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IMPROVEMENT OF WATER QUALITY THROUGH A COOPERATIVE WELL PLUGGING PROGRAM

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INTRODUCTION

A serious concern for the quality of water used for agricultural irrigation in the State of Florida has developed in the past few years. In the late 1960's and early 1970's, the practice of plugging artesian wells on a cost-sharing basis was provided by the Agricultural Stabilization and Conservation Service (ASCS) through the funding of the Federal Government. This cost-sharing program began in the southern portion of the state, and now in certain counties in the St. Johns River Water Management District (SJRWMD), monies have been allocated by the ASCS for this program. In most of the cost-sharing programs offered by the ASCS, the technical expertise was provided by the agricultural engineers of the Soil Conservation Service (SCS), but in the case of well plugging programs, expertise was provided by the Department of Natural Resources. Since the implementation of Chapter 373, Florida Statutes, responsibility for providing well plugging expertise has been delegated to the water management districts.

The plugging of these irrigation wells is specifically to restore the hydrologic conditions which existed before the well was constructed and also to eliminate the exchange of water between aquifers. Since this program was initiated in 1976, several deep irrigation wells have been plugged by methods provided by District staff in cooperation with the ASCS. The wells which have been corrected to date represent only a fraction of those which could benefit from this program. Data that have been collected illustrates that this procedure offers a practical method for controlling water quality problems in deep wells.

Location

The agricultural community of Hastings, located in southwestern St. Johns County within the St. Johns River Water Management District (Figure 1), is the largest producer of cabbage and potatoes in the southeastern United States. Approximately 6,400 acres of land are irrigated by artesian wells in the Floridan

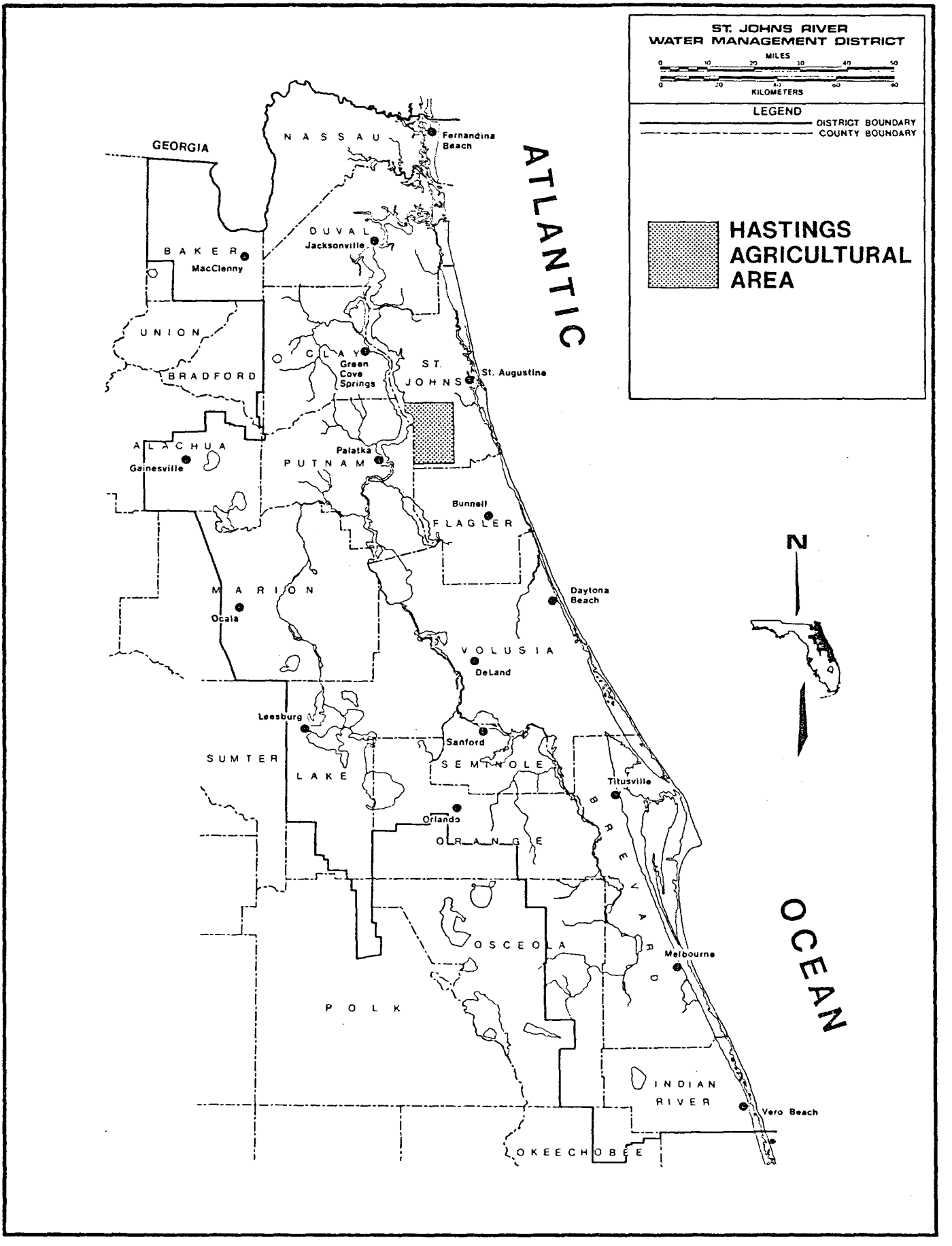

Figure 1. Location Map of the Hastings Agricultural Area

aquifer during the fall and winter months when insufficient amounts of rainfall cannot meet the demands of the winter vegetables.

Problem

All of the wells used for irrigation derive their water from the Floridan aquifer. The Floridan aquifer consists of a series of porous Eocene limestone formations (Figure 2) overlain in most areas by a semi-permeable clay unit known

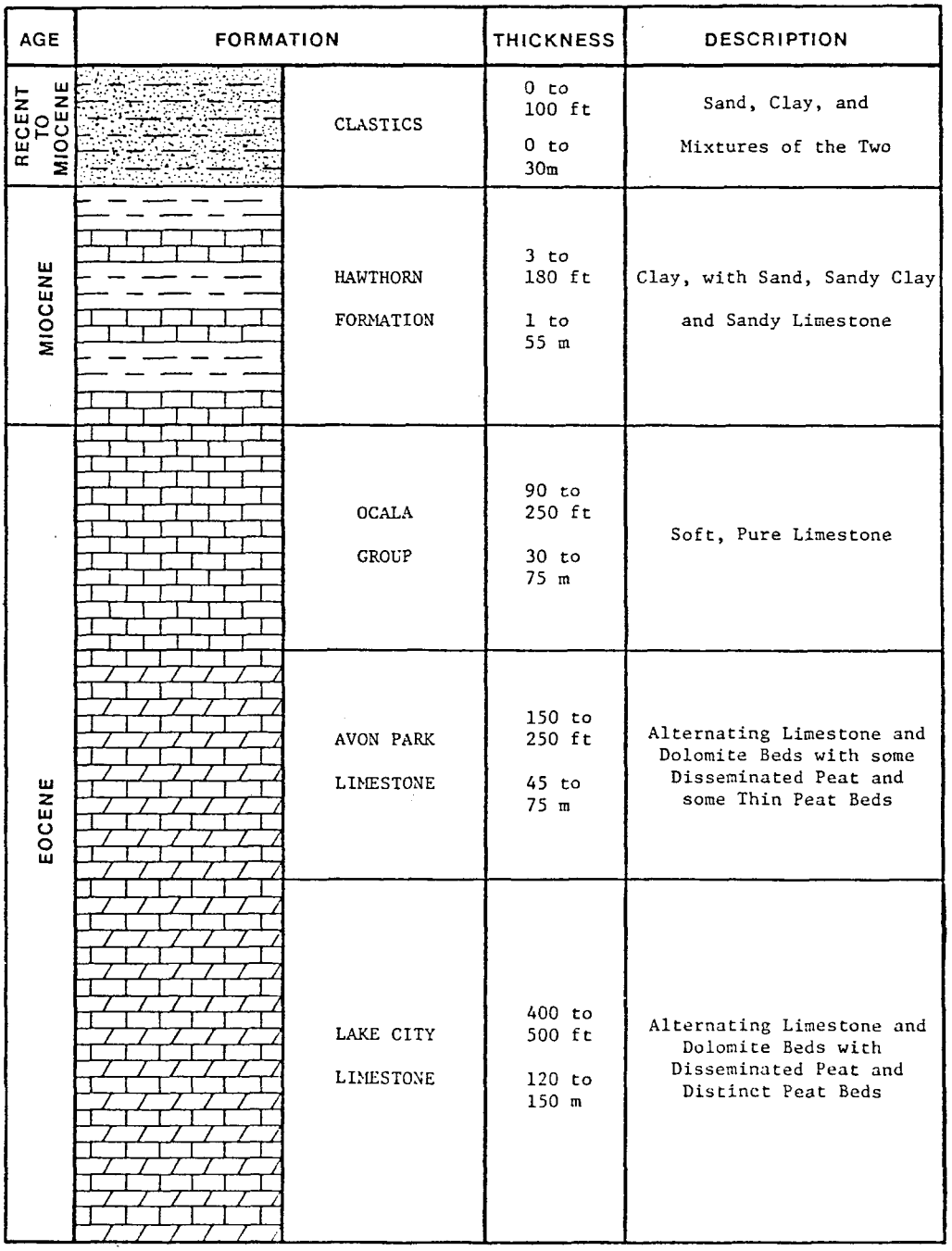

Figure 2. Generalized Geologic Column, Hastings Area

as the Hawthorn Formation. Due to the nature of the confining clay unit, the Floridan aquifer is under artesian pressure which, under natural conditions, allows many wells to freely flow above land surface. For the purpose of discussion, the Floridan aquifer is divided into two parts, the upper Floridan which consists of the Ocala Group and the lower Floridan which consists of the Avon Park, Lake City, and Oldsmar formations.

An index used for the determination of salt contamination is the concentration of chloride ions in the water. Irrigation water exceeding 1,000 parts per million (ppm) in chloride concentration is damaging to vegetable crops. The chloride content of water produced in the Hastings area (Figure 3) from the upper Floridan ranges from 250-900 ppm. Typically, water derived from the deeper zone exceeds 1,000 ppm and has been as high as 3,600 ppm in chloride concentration during low artesian levels.

Many of the irrigation wells located near the areas of denser crop cultivation become salt contaminated in two ways. A majority of the wells presently being used were drilled early in the agricultural history of the area. At that time, excessively deep wells were constructed to acquire greater quantities of natural artesian flow. By the late 1950's, water levels had steadily declined, and artesian flow from the wells could not supply the large quantities of water needed for the increased irrigated acreage of the area. Various types of power driven pumps were then installed on the wells to provide more water. As the pumping duration and intensity increased, so did the salt content of the water. In time these deeper wells become direct conduits for the upward migration of saltier water. Many acres of vegetables were ruined, and consequently, these wells were either abandoned or used only when absolutely necessary.

The other mechanism which allows for the contamination of irrigation wells is the process of salt water coning. This process involves overpumping of an

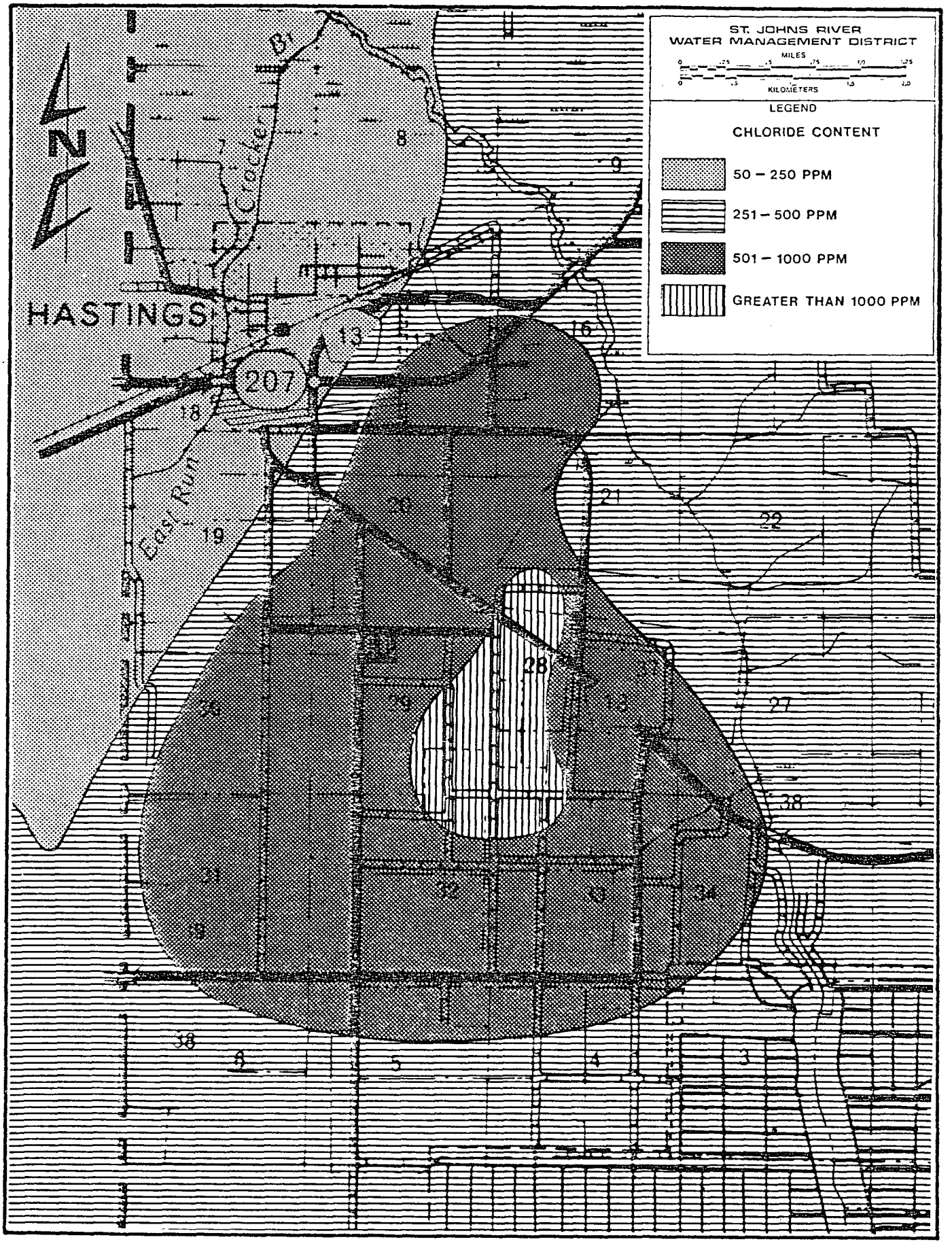

Figure 3. Map Showing the Chloride Concentration of the Upper Floridan Aquifer During March 1975

irrigation well during times of low artesian water levels, and thus inducing the coning of salt contaminated water directly beneath the well (Figure 4). Slowly, the contaminated water migrates upward through the porous limestone aquifer until the general area that the well derives its water from is completely contaminated.

Purpose and Objective

The purpose of this program is to accomplish water management goals in

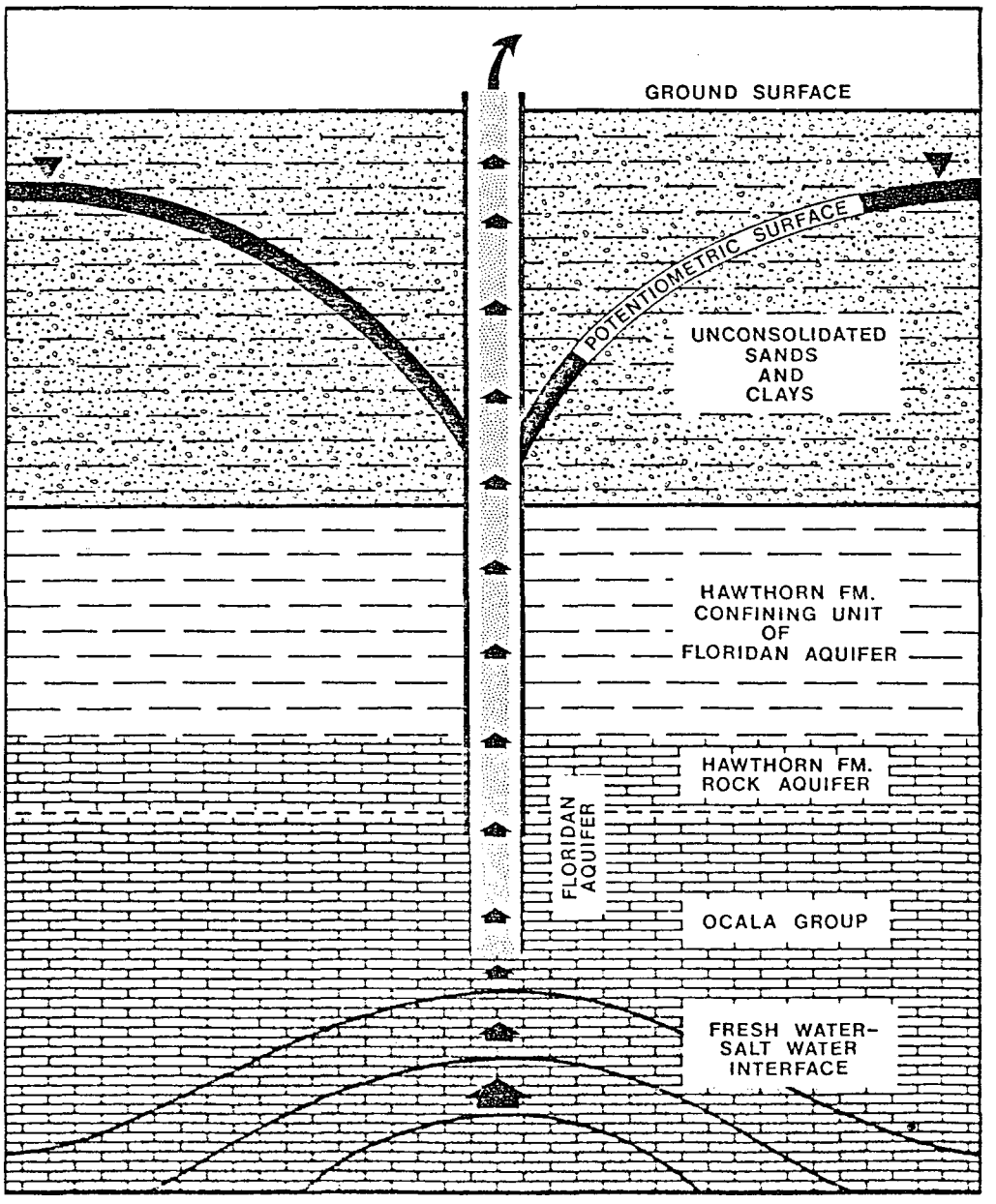

Figure 4. Generalized Diagram of Salt Water Coning Beneath a Pumping Well

hydrologically stressed areas through cooperation with other agencies. The objective is to upgrade ground water quality through methods of well rehabilitation which prevent contamination of the fresh water layers of the Floridan aquifer from deep wells which penetrate the saline zones below.

INTER-AGENCY COOPERATION

Planning

The initial outline and goals of the program were established after a series of workshops were held with local ASCS and SCS personnel in July 1976. The Water Resources Department of the SJRWMD was made responsible for outlining the program and procedures. The program focuses on the partial plugging of irrigation wells to alleviate the interchange of water between aquifers. The cost-sharing program will also apply if, after inspection, full plugging of a well is recommended. Wells to be considered for the program could be abandoned wells or currently used wells. To date, this program has been confined to the counties of Putnam, Flagler, and St. Johns in order to establish criteria and precedents for other counties within the District.

Program Responsibilities

The method for integrating the individual activities of the cooperating agencies into a working program employ the following steps:

1. Upon receipt of a referral, the SCS District conservationist will notify the appropriate water management district in writing. He will advise the water management district of the name of the landowner, a general description of the location, and the date of availability of the well in sufficient detail to enable a staff member of the water management district to inspect the well.
2. The water management district representative will geophysically log the well, then develop plans and specifications for plugging the well and give a copy to the SCS District conservationist for delivery to the landowner.

3. The SCS District conservationist will complete the need and practicability finding certification on the Agricultural Conservation Program (ACP) referral form.
4. The landowner will arrange for work to be done under the supervision of the water management district representative, and will notify him by phone when the work is completed.
5. The water management district representative will then inspect the well and state, in writing, to the SCS District conservationist that the well has or has not been plugged according to plans and specifications.
6. The SCS District conservationist will then so certify on the ACP-247 form which authorizes reimbursement of funds to the owner.

WELL PLUGGING

Previous Work

Early attempts to grout irrigation wells in this area consisted of merely pumping large quantities of neat cement down the well until either the driller exhausted his supply of cement or the well was completely filled to the top. At that time there was no possible way to determine any of the well characteristics except for total depth. Many wells could not be satisfactorily grouted due to the large voids and cavities in the porous Floridan aquifer limestone which could absorb tremendous quantities of cement. These early plugging attempts were rarely successful.

In 1976 the Southwest Florida Water Management District initiated a quality of water improvement program. Through this program, plugging techniques and a device to shut off the flow of contaminated waters from aquifers were developed. These procedures assure proper placement of the plug and require less cement to construct the plug within the cavities of the well. With confidence in this type of plugging technique, the staff of the St. Johns River Water Management District promoted these ideas to the local agricultural agencies.

Plugging Procedures

Once a request for plugging has been received by the District from the ASCS agent, arrangements are made with the owner to have the well made available for geophysical logging. Through the sophisticated electronics of the geophysical logger, important well characteristics can be determined. Figures 5 and 6 are typical examples of the problem wells encountered during the early stages of this program and the possible placement of the plugs for correction. Well depth, amount of casing, flow zones, and water quality of the various aquifers encountered are taken into consideration when plugging specifications are drawn up for each individual well by the District geologists. This information is shown in Figure 7. Specifications for the plugging, which include the location of the plug, the length and diameter of the plug, and the amount of cement needed are derived from the interpretations of the geophysical data.

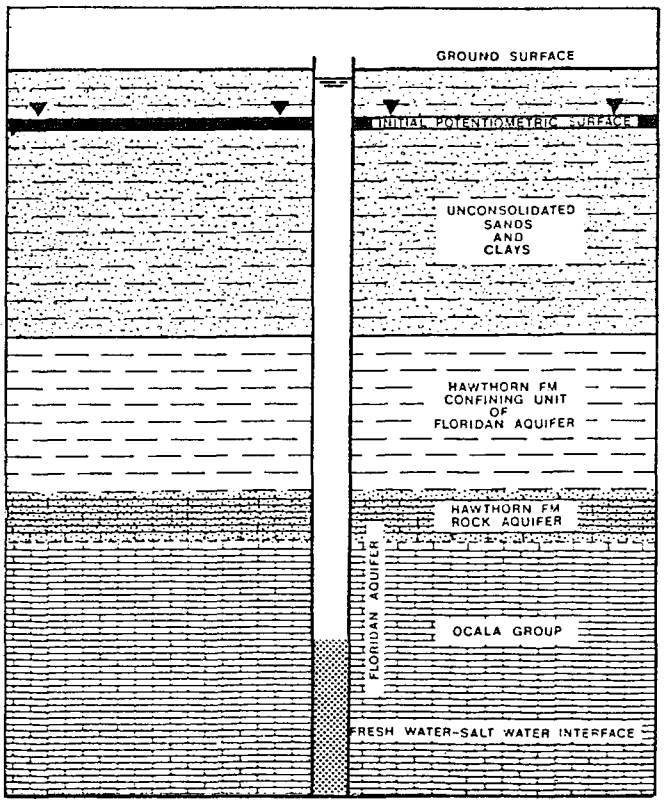

Figure 5. This case exemplifies a homogeneous aquifer in which the construction of the well, being too deep, would cause salt water contamination.

Indicates area to be plugged

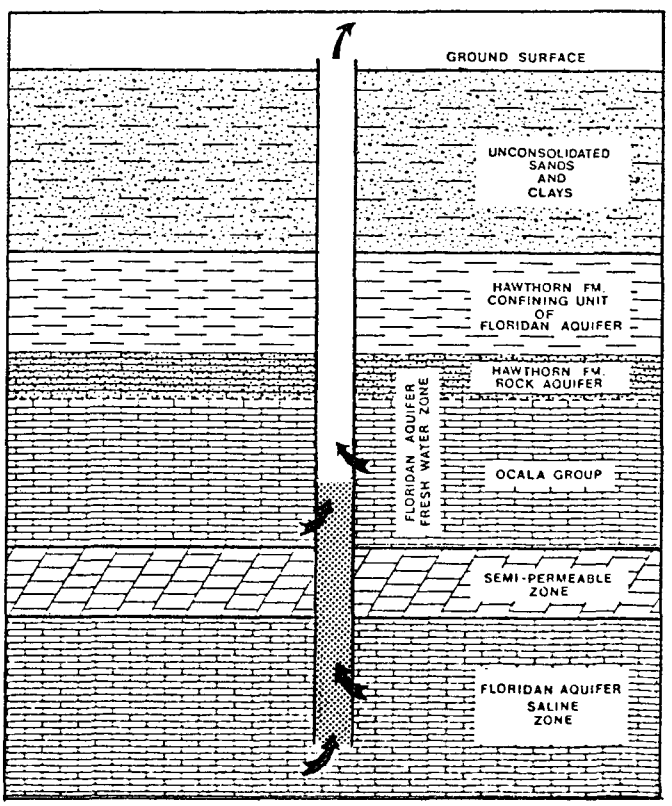

Figure 6. Well construction involving direct connection to the saline zone. Partial plugging should be done to avoid contamination by the saline zone, eliminating the exchange of water between aquifers.

Indicates area to be plugged

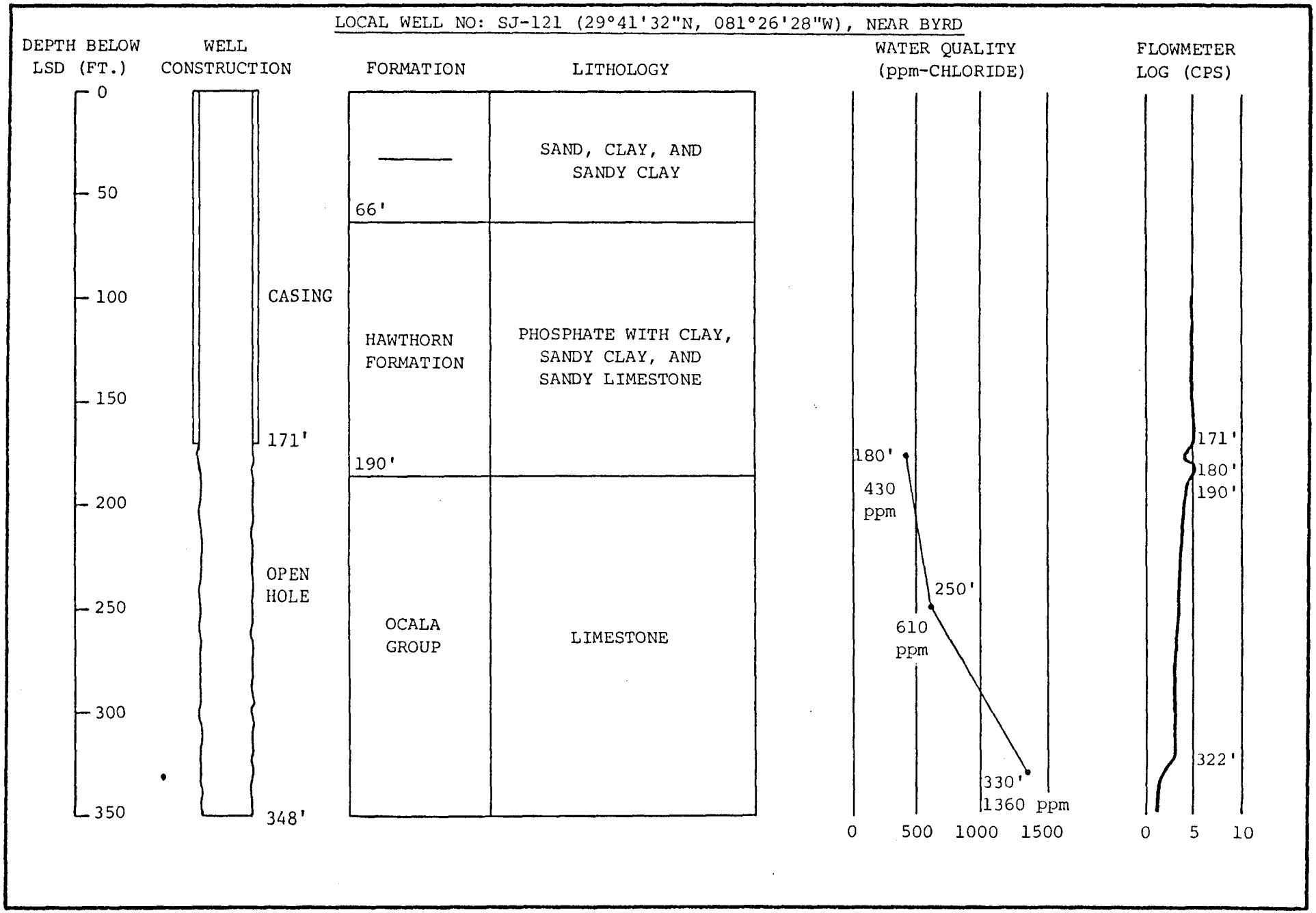

Figure 7. Well Data Interpreted from Geophysical Logs

These specifications are promptly sent back to the ASCS, and arrangements are made by the well owner for a water well drilling contractor to perform the work.

The plug is made to specifications using burlap material. This material is inexpensive and easy to work with, and when placed within the well and filled with cement, it conforms to the sides of the open borehole creating an effective seal.

At the well site, drilling equipment is set up over the existing well. The burlap plug is then placed around the outside of the first length of hollow drill stem (Figure 8). As the drill stem is lowered down the well, the burlap is carefully fed down the hole, making sure the drill rod does not rotate with the subsequent addition of more drill rod (Figure 9). Once the prescribed length of plug has been fed down the well, it is attached in a manner which will allow the drill stem to be pulled back out of the well without tearing the burlap. The plug is set into its proper place by the use of additional drill rod and is now ready to be filled with cement.

The quantity of Portland Type II or Type III cement needed to fill and expand the plug is carefully mixed in a calibrated hopper (Figures 10 and 11). After the grout has been thoroughly mixed, it is then pumped from the hopper and down the hollow drill stem (Figure 12) by an auxiliary mud pump mounted on the drill rig until the hopper has been completely emptied. As this process occurs, the burlap plug expands and conforms to the sides of the open borehole. The drill stem is then removed, leaving an effective seal between the contaminated and fresh water zones of the Floridan aquifer.

RESULTS

In order to appraise the effectiveness of the plugging operation, water samples are taken from the well prior to and after the grouting. Sampling is usually continued for several months thereafter followed by periodic checks for the purpose of evaluating long term effects.

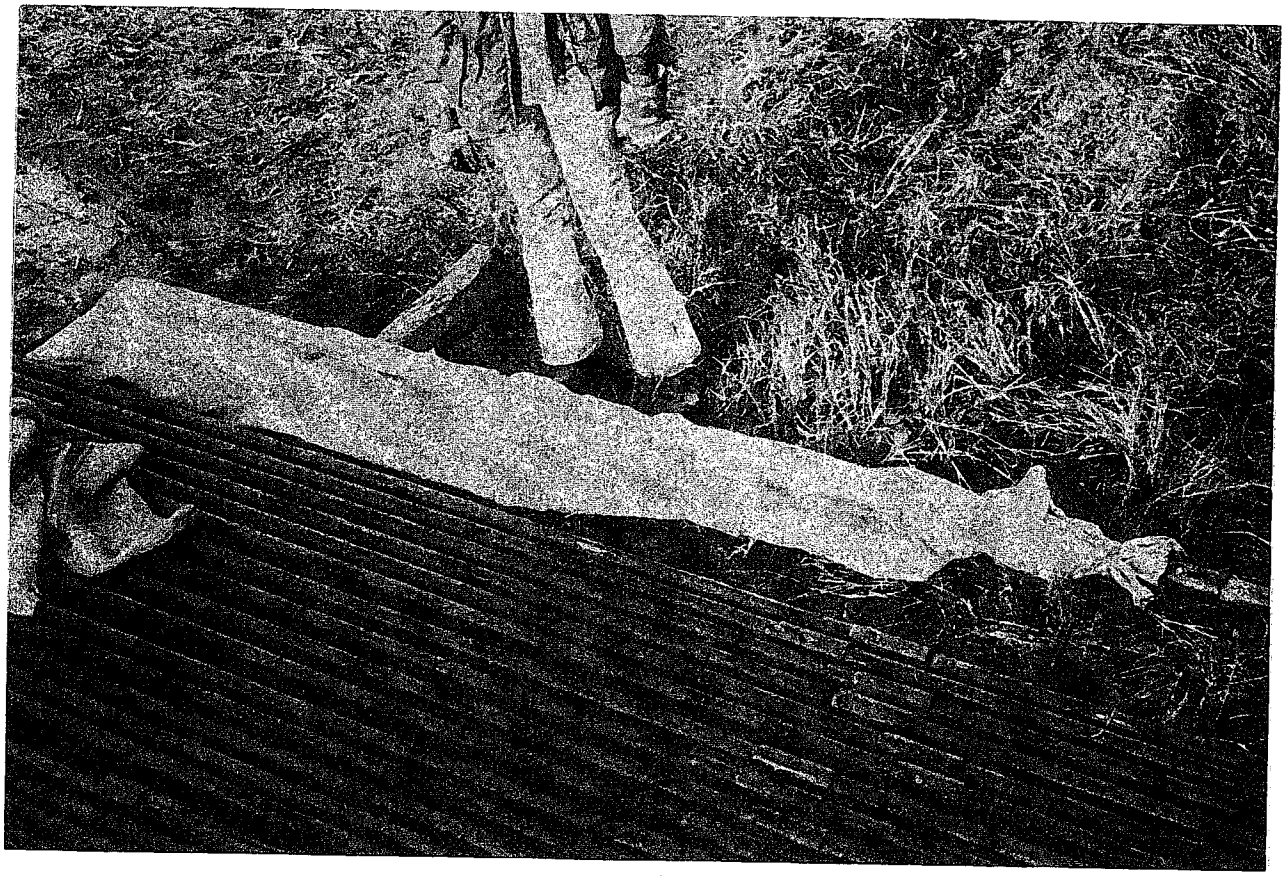

Figure 8. Placement of the Burlap Plug Around the Drill Stem

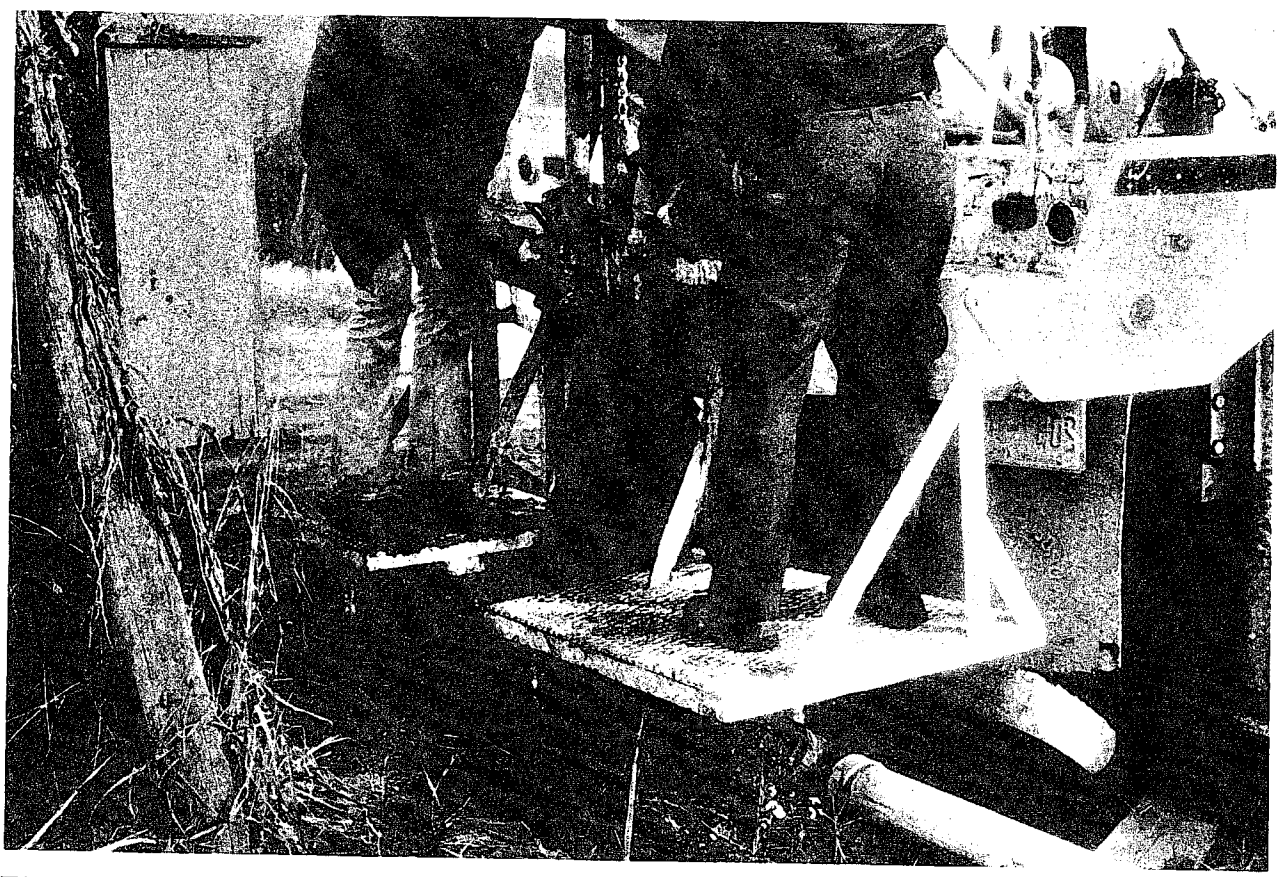

Figure 9. Drillers Inserting the Fabricated Plug Down the Well

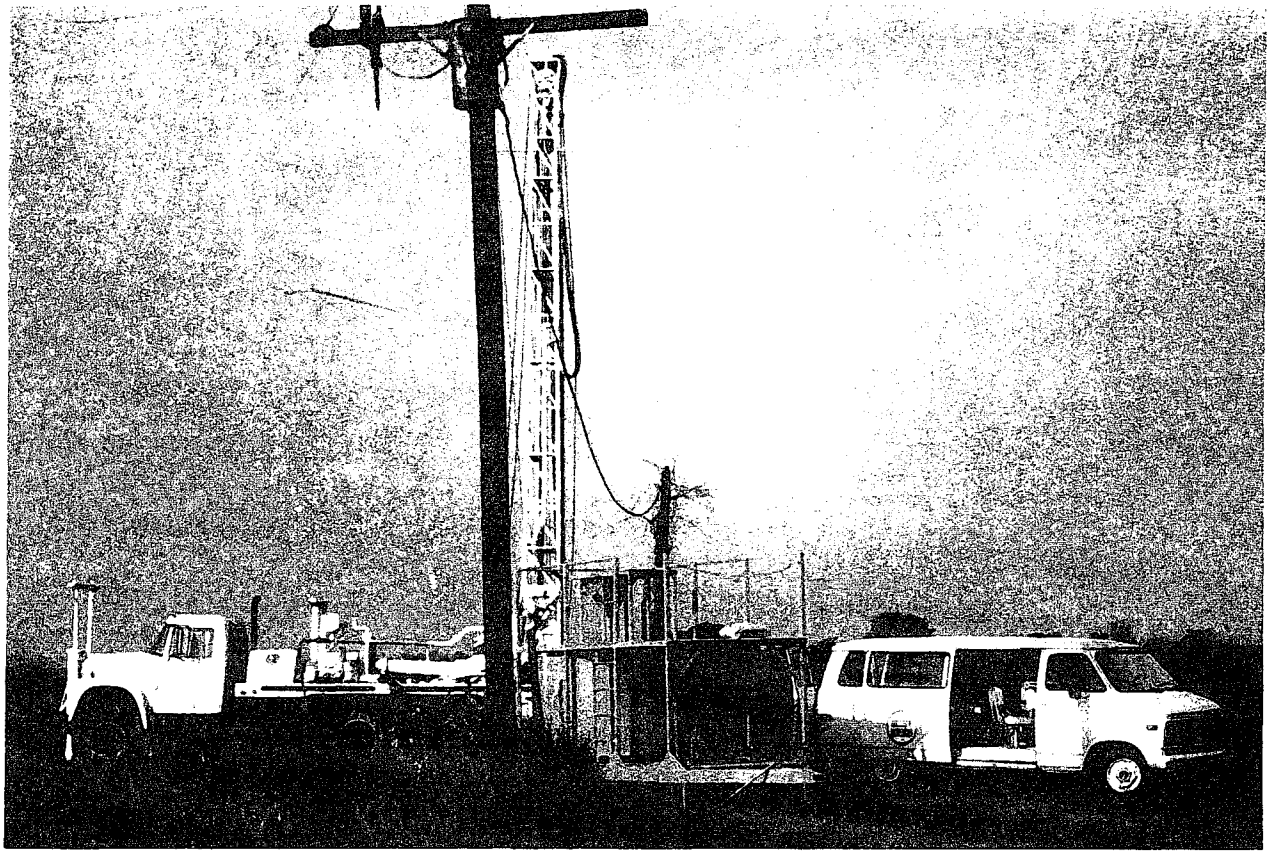

Figure 10. The Plugging Operation Involving the Geophysical Logging Van and the Drilling Equipment

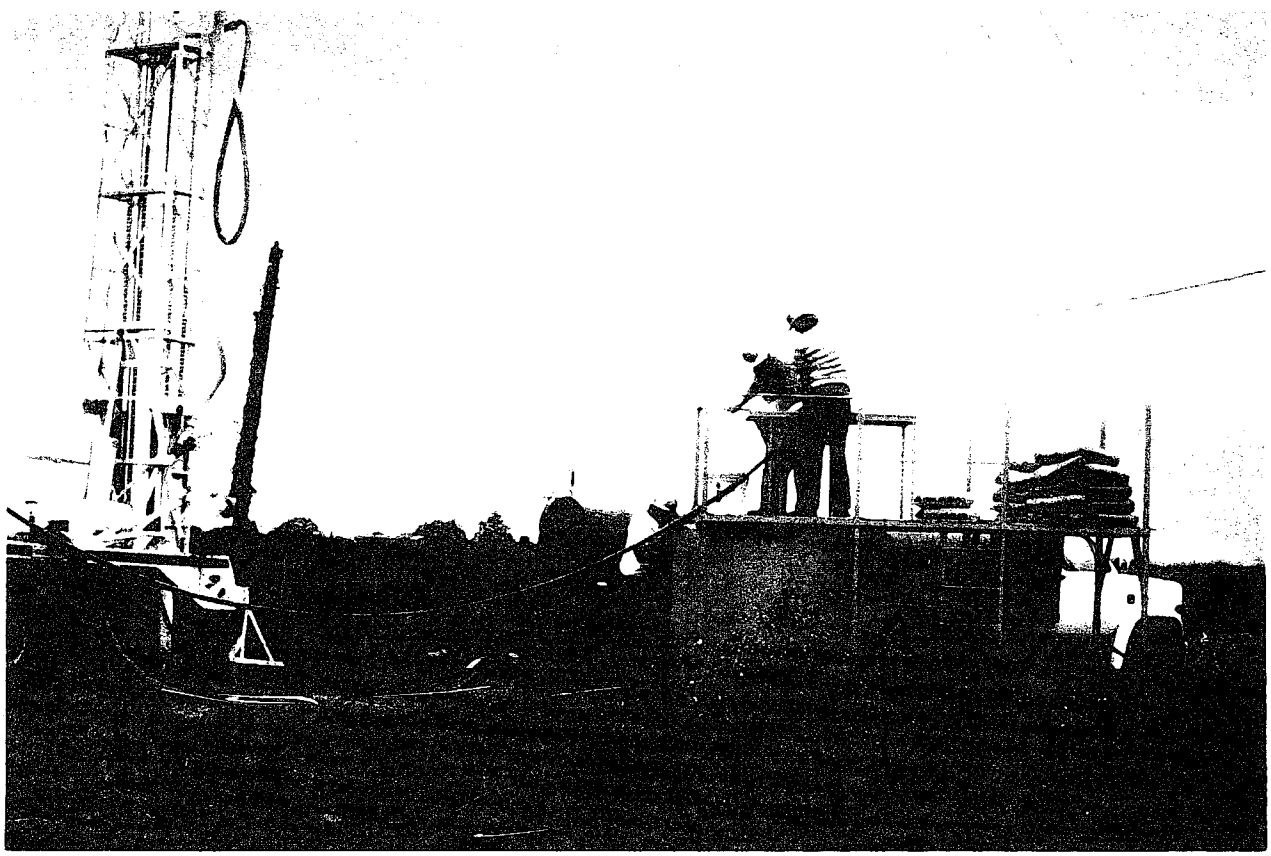

Figure 11. The Mixing of Cement in the Calibrated Hopper to be Pumped into the Well

Figures 13 and 14 show the data collected from two irrigation wells that have been plugged. Figure 13 illustrates the decrease in chloride concentration of the water resulting from the plugging of the lower contaminated zone. Data from the extended water sampling of this well over the past year shows the chloride content has not exceeded 820 parts per million. Again, Figure 14 portrays similar

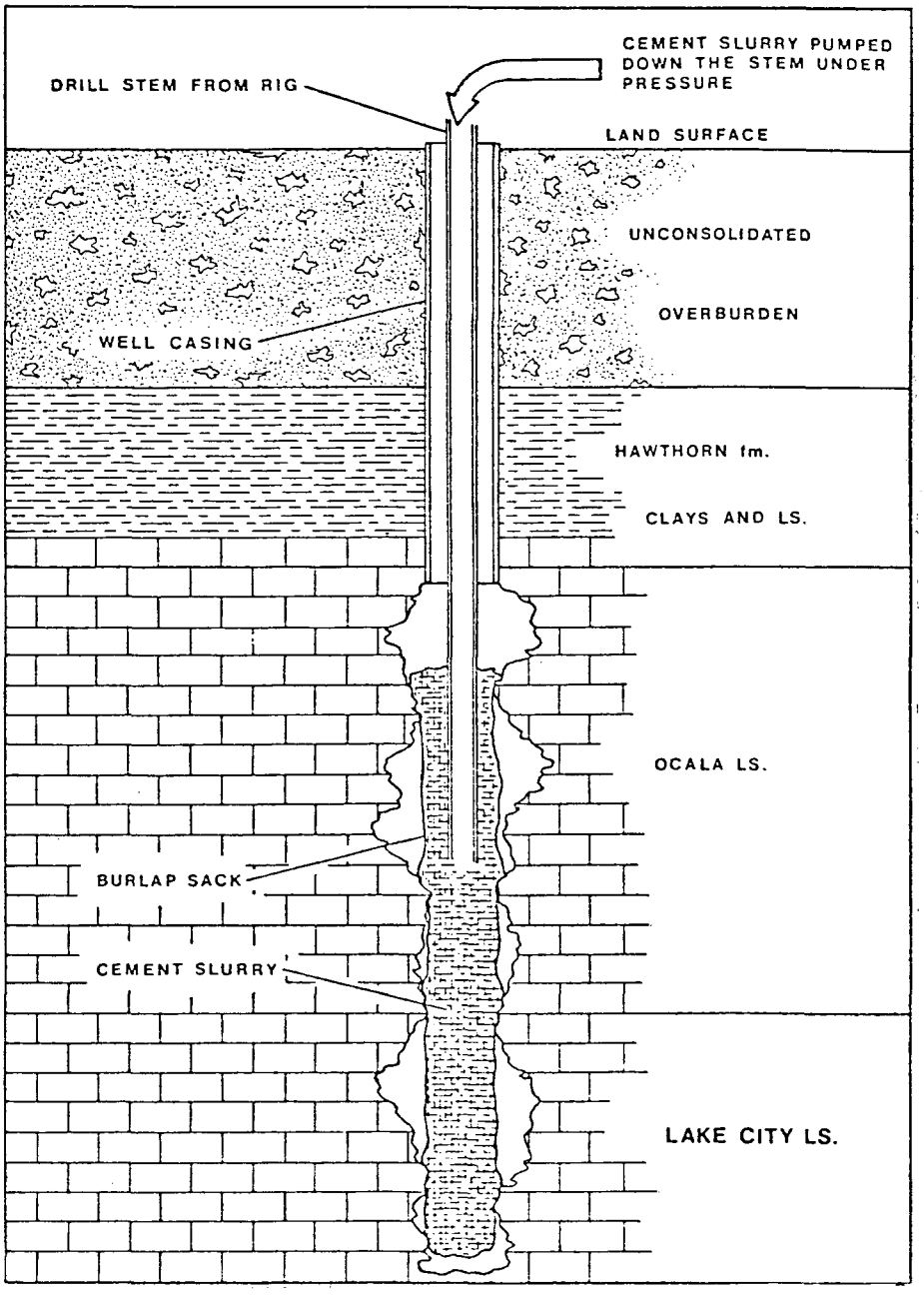

Figure 12. Generalized Cross Section Showing the Placement of the Plug Within the Aquifer

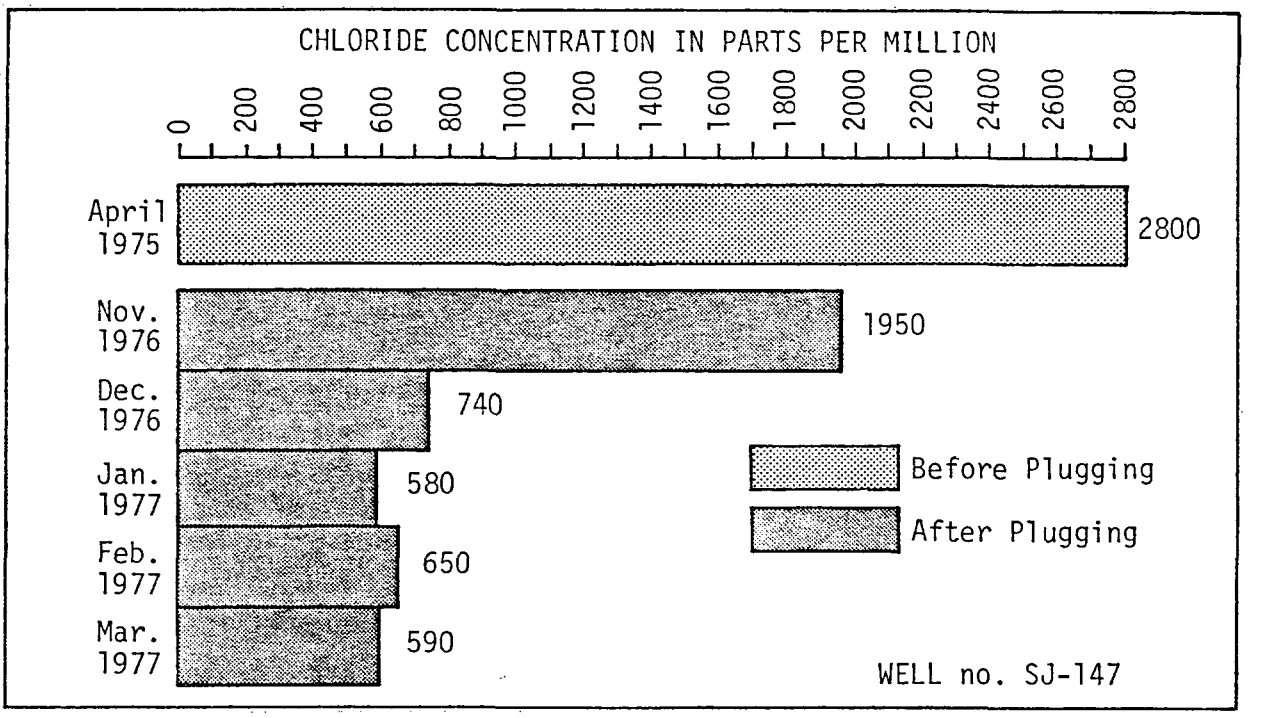

Figure 13. Chloride Data Collected from Well SJ-147; chloride concentration of this well before plugging attained 2800 ppm

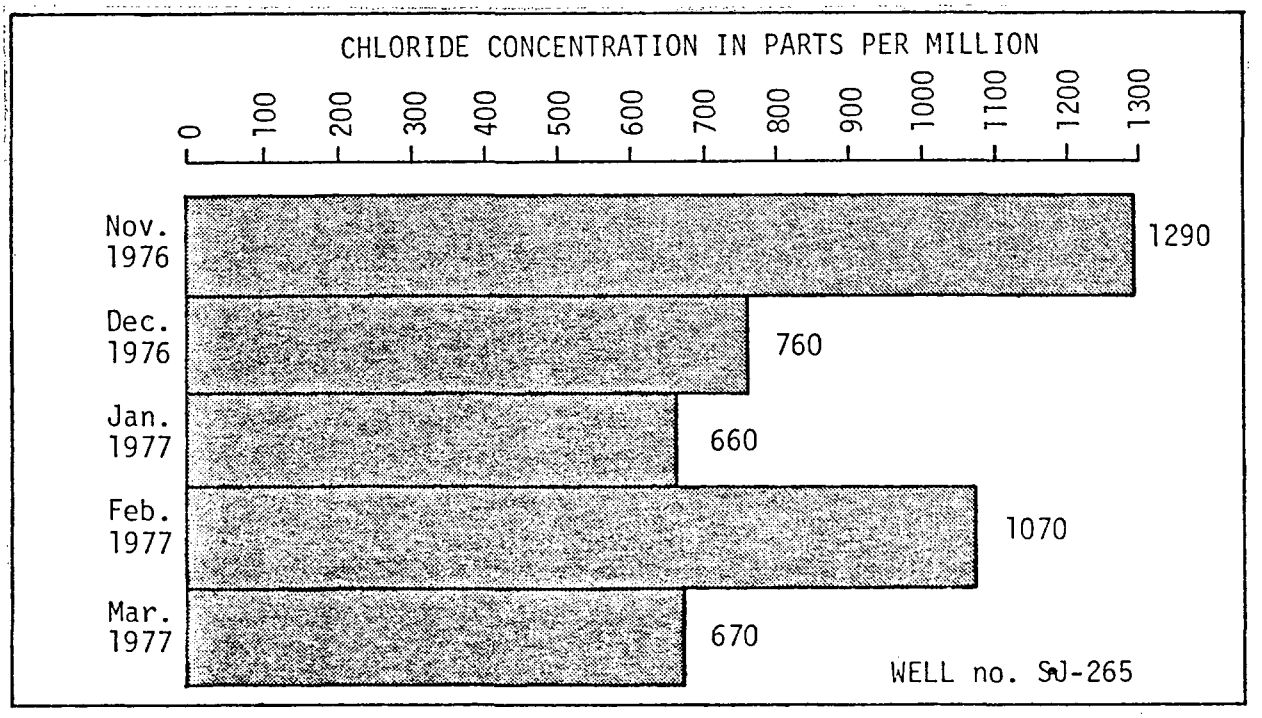

Figure 14. Chloride Data Collected from Well SJ-265; chloride concentration of this well, although not shown, attained 2100 ppm during October 1976

data from another irrigation well rehabilitated through this program. Several years prior to the establishment of the program, this well was unsuccessfully plugged at the owner's expense. Since the well continued to produce contaminated water, it was abandoned and capped. The owner made application to the St. Johns County ASCS in October 1976 for corrective plugging. The well was inspected by the District, and recommendations were followed by plugging in November. The well is now being actively used for irrigation purposes.

SUMMARY

The Floridan aquifer at the Hastings area of southwestern St. Johns County is comprised of thick Eocene limestone formations. During the fall and winter months, artesian water from this aquifer supply irrigation needs for the cultivation of cabbage and potatoes.

Water with less than 1,000 ppm chloride is supplied from wells penetrating only the upper portion of the Floridan aquifer. Those wells which penetrate both the lower and upper zones of the aquifer typically pump water exceeding the salt tolerance of the plants. These salty wells also act as direct conduits for the contamination of the upper fresh zone of the Floridan aquifer.

This program initiated with the Soil Conservation Service and the Agricultural Stabilization and Conservation Service has shown that water resource management programs can be accomplished in cooperation with concerned agencies.

Chloride data obtained from the wells which have been plugged substantiates that this well rehabilitation methodology provides an answer to water resource and subsequent economic problems. The use of the fabricated plug insures proper placement of the grout, decreases the amount of grout required, and provides an alternative to the construction of a new well. In general, chloride concentrations decreased substantially in those wells which were plugged according to program specifications. When these wells were monitored on a monthly schedule, chloride concentrations remained fairly stable even through times of increased irrigation demands.

The plugging operation provides a method of improving regional water quality conditions by preventing salt contamination in individual wells. Irrigation wells which continue to allow the interaquifer exchange of contaminated water will have a detrimental effect on those wells that have been plugged. In order to accomplish any regional improvement of the resource in this area, all such wells must be plugged to the proper specifications. The continuation of this program will accomplish this regional improvement, and agriculturalists are urged to take advantage of this program.

APPENDIX A

RECORD OF CHLORIDE CONCENTRATION IN PARTS PER MILLION
FROM PLUGGED WELLS

Date	SJ-265	SJ-147	SJ-378	SJ-214	SJ-146	SJ-177
4/75		2800*				
4/76			1360*			
8/76			720			
9/76			720			Well collapsed due to casing not seated into limestone aquifer.
11/76	1290*	1950*	970			
12/76	760	740	840			
1/77	660	580	760			
2/77	1070	650	790			
3/77	670	590	670			
4/77	1120	820	960			
5/77	--	--	700			
6/77	820	--	900			
7/77	620	--	850			
9/77	--	--	780			
10/77	1090	--	--			
11/77	870	725	790	1700*	1700*	
1/78	710	580	670	--	--	
2/78	--	--	790	--	--	
3/78	560	660	670	340	1100	

*Concentration of chloride before plugging.