rates have exceeded the upper Yorktown aquifer's yield.

Table 1. Environment, Health, and Natural Resources (EHNR) Monitoring Wells used by Dare County*

Well Name	Map ID - EHNR Quad Location	Date of Construction	Aquifer	Top of Screen (feet below land surface)	Bottom of Screen (feet below land surface)	1994 Actual Depth (feet below land surface)
Skyco	J3F4	unk	Surficial	8.0	13.0	13.9
Skyco	J3F3	7/26/72	upper Yorktown	200.0	210.0	188.0
Manteo Airport	I4V5	3/27/84	Surficial	15.0	20.0	18.1
Manteo Airport	I4V3	9/12/72	upper Yorktown	150.0	160.0	128.6
Wanchese Community Center	J3X9	10/20/83	Surficial	14.0	19.0	16.5
Wanchese Community Center	J3X13	11/30/83	upper Yorktown	173.0	183.0	87.1
Wanchese Station Pit	J3X20	3/22/84	Surficial	8.5	13.5	3.8
Wanchese Station Pit	J3X17	2/29/84	upper Yorktown	165.0	175.0	42.8
Eason	J3Y8	8/24/83	Surficial	13.0	18.0	18.7
Eason	J3Y5	8/17/83	upper Yorktown	174.0	184.0	72.2

* Measurements in Table 1 of the 1993 Monitoring Report are in error.

Figure 1. Roanoke Island - Skyco Water Plant

Dare Regional Water System

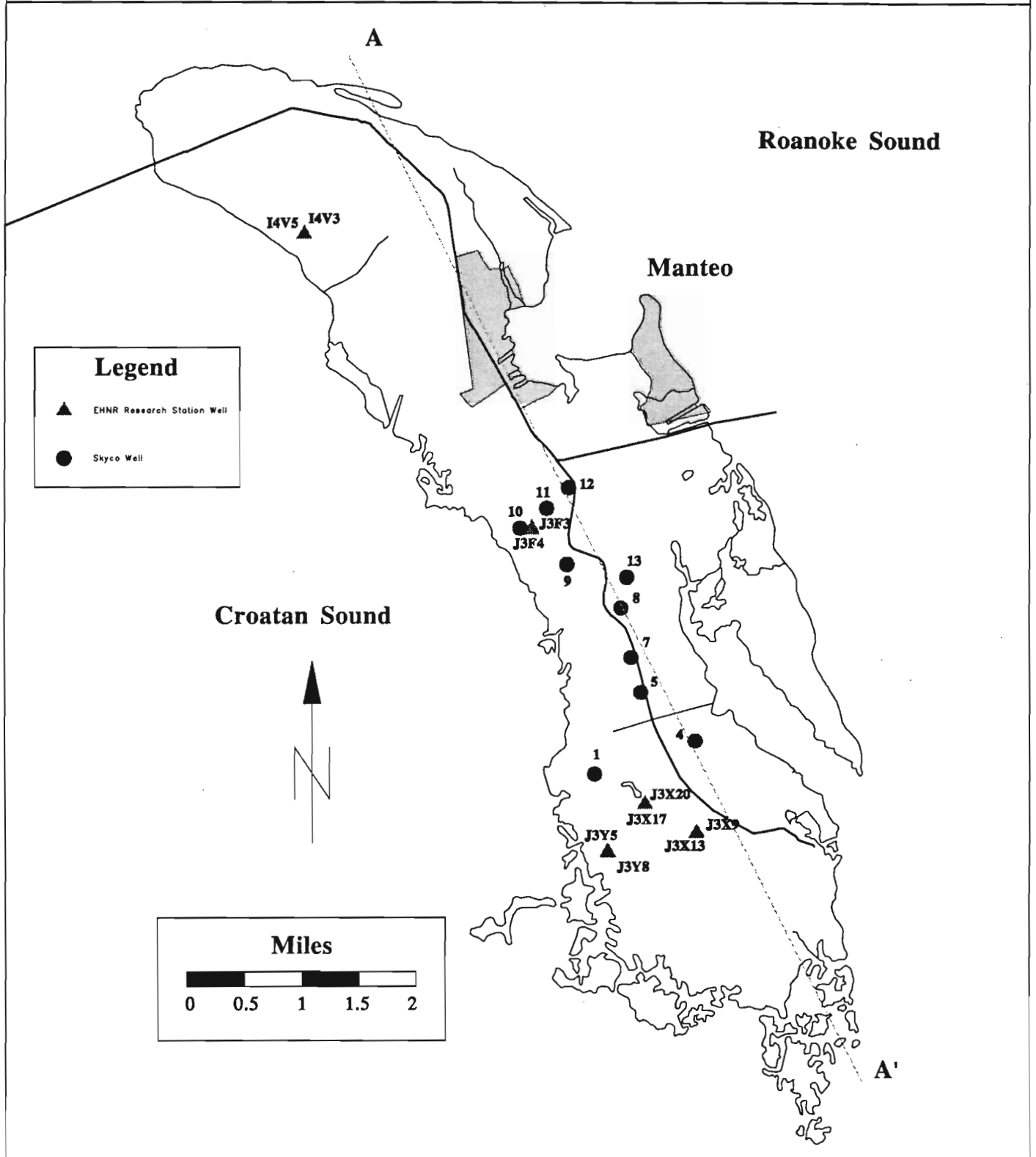
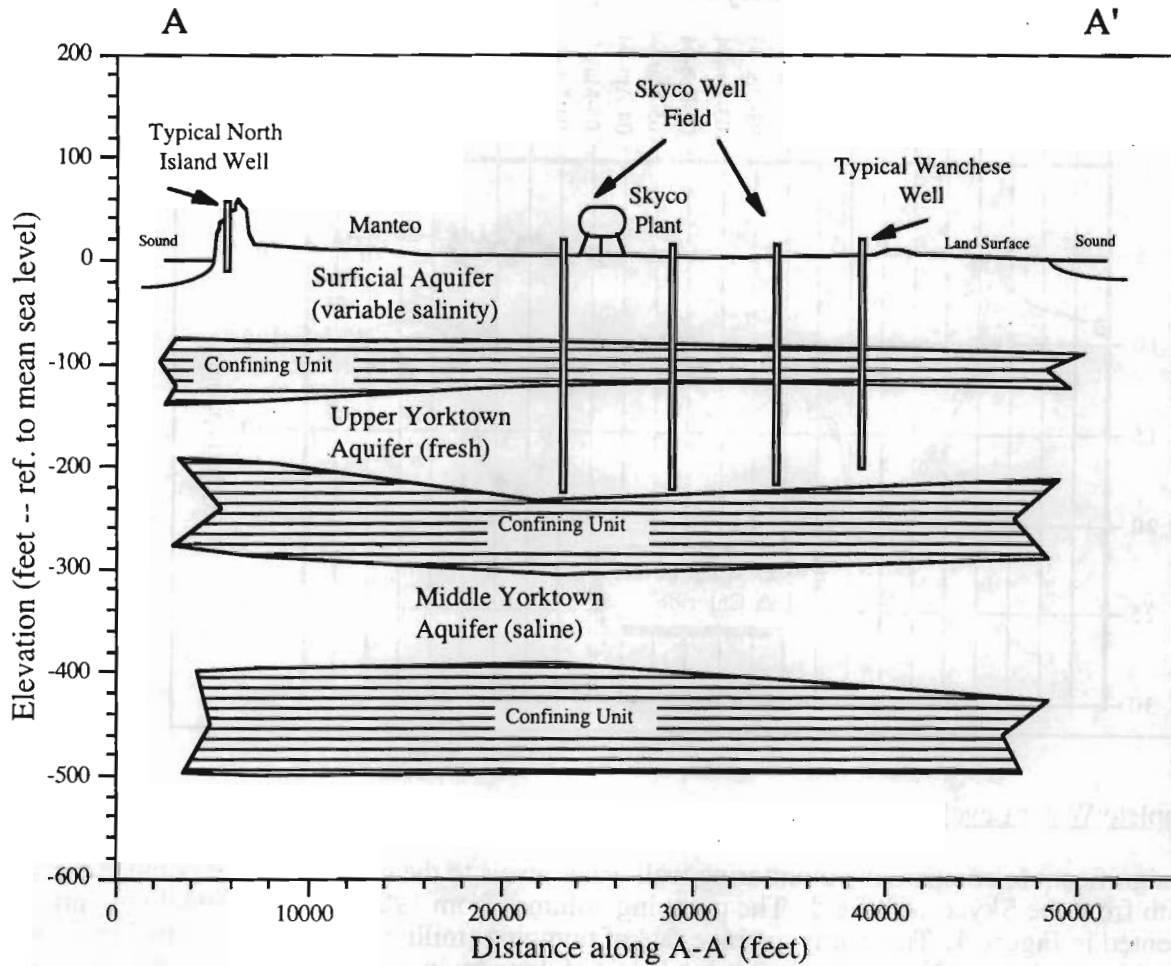


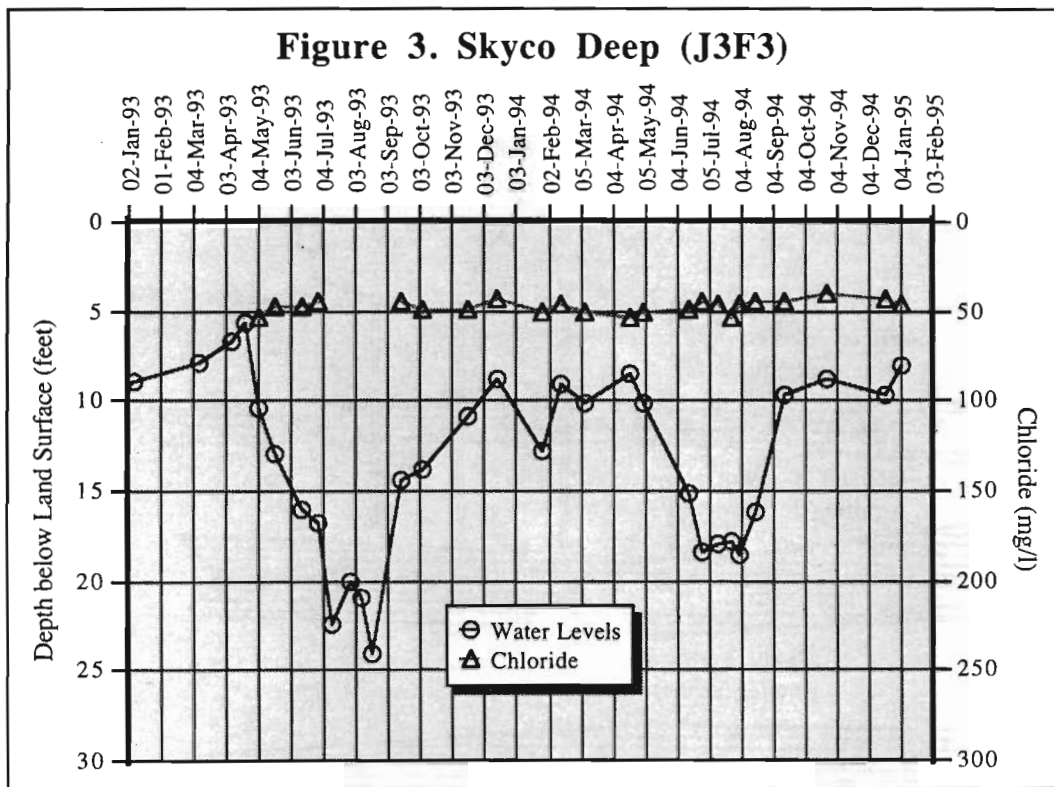
Figure 2. Aquifer framework in cross-section A-A'



Results and Interpretation

Water levels in these monitoring wells are shown in a series of graphs in Appendix A (Figures A-1 through A-20). Each page contains two graphs, one for the surficial aquifer well and the other for the upper Yorktown aquifer well. The first set (Figures A-1 to A-10) contains all water level data and chloride analysis data for that well from 1973 through January 1995. Because data from 1993 and 1994 are most critical, the second set (Figures A-11 to A-20) for the same wells spans January 1993 to January 1995 only.

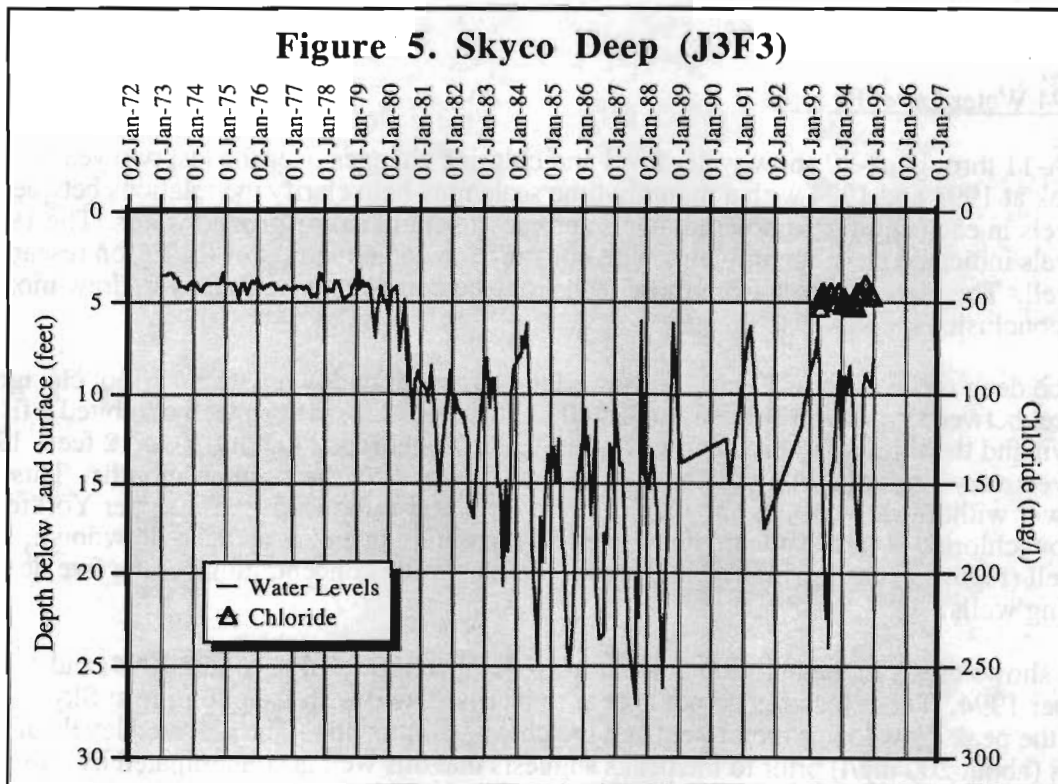
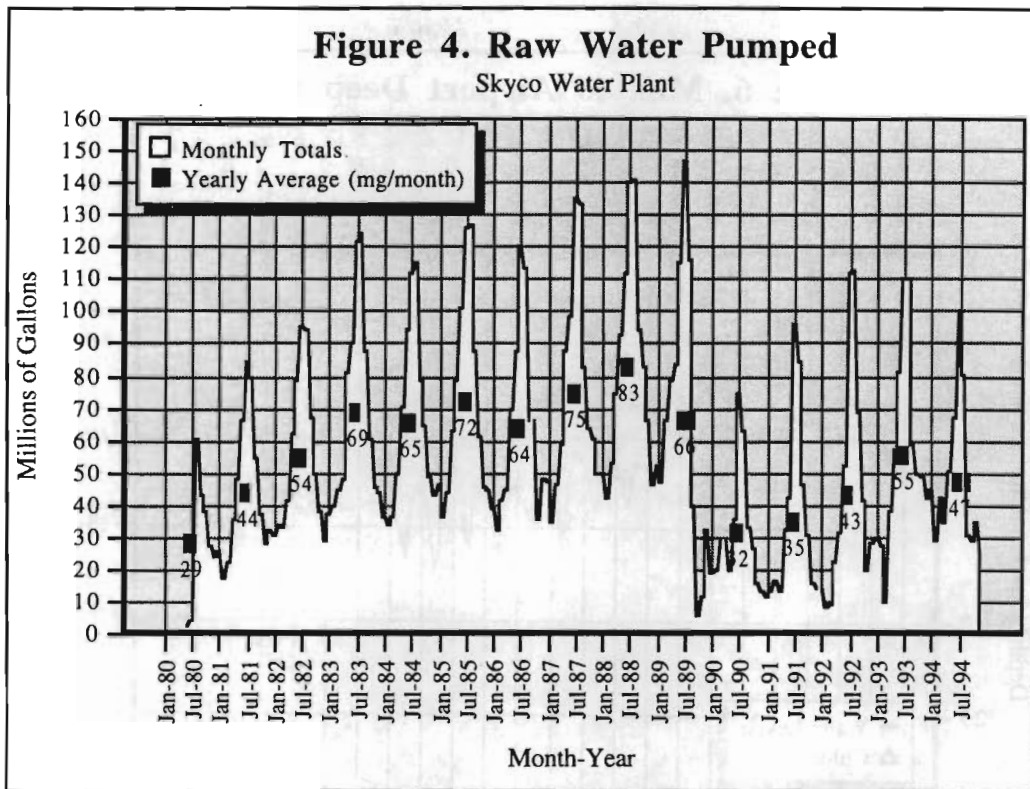
Depth below land surface increases downward on the left-hand y-axis as does chloride concentration on the right-hand y-axis (please note the different scales). Years or months progress from left to right on the x-axis. For example, on Figure 3 the deep Skyco monitoring well shows a reduction of water level from about 10 feet below land surface in March 1994 to 18 feet below land surface in July and August 1994. Chloride concentrations appear to be unaffected by the drawdown of water levels and remain at about 50 milligrams per liter (mg/l). The drinking water standard for chloride is 250 mg/l.

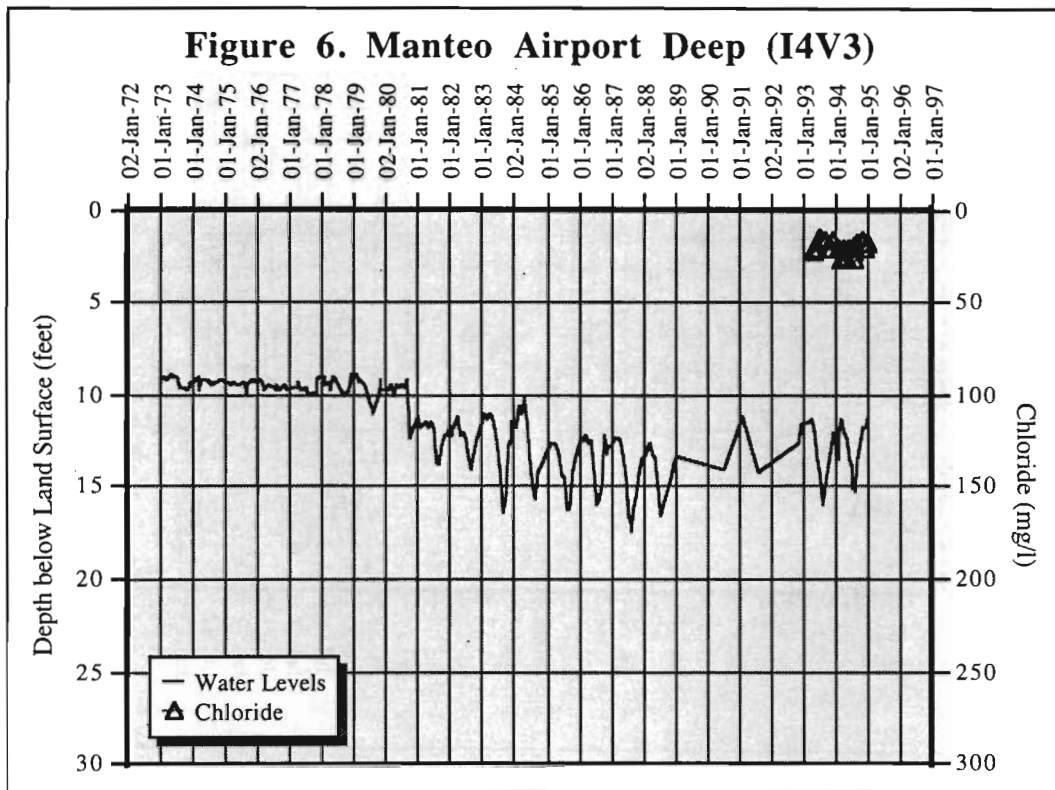


Complete Water Level Record

It is significant to compare the monitoring well water levels to the total raw water pumped per month from the Skyco well field. The pumping volumes from 1980 through 1994, by month, are presented in Figure 4. The yearly average rate of pumping (millions of gallons per month) is also plotted in this figure. Notice the deepening levels of drawdown recorded at Skyco and Manteo Airport deep wells (Figures 5 and 6) from 1980 to 1988. This correlates to the gradual increase in pumping from Skyco recorded in Figure 4. Although the monitoring data is skimpy from 1988 through 1992 pumping data from Skyco suggest that water levels recovered as the RO plant came on line in 1989. Water levels began dropping again after the RO cut back production in 1992. Levels recovered somewhat in 1994, as demand on Skyco decreased, following the addition of two new wells for the RO plant.

The shallow monitoring well water levels fluctuated two to four feet except for one anomalous reading in 1987 at the Eason shallow well. The surficial aquifer levels did not correlate to the increased pumping or the drawdowns seen in the deep monitoring wells. This relationship suggests the two aquifers are hydraulically distinct. The shallow well fluctuations in water levels and chloride concentrations exhibited might represent tidal effects, local shallow ground water pumping, rainfall, or overwash influences. The Skyco shallow well (Figure A-11) illustrates likely overwash events during the fall and winter of 1993 and 1994 because of the increase in chloride concentration.



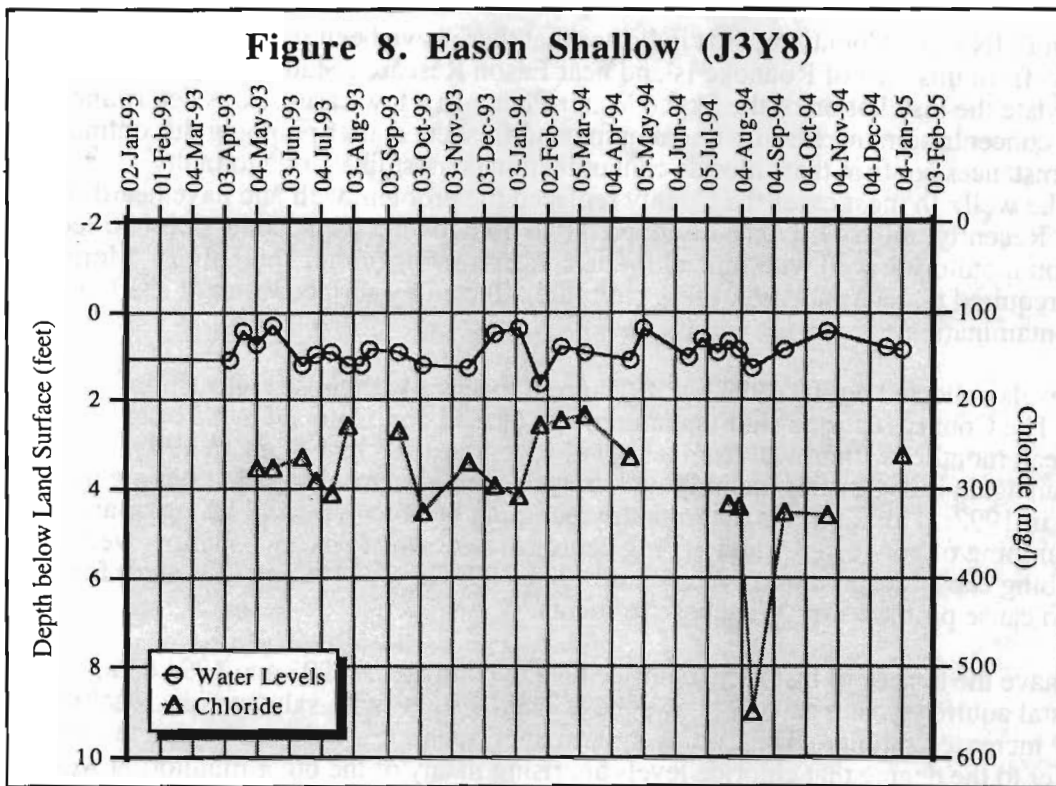
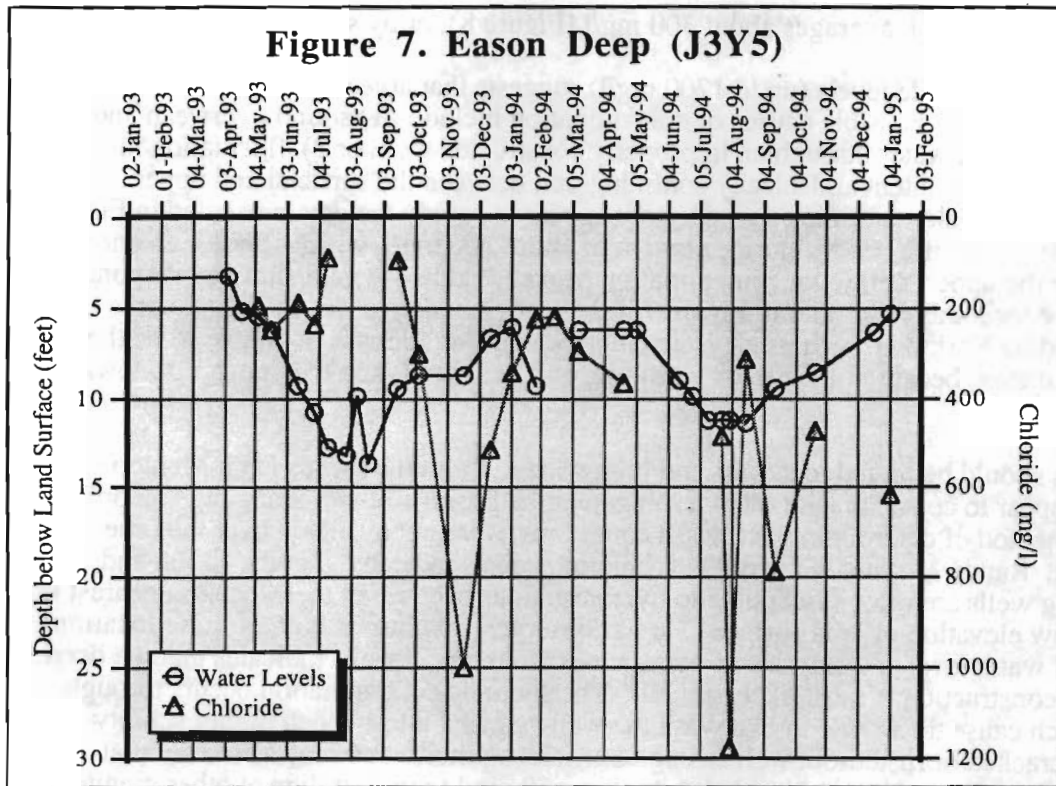


1993-1994 Water Level Record

Figures A-11 through A-20 show water level and chloride changes over the last two years. A closer look at 1993 and 1994 with a monthly time scale may help clarify the relations between water levels in each aquifer, and withdrawals and movement of saline ground water. The 1993 water levels indicated possible problems with construction and condition of the Eason research station well. The record of data from those wells may be complete enough now to draw more specific conclusions.

The Skyco deep well (A-12 or Figure 3) showed the largest drawdown with a 15-foot change in water level between April and July or August 1993. Manteo Airport deep well exhibited a five foot drawdown and the three southern deep wells had water level drops of about 10 to 12 feet. 1994 water levels vary similarly, but with less severe drawdowns over the summer months. This is due to the lower withdrawal volumes shown on Figure 4. Water samples from the upper Yorktown wells show chloride levels that were unaffected by the pumping and associated drawdown. The Eason well (Figure 7) has the highest and most erratic chloride concentrations of the five deep monitoring wells.

Figure 7 shows crests in the chloride content in November 1993, July-August 1994, and September 1994. These features do not appear to be associated with the pumping at Skyco, because the peak drawdowns are offset from the chloride intrusions. The elevated levels of chlorides (about 200 mg/l) prior to the peaks suggests that this well is contaminated by either



surficial aquifer water, which averages about 300 mg/l (Figure 8), or by surface water.

Also, the spike in the chloride levels (up to 1200 mg/l) suggests that at least some of the contamination is sporadic. Possible causes of contamination include: 1) sand overwash and contamination by surface water through an improperly constructed well; or 2) fluctuation in surficial aquifer chloride content and a leaky confining unit between the surficial and upper Yorktown aquifers. A leaky confining unit does not appear to satisfy the data presented in Figures 7 and 8. The surficial aquifer has a chloride content of about 300 mg/l, which is not high enough to be a source for the upper Yorktown contamination peaks. Figure 8 would show corresponding highs in chloride concentration similar to Figure 7 if the surficial aquifer was the only source of chloride. The middle Yorktown with its elevated chloride concentrations is not likely to be the source of contamination because of the thick confining unit between it and the upper Yorktown aquifer.

Overwash events should be linked to storms and high winds. Rainfall records from Manteo Airport do not appear to correlate with overwashing near the Eason wells. Tidal gauge records, the more direct method of determining overwash conditions, were not available over the time period of interest. Randy McPhee (Skyco Plant Superintendent) indicated that the Eason and Skyco monitoring wells are most susceptible to overwash tides because of their location nearest the Sound and the low elevation of land surface. He has observed flooding at both of these locations. The extra year of water level and chloride concentrations from Eason wells indicates that the deep monitoring well construction is most likely at fault. The sporadic contamination occurs through wind events which cause the Sound to overwash the well area and allow much higher salinity water to enter a cracked or rusted-out well casing. Surficial aquifer water may also enter that casing more consistently to elevate chloride levels above 50 mg/l (concentration at other monitoring wells).

Information from EHNR and County records indicates that there have been several reports of high chlorides in wells from this area of Roanoke Island near Eason Research Station. In some cases those reports predate the installation of the Skyco Water Plant. In a few cases it was determined that the chloride concentration increased with pumping and freshened after pumping discontinued. Both these circumstances confirm that chloride contamination is most likely due to faulty construction of the well. In most cases the County replaced the problem well and have heard of nothing further. Recently, Randy McPhee discovered two homeowner wells about 600-800 feet north of the Eason monitoring well with high chloride concentrations (about 1600 mg/l). More analysis will be required to determine how these wells are affected by surface water or shallow ground water contamination.

Overall, water levels collected during 1993 and 1994 seem to agree with those collected in previous years. The County reported significant numbers of well complaints in 1983 after increasing the peak monthly withdrawal from a high of 95 mg in 1982 to 123 mg in 1983. Complaints began again in 1992 after monthly withdrawals increased from a peak of 96 mg in 1991 to 112 mg in 1992. This suggests that monthly pumping between 96 and 112 mg or an average daily pumping of between 3.1 and 3.7 mg causes drawdowns to exceed shallow well pump and plumbing capacities in most of Wanchese. The 1994 high of 100 mg (3.2 mgd) for July did not appear to cause problems for Wanchese residents.

DWR does not have the benefit of historical chloride data to compare to 1993 and 1994 data; however, a coastal aquifer system usually shows the effects of stress with saltwater encroachment, as evidenced by increased salinity. The County system does not appear to have stressed the upper Yorktown aquifer to the degree that chloride levels are rising in any of the other monitoring wells

or the Skyco supply wells. Data from Eason and nearby homeowner wells suggest another local reason for the elevated chloride levels.

The Skyco plant draws water levels in the upper Yorktown aquifer down in the Wanchese area, especially during the high water use summer months. However, water levels recover during periods of lower water use. No damage to the aquifer is apparent from the 1973 to January 1995 data presented in this report. Thus, adequate ground water is available for existing uses in the Wanchese area if properly constructed individual wells and adequate deep well pumps are used.

RECOMMENDATIONS

Data Collection Activities

Dare County's monitoring efforts on Roanoke Island included waterlevels and chloride concentrations collected at monthly or twice monthly rates and prove to be helpful to the water system, State, and local observers. From this data it is possible to discern the effects of pumping from Skyco wells. Dare County benefits because they have a network in place to evaluate the aquifer conditions and can plan for contingencies more effectively. The general public can see the true impact of the Skyco pumping. DWR now has more of the tools necessary to analyze the aquifer system and to estimate yield.

Because of these useful products, DWR recommends that monitoring continue as long as Dare County uses the Skyco plant to produce water. The network should be expanded somewhat to include wells at the outer reaches of the island, especially the eastern and southeastern portions so as to better gauge the possibility of saltwater encroachment and to cover the entire community of Wanchese. It is clear that the well network needs to be refurbished. Each monitoring well needs sediments to be purged and the screen and casing integrity tested. The Eason deep monitoring well should be abandoned by filling with grout. Another Eason deep well (preferably J3Y3) might be used for monitoring after all wells at that site have been examined. EHNR is responsible for these tests and possible abandonment. The area near Eason research station requires more attention to discern the extent of higher chlorides in homeowner wells.

Future of Ground Water Use

Dare Regional Water System's RO facility is constructed to be expandable to meet increased water demand. Of course, delays will be experienced during the expansion process either to add wells or membrane units. Skyco water plant can be used to meet water demands during periods when the RO plant is not able to meet its share of the system's needs. It is important to include in the normal operation of Skyco the monitoring of water levels and chloride concentrations similar to methods used at the RO facility. Also, information given to residents of Roanoke Island not using the Dare Regional Water System must be consistent. It must include proper well construction and adequate pump and plumbing recommendations. Just as it is important to protect the membranes at the RO plant, the residents of Wanchese need protection against water level drawdowns and saltwater intrusion.

Preparation of this second annual report on Roanoke Island ground water monitoring is an important step toward ensuring the safe future use of the region's ground water. DWR believes

that Dare County is committed to protecting their ground water resources and looks forward to working with them to improve and expand their monitoring effort. Future reports will be published every other year beginning in 1997 with results of monitoring from 1995 and 1996.

ACKNOWLEDGMENTS

The Division of Water Resources wishes to thank Dare County for its assistance in preparing this report. Much of the data presented in this document was collected by Dare County employees. Special thanks go to Bob Oreskovich, Randy McPhee, and Kathy Wunderlich.

Appendix A. Monitoring Well Hydrographs

The 1993 version of this document reported water levels as depth below land surface when they were actually referenced to the top of the well casing. This inconsistency is harmless when the relative water level changes are of interest, but has been rectified in this document.

