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FIELD INVESTIGATION INTO THE FEASIBILITY OF STORING FRESH WATER IN SALINE PORTIONS OF THE FLORIDAN AQUIFER SYSTEM, ST. LUCIE COUNTY, FLORIDA

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FIELD INVESTIGATION INTO THE FEASIBILITY OF STORING FRESH WATER IN SALINE PORTIONS OF THE FLORIDAN AQUIFER SYSTEM, ST. LUCIE COUNTY, FLORIDA

by

Leslie A. Wedderburn
and
Michael S. Knapp

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The authors wish to acknowledge the assistance and guidance provided by Mr. Abe Kreitman, former Director, Groundwater Division, South Florida Water Management District, in the development and execution of this study. Thanks are also due to Mr. Fred Meyer, U. S. Geological Survey, Miami Sub-district Office, who willingly gave advice and assistance during the study. This study is one of the many technical investigations authorized by the South Florida Water Management District in the execution of its mandate to provide for the conservation, development, management and proper utilization of the water resources within its boundaries.

SUMMARY

This preliminary report presents data from the initial phase of field investigations into the feasibility of storing fresh water in the saline portion of the Floridan Aquifer System in St. Lucie County. During this study the lithology, water bearing properties, and water quality of the first potential injection horizon within the Floridan Aquifer System at the selected site were investigated. A brief injection/recovery test was performed to assess the operation of the system.

The study indicated that several zones existed within the upper part of the Floridan Aquifer System which could accept and store injected fresh water. Surface or shallow groundwater of marginally suitable characteristics for injection existed in the area. The major drawbacks with the available water were: a) variably moderate to high chloride concentrations (100 to 200 mg/l), b) variable but often high suspended solids concentrations in the surface water, and c) high iron concentrations in both surface and shallow ground water.

At the site chosen for exploratory work, a suitable injection horizon consisting of three producing zones was identified and tested. The injection horizon had moderate transmissivity (45,000 gpd/ft) and total dissolved solids concentration (approximately 2000 mg/l).

Water from a shallow well drilled on the site was injected at rates from 400 gpm to 200 gpm in the zone between 600 feet and 775 feet. Reduction in injection rate and increases in injection pressure indicated plugging of the well bore during injection. This was confirmed by high suspended solids concentration and total iron in backflush from the injection well.

Due to the initial high chloride content of the injected water, approximately 3 percent of the recovered water had chloride concentration below 250 mg/l. However, it was calculated that for an 80/20 blend of

injected water with native water, the recovery efficiency would be 33 percent for the first cycle of injection. At 100 percent recovery the recovered water was still significantly less mineralized than the native groundwater.

Water quality data indicated a gradual increase in mineralization of the recovered water, suggesting that the volume of water which can be recovered would vary in an approximately linear manner with the maximum allowable concentrations of critical water quality parameters (chloride and total dissolved solids). The quantity of recoverable water therefore depends both on the quality of the injected water and the maximum allowable concentrations in the recovered water.

Costs associated with the injection/recovery method are likely to exceed present costs for agricultural water in the area. The study, however, indicated that substantial cost reductions may be possible if suitable sites were obtained at which high rates of injection could be maintained without pretreatment of the injection water or frequent well rehabilitation, and if the quality of the recovered water was not a critical factor.

FIELD INVESTIGATION INTO THE FEASIBILITY OF STORING FRESH WATER IN SALINE PORTIONS OF THE FLORIDAN AQUIFER SYSTEM, ST. LUCIE COUNTY, FLORIDA

INTRODUCTION

In August 1980, the South Florida Water Management District released results of a preliminary investigation into the feasibility of cyclic storage of fresh water in the saline Floridan Aquifer System, Upper East Coast Planning Area (Khanal, 1980). This study indicated that the technique was feasible and recommended a program of field investigations to confirm the efficacy of the method. Field investigations were initiated in 1981 with the following objectives:

1) To identify a suitable location for construction of facilities to perform injection/recovery tests.
2) To design and construct an exploratory well to determine aquifer parameters, resident water quality, and optimum well design.
3) To design and construct a test-injection well and associated monitoring wells for long-term injection/recovery tests.
4) To design and implement long-term injection/recovery tests in the test injection well.

This interim report summarizes the results of the first two phases of the field investigations. The report is intended to form the basis for decisions as to the desirability of completing the final phases of the project which would include multiple-cycle long-term injection/recovery tests. It can also serve as supporting documentation for application for a Class V Underground Injection Control Permit as required by Chapter 17-28, Florida Administrative Code, should this be required for construction of facilities for the final phases of the project.

PREVIOUS INVESTIGATIONS

The techniques for injection of fresh water into saline aquifers are similar in many respects to those employed in artificial recharge to fresh water aquifers. Artificial recharge has been practiced successfully in many areas and much experience has been gained in solving problems associated with this technique. Some of the earliest work reported in the United States was done by the U. S. Geological Survey in the Grand Prairie Region, Arkansas (Sniegocki, 1959, 1963a, 1963b; Sniegocki, et al., 1965). These studies identified entrained air, turbidity and micro-organisms as major causes of plugging during injection and suggested methods to overcome these problems. In addition to these problems other technical considerations unique to injection in saline aquifers relate to the difference in water quality between the injected water and the resident aquifer water. Kimbler, et al. (1975), studied the miscible displacement and molecular diffusion processes which take place when a fluid is injected into another fluid of different composition, and defined the primary parameters that affect recovery efficiency of the injected and stored water.

Injection/recovery tests involving fresh water emplacement in saline aquifers have been carried out at a number of locations in Florida by the U. S. Geological Survey with reported recovery efficiencies varying from 0 to 47 percent. A summary of these tests is given by Merritt, Meyer, and Sonntag (in press). Preliminary field experience indicates possible problems where aquifer transmissivity is very high or very low, or when the injected water has high turbidity. Some problems in plugging of the injection well by inorganic precipitates or bacterial activity have also been indicated.

Comprehensive conceptual modeling of recovery efficiency as a function of a variety of hydraulic and water quality parameters has been completed by Merritt (in press). These studies indicated that aquifer permeability, anisotropy, hydrodynamic dispersion, resident fluid salinity, aquifer storativity, background hydraulic gradients, length of storage period, injection and recovery schedule, wellbore and aquifer plugging and location and operation of wells in multiple-well configurations all have some effect of recovery efficiency. Effects of partial penetration of the aquifer were shown to be negligible, but aquifer stratification (vertical variations in permeability) could have significant effect on recovery of fresh water.

Preliminary hydrogeologic data used in site selection were obtained from Reece, et al. (1980); Brown and Reece (1979); and Brown (1980). Preliminary water quality information on the canals in the area was obtained from Bearden (1972), Pitt (1972), and Federico (1983).

PURPOSE, SCOPE AND METHODS

Cyclic storage of fresh water is a water resources management alternative for efficient utilization of the resource when it is quantitatively adequate but unevenly distributed timewise. Conceptually, the process consists of injection of excess surface or groundwater during periods of availability, storage of this water in the saline aquifer until it is needed, and subsequent withdrawal of the fresh water until the concentrations of critical constituents of the recovered water reach maximum permissible limits.

The purpose of this study was to provide field verification of the feasibility of using this technique in the Upper East Coast Planning Area. The Floridan Aquifer System in this area is an important source of water supply, mainly for agricultural uses. The aquifer system consists of a relatively thick sequence of limestones and dolomitic limestones, confined above by low permeability and clastic, predominantly carbonate sediments and below by dense dolomitic limestones and evaporites. Several discrete producing zones of relatively high permeability occur within this sequence. These zones are separated by less permeable dense, sandy, or chalky limestones.

Groundwater in the system is under artesian pressure. Throughout the area potentiometric heads in the Floridan Aquifer System are above land surface, and wells which tap the system are free-flowing.

Groundwater from the Floridan Aquifer System in the vicinity of the study area is of marginal to poor quality for prevailing agricultural uses (mainly citrus irrigation). Surface water supplies in the area are generally of good quality but inadequate during dry periods. Surface water impoundments as a means of regulating supply are not favored due to cost, safety, environmental and other considerations. Cyclic storage of fresh water in the Floridan Aquifer System, if successfully implemented, could serve as a mechanism for regulating the availability of water, maintaining flowing artesian heads, and improving water quality locally.

The scope of the study included preliminary site selection, drilling and testing of an exploratory well and monitor well, and a short-term injection/recovery test. Based on this study the desirability of constructing a test/injection well for long-term multiple-cycle injection/recovery tests would be evaluated.

Preliminary site selection was based on a review of available pertinent hydrogeologic, geologic, and water quality data from the Upper East Coast Planning Area. The principal criteria used for site selection were:

1) An adequate supply of water suitable for injection should be available conveniently and economically. Preferably the chloride content of this water should not exceed 250 mg/l during periods of injection. Suspended solids concentrations during these periods should also be sufficiently low so as not to present major problems with plugging of the rock interstices in the aquifer.

2) A suitable injection zone should exist in the upper part of the Floridan Aquifer System. Criteria for suitability of the injection zone include:

a) Transmissivity in the range of 50,000 to 150,000 gpd/ft.

b) Chloride content significantly higher than that of the injected water but not excessive. A range between 1000 mg/l and 5000 mg/l would be considered suitable.

c) Consideration should be given to selecting an area with low groundwater gradients and low artesian head above land surface. Additionally the site should be located at least 1/4 mile from other active wells which might affect the results from tests. Other site considerations would include availability of land, convenience for access, and relevance of the site to present or potential areas of water demand.

The selected site, shown on Figure 1, is located at the northwestern corner of the intersection of Canal 24 and Header Canal, approximately 10 miles west of Fort Pierce, St. Lucie County (T 36S, R 39E, S 14DD; Latitude $27^{o}20'17''$N, Longitude $80^{o}29'53''$W). Review of available data indicated that the top of the Floridan Aquifer System occurred at approximately 500-550 feet below NGVD (National Geodetic Vertical Datum of 1929, approximately equivalent to mean sea level). The upper producing zone in this system was estimated to extend from the top of the aquifer to approximately 675 feet NGVD (Brown and Reece, 1979).

Total dissolved solids concentrations in the groundwater from this zone were reported as ranging from 1500 to 2000 mg/l. Chloride concentrations ranged from 1000 to 1200 mg/l. Aquifer transmissivities were within the range 100,000 to 500,000 gpd/ft (Brown, 1980) although these values represent contributions from more than one producing zone. Potentiometric heads were between 38 feet and 40 feet NGVD during 1977 (Brown and Reece, 1980).

Chloride concentrations in Canal 24, in the vicinity of the site, were shown by Bearden (1972) to vary between approximately 100 mg/l during high

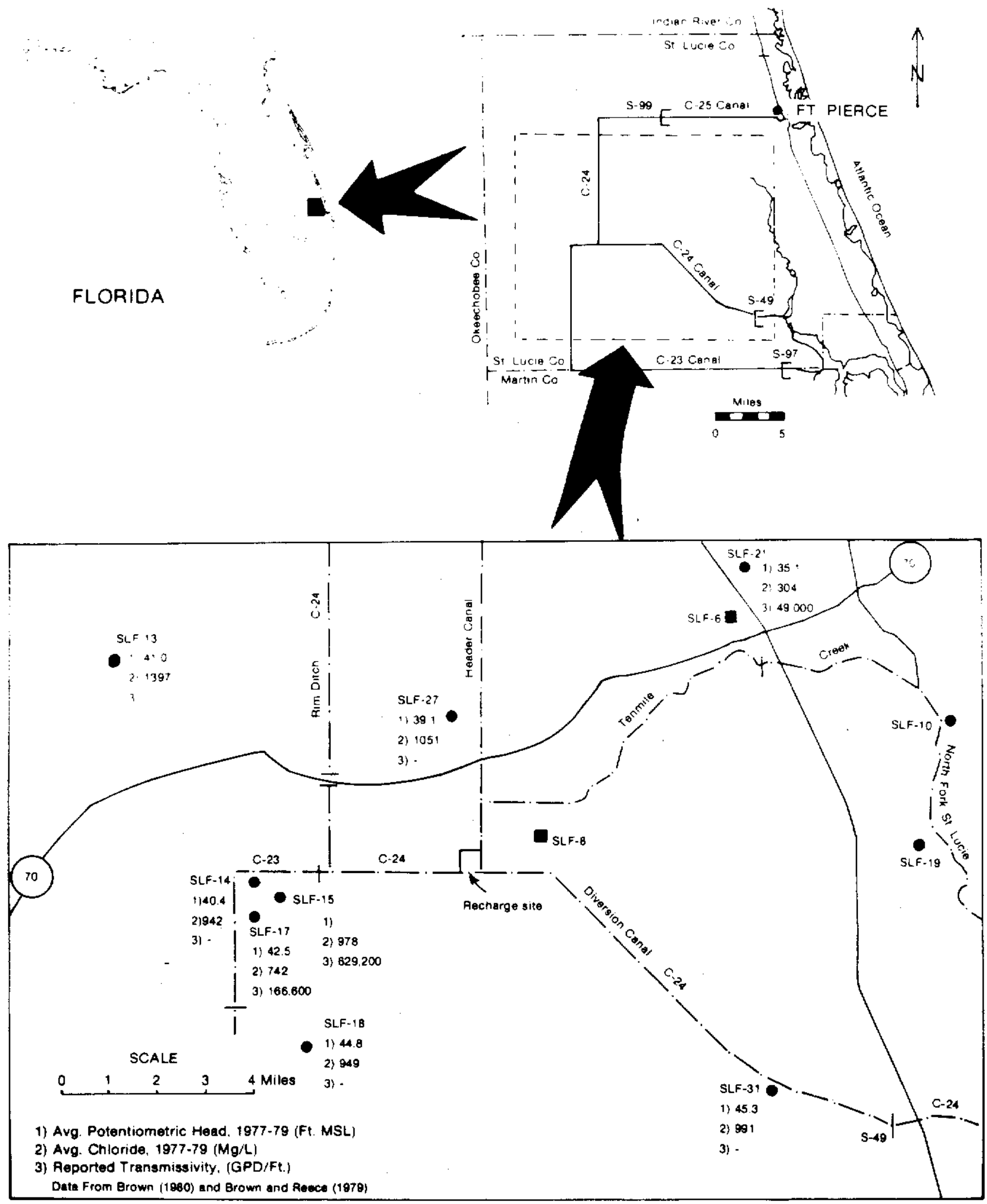


Figure 1 SITE LOCATION AND HYDROGEOLOGIC DATA IN VICINITY OF SITE

canal stage, and 350 mg/l during low canal stage. Federico (1983) reported minimum and maximum chloride concentrations in C-24 at S-49 of 152 and 534 mg/l respectively, during the period November 1, 1976 to October 31, 1977. Suspended sediment concentrations (Pitt, 1972) were between 2 mg/l during low stage and 360 mg/l during high stage. Ninety-five (95) percent of the sediment ranged in size from 0.004 millimeters (mm) to 0.062 mm.

Figure 2 shows locations of other Floridan wells in the vicinity of the site. Only one well was located within 1/4 mile of the site. This well was located in an abandoned grove, was infrequently used, and valved. Arrangements were made to utilize this well as a monitor well during aquifer recovery tests. No wells tapping the Surficial Aquifer System were found in the immediate area.

Field work was designed to obtain data on lithology, stratigraphy, hydrostratigraphy, aquifer parameters, and water quality at the selected site. Initially, two deep wells were drilled. The first was an exploratory well (SLF-50) which was drilled to 1000 feet depth below ground level. The lower portion of this hole was later cemented back to 775 feet. The second (SLF-51) was a monitor well drilled to a depth of 775 feet, based on identification of an injection horizon above this depth from data obtained from the exploratory well.

Construction of both wells was done using similar drilling and completion methods. The Surficial Aquifer System was drilled with a 17 inch diameter bit to its base at approximately 130 feet depth, using direct mud circulation. Twelve (12) inch schedule 40 polyvinyl chloride (PVC) casing was set and cemented to this depth. Neat cement was emplaced through an 1 1/4 inch tremie pipe in the annulus between the casing and the open hole. Drilling was then continued using an 11½ inch bit, to the top of the first persistent carbonate sequence (top of the Floridan Aquifer System) at approximately 600 feet depth.

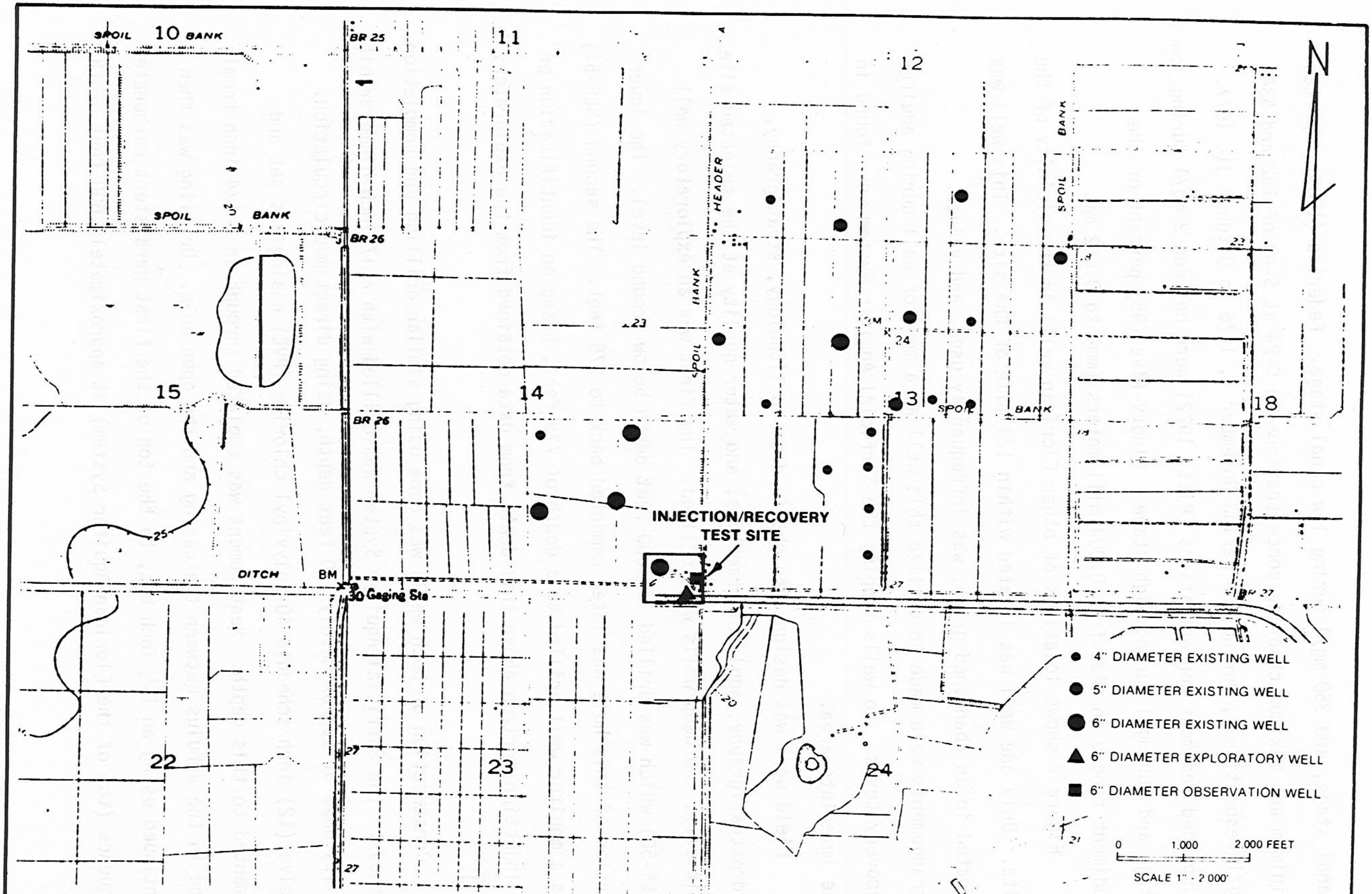


Figure 2 LOCATION OF WELLS TAPPING THE FLORIDAN AQUIFER SYSTEM IN THE VICINITY OF THE INJECTION SITE

Six (6) inch Schedule 40 PVC casing was set, centralized, and pressure cement grouted. Grouting of the annular space around the 6 inch casing was carried out from inside the casing. The casing was filled with drilling fluid, and a tremie pipe was lowered to the bottom of the hole. Neat cement was pumped in with sufficient pressure to be pushed into the annular space between the nominal 11½ inch drilled hole and the 6 inch PVC casing to displace the drilling fluid. Turbulent flow was maintained during the cementing process.

The final section of the hole was drilled with a 5 1/8 inch diameter bit, using reverse air circulation. In the exploratory well, this was done in stages with breaks at 627 feet, 747 feet and 870 feet depths below ground level to allow for testing of the well at these depths. Figures 3 and 4 show details of the site and finished dimensions of these wells.

During drilling operations cuttings were collected at 10 foot intervals. To ensure that representative samples were collected, the hole was cleared of cuttings after each 10 foot penetration by continuing circulation with the bit stationary until no further cuttings were being discharged. Geologic descriptions of these cuttings are given in Appendix 1.

During drilling of the wells geophysical surveys were run at various stages. In the exploratory well, surveys were run when the well was at 600 feet, 627 feet, 747 feet, and total depth (1000 feet). These surveys provided information which was used to determine casing settings and the termination depth for the well. In the monitor well, surveys were run at 600 feet to confirm the setting depth of the 6 inch casing and at completion of the well at 775 feet. The geophysical surveys included Spontaneous Potential, 16 inch Normal Resistivity, 64 inch Normal Resistivity, Flowmeter, Caliper, Natural Gamma, Neutron Porosity, Temperature Gradient, Differential Temperature, and Fluid Resistivity. The logs obtained from the exploratory well are shown in Appendix 2.

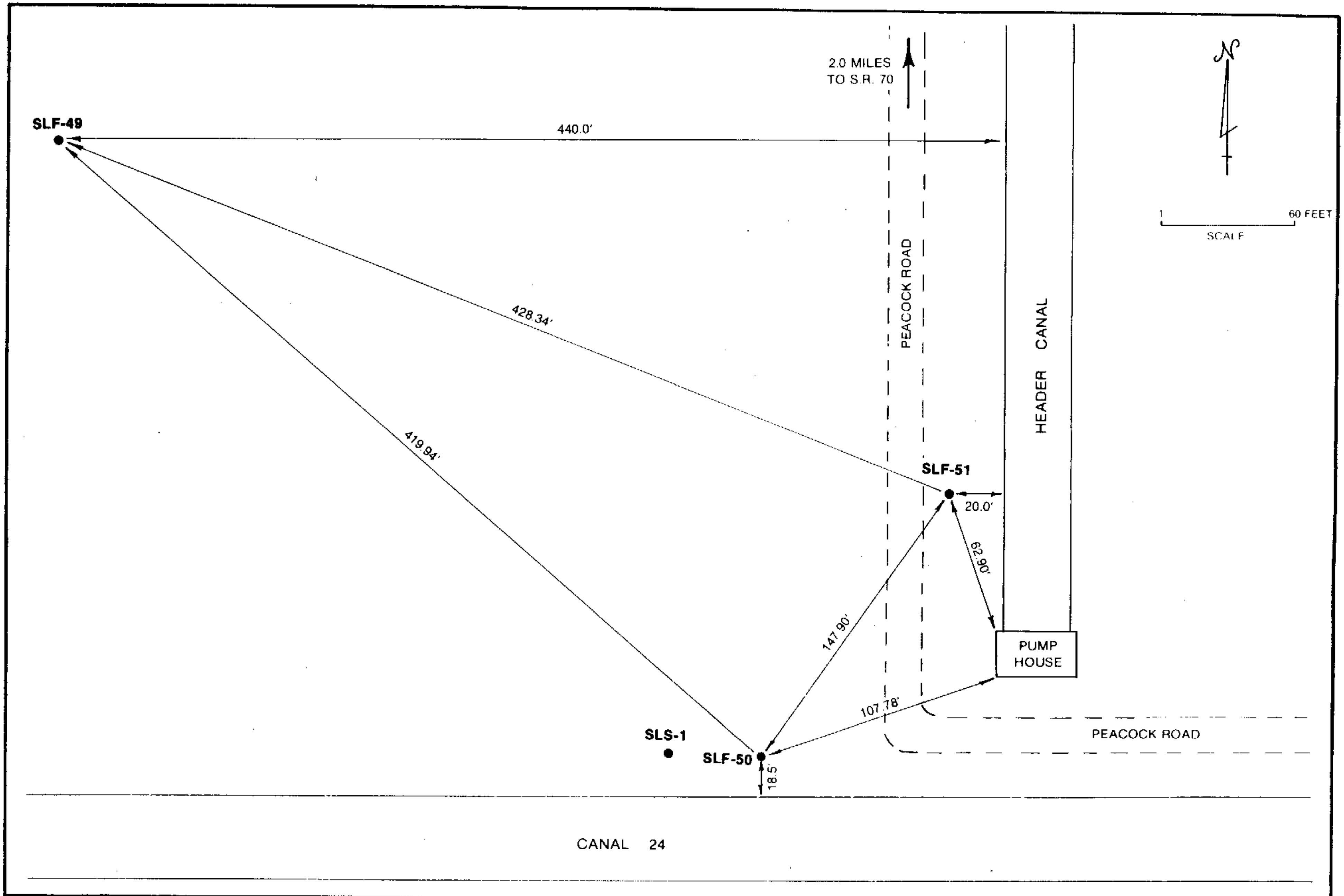


Figure 3 SITE PLAN

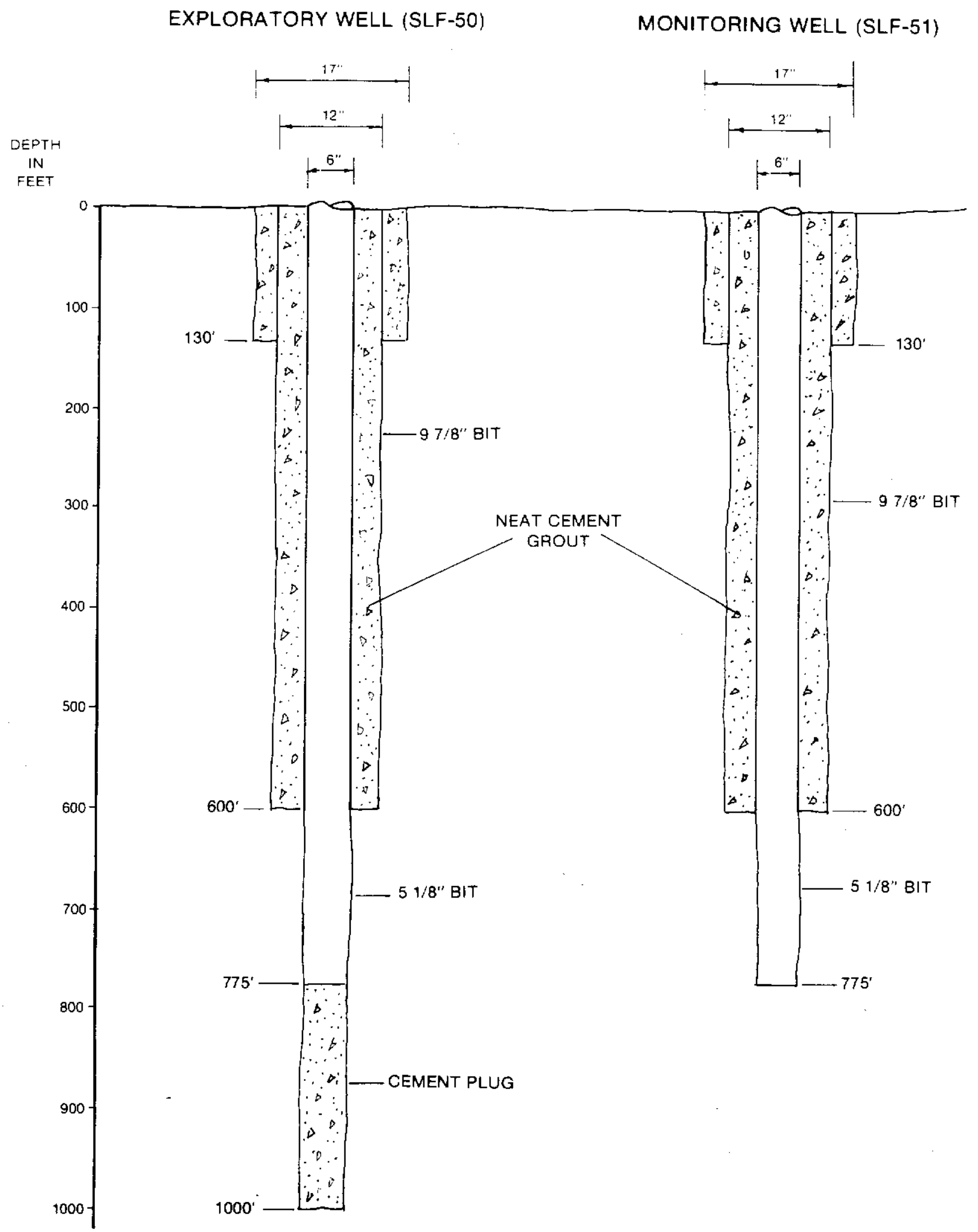


Figure 4 CONSTRUCTION DETAILS, EXPLORATORY WELL (SLF-50) AND MONITOR WELL (SLF-51)

Water samples were collected at 20 foot intervals during reverse air drilling. Groundwater samples were also collected periodically from the overflow from the wells. After completion of drilling, point samples were collected using a geophysical logger and a sampling tube. Samples were also collected during pumping, injection/recovery, and packer tests. The samples were chilled and transported to the South Florida Water Management District Laboratory for analyses. Results of the analyses are given in Appendix 3.

Four aquifer tests were run during and after drilling of the exploratory well and before completion of the monitor well. A 5 inch centripetal pump with a 4 inch drop pipe was used to withdraw water during the tests. Water level changes with time (drawdown and recovery) were measured with an electric tape inserted between the drop pipe and the casing when water levels were below ground surface in the pumping well. Measurements were made at the observation wells using a steel tape secured to a transparent quarter-inch diameter manometer tube attached to a tap on the sealed wellhead and extended approximately 16 feet above ground surface. A manometer tube was also used to measure recovery in the pumped well. Scaffolding was erected to allow for direct reading of water levels in the manometer tube. Data and analyses from these tests are presented in Appendix 4.

Packer tests were run in the completed exploratory well to determine the degree of isolation between the upper and lower producing intervals. The tests consisted of lowering a Tamset 5 7/8 inch diameter retrievable packer through the 6 inch casing to a depth of 776 feet within the open hole and inflating the packer hydraulically to form a seal within the borehole. Water quality and water level information were collected from above and below the packer. Details of the packer test are given in Appendix 5.

After completion of the exploratory well and the monitor well, a 72-hour aquifer test was run to provide more definitive data on the aquifer parameters of the selected injection zone. Details of this test are given in Appendix 4. During this test, water was withdrawn at a constant rate from Well SLF-51. Water level changes with time were recorded at the pumped well and at two observation wells (SLF-50 and SLF-49). Both wells SLF-50 and SLF-51 were 775 feet deep with casing to 600 feet. Well SLF-49 was 893 feet deep with casing to 560 feet.

Final testing to complete preliminary assessment of the site involved a short-term injection test. To provide water for injection a shallow 8 inch diameter well (SLS-1) was drilled close to the canal (C-24) and the exploratory well (SLF-50). This well was 55 feet deep and was cased to 35 feet. The well was designed to obtain sediment-free water from the canal through induced infiltration. This well produced approximately 800 gallons of water per minute with chloride concentration approximately 200 mg/l. Data and analyses from the injection/recovery test are given in Appendix 6.

Injection was carried out for 75 hours at rates varying from 250 gpm to 500 gpm and pressures ranging from 25 psi to 41 psi. A total of 1.48 million gallons of water was injected. The well was then shut in for 30 days, after which time, recovery was initiated. Recovery was effected by natural backflow over a period of four weeks, until withdrawn water was of approximately the same quality as resident aquifer water. Water quality data were taken at 2 hour intervals during the first part of the recovery cycle. This included on-site chloride, conductivity and temperature readings, and collection of samples for laboratory analysis. Results of all these tests are discussed in detail in subsequent sections of this report.

RESULTS OF INVESTIGATIONS

STRATIGRAPHY

INTRODUCTION

Figure 5 shows the major stratigraphic units encountered in the exploratory well (SLF-50) between land surface (+31.75 feet NGVD) and a depth of 1000 feet. The stratigraphic sequence penetrated ranged in age from Eocene to Recent. Eocene rock units include the Ocala Group and the Avon Park Limestone. The Miocene age Hawthorn Formation overlies the Ocala Group throughout the injection site area. The lowermost beds of the Hawthorn Formation are somewhat similar to lithologies that define the Tampa Formation and Suwannee Limestone (Oligocene) in other parts of Florida. However, due to the phosphatic nature of these beds they are here included in the Hawthorn Formation. Younger formations range in age from late Miocene/Pliocene to Recent and are represented by the Tamiami Formation, Anastasia Formation, and Undifferentiated terrace deposits.

CENOZOIC ERATHEM

Eocene Series

Avon Park Limestone

Applin and Applin (1944) proposed the name Avon Park Limestone to describe rocks of late Middle Eocene age in northern and peninsular Florida. They described the Avon Park Limestone as mainly a cream-colored, highly microfossiliferous chalky limestone, with gypsum and chert. The type locality is in a well in the Avon Park Bombing Range in Polk County, Florida. Where this formation crops out in Levy County, Florida it normally occurs as a tan to brown, very dense, poorly fossiliferous and massive dolomite (Knapp, 1978).

In the exploratory well the Avon Park Limestone was identified as a highly recrystallized, fossiliferous and dolomitic limestone. At total

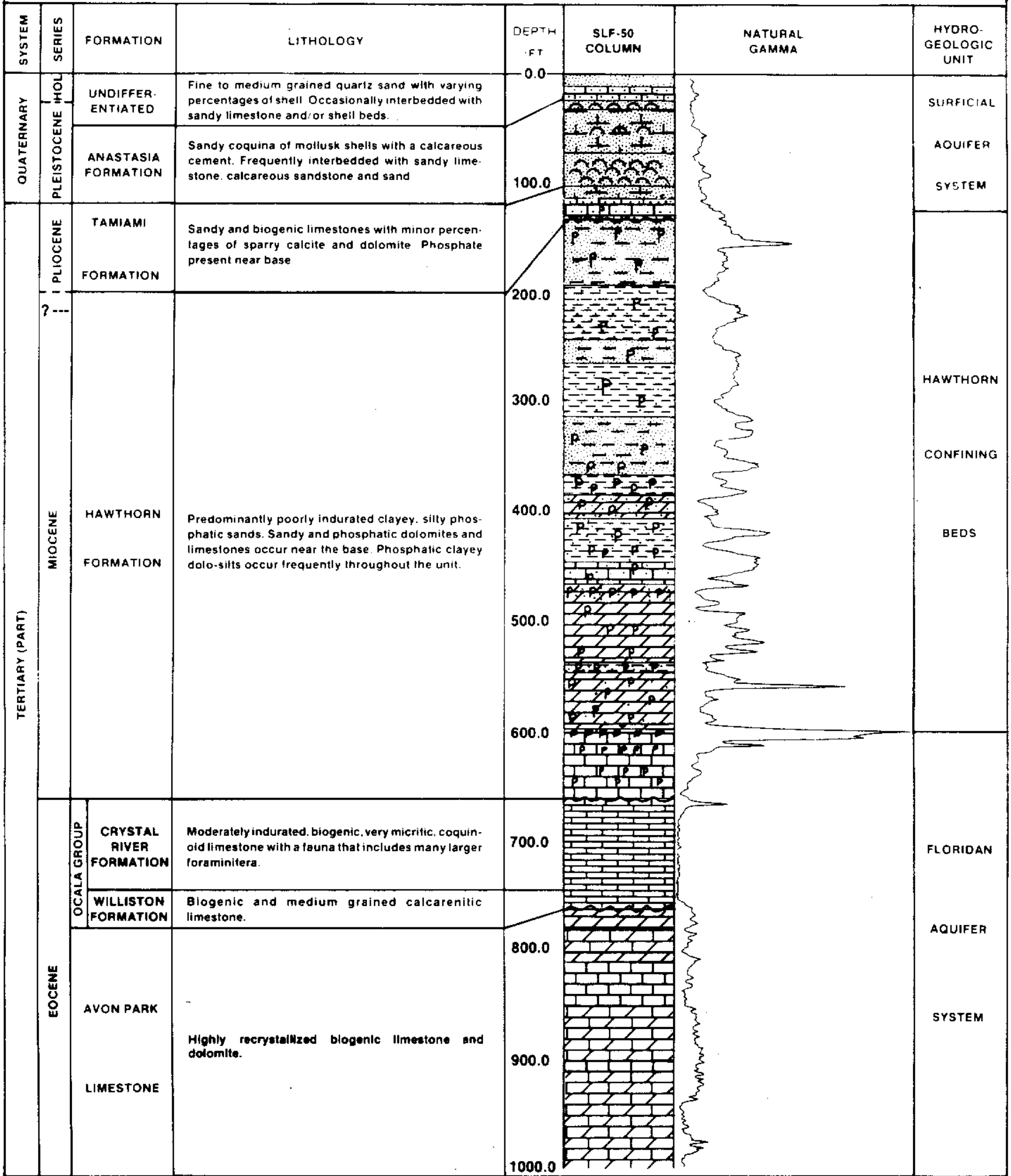


Figure 5 STRATIGRAPHY, LITHOLOGY AND HYDROGEOLOGY OF EXPLORATORY WELL SLF-50

depth, the well had penetrated 240 feet of these carbonates. A distinct lithologic change marks the boundary between the fossiliferous and dolomitic limestones of the Avon Park Limestone and the overlying calcarenitic limestones in the Williston Formation of the Ocala Group. Fossils present in the Avon Park Limestone include echinoids, foraminifera (especially Dictyoconus sp.), mollusks, bryozoans, and other fossil fragments. The Natural Gamma Ray log (Figure 5) shows an increase in radioactivity in this unit as compared to the overlying Ocala Group.

Ocala Group

The term "Ocala Limestone" was first used by Dall and Harris (1892) in a discussion of limestones being quarried near the town of Ocala in Marion County, Florida. Applin and Applin (1944) identified an upper and lower member within the "Ocala Limestone." This usage is still followed by the U. S. Geological Survey and many others. Puri (1953) followed Vernon (1951) in recognizing three distinct units that he believed were present within the strata of the "Ocala Limestone." He proposed for these units the names Crystal River Formation, Williston Formation, and Inglis Formation (in descending order of depth) and suggested that the new formations should be included in the Ocala Group. This usage is followed in this report.

The Crystal River and Williston Formations were both penetrated in the test wells. The Inglis Formation was not recognized in the area. The Crystal River Formation occurred as a coquina of larger foraminifera (Lepidocyclina sp.) in a carbonate mud matrix. The Williston Formation is a medium grained calcarenitic limetone. The unit is fossiliferous, but not coquinoid. The Ocala Group is 100 feet thick in well SLF-50. Only 20 feet of the Williston Formation was encountered in this well.

Miocene Series

Hawthorn Formation

The Hawthorn Formation overlies the Crystal River Formation at the test site area. The lowermost beds of this unit may be equivalent to the Suwannee Limestone, Tampa Formation, or Unnamed Limestone of Mooney (1980). Dall and Harris (1892) first used the term "Hawthorne beds" for phosphatic sediments being quarried for fertilizer near the town of Hawthorne, Alachua County, Florida. In recent work by Scott and Knapp (1983), continuous cores were described and correlated with the type and co-type sections. They described the Hawthorn Formation as "consisting of varous mixtures of clay, quartz sand, carbonate (dolomite to limestone), and phosphates." They also divided the Formation into two distinct units in southern peninsula Florida, a lower predominantly carbonate unit and an upper predominantly clastic unit.

As recognized in this report, the Hawthorn Formation is a heterogeneous sequence of phosphatic, sandy, clayey, calcareous, and dolomitic sediments of which the uppermost bed is an olive-gray, clayey phosphatic sand. The lowermost beds are very fine grained biogenic and slightly phosphatic limestones, which may in part be of Oligocene age (Armstrong, 1981). The Hawthorn Formation exhibits high gamma activity (Figure 5) due mostly to the presence of phosphatic sand. The total thickness of the Hawthorn Formation at the test site was 530 feet. The basal limestones were 60 feet thick.

Miocene/Pliocene Series

Tamiami Formation

Mansfield (1939) proposed the name "Tamiami Limestone" for a fossiliferous sandy limestone approximately 25 feet thick, which was penetrated in shallow ditches along the Tamiami Trail (U.S. Route 41) in parts of Collier and Monroe Counties, Florida. At the exploratory site the Tamiami Formation was recognized as a sandy, very fine grained limestone with very little phosphate. It was 30 feet thick in this well and extended from 100 feet to 130 feet below land surface.

Pleistocene/Holocene Series

Anastasia Formation

Sellards (1912) used the name Anastasia Formation for exposures of coquina rock extending southward along the Atlantic coast of Florida from St. Augustine. The rock is composed of sandy limestone, calcareous sandstone, and unconsolidated sand and shell (Puri and Vernon, 1964). In Well SLF-50 the Anastasia Formation occurs as a calcareous sandstone and shell bed approximately 70 feet thick between 30 and 100 foot depths below land surface.

Undifferentiated Terrace Deposits

The surficial deposits at the test site are composed of medium-grained sand, shell and calcareous clayey material about 30 feet thick. Some of the sediment penetrated by the exploratory well was evidently spoil material from the adjacent drainage canal.

HYDROSTRATIGRAPHY

INTRODUCTION

Three major hydrostratigraphic units were identified at the test site, extending from land surface (elevation +31.75 NGVD) to a depth of 1000 feet. These are the Surficial Aquifer System, Hawthorn Confining beds, and the Floridan Aquifer System. The Surficial Aquifer System was not examined in detail due to the scope of this project. The Hawthorn Confining beds have an overall low permeability and effectively separate the Surficial Aquifer System from the much deeper Floridan Aquifer System. The Floridan Aquifer System was found to contain multiple producing zones that correlated closely with highly porous beds identified from well cuttings and geophysical logs.

SURFICIAL AQUIFER SYSTEM

The Surficial Aquifer System is 130 feet thick at the test site and includes sediments associated with the Tamiami Formation, Anastasia Formation, and Undifferentiated deposits. It is underlain by the less permeable clayey sands and phosphatic dolo-silts of the Hawthorn Formation. Some of the individual limestone and sandstone beds within this system exhibit high permeability. A gray calcareous sandstone was penetrated between 30 and 50 feet which appeared to have high permeability. A shallow well completed subsequently in this zone produced in excess of 800 gallons per minute. The associated porosities are commonly of the intergranular, moldic, and intercrystalline varieties. The presence of shell beds with high intergranular porosities also contribute to the high permeability of this unit.

HAWTHORN CONFINING BEDS

The Hawthorn Confining beds are equated with the upper portion of the Hawthorn Formation and are contained wholly within that formation. The lowermost limestone beds of the Hawthorn Formation which are in hydraulic connection with the underlying Eocene sediments are considered part of the Floridan Aquifer System. The Hawthorn Confining beds are composed principally of phosphatic, clayey, dolomitic quartz sands. The presence of interbedded dolo-silts and the clayey matrix of the quartz sands give this unit an overall low permeability. The lithology of this unit is, however, not uniform and there are several well indurated porous limestone and dolomite beds within it, such as at 380 to 390 feet, 440 to 450 feet, and 540 to 550 feet. These beds may be capable of producing small quantities of water, but due to their relative thinness and apparent low permeability they are not considered a significant water supply source. These zones, along with the less permeable sandy and silty zones in the Hawthorn Formation, are generally cased off in wells which tap the Floridan Aquifer System. The base of the Hawthorn Confining beds is marked by a green clayey dolo-silt which extends from 580 feet to 600 feet. At the exploratory well site the Hawthorn Confining beds are 470 feet thick, and the top was logged at a depth of 130 feet.

FLORIDAN AQUIFER SYSTEM

The term "Floridan Aquifer" was established by Parker (Parker, et al., 1955) to describe water bearing rocks associated with the Lake City Limestone, Avon Park Limestone, Ocala Limestone, Suwannee Limestone, Tampa Limestone, and the lower permeable parts of the Hawthorn Formation which are in hydrologic contact with the underlying units. In describing this unit in southern Florida, Brown (1980) and Wedderburn, et al. (1982), used the term "Floridan Aquifer System" in recognition of the presence of multiple producing zones and confining zones within the sequence of rocks. This terminology is used in this report.

At the exploratory well site, the Floridan Aquifer System consists of a thick sequence of interbedded limestones and dolomites of Eocene to lower Miocene age extending from a depth of 600 feet to the bottom of the well (1000 feet). The well did not, however, penetrate the full thickness of the system. Previous work indicates that this aquifer system is areally extensive throughout south Florida and may be as much as 3000 feet in thickness in this area (Miller, 1982).

The top 60 feet of the system occurs within the Hawthorn Formation and consists of well-indurated fossiliferous limestones exhibiting moderate (approximately 15 percent) moldic and intergranular porosity. The base of this interval is marked by a pronounced gamma ray "kick." This section of the

Hawthorn Formation corresponds to the "Unnamed Limestone" identified by Mooney (1980) as Oligocene in age.

The coquinoid limestone beds of the Ocala Group and the highly recrystallized limestone and dolomite beds within the Avon Park Limestone are also water producing within the Floridan Aquifer System. Geophysical logs indicate that the major water production is confined to relatively narrow intervals which tend to correspond to stratigraphic contacts. Figure 6 shows Differential Temperature Log, Corrected Flowmeter Logs and lithology within the upper part of the Floridan Aquifer System. The Differential Temperature Log shows a number of peaks which indicate significant temperature differences within the system. These peaks generally correspond with zones of flow within the wellbore as detected by the Flowmeter Log. Six zones which contribute significant flow to the wellbore under natural flowing artesian conditions are indicated on the Flowmeter Log which has been corrected to minimize the effects of variations in borehole diameter. The first significant producing zone in the Floridan Aquifer System occurs between approximately 650 to 670 feet, and accounts for about 29 percent of the flow of the well. The most productive zone occurs between of 730 and 750 feet and accounts for about 40 percent of flow. A third zone which accounts for about 10 percent of flow occurs between 760 and 770 feet. These producing zones occur approximately at the contact between the Ocala Group and the Hawthorn Formation and Avon Park Limestone respectively, and may represent reworking or dissolution at the unconformities which mark depositional breaks in the strata.

The lower portion of the borehole below the third producing zone contributes less than 21 percent of the total natural flow from the well. Minor flow contributions are indicated at a depth of 840 to 842 feet (5 percent) and at a depth of 895 to 905 feet (9 percent). Between 955 and 960 feet some 7 percent of the flow from the well is produced.

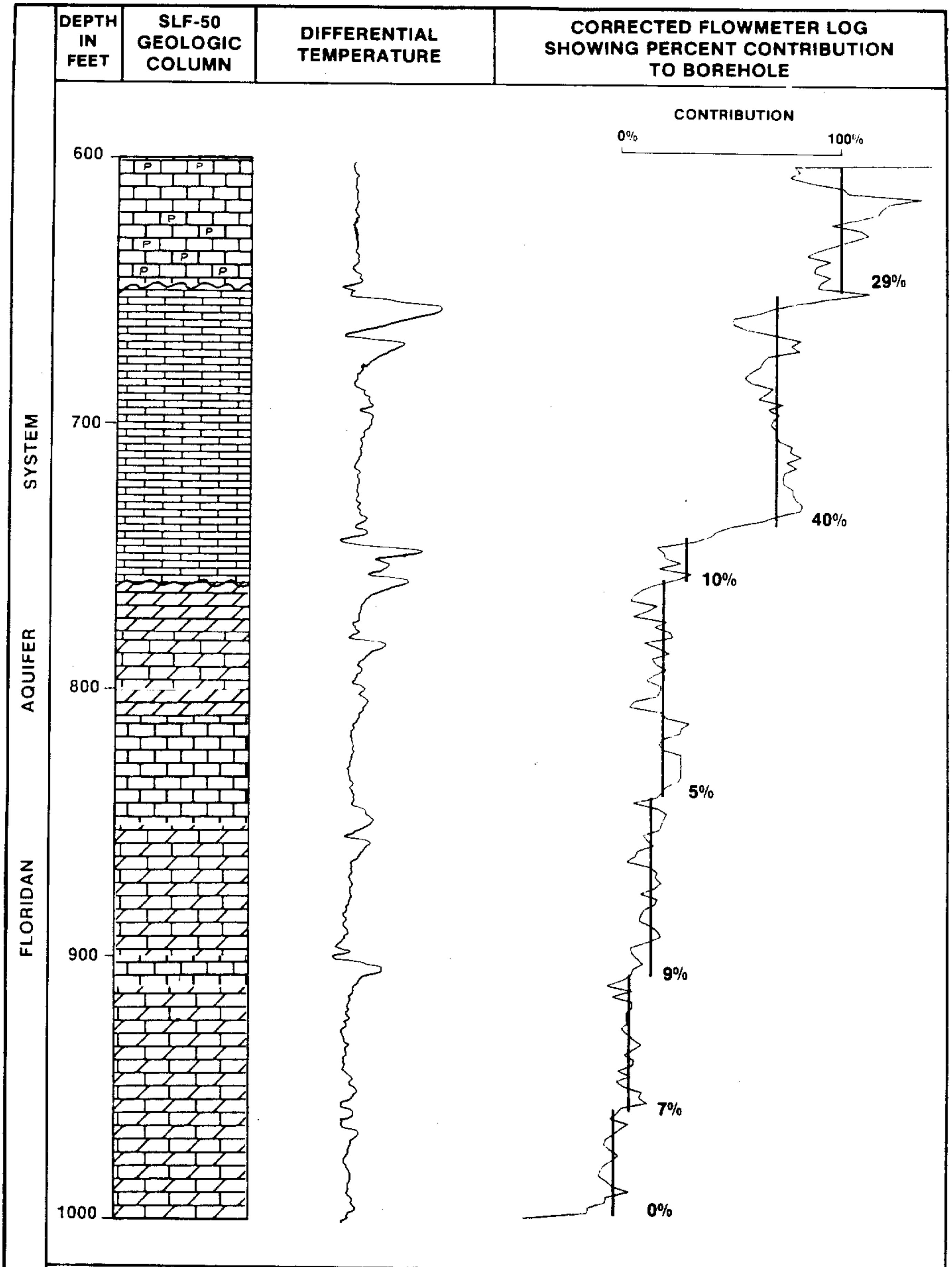


Figure 6 PRODUCING ZONES IN WELL SLF-50 AND PERCENT CONTRIBUTION OF EACH ZONE TO FLOW IN BOREHOLE

Based on the above information, the interval above 775 feet which contains the three major producing zones appeared to offer the best promise for injection of fresh water. The first two producing zones are each approximately each 20 feet thick and the third about 10 feet thick. These zones show a mixture of fracture, solution, and moldic porosity, and flow within then could be expected to differ significantly from isotropic, homogeneous porous media flow. Loss of injected water from this interval to the lower strata would be expected to be relatively small due to the much higher horizontal permeability in the injection horizon as compared to the permeability below this horizon.

AQUIFER PARAMETERS

The aquifer parameters of particular importance in assessing the feasibility of injecting fresh water into saline aquifers are permeability, porosity, longitudinal and vertical dispersivity and the coefficient of molecular diffusion (Khanal, 1980). A series of aquifer tests were designed to provide information on the transmissivity and permeability of the producing zones in the upper part of the aquifer system. Porosity was estimated from examination of the rock cuttings. The scope of the study did not allow for any tests to determine the longitudinal or vertical dispersivity or coefficient of molecular diffusion. These parameters were estimated based on experience in similar lithologies from tests conducted by other researchers.

The first set of 4 aquifer tests was performed on the exploratory well, to aid in selecting a suitable injection zone. Drilling of this well was halted at various depths to allow for the tests to be run. The well was developed, allowed to recover fully, then pumped at a constant rate. Data on water level changes with time were collected from the pumped well (SLF-50) and from an existing irrigation well (SLF-49). The Jacob semi-logarithmic method (Jacob, 1952) was used to analyze the recovery data for aquifer transmissivity. This method assumes interalia that the aquifer tested is isotropic, homogeneous, fully penetrated and fully confined. Since these assumptions were not expected to be fully met, the values derived from this analysis were expected to be approximate, and were utilized only as indicators of the relative transmissivities of different sections of the strata penetrated.

A fifth pumping test was run after completion of both the exploratory well and the monitoring well. This test was designed to provide more exact information on aquifer parameters in the selected injection horizon. The data from this test were analyzed by the Hantush/Jacob type curve method and the Hantush-Inflection point method (Hantush and Jacob, 1955; Hantush, 1964).

Table 1 summarizes the results of these pumping tests. The four initial pumping tests indicated a general trend toward increased transmissivity with depth of penetration of the aquifer. The first zone tested included the interval from the bottom of the casing (600 feet) to a depth of 627 feet. At this site the calculated transmissivity of this interval, which occurs at the very top of the Floridan Aquifer System, was low (9,428 gpd/ft). The second interval tested included all of the aquifer between 600 feet and 747 feet. The test indicated a significant increase in transmissivity (65,340 gpd/ft). At a depth of 870 feet the well was again tested, and the results indicated a further increase in calculated transmissivity (88,000 gpd/ft). The final preliminary test was run with the well at 1000 feet depth. This test yielded a transmissivity of 107,077 gpd/ft.

Based on the results of these tests and additional lithologic and geophysical information previously discussed, the interval from 600 feet to 775 feet was selected as a suitable injection horizon. This interval was isolated from the lower portion of the borehole using a Tamset retrievable/resettable packer set at 776 feet. The packer tests confirmed the presence of a major producing interval above the setting depth, and indicated

TABLE 1. SUMMARY OF PUMPING TEST DATA AND RESULTS

DATE OF TEST	DURATION OF PUMPING (HRS)	WELL DEPTH (FT) PUMPED WELL	WELL DEPTH (FT) OBS. WELLS	CASING DEPTH(FT) PUMPED WELL	CASING DEPTH(FT) OBS. WELL	PUMPING RATE (GPM)	MAXIMUM DRAW-DOWN (FT) PUMPED	MAXIMUM DRAW-DOWN (FT) OBS.	TRANSMISS. (GPD/FT)	STORAGE COEFFICIENT	LEAKAGE K'/m' (DAY^{-1})	REMARKS
1-5-82 to 1-6-82	2	627 (SLF-50)	893 (SLF-49)	600	560	55	35.73	ND	9,428*	-	-	Recovery data-pumped well Jacob semi-log analysis
1-19-82 to 1-21-82	46.25	747 (SLF-50)	893 (SLF-49)	600	560	396	32.69	ND	65,340*	-	-	Recovery data-pumped well Jacob semi-log analysis
2-2-82	6	870 (SLF-50)	893 (SLF-49)	600	560	450	29.0	ND	88,000*	-	-	Recovery data-pumped well Jacob semi-log analysis
2-9-82 to 2-10-82	24.15	1000 (SLF-50)	893 (SLF-49)	600	560	580	30.93	ND	107,077*	-	-	Recovery data-pumped well Jacob semi-log analysis
8-24-82 to 8-27-82	72	775 (SLF-51)	1) 775 (SLF-50) 2) 893 (SLF-49)	600	1) 600 2) 560	388	35.35	1) 2.37 2) ND	a) 44,233** b) 48,080** c) 43,416**	a) $1.64X10^{-4}$ b) $2.67X10^{-4}$ c) $1.65X10^{-4}$	a) .0432 b) .0470	a) Drawdown data-obs. well #1, Hantush/Jacob b) Recovery data-obs. well #1, Hantush/Jacob type curve analysis c) Drawdown data-obs. well #1, Hantush inflection point analysis

*Preliminary tests to determine relative transmissivity with depth. Values do not reflect true transmissivity since the effects of leakance are ignored.
**Values underlined reflect true aquifer characteristics of injection horizon.

relatively good confinement between this zone and the lower strata (see Appendix 5 for details of the Packer test). The exploratory well was then cemented back to 775 feet and a monitoring well constructed to enable monitoring of the zone between 600 feet and 775 feet depth.

The final pumping test was designed to provide definitive information on the aquifer parameters of the proposed injection horizon (600 feet to 775 feet). Well SLF-51 was pumped 72 hours at a constant discharge rate of approximately 388 gpm. Analysis of the data gave a transmissivity of 43,000 to 48,000 gpd/ft; a storage coefficient of 1.6 X 10^{-4} to 2.6 X 10^{-4}, and leakance coefficient of .043 to .047 day^{-1}. The lower value of transmissivity, compared to that obtained during the initial testing with the well at approximately the same depth (65,000 gpd/ft), is probably due to the effects of leakance which could not be addressed in the initial analysis due to the absence of a suitable observation well.

Porosity values were visually estimated as between 14 to 18 percent. The dominant types of porosity seen in the well cuttings were intergranular and moldic. No tests were run to determine the hydrodynamic dispersion parameters. Hydrodynamic dispersion refers to the spreading and mixing caused in part by molecular diffusion and microscopic variation in velocities within individual pores (Anderson, 1979). For regional applications, values of longitudinal dispersivity coefficient have been found to vary from tens to hundreds of meters. Segol and Pinder (1976) reported values of 6.7 meters and 0.7 meters respectively for longitudinal and transverse dispersivities in limestones in southeast Florida. Values of longitudinal dispersivity ranging from 3.1 meters to 61 meters have been reported for limestone aquifers (see Mercer et al., 1982). However, values ranging from 6.7 to 13.7 meters appear to match lithologic and hydrostratigraphic conditions similar to those in the study area.

WATER QUALITY

The water quality sampling program was designed to provide information on: a) the suitability of the available surface water for injection; b) water quality variations in the aquifer to assist in selection of an injection zone; and c) provide background data for use during injection/recovery tests. Water samples were collected using standard techniques and analyzed by the SFWMD Laboratories. Results of these analyses are tabulated in Appendix 3.

SURFACE WATER QUALITY

Data on chloride concentrations in surface water in the vicinity of the site prior to initiation of the exploratory program have been published by Pitt (1972) and Bearden (1972). Table 2 presents selected data on chloride concentrations in Canal 24, in the vicinity of the site, and associated water levels at Structure 49 (S-49), 11 miles downstream of the investigation site.

TABLE 2. Approximate Chloride Concentrations in C-24 Near Site, and Canal Levels at S-49 (From Bearden, 1972).

DATE	WATER LEVEL AT S-49, UPSTREAM (FT)	CHLORIDE CONCENTRATION IN C-24 NEAR SITE (mg/l)
09/21/67	18.82	150
04/02/68	17.15	360
05/01/68	15.10	250
10/08/68	18.95	150

The data in Table 2 indicate that chloride concentrations vary depending on canal levels; the minimum concentration recorded being 150 mg/l during a period of high water levels and the maximum being 360 mg/l during a period of low water levels. Data from Frederico (1983) (Figure 7) indicate that during 1976/1977 lowest chloride concentrations were found in the canal during the months of November and December 1976 and September, October and November 1977.

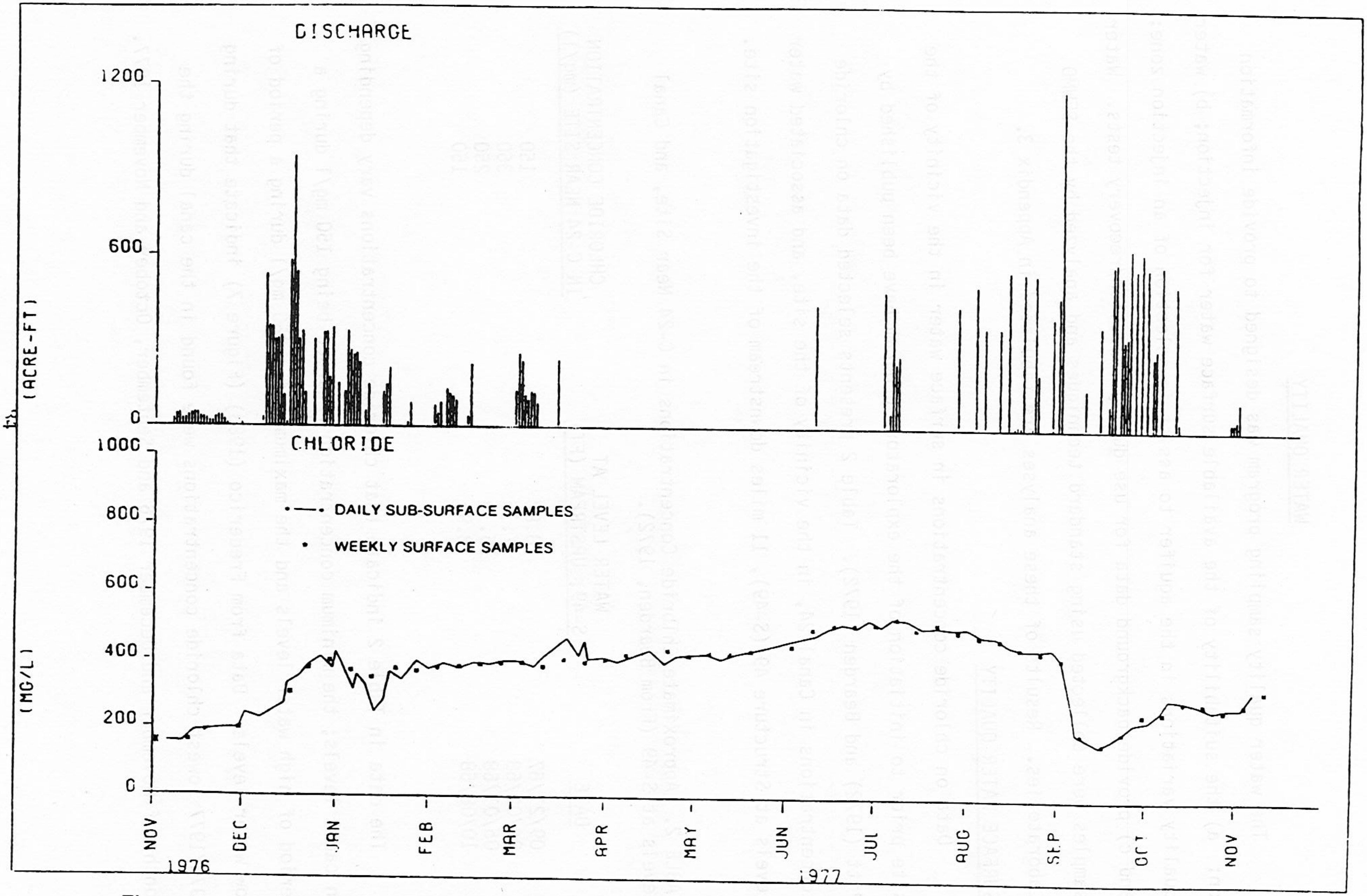


Figure 7 DAILY SUBSURFACE AND WEEKLY SURFACE CHLORIDE CONCENTRATIONS AT S-49 FROM FREDERICO, 1983

Some previous data on suspended sediment concentrations and particle size distribution in water from C-24 were reported by Pitt (1972). Sediment samples were taken at three different points across the canal 600 feet upstream of S-49 (approximately 11 miles downstream of the investigation site) during the period July to November 1969. Sediment concentrations were found to be the same at all three points. A direct relationship was found between discharge and sediment load. The sediment concentration was found to range from 2 to 360 mg/l during this period. Particle size of the sediment was mostly in the clay size range (.004 to .062 mm) (see Figure 8). According to Pitt, sediment in the canals originates in the cultivated areas from decomposition of vegetal material and soil erosion.

During the present study, water samples were collected from C-24 and Header Canal in the vicinity of the investigation site. All the samples were collected within six feet of the canal bank and less than 1 foot below the water surface. Measured chloride values in C-24 range from 555 mg/l to 107 mg/l. The highest value was recorded during discharge of saline water to the canal. The lowest value was recorded after a period of heavy rainfall (see Appendix 3). On the basis of the historic data and the analyses done during the investigations it was concluded that during the wet season the chloride concentrations in the canal could generally be expected to be below 200 mg/l. Samples taken from Header Canal show higher chloride values than those from C-24 and it was concluded that this canal would be a less suitable source of injection water.

Total Dissolved Solids concentrations in C-24 ranged from 520 mg/l to 1549 mg/l. The lowest value of 520 mg/l is assumed to be representative of uncontaminated surface water. The higher values reflect contamination of the canal by saline groundwater during drilling and aquifer testing. Dissolved iron concentrations in canal waters ranged from 0.41 to 0.44 mg/l. Sulfate

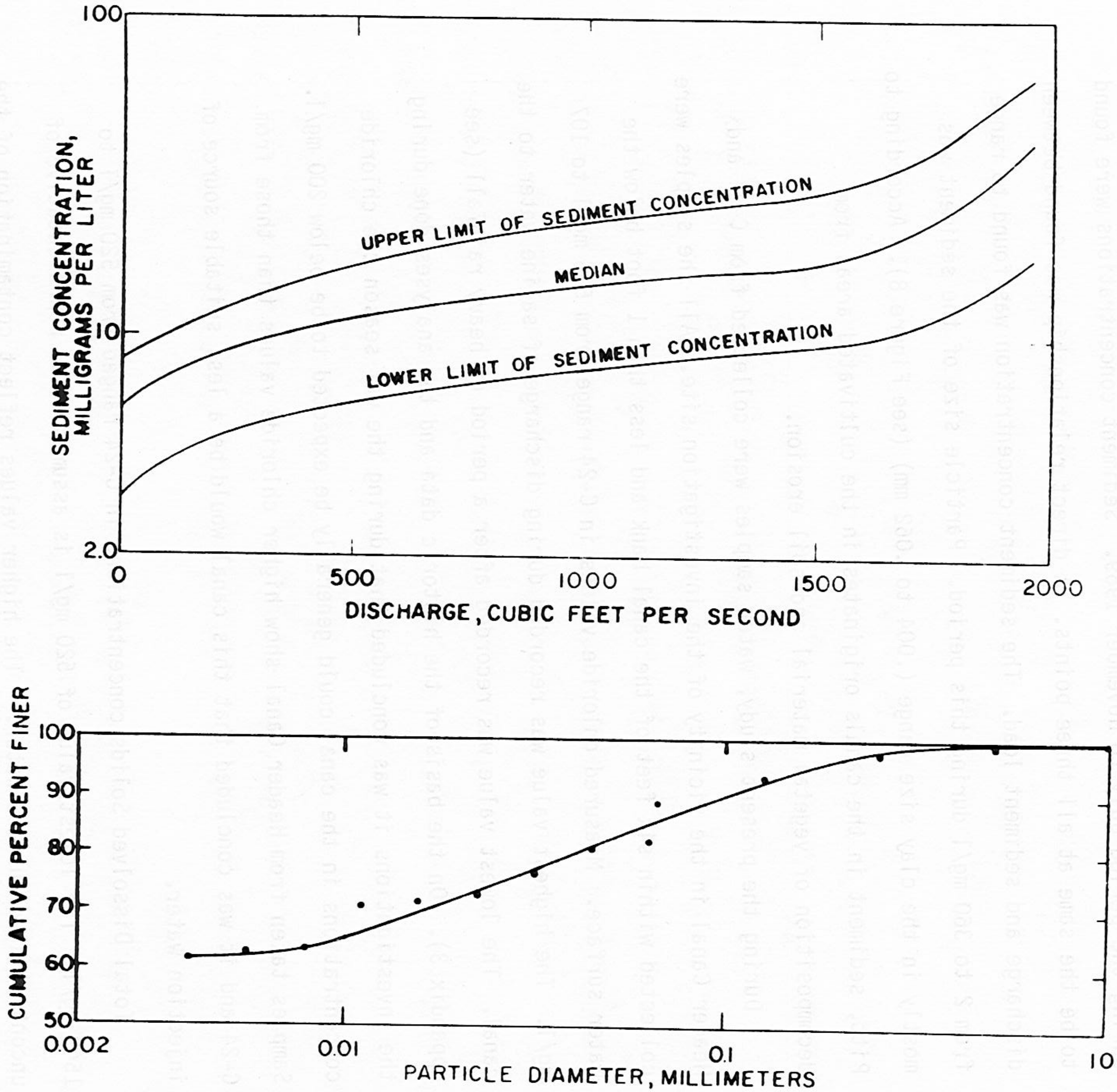


Figure 8 SEDIMENT CONCENTRATION AND PARTICLE SIZE, CANAL 24 AT S-49 (FROM PITT, 1972)

concentrations ranged from 42 to 179 mg/l. The higher sulfate values probably reflected contamination of the surface water by water from the Floridan Aquifer System.

In general, available water quality data indicate that water from C-24 was usable for recharge to the Floridan aquifer. However, water with chloride concentrations less than 250 mg/l would probably be available only during the late part of the year (September to December). Treatment of the surface water might prove to be advisable to mitigate problems with clogging. Since the required treatment would represent a significant part of the overall cost of the injection program, an alternate source of water was investigated.

SURFICIAL AQUIFER SYSTEM WATER QUALITY

A shallow well was drilled close to the canal in an attempt to induce infiltration from the canal and reduce suspended solids through the natural filtration by the strata. Examination of the lithologic data from the exploratory well showed that the surficial sediment consisted of a shallow, fine to coarse grained unconsolidated sand from land surface to 10 feet, a thin low permeability micritic limestone bed from 10 to 20 feet, a shell bed with micrite cement from 20 to 30 feet, and a well indurated calcareous sandstone between 30 and 50 feet. The sandstone showed well developed solution features and high moldic porosity, and was therefore assumed to have high permeability. This zone was targeted as a suitable source for withdrawing water for injection. The depth of the canal is about 20 feet (ten feet above the top of the sandstone), and it was therefore expected that some induced infiltration from the canal to the sandstone layer would occur.

The shallow well (SLS-1) was drilled to 55 feet and cased to 34 feet. The well was developed for two days, until the discharged water was sediment free, and tested at 800 gpm. Average chloride content of water from this well was 200 mg/l; average total dissolved solids content was 1000 mg/l; average total iron concentration was 5 mg/l; and average sulfate concentration was 200 mg/l.

FLORIDAN AQUIFER SYSTEM WATER QUALITY

As part of the exploratory program water samples were collected during drilling, logging, and pump testing. The sampling program was designed to identify variations in water quality between the producing zones in the aquifer system. However, because of the upward flow of water within the well bore, most of the sampling methods produced a mixture of waters from different zones.

Samples collected during reverse air drilling were expected to be most representative of water quality with depth. In this drilling technique air is injected into the hole during drilling and aquifer water and cuttings are discharged through the drill pipe. Water samples taken from this discharge are generally representative of water in the aquifer at the depth of penetration. Depth samples collected with a point sampler, on the other hand, were mixtures of waters from below the sampler, and except for samples taken near the bottom of the well, would not be representative of water quality in the aquifer at that depth. Samples taken during the aquifer tests consisted of a mixture of waters from all the zones penetrated by the well, with some water which may have leaked into the well from below due to the lowered hydraulic head during pumping.

Additional qualitative insight into the variations in water quality with depth was obtained from geophysical logs. Fluid Resistivity Logs run in the flowing well record the resistivity of the mixture of waters below the probe, and would not give an accurate indication of the resistivity of the water in the aquifer at a given depth except near the bottom of the hole. However, variations in the Fluid Resistivity Logs can generally be used to identify the approximate locations of zones of different water quality. This is also true of the 16 inch and 64 inch Normal Resistivity Logs if variations due to lithologic changes can be screened out or neglected.

All the sampling methods and the geophysical logs indicated non-uniformity in water quality with depth. The general picture shown is one of higher mineralization of the water in the upper part of the uncased borehole, a decrease in mineralization in the mid section and a slight increase in mineralization toward the base of the borehole. The most significant variations are found in temperature and chloride content. The chloride content variations are reflected in variations in conductivity and total dissolved solids. Temperature variations as shown on the Temperature Log (Appendix 2) were generally small (less than $3^{o}F$), although variations in water temperature between different producing zones were of sufficient magnitude to be used to identify these zones.

Water quality parameters for each producing zone could not be uniquely determined from any one set of samples due to inevitable mixture of waters during sampling. Based on samples taken during the first two pumping tests with the exploratory well at depths of 627 and 747 feet, it is assumed that the upper two producing zones have similar water quality. Chloride values from these tests varied between 974 and 1048 mg/l and total dissolved solids concentrations varied from 1791 to 2167 mg/l (see Appendix 3). Water quality from producing zone 6 can be determined from point sample values since the upward flow of water would prevent mixture with water above the sampler. Point sample values at depths of 950 and 995 feet give chloride concentrations of 898 and 882 mg/l, respectively, and total dissolved solids concentrations of 2220 and 2200 mg/l, respectively.

Based on the Fluid Resistivity Log (Figure 9), zones 4 and 5 would be expected to have relatively good quality water as shown by pronounced increases in resistivity adjacent to these zones. Similarly, producing zone 3

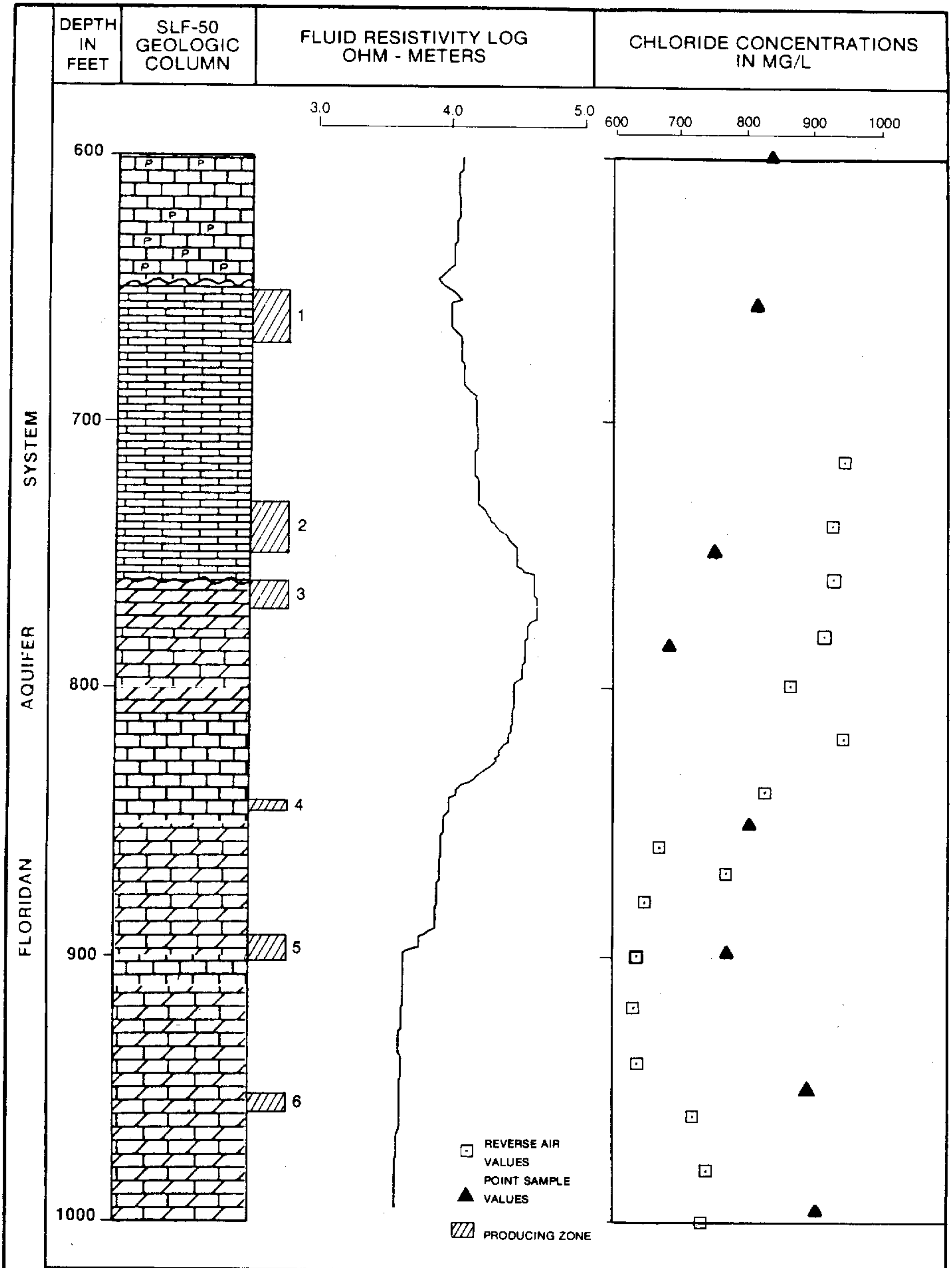


Figure 9 PRODUCING ZONES IN WELL SLF-50 AND WATER QUALITY PROFILES

appears to have relatively good quality water compared to zones 4 and 5 as evidenced by a further increase in fluid resistivity adjacent to this zone. Point sample values at depths between 750 feet and 900 feet, which includes producing zones 3, 4, and 5, indicate that chloride concentrations in these zones is below 800 mg/l.

Compared to water from C-24 and the shallow groundwater, water from the Floridan Aquifer System is high in calcium, sodium, chloride, magnesium, sulfate, and bicarbonate, but low in iron, phosphate, and nitrate. Chloride concentrations in the aquifer are typically more than four times as high as in available recharge water. The level of mineralization of the aquifer water is moderate, which will be a favorable factor in the recovery of injected water. Differences in water quality with depth are relatively small and are not expected to greatly influence recovery efficiency.

FLORIDAN AQUIFER SYSTEM WATER LEVELS

Three factors related to water levels in the aquifer are of importance in cyclic injection and recovery. These are: a) horizontal groundwater gradient, b) vertical groundwater gradient, and c) potentiometric head at the injection well. The horizontal groundwater gradient determines the rate and direction of groundwater flow, assuming aquifer homogeneity and isotropy. During cyclic injection, a steep groundwater gradient can move the slug of injected water down-gradient, thus reducing the amount of water which can be recovered from this well. The vertical groundwater gradient determines the potential direction of leakance between permeable strata. The potentiometric head at the injection well partly determines the wellhead pressure required to inject water into the well. Wellhead pressure is also a function of well construction (head loss due to casing and open hole diameter and roughness), aquifer transmissivity, fluid viscosity, and well losses due to plugging of the aquifer adjacent to the open borehole.

The regional horizontal groundwater gradient in the vicinity of the test site is approximately of 0.5 foot per mile in a northeasterly direction. Table 3 shows potentiometric heads in wells SLF-50, SLF-51, and SLF-49 for May and September 1982. The measurements indicate that the pressure head above the wellhead at SLF-50 averages about 9.70 feet of water (4.21 psi).

TABLE 3. POTENTIOMETRIC HEADS AT INJECTION SITE

WELL NO.	DEPTH (FT)	WELLHEAD ELEVATION FT NGVD	POTENTIOMETRIC LEVEL, FT NGVD 5/20/82	9/22/82
SLF-49	893	25.09	41.04	43.76
SLF-50	775	31.75	40.47	42.44
SLF-51	775	26.56	40.18	-

The difference between potentiometric levels in May (dry season) and September (wet season) was 1.97 feet at this well. Data obtained during the packer test indicated that the zone between 775 feet and 1000 feet had a potentiometric head +0.24 feet higher than the zone between 600 feet and 775 feet.

Figure 10 shows potentiometric level variations at well SLF-50 during the period July 20 to August 20. The hydrograph indicates both short-term and longer-term cyclic variations in water levels due to barometric and tidal effects. These variations could introduce small inaccuracies in head measurements during pumping tests, but would have negligible effect on the injection/recovery process.

HYDROGEOLOGIC MODEL OF THE INJECTION ZONE

A preliminary conceptual model of the injection zone was developed to serve as a basis for computer simulation of the injection/recovery process in the aquifer. The model is based on data developed during exploratory work and incorporates the variations in hydrogeologic properties and water quality previously discussed. The model is illustrated in Table 4.

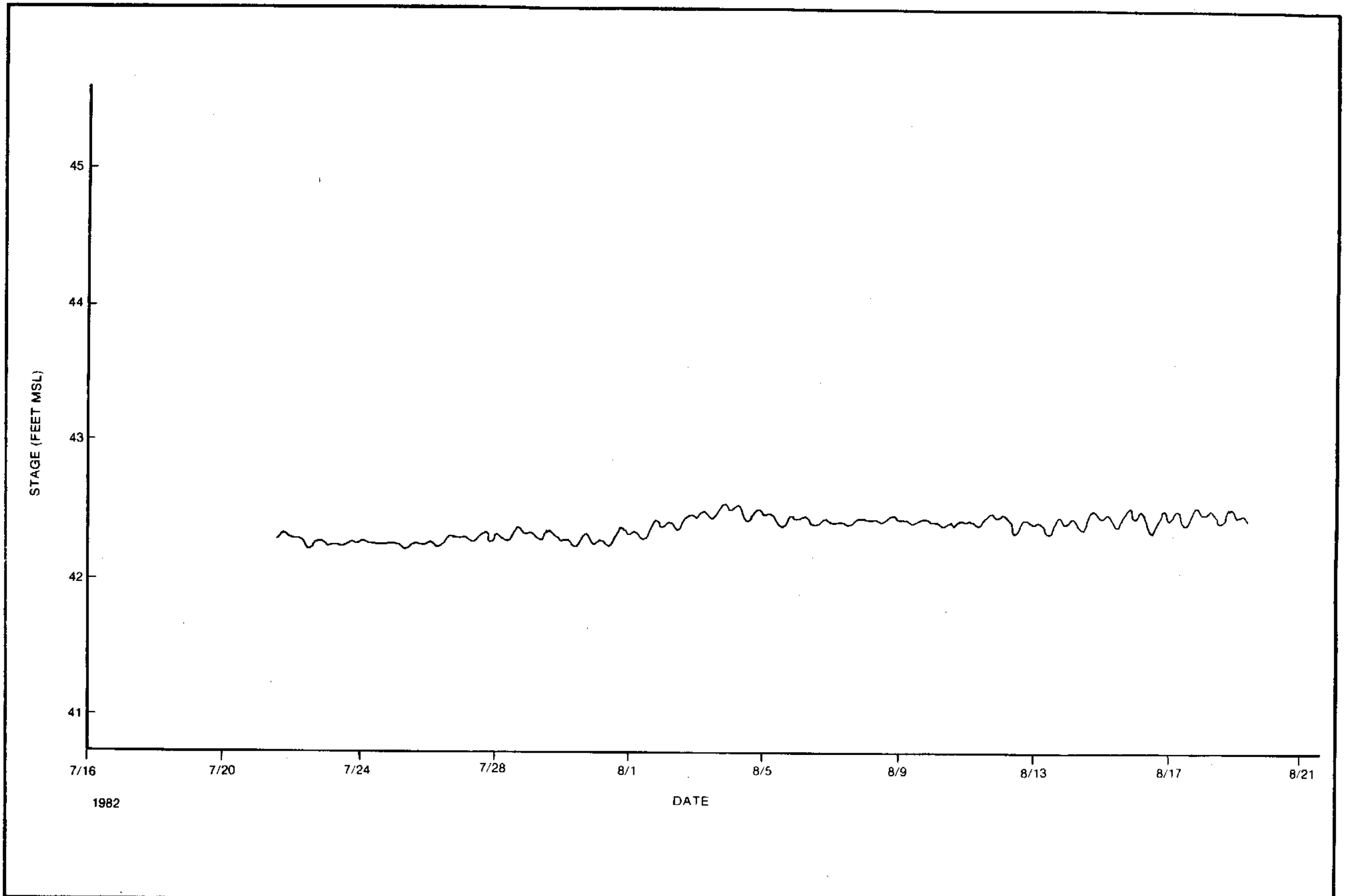


Figure 10 HYDROGRAPH OF WELL SLF 50 - JULY 20 TO AUGUST 20, 1982

TABLE 4. PRELIMINARY CONCEPTUAL MODEL OF INJECTION HORIZON

LAYER NO.	DEPTH (ft)	DESCRIPTION	K_H (ft/d)	K_V (ft/d)	M (ft)	Cl mg/l	TDS mg/l
-	130-600	Non leaky upper confining bed overlying injection horizon					
1	600-650	Low permeability zone in the injection horizon	3.15	3.15	50	1025	2050
2	650-670	High permeability zone in the injection horizon (Prod. Zone 1)	103.45	103.45	2	~950	1900
3	670-730	Low permeability zone in the injection horizon	3.15	3.15	60	~950	1900
4	730-750	High permeability zone in the injection horizon (Prod. Zone 2)	142.73	142.73	20	~955	1900
5	750-760	Low permeability zone in the injection horizon	3.15	3.15	10	~950	1900
6	760-770	High permeability zone in the injection horizon (Prod. Zone 3)	71.36	71.36	10	750	1500
-	770-840	Low permeability semi confining zone beneath the injection horizon	3.15	3.15	70	800-950	1600-1900

The injection horizon extends from a depth of 600 feet to a depth of 770 feet. It is bounded above by an essentially non-leaky confining bed, and below by a leaky confining bed with a coefficient of leakance of .045 day^{-1}. The basal confining bed is 70 feet thick, thus the vertical permeability of this bed is 3.15 ft/day. This value corresponds closely to average values of permeabilities typical of fine-grained limestones (Bouwer, 1978).

The injection horizon consists of three layers of relatively high permeability (producing zones) and 3 layers of low permeability. The high permeability layers correspond to the producing zones identified on Figure 9. The upper two producing zones are each 20 feet thick (650 to 670 feet and 730 to 750 feet) while the lowermost producing zone is 10 feet thick (750 to 760 feet). Relative permeabilities of the producing zones were calculated based on the following assumptions.

1) The intervening low permeability zones have uniform permeability of 3.15 ft/day.
2) The relative permeabilities of the producing zones correspond to their relative flow contributions to the borehole.

The transmissivity of the low permeability beds to the average transmissivity of the injection horizon can be calculated using the equation.

$$T_L = K_L M_L = 3.15 \times 120 = 378 \text{ ft}^2/\text{d}$$

Where,

T_L = Average transmissivity of low permeability beds.

K_L = Permeability of low permeability beds (3.15 ft/d).

M_L = Total thickness of low permeability beds (120 ft).

Consequently the contribution of the producing zones to the transmissivity of the horizon is:

$$T_P = T - T_L = 6016 - 378 = 5638 \text{ ft}^2/\text{d}.$$

Where,

T_P = Transmissivity of producing zones.

Similarly, the permeabilities of the individual producing zones can be calculated as follows:

$$K_{P1} = \frac{T_H}{M_{P1}} X \frac{Q_{H1}}{Q_T} = \frac{5638}{20} X \frac{29}{79} = 103.45 \text{ ft/d}$$

$$K_{P2} = \frac{T_H}{M_{P2}} X \frac{Q_{H2}}{Q_T} = \frac{5638}{20} X \frac{40}{79} = 142.73 \text{ ft/d}$$

$$K_{P3} = \frac{T_H}{M_{P3}} X \frac{Q_{H3}}{Q_T} = \frac{5638}{10} X \frac{10}{79} = 71.36 \text{ ft/d}$$

Where,

K_{P1}, K_{P2}, K_{P3} = Permeabilities of producing zones 1, 2, and 3.

T_P = Transmissivity of producing zones (5638 ft^2/d).

M_{P1}, M_{P2}, M_{P3}, = Thicknesses of producing zones 1, 2, and 3 (20 ft, 20 ft and 10 ft, respectively).

Q_{P1}, Q_{P2}, Q_{P3} = Percent contribution to flow of producing zones 1, 2, and 3 (29%, 40%, and 10%, respectively).

Q_T = Total percent contribution of producing zones (79%).

For the purpose of this model it is assumed that within each zone, vertical and horizontal permeability values are the same. This assumption is based on the observed essentially isotropic distribution of porosity within these zones.

Water quality parameter values were assigned to the various layers as follows. The first low permeability zone within the injection horizon was assumed to have relatively high mineralization as indicated by water samples taken during the first pumping test (well depth 647 feet) (Chlorides approximately 1025 mg/l, TDS approximately 2050 mg/l). The upper two producing zones and the intervening low permeability zones were assumed to have similar water quality and to be somewhat less mineralized. Based on reverse air samples taken at depths of 715 feet and 740 feet, the chloride concentration in these layers averaged about 900 to 950 mg/l and total dissolved solids averaged 1800 to 1950 mg/l. The lowermost producing zone and the semi-confining bed below the injection horizon was assumed to have an average chloride concentration of 700 to 800 mg/l and a total dissolved solids concentration of 1600 to 1750 mg/l, based on values from point samples.

Potentiometric surface elevation at the exploratory well was measured on September 22 as 42.44 feet NGVD. Land elevation was measured as 31.13 feet NGVD, giving a head above land surface of 11.31 feet (4.90 psi wellhead pressure). The regional groundwater gradient estimated from potentiometric maps by Brown and Reece (1979) was 0.5 foot per mile in a northeast direction.

No estimates of parameters governing dispersive mixing were obtainable from the exploratory work. Estimates of longitudinal and transverse dispersivity from tracer tests and model studies for various materials are summarized by Mercer et al. (1982). They showed measured values of longitudinal and dispersivity in carbonate rocks as ranging from 1.0 meters for an intact chalk aquifer to 38.1 meters for fractured dolomite, with an average value for carbonate rocks of 13.7 meters. Segol and Pinder (1976) estimated longitudinal and transverse dispersivities for the limestones in southeast Florida as 6.7 and 0.7 meters, respectively. On this basis a preliminary estimate of longitudinal transmissivity for the injection horizon was assumed to be in the range of 6 to 15 meters. Transverse dispersivity was assumed to be in the order of 1 meter, based on the estimate by Segol and Pinder. Dispersivity, along with flow anisotropy affect the recoverability of injected water. In aquifers with fracture or solution porosity, such as is usually found in the limestone aquifers of the Floridan Aquifer System, mathematical formulations for recovery efficiency may inadequately represent the natural flow system resulting in significant differences between field results and theoretical estimates of recoverability (Merritt, 1982).

INJECTION/RECOVERY TEST

A short-term injection/recovery test was performed at the exploratory well (SLF-50) to evaluate problems associated with the technique and provide preliminary data for comparison with theoretical results. The test consisted of injecting approximately 1.5 million gallons of water into the exploratory well, and recovering this water by natural backflow after a residence period of 30 days. Data from this test are summarized in Appendix 6. Figures 11 and 12 illustrate data relevant to the injection phase. The data indicate a steady decline in injection capacity with time (Figure 12). It should be noted that the pumping rate was adjusted to maintain injection pressures below approximately 40 psi. The well was backflowed after 3392 minutes for approximately 30 minutes, and backflowed and surged with the pump at 4320 minutes for 1 hour. On both occasions there was some improvement in injection capacity of the well. Water extracted during backflowing and surging was murky with a reddish precipitate. Chemical analyses showed high total iron content in a sample taken from the backflow (39.42 mg/l total iron), indicating that iron precipitation may be a factor in plugging of the well.

Figure 12 also shows variations in potentiometric levels in monitor wells SLF-49 and SLF-51. Very little response was noted in well SLF-49 which is located 420 feet northwest of the injection well. Well SLF-51, which is located 148 feet northeast of the injection well, showed potentiometric head variations consistent with plugging of the injection well. In spite of increased injection pressures needed to force water into the injection horizon, water levels in monitor well SLF-51 showed a consistent decline. This was due to the reduction in the volume of water which entered the aquifer and, consequently, the lower pressures developed in the aquifer away from the injection well.

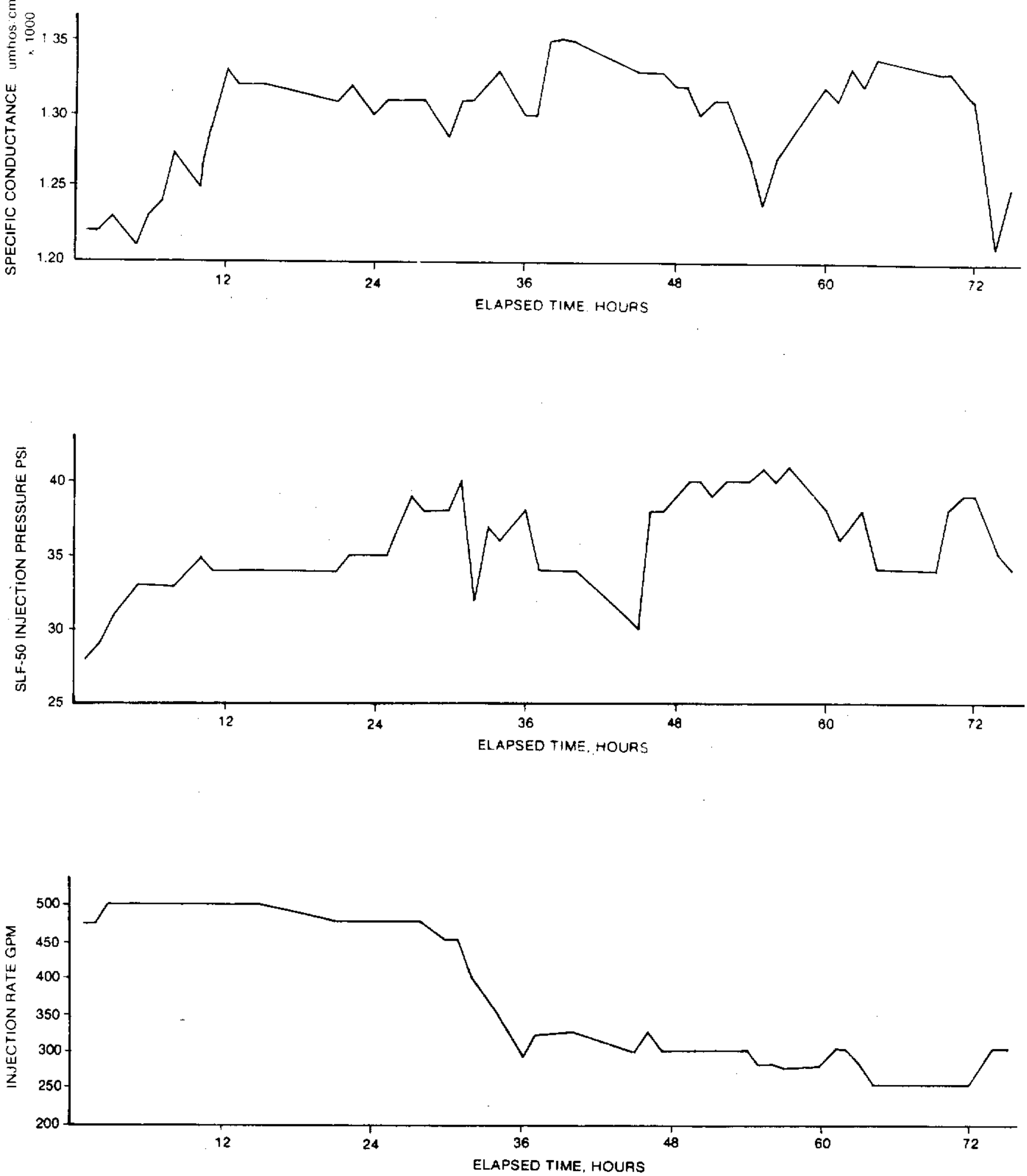


Figure 11 VARIATIONS IN INJECTION RATE, INJECTION PRESSURE AND SPECIFIC CONDUCTANCE DURING INJECTION TEST

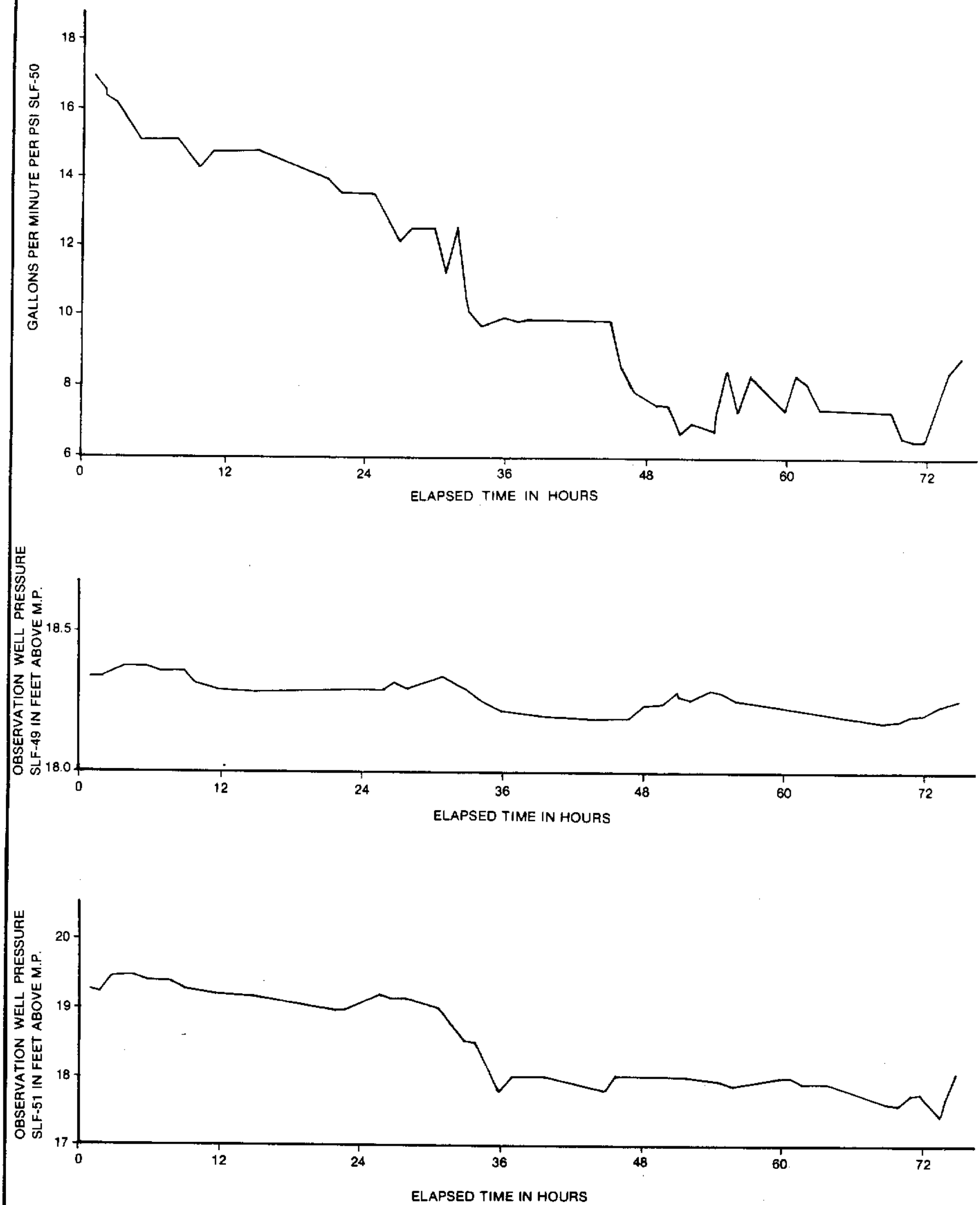


Figure 12 VARIATIONS IN INJECTION CAPACITY AND POTENTIOMETRIC HEADS DURING INJECTION TEST

Injection was terminated after 4500 minutes. Recovery began 30 days after the end of injection. Recovery was carried out over a period of six weeks at rates varying from 140 to 250 gpm. Chloride concentrations and specific conductance and temperature were measured at frequent intervals in the field during recovery. Variations in these parameters as a function of volume of water recovered are shown on Figures 13, 14, and 15. Chloride concentrations showed good correlation with specific conductance values as shown on Figure 15. In general the recovery data showed a gradual increase in mineralization in the water as recovery progressed.

Figures 17 to 27 show plots of the variations in selected water quality parameters measured in the laboratory. The majority of chemical parameters show a gradual increase as recovery progressed, reflecting the higher percentage of more mineralized native water in the recovered water. Calcium and alkalinity concentrations, however, declined as recovery progressed. Sulphate concentrations remained relatively stable during the initial part of the test, but showed a sudden decrease after a break of 1 month in the recovery cycle when sulphate concentrations fell below the levels in both the injected water and native water. Assuming that this apparent reduction was not due to sampling or analytical error, a possible explanation could be conversion of sulphates to sulphides by bacterial activity and the release of hydrogen sulphide from the samples.

Total iron concentrations varied from 39.42 mg/l to less than 0.03 mg/l during recovery (see Appendix 3). The highest concentration was found during initial backflowing of the injection well at the end of the injection cycle. This sample was reddish in color and contained a reddish gelatinous precipitate. After approximately 14 minutes of backflow the reddish coloration and precipitate were no longer apparent. Other anomalously high values of total iron were found, mainly in samples taken after breaks in the

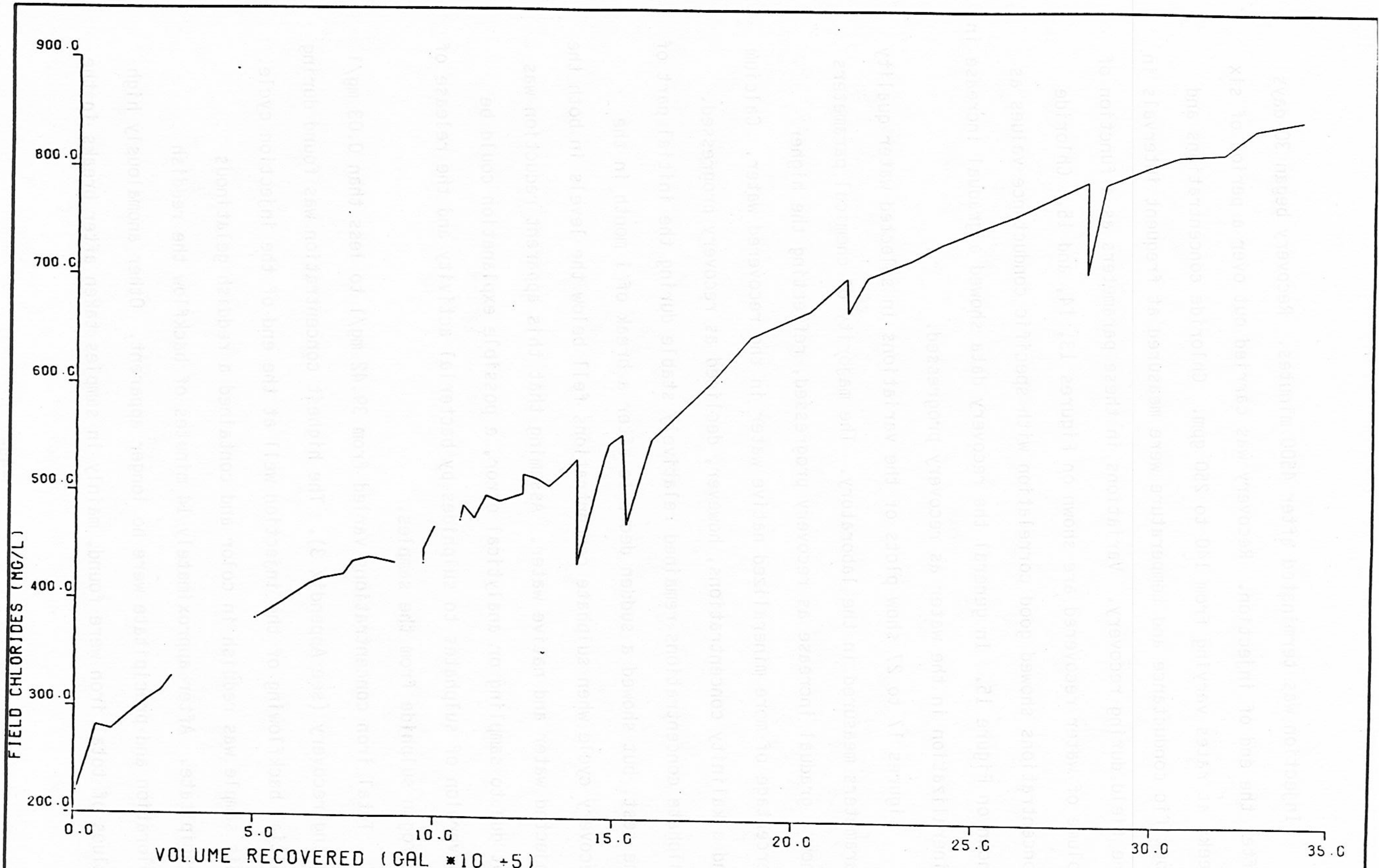


Figure 13 VARIATIONS IN CHLORIDE (FIELD VALUES) WITH VOLUME OF WATER RECOVERED

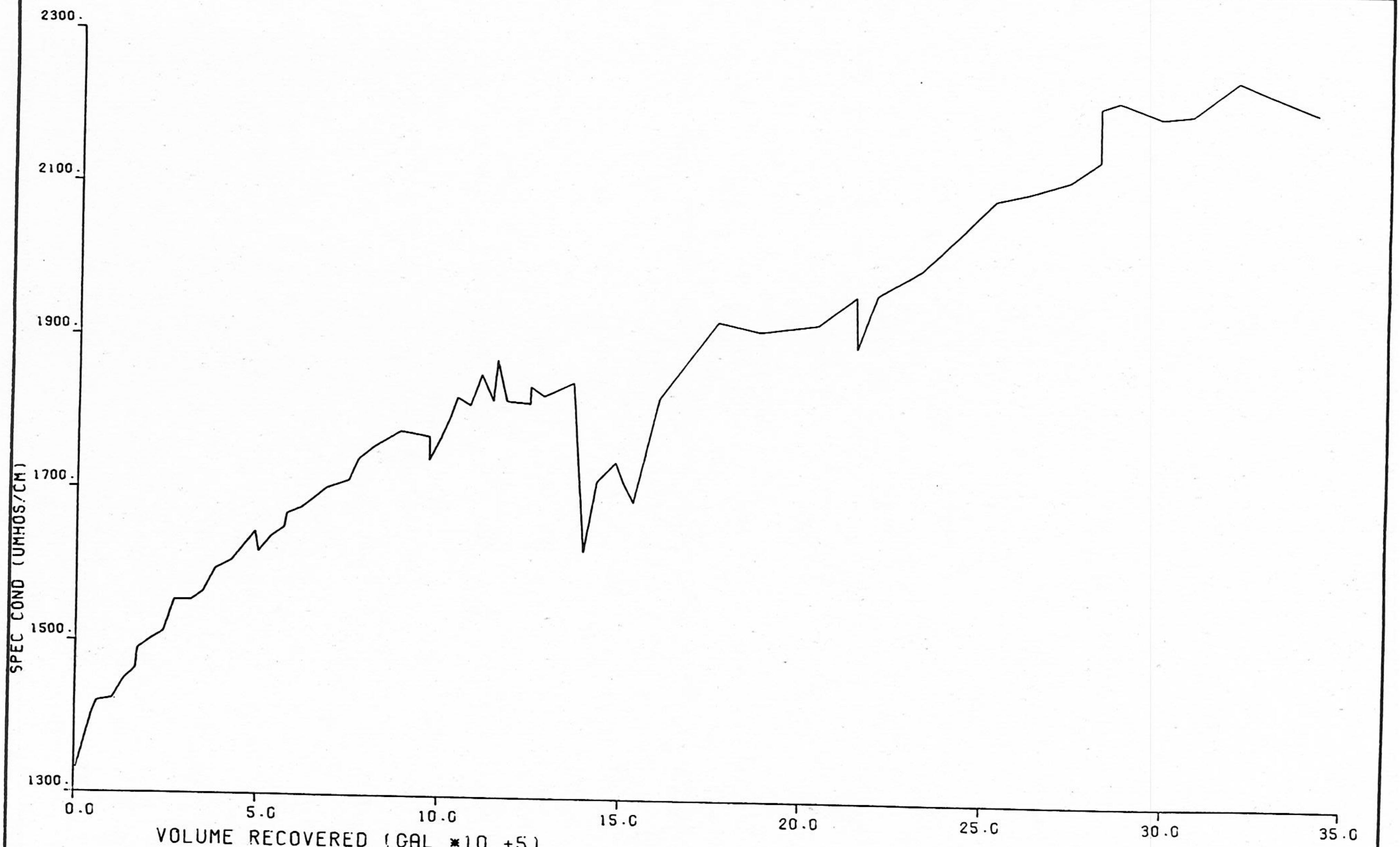


Figure 14 VARIATIONS IN SPECIFIC CONDUCTANCE (FIELD VALUES) WITH VOLUME OF WATER RECOVERED

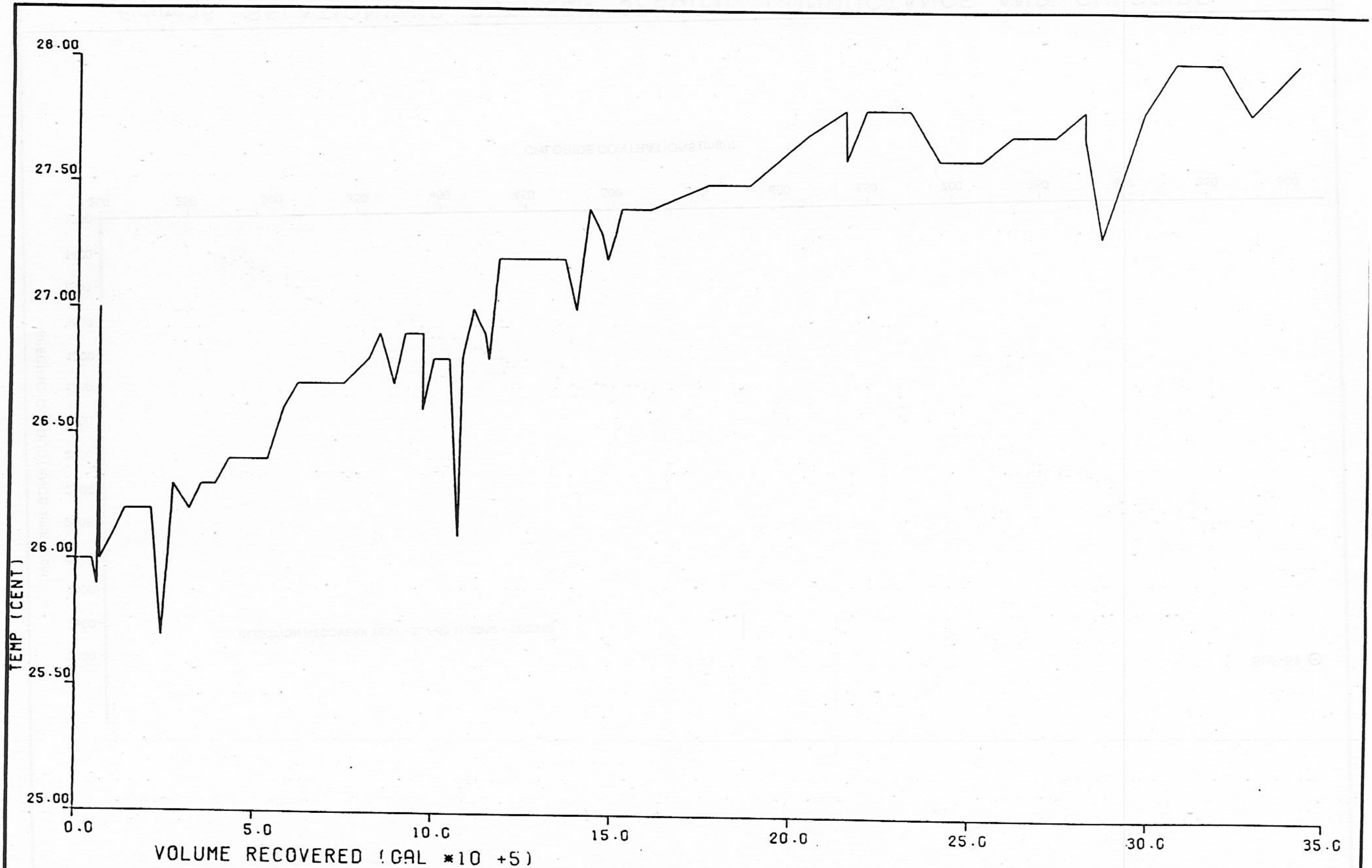


Figure 15 VARIATIONS IN TEMPERATURE (FIELD VALUES) WITH VOLUME OF WATER RECOVERED

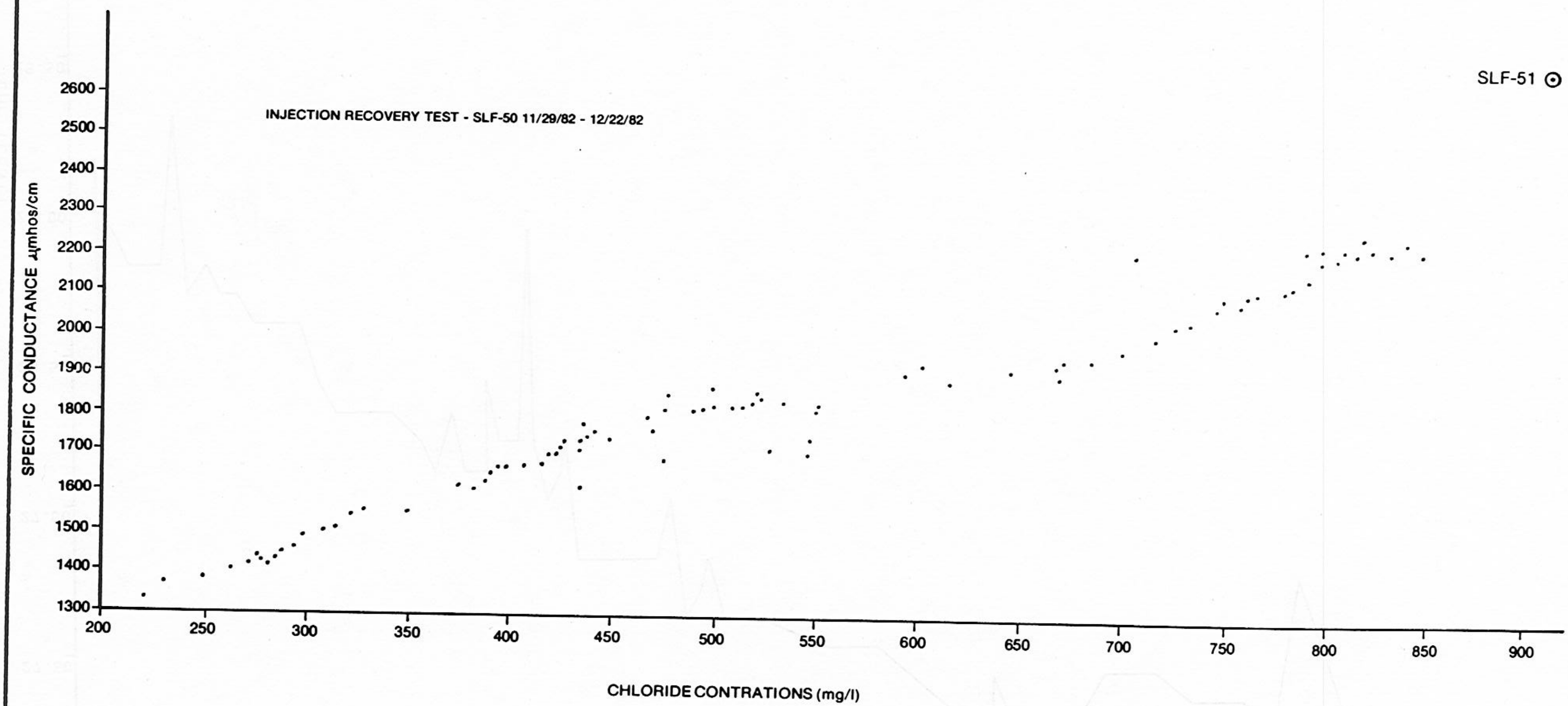


Figure 16 RELATIONSHIP BETWEEN SPECIFIC CONDUCTANCE AND CHLORIDE CONCENTRATIONS IN RECOVERED WATER (FIELD VALUES)

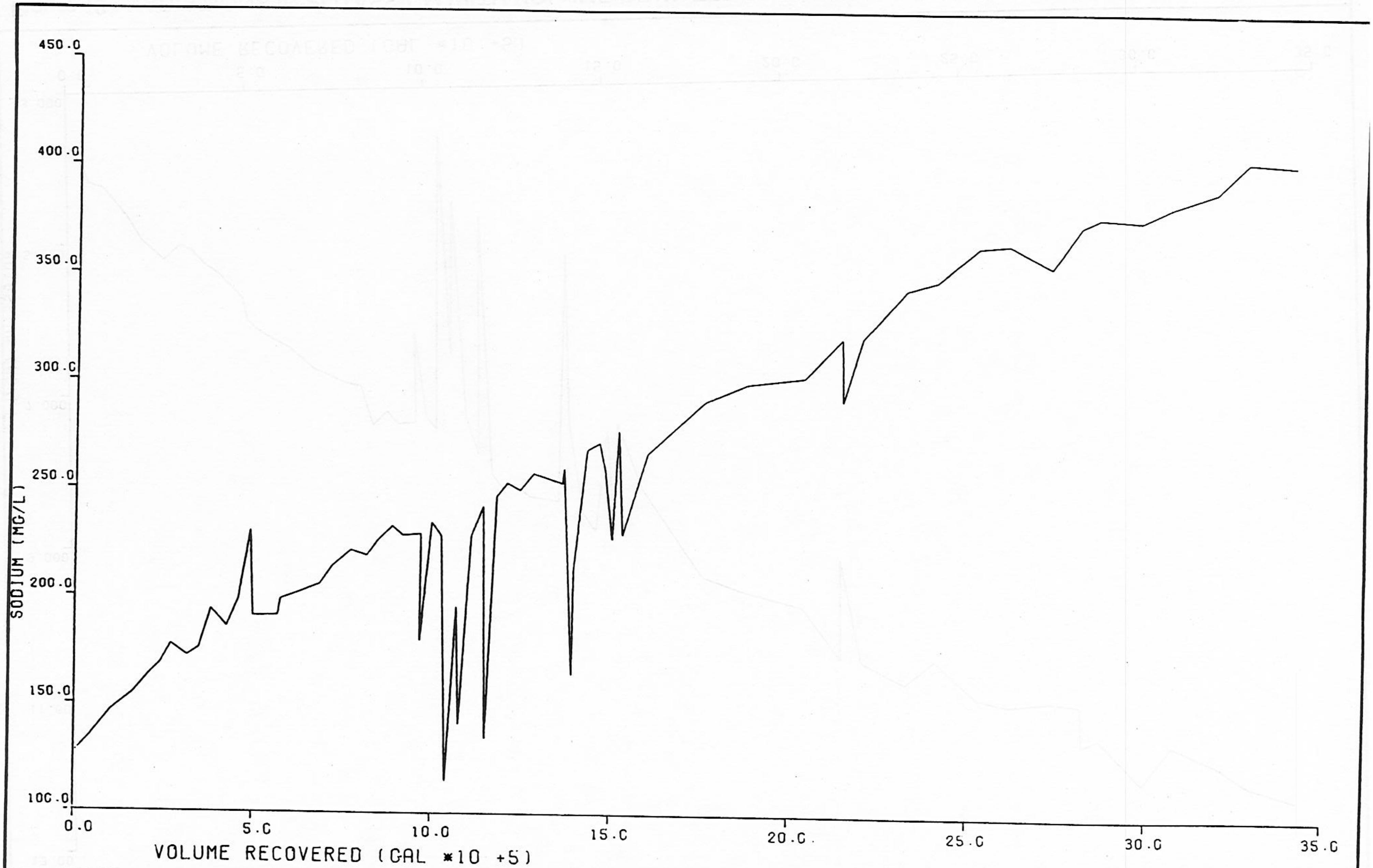


Figure 17 VARIATIONS IN SODIUM WITH VOLUME OF WATER RECOVERED

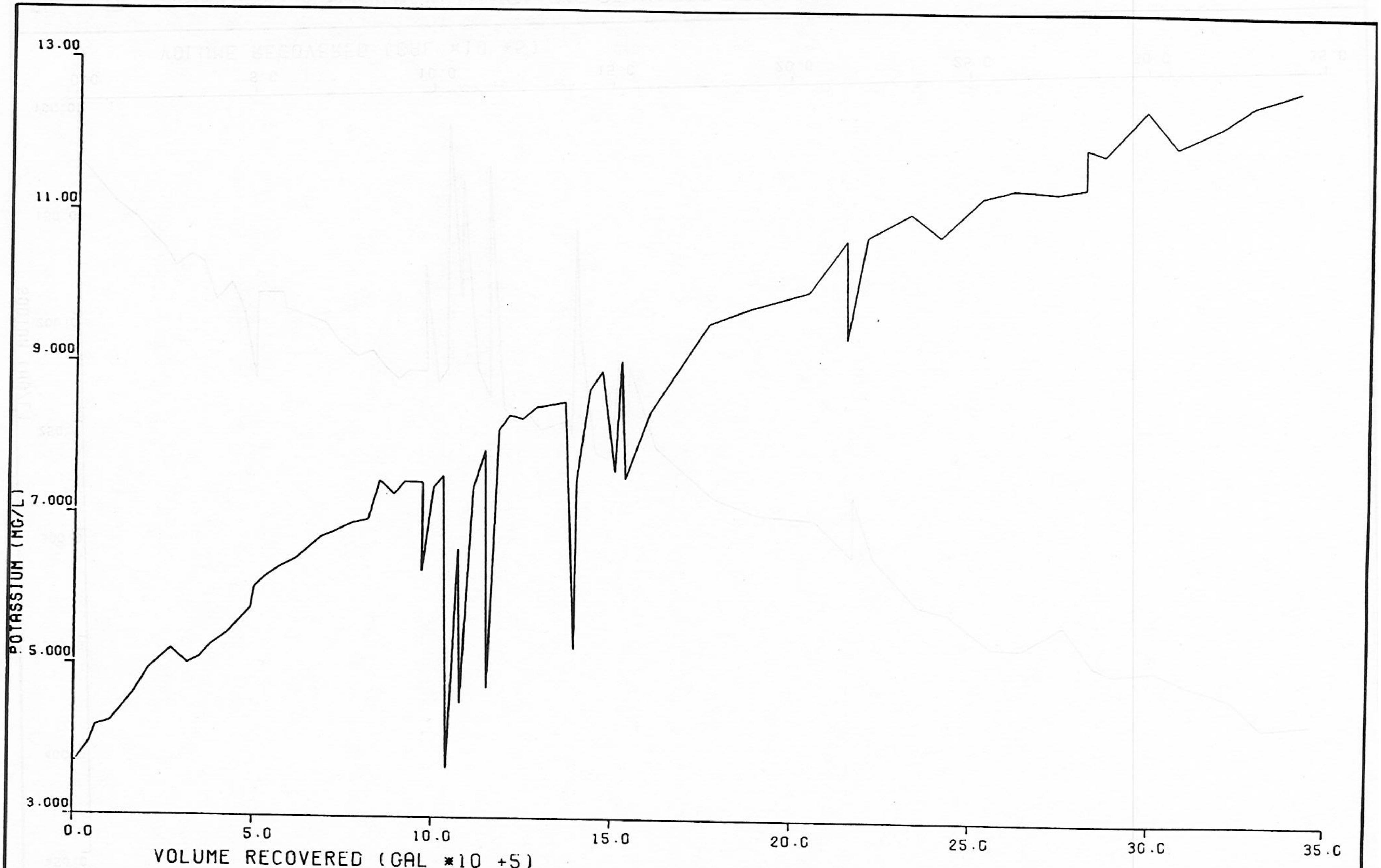


Figure 18 VARIATIONS IN POTASSIUM WITH VOLUME OF WATER RECOVERED

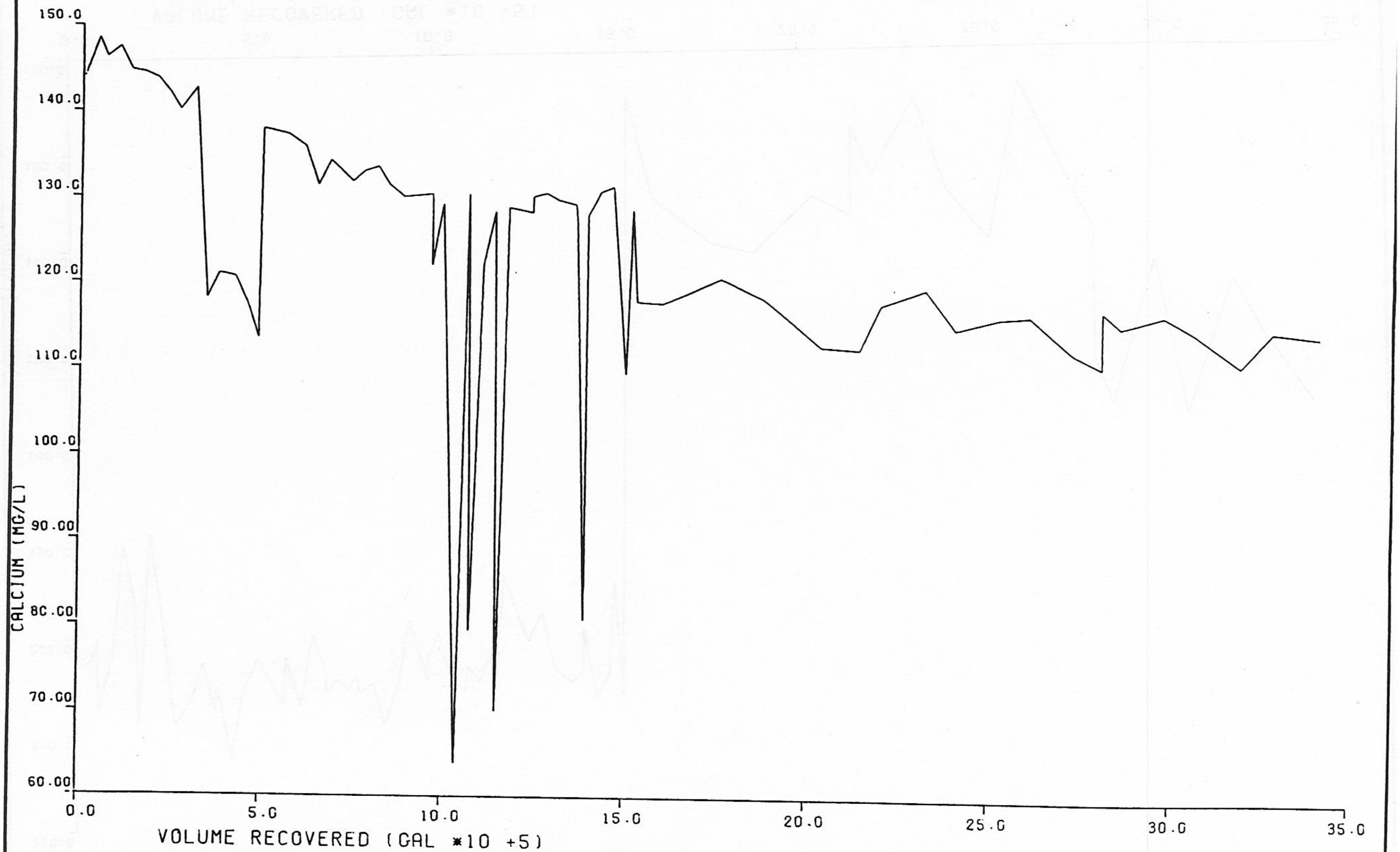


Figure 19 VARIATIONS IN CALCIUM WITH VOLUME OF WATER RECOVERED

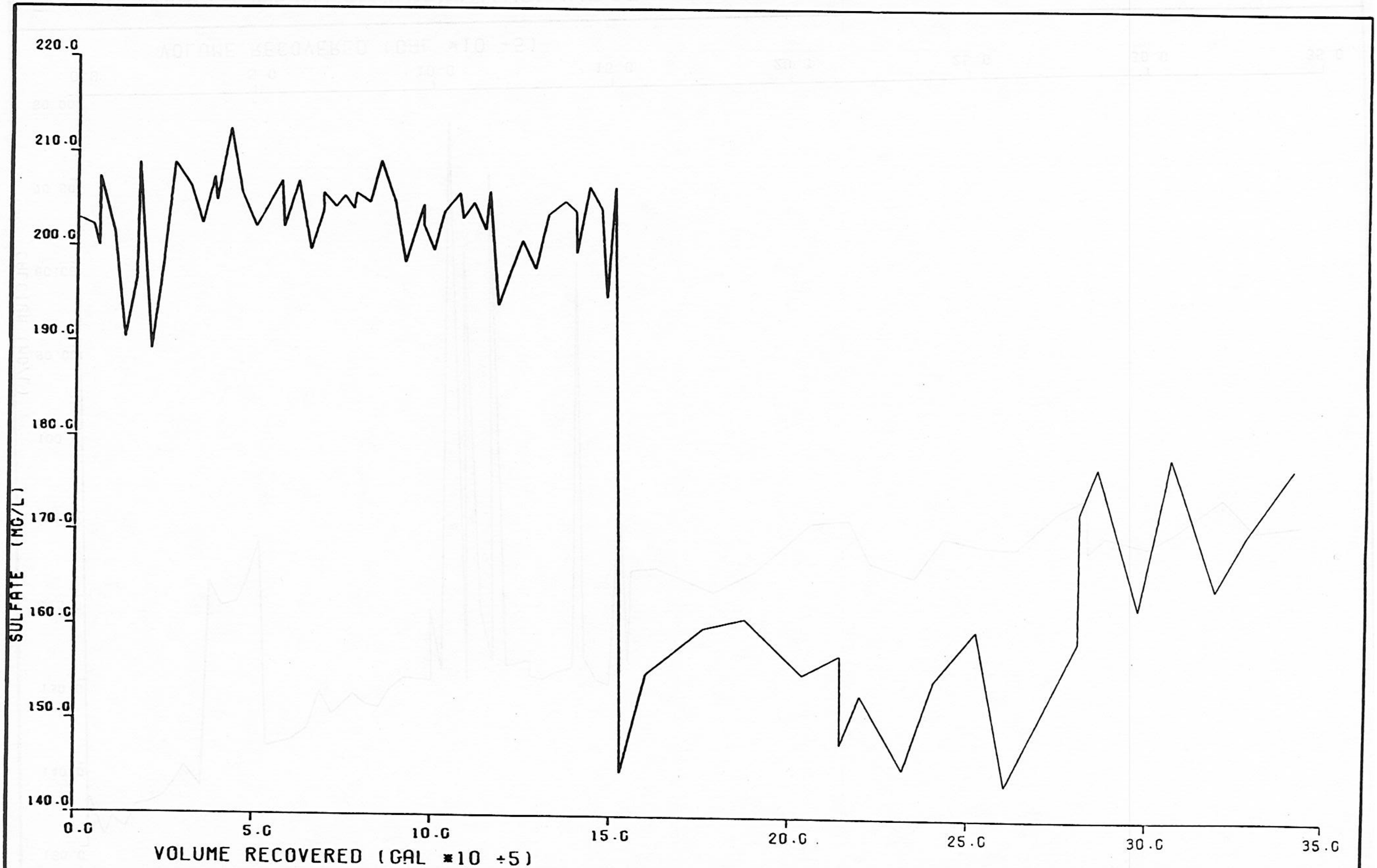


Figure 20 VARIATIONS IN SULFATE WITH VOLUME OF WATER RECOVERED

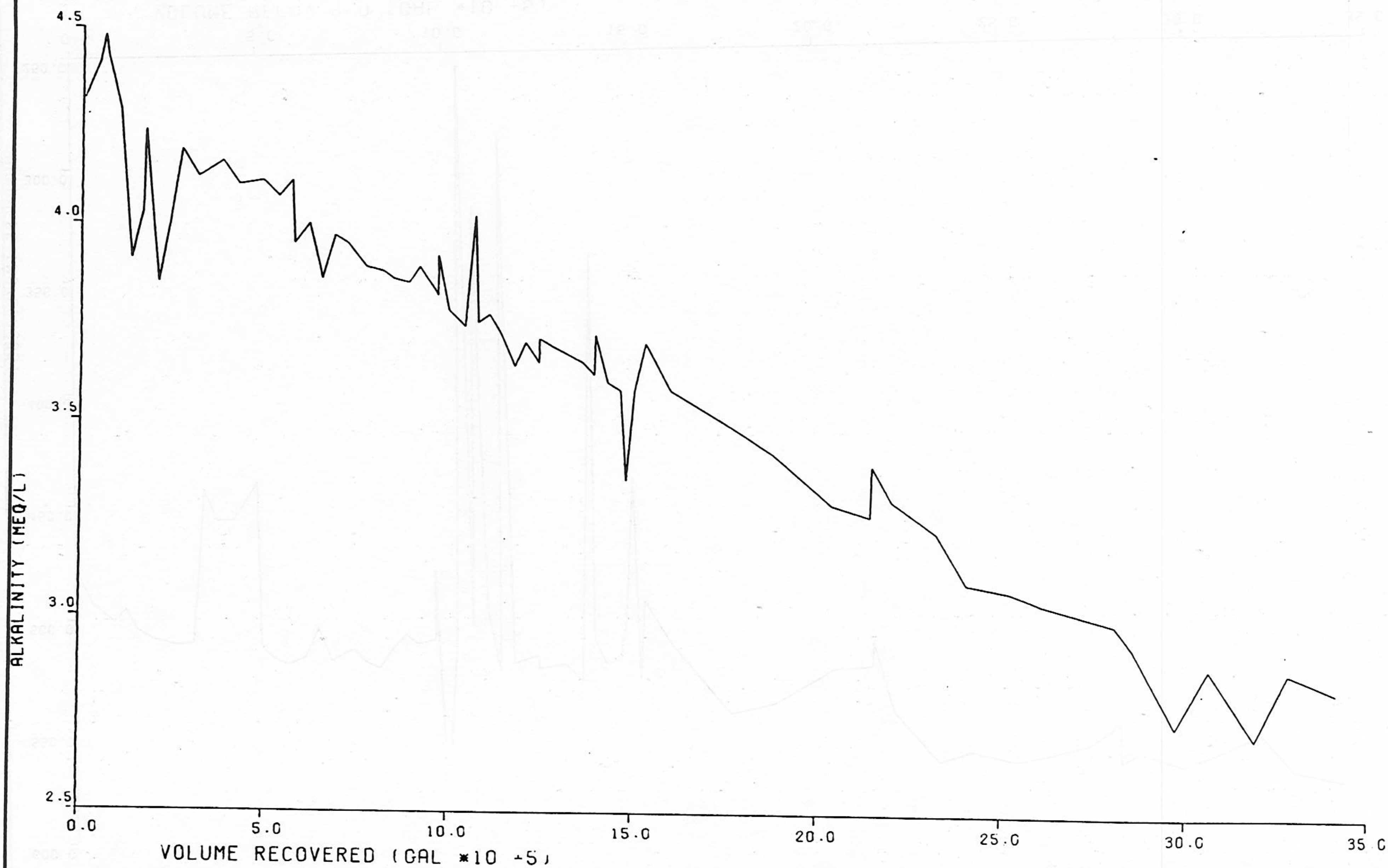


Figure 21 VARIATIONS IN ALKALINITY WITH VOLUME OF WATER RECOVERED

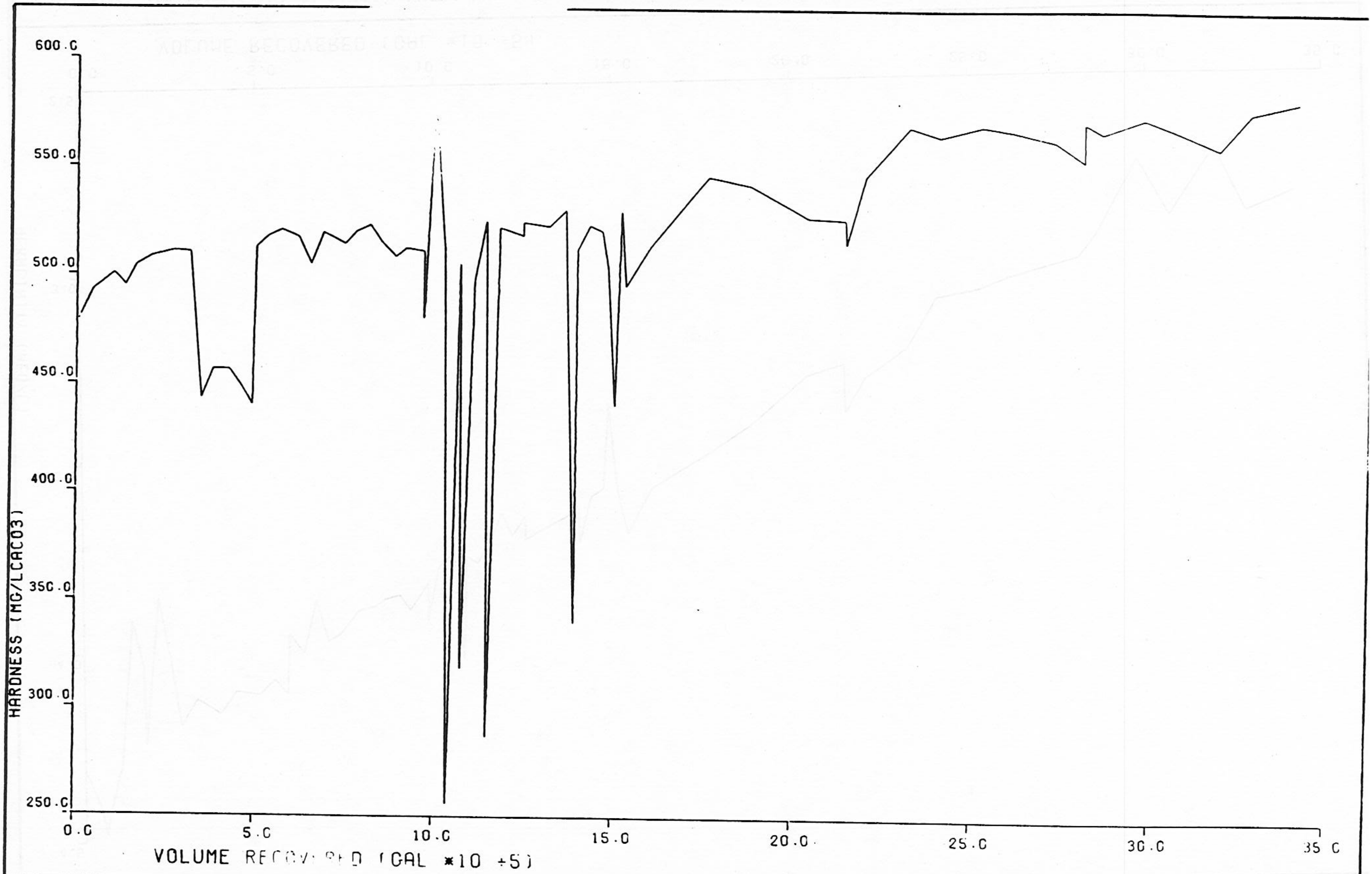


Figure 22 VARIATIONS IN HARDNESS WITH VOLUME OF WATER RECOVERED

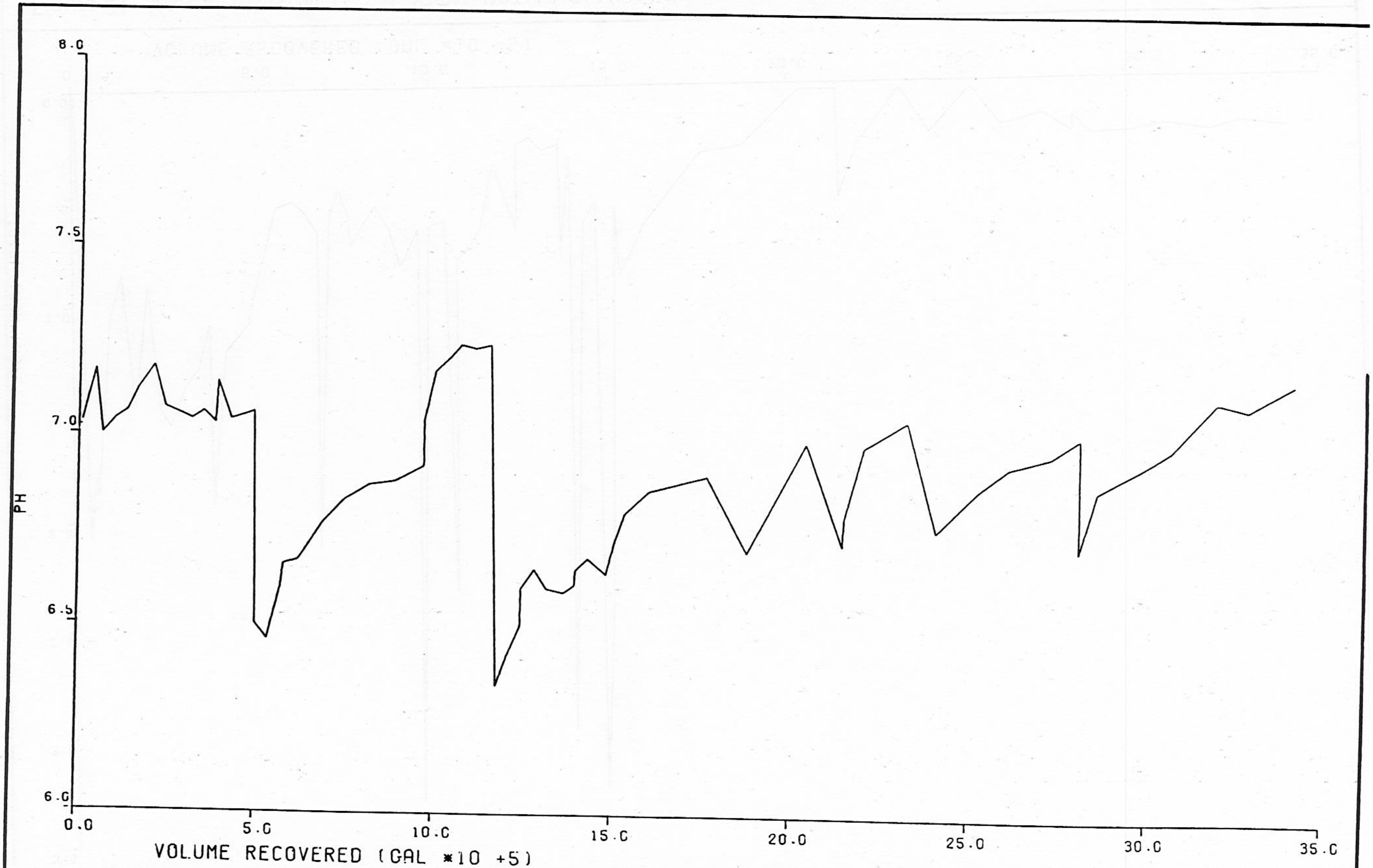


Figure 23 VARIATIONS IN PH WITH VOLUME OF WATER RECOVERED

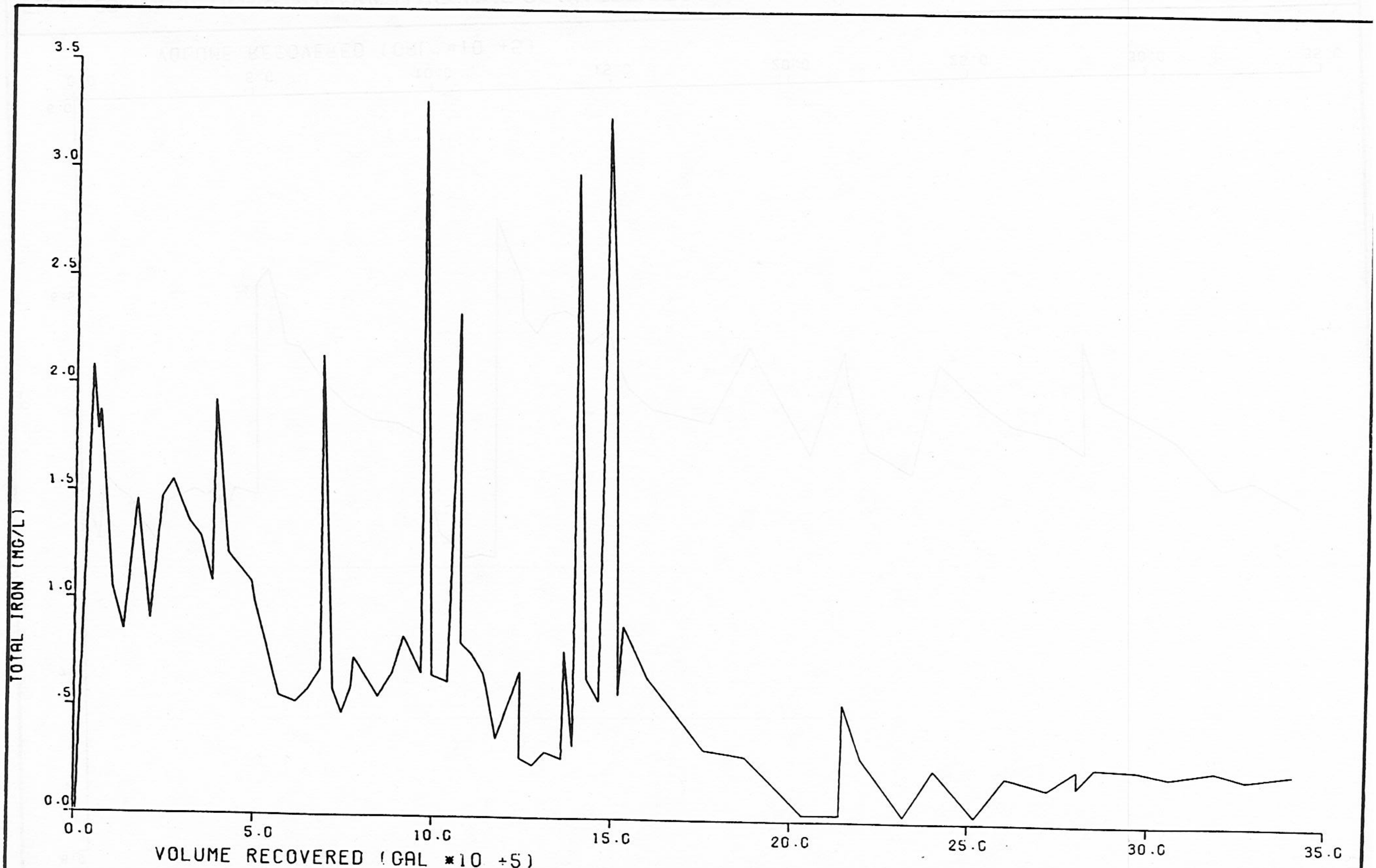


Figure 24 VARIATIONS IN TOTAL IRON WITH VOLUME OF WATER RECOVERED

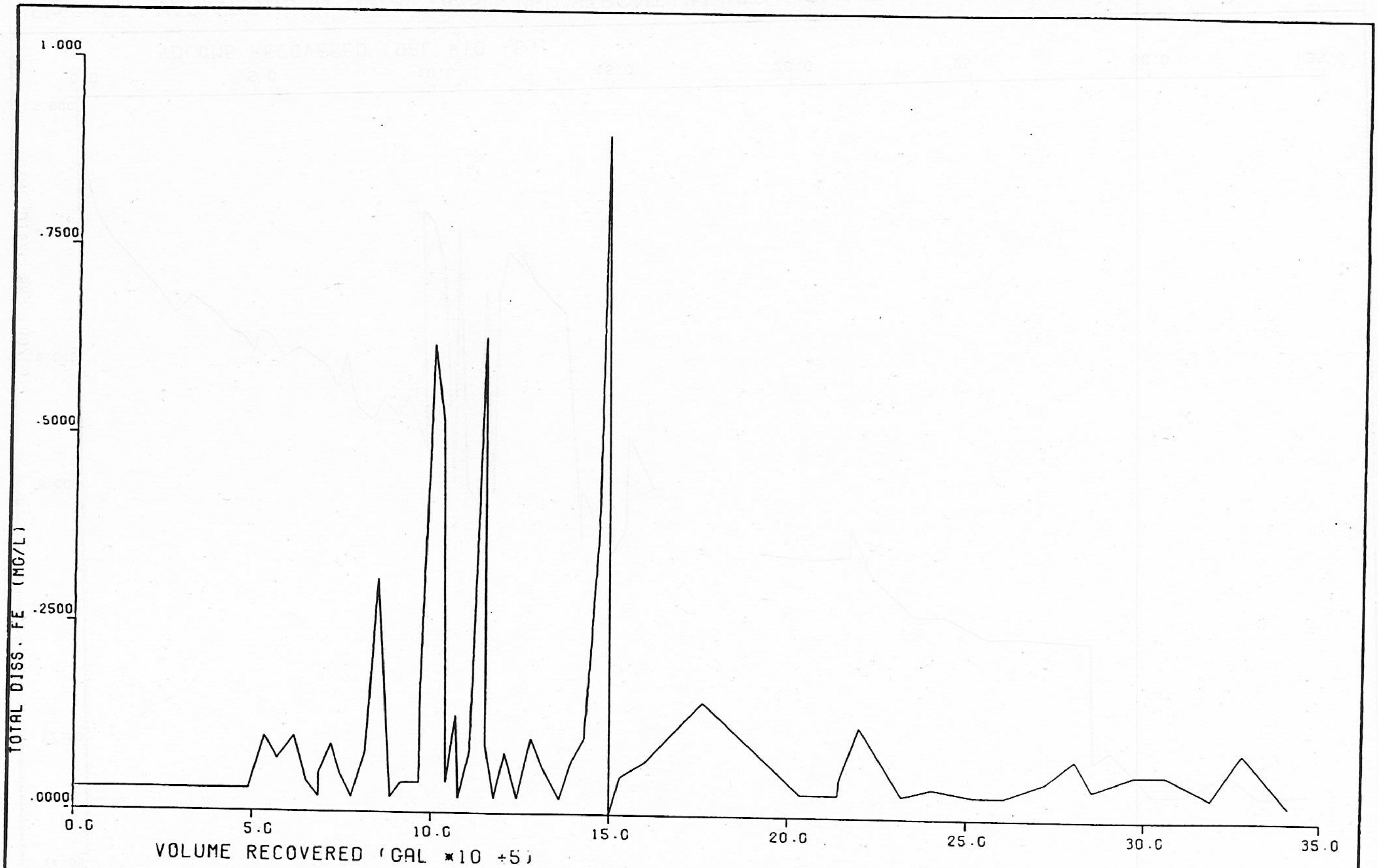


Figure 25 VARIATIONS IN TOTAL DISSOLVED IRON WITH VOLUME OF WATER RECOVERED

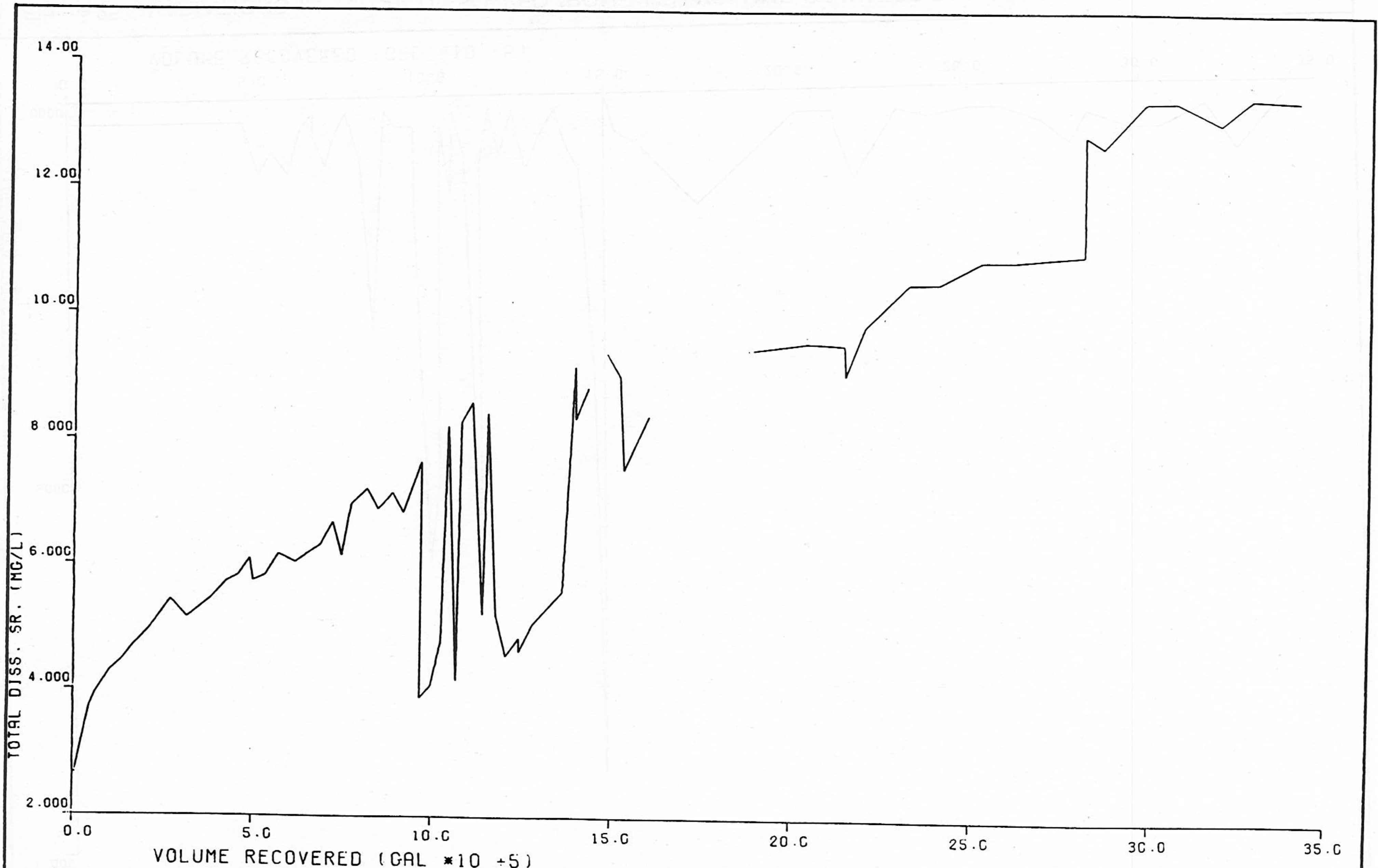


Figure 26 VARIATIONS IN TOTAL DISSOLVED STRONTIUM WITH VOLUME OF WATER RECOVERED

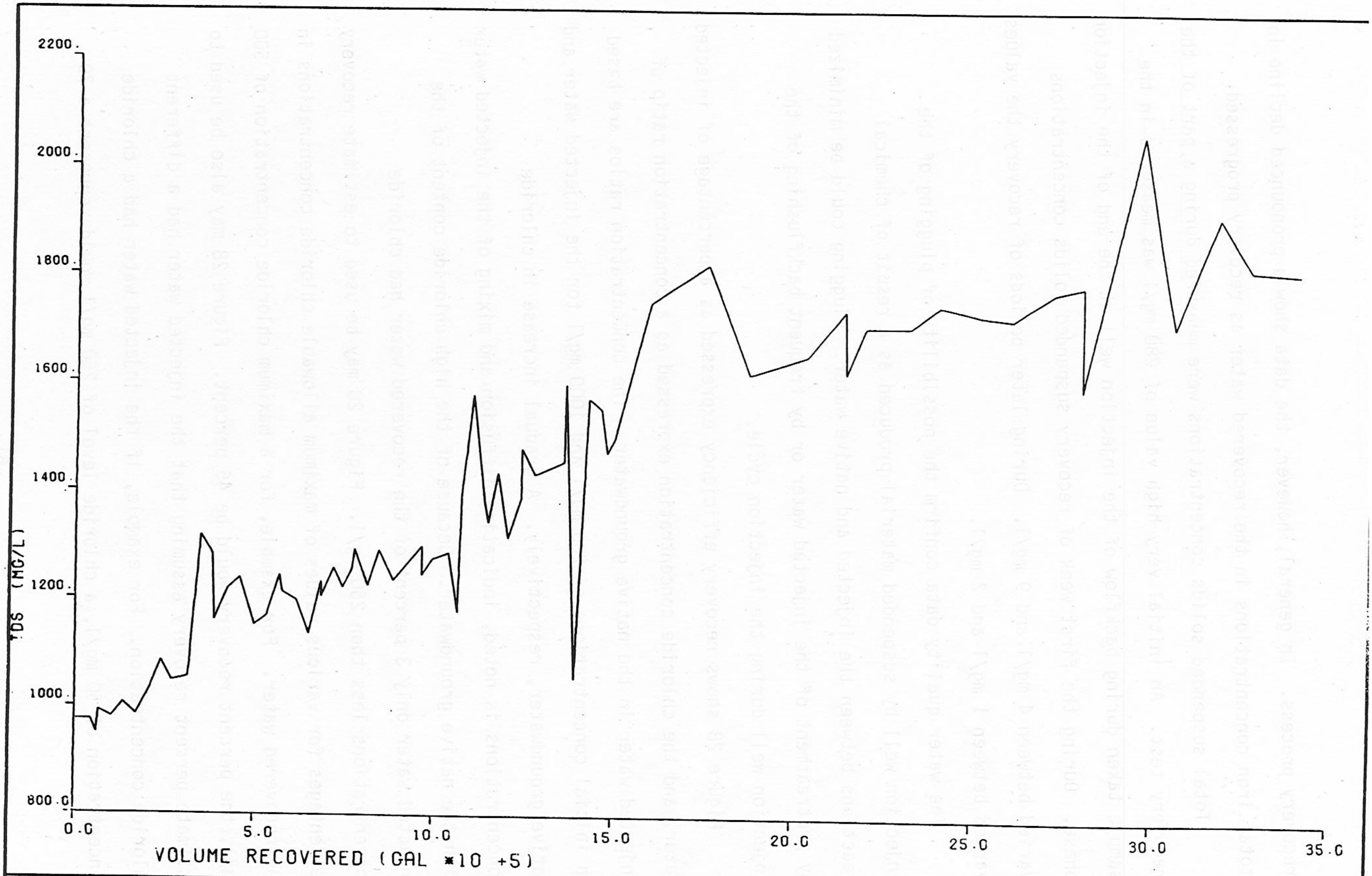


Figure 27 VARIATIONS IN TOTAL DISSOLVED SOLIDS WITH VOLUME OF WATER RECOVERED

recovery process. In general, however, the data show a pronounced decline in total iron concentrations in the recovered water as recovery progressed.

Total suspended solids concentrations were measured during a part of the recovery test. An initial very high value of 280 mg/l was measured in the sample taken during backflow of the injection well at the end of the injection phase. During the first week of recovery suspended solids concentrations varied between 4 mg/l and 9 mg/l. During later periods of recovery the values varied between 1 mg/l and 2 mg/l.

The water quality data confirm the possibility of plugging of the injection well by suspended material produced as a result of chemical reactions between the injected and native water. Plugging could be minimized by pretreatment of the injected water or by frequent backflushing of the injection well during the injection cycle.

Figure 28 shows recovery efficiency expressed as a percentage of injected water, and the chloride concentration expressed as a concentration ratio of injected water in the native groundwater. The concentration ratios are based on initial concentrations of 200 mg/l and 1000 mg/l for the injected water and native groundwater, respectively. A gradual increase in chloride concentrations is noted, indicating diffusion and mixing of the injected water with the native groundwater. Because of the high chloride content of the injected water only 3 percent of the recovered water had chloride concentrations less than 250 mg/l. Figure 28 may be used to estimate recovery percentages for various values of maximum allowable chloride concentrations in the recovered water. For example, for a maximum chloride concentration of 500 mg/l, the percent recovery would be 45 percent. Figure 28 may also be used to estimate percent recovery assuming that the injected water had a different chloride concentration. For example, if the injected water had a chloride concentration of 50 mg/l, a chloride level of 250 mg/l would represent a 79

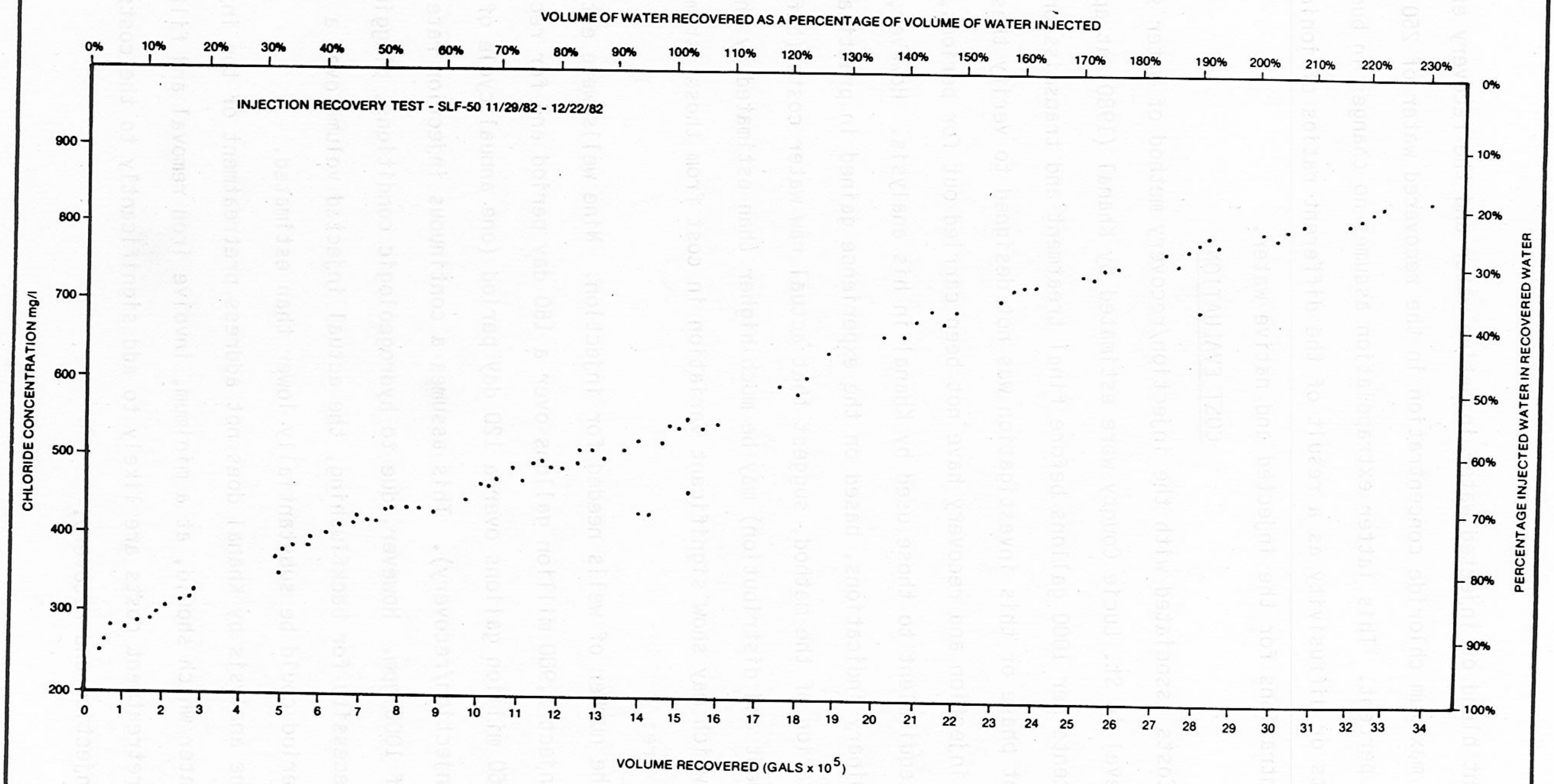


Figure 28 RECOVERY EFFICIENCY BASED ON CHLORIDE CONCENTRATIONS IN RECOVERED WATER

percent blend of injected water in native water and the recovery efficiency for a maximum chloride concentration in the recovered water of 250 mg/l would be 33 percent. This latter extrapolation assumes no changes in buoyancy effects or diffusivity as a result of the different ratios of ionic concentrations for the injected and native water.

COST EVALUATION

Costs associated with the injection/recovery method of water storage and retrieval in St. Lucie County were estimated by Khanal (1980) at approximately five cents per 1000 gallons before final treatment and transmission. The present phase of this investigation was not designed to verify these costs since injection and recovery have not been carried out for periods, or at rates equivalent to those used by Khanal in his analysis. However, preliminary indications, based on the experience gained in practical application of the method, suggest that actual raw water costs (before final treatment and distribution) may be much higher than estimated by Khanal. The items which may show significant variation in cost from those estimated by Khanal are:

1) The number of wells needed for injection. Nine wells were estimated to inject 1,900 million gallons over a 150 day period and for recovery of 960 million gallons over a 120 day period (one annual cycle of injection/recovery). This assumes a continuous injection rate per well of 1000 gpm. However, due to hydrogeologic conditions, plugging, and the necessity for backflushing, the actual injected volume over a 150 day period could be substantially lower than estimated.
2) The analysis by Khanal does not address pretreatment of the injected water which should, at a minimum, involve iron removal and filtration. Pretreatment costs are likely to add significantly to the costs for injection and recovery.

3) Operating costs associated with monitoring injection pressures, temporary halting of injection for backflushing, and resumption of injection are likely to be high. This could add significantly to the overall cost of the injection/recovery system.

Preliminary cost estimates for a single well, based on the aquifer and injection characteristics encountered at the exploratory site, are detailed on Table 5. Based on these estimates a more generalized assessment of costs is developed and displayed on Figure 29. The importance of the injection rate per well and the percentage of usable water which can be recovered in determining costs is well illustrated. In developing this figure only power costs and overheads were adjusted to take into account different injection rates. It was assumed that other costs would remain relatively constant. The period of 150 days of injection used in the calculations does not include time for rehabilitation or backflushing of the well.

For any specific application and hydrogeologic situation, the percent of usable water which can be recovered depends on the water quality which is considered suitable for that use. For example, for domestic use, the chloride limit is generally accepted to be 250 mg/l unless the water is to be blended with water from other sources. At this particular site, due to the relatively high chloride content of the water available for injection, the percent usable water recovered with a chloride concentration at or below 250 mg/l was approximately 3%. Assuming that the initial injection rate of approximately 400 gpm could be maintained, the costs would still be exhorbitant (more than $10 per 1000 gallons). It should be born in mind, however, that at the site investigated, this injection rate could probably be maintained only if the injected water were pretreated or the injection well were frequently rehabilitated. These operations would add significantly to the costs of the process.

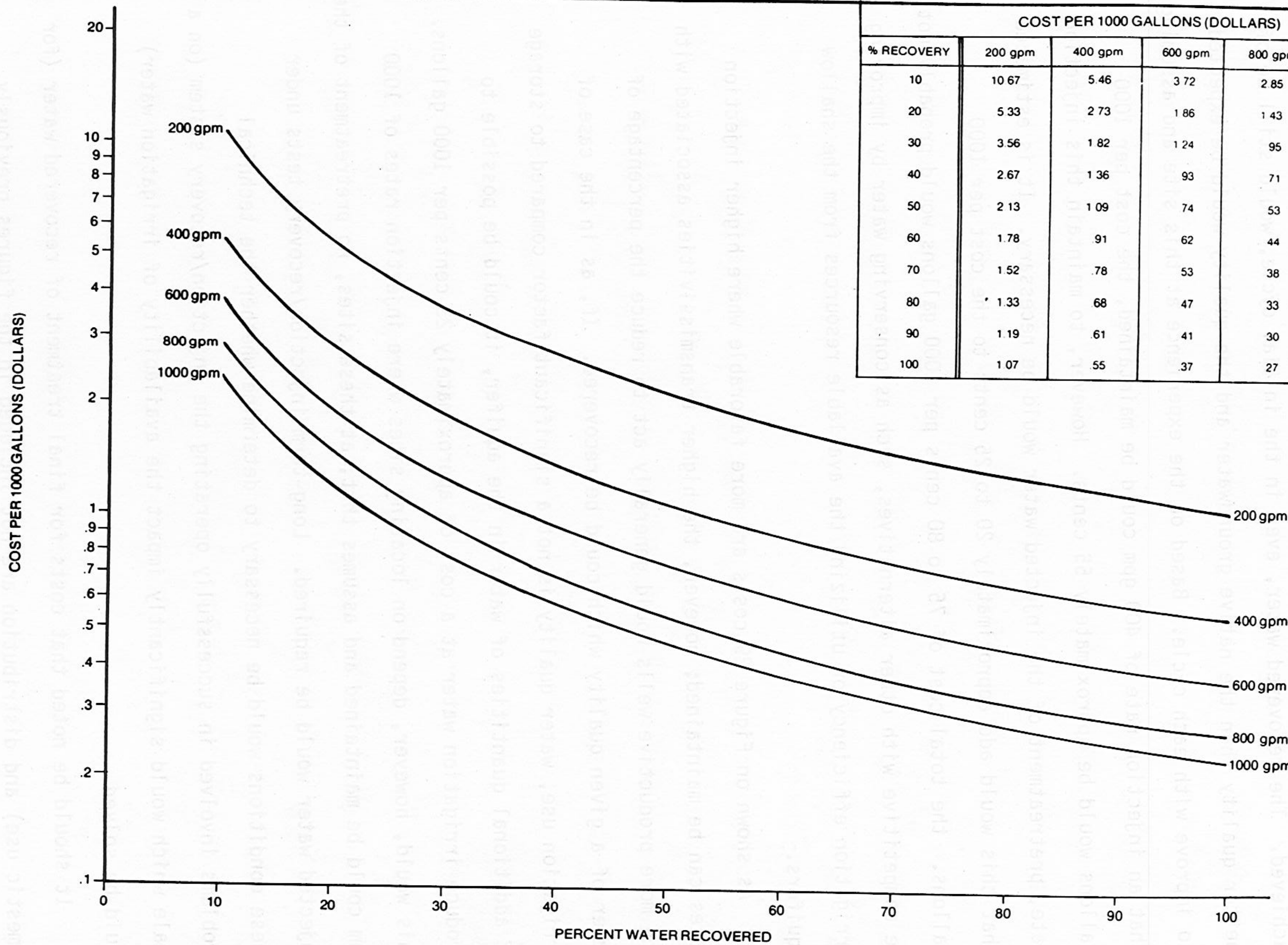
TABLE 5. COSTS PER WELL BASED ON HYDROGEOLOGIC CONDITIONS AT WELL SLF-50

		Cost
1.	**Capital Costs**	
a.	Hydrogeologic Surveys (1 hydrogeologist for 1 month)	$ 2,500
b.	Land Acquisition 1/2 acre at $5000 per acre	2,500
c.	Well Construction Total Depth 775' Casing - 36" X 50' X 3/8" steel, grouted in place 20" X 130' X 3/8" steel, grouted in place 12" X 600' X 3/8" steel, grouted in place Open hole 175' (600' - 775') Wellhead and Piping 50 X 12" pipe Flow regulator, pressure recorder, air relief valve, backflow preventer, water hammer protection Other Fittings	150,000
d.	Hydrologic and System Testing	20,000
e.	Pump and Switchgear (25 hp 12" X 12" electric pump & motor)	5,000
f.	Engineering and Legal Fees (25% of a, b, c, d, e)	45,000
g.	Contingency (20% of a, b, c, d, e, f)	45,000
	TOTAL CAPITAL COSTS	$270,000
2.	**Annual Costs**	
a.	Debt service on $270,000 + capital recovery Amortized over 20 years, 10% interest	$ 31,714
b.	Operating Costs Power 400 gpm, TDH 100' efficiency 80% per 150 days = 33909 kwh X 4.5¢ per kwh Rehabilitation and backflush Parts and Repair (10% of pump and switchgear costs) Personnel	11,026
c.	Overhead (40% of b)	4,410
	TOTAL ANNUAL COSTS	$ 47,150

3. Cost per 1000 gallons (example calculation for 400 gpm injection rate for 150 days, 50% recovery)

Total quantity of new water = 50% X 400 X 60 X 24 X 150 = 43,200,000 gallons

Cost per 1000 gallons = $\frac{\$47,150}{43,200 \text{ (1000 gallons)}} = \$1.09$



COST PER 1000 GALLONS (DOLLARS)					
% RECOVERY	200 gpm	400 gpm	600 gpm	800 gpm	1000 gpm
10	10 67	5.46	3 72	2.85	2 33
20	5 33	2 73	1 86	1 43	1 17
30	3.56	1 82	1 24	95	78
40	2.67	1 36	93	71	58
50	2 13	1 09	74	53	47
60	1.78	.91	62	44	39
70	1.52	.78	53	38	33
80	1.33	.68	47	33	29
90	1.19	.61	41	30	26
100	1 07	.55	.37	27	23

Figure 29 COSTS PER THOUSAND GALLONS OF USEABLE WATER RECOVERED

For irrigation use, full recovery (100%) of injected water could be achieved. The recovered water, even in the initial cycle, would still be of better quality than the native groundwater and the quality would be expected to improve with each cycle. Based on the experience at this site and assuming that an injection rate of 400 gpm could be maintained, the cost per 1000 gallons would be approximately 55 cents. However, to maintain this injection rate, pretreatment of the injected water would be necessary. It is estimated that this would add approximately 20 to 25 cents to the cost per 1000 gallons. the total cost of 75 to 80 cents per 1000 gallons would probably not be competitive with other alternatives, such as conserving water by improving irrigation efficiency or utilizing the available resources from the shallow aquifers.

As shown on Figure 29 costs are more favorable where higher injection rates can be maintained; however, the higher transmissivities associated with the more productive wells would generally act to reduce the percentage of water of a given quality which could be recovered. If, as in the case of irrigation use, water quality is not a significant factor compared to storage of additional quantities of water in the aquifer, it could be possible to produce irrigation water at a cost of approximately 23 cents per 1000 gallons. This would, however, depend on locating sites where injection rates of 1000 gpm could be maintained and assumes that, at these sites, no pretreatment of the injected water would be required. Long-term injection/recovery tests under these conditions would be necessary to determine whether the technical problems involved in successfully operating the injection/recovery system (on a scale which would significantly impact the availability of irrigation water) could be solved.

It should be noted that costs for final treatment of recovered water (for domestic use) and distribution are not included in the figures previously presented. Costs may also vary depending on variations in well design (for example, if deeper or larger diameter wells are required to achieve higher injection rates).

CONCLUSIONS

Based on the experience gained at this site it is concluded that:

1) Overall costs for treatment, injection and recovery of groundwater do not appear to be competitive with present costs for domestic or irrigation water.

2) Although suitable hydrogeologic conditions exist in the area, a successful injection/recovery system would require the availability of water with low chloride, iron, and total suspended solids concentrations for injection. The most cost-effective method of meeting these constraints would be to develop the program in conjunction with existing or proposed water treatment facilities.

3) Suitable hydrogeologic conditions exist in the area which would make large scale injection/recovery systems technically feasible. However, cost and operational complexity make this technique unfavorable at this time as a regional water resource management alternative.

4) The technique may have some applicability to specific non-potable uses, due to the high recovery efficiencies which can be achieved if the quality of the recovered water is not a critical factor.

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APPENDIX 1

Lithologic Log, Well SLF-50

W-SL001

ST. LUCIE CO. T36S R39E SEC 1400 27 20 17 N 80 29 53 W
TOTAL DEPTH- 1000 FT. ELEV.- 25 FT. 100 SAMPLES- 0- 1000 FT.
COMPLETED- 82.02.20 DEPTH WORKED 1000 FT.

OTHER GEOPHYSICAL LOGS AVAILABLE -

GAMMA
NEUTRON
CALIPHER
ELECTRIC
TEMPERATURE

WELL NAME-
RECOVERY TEST WELL (SLF-50),STA.I.D.-11100050,DRILLER ALVIN WOOSTER.
REMARKS-
CUTTINGS DESCRIBED BY MIKE KNAPP (2-22-82), SAMPLE QUALITY (GOOD),REVERSE AIR DRILLING, WATER QUAL.,POINT SAMPLE,PUMP TEST, AND OTHER GEOPHYSICAL DATA AVAILABLE.

HYDROGEOLOGIC UNITS

0.0	130.0	SURFICIAL AQUIFER SYSTEM
130.0	600.0	HAWTHORN CONFINING BEDS
600.0	1000.0	FLORIDAN AQUIFER SYSTEM

STRATIGRAPHIC FORMATIONS -

0.0-	30.0	UNDIFFERENTIATED SAND AND CLAY
30.0-	100.0	ANASTASIA FORMATION
100.0-	130.0	TAMIAMI FORMATION
130.0-	660.0	HAWTHORN FORMATION
660.0-	740.0	CRYSTAL RIVER FORMATION
740.0-	760.0	WILLISTON FORMATION
760.0-	1000.0	AVON PARK LIMESTONE

LITHOLOGIC LOG
W-SL001 . ST. LUCIE CO. T36S, R39E, SEC 1400

0.0- 10.0 SAND, GRAYISH ORANGE TO GRAYISH BROWN, 35% POROSITY, INTERGRANULAR, GRAIN SIZE: MEDIUM, RANGE: VERY FINE TO COARSE, SUB-ANGULAR, ANGULAR, MEDIUM SPHERICITY, UNCONSOLIDATED,

10.0- 20.0 LIMESTONE, VERY LIGHT ORANGE TO WHITE, 12% POROSITY, INTERGRANULAR, GRAIN TYPE: CALCILUTITE, GRAIN SIZE: VERY FINE, RANGE: MICROCRYSTALLINE TO COARSE, POOR INDURATION, CALCILUTITE MATRIX, 20% QUARTZ SAND, MOLLUSKS,

FILL MATERIAL FROM ADJACENT CANAL

20.0- 30.0 SHELL BED, GRAYISH BROWN TO MODERATE GRAY, 25% POROSITY, INTERGRANULAR, POOR INDURATION, IRON CEMENT, CALCILUTITE MATRIX, 20% QUARTZ SAND, 02% CALCILUTITE, MOLLUSKS,

SOME FRAGS ARE WELL INDURATED SANDSTONE

30.0- 40.0 SANDSTONE, GREENISH GRAY, 12% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, POSSIBLY HIGH PERMEABILITY, GRAIN SIZE: MEDIUM, RANGE: VERY FINE TO COARSE, SUB-ANGULAR, ROUNDED, MEDIUM SPHERICITY, GOOD INDURATION, CALCILUTITE MATRIX, SPARRY CALCITE CEMENT, 10% CALCILUTITE, 10% SPAR, MOLLUSKS, FOSSIL MOLDS,

40.0- 50.0 AS ABOVE,

50.0- 60.0 INTERMIXED SANDSTONE AND SHELL

60.0- 70.0 AS ABOVE,

70.0- 80.0 SHELL BED, WHITE TO MODERATE LIGHT GRAY, 25% POROSITY, INTERGRANULAR, POOR INDURATION, CALCILUTITE MATRIX, 05% CALCILUTITE, 25% QUARTZ SAND, MOLLUSKS, ECHINOID, CORAL,

80.0- 100.0 AS ABOVE,

100.0- 110.0 SANDSTONE, WHITE TO LIGHT GREENISH GRAY, 15% POROSITY, INTERGRANULAR, GRAIN SIZE: FINE, RANGE: VERY FINE TO MEDIUM, SUB-ANGULAR, MEDIUM SPHERICITY, POOR INDURATION, CALCILUTITE MATRIX, 15% CALCILUTITE, MOLLUSKS,

110.0- 120.0 LIMESTONE, YELLOWISH GRAY, 15% POROSITY, INTERGRANULAR, GRAIN TYPE: CALCILUTITE, BIOGENIC, SKELETAL, 05% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: MICROCRYSTALLINE, RANGE: MICROCRYSTALLINE TO COARSE, MODERATE INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, 10% DOLOMITE, 02% PHOSPHATIC SAND, 25% QUARTZ SAND, MOLLUSKS, CORAL,

120.0- 130.0 AS ABOVE,

130.0- 140.0 SAND, LIGHT OLIVE GRAY TO GRAYISH OLIVE, 12% POROSITY, INTERGRANULAR, LOW PERMEABILITY, GRAIN SIZE: FINE, RANGE: VERY FINE TO MEDIUM, SUB-ANGULAR, ANGULAR, MEDIUM SPHERICITY, POOR INDURATION, DOLOMITE CEMENT, CLAY MATRIX, 10% DOLOMITE, 05% CLAY, 07% PHOSPHATIC SAND, CALCAREOUS, DOLOMITIC, MOLLUSKS,

140.0- 170.0 AS ABOVE,

170.0- 180.0 SAND, GRAYISH OLIVE, 12% POROSITY, INTERGRANULAR, LOW PERMEABILITY, GRAIN SIZE: VERY FINE, RANGE: VERY FINE TO MEDIUM, SUB-ANGULAR, ANGULAR, MEDIUM SPHERICITY, POOR INDURATION, DOLOMITE CEMENT, CLAY MATRIX, 10% DOLOMITE, 05% CLAY, 03% PHOSPHATIC SAND, CALCAREOUS, DOLOMITIC, MOLLUSKS,

180.0- 190.0 AS ABOVE,

190.0- 200.0 DOLO-SILT, LIGHT OLIVE GRAY, 10% POROSITY, INTERGRANULAR, LOW PERMEABILITY, POOR INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, CLAY MATRIX, 10% CALCILUTITE, 05% CLAY, 30% QUARTZ SAND, 03% PHOSPHATIC SAND, MOLLUSKS, DIATOMS, BENTHONIC FORAMINIFERA,

200.0- 240.0 AS ABOVE,

240.0- 250.0 SAND, GRAYISH OLIVE, 10% POROSITY, INTERGRANULAR, LOW PERMEABILITY, GRAIN SIZE: VERY FINE, RANGE: VERY FINE TO MEDIUM, SUB-ANGULAR, ANGULAR, MEDIUM SPHERICITY, POOR INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, CLAY MATRIX, 10% DOLOMITE, 05% CALCILUTITE, 05% CLAY, 02% PHOSPHATIC SAND, DIATOMS, BENTHONIC FORAMINIFERA, PLANKTONIC FORAMINIFERA,

250.0- 260.0 AS ABOVE,

260.0- 270.0 DOLO-SILT, GRAYISH OLIVE, 10% POROSITY, INTERGRANULAR, LOW PERMEABILITY, POOR INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, CLAY MATRIX, 10% CALCILUTITE, 05% CLAY, 35% SILT, 01% PHOSPHATIC SAND, BENTHONIC FORAMINIFERA,

270.0- 290.0 AS ABOVE,

290.0- 300.0 DOLO-SILT, GRAYISH OLIVE, 10% POROSITY, INTERGRANULAR, LOW PERMEABILITY, POOR INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, CLAY MATRIX, 10% CALCILUTITE, 05% CLAY, 35% SILT, 01% PHOSPHATIC SAND, DIATOMS, BENTHONIC FORAMINIFERA, PLANKTONIC FORAMINIFERA,

300.0- 310.0 AS ABOVE,

310.0- 320.0 SAND, GRAYISH OLIVE, 12% POROSITY, INTERGRANULAR, LOW PERMEABILITY, GRAIN SIZE: VERY FINE, RANGE: VERY FINE TO COARSE, SUB-ANGULAR, ANGULAR, MEDIUM SPHERICITY, POOR INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, CLAY MATRIX, 25% DOLOMITE, 05% CALCILUTITE, 02% CLAY, BENTHONIC FORAMINIFERA,

320.0- 330.0 AS ABOVE,

330.0- 340.0 SAND, LIGHT OLIVE, 14% POROSITY, INTERGRANULAR, LOW PERMEABILITY, GRAIN SIZE: VERY FINE, RANGE: VERY FINE TO COARSE, SUB-ANGULAR, MEDIUM SPHERICITY, POOR INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, CLAY MATRIX, 25% DOLOMITE, 15% CALCILUTITE, 01% CLAY, 03% PHOSPHATIC SAND, MOLLUSKS, BENTHONIC FORAMINIFERA,

340.0- 350.0 AS ABOVE,

350.0- 360.0 SAND, LIGHT OLIVE, 15% POROSITY, INTERGRANULAR, LOW PERMEABILITY, GRAIN SIZE: MEDIUM, RANGE: VERY FINE TO COARSE, SUB-ANGULAR, ROUNDED, MEDIUM SPHERICITY, POOR INDURATION, DOLOMITE CEMENT, CLAY MATRIX, 15% DOLOMITE, 02% CLAY, 03% PHOSPHATIC SAND, MOLLUSKS, BENTHONIC FORAMINIFERA,

360.0- 370.0 DOLO-SILT, LIGHT OLIVE, 12% POROSITY, INTERGRANULAR, LOW PERMEABILITY, POOR INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, CLAY MATRIX, 15% CALCILUTITE, 01% CLAY, 02% PHOSPHATIC GRAVEL, 03% PHOSPHATIC SAND, MOLLUSKS, CORAL, BENTHONIC FORAMINIFERA,

370.0- 380.0 AS ABOVE,

380.0- 390.0 DOLOMITE, LIGHT GREENISH YELLOW TO LIGHT OLIVE, 13% POROSITY, INTERGRANULAR, 50-90% ALTERED, EUHEDRAL, GRAIN SIZE: VERY FINE, RANGE: VERY FINE TO MICROCRYSTALLINE, MODERATE INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, 20% CALCILUTITE, 04% PHOSPHATIC SAND, 02% PHOSPHATIC GRAVEL, 10% QUARTZ SAND, MOLLUSKS,

390.0- 400.0 AS ABOVE,

400.0- 410.0 DOLO-SILT, LIGHT OLIVE, 12% POROSITY, INTERGRANULAR, LOW PERMEABILITY, POOR INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, CLAY MATRIX, 10% CALCILUTITE, 05% CLAY, 15% QUARTZ SAND, 06% PHOSPHATIC SAND, MOLLUSKS,

410.0- 440.0 AS ABOVE,

440.0- 450.0 LIMESTONE, WHITE, 12% POROSITY, INTERGRANULAR, GRAIN TYPE: CALCILUTITE, CRYSTALS, 01% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: MICROCRYSTALLINE, RANGE: MICROCRYSTALLINE TO VERY FINE, MODERATE INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, 15% DOLOMITE, 03% PHOSPHATIC SAND, 02% QUARTZ SAND,

SAMPLE IS MIXTURE OF L/S AND DOLO-SILT

450.0- 460.0 AS ABOVE,

460.0- 470.0 DOLOMITE, LIGHT OLIVE TO VERY LIGHT GRAY, 12% POROSITY, INTERGRANULAR, LOW PERMEABILITY, 50-90% ALTERED, EUHEDRAL, GRAIN SIZE: VERY FINE, RANGE: VERY FINE TO MICROCRYSTALLINE, MODERATE INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, 30% CALCILUTITE, 08% PHOSPHATIC SAND, 05% QUARTZ SAND, ECHINOID, MOLLUSKS,

470.0- 480.0 AS ABOVE,

480.0- 490.0 DOLOMITE, VERY LIGHT ORANGE, 12% POROSITY, INTERGRANULAR, 50-90% ALTERED, EUHEDRAL, GRAIN SIZE: VERY FINE, RANGE: VERY FINE TO MICROCRYSTALLINE, MODERATE INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, 35% CALCILUTITE, 03% PHOSPHATIC SAND, MOLLUSKS,

490.0- 510.0 AS ABOVE,

510.0- 520.0 SAMPLE IS MIXTURE OF DOLOMITE AND DOLO-SILT

520.0- 530.0 AS ABOVE,

530.0- 540.0 DOLO-SILT, LIGHT OLIVE, 12% POROSITY, INTERGRANULAR, LOW PERMEABILITY, POOR INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, CLAY MATRIX, 15% CALCILUTITE, 15% CLAY, 06% PHOSPHATIC SAND, 15% QUARTZ SAND, MOLLUSKS,

540.0- 550.0 DOLOMITE, VERY LIGHT ORANGE, 12% POROSITY, INTERGRANULAR, 50-90% ALTERED, EUHEDRAL, GRAIN SIZE: VERY FINE, RANGE: VERY FINE TO MICROCRYSTALLINE, MODERATE INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, 25% CALCILUTITE, 04% PHOSPHATIC SAND, 02% QUARTZ SAND, MOLLUSKS,

550.0- 570.0 AS ABOVE,

570.0- 580.0 DOLOMITE, VERY LIGHT ORANGE, 12% POROSITY, INTERGRANULAR, 50-90% ALTERED, EUHEDRAL, GRAIN SIZE: VERY FINE, RANGE: VERY FINE TO MICROCRYSTALLINE, MODERATE INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, 20% CALCILUTITE, 03% PHOSPHATIC SAND, 02% QUARTZ SAND, MOLLUSKS,

580.0- 590.0 SAMPLE IS MIXT. OF DOLOMITE,L/S,AND GREEN CLAY

590.0- 600.0 AS ABOVE,

600.0- 610.0 LIMESTONE, VERY LIGHT ORANGE, 14% POROSITY, INTERGRANULAR, MOLDIC, GRAIN TYPE: CALCILUTITE, SKELETAL, BIOGENIC, 30% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: MICROCRYSTALLINE, RANGE: MICROCRYSTALLINE TO COARSE, GOOD INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, 15% DOLOMITE, 10% PHOSPHATIC SAND, MOLLUSKS, BRYOZOA, BENTHONIC FORAMINIFERA, ECHINOID,

610.0- 620.0 AS ABOVE WITH COARSE PHOS.(15%)

620.0- 635.0 AS ABOVE,

635.0- 650.0 V.C. PHOS. AND BIOGENIC L/S IN SAMPLE.

650.0- 660.0 LIMESTONE, VERY LIGHT ORANGE, 16% POROSITY, INTERGRANULAR, GRAIN TYPE: BIOGENIC, CRYSTALS, CALCILUTITE, 50% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: VERY FINE, RANGE: MICROCRYSTALLINE TO COARSE, GOOD INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, SPARRY CALCITE CEMENT, 15% DOLOMITE, BENTHONIC FORAMINIFERA, MOLLUSKS, ECHINOID, FOSSIL MOLDS,

660.0- 670.0 LIMESTONE, VERY LIGHT ORANGE TO WHITE, 16% POROSITY, INTERGRANULAR, GRAIN TYPE: SKELETAL, CALCILUTITE, CRYSTALS, 65% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: MEDIUM, RANGE: MICROCRYSTALLINE TO COARSE, GOOD INDURATION, CALCILUTITE MATRIX, BENTHONIC FORAMINIFERA, MOLLUSKS, ECHINOID, BRYOZOA,

LEPIDOCYCLINA SP.,PHOSPHATIC L/S,AND HIGHLY RXTAL DOLO.

670.0- 680.0 LIMESTONE, VERY LIGHT ORANGE TO WHITE, 18% POROSITY, INTERGRANULAR, POSSIBLY HIGH PERMEABILITY, GRAIN TYPE: BIOGENIC, CALCILUTITE, SKELETAL, 75% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: MEDIUM, RANGE: MICROCRYSTALLINE TO COARSE, GOOD INDURATION, CALCILUTITE MATRIX, COQUINA, BENTHONIC FORAMINIFERA, MOLLUSKS, ECHINOID, BRYOZOA,

680.0- 700.0 AS ABOVE,

700.0- 712.0 COQUINA OF LEPS,GOOD POROSITY.

712.0- 720.0 AS ABOVE,

720.0- 730.0 LIMESTONE, VERY LIGHT ORANGE TO WHITE, 18% POROSITY, INTERGRANULAR, POSSIBLY HIGH PERMEABILITY, GRAIN TYPE: BIOGENIC, CALCILUTITE, SKELETAL, 75% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: MEDIUM, RANGE: MICROCRYSTALLINE TO COARSE, GOOD INDURATION, CALCILUTITE MATRIX, COQUINA, CHALKY, BENTHONIC FORAMINIFERA, MOLLUSKS, ECHINOID, BRYOZOA, CORAL,

730.0- 740.0 AS ABOVE,

740.0- 750.0 LIMESTONE, VERY LIGHT ORANGE, 14% POROSITY, INTERGRANULAR, GRAIN TYPE: BIOGENIC, SKELETAL, CRYSTALS, 60% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: FINE, RANGE: MICROCRYSTALLINE TO MEDIUM, GOOD INDURATION, CALCILUTITE MATRIX, SPARRY CALCITE CEMENT, BENTHONIC FORAMINIFERA, MOLLUSKS, ECHINOID, BRYOZOA CORAL,

MOSTLY SMALLER FORAMS (AMPHISTEGINA SP.?)

750.0- 760.0 AS ABOVE,

760.0- 767.0 DOLOMITE, MODERATE YELLOWISH BROWN, 10% POROSITY, INTERCRYSTALLINE, MOLDIC, INTERGRANULAR, 50-90% ALTERED, EUHEDRAL, GRAIN SIZE: VERY FINE, RANGE: VERY FINE TO MICROCRYSTALLINE, GOOD INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, 10% CALCILUTITE, FOSSIL MOLDS,

767.0- 775.0 AS ABOVE,

775.0- 780.0 LIMESTONE, WHITE, 12% POROSITY, INTERGRANULAR, GRAIN TYPE: CALCILUTITE, BIOGENIC, CRYSTALS, 30% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: MICROCRYSTALLINE, RANGE: MICROCRYSTALLINE TO MEDIUM, GOOD INDURATION, CALCILUTITE MATRIX, BENTHONIC FORAMINIFERA, FOSSIL MOLDS, CONES,

DICTYOCONUS COOKEI

780.0- 790.0 LIMESTONE, VERY LIGHT ORANGE, 14% POROSITY, INTERGRANULAR, GRAIN TYPE: CALCILUTITE, BIOGENIC, SKELETAL, 55% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: FINE, RANGE: MICROCRYSTALLINE TO MEDIUM, GOOD INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, 20% DOLOMITE, BENTHONIC FORAMINIFERA, ECHINOID,

790.0- 800.0 SOME FRAGS. HAVE GOOD POROSITY

800.0- 810.0 DOLOMITE, GRAYISH ORANGE TO MODERATE YELLOWISH BROWN, 10% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, MOLDIC, 50-90% ALTERED, EUHEDRAL, GRAIN SIZE: VERY FINE, RANGE: VERY FINE TO MICROCRYSTALLINE, GOOD INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, 10% CALCILUTITE, FOSSIL MOLDS,

810.0- 820.0 CALCARENITE, VERY LIGHT ORANGE, 15% POROSITY, INTERGRANULAR, GOOD INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, 10% DOLOMITE, BENTHONIC FORAMINIFERA, MOLLUSKS, ECHINOID,

820.0- 830.0 AS ABOVE,

830.0- 840.0 LIMESTONE, VERY LIGHT ORANGE, 13% POROSITY, INTERGRANULAR, GRAIN TYPE: BIOGENIC, CALCILUTITE, CRYSTALS, 60% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: FINE, RANGE: MICROCRYSTALLINE TO COARSE, GOOD INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, SPARRY CALCITE CEMENT, 15% DOLOMITE, BENTHONIC FORAMINIFERA, MOLLUSKS, ECHINOID, CONES,

MANY CONES

840.0- 850.0 AS ABOVE,

850.0- 860.0 LIMESTONE, VERY LIGHT ORANGE TO GRAYISH ORANGE, 10% POROSITY, INTERGRANULAR, MOLDIC, INTERCRYSTALLINE, GRAIN TYPE: BIOGENIC, CALCILUTITE, CRYSTALS, 40% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: MICROCRYSTALLINE, RANGE: MICROCRYSTALLINE TO COARSE, GOOD INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, SPARRY CALCITE CEMENT, 30% DOLOMITE, BENTHONIC FORAMINIFERA, FOSSIL MOLDS,

860.0- 870.0 AS ABOVE,

870.0- 880.0 AS ABOVE WITH DICTYOCONUS COOKEI, AND GYPSINA SP.

880.0- 890.0 AS ABOVE,

890.0- 900.0 LIMESTONE, VERY LIGHT ORANGE TO GRAYISH ORANGE, 08% POROSITY, INTERGRANULAR, MOLDIC, GRAIN TYPE: BIOGENIC, CALCILUTITE, CRYSTALS, 20% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: MICROCRYSTALLINE, RANGE: MICROCRYSTALLINE TO MEDIUM, GOOD INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, SPARRY CALCITE CEMENT, 30% DOLOMITE, FOSSIL MOLDS, BENTHONIC FORAMINIFERA,

900.0- 910.0 CALCARENITE, VERY LIGHT ORANGE, 13% POROSITY, INTERGRANULAR, GOOD INDURATION, CALCILUTITE MATRIX, SPARRY CALCITE CEMENT, BENTHONIC FORAMINIFERA, MOLLUSKS, ECHINOID, CONES,

910.0- 915.0 DOLOMITE, GRAYISH BROWN, 10% POROSITY, INTERCRYSTALLINE, INTERGRANULAR, MOLDIC, 50-90% ALTERED, EUHEDRAL, GRAIN SIZE: VERY FINE, RANGE: VERY FINE TO MICROCRYSTALLINE, GOOD INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, 10% CALCILUTITE, FOSSIL MOLDS,

915.0- 920.0 LIMESTONE, VERY LIGHT ORANGE, 12% POROSITY, INTERGRANULAR, GRAIN TYPE: BIOGENIC, CALCILUTITE, SKELETAL, 50% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: FINE, RANGE: MICROCRYSTALLINE TO COARSE, GOOD INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, SPARRY CALCITE CEMENT, 15% DOLOMITE, BENTHONIC FORAMINIFERA, MOLLUSKS, ECHINOID, CONES,

920.0- 930.0 LIMESTONE, VERY LIGHT ORANGE TO GRAYISH ORANGE, 08% POROSITY, INTERGRANULAR, LOW PERMEABILITY, GRAIN TYPE: CALCILUTITE, CRYSTALS, 10% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: MICROCRYSTALLINE, RANGE: MICROCRYSTALLINE TO FINE, GOOD INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, SPARRY CALCITE CEMENT, 25% DOLOMITE, FOSSIL MOLDS,

930.0- 940.0 AS ABOVE,

940.0- 950.0 DOLOMITE, LIGHT GRAY, 08% POROSITY, INTERGRANULAR, MOLDIC, LOW PERMEABILITY, 50-90% ALTERED, EUHEDRAL, GRAIN SIZE: VERY FINE, RANGE: VERY FINE TO MICROCRYSTALLINE, GOOD INDURATION, DOLOMITE CEMENT, CALCILUTITE MATRIX, 20% CALCILUTITE, BENTHONIC FORAMINIFERA, FOSSIL MOLDS,

950.0- 956.0 AS ABOVE,

956.0- 960.0 LIMESTONE, VERY LIGHT ORANGE, 12% POROSITY, INTERGRANULAR, GRAIN TYPE: BIOGENIC, CALCILUTITE, CRYSTALS, 40% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: MICROCRYSTALLINE, RANGE: MICROCRYSTALLINE TO COARSE, GOOD INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, 15% DOLOMITE, BENTHONIC FORAMINIFERA, MOLLUSKS, ECHINOID,

960.0- 970.0 LIMESTONE, VERY LIGHT ORANGE TO LIGHT GRAY, 08% POROSITY, INTERGRANULAR, LOW PERMEABILITY, MOLDIC, GRAIN TYPE: BIOGENIC, CALCILUTITE, 10% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: MICROCRYSTALLINE, RANGE: MICROCRYSTALLINE TO FINE, GOOD INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, 25% DOLOMITE, FOSSIL MOLDS,

970.0- 980.0 LIMESTONE, VERY LIGHT ORANGE, 11% POROSITY, INTERGRANULAR, GRAIN TYPE: BIOGENIC, CALCILUTITE, SKELETAL, 50% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: FINE, RANGE: MICROCRYSTALLINE TO COARSE, GOOD INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, 10% DOLOMITE, BENTHONIC FORAMINIFERA, MOLLUSKS, ECHINOID,

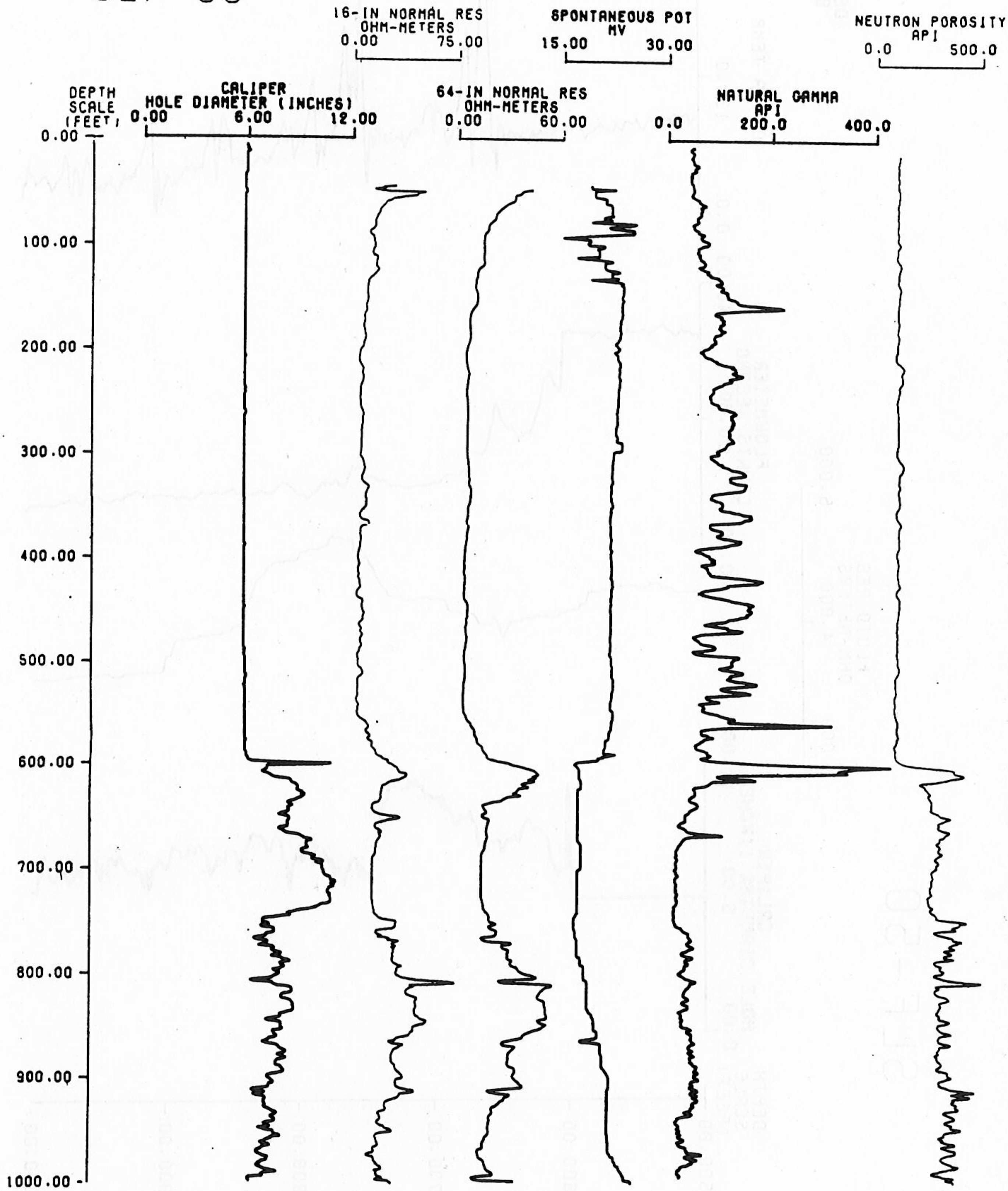
980.0- 990.0 AS ABOVE,

990.0- 1000.0 LIMESTONE, VERY LIGHT ORANGE, 12% POROSITY, INTERGRANULAR, GRAIN TYPE: BIOGENIC, CALCILUTITE, SKELETAL, 60% ALLOCHEMICAL CONSTITUENTS, GRAIN SIZE: FINE, RANGE: MICROCRYSTALLINE TO COARSE, GOOD INDURATION, CALCILUTITE MATRIX, DOLOMITE CEMENT, 10% DOLOMITE, BENTHONIC FORAMINIFERA, MOLLUSKS, ECHINOID,

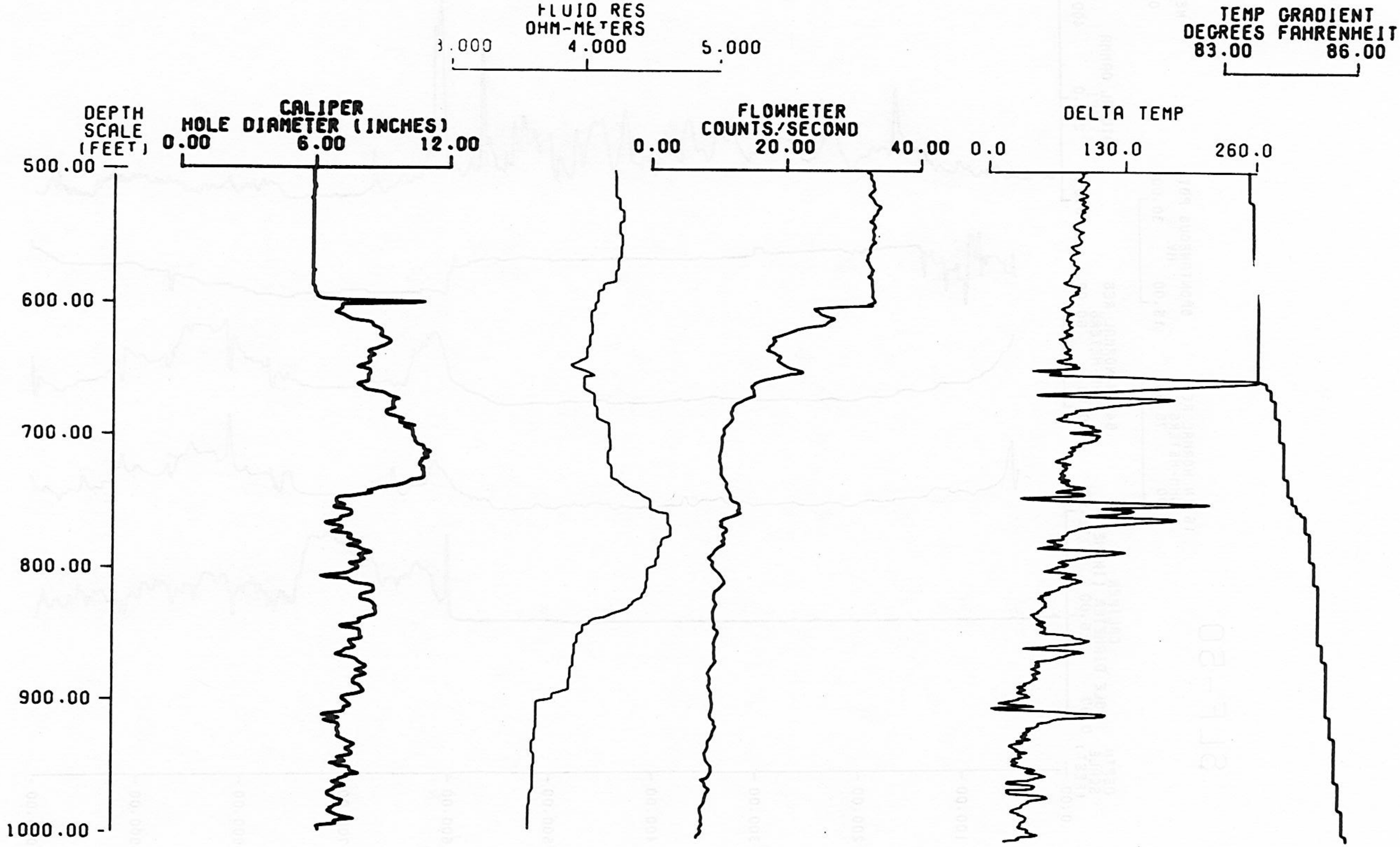
APPENDIX 2

Geophysical Logs, Well SLF-50

SLF-50


16-IN NORMAL RES
OHM-METERS
0.00 75.00
SPONTANEOUS POT
MV
15.00 30.00
NEUTRON POROSITY
API
0.0 500.0
DEPTH
SCALE
(FEET)
CALIPER
HOLE DIAMETER (INCHES)
0.00 6.00 12.00
64-IN NORMAL RES
OHM-METERS
0.00 60.00
NATURAL GAMMA
API
0.0 200.0 400.0
0.00
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.00

SLF-50


FLUID RES
OHM-METERS
3.000
4.000
5.000
TEMP GRADIENT
DEGREES FAHRENHEIT
83.00
86.00
DEPTH
SCALE
(FEET)
CALIPER
HOLE DIAMETER (INCHES)
0.00
6.00
12.00
FLOWMETER
COUNTS/SECOND
0.00
20.00
40.00
DELTA TEMP
0.0
130.0
260.0
500.00
600.00
700.00
800.00
900.00
1000.00

APPENDIX 3

Water Quality

A. MISCELLANEOUS SAMPLES

STATION CODE		DATE MO/DA/YR	TIME HOUR,MIN	NA MG/L	K MG/L	CA MG/L	MG MG/L	CL MG/L	SO4 MG/L	ALK MEQ/L	HARDNESS MG/LCACO	CODE TOTAL FE MG/L	DISS F MG/L
C24-	1	10/27/81	1330.	120.12	6.57	87.45	22.57	212.6	63.7	2.66	311.3	.59	.42
C24-	1	12/ 2/81	1520.	181.60	9.15	125.00	31.60	325.2	97.1	3.63	442.2		.24
C24-	1	2/ 2/82		232.80	10.30	148.00	44.00	426.6		3.81	550.7		.02
C24-	1	2/16/82	1120.	287.20	12.60	144.10	45.80	555.6	179.8	3.57	548.3		.04
C24-	1	3/12/82	1500.	220.00	8.00	139.50	38.90	452.9	152.9	2.72	508.4		.07
C24-	1	4/27/82	1105.	69.20	4.05	48.10	12.50	153.2	41.6	1.37	171.6		.37
C24-	1	4/27/82	1105.	74.10	4.40	50.10	13.50	156.2	42.7	1.37	160.7		.34
C24-	1	8/24/82	1015.	39.90	1.97	44.20	7.50				141.2		.46
C24-	1	10/14/82	1000.	50.30	1.65	40.50	8.80	112.1	27.0	1.10	137.3		.59
C-24		1/19/83	950.	140.40	5.93	90.20	24.50	351.4	107.2	3.24	326.1		
HRC-	1	10/27/81	1300.	138.93	6.79	98.25	25.72	274.9	70.5	2.85	351.2	1.05	.41
HRC-	1	10/27/81	1315.	138.67	6.79	96.10	25.72	261.5	73.2	2.82	345.8	.76	.44
HRC-	1	12/ 2/81	1430.	225.00	10.54	158.00	43.00	481.5	161.1	3.96	571.5		.12
HRC-	1	12/ 2/81	1500.	236.40	10.33	147.00	43.00	506.7	167.6	4.02	545.5		.12
SLF-	49	10/27/81	1345.	445.98	13.25	120.90	85.40	876.1	169.6	2.66	658.0	1.12	.09
SLF-	49	12/ 2/81	1540.	604.60	15.52	146.00	101.20	1154.9	172.8	2.57	761.1		.12
SLF-	49	12/ 2/81	1600.	599.20	15.24	148.00	100.60	1047.9	167.8	2.49	764.4		.12
SLF-	49	1/ 5/82	1200.	462.40	14.24	129.20	68.40	1142.3	160.4	2.57	666.5		.05
SLS-	1	10/14/82	930.	100.00	3.45	163.40	22.70	199.8	208.2	4.73	501.4		.09
SLF-	50	10/14/82	1100.	323.60	11.33	86.30	63.70	673.6	161.3	2.59	477.7		.08
SLF-	51	1/19/83	942.	340.00	11.55	85.50	62.50	903.0	172.1	2.55	470.7		.11

A. MISCELLANEOUS SAMPLES (CONTINUED)

STATION CODE	DATE MO/DA/YR	TIME HOUR,MIN	SP COND UMHOS/CM	LAB COND UMHOS/CM	LAB PH	T.SUS.SD MG/L	NO2 MG N/L	NH4 MG N/L	OPO4 MG P/L	NO3 MG N/L	T.DIS.SD MG/L
C24- 1	10/27/81	1330.	1180.	1260.	7.36		.249	.02	.541	.256	890.0
C24- 1	12/ 2/81	1520.	1710.	1700.	7.65		.151	.16	.595	.709	1088.0
C24- 1	2/ 2/82		2190.	2375.	7.65						1545.0
C24- 1	2/18/82	1120.		2450.	7.74	3.0					1549.0
C24- 1	3/12/82	1500.		2100.	7.81						1496.0
C24- 1	4/27/82	1105.	635.	830.	7.09						520.0
C24- 1	4/27/82	1105.	635.	635.	7.15						534.0
C24- 1	8/24/82	1015.		450.	6.99						346.0
C24- 1	10/14/82	1000.	510.	520.	7.30	2.0					390.0
C-24	1/19/83	950.	1272.								1212.0
HRC- 1	10/27/81	1300.	1355.	1380.	7.35		.211	.11	.650	.291	1027.0
HRC- 1	10/27/81	1315.	1330.	1400.	7.29		.219	.10	.553	.198	979.0
HRC- 1	12/ 2/81	1430.	2240.	2250.	7.66		< .004	< .01	.023	.036	1506.6
HRC- 1	12/ 2/81	1500.	2276.	2220.	7.78		< .004	< .01	.017	.030	1500.0
SLF- 49	10/27/81	1345.	3382.	3500.	7.67		< .004	.54	.003	.005	2182.0
SLF- 49	12/ 2/81	1540.	4311.	4290.	7.39		< .004	.73	< .002	< .004	2801.0
SLF- 49	12/ 2/81	1600.	4311.	4240.	7.36		.005	.67	< .002	.286	2522.0
SLF- 49	1/ 5/82	1200.		3850.	7.47						2245.0
SLS- 1	10/14/82	930.	1270.	1330.	7.74	12.0					932.0
SLF- 50	10/14/82	1100.	2270.	2450.	7.72	< 1.0					1436.0
SLF- 51	1/19/83	942.	2656.								2104.0

B. REVERSE AIR SAMPLES

STATION CODE	DATE MO/DA/YR	DEPTH FEET	NA MG/L	K MG/L	CA MG/L	MG MG/L	CL MG/L	SO4 MG/L	ALK MEQ/L	HARDNESS MG/LCACO
SLF- 50	1/14/82	715	535.60	15.66	108.90	83.00	949.8	198.2	2.73	613.6
SLF- 50	1/14/82	740	528.40	15.28	108.80	84.56	933.7	198.8	2.72	619.7
SLF- 50	1/26/82	760	456.40	15.20	112.80	81.80	927.5	185.0	2.92	618.4
SLF- 50	1/26/82	780	450.00	14.60	110.10	79.00	906.3	190.4	2.62	600.1
SLF- 50	1/26/82	800	430.00	14.00	109.60	77.20	865.3	188.4	2.97	591.4
SLF- 50	1/26/82	820	417.60	14.40	106.40	77.00	952.3	170.5	2.66	582.6
SLF- 50	1/26/82	840	366.60	13.00	98.10	70.20	834.2	177.6	2.68	533.9
SLF- 50	1/26/82	860	382.80	13.00	96.60	70.40	673.7	169.0	2.84	531.0
SLF- 50	1/26/82	870	378.40	12.80	97.20	70.60	770.7	170.5	3.05	533.3
SLF- 50	2/ 3/82	880	359.60	11.60	96.40	72.20	646.2	164.3	2.87	537.9
SLF- 50	2/ 3/82	900	349.20	11.60	93.90	68.00	637.8	160.1	2.86	514.4
SLF- 50	2/ 3/82	920	358.00	11.60	94.30	69.60	632.5	163.2	2.78	521.9
SLF- 50	2/ 3/82	940	348.80	11.60	94.90	68.40	635.7	155.9	2.84	518.5
SLF- 50	2/ 3/82	960	393.20	12.40	103.30	77.20	720.1	172.8	2.76	575.7
SLF- 50	2/ 3/82	980	385.20	12.80	111.50	76.40	739.1	170.0	3.03	592.9
SLF- 50	2/ 3/82	1000	380.80	12.40	99.50	74.40	733.8	164.3	2.83	554.7

STATION CODE	DATE MO/DA/YR	DEPTH FEET	SP COND UMHOS/CM	LAB COND UMHOS/CM	LAB PH	TDISS FE MG/L	TDISS SR MG/L	T.DIS.SD MG/L
SLF- 50	1/14/82	715		3560.	7.76	< .02		2005.0
SLF- 50	1/14/82	740		3550.	7.40	< .02		1898.6
SLF- 50	1/26/82	760		3500.	7.93	< .02	14.000	2109.0
SLF- 50	1/26/82	780		3350.	7.95	< .02	12.800	2051.0
SLF- 50	1/26/82	800		3250.	8.13	< .02	12.200	1903.0
SLF- 50	1/26/82	820		3300.	8.13	< .02	11.000	2183.0
SLF- 50	1/26/82	840		3200.	7.98	< .02	6.400	1506.0
SLF- 50	1/26/82	860		2950.	7.96	< .02	10.700	1726.0
SLF- 50	1/26/82	870	4320.	2900.	7.95	< .02	11.000	1685.0
SLF- 50	2/ 3/82	880		2920.	7.80	< .02	11.600	1694.0
SLF- 50	2/ 3/82	900		2725.	7.75	< .02	10.700	1541.0
SLF- 50	2/ 3/82	920		2875.	7.82	< .02	11.100	1587.0
SLF- 50	2/ 3/82	940		2900.	7.75	< .02	11.900	1559.0
SLF- 50	2/ 3/82	960		3100.	7.73	< .02	12.600	1734.0
SLF- 50	2/ 3/82	980		3075.	7.50	< .02	13.400	1905.0
SLF- 50	2/ 3/82	1000	4320.	3050.	7.73	< .02	12.000	1739.0

C. POINT SAMPLES

STATION CODE	DATE MO/DA/YR	DEPTH FEET	NA MG/L	K MG/L	CA MG/L	MG MG/L	CL MG/L	SO4 MG/L	ALK MEQ/L	HARDNESS MG/LCACO
SLF- 50	2/25/82	995'	478.00	15.60	113.60	83.20	882.7	159.6	2.57	626.1
SLF- 50	2/25/82	950'	491.60	15.60	119.50	81.60	898.4	187.3	2.46	634.3
SLF- 50	2/25/82	900'	394.80	13.20	100.40	72.40	751.2	151.1	2.65	548.7
SLF- 50	2/25/82	850'	418.40	14.00	104.30	73.60	781.7	161.0	2.64	563.4
SLF- 50	2/25/82	785'	365.20	12.40	90.60	65.20	677.6	151.9	2.71	494.6
SLF- 50	2/25/82	750'	385.60	13.20	98.70	70.00	740.7	152.5	2.68	534.6
SLF- 50	2/25/82	660'	438.40	14.80	105.00	74.80	809.1	178.7	2.60	570.1
SLF- 50	2/25/82	TOC	470.00	16.00	108.70	78.00	838.5	182.6	2.57	592.5

STATION CODE	DATE MO/DA/YR	DEPTH FEET	LAB COND UMHOS/CM	LAB PH	TDISS FE MG/L	TDISS SR MG/L	T.DISS.SO MG/L
SLF- 50	2/25/82	995'	3550.	7.53	.05	12.800	2200.0
SLF- 50	2/25/82	950'	3550.	7.45	.04	15.400	2220.0
SLF- 50	2/25/82	900'	2950.	7.45	.05	12.700	1834.0
SLF- 50	2/25/82	850'	3050.	7.42	.07	13.100	1933.0
SLF- 50	2/25/82	785'	2650.	7.47	.06	13.000	1591.0
SLF- 50	2/25/82	750'	2875.	7.41	.04	13.100	1732.0
SLF- 50	2/25/82	660'	3150.	7.39	.04	13.400	1911.0
SLF- 50	2/25/82	TOC	3275.	7.40	.03	14.200	2136.0

D. PUMPING TEST SAMPLES

STATION CODE	DATE MO/DA/YR	TIME HOUR,MIN	NA MG/L	K MG/L	CA MG/L	MG MG/L	CL MG/L	SO4 MG/L	ALK MEQ/L	HARDNESS MG/LCACO
				PUMPING TEST 1						
SLF- 50	1/ 5/82	1510.	428.00	15.52	108.10	80.00	1048.2	210.8	2.74	599.2
SLF- 50	1/ 5/82	1600.	449.20	15.70	107.80	78.10	1037.9	216.9	2.83	590.6
SLF- 50	1/ 5/82	1716.	441.20	15.22	107.10	74.24	1031.5	217.8	2.76	573.0
				PUMPING TEST 2						
SLF- 50	1/19/82	1130.	293.20	9.10	70.20		1006.6	176.1	2.65	
SLF- 50	1/19/82	1330.	469.20	15.20	111.90		974.9	195.8	2.68	
SLF- 50	1/20/82	930.	468.40	15.00	113.10		1019.2	199.3	2.74	
SLF- 50	1/21/82	930.	324.00	10.30	80.80		1000.2	194.3	2.85	
				PUMPING TEST 3						
SLF- 50	2/ 2/82		427.00	130.00	106.30	84.00	840.8		2.73	611.2
SLF- 50	2/ 2/82		413.00	130.00	105.10	75.00	799.4		2.73	571.1
				PUMPING TEST 4						
SLF- 50	2/ 9/82	1130.	403.00	13.60	105.80	76.40	817.1	174.2	2.66	578.6
SLF- 50	2/10/82	930.	408.40	13.60	107.00	76.80	808.7	180.1	2.67	583.3
				PUMPING TEST 5						
SLF- 51	8/24/82	1013.	422.80	14.60	111.30	78.00				599.0
SLF- 51	8/25/82	1243.	429.60	15.28	113.60	79.60				611.3
SLF- 51	8/26/82	2043.	420.60	15.04	113.30	80.00				612.2
SLF- 51	8/27/82	843.	429.60	14.88	113.90	80.40				615.3

D. PUMPING TEST SAMPLES (CONTINUED)

STATION CODE	DATE MO/DA/YR	TIME HOUR,MIN	TEMP CENT	SP COND UMHOS/CM	LAB COND UMHOS/CM	LAB PH	T.SUS.SD MG/L	TDISS FE MG/L	TDISS SR MG/L	T.DIS.SD MG/L	ALK MEQ/L
				PUMPING TEST 1							
SLF- 50	1/ 5/82	1510.	26.2		3410.	7.52		.03	15.440	1896.0	2.74
SLF- 50	1/ 5/82	1600.	26.2		3580.	7.42		.04	15.340	1931.0	2.83
SLF- 50	1/ 5/82	1718.	28.4		3400.	7.61		< .02	14.940	1791.0	2.76
				PUMPING TEST 2							
SLF- 50	1/19/82	1130.	30.4	3650.	3540.	7.36	2.0	< .02		2004.0	2.65
SLF- 50	1/19/82	1330.	30.1	3610.	3480.	7.45	5.0	< .02		2085.0	2.68
SLF- 50	1/20/82	930.	29.9	3702.	3480.	7.39	2.0	< .02		2065.0	2.74
SLF- 50	1/21/82	930.	30.0	3535.	3450.	7.50	4.0	.02		2167.0	2.85
				PUMPING TEST 3							
SLF- 50	2/ 2/82		26.0	3350.	3500.	7.48		< .02	12.500	2115.0	2.73
SLF- 50	2/ 2/82				3500.	7.24		< .02	13.600	2127.0	2.73
				PUMPING TEST 4							
SLF- 50	2/ 9/82	1130.	29.7	3290.	3250.	7.37		< .02	12.400	1883.0	2.68
SLF- 50	2/10/82	930.		3350.	3350.	7.45		< .02	12.900	1896.0	2.67
				PUMPING TEST 5							
SLF- 51	8/24/82	1013.	<	.02	3500.	7.39	1979.0				
SLF- 51	8/25/82	1243.	<	.02	3330.	7.43	2280.0				
SLF- 51	8/26/82	2043.	<	.02	3440.	7.45	1936.0				
SLF- 51	8/27/82	843.	<	.02	3340.	7.42	1997.0				

INJECTION TEST

E. INJECTION TEST SAMPLES

STATION CODE	DATE MO/DA/YR	TIME HOUR,MIN	NA MG/L	K MG/L	CA MG/L	MG MG/L	CL MG/L	SO4 MG/L	ALK MEQ/L	HARDNESS MG/LCACO
SLS- 1	10/19/82	1030.	108.90	3.09	160.00	23.50	182.7	224.0	4.27	496.2
SLS- 1	10/20/82	1630.	103.80	2.99	137.30	20.20	148.9	186.2	3.07	426.0
SLS- 1	10/21/82	1730.	112.70	3.38	153.20	22.50	197.0	217.2	3.89	475.2
* SLS- 1	10/21/82	1911.	118.70	3.37	158.80	23.40	196.0	216.9	3.75	492.8

STATION CODE	DATE MO/DA/YR	TIME HOUR,MIN	TEMP CENT	SP COND UMHOS/CM	LAB COND UMHOS/CM	LAB PH	T.SUS.SD MG/L	TOTAL FE MG/L	TDISS FE MG/L	TDISS SR MG/L
SLS- 1	10/19/82	1030.	24.8	1230.	1420.	7.34	2.0	5.24	.20	1.760
SLS- 1	10/20/82	1630.	25.1	1285.	1280.	7.36	3.0	4.57	.15	1.510
SLS- 1	10/21/82	1730.	24.9	1240.	1425.	7.61	1.0	5.52	.25	1.670
* SLS- 1	10/21/82	1911.	24.4	1300.	1465.	7.24	280.0	39.42	.14	1.710

* BACKFLOW FROM INJECTION WELL

F. RECOVERY TEST SAMPLES

STATION CODE	DATE MO/DA/YR	TIME HOUR,MIN	NA MG/L	K MG/L	CA MG/L	MG MG/L	CL MG/L	SO4 MG/L	ALK MEQ/L	HARDNESS MG/LCACO
SLF- 50	11/29/82	1201.	127.60	3.70	144.00	29.10	207.4	202.9	4.32	479.3
SLF- 50	11/29/82	1620.	134.60	3.96	148.50	29.70	217.5	202.2	4.41	493.0
SLF- 50	11/29/82	1750.	138.00	3.98	148.40	30.70	226.5	200.0	4.48	496.9
SLF- 50	11/30/82	703.	136.60	4.18	148.40	30.40	226.5	207.4	4.45	495.7
SLF- 50	11/30/82	733.	139.60	4.25	146.30	30.40	230.5	206.4	4.43	490.4
SLF- 50	11/30/82	1103.	146.60	4.24	147.50	32.10	230.5	201.4	4.29	500.4
SLF- 50	11/30/82	1403.	148.00	4.32	144.80	32.40	230.5	190.3	3.91	494.9
SLF- 50	11/30/82	1703.	155.00	4.60	144.60	34.80	260.6	196.5	4.03	504.3
SLF- 50	12/ 1/82	735.	154.50	4.54	144.50	34.10	261.6	208.9	4.24	501.2
SLF- 50	12/ 1/82	1103.	163.50	4.94	143.80	36.30	265.6	189.1	3.85	508.5
SLF- 50	12/ 1/82	1405.	166.80	4.92	142.20	37.20	270.7	198.5	4.01	508.2
SLF- 50	12/ 2/82	735.	177.60	5.20	140.20	39.10	301.6	208.9	4.19	511.0
SLF- 50	12/ 2/82	1105.	172.40	5.01	142.70	37.40	290.7	206.4	4.12	510.3
SLF- 50	12/ 2/82	1405.	176.00	5.09	118.20	36.00	324.6	202.4	4.11	443.3
SLF- 50	12/ 2/82	1705.	194.00	5.26	121.10	37.50	349.1	207.4	4.16	456.7
SLF- 50	12/ 3/82	735.	189.60	5.29	122.30	37.10	355.2	204.9	4.13	458.1
SLF- 50	12/ 3/82	1105.	186.00	5.41	120.70	37.70	352.2	212.5	4.10	456.6
SLF- 50	12/ 3/82	1405.	196.80	5.45	117.70	37.70	360.3	205.7	4.09	449.1
SLF- 50	12/ 3/82	1705.	230.60	5.74	113.50	38.10	364.3	206.2	4.11	440.2
SLF- 50	12/ 6/82	1100.	191.00	6.02	138.00	40.90	381.0	202.1	4.11	512.9
SLF- 50	12/ 6/82	1400.	192.40	6.17	137.80	42.20	390.4	201.6	4.07	517.8
SLF- 50	12/ 6/82	1700.	191.40	6.29	137.30	43.20	388.3	207.0	4.11	520.6
SLF- 50	12/ 7/82	735.	199.00	6.25	138.50	42.90	400.9	202.1	3.95	522.4
SLF- 50	12/ 7/82	1105.	201.40	6.41	135.90	43.20	411.3	207.0	4.00	517.2
SLF- 50	12/ 7/82	1405.	202.40	6.39	131.50	42.90	398.8	199.7	3.86	504.9
SLF- 50	12/ 7/82	1705.	206.00	6.70	134.30	44.70	420.7	203.8	3.97	519.3
SLF- 50	12/ 8/82	700.	210.60	6.72	134.30	44.30	410.3	205.8	3.97	517.7
SLF- 50	12/ 8/82	1105.	214.40	6.77	134.10	44.60	421.8	204.3	3.95	518.4
SLF- 50	12/ 8/82	1405.	218.40	6.76	131.90	44.90	435.4	205.5	3.92	514.2
SLF- 50	12/ 8/82	1705.	221.80	6.89	131.10	44.80	437.5	204.1	3.89	511.8
SLF- 50	12/ 9/82	735.	227.20	6.90	133.10	45.60	441.7	205.8	3.90	520.0
SLF- 50	12/ 9/82	1105.	219.40	6.94	133.60	46.00	448.0	204.8	3.88	522.9
SLF- 50	12/ 9/82	1405.	226.40	7.45	131.50	45.40	449.0	209.2	3.86	515.2
SLF- 50	12/ 9/82	1805.	233.00	7.28	130.10	44.60	449.0	204.8	3.85	508.4
SLF- 50	12/10/82	1008.	226.60	7.44	131.00	45.00	467.9	198.4	3.89	512.3
SLF- 50	12/10/82	1508.	229.60	7.43	130.40	45.00	473.1	204.6	3.82	510.8
SLF- 50	12/13/82	1000.	179.80	6.25	122.10	42.60	368.4	202.4	3.92	460.2
SLF- 50	12/13/82	1300.	234.60	7.37	129.30	45.00	461.6	199.7	3.78	508.1
SLF- 50	12/13/82	1600.	228.80	7.52	129.90	45.40	454.3	203.8	3.79	511.2
SLF- 50	12/13/82	1800.	115.10	3.66	63.90	23.40	474.2	204.8	3.74	255.9

F. RECOVERY TEST SAMPLES (CONTINUED)

STATION CODE	DATE MO/DA/YR	TIME HOUR,MIN	NA MG/L	K MG/L	CA MG/L	MG MG/L	CL MG/L	SO4 MG/L	ALK MEQ/L	HARDNESS MG/LCACO
SLF- 50	12/14/82	700.	195.80	6.55	130.40	43.60	378.9	205.8	4.02	505.1
SLF- 50	12/14/82	1100.	141.40	4.52	79.50	29.20	477.3	203.1	3.75	318.7
SLF- 50	12/14/82	1400.	228.80	7.36	122.10	46.80	467.9	204.8	3.77	497.5
SLF- 50	12/14/82	1700.	242.40	7.86	128.40	49.60	483.6	201.9	3.72	524.8
SLF- 50	12/15/82	710.	134.80	4.72	70.10	27.20	488.8	206.0	3.74	287.0
SLF- 50	12/15/82	1000.	247.20	8.13	126.90	48.56	499.5	193.9	3.64	521.7
SLF- 50	12/15/82	1310.	253.20	8.32	129.60	48.16	494.5	197.1	3.70	521.8
SLF- 50	12/15/82	1710.	250.00	8.27	128.30	48.04	498.6	200.8	3.65	518.1
SLF- 50	12/16/82	700.	255.60	8.32	130.20	48.40	490.3	199.5	3.71	524.5
SLF- 50	12/16/82	1000.	257.60	8.43	130.60	49.04	514.1	197.8	3.69	523.8
SLF- 50	12/16/82	1300.	258.40	8.43	129.80	48.20	519.2	203.6	3.68	522.5
SLF- 50	12/16/82	1700.	253.20	8.50	129.30	50.32	520.2	205.0	3.65	530.0
SLF- 50	12/17/82	645.	260.00	8.33	127.40	44.40	513.0	205.0	3.67	500.9
SLF- 50	12/17/82	1000.	164.80	5.24	80.80	33.64	530.6	203.9	3.62	340.2
SLF- 50	12/21/82	1015.	213.20	7.47	128.00	46.72	436.7	199.5	3.72	511.9
SLF- 50	12/21/82	1315.	266.60	8.66	130.80	47.72	504.8	206.6	3.60	523.0
SLF- 50	12/21/82	1615.	272.00	8.91	131.40	46.72	520.2	204.2	3.58	520.4
SLF- 50	12/22/82	700.	258.60	8.90	130.10	43.40	488.3	194.8	3.35	503.5
SLF- 50	12/22/82	900.	227.60	7.59	109.50	40.56	544.0	206.6	3.58	440.4
SLF- 50	12/22/82	1030.	277.60	9.05	128.70	50.56	553.9	206.4	3.57	529.5
SLF- 50	1/19/83	1100.	229.60	7.50	117.90	48.80	500.5	144.6	3.70	495.3
SLF- 50	1/19/83	1700.	267.20	8.38	117.70	53.40	576.1	155.2	3.58	513.7
SLF- 50	1/20/83	700.	291.60	9.54	120.70	59.40	627.5	160.0	3.49	545.9
SLF- 50	1/20/83	1700.	299.60	9.75	118.40	59.80	641.7	161.0	3.42	541.8
SLF- 50	1/21/83	700.	302.80	9.97	112.80	59.60	681.0	155.2	3.29	527.0
SLF- 50	1/21/83	1600.	320.80	10.66	112.50	59.60	698.1	157.3	3.26	526.2
SLF- 50	1/24/83	1100.	292.00	9.35	112.00	57.20	658.8	147.8	3.39	515.1
SLF- 50	1/24/83	1700.	321.20	10.71	117.70	61.40	711.3	153.1	3.30	546.6
SLF- 50	1/25/83	700.	344.00	11.02	119.60	65.80	722.3	145.2	3.22	569.5
SLF- 50	1/25/83	1700.	348.00	10.72	114.90	67.60	743.5	154.7	3.09	565.1
SLF- 50	1/26/83	700.	364.00	11.24	116.20	68.00	767.7	160.0	3.07	570.0
SLF- 50	1/26/83	1700.	365.20	11.34	116.50	67.20	777.8	143.6	3.04	567.5
SLF- 50	1/27/83	700.	354.80	11.30	112.30	68.60	787.9	152.6	3.01	562.8
SLF- 50	1/27/83	1630.	374.00	11.36	110.60	67.40	794.0	158.9	2.99	553.6
SLF- 50	2/ 1/83	1100.	376.80	11.88	117.10	67.80	803.0	172.5	2.96	571.5
SLF- 50	2/ 1/83	1700.	377.60	11.80	115.30	67.80	805.0	177.3	2.93	567.0
SLF- 50	2/ 2/83	700.	376.40	12.40	116.70	68.60	768.0	162.3	2.73	573.8
SLF- 50	2/ 2/83	1700.	383.20	11.92	114.70	68.60	821.5	178.4	2.88	568.8
SLF- 50	2/ 3/83	700.	390.40	12.20	111.00	68.80	799.9	164.4	2.70	560.3
SLF- 50	2/ 3/83	1700.	404.40	12.48	115.00	70.40	859.7	170.3	2.87	576.9
SLF- 50	2/ 4/83	730.	402.80	12.68	114.40	72.00	854.5	177.3	2.82	582.0

F. RECOVERY TEST SAMPLES (CONTINUED)

STATION CODE	DATE MO/DA/YR	TIME HOUR,MIN	TEMP CENT	SP COND UMHOS/CM	LAB COND UMHOS/CM	LAB PH	TOTAL FE MG/L	TDISS FE MG/L	TDISS SR MG/L	T.DIS.SO MG/L
SLF- 50	11/29/82	1201.	26.0	1334.	1500.	7.02		< .03	2.660	975.0
SLF- 50	11/29/82	1620.	26.0	1404.	1520.	7.17	2.08	< .03	3.720	975.0
SLF- 50	11/29/82	1750.	25.9	1422.	1560.	7.05	1.78	< .03	3.750	968.0
SLF- 50	11/30/82	705.	27.0	1432.	1540.	7.03	1.62	< .03	3.940	950.0
SLF- 50	11/30/82	735.	26.0	1423.	1540.	7.00	1.87	< .03	3.850	992.0
SLF- 50	11/30/82	1105.	26.1	1426.	1580.	7.04	1.05	< .03	4.300	960.0
SLF- 50	11/30/82	1405.	26.2	1452.	1580.	7.06	.65	< .03	4.400	1006.0
SLF- 50	11/30/82	1705.	26.2	1468.	1640.	7.12	.65	< .03	4.660	1009.0
SLF- 50	12/ 1/82	735.	26.2	1492.	1640.	7.10	1.46	< .03	4.530	985.0
SLF- 50	12/ 1/82	1105.	26.2	1505.	1650.	7.18	.90	< .03	4.940	1032.0
SLF- 50	12/ 1/82	1405.	25.7	1514.	1650.	7.07	1.47	< .03	4.910	1085.0
SLF- 50	12/ 2/82	735.	26.3	1556.	1730.	7.06	1.55	< .03	5.420	1048.0
SLF- 50	12/ 2/82	1105.	26.2	1556.	1700.	7.04	1.36	< .03	5.140	1055.0
SLF- 50	12/ 2/82	1405.	26.3	1565.	1740.	7.06	1.29	< .03	5.070	1317.0
SLF- 50	12/ 2/82	1705.	26.3	1595.	1750.	7.03	1.08	< .03	5.440	1282.0
SLF- 50	12/ 3/82	735.	26.3	1605.	1750.	7.14	1.92	< .03	5.270	1160.0
SLF- 50	12/ 3/82	1105.	26.4	1606.	1760.	7.04	1.21	< .03	5.720	1219.0
SLF- 50	12/ 3/82	1405.	26.4	1613.	1800.	7.04	1.21	< .03	5.820	1238.0
SLF- 50	12/ 3/82	1705.	26.4	1644.	1840.	7.06	1.08	< .03	6.090	1228.0
SLF- 50	12/ 6/82	1100.	26.4	1618.	1502.	6.50	.99	.04	5.730	1151.0
SLF- 50	12/ 6/82	1400.	26.4	1638.	1450.	6.46	.78	.10	5.820	1168.0
SLF- 50	12/ 6/82	1700.	26.4	1650.	1460.	6.60	.55	.07	6.160	1244.0
SLF- 50	12/ 7/82	735.	26.6	1668.	1460.	6.66	.59	.06	6.180	1213.0
SLF- 50	12/ 7/82	1105.	26.7	1676.	1442.	6.67	.52	.10	6.030	1197.0
SLF- 50	12/ 7/82	1405.	26.7	1679.	1488.	6.72	.58	.04	6.180	1135.0
SLF- 50	12/ 7/82	1705.	26.7	1702.	1590.	6.73	.67	< .02	6.310	1232.0
SLF- 50	12/ 8/82	700.	26.7	1715.	1580.	6.77	2.13	.05	6.430	1204.0
SLF- 50	12/ 8/82	1105.	26.7	1707.	1582.	6.76	.56	.09	6.680	1257.0
SLF- 50	12/ 8/82	1405.	26.7	1712.	1620.	6.83	.47	.05	6.140	1221.0
SLF- 50	12/ 8/82	1705.	26.7	1740.	1548.	6.83	.59	.05	6.970	1255.0
SLF- 50	12/ 9/82	735.	26.7	1746.	1560.	6.84	.73	.02	7.010	1292.0
SLF- 50	12/ 9/82	1105.	26.8	1757.	1600.	6.87	.63	.08	7.210	1225.0
SLF- 50	12/ 9/82	1405.	26.9	1750.	1690.	6.87	.55	.31	6.690	1290.0
SLF- 50	12/ 9/82	1805.	26.7	1777.	1710.	6.88	.66	.02	7.150	1235.0
SLF- 50	12/10/82	1008.	26.9	1770.	1660.	6.90	.63	.04	6.840	1245.0
SLF- 50	12/10/82	1508.	26.9	1770.	1700.	6.92	.66	.04	7.640	1298.0
SLF- 50	12/13/82	1000.	26.6	1440.	1550.	7.04	3.31	.16	3.890	1245.0
SLF- 50	12/13/82	1300.	26.8	1768.	1670.	7.17	.65	.62	4.060	1275.0
SLF- 50	12/13/82	1600.	26.8	1796.	1640.	7.19	.69	.52	4.780	1290.0
SLF- 50	12/13/82	1800.	26.8	1822.	1840.	7.21	.62	.04	8.210	1286.0

F. RECOVERY TEST DATA (CONTINUED)

STATION CODE	DATE MO/DA/YR	TIME HOUR,MIN	TEMP CENT	SP COND UMHOS/CM	LAB COND UMHOS/CM	LAB PH	TOTAL FE MG/L	TDISS FE MG/L	TDISS SR MG/L	T.DIS.SL MG/L
SLF- 50	12/14/82	700.	26.1	1813.	1640.	7.24	2.33	.13	4.170	1177.0
SLF- 50	12/14/82	1100.	26.8	1812.	1860.	7.23	.80	< .02	6.270	1396.0
SLF- 50	12/14/82	1400.	27.0	1852.	1920.	7.23	.75	.08	6.580	1578.0
SLF- 50	12/14/82	1700.	26.9	1818.	1890.	7.22	.06	.63	5.210	1363.0
SLF- 50	12/15/82	710.	26.8	1871.	1900.	7.24	.58	.09	6.410	1343.0
SLF- 50	12/15/82	1000.	25.5	1818.	1940.	6.34	.36	< .02	5.210	1435.0
SLF- 50	12/15/82	1310.	25.5	1817.	1950.	6.42	.33	.08	4.560	1314.0
SLF- 50	12/15/82	1710.	25.5	1815.	1960.	6.50	.67	< .02	4.840	1389.0
SLF- 50	12/16/82	700.	25.5	1837.	1955.	5.60	.27	< .02	4.630	1460.0
SLF- 50	12/16/82	1000.	25.5	1825.	1900.	5.65	.24	.10	5.060	1432.0
SLF- 50	12/16/82	1300.	25.5	1827.	1947.	6.60	.30	.06	5.060	1435.0
SLF- 50	12/16/82	1700.	25.5	1843.	1950.	6.59	.27	< .02	5.580	1456.0
SLF- 50	12/17/82	645.	25.5	1849.	1940.	6.62	.77	< .02	5.520	1598.0
SLF- 50	12/17/82	1000.	25.5	1842.	2020.	6.61	.33	.02	9.160	1608.0
SLF- 50	12/21/82	1015.	27.0	1623.	1820.	6.65	2.96	.07	8.330	1056.0
SLF- 50	12/21/82	1315.	27.4	1715.	2050.	6.66	.64	.10	6.820	1572.0
SLF- 50	12/21/82	1615.	27.3	1713.	2050.	6.67	.54	.37		1552.0
SLF- 50	12/22/82	700.	27.2	1740.	2050.	6.64	3.24	.90	9.360	1472.0
SLF- 50	12/22/82	900.	27.3	1714.	2010.	6.72	2.40		9.420	1500.0
SLF- 50	12/22/82	1030.	27.4	1702.	2050.	6.71	.57		9.000	1542.0
SLF- 50	1/19/83	1100.	27.4	1688.	2110.	6.60	.89	.05	7.530	1546.0
SLF- 50	1/19/83	1700.	27.4	1824.	2320.	6.66	.65	.07	6.380	1750.0
SLF- 50	1/20/83	700.	27.5	1924.	2390.	6.90	.32	.15		1820.0
SLF- 50	1/20/83	1700.	27.5	1912.	2490.	6.70	.29	.10	9.420	1618.0
SLF- 50	1/21/83	700.	27.7	1922.	2540.	6.99	< .03	< .03	9.540	1652.0
SLF- 50	1/21/83	1600.	27.8	1960.	2600.	6.72	< .03	< .03	9.510	1736.0
SLF- 50	1/24/83	1100.	27.6	1892.	2560.	6.79	.54	.05	9.040	1620.0
SLF- 50	1/24/83	1700.	27.8	1962.	2700.	6.98	.29	.12	9.810	1706.0
SLF- 50	1/25/83	700.	27.6	1995.	2750.	7.05	< .03	.03	10.490	1706.0
SLF- 50	1/25/83	1700.	27.6	2032.	2750.	6.76	.24	.04	10.500	1746.0
SLF- 50	1/26/83	700.	27.6	2087.	2840.	6.67	< .03	< .03	10.860	1728.0
SLF- 50	1/26/83	1700.	27.7	2096.	2540.	6.93	.21	< .03	10.860	1722.0
SLF- 50	1/27/83	700.	27.7	2113.	2860.	6.96	.16	.05	10.920	1772.0
SLF- 50	1/27/83	1630.	27.8	2140.	2940.	7.01	.25	.08	10.960	1784.0
SLF- 50	2/ 1/83	1100.	27.7	2210.	2346.	6.71	.17	.09	12.840	1594.0
SLF- 50	2/ 1/83	1700.	27.3	2218.	2400.	6.87	.26	.04	12.660	1736.0
SLF- 50	2/ 2/83	700.	27.8	2198.	2405.	6.93	.25	.06	13.380	2066.0
SLF- 50	2/ 2/83	1700.	26.0	2203.	2700.	6.98	.22	.06	13.400	1710.0
SLF- 50	2/ 3/83	700.	28.0	2248.	2490.	7.11	.25	< .03	13.060	1916.0
SLF- 50	2/ 3/83	1700.	27.8	2231.	2460.	7.09	.21	.09	13.460	1818.0
SLF- 50	2/ 4/83	730.	26.0	2207.	2440.	7.16	.24	.22	13.420	1812.0

G. PACKER TEST VALUES

STATION CODE	DATE MO/DA/YR	TIME HOUR,MIN	NA MG/L	K MG/L	CA MG/L	MG MG/L	CL MG/L	SO4 MG/L	ALK MEQ/L	HARDNESS MG/LCACO
SLF- 50	3/12/82	1035.	485.60	14.80	114.20	81.60	1025.7	176.2	2.62	621.0
SLF- 50	3/12/82	1200.	502.40	16.00	112.70	76.00	886.2	161.2	2.24	594.2
SLF- 50	3/12/82	1335.	451.20	13.60	108.90	77.20	1015.3	177.4	2.56	589.7
SLF- 50	3/12/82	1500.	476.80	14.80	107.50	78.80	954.9	184.2	2.26	592.8
SLF- 51	3/12/82	1200.	494.40	15.60	113.10	80.00	1021.5	199.2	2.40	611.7
SLF- 51	3/12/82	1335.	501.60	16.00	111.50	81.60	1077.8	193.0	2.53	614.3

STATION CODE	DATE MO/DA/YR	TIME HOUR,MIN	LAB COND UMHOS/CM	LAB PH	T.DIS.SO MG/L	TDISS FE MG/L	TDISS SR MG/L	COMMENTS
SLF- 50	3/12/82	1035.	3450.	7.63	1474.0	.03	16.400	BELOW PACKER
SLF- 50	3/12/82	1200.	3400.	7.53	2056.0	.03	15.600	ABOVE PACKER
SLF- 50	3/12/82	1335.	3200.	7.55	1888.0	.03	15.600	BELOW PACKER
SLF- 50	3/12/82	1500.	3325.	7.45	2379.0	.03	15.400	COMBO WELLHEAD
SLF- 51	3/12/82	1200.	3500.		2143.0	.03	15.600	OBS. WELL
SLF- 51	3/12/82	1335.	3500.	6.17	2180.0	.03	15.600	OBS. WELL

APPENDIX 4

Aquifer Test Data and Analyses

APPENDIX 4a. Aquifer Test No. 1

PUMPED WELL: SLF-50

DATE: 1/5/82 to 1/6/82

CASING DEPTH: 600 ft

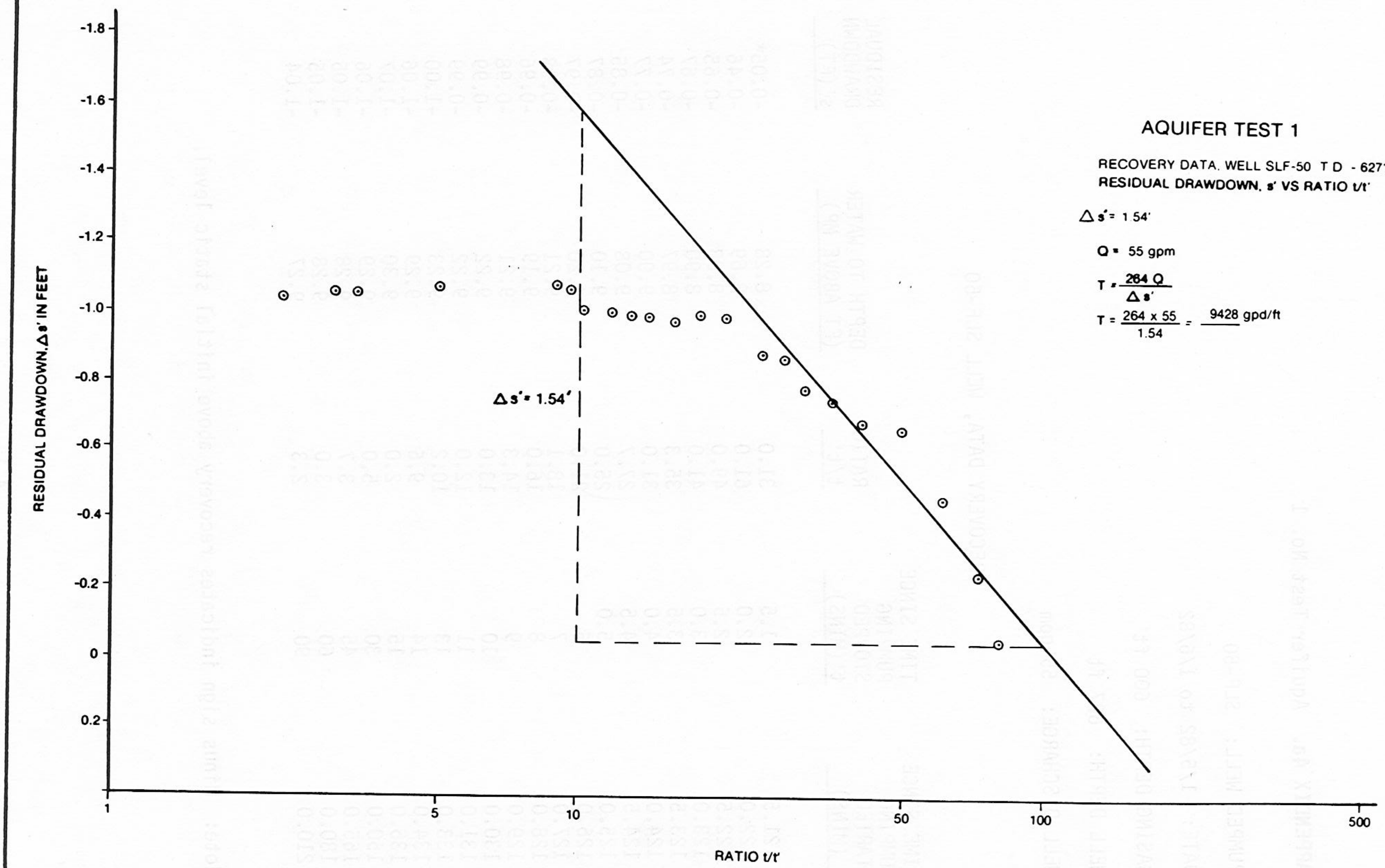
WELL DEPTH: 627 ft

WELL DISCHARGE: 55 gpm

RECOVERY DATA, WELL SLF-50

TIME SINCE PUMPING STARTED t (MINS)	TIME SINCE PUMPING STOPPED t'(MINS)	RATIO t/t'	DEPTH TO WATER (FT ABOVE MP)	RESIDUAL DRAWDOWN s'(FT)
121.5	1.5	31.0	8.28	-0.05*
122.0	2.0	61.0	8.69	-0.46
122.5	2.5	49.0	8.88	-0.65
123.0	3.0	41.0	8.90	-0.67
123.5	3.5	35.3	8.97	-0.74
124.0	4.0	31.0	9.00	-0.77
124.5	4.5	27.7	9.08	-0.85
125.0	5.0	25.0	9.10	-0.87
126.0	6	21.0	9.20	-0.97
127.0	7	18.1	9.21	-0.98
128.0	8	16.0	9.19	-0.96
129.0	9	14.3	9.21	-0.98
130.0	10	13.0	9.22	-0.99
131.0	11	12.0	9.22	-0.99
133.0	13	10.2	9.23	-1.00
134.0	14	9.6	9.29	-1.06
135.0	15	2.0	9.30	-1.07
150.0	30	5.0	9.29	-1.06
165.0	45	3.7	9.28	-1.05
180.0	60	3.0	9.28	-1.05
210.0	90	2.3	9.27	-1.04

*Note: Minus sign indicates recovery above initial static level.


AQUIFER TEST 1
RECOVERY DATA, WELL SLF-50 T D - 627'.
RESIDUAL DRAWDOWN, s' VS RATIO t/t'
Δs' = 1.54'
Q = 55 gpm
T = 264 Q / Δs'
T = 264 x 55 / 1.54 = 9428 gpd/ft
Δs' = 1.54'
RESIDUAL DRAWDOWN, Δs' IN FEET
-1.8
-1.6
-1.4
-1.2
-1.0
-0.8
-0.6
-0.4
-0.2
0
0.2
1
5
10
50
100
500
RATIO t/t'

APPENDIX 4b. Aquifer Test No. 2

PUMPED WELL: SLF-50

DATE: 1/21/82

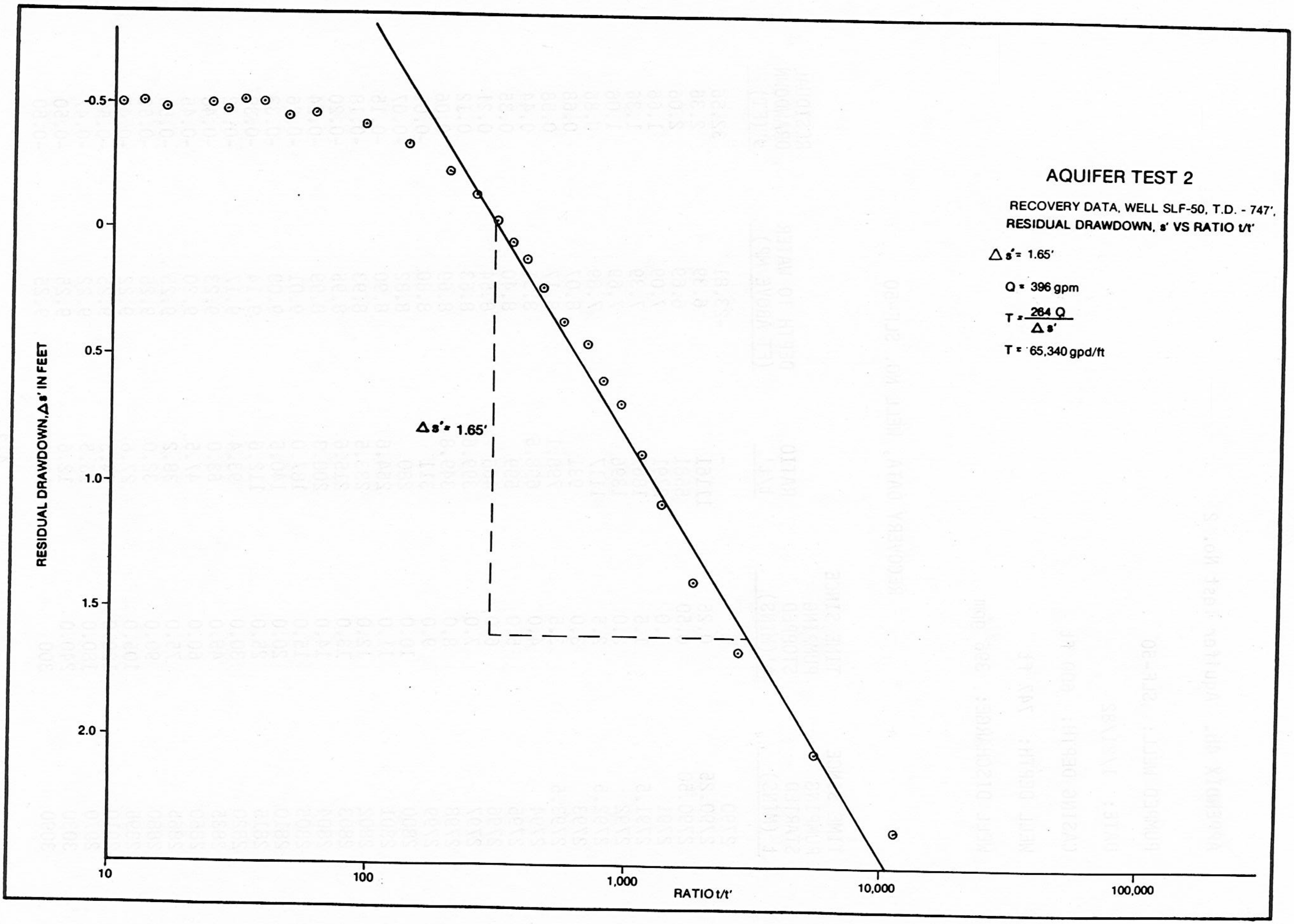
CASING DEPTH: 600 ft

WELL DEPTH: 747 ft

WELL DISCHARGE: 396 gpm

RECOVERY DATA, WELL NO. SLF-50

TIME SINCE PUMPING STARTED t (MINS)	TIME SINCE PUMPING STOPPED t'(MINS)	RATIO t/t'	DEPTH TO WATER (FT ABOVE MP)	RESIDUAL DRAWDOWN s'(FT)
2790	0	-	-23.81	32.56
2790.25	0.25	11161	6.39	2.36
2790.50	0.50	5581	6.69	2.06
2791	1.0	2791	7.09	1.66
2791.5	1.5	1861	7.39	1.36
2792	2.0	1396	7.69	1.06
2792.5	2.5	1117	7.89	0.86
2793	3.0	931	8.07	0.68
2793.5	3.5	798.1	8.17	0.58
2794	4.0	698.5	8.31	0.44
2795	5.0	559	8.40	0.35
2796	6.0	466	8.54	0.21
2797	7.0	399.6	8.63	0.12
2798	8.0	349.8	8.69	0.06
2799	9.0	311	8.80	-0.05
2800	10.0	280	8.82	-0.07
2801	11.0	254.6	8.90	-0.15
2802	12.0	233.5	8.93	-0.18
2803	13.0	215.6	8.95	-0.20
2804	14.0	200.3	8.99	-0.24
2805	15.0	187.0	9.01	-0.26
2810	20.0	140.5	9.08	-0.33
2815	25.0	112.6	9.14	-0.39
2820	30.0	93.4	9.17	-0.42
2835	45.0	63.0	9.23	-0.48
2850	60.0	47.5	9.20	-0.45
2865	75.0	38.2	9.25	-0.50
2880	90.0	32.0	9.25	-0.50
2895	105.0	27.6	9.22	-0.47
2910	120.0	24.3	9.25	-0.50
2970	180.0	16.5	9.22	-0.47
3030	240.0	12.6	9.25	-0.50
3090	300	10.3	9.25	-0.50


AQUIFER TEST 2
RECOVERY DATA, WELL SLF-50, T.D. - 747',
RESIDUAL DRAWDOWN, s' VS RATIO t/t'
△s' = 1.65'
Q = 396 gpm
T = 264 Q / △s'
T = 65,340 gpd/ft
△s' = 1.65'
RESIDUAL DRAWDOWN, △s' IN FEET
RATIO t/t'
-0.5
0
0.5
1.0
1.5
2.0
10
100
1,000
10,000
100,000

APPENDIX 4c. Aquifer Test No. 3

PUMPED WELL: SLF-50

DATE: 2/2/83

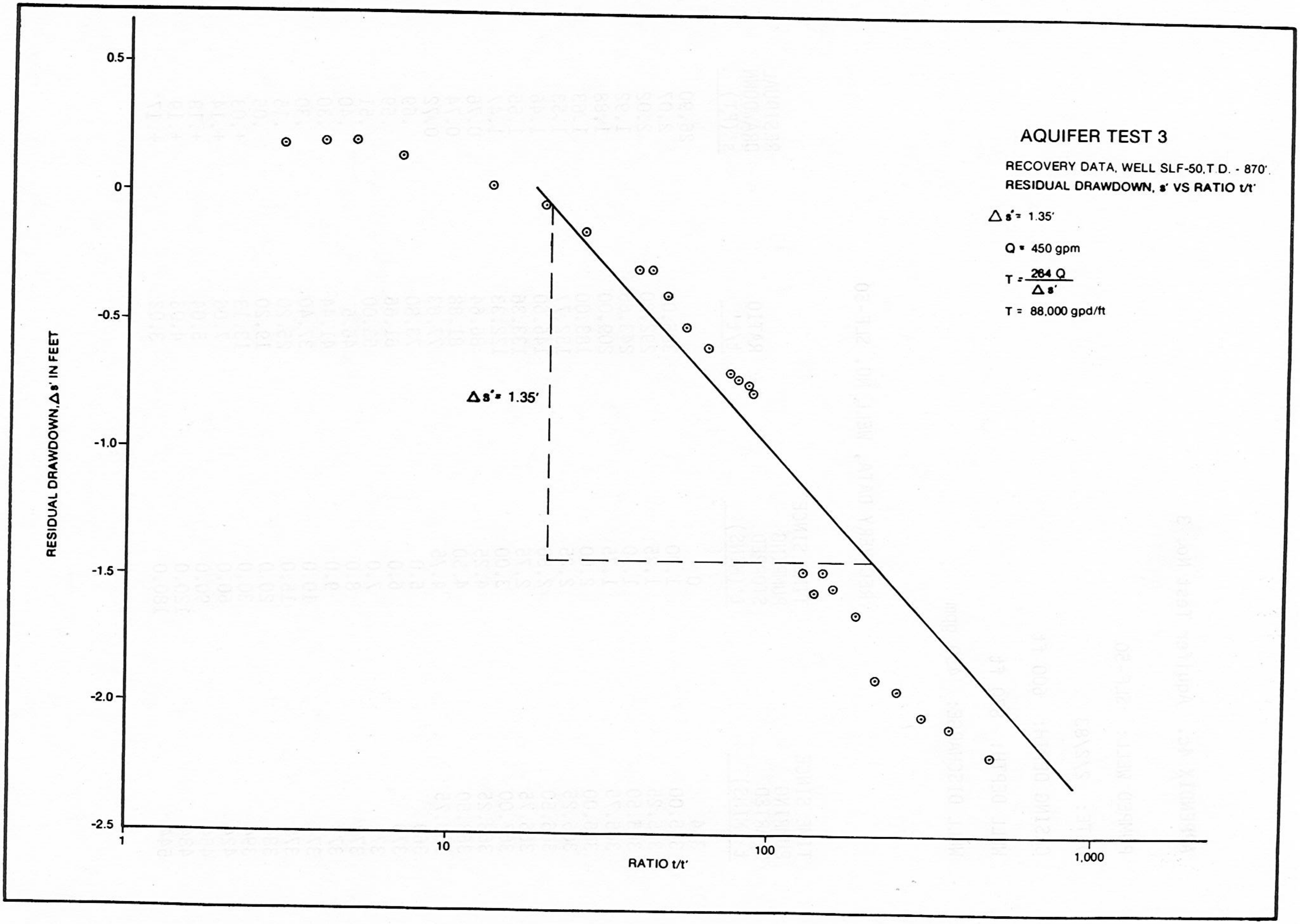
CASING DEPTH: 600 ft

WELL DEPTH: 870 ft

WELL DISCHARGE: 450 gpm

RECOVERY DATA, WELL NO. SLF-50

TIME SINCE PUMPING STARTED t (MINS)	TIME SINCE PUMPING STOPPED t'(MINS)	RATIO t/t'	RESIDUAL DRAWDOWN s'(FT)
364	0	-	26.90
365.00	1.00	365.00	2.07
365.25	1.25	292.20	2.02
365.50	1.50	243.66	1.92
365.75	1.75	209.00	1.88
366.00	2.00	183.00	1.63
366.25	2.25	152.77	1.53
366.50	2.50	146.60	1.46
366.75	2.75	133.36	1.55
367.00	3.00	122.33	1.47
368.25	4.25	86.64	0.76
368.50	4.50	81.88	0.74
368.75	4.75	77.63	0.72
369	5.0	73.80	.69
370	6.0	61.66	.59
371	7.0	53.00	.51
372	8.0	46.5	.40
373	9.0	41.44	.30
374	10.0	37.40	.30
379	15.0	25.20	.15
384	20.0	19.20	.05
394	30.0	13.13	+.03
424	60.0	7.06	+.14
454	90.0	5.04	+.18
484	120.0	4.03	+.19
544	180.0	3.02	+.17


AQUIFER TEST 3
RECOVERY DATA, WELL SLF-50, T.D. - 870'
RESIDUAL DRAWDOWN, s' VS RATIO t/t'
Δs' = 1.35'
Q = 450 gpm
T = 264 Q / Δs'
T = 88,000 gpd/ft
Δs' = 1.35'
RESIDUAL DRAWDOWN, Δs' IN FEET
0.5
0
-0.5
-1.0
-1.5
-2.0
-2.5
1
10
100
1,000
RATIO t/t'

APPENDIX 4d. Aquifer Test No. 4

PUMPED WELL: SLF-50

DATE: 2/10/82 to 2/11/82

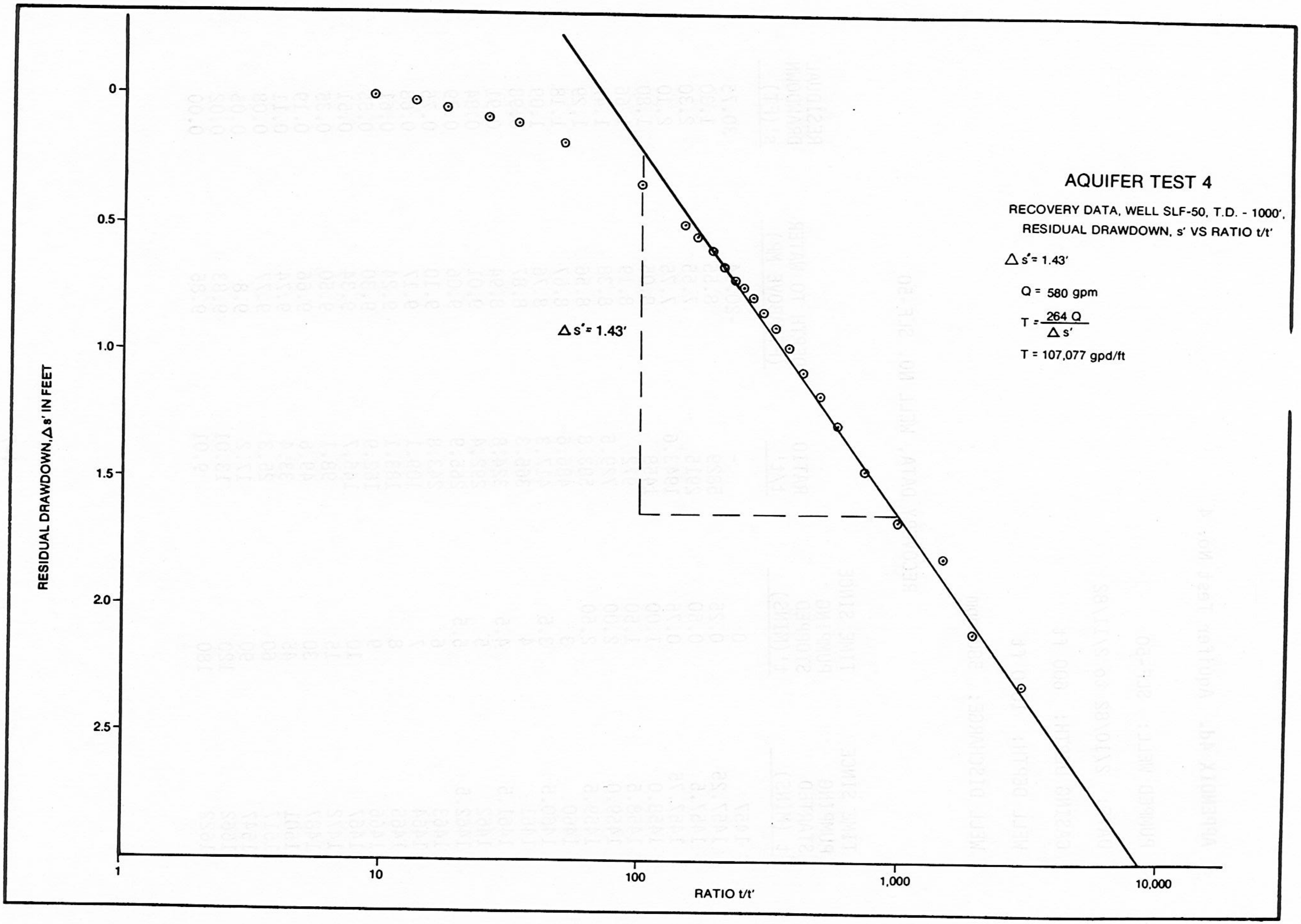
CASING DEPTH: 600 ft

WELL DEPTH: 1000 ft

WELL DISCHARGE: 580 gpm

RECOVERY DATA, WELL NO. SLF-50

TIME SINCE PUMPING STARTED t (MINS)	TIME SINCE PUMPING STOPPED t'(MINS)	RATIO t/t'	DEPTH TO WATER (FT ABOVE MP)	RESIDUAL DRAWDOWN s'(FT)
1457	0	-	-20.94	30.75
1457.25	0.25	5829	8.55	1.30
1457.5	0.50	2915	7.55	2.30
1457.75	0.75	1943.6	7.75	2.10
1458.0	1.00	1458	8.05	1.80
1458.5	1.50	972	8.19	1.66
1459.0	2.00	729.5	8.38	1.47
1459.5	2.50	583.8	8.56	1.29
1460	3	486.6	8.67	1.18
1460.5	3.5	417.3	8.76	1.09
1461	4	365.3	8.87	0.98
1461.5	4.5	324.8	8.94	0.91
1462	5	292.4	9.01	0.84
1462.5	5.5	265.9	9.06	0.79
1463	6	243.8	9.10	0.75
1464	7	109.1	9.17	0.68
1465	8	183.1	9.24	0.61
1466	9	162.9	9.30	0.55
1467	10	146.7	9.34	0.51
1472	15	98.1	9.50	0.35
1487	30	49.6	9.66	0.19
1501	45	33.4	9.74	0.11
1517	60	25.3	9.77	0.08
1547	90	17.2	9.8	0.05
1562	120	13.01	9.83	0.02
1622	180	9.01	9.85	0.00



AQUIFER TEST 4
RECOVERY DATA, WELL SLF-50, T.D. - 1000',
RESIDUAL DRAWDOWN, s' VS RATIO t/t'
Δ s' = 1.43'
Q = 580 gpm
T = 264 Q / Δ s'
T = 107,077 gpd/ft
Δ s' = 1.43'
RESIDUAL DRAWDOWN, Δ s' IN FEET
0
0.5
1.0
1.5
2.0
2.5
1
10
100
1,000
10,000
RATIO t/t'

APPENDIX 4e. Aquifer Test No. 5 (8/24/82 to 8/26/82)

Table . Data on Wells Used in Pumping Test

WELL NUMBER	DEPTH (FT)	CASING DEPTH (FT)	CASING DIAMETER (INCHES)	DISTANCE FROM PUMPED WELL (FT)
SLF-49	893	560	6	428.34
SLF-50	775	600	6	147.90
SLF-51	775	600	6	-

PUMPING DATA, AQUIFER TEST NO. 5

ELAPSED TIME (MINS)	DRAWDOWN SLF-49 (FT)	DRAWDOWN SLF-50 (FT)	DRAWDOWN SLF-51 (FT)	PUMPING RATE (GAL/MIN)
0	0	0	0	0
0.25	0	0.19	41.11	393
.50	.01	0.56		455
.75	.01	0.84		413
1.00	.01	1.04	40.30	396
1.25	.01	1.19		469
1.50	.01	1.31		463
1.75	.01	1.42		450
2.00	.02	1.51	40.44	444
2.25	.02	1.59		437
2.50	.02	1.66	41.32	440
2.75	.02	1.73		432
3.00	.02	1.78	42.09	413
3.25	.02	1.83		406
3.50	.02	1.86	39.97	403
3.75	.02	1.90		388
4.00	.02	1.93	38.59	375
4.25	.02	1.96		369
4.50	.02	1.98		380
4.75	.03	1.99		375
5.00	.02	2.00	36.7	385
6.00	.025	2.03	34.84	377
7	.025	2.01	32.99	378
8	.03	2.01	31.33	369
9	.03	2.01	30.90	366
10	.03	2.01	30.79	355
11.00	.03	2.01	30.92	360
12	.03	2.02	30.94	358
13	.03	2.04	31.03	360
14	.03	2.05	31.08	360
15	.03	2.07	31.17	358
20	.03	2.12	31.24	360
25	.03	2.16	32.72	369

PUMPING DATA, AQUIFER TEST NO. 5 (Continued)

ELAPSED TIME (MINS)	DRAWDOWN SLF-49 (FT)	DRAWDOWN SLF-50 (FT)	DRAWDOWN SLF-51 (FT)	PUMPING RATE (GAL/MIN)
30	.03	2.22	31.98	372
60	.035	2.28	32.06	369
90	.035	2.25	32.12	360
120	.035	2.24	32.12	360
150	.035	2.23	32.32	357
180	.035	2.28	33.69	369
240	.02	2.40	33.34	385
300	.02	2.39	33.39	380
360	.01	2.37	33.19	380
420	.00	2.33	33.19	380
480	.00	2.30	33.24	383
540	.01	2.28	33.24	383
600	.02	2.28	34.18	385
660	.04	2.29	34.11	384
780	.06	2.30	34.37	388
840	.07	2.31	34.63	388
900	.08	2.315	34.51	388
960	.08	2.32	34.73	388
1020	.08	2.32	34.64	388
1320	.11	2.33	34.84	389
1380	.11	2.33	34.81	389
1440	.10	2.34	34.73	388
1500	.105	2.34	34.93	389
1560	.09	2.32	34.83	385
1620	.07	2.32	34.73	388
1680	.04	2.31	34.99	388
1740	.02	2.28	34.98	389
1800	.00	2.27	35.03	388
1860	.01	2.26	NR	390
1920	.00	2.27	35.03	390
1980	.03	2.25	34.775	389
2220	.07	2.27	34.91	390
2280	.08	2.28	34.84	390
2340	.07	2.27	35.11	390
2400	.08	2.31	35.38	393
2460	.07	2.30	35.08	391
2640	.06	2.27	35.20	389
2700	.07	2.28	35.24	389
2760	.08	2.29	35.31	391
2820	.09	2.31	35.35	391
2880	.08	2.30	34.93	388
3000	.09	2.31	35.31	389
3060	.07	2.31	35.31	389
3120	.05	2.25	34.17	380
3180	.03	2.21	34.01	381
3240	.00	2.19	34.16	381
3300	.03	2.22	34.31	384

PUMPING DATA, AQUIFER TEST NO. 5 (Continued)

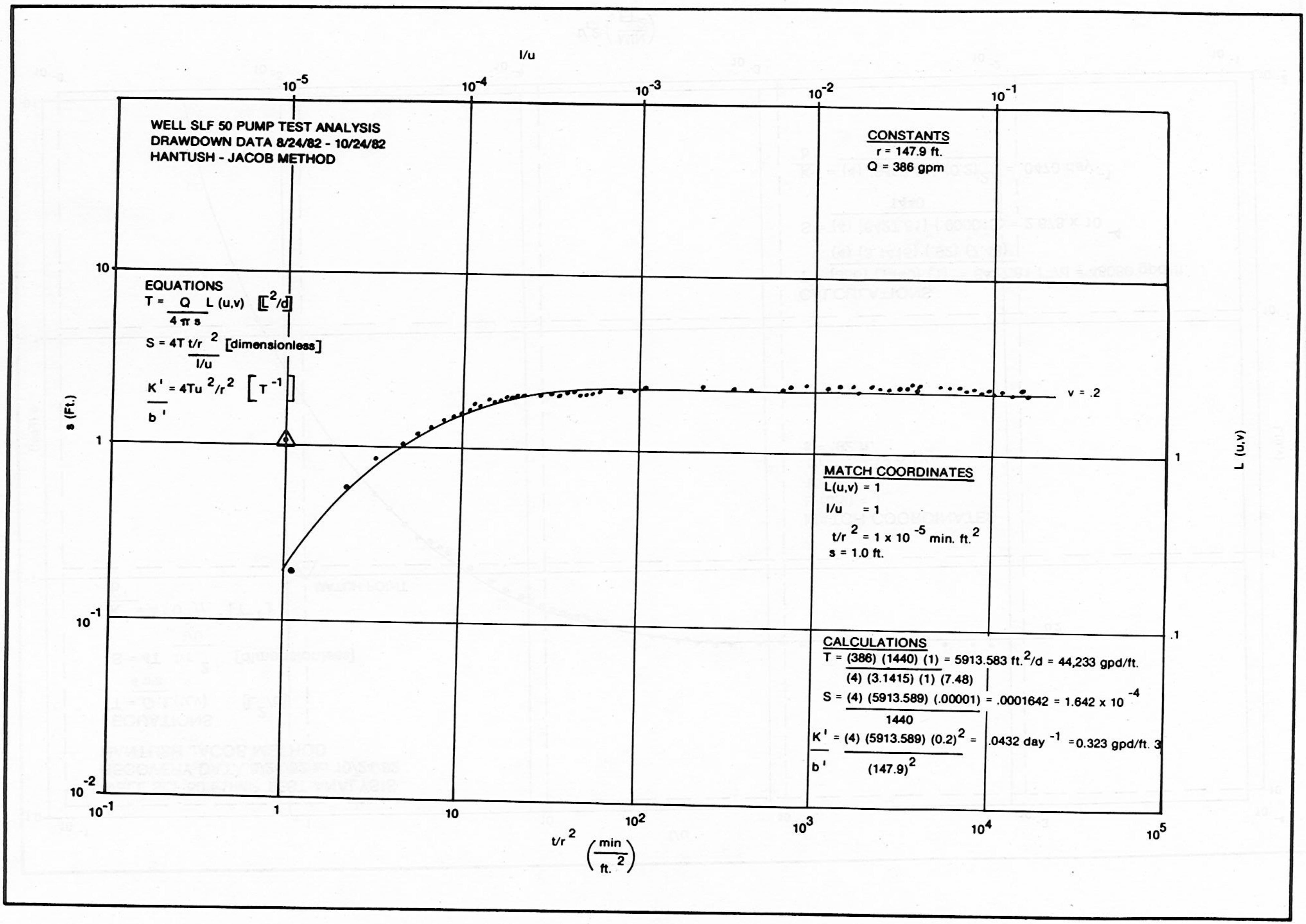
ELAPSED TIME (MINS)	DRAWDOWN SLF-49 (FT)	DRAWDOWN SLF-50 (FT)	DRAWDOWN SLF-51 (FT)	PUMPING RATE (GAL/MIN)
3360	.02	2.17	34.27	384
3420			34.21	
3480			34.34	
3540	.02	2.17	34.39	384
3600	.05	2.18	34.43	386
3660	.07	2.22	34.59	386
8720	.09	2.24		388
3780	.08	2.24		388
4020	.08	2.21	34.74	390
4080	.07	2.19	34.73	390
4140	.08	2.21	34.64	388
4200	.08	2.22	34.52	386
4260	.09	2.23	34.53	383
4320	.10		34.29	

RECOVERY DATA, AQUIFER TEST NO. 5

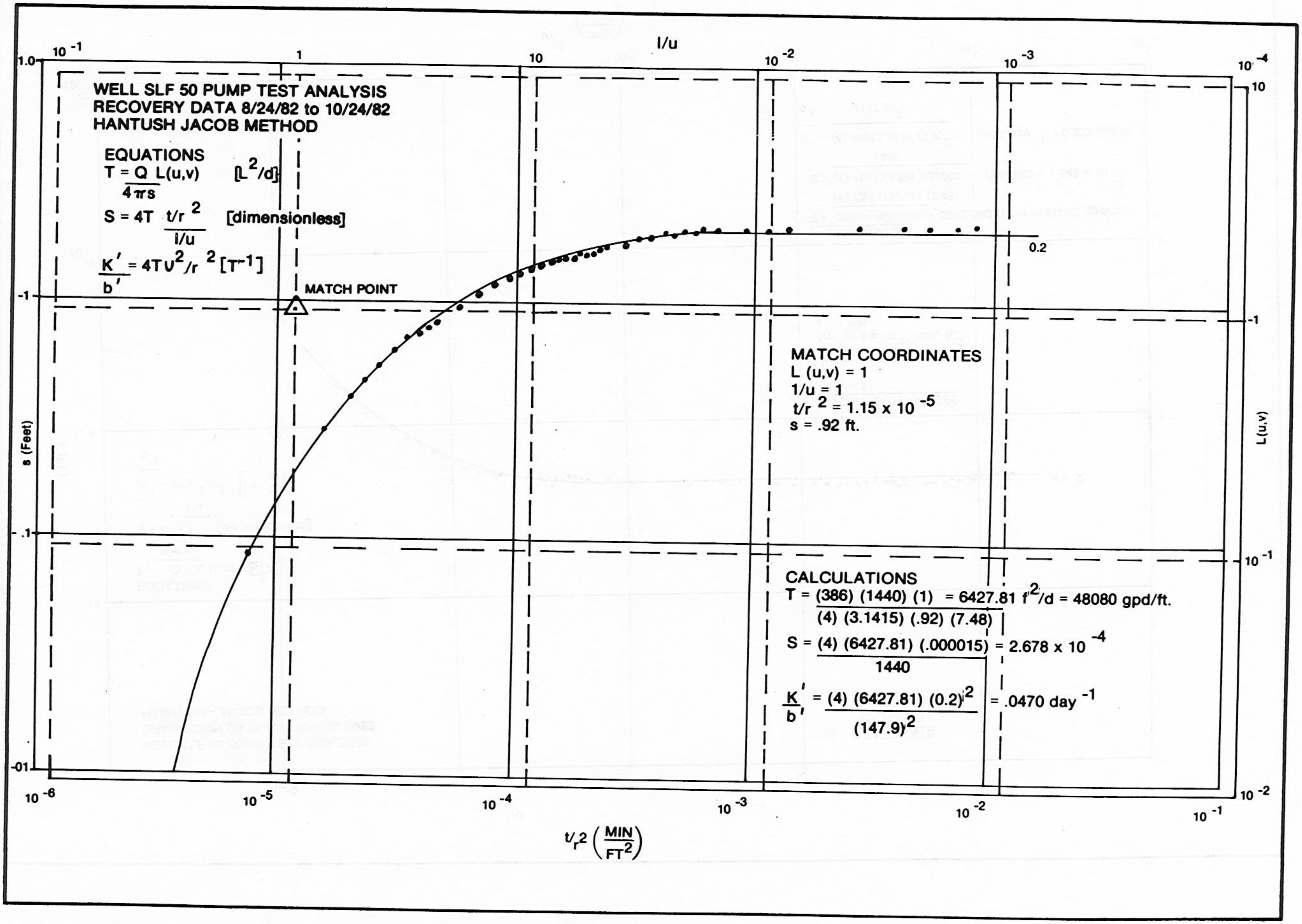
TIME SINCE PUMPING STARTED t (MINS)	TIME SINCE PUMPING STOPPED t'(MINS)	RATIO t/t'	RESIDUAL DRAWDOWN SLF-49 (FT)	RESIDUAL DRAWDOWN SLF-50 (FT)	RESIDUAL DRAWDOWN SLF-51 (FT)
4320.00	0		.10		0
4320.08	.08	54001.0		2.22	
4320.17	.17	25412.8		2.14	
4320.25	.25	17281.0	.10	2.06	1.81
4320.33	.33	13091.9		1.94	
4320.42	.42	10286.7		1.84	
4320.50	.50	8641.0	.10	1.76	1.46
4320.58	.58	7449.3		1.69	
4320.67	.67	6448.8		1.6	
4320.75	.75	5461.0	.10	1.53	1.33
4320.83	.83	5205.8		1.49	
4320.92	.92	4696.7		1.44	
4321.00	1.00	4321.0	.10	1.39	1.12
4321.25	1.25	3457.0	.09	1.26	1.00
4321.50	1.50	2881.0	.09	1.14	0.89
4321.75	1.75	2469.6	.085	1.05	0.81
4322.00	2.00	2161.0	.085	.97	0.73
4322.25	2.25	1921.1	.085	.91	0.68
4322.50	2.50	1729.0	.08	.85	0.62
4322.75	2.75	1571.9	.08	.80	0.57
4323.00	3.00	1441.0	.08	.76	0.52
4323.25	3.25	1330.2	.08	.72	0.49
4323.50	3.50	1235.2	.08	.67	0.45
4323.75	3.75	1153.0	.08	.65	0.41
4324.00	4.00	1081.0	.08	.62	0.39

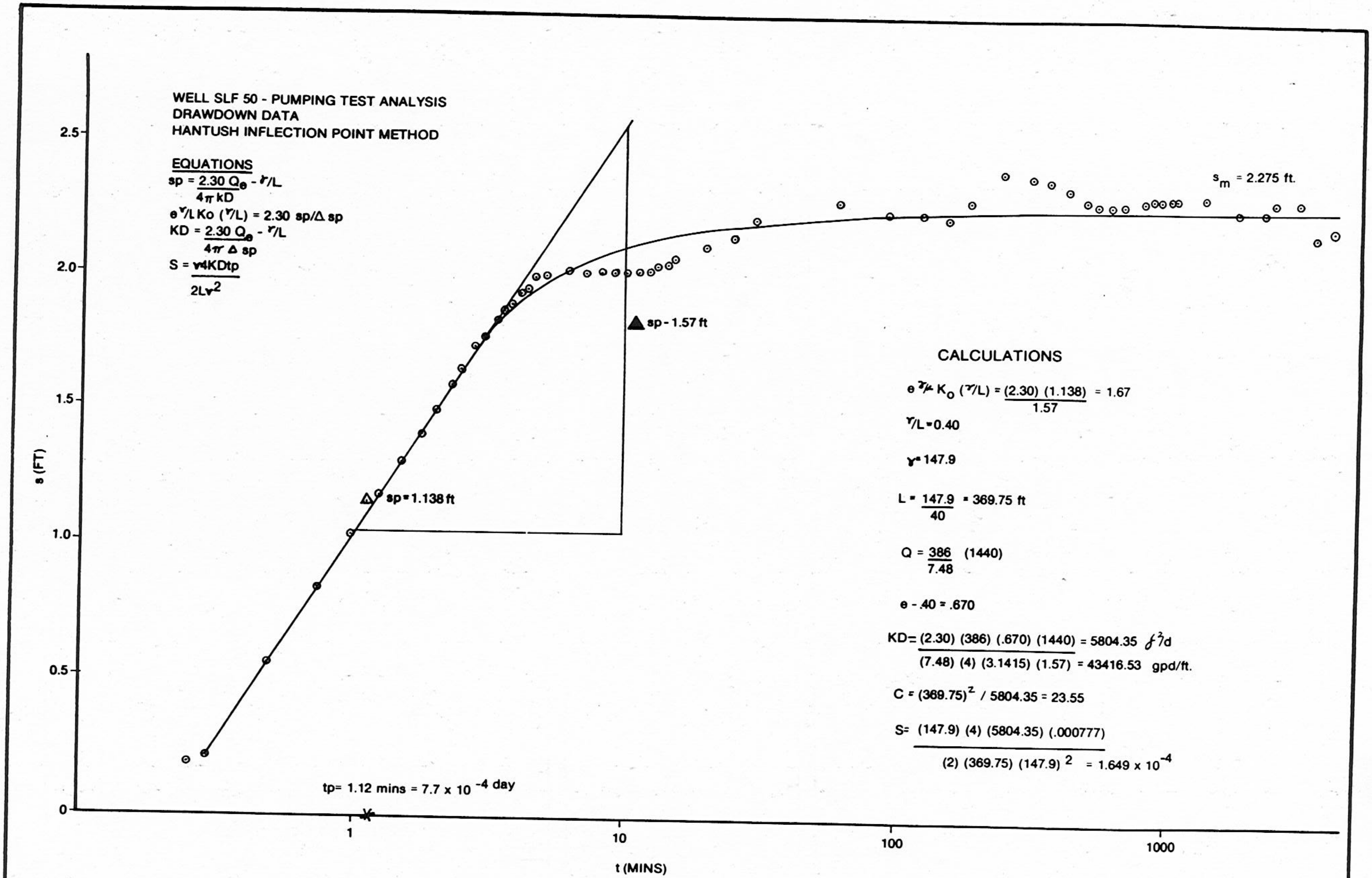
RECOVERY DATA, AQUIFER TEST NO. 5 (Continued)

TIME SINCE PUMPING STARTED t (MINS)	TIME SINCE PUMPING STOPPED t'(MINS)	RATIO t/t'	RESIDUAL DRAWDOWN SLF-49 (FT)	RESIDUAL DRAWDOWN SLF-50 (FT)	RESIDUAL DRAWDOWN SLF-51 (FT)
4324.25	4.25	1017.5	.08	.59	0.36
4324.50	4.50	961.0	.08	.56	0.33
4324.75	4.75	210.5	.08	.54	0.31
4325.00	5.00	865.0	.075	.51	0.28
4326	6.00	421.0	.07	.44	0.20
4327	7.00	618.1	.07	.38	0.14
4328	8.00	541.0	.07	.33	0.09
4329	9.00	481.0	.07	.29	.05
4330	10.00	433.0	.065	.26	.01
4331	11.00	393.7	.065	.23	-.02
4332	12	361.0	.06	.22	-.05
4333	13	333.3	.06	.19	-.07
4334	14	309.6	.06	.18	-.09
4335	15	289.0	.06	.16	-.11
4340	20	217	.06	.10	-.16
4345	25	173.8	.055	.06	-.20
4350	30	145.0	.05	.03	-.22
4380	60	73.0	.04	-.04	-.28
4410	90	49.0	.035	-.06	-.30
4440	120	37.0	.035	-.08	-.30
4470	150	29.8	.03	-.09	-.30
4500	180	25.0	.02	-.10	-.30



WELL SLF 50 PUMP TEST ANALYSIS
DRAWDOWN DATA 8/24/82 - 10/24/82
HANTUSH - JACOB METHOD
l/u
10^-5
10^-4
10^-3
10^-2
10^-1
CONSTANTS
r = 147.9 ft.
Q = 386 gpm
EQUATIONS
T = Q / 4 π s L (u,v) [L^2/d]
S = 4T t/r^2 / l/u [dimensionless]
K' / b' = 4Tu^2/r^2 [T^-1]
s (Ft.)
10
1
10^-1
10^-2
v = .2
L (u,v)
1
.1
MATCH COORDINATES
L(u,v) = 1
l/u = 1
t/r^2 = 1 x 10^-5 min. ft.^2
s = 1.0 ft.
CALCULATIONS
T = (386) (1440) (1) / (4) (3.1415) (1) (7.48) = 5913.583 ft.^2/d = 44,233 gpd/ft.
S = (4) (5913.589) (.00001) / 1440 = .0001642 = 1.642 x 10^-4
K' / b' = (4) (5913.589) (0.2)^2 / (147.9)^2 = .0432 day^-1 =0.323 gpd/ft. 3
10^-1
1
10
10^2
10^3
10^4
10^5
t/r^2 (min / ft.^2)


WELL SLF 50 PUMP TEST ANALYSIS
RECOVERY DATA 8/24/82 to 10/24/82
HANTUSH JACOB METHOD
EQUATIONS
T = Q L(u,v) / 4πs [L²/d]
S = 4T t/r² / 1/u [dimensionless]
K′/b′ = 4Tv²/r² [T⁻¹]
MATCH POINT
MATCH COORDINATES
L (u,v) = 1
1/u = 1
t/r² = 1.15 x 10⁻⁵
s = .92 ft.
CALCULATIONS
T = (386) (1440) (1) / (4) (3.1415) (.92) (7.48) = 6427.81 f²/d = 48080 gpd/ft.
S = (4) (6427.81) (.000015) / 1440 = 2.678 x 10⁻⁴
K′/b′ = (4) (6427.81) (0.2)² / (147.9)² = .0470 day⁻¹
1/u
s (Feet)
L(u,v)
t/r² (MIN/FT²)
0.2


WELL SLF 50 - PUMPING TEST ANALYSIS
DRAWDOWN DATA
HANTUSH INFLECTION POINT METHOD
EQUATIONS
sp = 2.30 Qe / 4π kD - r/L
e r/L Ko (r/L) = 2.30 sp/Δ sp
KD = 2.30 Qe / 4π Δ sp - r/L
S = r4KDtp / 2Lr2
sm = 2.275 ft.
sp - 1.57 ft
sp = 1.138 ft
tp= 1.12 mins = 7.7 x 10 -4 day
CALCULATIONS
e r/L Ko (r/L) = (2.30) (1.138) / 1.57 = 1.67
r/L = 0.40
r = 147.9
L = 147.9 / 40 = 369.75 ft
Q = 386 / 7.48 (1440)
e - .40 = .670
KD = (2.30) (386) (.670) (1440) / (7.48) (4) (3.1415) (1.57) = 5804.35 ft2/d = 43416.53 gpd/ft.
C = (369.75)2 / 5804.35 = 23.55
S = (147.9) (4) (5804.35) (.000777) / (2) (369.75) (147.9) 2 = 1.649 x 10-4
2.5
2.0
1.5
1.0
0.5
0
s (FT)
1
10
100
1000
t (MINS)

APPENDIX 5

Summary of Packer Test, SLF-50

APPENDIX 5. Packer Test, Well SLF-50

Introduction

A packer test was performed at well SLF-50 on March 11 and 12, 1982 to provide additional information on the hydrologic properties of the Floridan Aquifer System. At the time of testing the well was 1000 feet deep, and was cased to a depth of 600 feet.

A packer is a mechanical device which is lowered into the wellbore and expanded at a given depth to provide a seal against the borehole wall. The purpose of the packer test was to:

a) Isolate the potential injection horizon from the lower portion of the borehole.

b) Determine the degree of interconnection between the potential injection horizon and the lower portion of the borehole.

c) Determine differences in potentiometric head and water quality.

d) Determine relative flow contributions from the two intervals under natural flowing conditions.

The setting depth of the packer was chosen based on hydrogeologic and borehole conditions. Geophysical, lithologic, and aquifer test data indicated that the interval between 600 feet and 775 feet was potentially the most productive zone in the sequence penetrated by the borehole. This interval consisted of medium-grained coquinoid limestones with well developed moldic and intergranular porosity. The Caliper Log of the well indicated considerable washout in this interval, probably due to poor cementing of the fossil fragments in the limestone matrix. The Flowmeter Log indicated three zones of substantial flow contribution in this interval. Pumping test data indicated significantly higher transmissivity values compared to the lower section of the strata penetrated.

Final choice of the setting depth was based on the borehole condition. Successful setting of the packer requires a relatively smooth section of borehole which has a diameter not more than 8 inches. The interval between 760 feet and 770 feet met these criteria. The 4 foot long expanding element was set between 766 feet and 770 feet depth below ground surface.

Equipment and Methods

The packer used was a 5 5/8 inch O.D. retrievable tool (TAM International Model Tamset) with a 4 foot long inflatable rubber element. The tool was lowered through the 6-inch PVC casing and into the open bore. Centralizers were placed on the drill stem close to the packer and also within the casing to hold the tool in the center of the hole and ensure smooth reentry into the casing on retrieval. At the setting depth, the tool was inflated and the circulating sleeve opened, using hydraulic pressure transmitted through the drill pipe. This effected a seal within the borehole and allowed water from below the packer to flow upward through the drill pipe. Groundwater from the strata isolated above the packer flowed through the annular space between the open bore or casing and the drill pipe. The tool is equipped with a deflating mechanism for retrieval.

Shut in of the drill stem and annular space were effected using a solid plug and a sandwich seal respectively. Shut-in heads were measured by means of manometer tubes tapped into the plug and seal. Manometer tubes were also installed on the monitoring well SLF-51 which was 775 feet deep and located 147.9 feet northeast of the exploratory well. Water samples and water quality data were taken after discharging for 2 hours and then allowing levels to stabilize. The two zones were allowed to discharge alternately and the effects on the other zone and on the observation wells were recorded. Table 5-1 summarzies data from these tests.

Static potentiometric level in the zone below the packer was 0.24 feet above the level in the upper zone, indicating some degree of isolation between these zones. This was further confirmed by data from the discharge tests. As shown on Table 5-1, discharging water from the lower zone caused no drawdown in the upper zone for a drawdown in the lower zone of 15 feet. The negligible effect observed at the monitor well could be due to measurement errors or natural fluctuations in water level, since this well was open to the upper zone only. Discharging water from the upper zone had a considerable effect on levels in the monitoring well (0.94 feet drawdown), but little effect on the water level in the lower zone (0.13 feet drawdown).

Water quality data were ambiguous but indicate that differences in quality between the zones probably exist. No consistent pattern in specific conductance, chloride, or total dissolved solids content was found which could be explained in terms of the separate zones isolated by the packer. Samples from well SLF-51 and the lower zone in well SLF-50 (depth 766 feet) showed the highest chloride concentrations. The annulus sample from the upper zone above 775 feet showed the lowest chloride concentration of 888 mg/l. The wellhead sample at SLF-50, after removal of the packer, had a chloride concentration intermediate between these. This tended to indicate that the upper zone was less mineralized than the lower zone. However, specific conductance and total dissolved solids concentrations were inconsistent with the chloride values. No measurable differences in temperature were observed. This may be due to temperature equalization during upward flow of water from the lower zone through the drill stem. However, temperature logs run prior to the packer test indicated an increase in temperature with depth from a value of 83.5°F at 600 feet to approximately 85.8°F at 1000 feet.

TABLE 5-1

WATER LEVEL AND WATER QUALITY DATA - PACKER TEST, WELL SLF-50

ACTIVITY	WATER LEVEL OR DRAWDOWN IN UPPER ZONE (FT NGVD)	WATER LEVEL OR DRAWDOWN IN LOWER ZONE (FT NGVD)	WATER LEVEL OR DRAWDOWN SLF-51 (FT NGVD)
All wells shut in (static condition).	42.86	43.10	42.34
Lower zone pumped at 30 gallons per minute for 1 hour.	(0.00)*	(15.0)*	(0.06)*
Upper zone discharged by free-flow at 200 gpm for 1 hour.	(10.60)*	(0.13)*	(0.94)*

*NOTE: Numbers in brackets indicate drawdown.

WATER QUALITY DATA, PACKER TEST

SAMPLING POINT	T°F	pH	SPEC. COND. umhos/cm	Cl mg/l	TDS mg/l
Drill stem - SLF-50 (lower zone)	82°	7.63 7.55	3450 3200	1025 1015	1474 1888
Annulus - SLF-50 (upper zone)	82°	7.53	3400	888	2058
Wellhead - SLF-50 (after removal of packer)	82°	7.45	3325	954.9	2379
Wellhead - Obs. Well SLF-51	82°	6.17	3500 3500	1077.8 1021.5	2180 2143

In summary, the packer test confirmed that the interval above 766 feet produced the major flow to the borehole and that there was good lateral hydraulic connection within this interval between the exploratory well and the monitor well. This zone is separated from the lower strata by a low permeability confining layer. There is a small difference in heads between these two intervals. It would be expected that vertical leakage between the upper zone and lower zone would be small, compared to horizontal flow. Water quality differences between the two zones were relatively small and would therefore not be expected to have any significant effect on the injection/recovery process.

APPENDIX 6

Data from Injection/Recovery Tests

APPENDIX 6a. DATA FROM INJECTION PHASE OF INJECTION/RECOVERY TEST, WELL SLF-50, ST. LUCIE

DATE	TIME	ELAPSED TIME (min)	Qin (gpm)	INJECTION PRESSURE SLF-50 (psi)	SPECIFIC CONDUCTANCE (umhos/cm)	OBS.WELL PRESSURE SLF-51 (ft TOC)	REMARKS
10/19/82	1114	60	475	28	1,220	19.22	
10/19/82	1214	120	475	29	1,220	19.20	Pump adjusted to 500 gpm at 1240.
10/19/83	1314	180	500	31	1,230	19.46	
10/19/82	1414	240	500	32	1,221	19.45	
10/19/82	1514	300	500	33	1,210	19.44	
10/19/82	1614	360	500	33	1,230	19.37	
10/19/82	1714	420	500	33	1,240	19.36	
10/19/82	1814	480	500	33	1,272	19.32	
10/19/82	1914	540	500	34	1,260	19.27	
10/19/82	1914	540	500	34	1,260	19.27	
10/19/82	2014	600	500	35	1,250	19.25	
10/19/82	2114	660	500	34	1,290	19.20	
10/19/82	2214	720	500	34	1,330	19.17	
10/19/82	2314	780	500	34	1,320	19.13	.374 total gallons X 1000.
10/19/82	2414	840	500	34	1,320	19.12	
10/20/82	0114	900	500	34	1,320	19.12	
10/20/82	0714	1260	475	34	1,210	18.98	
10/20/82	0814	1320	475	35	1,320	18.94	
10/20/82	0914	1380	475	35	1,310	18.95	
10/20/82	1014	1440	475	36	1,300	19.00	
10/20/82	1114	1500	475	35	1,310	19.10	

APPENDIX 6a (Continued)

DATE	TIME	ELAPSED TIME (min)	Qin (gpm)	INJECTION PRESSURE SLF-50 (psi)	SPECIFIC CONDUCTANCE (umhos/cm)	OBS.WELL PRESSURE SLF-51 (ft TOC)	REMARKS
10/20/82	1214	1560	475	37	1,310	19.16	
10/20/82	1314	1620	475	39	1,310	19.12	
10/20/82	1414	1680	475	38	1,310	19.12	
10/20/82	1614	1800	450	38	1,285	19.01	
10/20/82	1714	1860	450	40	1,310	18.96	
10/20/82	1814	1920	400	32	1,310	18.68	Pump adjusted to reduce injection pressure.
10/20/81	1914	1980	375	37	1,320	18.53	
10/20/82	2014	2040	350	36	1,330	18.48	
10/20/82	2214	2160	280	28	1,300	17.79	Pump adjusted to reduce injection pressure.
10/20/82	2234	2180	325	34	1,300	-	
10/20/82	2314	2220	325	34	1,300	18.00	
10/20/82	2414	2280	325	34	1,350	17.98	
10/21/82	0114	2340	325	34	1,350	18.00	
10/21/82	0214	2400	325	34	1,350	17.99	
10/21/82	0714	2700	300	30	1,330	17.80	Pump adjusted.
10/21/82	0814	2760	325	38	1,330	18.01	
10/21/82	0914	2820	300	38	1,330	18.00	
10/21/82	1014	2880	300	39	1,320	17.98	
10/21/82	1114	2940	300	40	1,320	17.98	
10/21/82	1214	3000	300	40	1,300	17.95	
10/21/82	1314	3060	300	39	1,310	18.01	

APPENDIX 6a (Continued)

DATE	TIME	ELAPSED TIME (min)	Qin (gpm)	INJECTION PRESSURE SLF-50 (psi)	SPECIFIC CONDUCTANCE (umhos/cm)	OBS.WELL PRESSURE SLF-51 (ft TOC)	REMARKS
10/21/82	1414	3120	300	40	1,310	17.97	
10/21/82	1614	3240	300	40	1,270	17.94	
10/21/82	1714	3300	275	41	1,240	17.92	Water sample taken.
10/21/82	1814	3360	280	40	1,270	17.88	
10/21/82	1844	3390	275	41	-	-	Total gallons injected 1,279,300.
10/21/82	1846	3392					Recovery halted to clean well by backflow. Backflow started at 1851.
10/21/82	1851	3397			1,330		Water murky after 10 min. T=76^{o}F.
10/21/82	1920	3426					Backflow completed.
10/21/82	1926	3432					Injection restarted.
10/21/82	1920	3436	325	38	1,270	17.87	
10/21/82	2214	3600	280	38	1,320	17.99	
10/21/82	2314	3660	300	36	1,310	17.96	
10/22/82	2414	3720	300	37	1,330	17.90	
10/22/82	0114	3780	280	38	1,320	17.88	
10/22/82	0214	3840	250	34	1,340	17.89	
10/22/82	0714	4140	250	34	1,330	17.58	
10/22/82	0814	4200	250	38	1,330	17.59	
10/22/82	0914	4260	250	39	1,320	17.72	
10/22/82	1014	4320	250	39	1,310	17.73	
10/22/83	1018	4324					Injection halted to redevelop well. Total gallons injected 1,476,200.
10/22/83	1020	4326					Backflow started.

APPENDIX 6a (Continued)

DATE	TIME	ELAPSED TIME (min)	Q_{in} (gpm)	INJECTION PRESSURE SLF-50 (psi)	SPECIFIC CONDUCTANCE (umhos/cm)	OBS.WELL PRESSURE SLF-51 (ft TOC)	REMARKS
10/22/83	1029	4335					Backflow stopped.
10/22/83	1039	4345					Surging with pump started. Water dark brown at start, clear after 15 min.
10/22/83	1120	4386			1,290		End of surging.
10/22/83	1131	4397					Pumping resumed.
10/22/83	1132	4398	300	35	1,210	17.45	
10/22/83	0114	4500	300	34	1,250	18.06	Injection terminated. Total gallons injected 1,488,100.

APPENDIX 6b. Data from Recovery Test, Well SLF-50, St. Lucie County

DATE	TIME	VOLUME DISCH. GALS.	SPECIFIC CONDUCT. umhos/cm	CHLORIDE CONCEN. mg/l	TEMP. °F	REMARKS
11/29/82	1150	0	-	-	-	
11/29/82	1153	-	1332.0	220	78.8	Water Sample #1.
11/29/82	1220	6100	1372.0	230	78.8	
11/29/82	1250	10000	1372.0	-	78.8	
11/29/82	1350	21200	1372.0	-	78.8	
11/29/82	1450	31400	1372.0	-	78.8	
11/29/82	1550	40800	1386.0	250	78.8	
11/29/82	1620	45700	1402.0	262	78.8	Water Sample #2.
11/29/82	1650	51100	1414.0	-	78.8	
11/29/82	1720	56200	1414.0	-	78.8	
11/29/82	1750	60600	1420.0	282	78.8	Water Sample #3; recovery halted.
11/30/82	0703	62000	1430.0	277	80.6	Recovery resumed.
11/30/82	0733	16100	1421.0	271	78.8	Water Sample #4.
11/30/82	0803	72200	1421.0	-	78.8	Water Sample #5.
11/30/82	0903	82500	1420.0	-	78.8	
11/30/82	1003	92900	1416.0	-	79.0	
11/30/82	1103	103200	1424.0	278	79.0	Water Sample #6.
11/30/82	1203	113600	1434.0	-	79.0	
11/30/82	1303	123900	1438.0	-	79.0	
11/30/82	1403	135300	1450.0	288	79.1	Water Sample #7; water clear.
11/30/82	1503	144800	1449.0	-	79.1	
11/30/82	1603	155100	1461.0	-	79.1	Water Sample #8; recovery halted.
12/01/82	0705	167400	1434.0	285	79.1	Recovery resumed.
12/01/82	0735	171700	1490.0	298	79.1	Water Sample #9; water clear.
12/01/82	0805	177000	1497.0	-	79.1	
12/01/82	0905	187700	1497.0	-	79.2	
12/01/82	1005	198300	1497.0	-	79.2	
12/01/82	1105	209000	1503.0	308	79.2	Water Sample #10; water clear.
12/01/82	1505	251600	1522.0	-	79.4	
12/01/82	1605	262200	1529.0	-	79.4	
12/01/82	1645	270100	1543.0	322	79.4	Recovery halted.
12/02/82	0700	270200	-	-	79.4	Recovery resumed.
12/02/82	0705	271100	1553.0	328	-	
12/02/82	0735	277500	1553.0	328	79.2	Water Sample #12.
12/02/82	0805	281800	1552.0	-	79.2	
12/02/82	0905	292700	1547.0	-	79.2	
12/02/82	1005	303600	1548.0	-	79.2	
12/02/82	1105	315500	1554.0	-	79.2	Water Sample #13.
12/02/82	1205	325800	1556.0	-	79.4	
12/02/82	1305	336600	1556.0	-	79.4	
12/02/82	1405	348500	1565.0	-	79.4	Water Sample #14.

APPENDIX 6b. Data from Recovery Test, Well SLF-50, St. Lucie County (Continued)

DATE	TIME	VOLUME DISCH. GALS.	SPECIFIC CONDUCT. umhos/cm	CHLORIDE CONCEN. mg/l	TEMP. °F	REMARKS
12/02/82	1505	358700	1565.0	-	79.4	
12/02/82	1605	370400	1574.0	-	79.4	
12/02/82	1705	381200	1595.0	-	79.4	Water Sample #15; recovery halted.
12/03/82	0700	381300	-	-	-	Recovery resumed.
12/03/82	0705	382200	1605.0	-	77.2	
12/03/82	0735	387500	1605.0	-	79.4	Water Sample #16.
12/03/82	0805	392000	1605.0	-	79.4	
12/03/82	0905	402900	1606.0	-	79.4	
12/03/82	1005	413700	1606.0	-	79.6	
12/02/82	1105	425500	1606.0	-	79.6	Water Sample #17.
12/03/82	1205	436400	1612.0	-	79.6	
12/03/82	1305	447300	1612.0	-	79.6	
12/03/82	1405	458100	1613.0	-	79.6	Water Sample #18.
12/03/82	1505	468000	1625.0	-	79.6	
12/03/82	1605	478900	1634.0	-	79.6	
12/03/82	1705	489800	1644.0	-	79.6	Water Sample #19; recovery halted.
12/06/82	1015	489900	-	-	-	Recovery resumed.
12/06/82	1020	490800	1624.0	375	79.0	
12/06/82	1030	492900	1556.0	351	79.4	
12/06/82	1100	498800	1618.0	382	79.5	Water Sample #20.
12/06/82	1200	510000	1615.0	-	79.6	
12/06/82	1300	521800	1620.0	-	79.6	
12/06/82	1400	533100	1638.0	389	79.6	Water Sample #21.
12/06/82	1500	544900	1638.0	-	79.6	
12/06/82	1600	557400	1648.0	-	79.6	
12/06/82	1700	569000	1650.0	391	79.6	Water Sample #22; recovery halted.
12/07/82	0700	569200	-	-	-	Recovery resumed.
12/07/82	0705	570100	1667.0	396	79.3	
12/07/82	0735	575900	1668.0	398	79.8	Water Sample #23.
12/07/82	0805	581600	1668.0	-	79.8	
12/07/82	0905	593000	1665.0	-	79.9	
12/07/82	1005	605500	1672.0	-	80.0	
12/07/82	1105	616000	1676.0	407	80.0	Water Sample #24.
12/07/82	1205	627400	1676.0	-	80.0	
12/07/82	1305	638900	1679.0	-	80.0	
12/07/82	1405	651400	1679.0	415	80.0	Water Sample #25.
12/07/82	1505	661900	1678.0	-	80.0	
12/07/82	1605	674400	1688.0	-	80.0	
12/07/82	1705	684900	1702.0	420	80.0	Water Sample #26; recovery halted.
12/08/82	0700	685000	-	-	-	Recovery resumed.
12/08/82	0705	686200	1714.0	-	80.0	
12/08/82	0735	691500	1715.0	426	80.0	Water Sample #27.

APPENDIX 6b. Data from Recovery Test, Well SLF-50, St. Lucie County (Continued)

DATE	TIME	VOLUME DISCH. GALS.	SPECIFIC CONDUCT. umhos/cm	CHLORIDE CONCEN. mg/l	TEMP. °F	REMARKS
12/08/82	0805	694700	1714.0	-	80.0	
12/08/82	0905	703000	1708.0	-	80.0	
12/08/82	1005	711200	1696.0	-	80.0	
12/08/82	1105	719700	1707.0	422	80.1	Water Sample #28.
12/08/82	1205	728100	1704.0	-	80.1	
12/08/82	1305	736600	1704.0	-	80.1	
12/08/82	1405	745100	1712.0	424	80.1	Water Sample #29.
12/08/82	1505	753600	1713.0	-	80.1	
12/08/82	1605	762100	1731.0	-	80.1	
12/08/82	1705	770700	1740.0	436	80.1	Water Sample #30; recovery halted.
12/09/82	0700	770800	-	-	-	Recovery resumed.
12/09/82	0705	771800	1743.0	-	80.4	Water Sample #31.
12/09/82	0735	777400	1746.0	437	80.1	
12/09/82	0805	782900	1749.0	-	80.1	
12/09/82	0905	793900	1750.0	-	80.1	
12/09/82	1005	804700	1751.0	-	80.2	
12/09/82	1105	815200	1757.0	440	80.2	Water Sample #32.
12/09/82	1205	825300	1758.0	-	80.2	
12/09/82	1305	835900	1760.0	-	80.2	
12/09/82	1405	846100	1750.0	438	80.4	Water Sample #33.
12/09/82	1505	856100	1749.0	-	80.2	
12/09/82	1605	867400	1727.0	-	80.4	
12/09/82	1705	875800	1768.0	-	80.1	
12/09/82	1805	886400	1777.0	435	80.1	Water Sample #34; recovery halted.
12/10/82	0707	888600	1725.0	-	79.7	Recovery resumed.
12/10/82	0808	896400	1765.0	-	78.8	
12/10/82	0908	906800	1770.0	-	80.6	
12/10/82	1008	915900	1770.0	-	80.6	Water Sample #35.
12/10/82	1108	926300	1763.0	-	80.6	
12/10/82	1206	935700	1766.0	-	80.6	
12/10/82	1306	945500	1768.0	-	80.6	
12/10/82	1408	956000	1786.0	-	80.6	
12/10/82	1506	965900	1770.0	-	80.6	Water Sample #36; recovery halted.
12/13/82	1020	965900	1740.0	448	79.8	Water Sample #37; recovery resumed.
12/13/82	1100	973500	1763.0	-	80.4	
12/13/82	1200	984400	1776.0	-	80.4	
12/13/82	1300	996100	1768.0	469	80.4	Water Sample #38.
12/13/82	1400	1005500	1848.0	-	80.4	
12/13/82	1500	1014300	1846.0	-	80.4	
12/13/82	1600	1023100	1798.0	467	80.3	Water Sample #39.
12/13/82	1700	1032100	1854.0	-	80.3	
12/13/82	1800	1040300	1822.0	-	80.4	Water Sample #40; recovery halted.

APPENDIX 6b. Data from Recovery Test, Well SLF-50, St. Lucie County (Continued)

DATE	TIME	VOLUME DISCH. GALS.	SPECIFIC CONDUCT. umhos/cm	CHLORIDE CONCEN. mg/l	TEMP. °F	REMARKS
12/15/82	0710	1149800	1871.0	498	80.4	Water Sample #45; recovery resumed.
12/15/82	0810	1157400	1842.0	-	80.6	
12/15/82	0910	1166300	1828.0	-	80.6	
12/15/82	1010	1175900	1818.0	493	81.0	Water Sample #46.
12/15/82	1110	1185000	1824.0	-	81.0	
12/15/82	1210	1195400	1817.0	-	81.0	
12/15/82	1310	1205100	1817.0	494	81.0	Water Sample #47.
12/15/82	1410	1212900	1811.0	-	81.0	
12/15/82	1510	1223300	1804.0	-	81.0	
12/15/82	1610	1231600	1812.0	-	81.0	
12/15/82	1710	1240900	1815.0	500	81.0	Water Sample #48; recovery halted.
12/16/82	0700	1242100	1837.0	518	81.0	Water Sample #49; recovery resumed.
12/16/82	0800	1254500	1839.0	-	81.0	
12/16/82	0900	1266500	1827.0	-	81.0	
12/16/82	1000	1278300	1825.0	514	81.0	Water Sample #50.
12/16/82	1100	1289200	1825.0	-	81.0	
12/16/82	1200	1300900	1825.0	-	81.0	
12/16/82	1300	1312700	1827.0	507	81.0	Water Sample #51.
12/16/82	1400	1325500	1825.0	-	81.0	
12/16/82	1500	1337300	1825.0	-	81.0	
12/16/82	1600	1348100	1838.0	-	81.0	
12/16/82	1700	1359900	1843.0	521	81.0	Water Sample #52; recovery halted.
12/17/82	0700	1363400	1849.0	520	81.0	Water Sample #53; recovery resumed.
12/17/82	0800	1371600	1849.0	-	81.0	
12/17/82	0900	1381500	1847.0	-	81.0	
12/17/82	1000	1390500	1842.0	532	81.0	Water Sample #54; recovery halted.
12/21/82	1000	1390500	-	-	-	Recovery resumed.
12/21/82	1015	1393000	1623.0	435	81.6	Water Sample #55.
12/21/82	1115	1405000	1723.0	-	81.2	
12/21/82	1215	1415600	1720.0	-	81.2	
12/21/82	1315	1427200	1715.0	433	81.4	Water Sample #56.
12/21/82	1415	1438700	1715.0	-	81.4	
12/21/82	1515	1450300	1700.0	-	81.4	
12/21/82	1615	1461900	1713.0	527	81.2	Water Sample #57.
12/21/82	1715	1474500	1719.0	-	81.2	Recovery halted.
12/22/82	0630	1474500	-	-	-	Recovery resumed.
12/22/82	0700	1478800	1740.0	546	81.0	Water Sample #58.
12/22/82	0800	1490300	1720.0	-	81.0	
12/22/82	0900	1499900	1714.0	546	81.2	Water Sample #59.
12/22/82	1000	1511400	1715.0	-	81.4	

APPENDIX 6b. Data from Recovery Test, Well SLF-50, St. Lucie County (Continued)

DATE	TIME	VOLUME DISCH. GALS.	SPECIFIC CONDUCT. umhos/cm	CHLORIDE CONCEN. mg/l	TEMP. °F	REMARKS
12/22/82	1030	1515700	1702.0	555	81.4	Water Sample #60; recovery halted.
1/19/83	1000	1515700	-	-	-	Recovery resumed.
1/19/83	1100	1528900	1688.0	472	81.4	Water Sample #61.
1/19/83	1400	1562600	1817.0	549	81.4	
1/19/83	1700	1596800	1824.0	551	81.4	Water Sample #62.
1/20/83	0700	1757600	1924.0	602	81.5	Water Sample #63.
1/20/83	1000	1792200	1904.0	593	81.5	
1/20/83	1300	1826700	1888.0	615	81.5	
1/20/83	1700	1872800	1912.0	645	81.5	Water Sample #64.
1/21/83	0700	2034800	1922.0	669	81.8	Water Sample #65.
1/21/83	1000	2069600	1932.0	670	81.8	
1/21/83	1300	2105400	1943.0	686	82.0	
1/21/83	1600	2139300	1960.0	700	82.0	Water Sample #66 recovery halted.
1/24/83	1030	2139300	-	-	-	Recovery resumed.
1/24/83	1100	2142800	1892.0	668	81.7	Water Sample #67.
1/24/83	1400	2169200	1940.0	684	82.0	
1/24/83	1700	2196800	1962.0	701	82.0	Water Sample #68.
1/25/83	0700	2318400	1995.0	717	82.0	Water Sample #69.
1/25/83	1000	2343400	2028.0	726	81.6	
1/25/83	1300	2368400	2032.0	732	81.7	
1/25/83	1700	2402000	2032.0	732	81.7	Water Sample #70.
1/26/83	0700	2519000	2087.0	748	81.6	Water Sample #71.
1/26/83	1000	2544200	2067.0	745	81.7	
1/26/83	1300	2569400	2076.0	756	81.9	
1/26/83	1700	2604500	1096.0	759	81.9	Water Sample #72.
1/27/83	0700	2720900	2113.0	778	81.8	Water Sample #73.
1/27/83	1000	2746100	2103.0	763	82.0	
1/27/83	1300	2771800	2122.0	782	82.0	
1/27/83	1630	2802500	2140.0	791	82.0	Water Sample #74; recovery halted.
2/01/83	1100	2802500	2210.0	706	81.9	Water Sample #75; recovery resumed.
2/01/83	1400	2827100	2187.0	797	81.7	
2/01/83	1700	2852500	2218.0	789	81.1	Water Sample #76.
2/02/83	0700	2971500	2198.0	805	82.0	Water Sample #77.
2/02/83	1100	3006800	2220.0	797	82.2	
2/02/83	1400	3033600	2210.0	808	81.9	
2/02/83	1700	3060700	2203.0	815	82.4	Water Sample #78.
2/03/83	0700	3191200	2248.0	818	82.4	Water Sample #79.
2/03/83	1100	3227800	2218.0	823	82.4	
2/03/83	1400	3253900	2202.0	832	82.0	
2/03/83	1700	3280000	2231.0	840	82.0	Water Sample #80.
2/04/83	0730	3411500	2207.0	848	82.4	Water Sample #81.