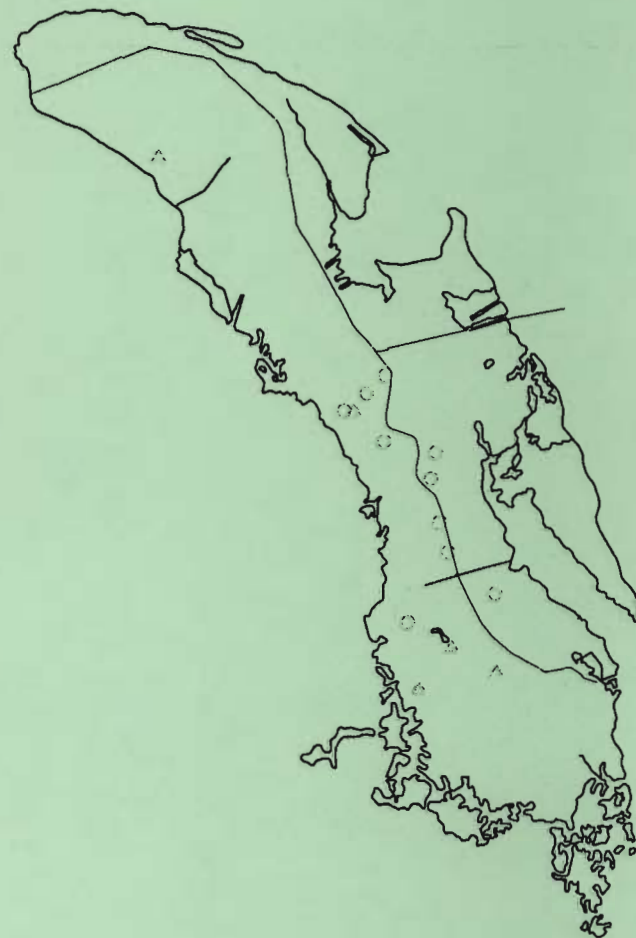


Roanoke Island
Ground Water Monitoring Report
for 1995 & 1996

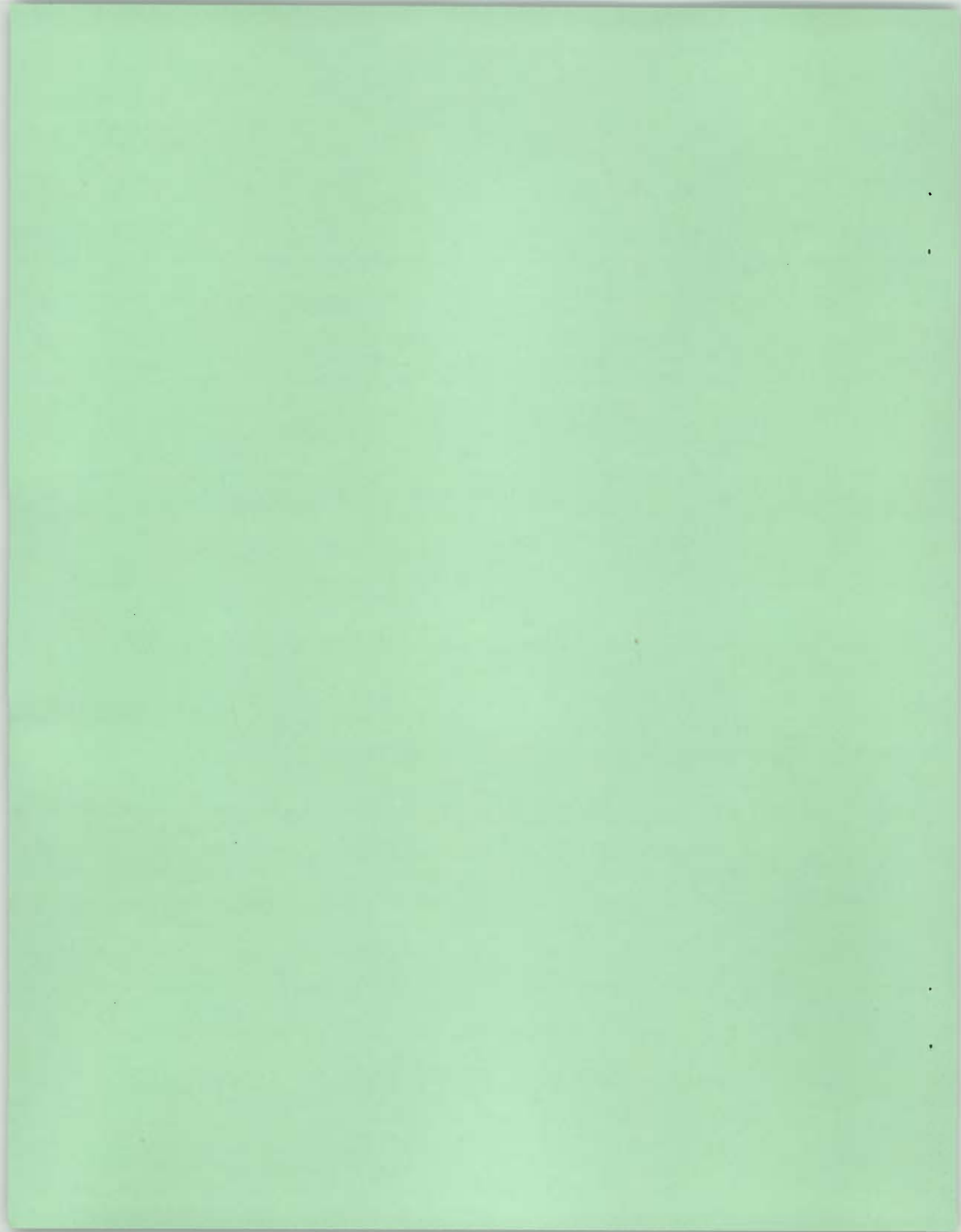
Prepared by
Nathaniel C. Wilson, P.G.

North Carolina
Department of Environment, Health, and
Natural Resources

Division of Water Resources



June 1997



Roanoke Island
Ground Water Monitoring Report
for 1995 & 1996

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Roanoke Island Ground Water Monitoring Report for 1995 & 1996

INTRODUCTION

This third report on ground water level conditions beneath Roanoke Island is a follow-up study to the 1993 and 1994 reports. In both the first and second summaries, the Division of Water Resources (DWR) documented Dare County's successful establishment of a monitoring well network and their commitment to good management of ground water resources. This monitoring report is similar in format to the first two and includes water level and chloride concentration data from previous reports. As stated in the conclusions, future reports by DWR are deemed unnecessary. However, DWR recommends that Dare Regional Water Supply System continue to collect and publish water level information in their annual reports. DWR will be willing to assist the County with the interpretation of water level data and their presentation.

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 agreed 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, false impressions about the state of ground water resources can develop.

Monitoring Report

Beginning in the early 1980s the County received reports of pump and water level problems from residents of Wanchese. There were no reported problems from 1989 to 1991, when the RO water plant came on-line, but problems reappeared in 1992 when the RO plant slowed production of water and heavier withdrawals were made from Roanoke Island.

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 were 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 Water Quality (DWQ) and County records showed that the reported problems continue to occur because of inadequate water pumps and plumbing. These problems, in combination with seasonal 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 production from the two other sources (Fresh Pond and the Reverse Osmosis Plant) in the Dare Regional System. An overview of the Dare County Regional System was included in the 1993 report. The addition of two RO wells in 1994 was recorded in the 1994 report. No other major changes have occurred.

DATA COLLECTION AND INTERPRETATION

Data Collection

Dare County continues to measure water levels and collect water samples from five pairs of wells located on Roanoke Island (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 to determine their actual depths (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 the integrity of its screen and casing checked. One group of wells is located north of the Skyco well field; another is located in the well field; and three pairs of wells are located south of the well field in Wanchese (see Figure 1). Three additional wells located in Manns Harbor have been included in this report (see Table 1). Dare County started to measure and sample these wells in 1994.

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. Department of Environment, Health, and Natural Resources (DEHNR) Monitoring Wells used by Dare County

Well Name	Map ID - DEHNR Quad Location ¹	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	J3O4	unk	Surficial	8.0	13.0	13.9
Skyco	J3O3	7/26/72	upper Yorktown	200.0	210.0	188.0
Manteo Airport	I4W5	3/27/84	Surficial	15.0	20.0	18.1
Manteo Airport	I4W3	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
Manns Harbor ²	J5J2	10/4/72	upper Yorktown	162.0	172.0	unk
Gateway ²	J5M3	3/27/84	Surficial	19.0	24.0	unk
Gateway ²	J5M2	1/31/73	upper Yorktown	140.0	150.0	unk

¹ Some quad designations changed after wells were located using a Global Positioning System.

² Dare County monitoring began in 1994.

Figure 1. Roanoke Island - Skyco Water Plant

Dare Regional Water System

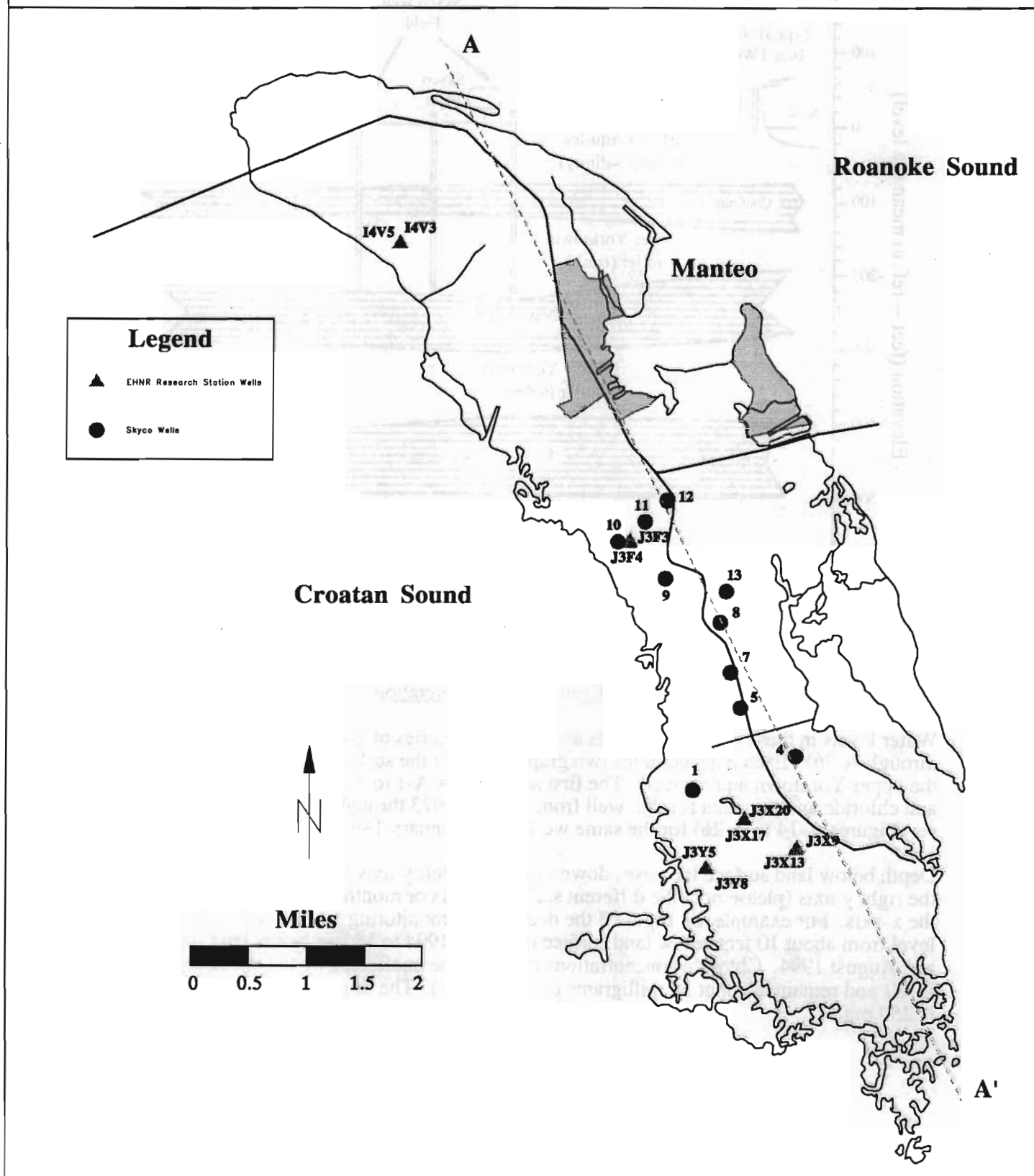
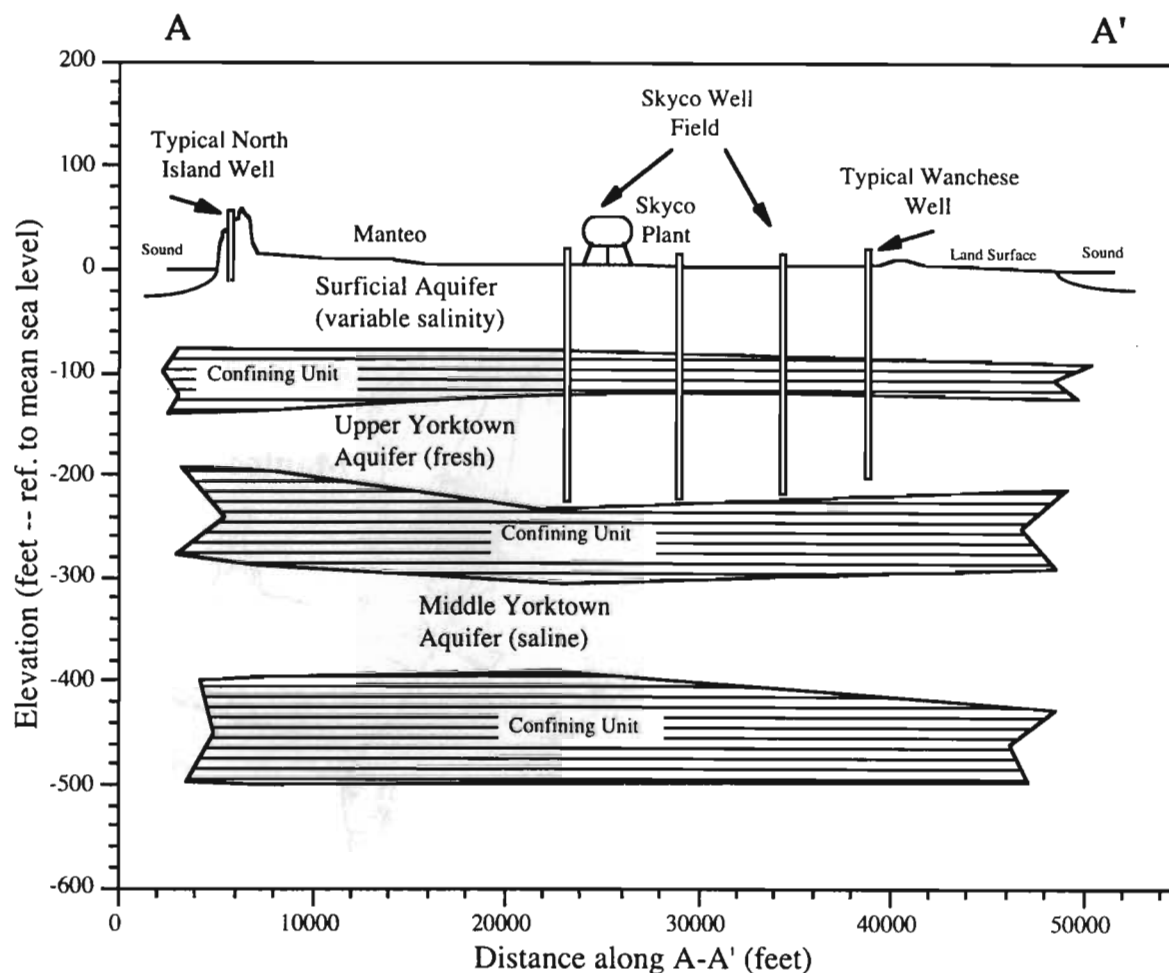


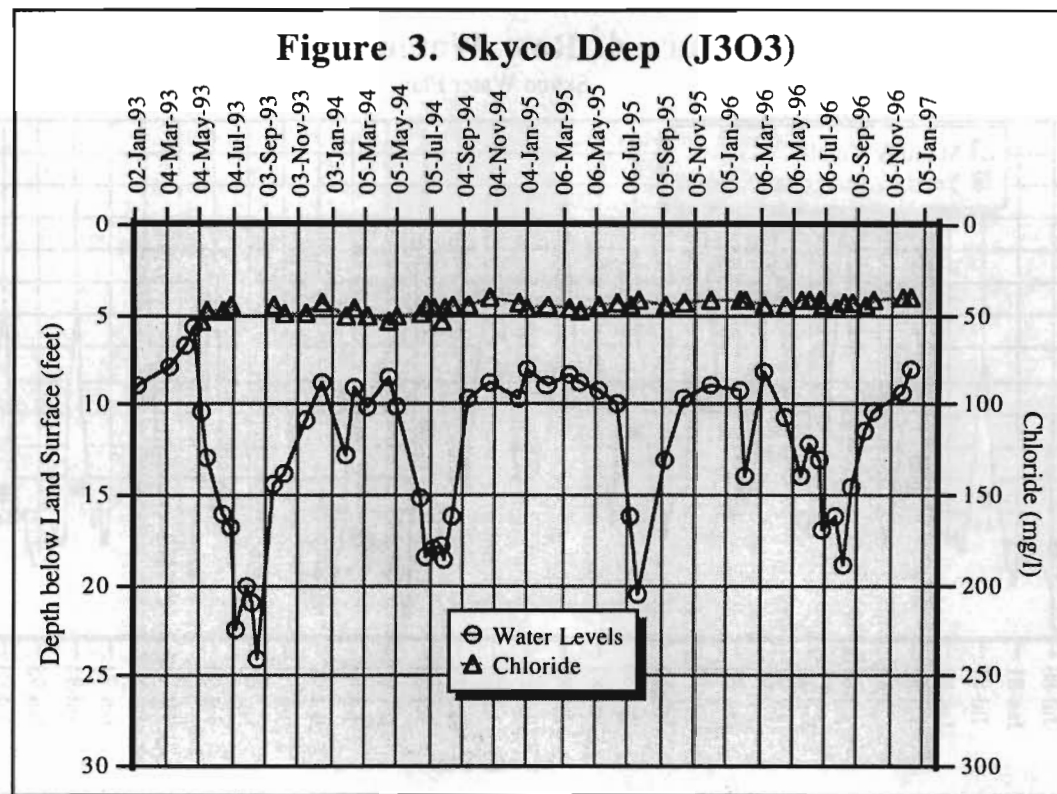
Figure 2. Aquifer framework in cross-section A-A'



Results and Interpretation

Water levels in these monitoring wells are shown in a series of graphs in Appendix A (Figures A-1 through A-26). 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-13) contains all water level data and chloride analysis data for that well from January 1973 through December 1996. The second set (Figures A-14 to A-26) for the same wells spans January 1993 to December 1996 only.

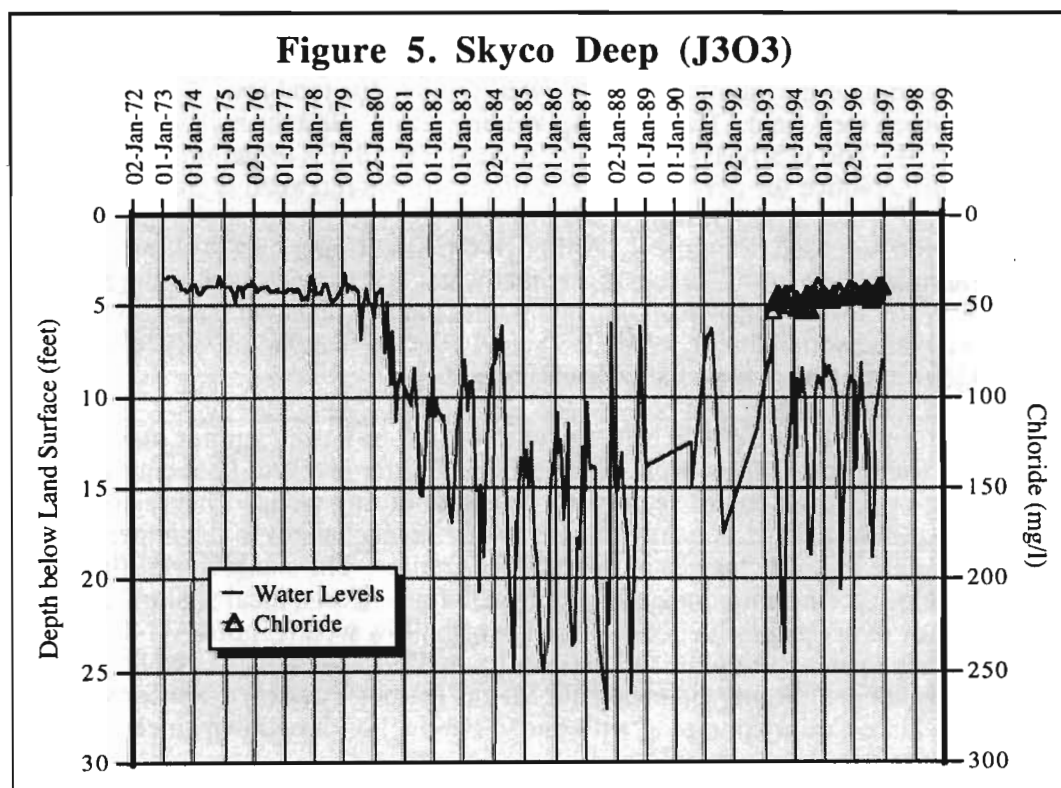
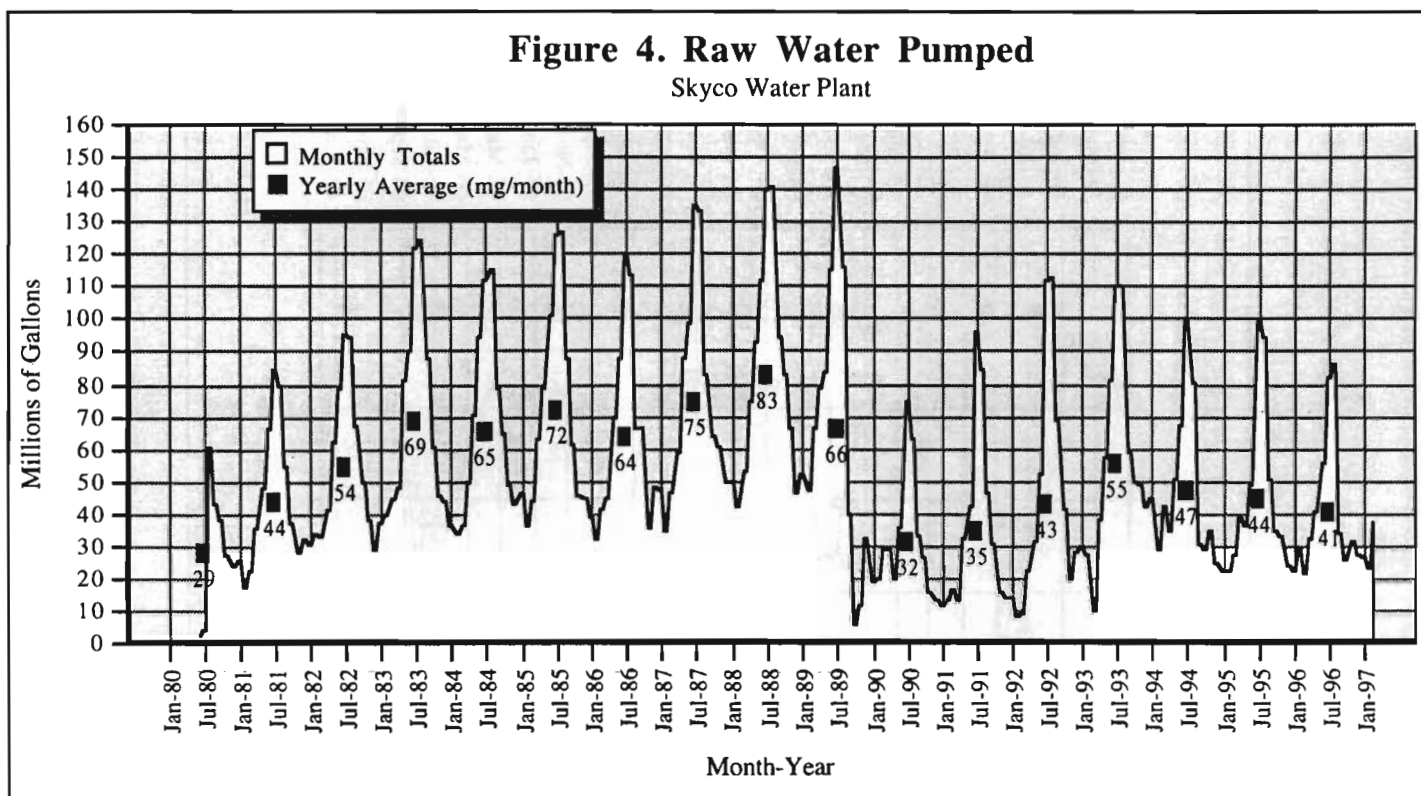
Depth below land surface increases downward on the left y-axis as does chloride concentration on the right y-axis (please note the different scales). Years or months progress from left to right on the x-axis. For example, on Figure 3 the deep Skyco monitoring well shows a reduction of water level from 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.

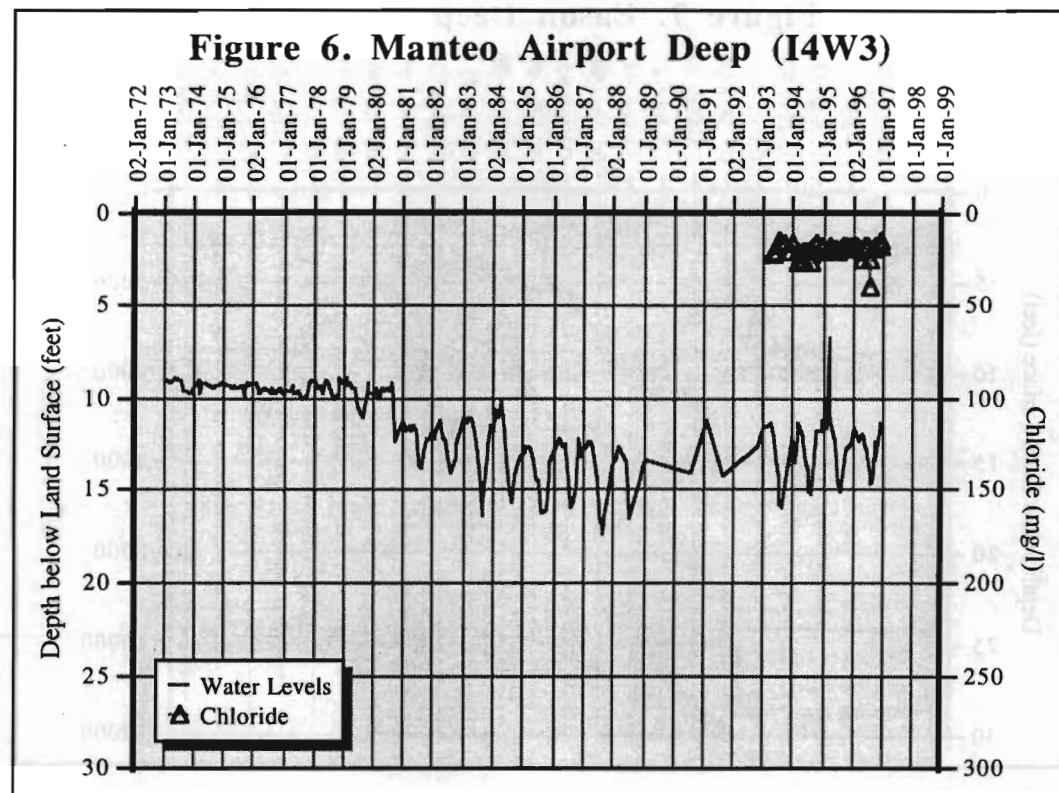


Complete Water Level Record

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 1996, 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 plant cut back production in 1992. Levels recovered somewhat in 1994, 1995, and 1996 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; water level changes in the upper Yorktown aquifer do not correlate to level changes in the surficial aquifer. The shallow well fluctuations in water levels and chloride concentrations might represent tidal effects, local shallow ground water pumping, rainfall, or overwash influences. The Skyco shallow well (Figure A-14) was likely affected by overwash events during the fall and winter of 1993, 1994, and 1995 because of the increase in chloride concentration. Gateway and Manns Harbor Yorktown aquifer wells show slight effects from Dare County pumping with one to two feet of drawdown since 1980.



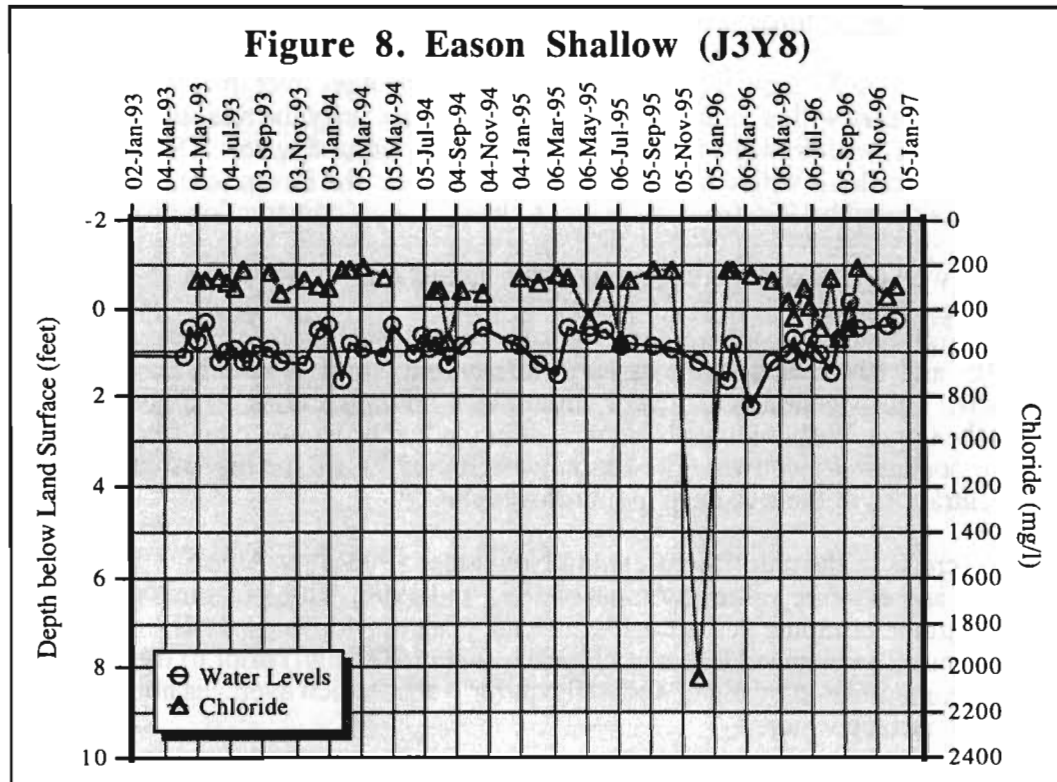
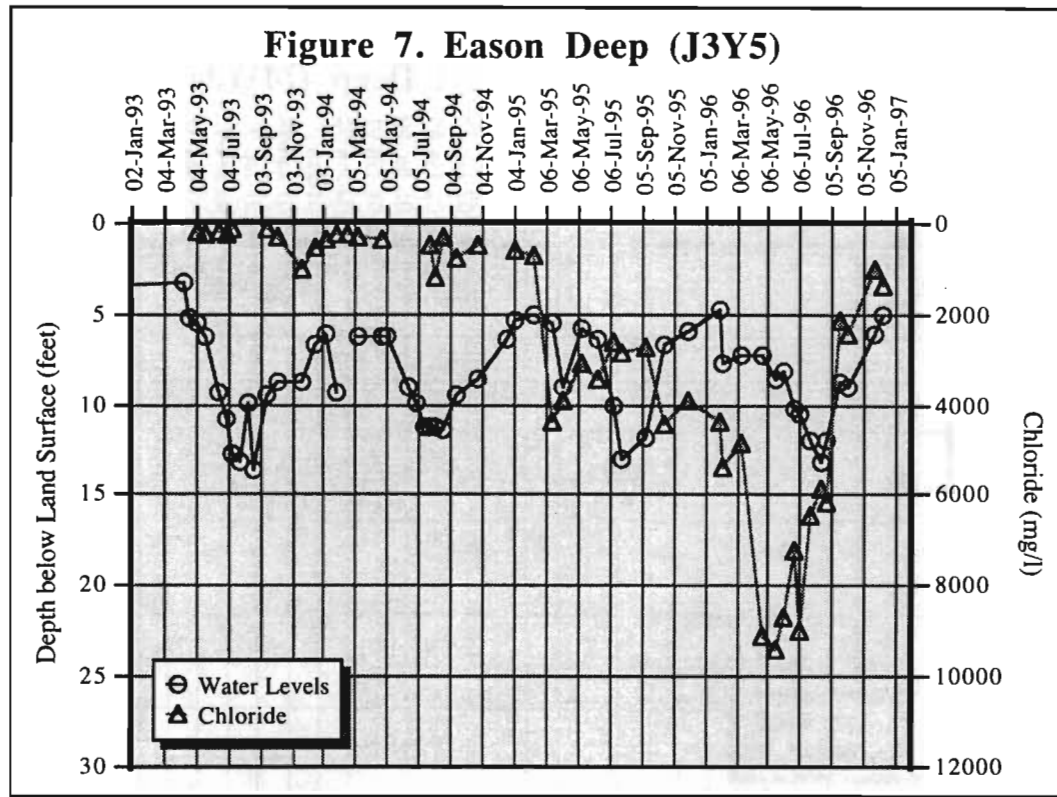


1993-1996 Water Level Record

Figures A-14 through A-26 show water level and chloride changes over the last four years. A closer look at these years with a monthly time scale may help clarify the relations between water levels in each aquifer, 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 through 1996 from those wells clearly shows construction problems.

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. The 1994, 1995, and 1996 water levels varied similarly, but with less severe drawdowns over the summer months. This was due to the lower withdrawal volumes shown on Figure 4. Water samples from the upper Yorktown wells showed chloride levels that were unaffected by the pumping and associated drawdown. The Eason well (Figure 7) had 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 and extreme values for most of 1995 and 1996. 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 spikes in the chloride levels (up to 9500 mg/l) suggest that the contamination is sporadic. Possible causes of contamination include: 1) sound 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 (previous 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 years of water level and chloride concentrations from Eason wells indicates that the deep monitoring well construction is 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.

Information from DEHNR 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 wells. In most cases the County replaced the problem well and have heard of nothing further. In 1994 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 from 1993 to 1996 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. Neither the 1994 or 1995 highs of 100 mg (3.2 mgd) for July caused 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 December 1996 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 continued monitoring efforts on Roanoke Island include water levels and chloride concentrations collected at monthly or twice monthly rates. Their monitoring has proved to be helpful to the water system, the 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.

Because of these useful products, DWR recommends that monitoring continue as long as Dare County uses the Skyco plant to produce water. 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 and possibly other wells at that research station 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. DEHNR is responsible for these tests and possible abandonment. These conclusions were expressed in the 1994 report and no progress has been made to rectify the situation. DWR hopes that funds will become available to maintain the monitoring well network on Roanoke Island and throughout the State in the near future.

Future of Ground Water Use

Dare Regional Water System's RO facility is constructed to be expandable to meet increased water demand. Delays are often experienced during the expansion process either to add wells or membrane units. The 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.

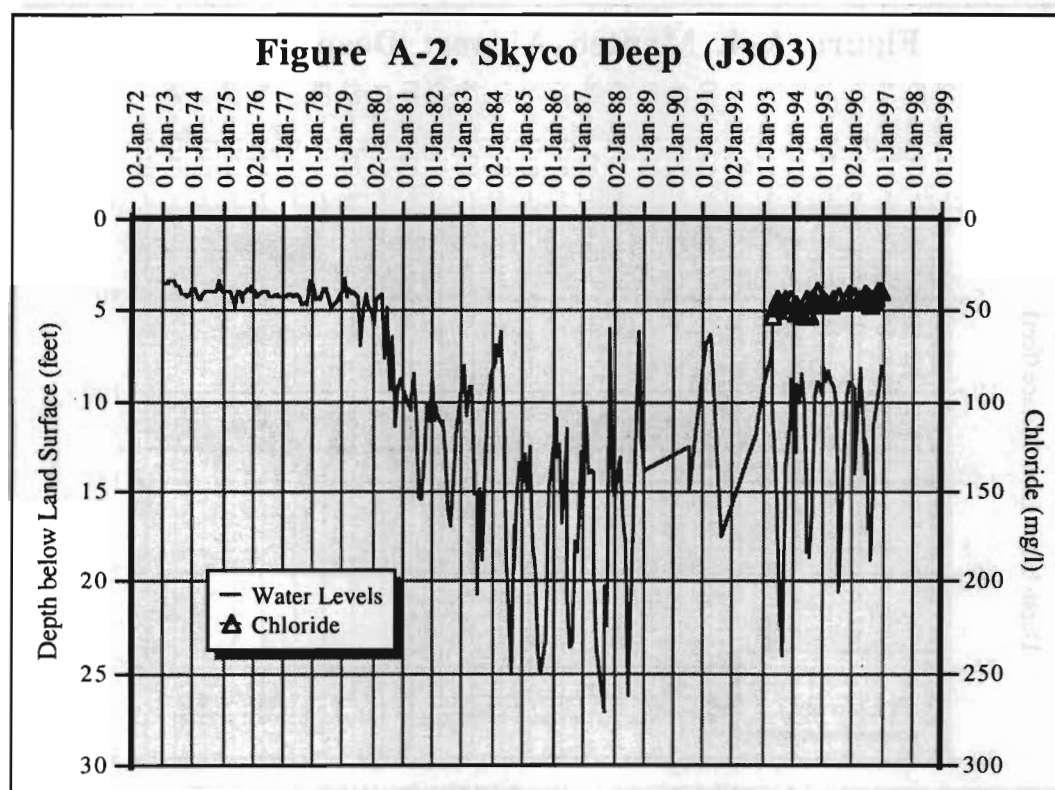
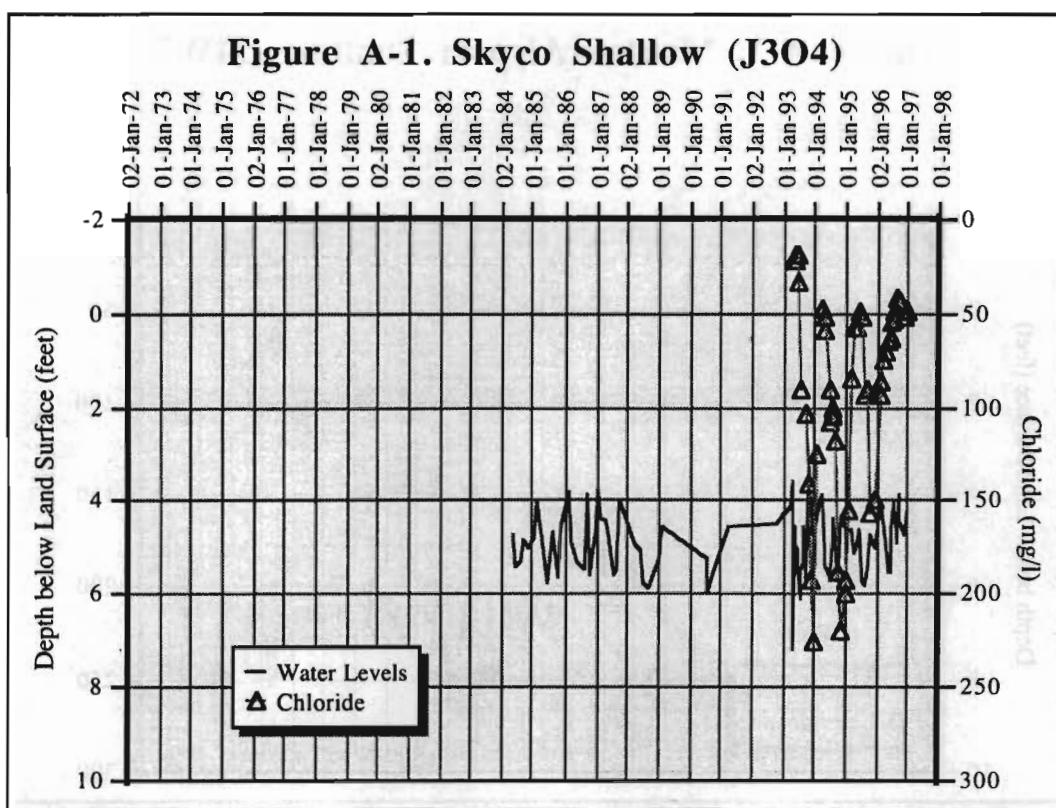
DWR believes that Dare County is committed to protecting their ground water resources and looks forward to working with them in their monitoring effort. Preparation of this third report on Roanoke Island ground water monitoring has shown that the Yorktown aquifer is capable of providing significant portions of the Dare County demand and that future reports by DWR seem unnecessary. But, DWR recommends that monitoring continue and be presented in the Dare Regional Water Supply's annual reports and shared with the Division for inclusion in our statewide water level database. DWR can assist with interpretation as needed.

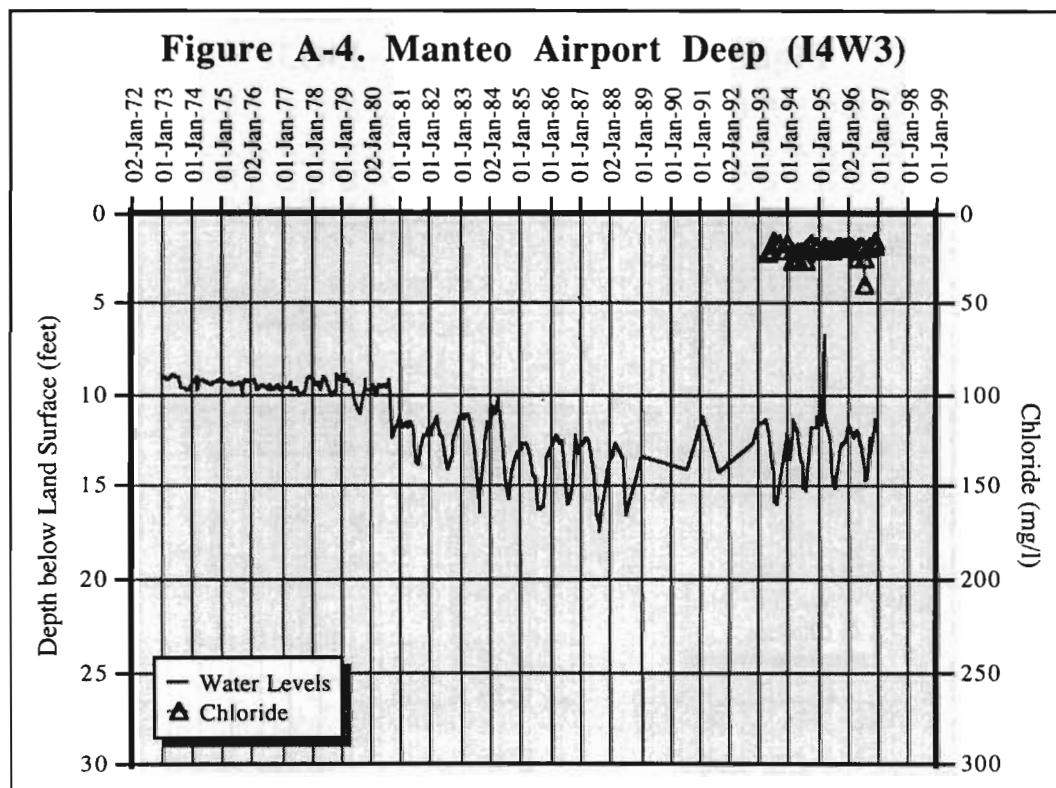
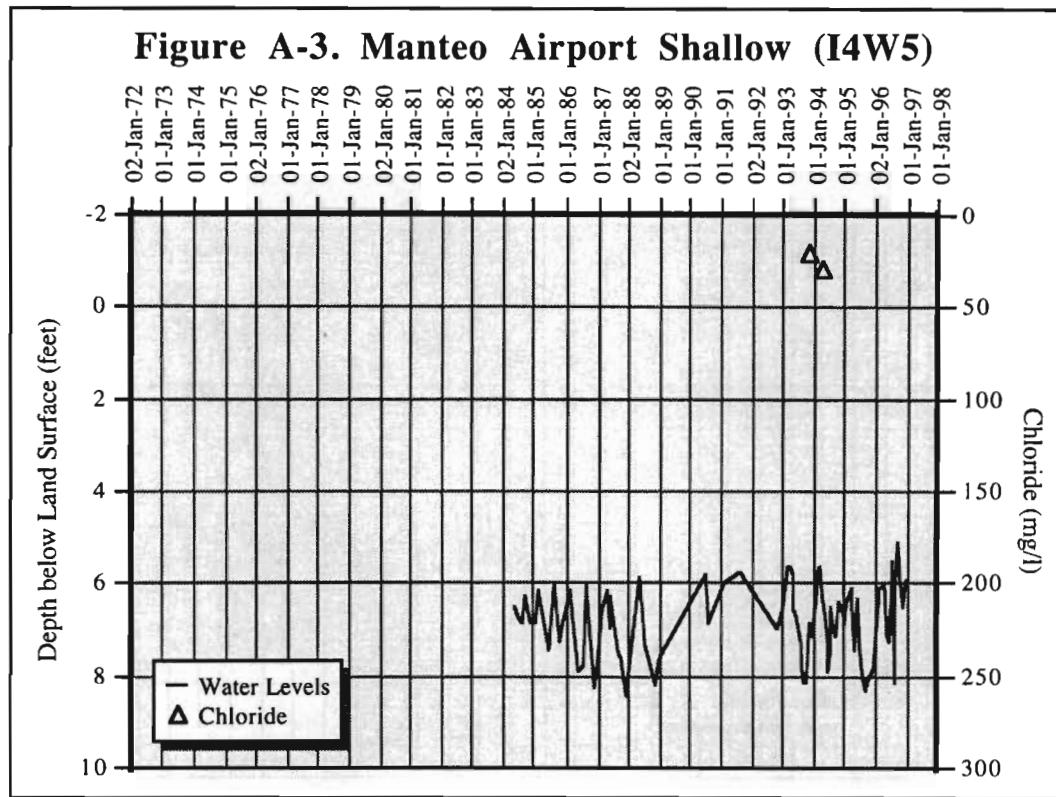
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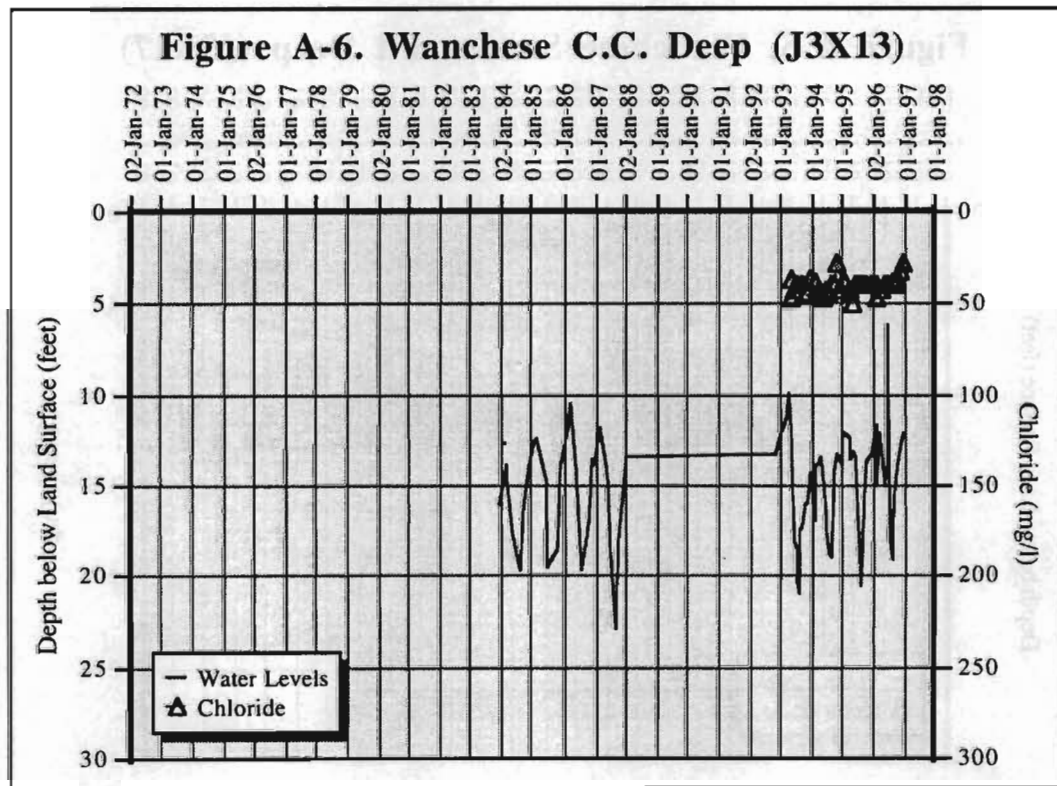
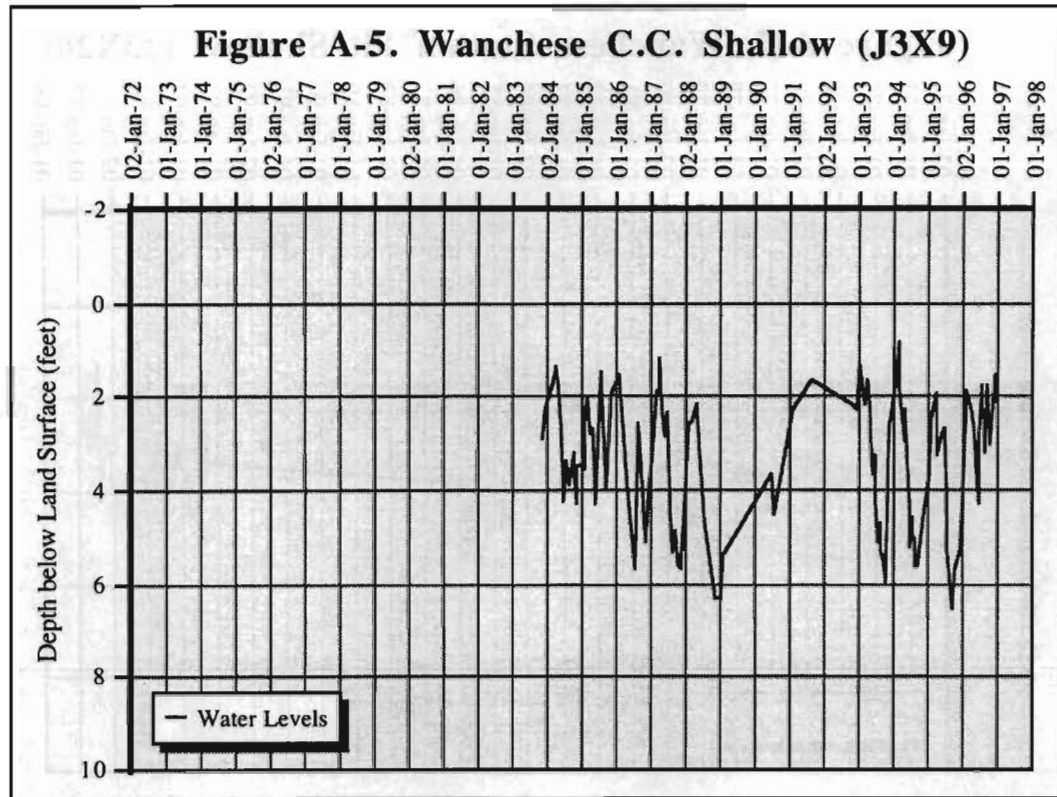
The Division of Water Resources wishes to thank Dare County for its assistance in preparing this report. Much of the data presented in this document was collected by Dare County employees. Special thanks go to Donnie Ross and Bob Oreskovich.

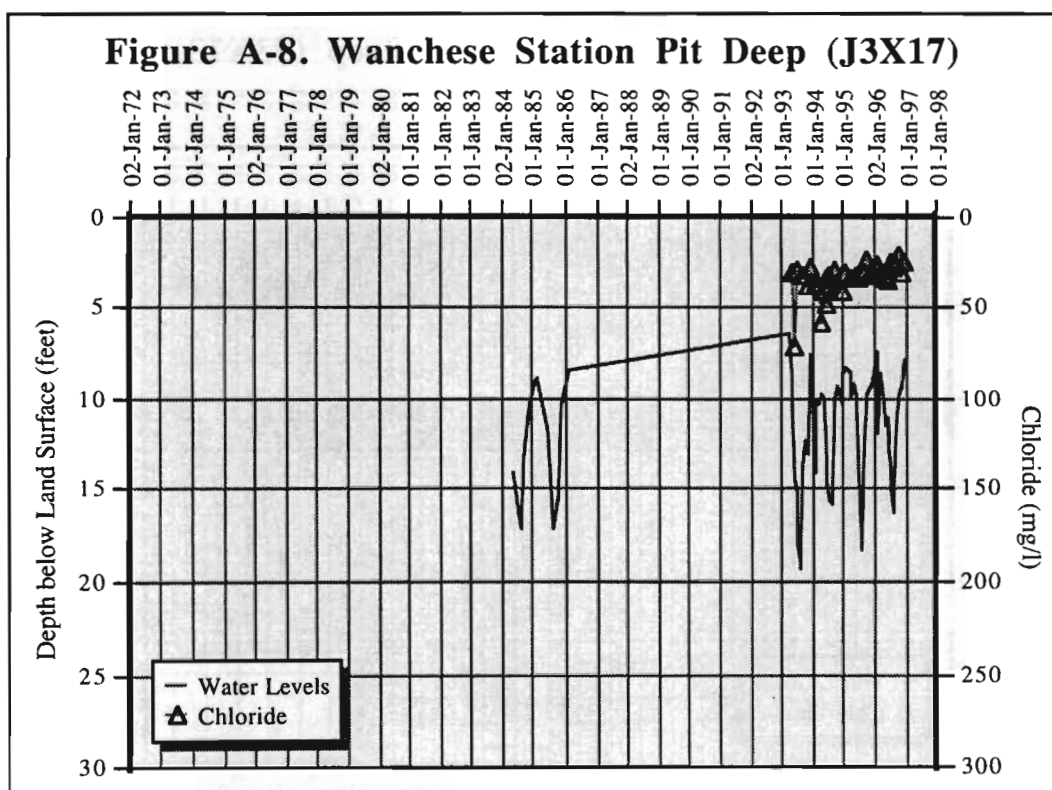
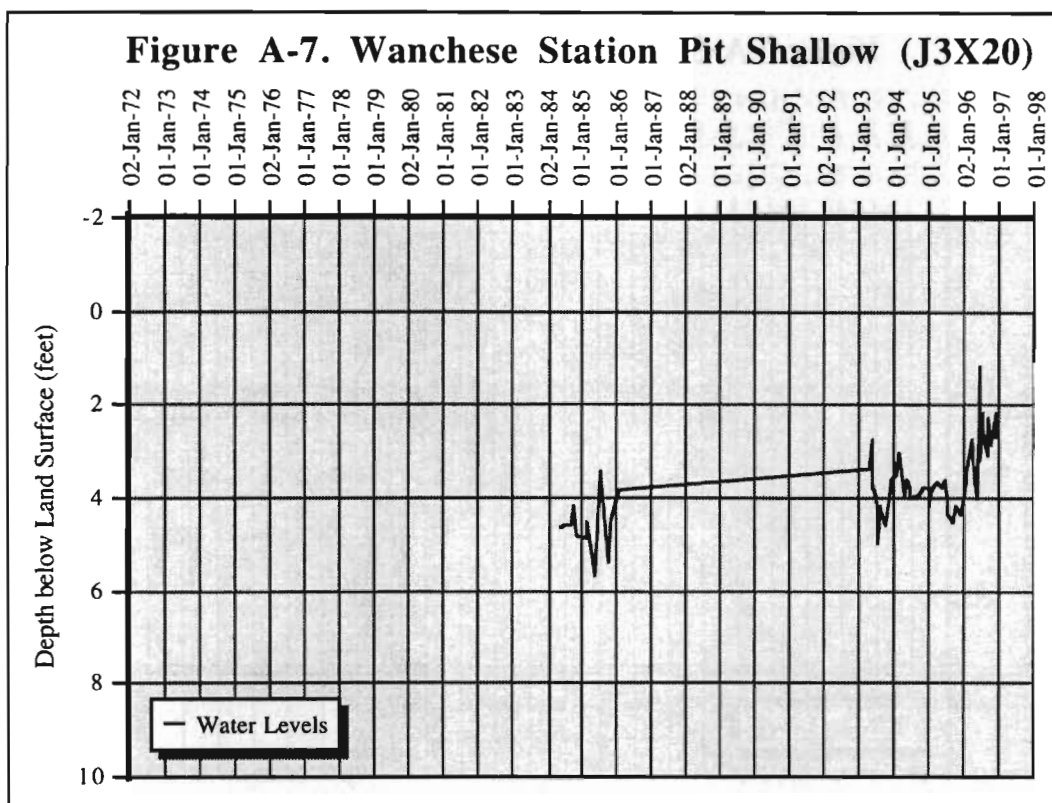
Appendix A. Monitoring Well Hydrographs

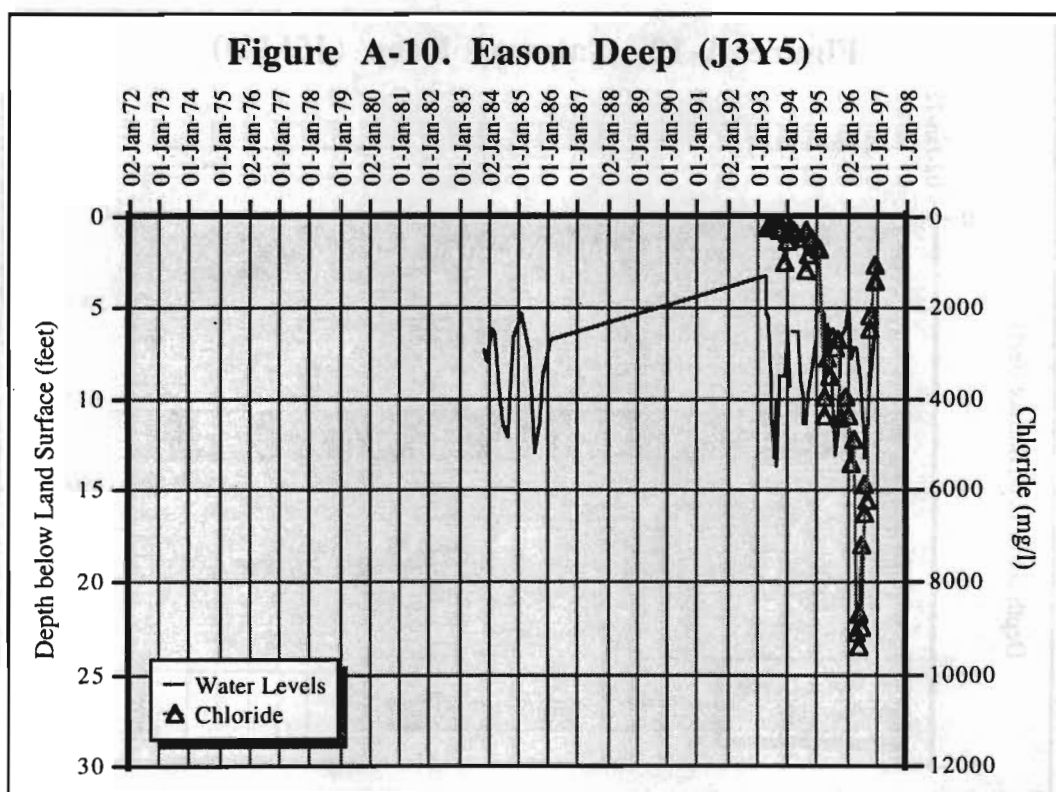
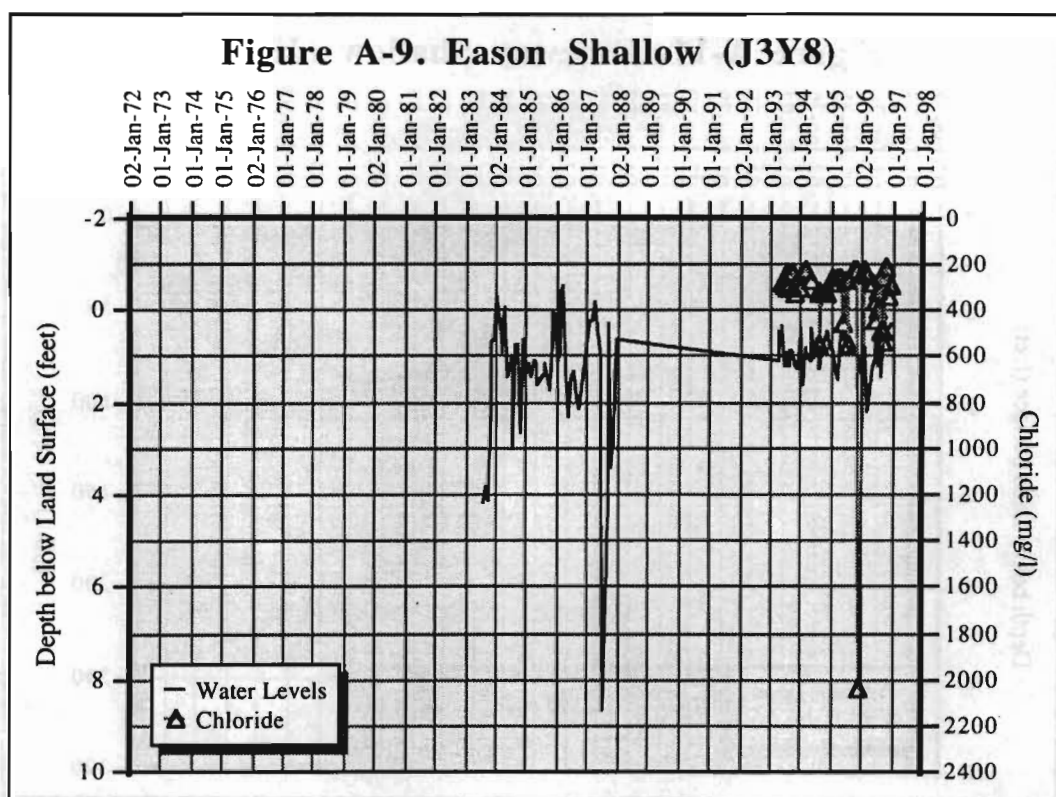
The 1993 version of this document reported water levels as depth below land surface when they were actually referenced to the top of the well casing. This inconsistency is harmless when the relative water level changes are of interest, but was remedied in the 1994 report and this document.

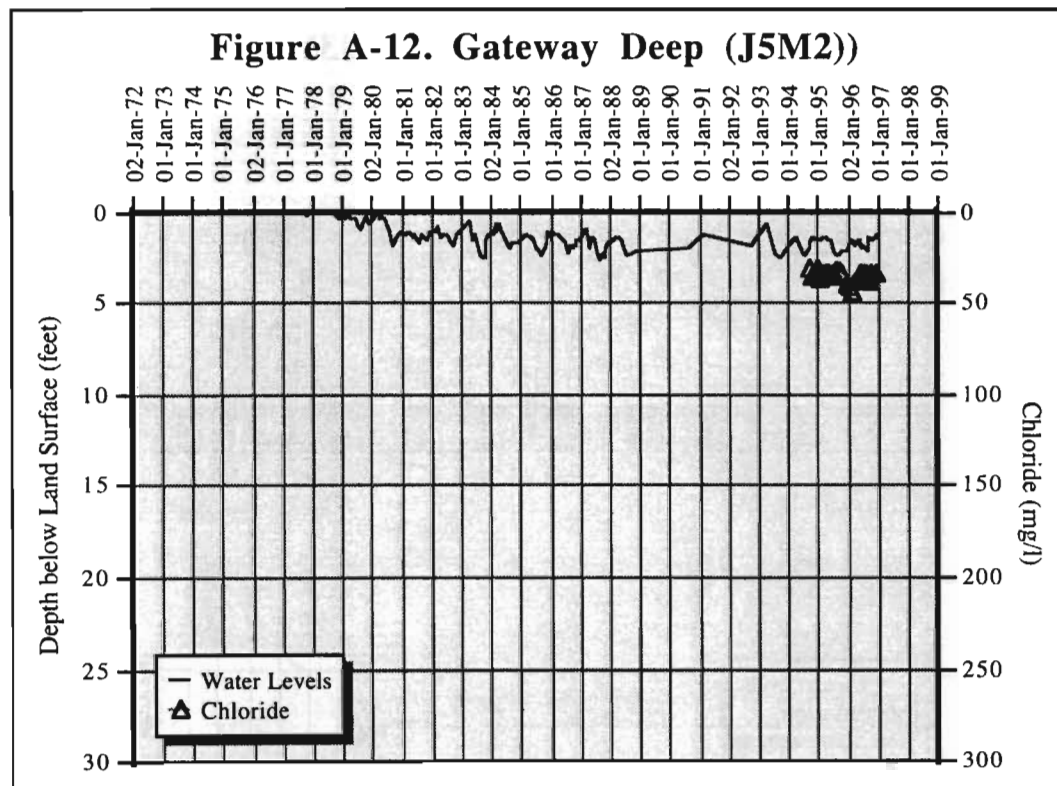
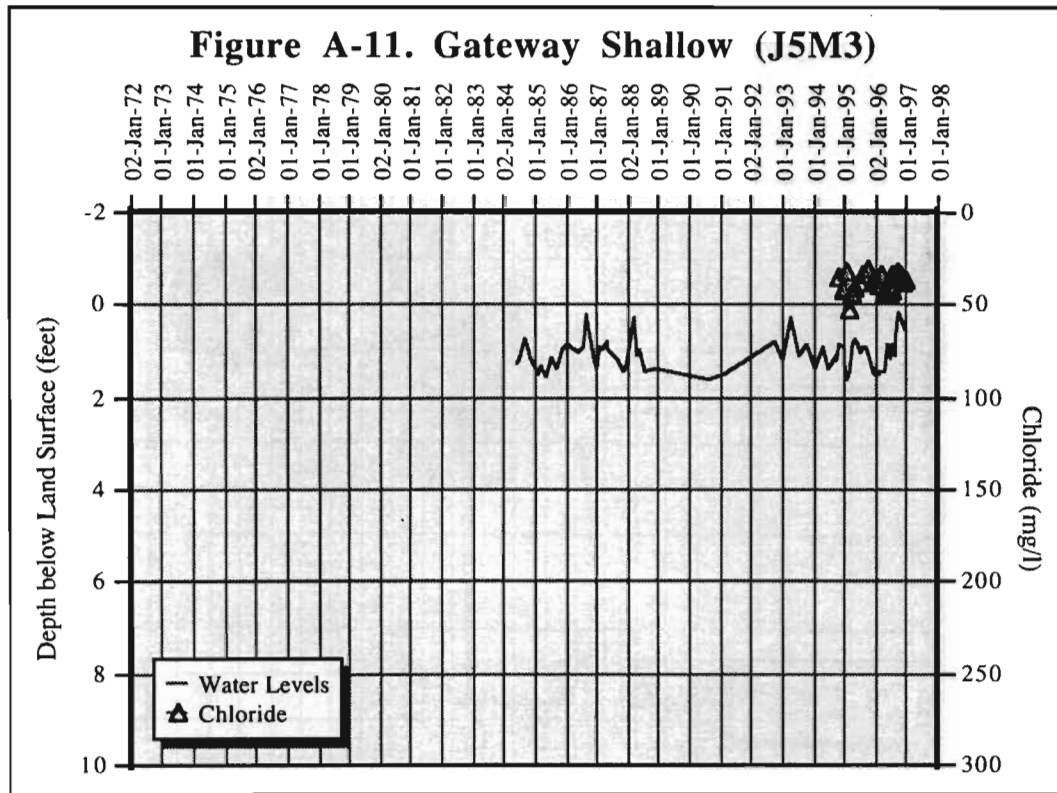


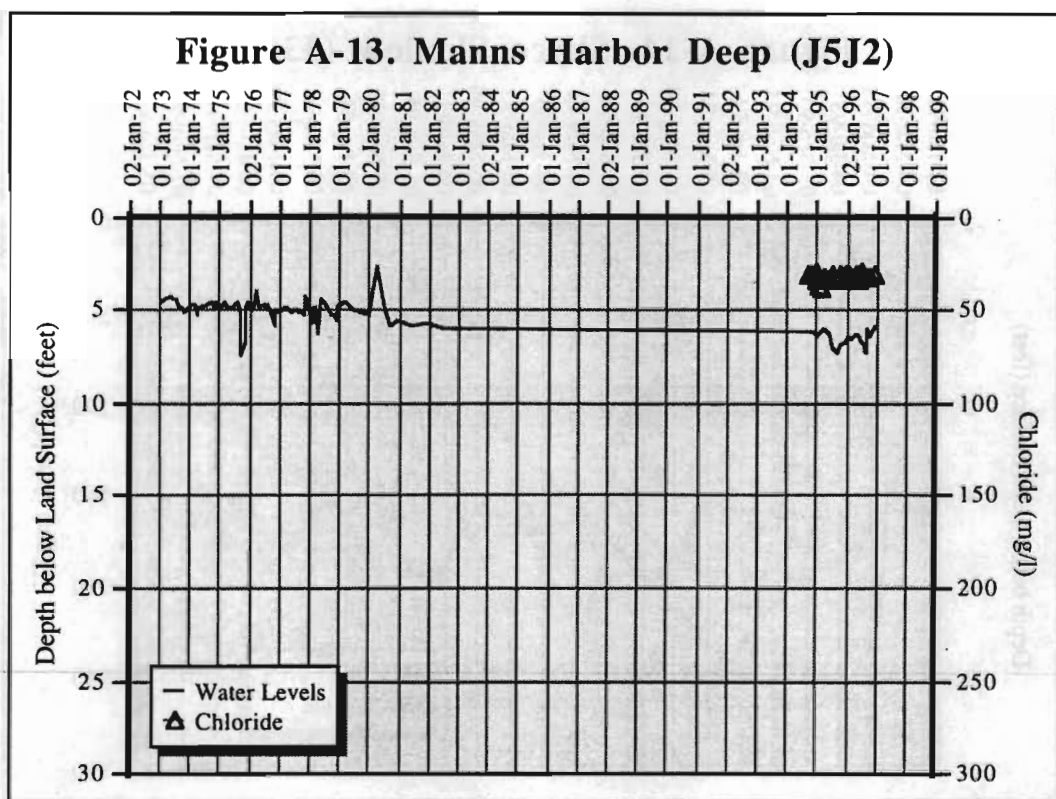


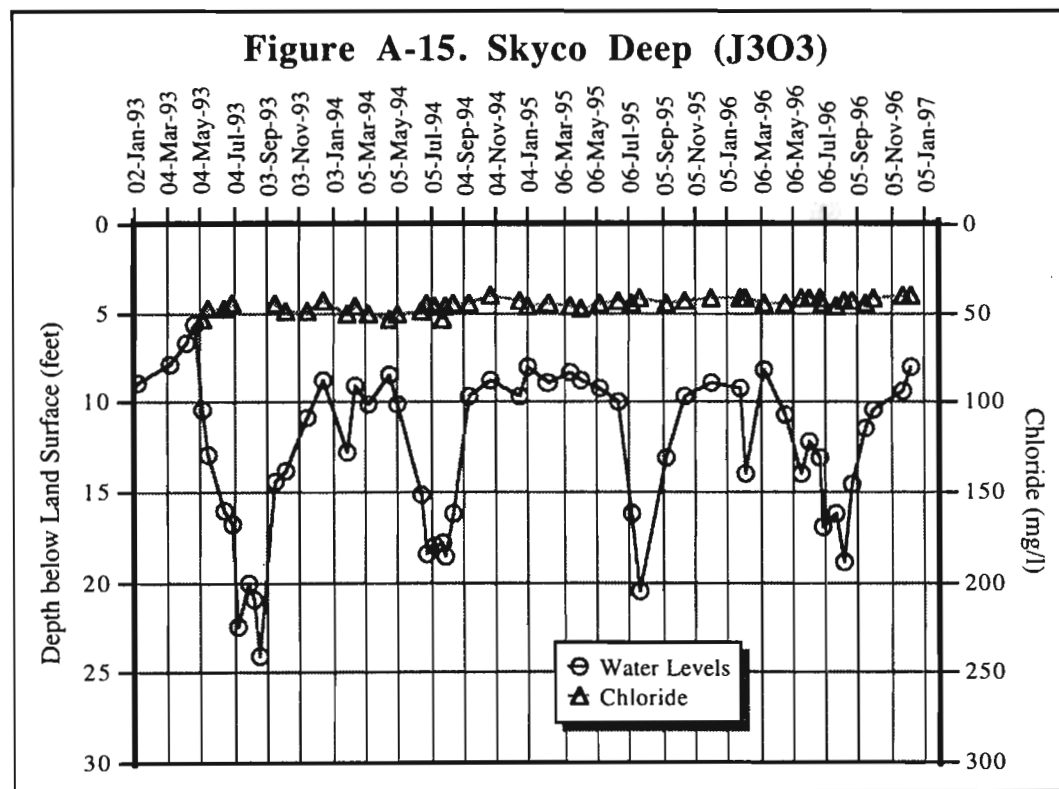
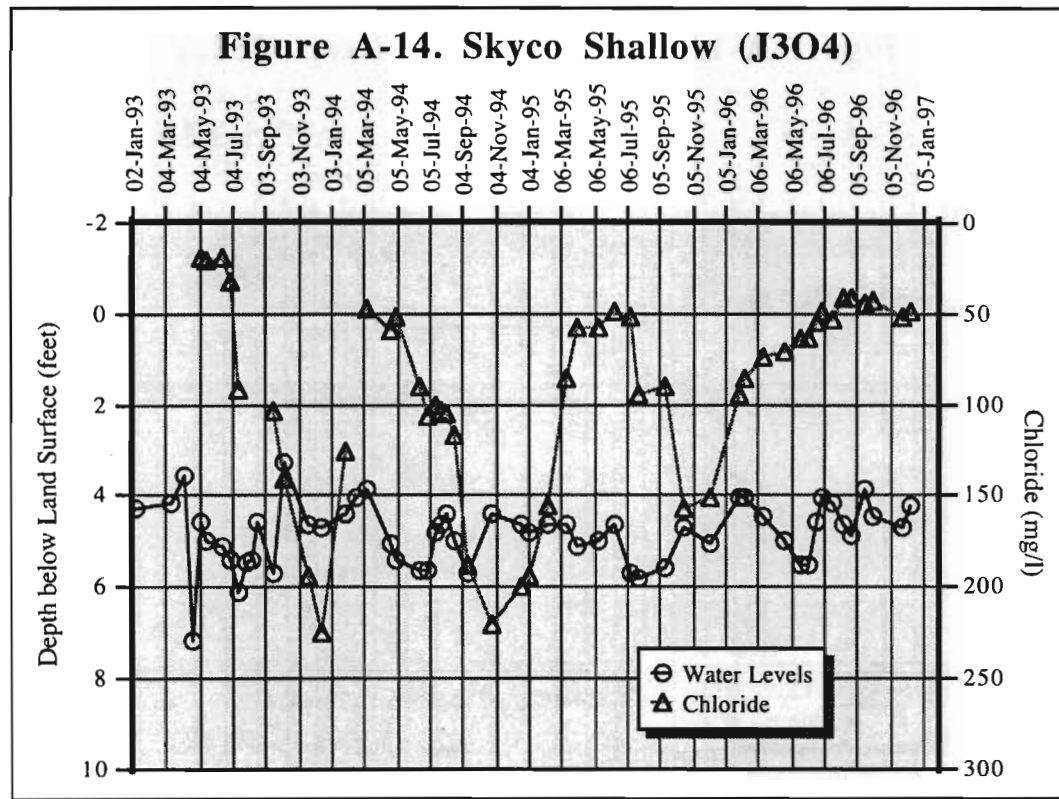


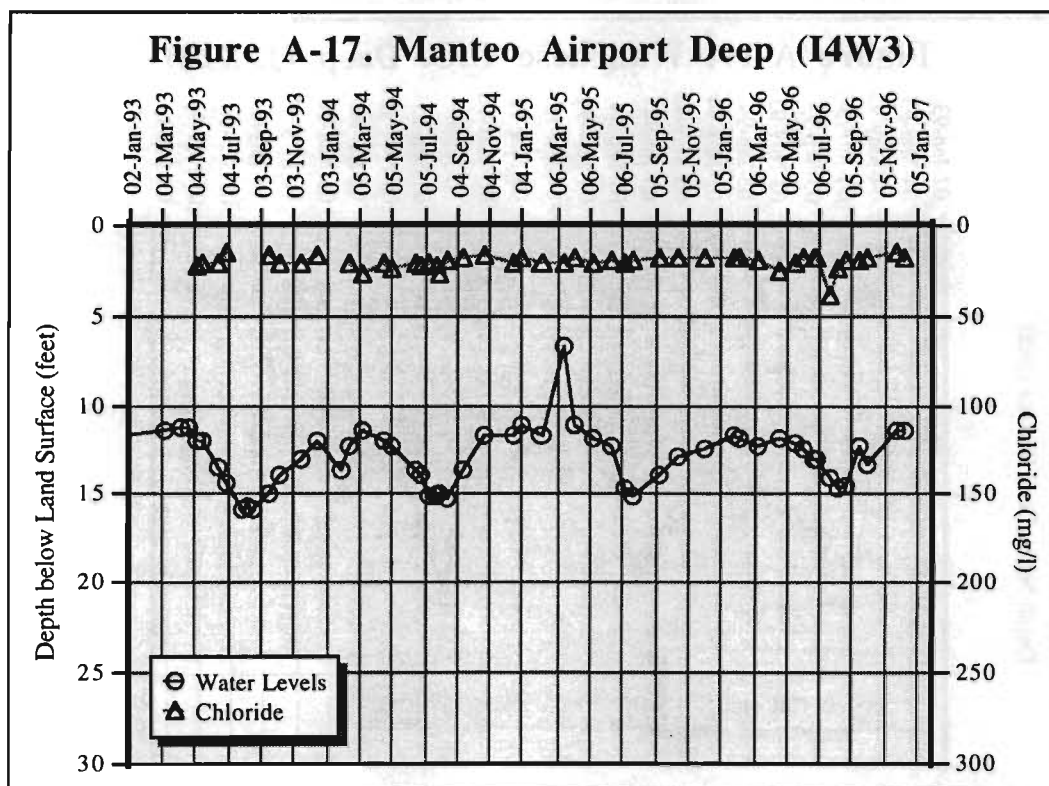
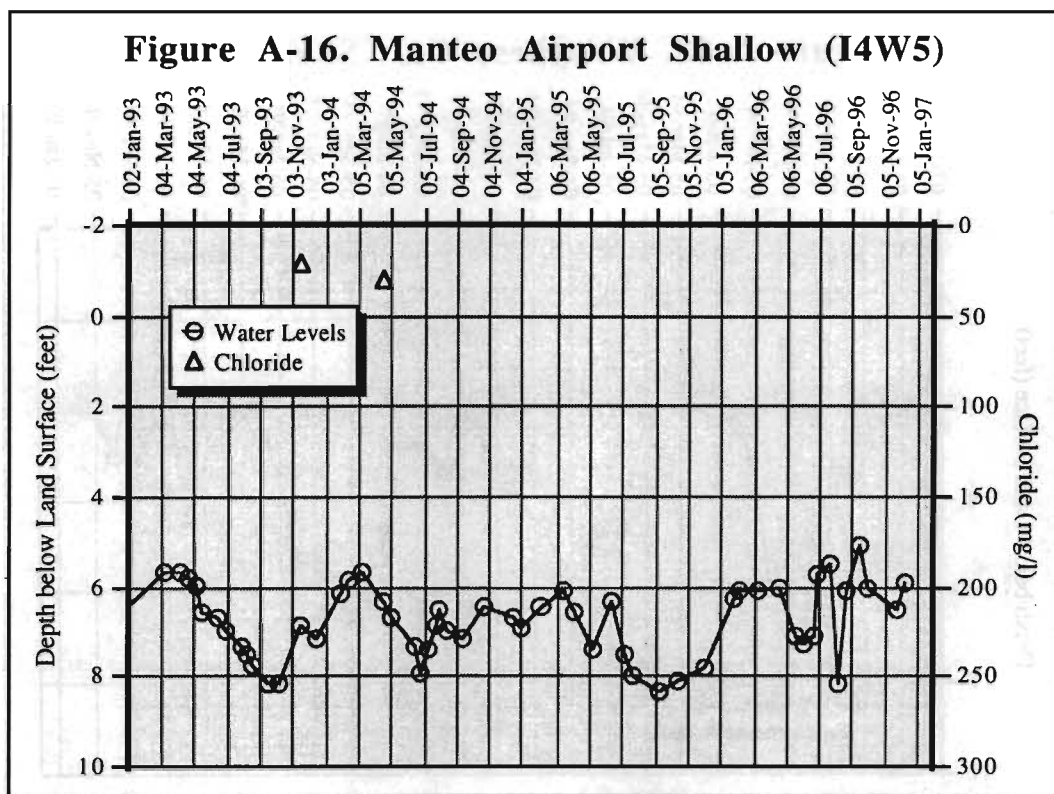


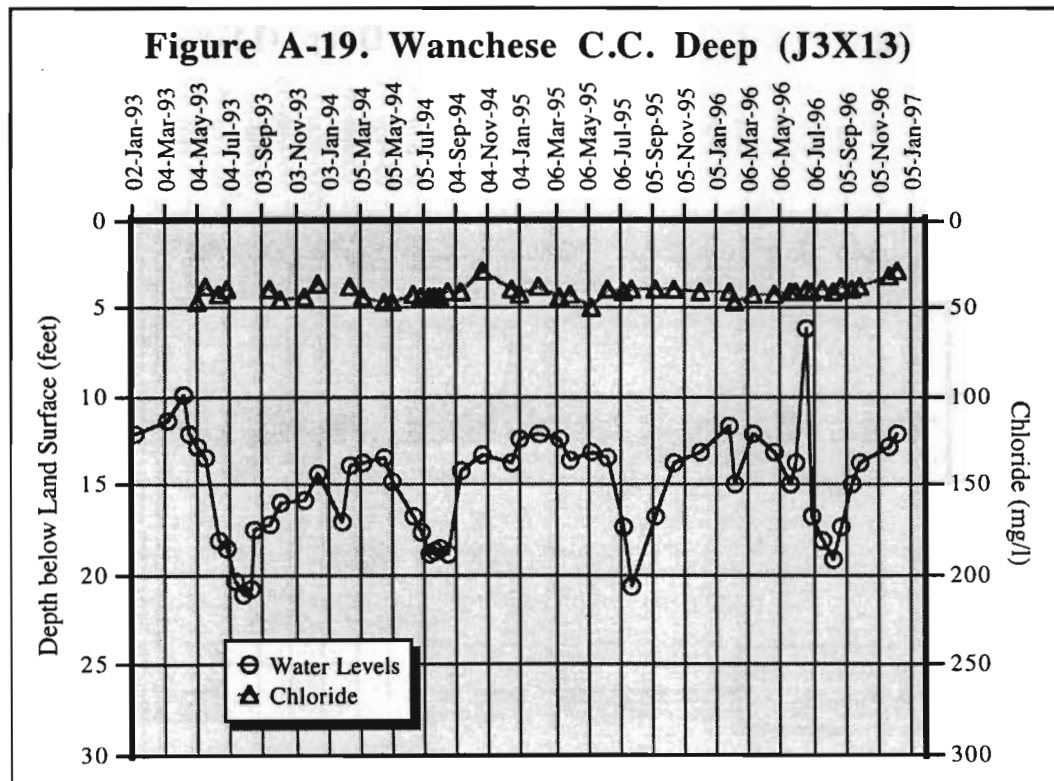
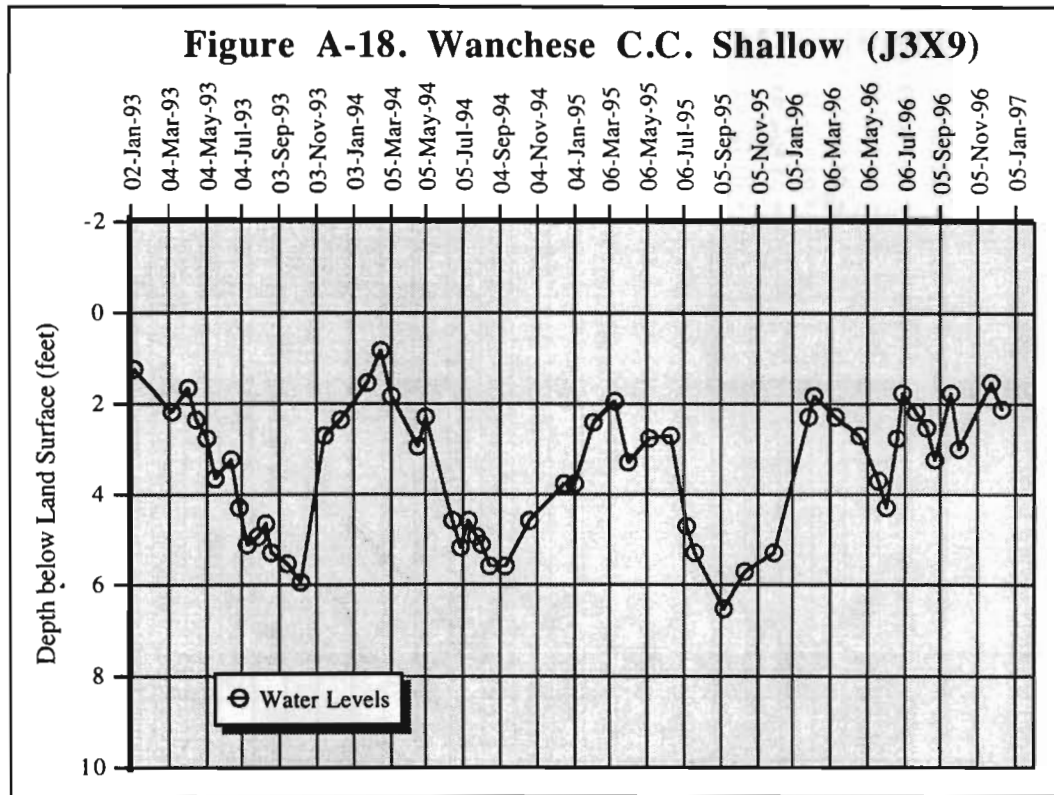


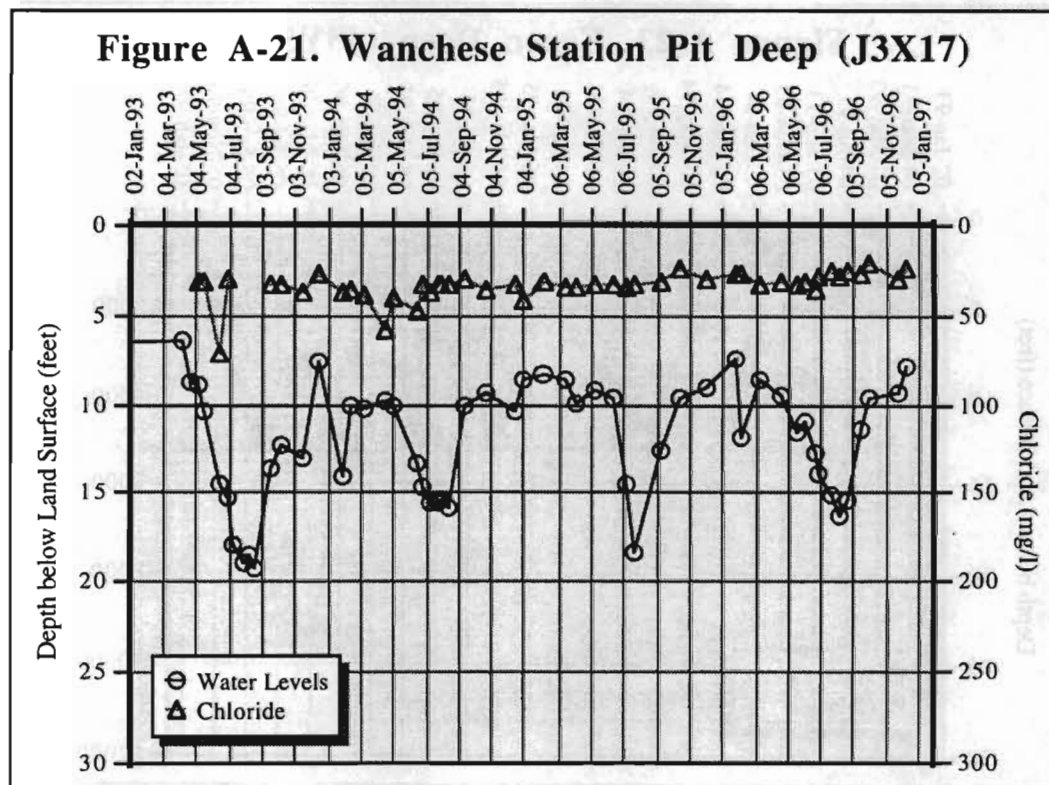
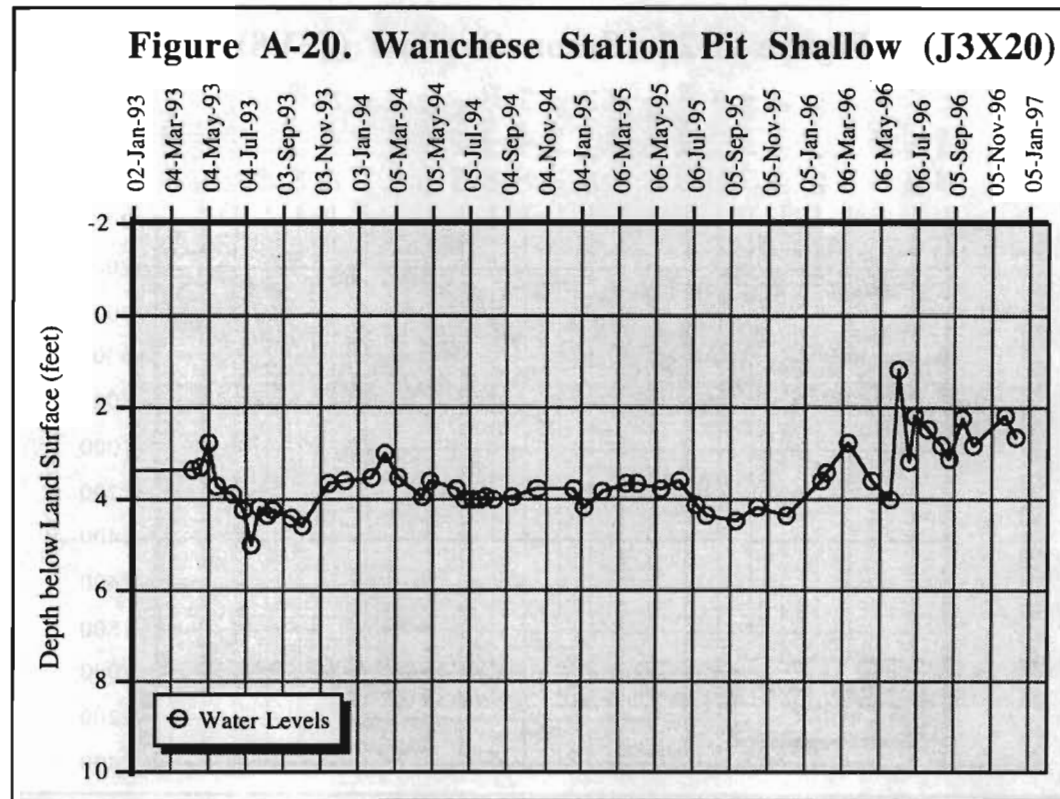


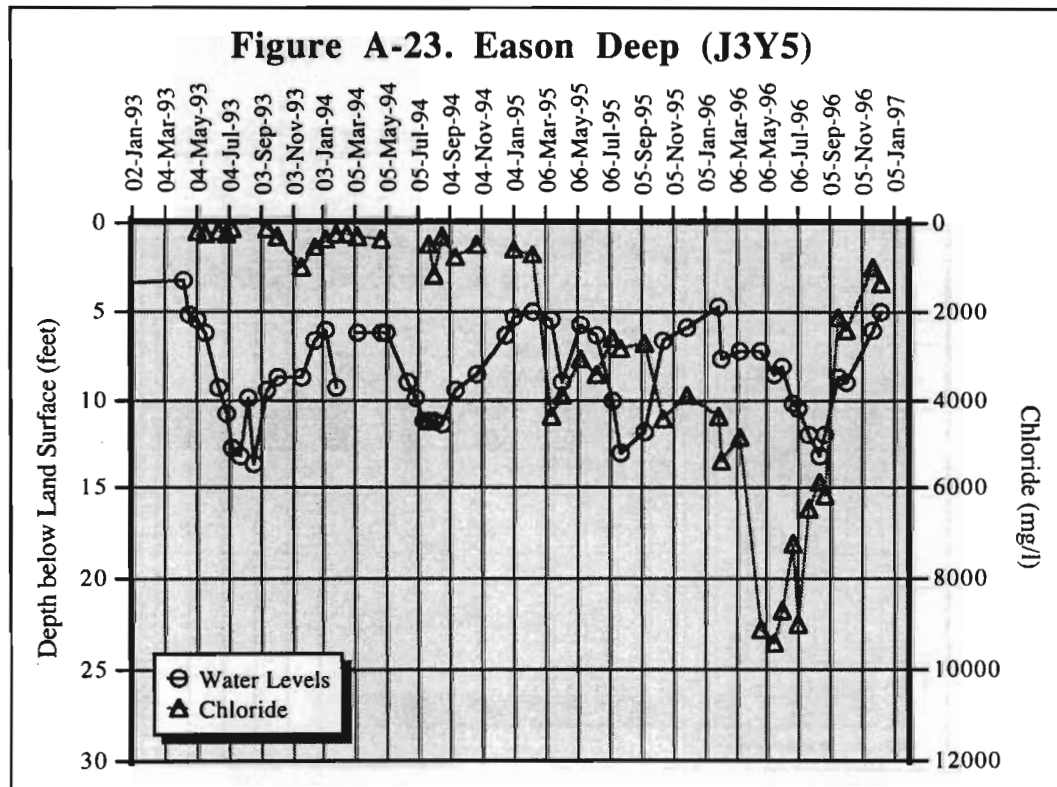
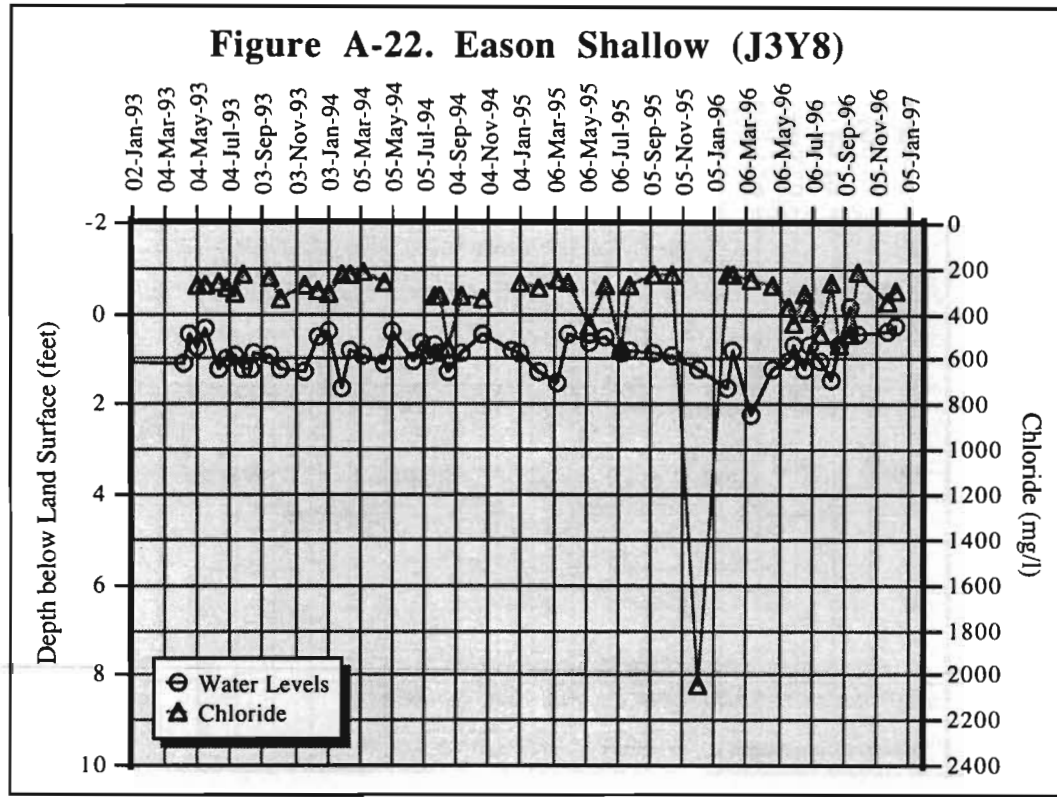


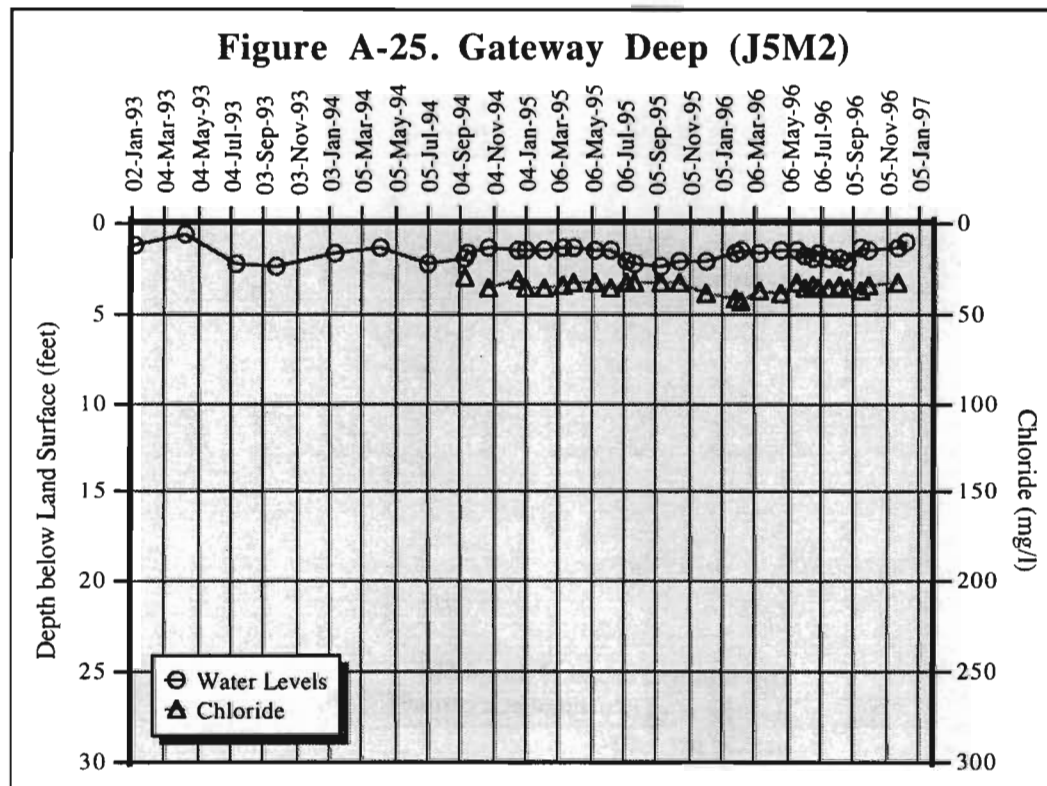
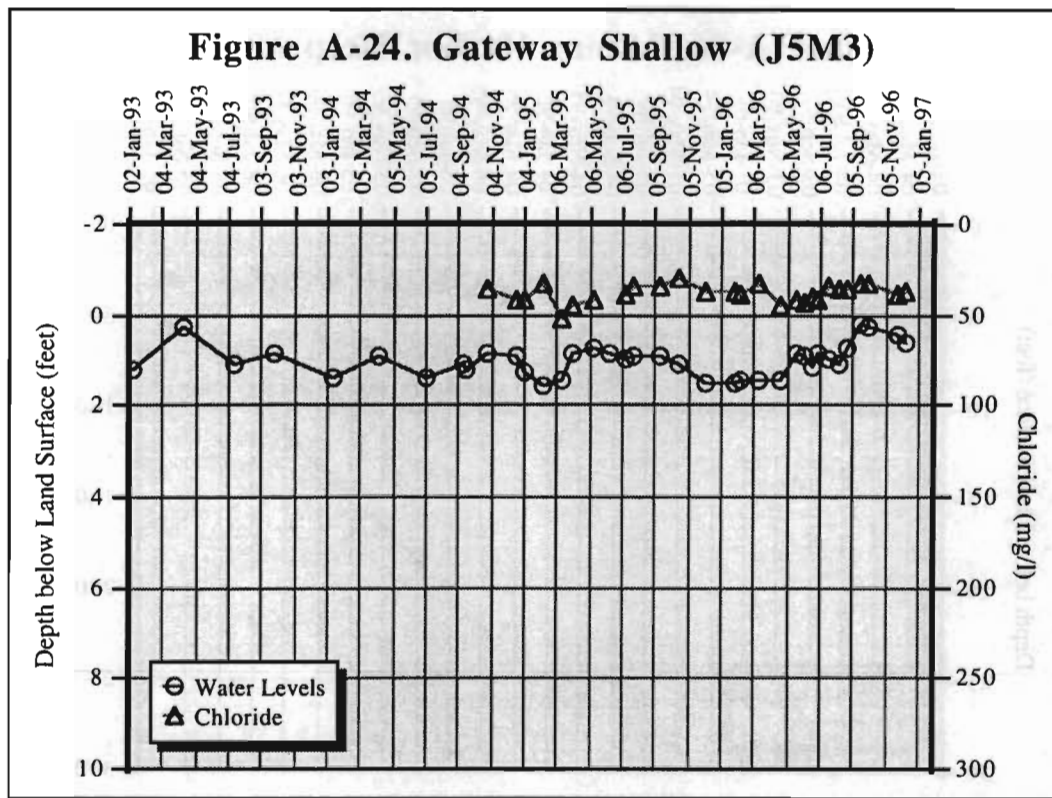


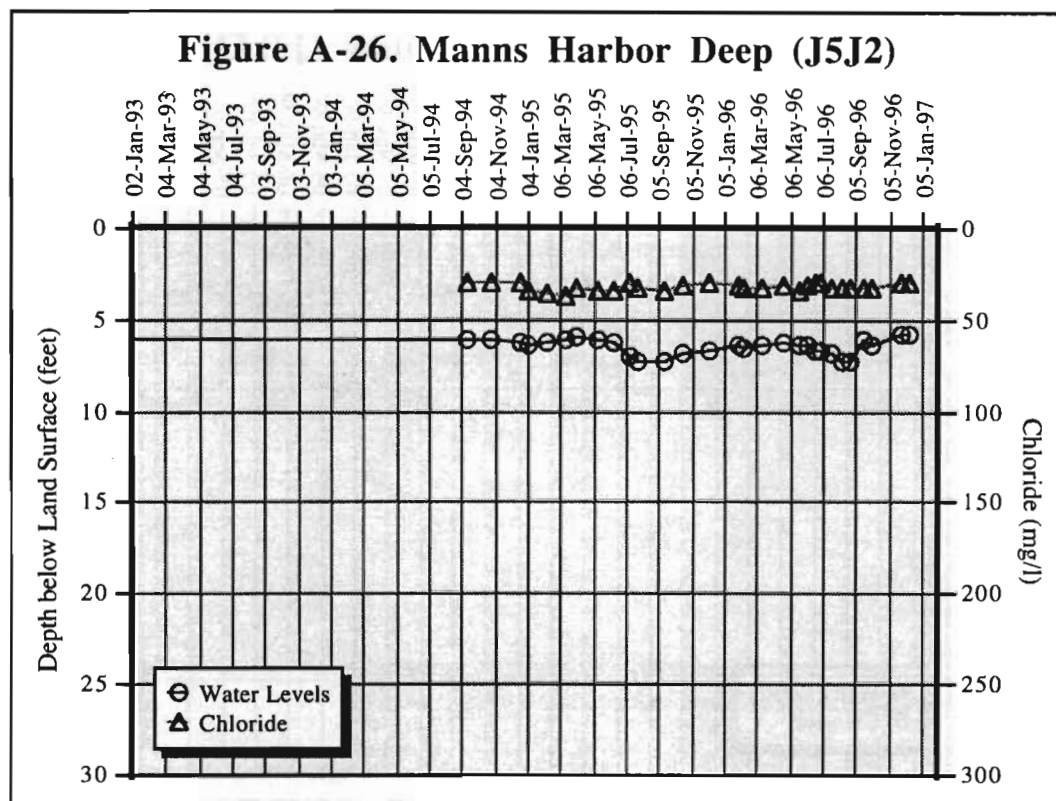












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