UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

MEMORANDUM ON THE GEOLOGY AND GROUND-WATER RESOURCES OF THE PARRIS ISLAND AREA, SOUTH CAROLINA

by George E. Siple
April 1, 1956

Open-File Report 57-100

NOTE: The original of this report is not available. This report was copied from a carbon copy and, therefore, is the best that can be furnished.

Preliminary report subject to revision

CONTENTS

ILLUSTRATIONS

MEMORANDUM ON THE GEOLOGY AND GROUND-WATER RESOURCES OF THE PARRIS ISLAND, AREA, S.C.

by George E. Siple

U. S. Geological Survey

INTRODUCTION

Purpose and Scope of Investigation

This memorandum gives the results of a short investigation of the geology and ground-water resources of the Parris Island area, which has been made by the U.S. Geological Survey at the request of the District Public Works Officer of the Sixth Naval District, Charleston, S. C. and the Commandant of the Marine Corps Recruit Depot at Parris Island, S. C. The program was initially requested and sponsored by the District Public Works Office, U.S. Navy Department. Subsequently, this sponsorship was changed to that of the Marine Corp Recruit Depot. A further change brought the program under the present sponsorship of the Sixth Naval District, U.S. Navy.

The program was limited essentially to the collection and interpretation of basic data and designed to supply some of the basic water records that will be needed in a study of the problems of the Beaufort area. Although the program is now only partially complete, this memorandum has been prepared in response to a request from the Sixth Naval District for a summary of the conclusions which can be made at this time on the basis of the data collected to date.

Location of Area

The area concerned is that immediately surrounding Parris Island and Port Royal Island and adjacent areas in the southern part of Beaufort County together with the eastern part of Jasper County, South

Carolina. It is limited generally by the latitudes of 32°10' N to 32°45' N and the longitudes of 80°30' W to 80°55' W.

Previous Investigations

Previous reports include a memorandum, "Ground Water in the Beaufort Area, S.C." by M.J. Mundorff, U.S. Geological Survey, in 1944, and a "Comprehensive plan for the development of an adequate water supply for the Marine Corp Recruit Depot at Parris Island, South Carolina," by Daniel A. Kendall of the Bureau of Yards and Docks, Navy Department, in 1948. An engineering report, "Water Supply—Beaufort County Water Authority, Beaufort, South Carolina", was prepared by the engineering firm of Barker, Keels and Associates, Inc. in October of 1954.

The Surface Water Branch of the U.S. Geological Survey is currently engaged in a study of the Combahee River as an alternate water supply for the Naval installations in the Beaufort area, and the Quality of Water Branch is engaged in salinity studies of this river for the same purpose.

An investigation of the ground-water resources of Chatham County, Georgia, with special reference to the problem of salt-water encroachment, is currently being carried out by the U.S. Geological Survey in cooperation with the City of Savannah and Chatham County, through the Department of Mines, Mining and Geology of the Georgia Division of Conservation.

GEOLOGY

General Geology and Stratigraphy

The area lies in the southern part of the Coastal Plain province and is a part of the Sea Island section. With the submergence of the coastal areas during recent time the sea has encroached landward up broad estuaries and formed numerous islands. These islands, cut off from the mainland by tidewater flows, are characteristically flat but some have considerable relief due to the presence of fossil dunes, and so-called "sinks". Some of the latter are probably the remnants of old tidewater estuaries and some may have been caused by solution in the subsurface, followed by subsequent caving of the overlying surface material.

The Coastal Plain consists of a flat broad plain underlain by a series of unconsolidated to semi-consolidated sedimentary formations, deposited with a simple homoclinal structure over an ancient peneplain eroded on crystalline rocks. These basement rocks are composed of granite, gneiss, schist, and diabasic rocks. At the inner margin of the Coastal Plain, near the Savannah River, these rocks occur at altitudes of about 100 feet above mean sea level. In the Parris Island area they occur at depths more than 3400 feet below msl.

Overlying the basement rocks are the Coastal Plain formations, consisting of gravel, sand, clay, limestone, marl and shale. In ascending order they represent deposits of Late Cretaceous, Tertiary, and Pleistocene to Recent age. They strike in a northeast-southwest direction and dip to the south, southeast at 8 to 33 feet per mile.

Principal Aquifer in the Parris Island Area

The principal aquifer in the Parris Island area is a white to cream-colored, fossiliferous, limestone which was previously considered to be of middle to late Eocene age. Geologic data collected to date are not sufficiently complete to distinguish between this formation and others of Oligocene, Miocene, Pliocene and Pleistocene age, one or more of which may overlie the limestone in this area. The principal aquifer referred to as the Ocala in Georgia and Florida, was previously considered equivalent to the Santee limestone and Cooper marl in South Carolina. Subsequently, the upper part, or Cooper marl, has been designated as Oligocene in age, and the lower or Santee limestone as of middle Eocene age. The Santee limestone and Cooper marl crop out in an arcuate belt, approximately 25 miles wide, extending from Allendale County of the Savannah River, eastward to the Santee River and the northern part of Charleston County. In the outcrop area the limestone is somewhat soft except that weathered exposures contain ledges of recalcified and indurated rock.

The most permeable part of the limestone appears to be the upper part, which is reportedly cavernous in places. It is possible that the aquifer used in the area consists of limestone of more than one epoch but is referred to collectively as the Ocala formation or Santee formation. It is also possible or even probable that the limestone used as an aquifer is actually younger than Eocene and up to Early Miocene in age.

From its outcrop area, the Santee limestone dips to the south-southeast at a very low angle and in the upper part of Beaufort County, it is covered by the Hawthorn formation of Miocene age. The true structure of the upper units in this area is not clearly understood at the present time. The limestone (Santee ?) appears to reverse its dip in the vicinity of Beaufort and come closer to the ground surface than in areas to the north and northwest. However, this might be due to the fact that the principal limestone aquifer is not the Santee limestone but rather a younger formation such as the Cooper or possibly an early Miocene limestone equivalent to the Tampa limestone of Florida. The discordant dip between the top of the Santee limestone in the inland area with that of the top of the limestone in Beaufort County almost precludes the possibility of its being the same formation. If this is so, the Cooper has changed from a soft marl in the outcrop area to an indurated limestone in the vicinity of Beaufort. There is also an apparent dip to the southwest from the vicinity of Beaufort because the top of the limestone in the Savannah area occurs at an altitude of about -180 feet, whereas at Beaufrot it occurs at an altitude of approximately -50 feet. At Pritchardville, 10 miles southwest of Beaufort, the limestone has been reported at an altitude of -168 feet.

During the present study, a series of six monitoring wells were drilled, five around the perimeter of the Burton well field and one about 3 miles north of the Naval Air Station, on the right-of-way of S.C. Highway 70. The examination and identification of lithologic units and fauna in representative samples from these wells is not yet complete enough to make possible an accurate description of the stratigraphic column in the northern and central parts of the area. In the southern part of the area, records of wells drilled on Parris Island show that the limestone occurs at depths of from 55 to 100 feet and is immediately overlain by 1 foot of hard phosphate rock, referred to by the drillers as "cap rock". Overlying this rock are accumulations of fine sand, blue clay and sand mixed with shells. In general the material between 0 and 40 feet is considered to be representative of the Pamlico formation of Pleistocene time, that from 40-70 feet as the Hawthorn formation of Miocene age, and that from 80 to more than 200 feet as the

Cooper formation of Oligocene age. These deposits which overlie the limestone are not uniform in either thickness or areal extent, and the material found in one well is not always found in adjacent wells. It is assumed that the Hawthorn formation, a phosphatic sandy clay, together with the siliceous phosphate "cap rock", forms the confining bed for the artesian water in the limestone. It is possible, however, that younger deposits constitute the only confining bed in some places because during and since Pleistocene time, there has been considerable [~~desiccation and~~] erosion of the Hawthorn formation in this general area. At these times, the level of the sea was about 100 feet lower than it is now, and the rivers probably cut deeply into the Hawthorn and older formations. Thus the Hawthorn formation is quite thin wherever it is present and in some parts of the area it may not be present at all. In a well drilled at Frogmore, 6 miles southeast of Beaufort, no trace of the Hawthorn formation was found. The Cooper marl which has considerable extent in its outcrop area, either constitutes the upper part of the limestone aquifer in the Beaufort area or else is nonexistent.

In the northern part of the area, there was a decided difference between the composition of the cuttings from monitoring well M-4 and that of cuttings from the two new supply wells drilled at the Naval Air Station. The cuttings from well M-4 were mostly sand whereas those from the Naval Air Station wells contained considerable amounts of clay and shells.

The top of the limestone aquifer is about 50 feet below mean sea level in the Beaufort area. Some of the estuaries or rivers such as the Broad River and the Beaufort River are reportedly 50 feet deep at low tide. Therefore, the limestone aquifer is probably exposed at or near the bottoms of these rivers and in contact with salt water. Dredging operations now being planned or undertaken in connection with the development of Port Royal as a seaport may provide easier access of the salt water into the aquifer in that area. If so, it might affect the chloride content of all wells in the area.

Other Aquifers in the Parris Island Area

This report is concerned primarily with the characteristics of the Tertiary limestone aquifer. However, there is a possibility of utilizing one or more of the deeper aquifers in formations of early Tertiary or Late Cretaceous age. The two deep wells on Parris Island penetrated approximately 3450 feet of sediments and after several tests, the wells were developed between depths of 2600 and 2950 feet. The tops of formations are indicated in a log of one of these wells, included in the appendix of the Mundorff report. In 1939, chloride analyses were obtained of the water between 990 feet and 2600 feet in well No. 2. Reportedly the chlorides amounted to 8,500 ppm between depths of 990 ft. and 1149 feet; 925 ppm from 1850 ft. to 1900 feet; 435 ppm from 1850 ft. to 2500 feet; and 82 ppm in waters obtained in the 2600-2811 ft. interval.

As reported by Mundorff, the well at the Enterprise Ice.Co. in Burton bypassed a good supply of fresh water at about 450 feet because there was a hope of obtaining a natural flow from a greater depth. The well was finally developed at 750 feet but the supply was small and the well did not flow.

Wells on the north side of Coosaw River, about 6 miles north of Beaufort, were reported to be 1400 feet deep and yield fresh water.

Presumably, the water is obtained from the top of the Peedee formation of Late Cretaceous age. This water is typically a sodium bicarbonate water, is very soft, but has up to 3.0 ppm of fluoride.

In 1943 the Layne Atlantic Company drilled a 340 ft. well for the Ocmulgee Farm, near Burton. The drillers reported white marl from 70 to 220 feet and sticky white marl from 220 to 340 feet. The casing in the well was pulled because of the low yield (75 gallons per minute with a 25 foot drawdown). Another well in the same area reached white marl at a depth of 60 feet and was drilled to a depth of 214 feet. The static level was 7 feet below ground surface and the yield was 270 gpm with a 20 foot drawdown.

A well drilled in 1907 for the Charleston Mining and Mfg. Co., 7 miles northeast of Beaufort on Chisolms Island, went to a depth of 710 feet. The uppermost part of the limestone aquifer, from 57 ft. to 70 ft., contained salt water. After the well was developed at a depth of 681 feet, water flowed over the top of the casing at a rate of 10 gpm. The driller reported that the well would yield 100 gpm with a pump. Presumably, the water was not salty. The aquifer was probably one of middle Eocene age.

A well was drilled in 1905 for the Penn Normal Industrial and Agricultural School at Frogmore, by the Hughes Specialty Well Drilling Company of Charleston. Originally this well was drilled to 960 feet. In 1943 Mr. J.R. Connolly, well driller, reported that at some previous time while he was working on the well, salt water was encountered and the well abandoned; also that a satisfactory water supply was obtained from a depth of about 200 feet.

In the spring of 1954 two test wells were drilled in connection with the ground-water investigation at Savannah, Ga. One was drilled on Cockspur Island, about 12 miles east of Savannah and the other on Hilton Head Island about 22 miles east-northeast of Savannah. Both wells were drilled to approximately the same depth, 750 feet. They penetrated the limestone aquifer at a depth of about 725 feet and went some 20 feet into underlying clay. In the well on Cockspur Island, the chloride content was less than 40 ppm in water samples taken throughout the entire depth of the well. On the other hand, the water in the Hilton Head Island well showed an increase in chloride with depth, and the bottom sample reportedly contained over 500 ppm of chloride.

From the data available, it appears likely that water may be obtained from some of the deeper formations, but there is doubt as to whether it will be fresh enought for drinking purposes. The probabilities of developing a supply of water of satisfactory quality from one of the deeper aquifers are more favorable at places distant from salt water estuaries.

HYDROLOGY OF THE LIMESTONE AQUIFER IN THE PARRIS ISLAND AREA.

The problem in the Parris Island area revolves around the uncertainty as to the amount of water that may be withdrawn from the limestone aquifer without causing salt-water encroachment.

It must be emphasized that an adequate appraisal of this problem requires considerably more time and data than that included in the present study and that any appraisal of the situation at this time necessarily involves a large risk of misinterpretation of data. An additional complication arises from the fact that some of the reported data may be inaccurate or unreliable.

Piezometric Surface

Of primary consideration in an appraisal of the capacity of an aquifer is the position of the water-table or piezometric surface. This is obtained by careful measurement of water levels in wells. A corollary factor, in this case, is the change in chloride content of the water with a change in water level due to pumping.

The history and description of the Parris Island water-supply, comprised of Jericho, Burton and Naval Air Station well fields, is contained in the reports mentioned above. By the end of 1955 the major change in status of this supply involved the transfer of the Naval Air Station well field (wells 11, 12, and 13) to the Air Station Administration. Thus, the Marine Corp Recruit Depot has at the present time only the Burton well field for practical or everyday use. The Jericho well field has been pumped but a few hours a month during the past two years. Table 1 lists the present supply wells and the monitoring wells surrounding the area. Each supply well is metered and currently the Maintenance Department at the Marine Corp Recruit Depot records the monthly pumpage from each well and makes monthly measurements of the static and pumping water levels in the supply wells. Analyses of the salt content of each well is also reported. Water levels are measured with a pressure gage attached to the air-line. Inasmuch as one pound per square inch of pressure is the equivalent of 2.31 feet of water, then water levels measured with an air gage reading to the nearest ¼ pound are accurate to within only one-half foot. Because of the possibilities involved of inaccurate estimates of the change in water levels with

Table .1. Well data on the supply and monitoring walls of the Marine Corp Recruit Depot, Parris Island, S.C.

Table 1.—Well data on the supply and monitoring wells of the Marine Corps Recruit Depot, Parris Island, S.C.

REVISED

Parris Island No.	Mun-dorff No.	USGS Co. No.	Alti-tude1/ above datum (ft.)	Depth (ft.)	Dia. (in.)	Cas-ing Depth (ft.)	Depth to lime-stone (ft.)	Average depth to water be-low measuring point (ft.)	Elev msl	Period of water depth measurement	Average chloride for same period (ppm)	Remarks
1	11	BFT-11	120.77	2830	18	2600					10	Deep well at Water Works-Chlor as of 10/15/54
2	10	BFT-10	120.96	3450	18	2900					58	Deep well at Rifle Range-Chlor as of 10/20/54
3	19	BFT-19	24.57 130.7	127	18	127		23.8		1/55-1/56	69	MP 2/ is air line=datum + 2.0± ft.
4	21	21	21.23 125.73	147	18	147		22.3		4/55-1/56	30	"
5	20	20	[illegible] 122.18	90	10	82		16.5		1/55-1/56	63	"
6	22	22	11.70 114.50	84	12	80		16.2	(-4.5)	"	23	"
7	24	24	14.42 117.85	84	12	84		18.3	(-3.88)	"	20	"
8	—	107	23.16 126.40	96	12	77		27.4		"	27	"
9	—	108	25.48 128.80	100	12	82		28.5	(-3.02)	"	20	"
11	25	25	125.50	80	12	80		15.1	10.4	6/53-2/54	21	"
12	26	26	138.50	117	8	94		24.0	14.5	"	23	"
13	27	27	135.00	98	8	80		29.4	6.1	"	20	"
21	—	109	21.94 ~~133.35~~	103	10	87		21.7	1.7	1/55-1/56	27	"
22	—	110	23.71 ~~134.34~~	100	10	91		24.8	1.5	"	22	"
23	—	111	22.98 ~~125.15~~	101	10	86		26.7	-1.5	"	25	"
24	—	112	18.96 ~~120.72~~	105	10	85		21.2	-0.5	"	28	"

Table 1.-- Continued

Parris Island No.	Mun-dorff-No.	USGS Co. No.	Altitude[1] above datum (ft.)	Depth (ft.)	Dia. (in.)	Casing Depth (ft.)	Depth to lime-stone (ft.)	Average depth to water below measuring point (ft.)	Period of water depth measurement	Average chloride for same period (ppm)	Remarks
26	--	BFT-114	[illegible]	100	10	82		23.9	4/55-1/56	22	MP[2] is air line = datum + 2.0
27	--	115	[illegible]	95	12	78		27.3	"	23	"
28	--	116	125.11	97	12	78		24.1	"	19	"
29	--	117	123.24	95	12	76		24.7	"	20	"
?	--	131	[illegible]	110				12.42	11/4/55		New supply well #1 at NAS Yield=300 gpm[3]. MP is datum
?	--	132	24.26	102				13.25	10/27/55		New supply well #2 at NAS Yield=300 gpm. MP is datum
M-1	--	118	13?.77	109	12						Monitoring well
M-2	--	119	125.70	93	10	81		22.6		20	Monitoring well, chloride is average of 2 analyses-1/12 & 2/9,
M-3	--	120	117.26	85	10	72	69	16	2/10-2/17/55	23	"
M-4	--	121	128.00	105	10	85	81	13	4/19/55-1/28/56	23	"
M-5	--	122	110.93	75	10	59	65	5.68	3/24-4/15/55	31	Monitoring well, chloride is average of 3 analyses, 3/17/55; 1/56 & 2/9/56-Yield = 440 gpm.
M-6	--	123	135.81	115	10	96	96	22.5		22	Monitoring well. Chloride is average of 3 analyses-4/21/55;1/1 and 2/9/56. Yield = 400 gpm.
M-7	--	133	[illegible]	110	10	68	60	12.20	1/27/56		Monitoring well - Yield = 180 at Lobeco.
X-1	--	124	129.45	107	12	97		12.35	4/26-8/8/55	26	Experimental well on NAS-Chloride is average of 2 analyses, 2/6/
X-2	--	125	132.57	167	12	140				27	"

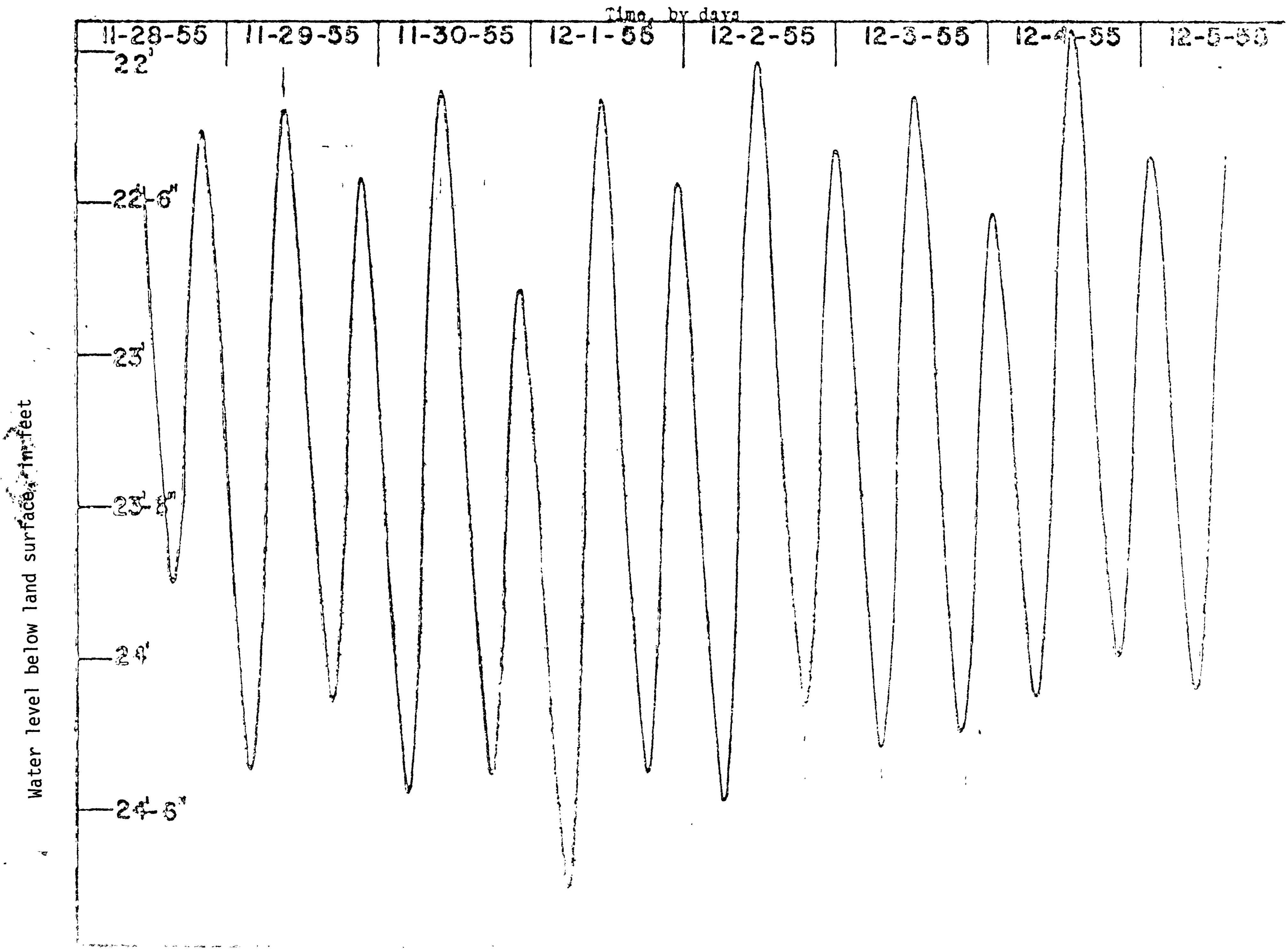
1/ datum used by MCRD at Parris Island, assumed to be 100 ft. below mean low water, or as used in previous reports, 103.5 ft. below mean sea level.

2/ MP= measuring point

3/ gpm = gallons per minute

respect to time and pumpage, the Survey recommended certain changes in the obtainment and recording of such data. These changes were concerned chiefly with the use of a constant recovery time (4 hours) before the static or pumping water level was measured in a well which had been previously running or shut down respectively.

The principal limestone aquifer contains water under artesian conditions. There may be some exceptions to this, but it applies to the greater part of the area. Water-levels in artesian wells fluctuate due to a number of factors. These factors include near-by pumping, barometric changes, tides, and other loading phenomena. In order to identify the nature and amount of these water-level changes, automatic recording gages were installed on several supply wells and monitoring wells in the Jericho, Burton and Naval Air Station areas. A continuous recorder was installed on Jericho well No. 4 for approximately 60 days during the first half of 1955. The record showed that the water level in this well was affected by oceanic tides and that the semi-diurnal change caused by this factor alone amounted to as much as 1.6 ft. Gradual changes over a period of about 28 days coincided with varying phases of the moon and changes in barometric pressure. The barometric changes are recorded by a microbarograph located within the well-house or recorder shelter. Two weekly recorders have been installed in turn on wells M-2 and M-3 in the Burton well field; on wells M-5 and No. 25 in the vicinity of Burton; on wells X-1 and X-2 at the Naval Air Station and on well M-6, southwest of the Burton well field and near Broad River. A continuous recorder has been in operation on well M-4 at the Naval Air Station since April 1955. The records obtained from these wells indicated a tidal effect on water levels for all wells except M-4. Tidal fluctuations


Time, by days
11-28-55
11-29-55
11-30-55
12-1-55
12-2-55
12-3-55
12-4-55
12-5-55
22'
22'-6"
23'
23'-6"
24'
24'-6"
Water level below land surface, in feet

could not be discerned with certainty in the record for well M-4, possibly due to the fact that they were screened out by numerous changes due to pumping or because the well reflected water-table conditions. In other wells, however, the semi-diurnal change in water level due to tides ranged from .05 foot in well X-1 to 2.6 feet in well M-6(Fig. 1). The net change in water level during the period October 4 to November 28, 1955, due to the tide, amounted to 4.45 feet in well M-6. The tidal-response ratio (the ratio of the change in water level in a well to the range in tide) ranged from 0.0066 to 0.347 in the wells observed. The fluctuations (of about .05 foot) thought to be due to tidal effect in wells X-1, X-2, and No. 25 are so small and occur at such times as to indicate the possibility that they may be due in part to change in barometric pressure.

Pumping of near-by wells is the greatest factor affecting the water levels in other wells in the area. The amount by which pumping one well will affect water levels in other wells depends upon the rate and duration of pumping, the distance between wells, the permeability of the aquifer, and the entrance losses in the observed well.

In order to obtain data on the drawdown caused by pumping, a pumping test was made on well 26 during July 21 and 22, 1955. The test consisted of measuring the recovery of water levels in wells M-5, M-2, M-4, X-1 and 25 after shutting down well 26, which had been pumped for 9 days, 8 hours and 45 minutes, at a rate of 225 gpm. Depths to water were measured in wells M-2, M-5, and 26 with a wetted tape; wells M-4, X-1 and 25 were equipped with automatic recording gages. The test indicated that no detectable drawdown occurred in wells M-2 or M-5, they being too far away to have a measurable drawdown within the time of the test. The drawdown during the first 24-hour period was 4.2 feet in well M-4, 0.95 foot in well 25, and 0.39 foot in well X-1. Well M-4 is approximately 2000 feet east of well No. 26 and well 25 about 3950 feet southwest of well 26. The unreliability of information on the distances between wells affects the interpretation of the results of this test. The distances as taken from the available maps, are not sufficiently accurate for the computations involved. Thus, wells represented as closer to the pumped wells have lesser drawdowns than those farther away——which is possible but unlikely.

When well 26 is pumped at the usual rate of 250-300 gpm, it requires approximately 65 hours for the water level to stabilize in well M-4, and 12 hours to stabilize in Well 25. This appears to indicate that either (1) the permeability of the aquifer decreases considerably in the direction towards the Naval Air Station (and well M-4) or (2) the entrance losses in well M-4 are considerably larger than in other wells or (3) some unknown geologic change occurs between the Naval Air Station and well 25. There is some indication that the permeability of the aquifer is greater in the Burton well field than in the area near the Naval Air Station.

A weekly recorder was in operation in monitoring well, M-3, in the Burton well field during the period February 10 through March 17, 1955. M-3 is located 1,075 feet from well 6, which is pumped at a greater rate (400-450 gpm) than any other well in the field. The period of record is too short to make many definite conclusions, but when the total pumping rates were 500 gpm or less there was no apparent affect on water levels in well M-3. A total pumpage of 1000 to 1700 gpm apparently caused a 2 foot drop in water level in well M-3 whereas a total pumpage of 1900 gpm on February 21 caused a 6 foot drop in well M-3. Additional records of water levels in this well would be of definite advantage.

Two pumping tests were made in the Burton well field during the period January 26-27, 1956. For the first test well 23 was pumped at a rate of 300 gpm and wells 24, 27, 8, and M-3 were used as observation wells. Continued pumping for 8 hours failed to reveal any detectable drawdown in the observation wells. For the second test well 6 was pumped at a rate of 680 gpm and wells 27, 8, and M-3 were used as observation wells. The distances between these wells are not accurately represented on existing maps but the writer made a compass and tape traverse and obtained 1,075 ft. for the distance between wells 6 and M-3; and 1,270 ft. for the distance between wells 6 and 8. Time did not permit a similar traverse to well 27 from M-6, but, judging from the amount of drawdown in well 27, it is estimated to be between 700 and 900 ft. from well M-6. The water-levels in well M-3 were measured with a steel tape; those in wells 6, 8, and 27 with an air gage. After about 6 hours continuous pumping the water levels in all wells had essentially stabilized. The drawdown in well 8 amounted to 3.0 feet; that in well M-3, 3.62 feet; and that in well 27 amounted to 4.0 feet. Although the duration of the test coincided roughly with the receding tide, the effect of the tide probably was not significant because the tidal affect in well M-3, as determined with the recording gage, amounted to less than 0.2 foot. Figure 2 shows the general relationship of the water levels before and near the end of the test in the Burton well field on January 26-27.

There was not sufficient time nor data available for construction of a piezometric map, but a comparison of the data used for such a map is afforded in Table 2, which lists the recent water levels in specific wells compared with water levels measured at previous times.

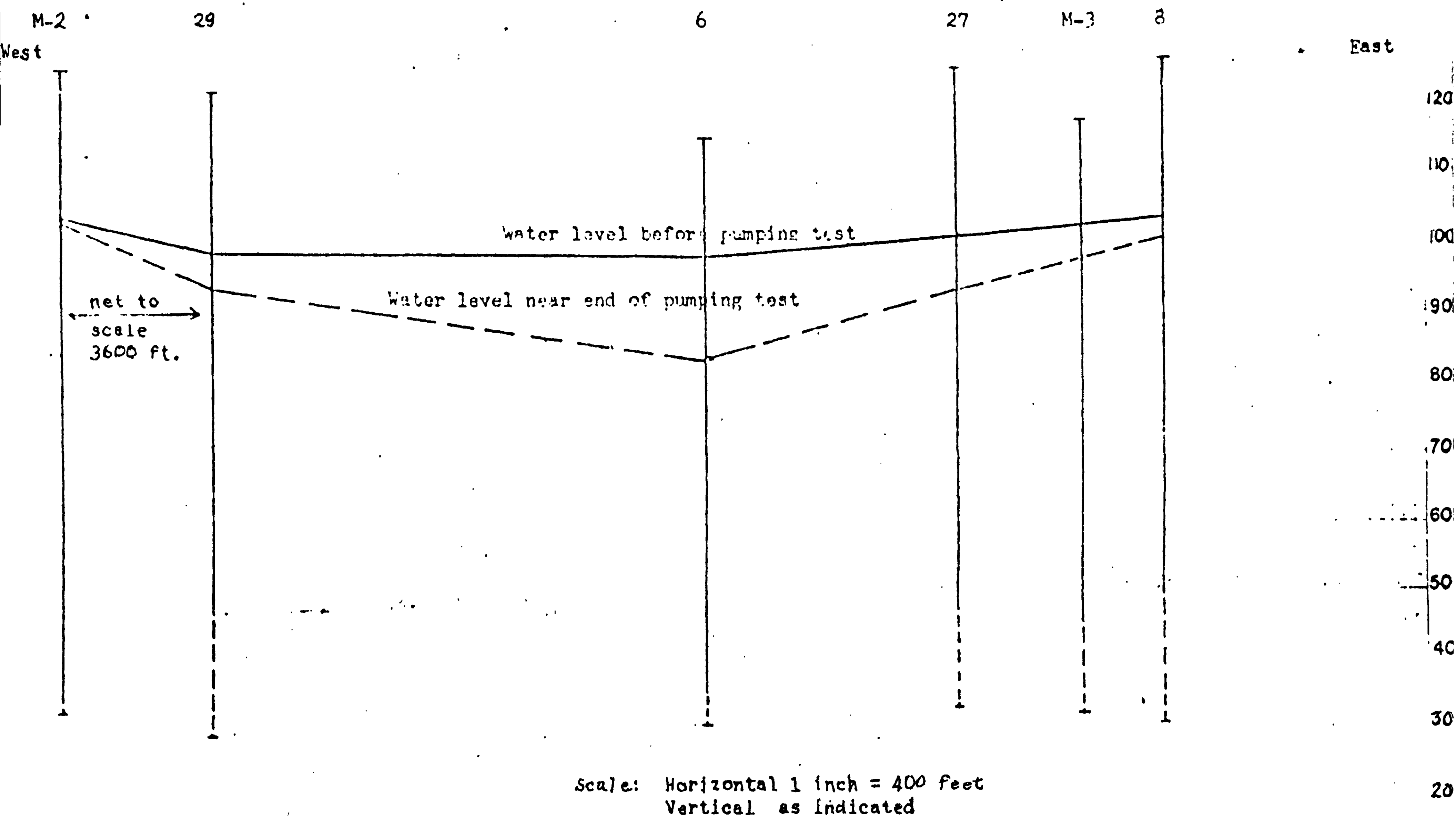


Figure 2. Drawdowns in the Burton well field produced by pumping well 6 for 6 hours at 680 gpm

Table 2.- Comparative water levels in wells in Beaufort and Jasper Counties during the period 1941-1956.

WELL NUMBER		MEASURING POINT		WATER LEVEL			REMARKS
Parris Island Number	Mundorff Number	Description	Altitude* (feet)	Depth (feet)	Altitude (feet)	Date	
3	19	hole in pump base	26.63	22.31	+4.32	4/15/44	
"	"	air-line pipe	29.2	23.8	+4.4	Average 1/55-1/56	Top of pump base = 25.6
4	21	hole in pump base	21.5±	20.23	+1.25	4/15/44	Top of pump base = 21.3
"	"	top of pump base ~~air-line~~	21.35 24.2	22.3	-0.95 +1.9	Average 4/55-1/56	
6	22	hole in pump base	11.62	11.23	+0.39	4/14/44	
"	"	air-line	11.7 13.0	16.2	-4.5 -3.2	Average 1/55-1/56	Top of pump base = 11
11	25	top of pump foundation	25.5	14.13	+11.37	4/9/44	
"	"	air-line	27.5	15.1	+12.4	Average 1/53-2/54	
12	26	top of pump foundation	13.5 (?)	5.60	+7.90	4/8/44	Large difference in altitude of measuring point indicates obvious error.
"	"	air-line	37.0	24.0	+13.0	Average 1/53-2/54	
13	27	top of pump foundation	35.0 (?)	8.15	+26.85	4/7/44	
"	"	air-line	33.5	29.4	+4.1	Average 1/53-2/54	Well deepened since 1944.
USGS Co. No.							
BFT-28	28	floor of pump house pit	25.5	24.0	+1.5	4/10/41	
"	"	top of casing	14.1	10.85	+3.2	4/17/44	
29	29	hole in casing	7.05' below sill	8.19	[illegible]	[illegible]	Town of Beaufort No. 2

Table 2.- Continued

WELL NUMBER		MEASURING POINT		WATER LEVEL			REMARKS
USGS No.	Mundorff Number	Description	Altitude* (feet)	Depth (feet)	Altitude (feet)	Date	
29	29	top of casing	9.0± ft. below door sill	8.16	+4.0 ±	1:43 PM 7/20/55 BFT #2	Stopped pump 24 minutes previously.
34W	—	top of casing	23.9	9.54	+14.36	3/20/41	
"	—	top of casing	"	10.4	+13.5	4/26/55	
46	46	top of casing	20.4	18.05	+2.35	12:00 Noon 4/10/41	
"	"	" " "	"	18.15	+2.25	2:40 PM 4/11/44	
"	"	" " "	"	19.06	+1.34	10:32 PM 7/21/55	Ext ? C.
53	53	base of pump valve	44.26	20.87	+23.39	12:00 Noon 4/12/44	
"	"	top of casing	42.0±	22.25	+19.75	5:05 PM 7/11/55	May be different well.
BFT-56	56	reducer at top of casing	13.22	5.05	+8.17	3/20/41	
"	"	" " "	"	5.31	+7.91	4/12/44	
"	"	" " "	"	6.78	+6.44	4/30/44	
"	"	" " "	"	8.63	+4.59	4/20/55	
JAS-25	76	top of casing	37.2	20.0	+17.2	4/21/44	
"	"	" " "	"	19.8	+17.4	10/30/47	
"	"	3" thread protector	38.25	22.60	+15.60	4/19/55	
JAS-26	73	top of wood platform	23.85	12.06	+11.79	3/13/41	
"	"	" " "	"	12.77	+11.08	10/30/47	
"	"	top of thread protector	24.05	16.98	+7.07	4/19/55	

Table 2.- Continued

WELL NUMBER		MEASURING POINT		WATER LEVEL			REMARKS
USGS Number	Mundorff Number	Description	Altitude* (feet)	Depth (feet)	Altitude (feet)	Date	
JAS-32	79	top of 3" tee	9.2	+3.6	+12.8	3/20/41	
"	"	" " " "	"	+3.66	+12.86	4/8/41	
"	"	" " " "	"	+3.3	+12.5	10/29/47	
"	"	" " " "	"	+3.1	+12.3	4/20/55	
HAM-6	80	top of casing	22.8	+11.2	+34.0	4/8/41	
"	"	" " "	"	+12.2	+35.0	10/29/47	
"	"	" " "	"	+9.8	+32.6	7/19/55	

It may be seen that whereas some wells, particularly in the western or southwestern part of the area, (towards Savannah), appear to have lower water levels in 1955 than in 1944 or 1941, the decline in water level amounts to less than 3 feet. This may represent a drop in water level caused by increased pumpage in the Savannah area. However, those wells which show the greatest drop in water level are close to tide water and therefore affected by the tide. The drop in water level in these wells is less than the fluctuations of water levels in response to tide, as noted in other wells similarly located. In the Burton and Beaufort areas the apparent drop in water level has been of the same magnitude approximately, but when it is remembered that the effects of tide, differences in altitude of measuring point, and discrepancies of water level measurements may individually or collectively produce an error as great if not greater than the apparent drop in water level, then it is evident that additional, more accurate information must be obtained in order to determine whether a progressive lowering of water levels is taking place.

Whereas the piezometric map produced by Mundorff indicated the lowest water level in the Burton well field to be at an altitude of -1.85 feet, present data show that the lowest average water level during 1955 was -3.5 feet. Thus in the cone produced by pumpage in the Burton well field, there is an apparent drop of water levels in the order of 2.0 feet.

Figure 3 shows a cross section of wells from the northwest to the southeast, extending from the Naval Air Station to the entrance of the Marine Corp Recruit Depot at Parris Island. The curves show the reported water levels in wells at the time of high pumpage (Aug. 1954), at a time of intermediate pumpage (July 1955), and at a time of low pumpage (Dec. 1954). The pumpage amounted to [illegible].4, 56.8, and 30.2 million gallons per month, respectively. The average difference in water level between that reported during the greatest pumpage and that for the least pumpage is approximately 10 feet in the Burton well field and less in surrounding areas. The water levels in these wells appear to be a reflection of the surface topography, which might lead to the conclusion that they represent water-table conditions. However, the configuration of the water levels is also due to the fact that pumpage in the Jericho and Naval Air Station well fields is considerably lower than that in Burton, and coincidently these two areas are higher topographically than the Burton well field area.

The distance to the recharge area of the limestone aquifer has heretofore been considered to be approximately 30-40 miles in a northwest direction. However, there is some basis for assuming that local recharge takes place either by leakage through the confining bed or through places where the confining bed is absent. The water levels at the Naval Air Station and those mentioned by Mundorff in the Lobeco area, are substantially higher than those in the area around Burton, Beaufort, or the lower part of Port Royal Island. These higher water levels might be accounted for by other factors but they might also represent areas of local recharge, effected through the water-table. In addition, it was noted that whereas the use of pitcher pumps in the water-table aquifer on Port Royal Island has been widespread in previous years, they can not be used at the present time because of a lowered water level. Again this may be accounted for by the depletion of the water-table aquifer because of prolonged dry periods, but it could also indicate that the relief of pressure on the confining bed, due to pumping the Burton well field, has caused leakage through the confining bed and loss of water from the water-table aquifer.

Transmissibility and Coefficient of Storage

Pumping tests were made by Mundorff in 1944 and subsequently during this investigation for the purpose of determining the fundamental aquifer constants of transmissibility and coefficient of storage. Mundorff's tests in the Burton well field indicated the average transmissibility of the aquifer in that area to be about 90,000 gallons per day per foot. Tests at the Naval Air Station indicated that the transmissibility there was only 45,000 gallons per day per foot. The transmissibility represents the number of gallons of water per day which will percolate through each section of the aquifer one foot wide, and having a unit hydraulic gradient.

The transmissibilities obtained as a result of recent pumping tests were calculated by use of the Theis non-equilibrium method,[1] wherein

$$T = 114.6 \frac{Q \; W(u)}{s}$$

and

$$S = \frac{uTt}{1.87 r^2}$$

where
- T = transmissibility in gallons per day per foot
- S = coefficient of storage, a dimensionless fraction
- Q = pumping rate in gallons per minute
- r = distance between pumped well and observation well, in feet
- t = time since pumping began (or stopped), in days

$$u = \frac{1.87 r^2 S}{Tt}$$

$$W(u) = -0.5772 - \log_e u + u - \frac{u^2}{2.2!} + \frac{u^3}{3.3!} - \frac{u^4}{4.4!}$$

The tests conducted in 1955 and 1956 indicate values for transmissibility in the Burton well field corresponding closely to those obtained

1/ Theis, C.V. The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground Water Storage. Trans. Am. Geophys. Union, 16 :519 (1935) in 1944. No recent test has been conducted at the Naval Air Station—primarily because of the constructional activities currently in progress in that area. But a test on well 26 just south of the Naval Air Station, obtained indecisive results. The transmissibility calculated from water levels in well 25, (figure 4) in the direction of Burton well field, was approximately 90,000 gallons per day but the transmissibility as calculated from the water levels in N-4, on the southern edge of the Naval Air Station, amounted to only 25,000 gallons per day (fig.5). Computations of the coefficient of storage indicated a value approximating 1×10^{-4} for tests in the Burton well field and 3.5×10^{-5} for those near the Naval Air Station. The coefficient of storage is defined by the U.S. Geological Survey as follows: The coefficient of storage of an aquifer is the volume of water it releases from or takes into storage per unit surface area of the aquifer per unit change in the component of head normal to the surface. Although not included in his report, Mundorff's calculations of the storage coefficient in the Burton area, as obtained from his notes, agreed substantially with those calculated from the recent tests.

Possible Processes by which the Aquifer may become contaminated with salt water

The aquifer used in the Parris Island area is overlain in contiguous areas by salty surface water and by materials saturated with salt water. Salt water or brackish water also occurs in aquifers underlying the fresh-water aquifer. Thus, contamination can result from (1) downward seepage of salty or brackish water from surface sources,or overlying beds (2) lateral migration through the limestone (3) upward movement of underlying salty waters, and (4) leakage through defective wells.

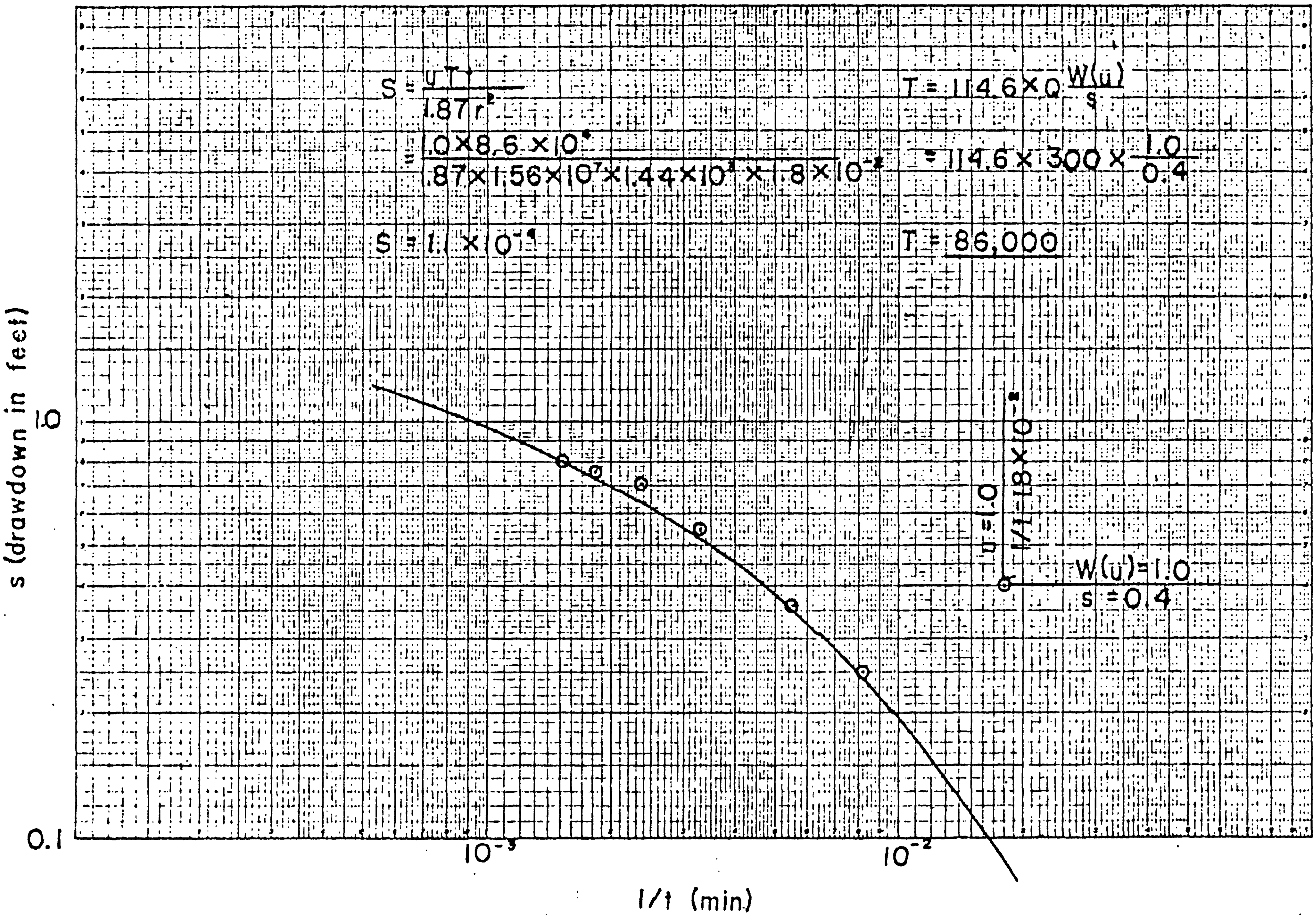


Figure 4.- Calculation of transmissibility and storage coefficient from drawdowns in well 25 caused by pumping well 26 on January 26, 27 1956.

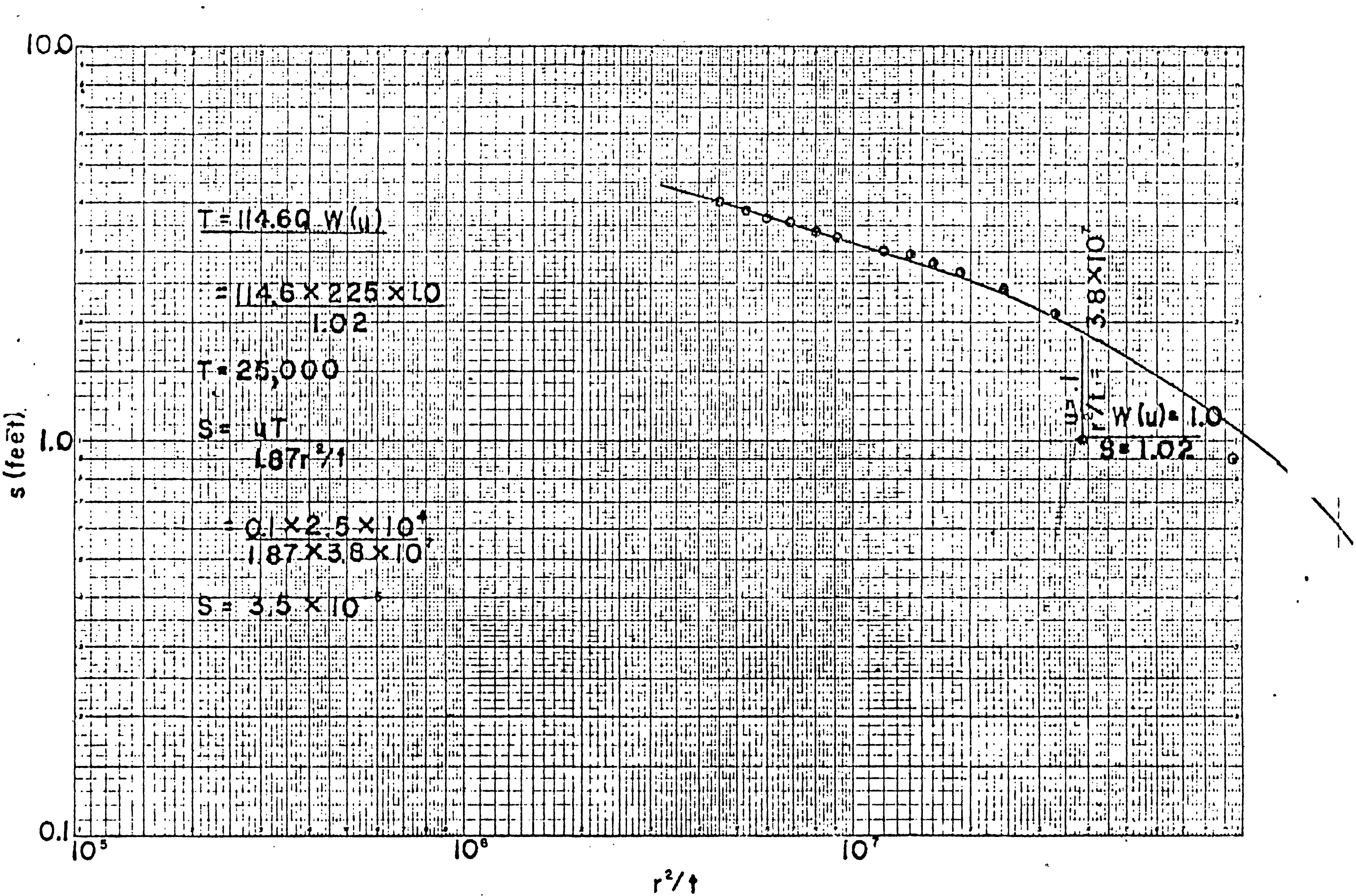


Figure 5.- Calculations of transmissibility and storage coefficient from drawdowns in well M-4, casued by pumping well 26 on June 21-22, 1955.

As mentioned previously the limestone occurs at altitudes above -50 feet in this area and the depths of such estuaries as the Beaufort, Broad, and Coosaw Rivers may expose the aquifer to salt water. Thus, lateral migration of salt water from a place where the aquifer is in contact with sea water is considered one of the most probable processes by which contamination occurs in this area. However, contamination may come about in other ways. Thus, if the high water levels in the areas around the Naval Air Station and the lower part of the Jericho well (figure 2) field occur as a result of recharge from the water-table through discontinuities in the confining layers, then contamination can occur in these areas by a movement of salty surface water through the gap in the confining bed. This may account for the contamination in the Burton (town) area, near Abagota Creek.

A number of undrained depressions, locally called "sinks", are present throughout the area. This topographic feature may be responsible for the discontinuities or breaks in the confining bed which enable local recharge to take place. The origin or the so-called sink may be accounted for by (1) underground solution forming cavities which are subsequently filled with sand, (2) stream erosion during Late Tertiary or Pleistocene time which cut through the confining layers, forming valleys which have since been filled with sand, or (3) seismic disturbances such as the Charleston earthquake or some previous earthquake, which created fractures in the confining bed and filled them with sand both at the time of the quake and at some subsequent time. Whatever their origin, their presence could account for the local recharge to the artesian aquifer and would increase the possibilities of salt water contamination by downward seepage. Well I-2 is in one of these sinks, and its water level is one of the highest in the area.

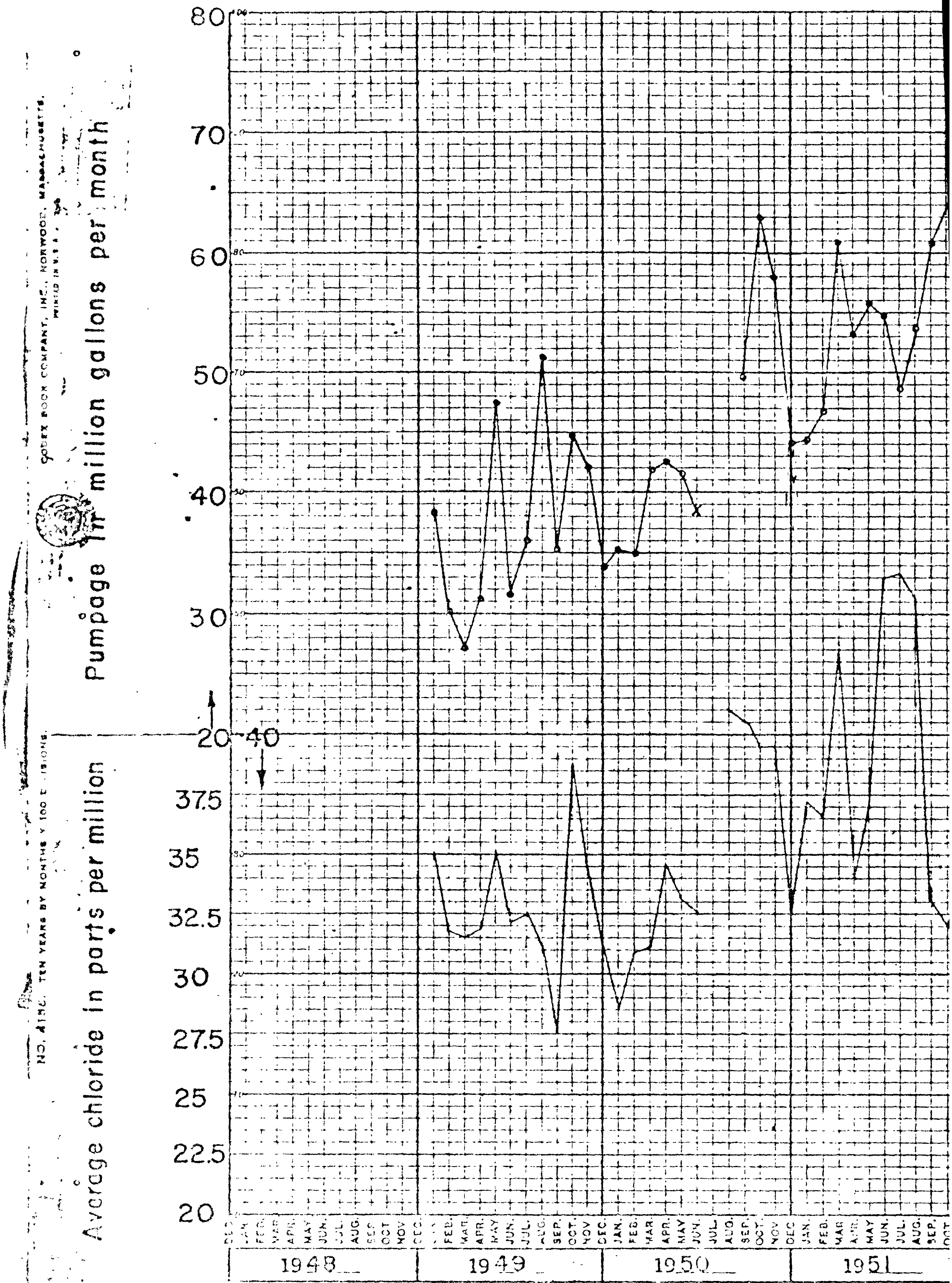
Mundorff believed that the source of contamination in the Jericho well field was the lateral migration of salt water from Battery Creek. But, as he mentioned, there is also the possibility of contamination by a movement of salt water through defective wells.

Relation between Pumpage and Chloride Content

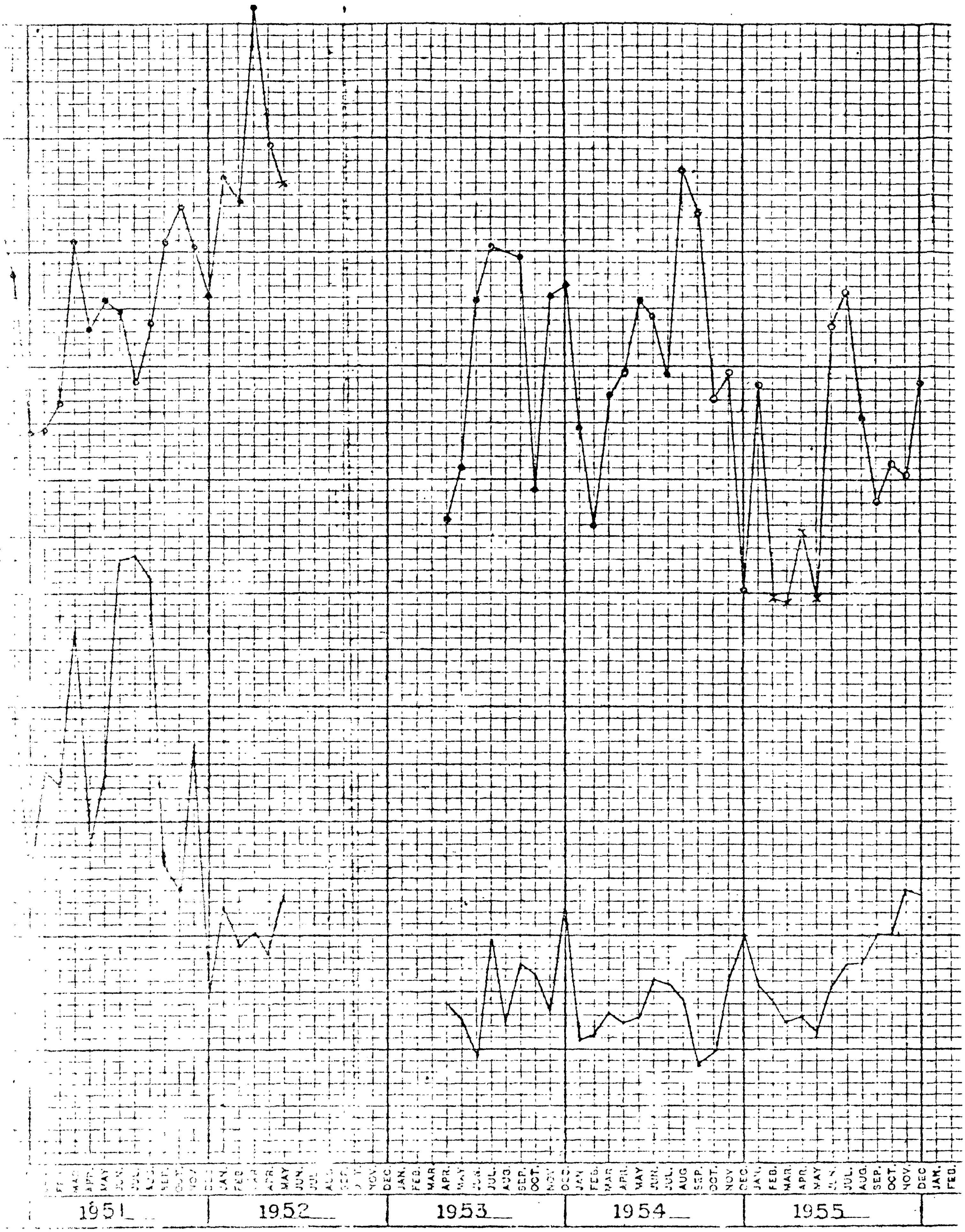
Figure 6 shows the relationship between the pumpage and chloride content of well waters as reported by the Maintenance Department of the Marine Corp Recruit Depot. Either the data is not sufficiently complete or else the relationship is vague at best. Some general conformity prevails but the period of highest pumpage (March 1952) coincides with a period of low average chloride content.

Figures 7, 8, 9, 10, 11, and 12, show the comparison between pumpage from individual wells with the average chloride content of these waters, as reported by the Marine Corp Recruit Depot. The correlations between pumpage and chloride is fair to poor. The correlation is best in the data from wells 6, 22, and 29 (figures 9, 10, and 12 respectively), all in the Burton well field.

The highest chloride reported from wells operated by the Marine Corp Recruit Depot is obtained from well 3 in the Jericho well field. Figure 13 represents the monthly pumpage in wells 3, 21, and the sum of pumpage from 21 and 22 as compared with the chloride content of waters from well 3. It may be seen that there is little if any conformity between the curves representing pumpage from well 3 with the chloride content. But well 3 is pumped an average of only 4 hours per month. However, the curve representing pumpage from well 21 and that representing the total pumpage of wells 21 and 22 (nearest regularly pumped wells to the Jericho well field) show a much closer correlation with the curve representing

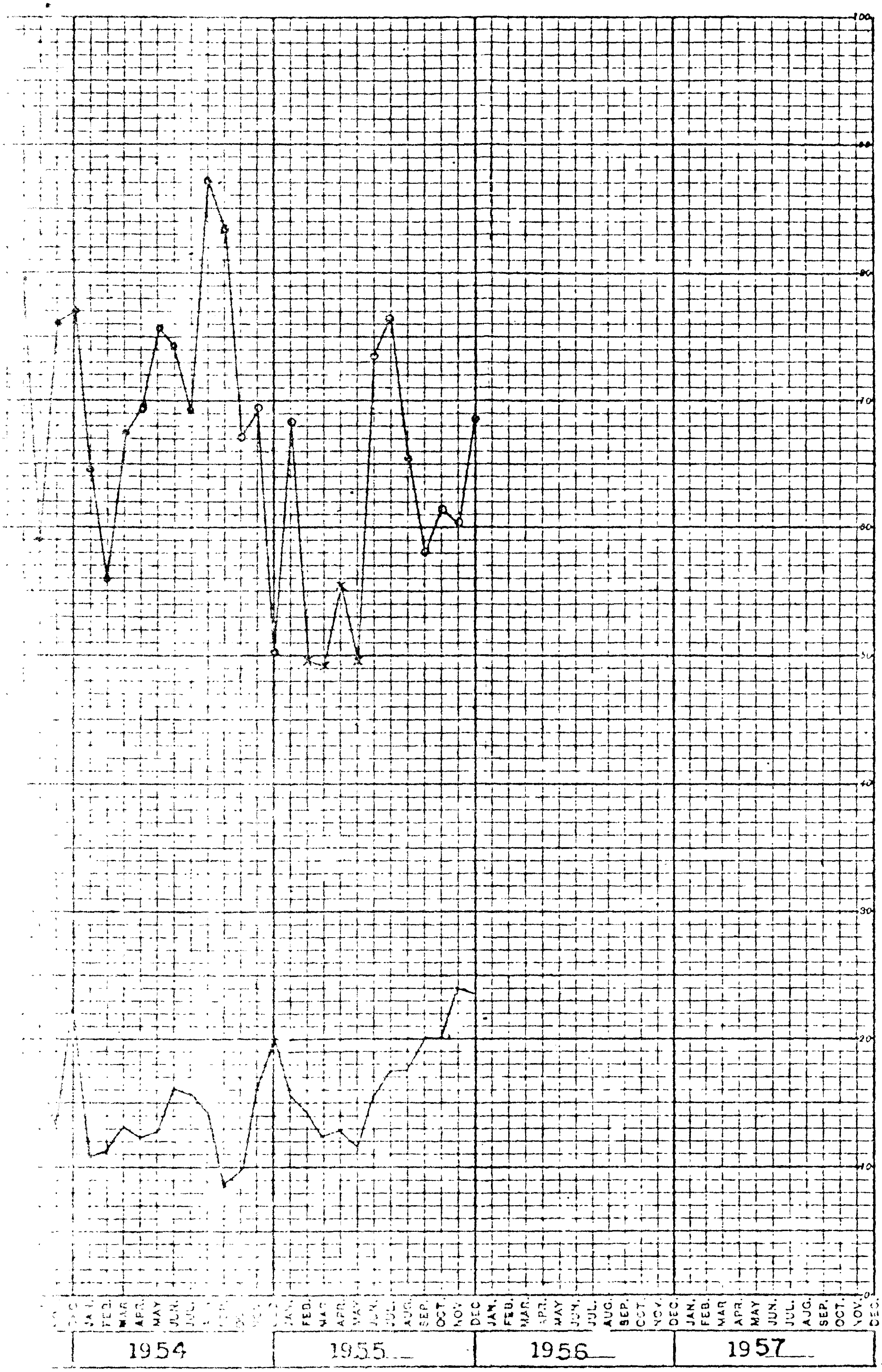


Pumpage versus average salinity in wells o

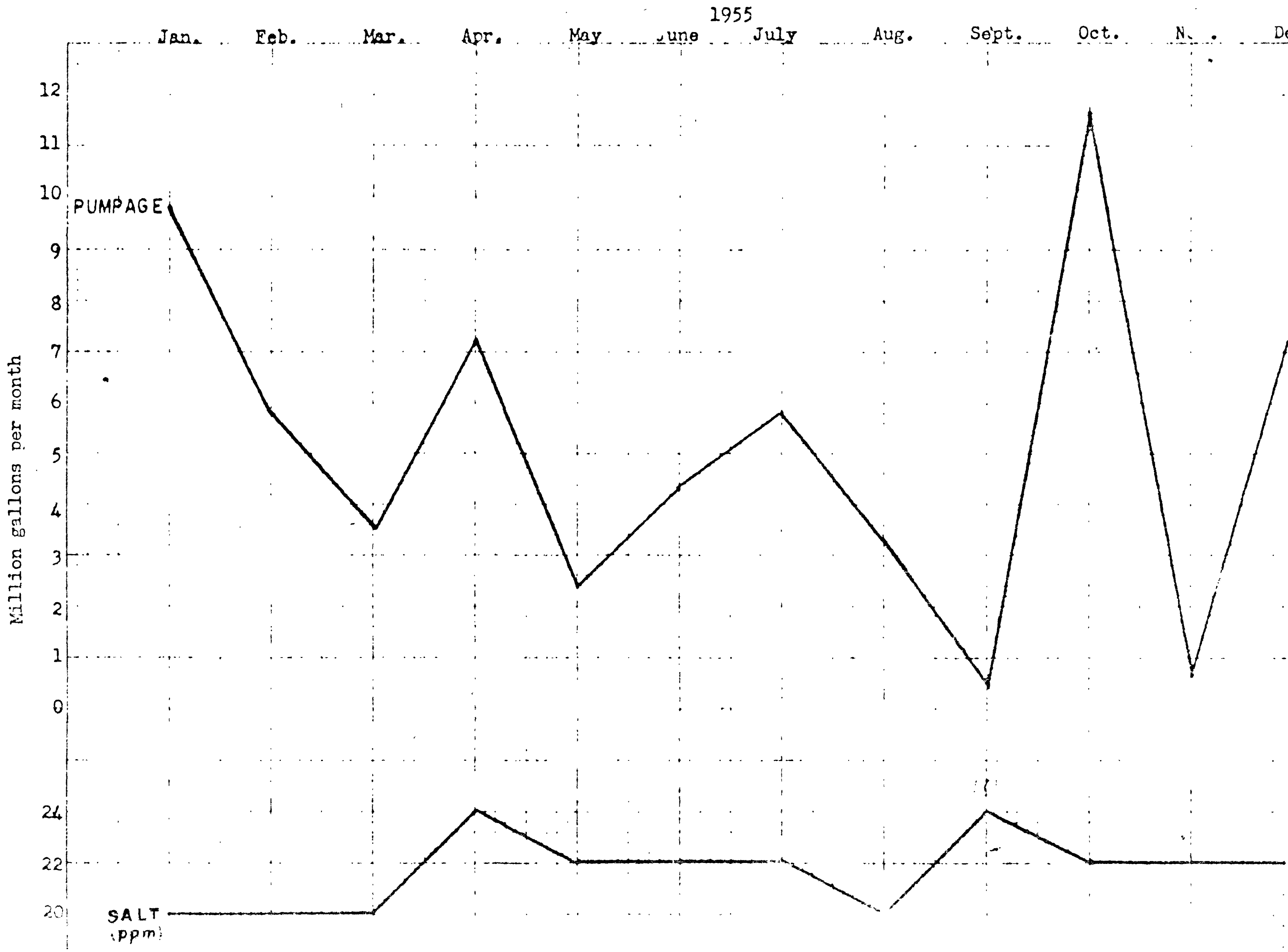


in wells operated by M.C.R.D., Parris Island, S.C.

O—Meter Discharge
X—Computed Discharge



...rris Island, S. C.


1955
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Million gallons per month
12
11
10
9
8
7
6
5
4
3
2
1
0
24
22
20
PUMPAGE
SALT
(ppm)

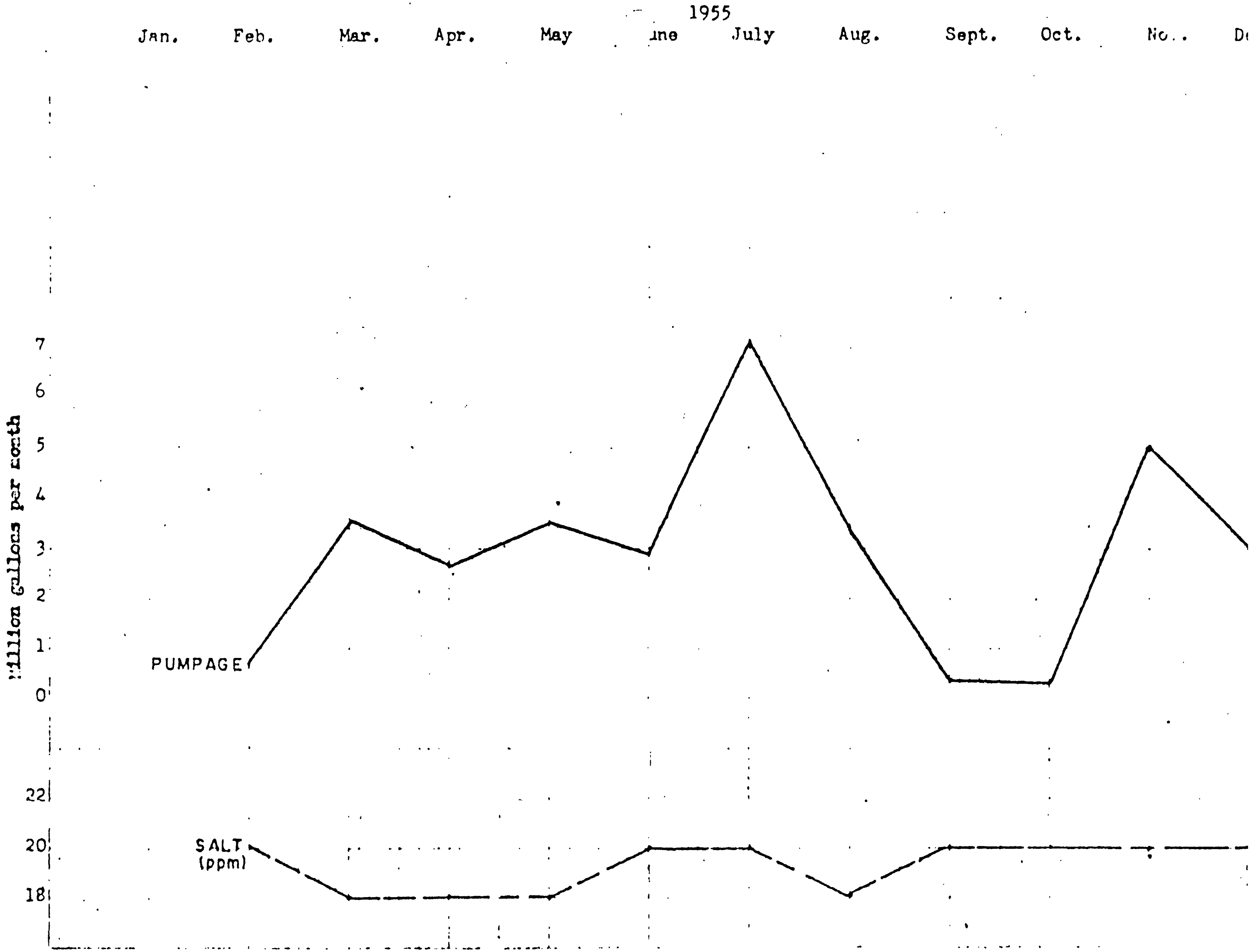


Fig. 8 - Pumpage and chloride content of water from well No. 28, Parris Island, S.C.

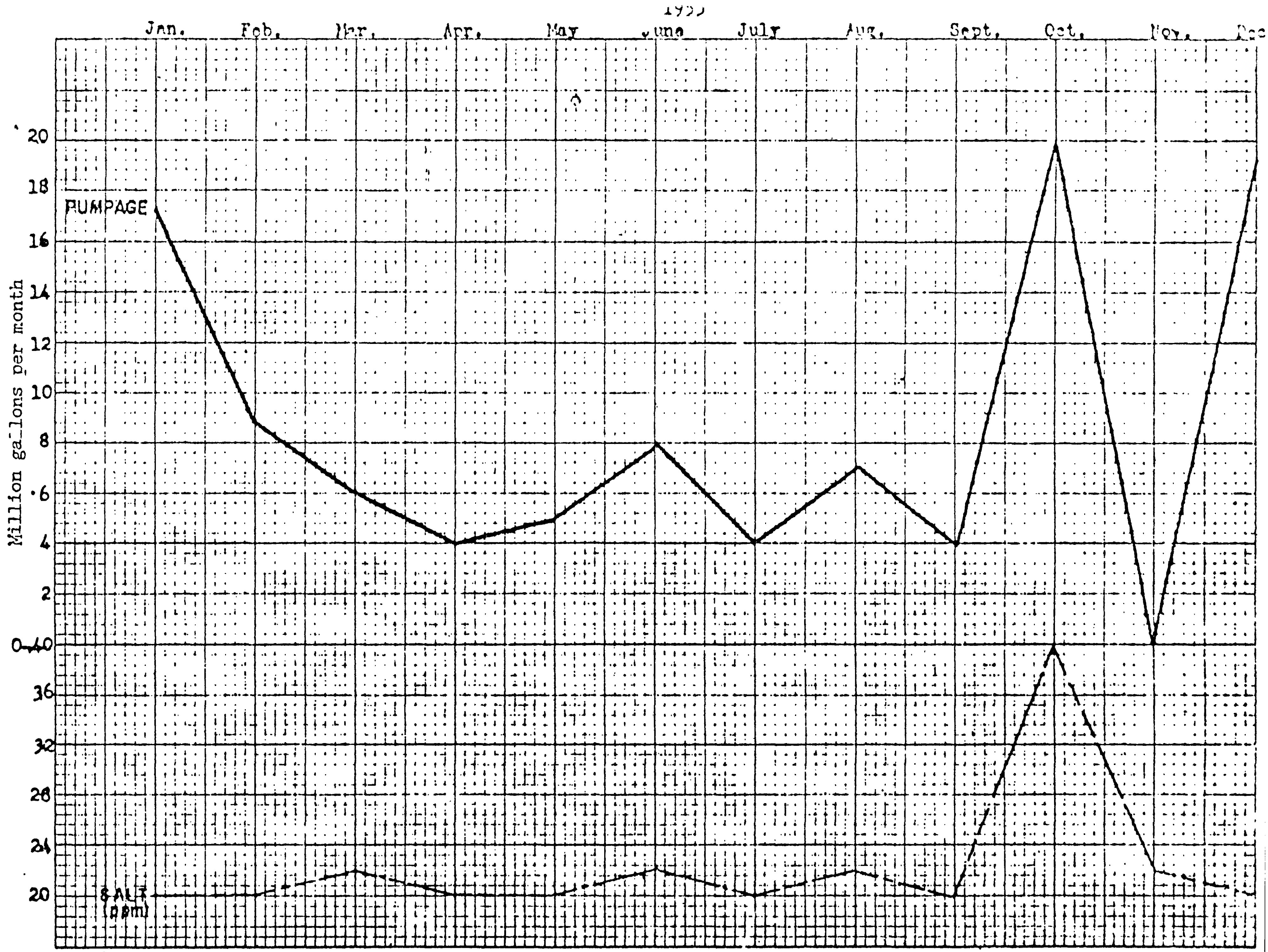
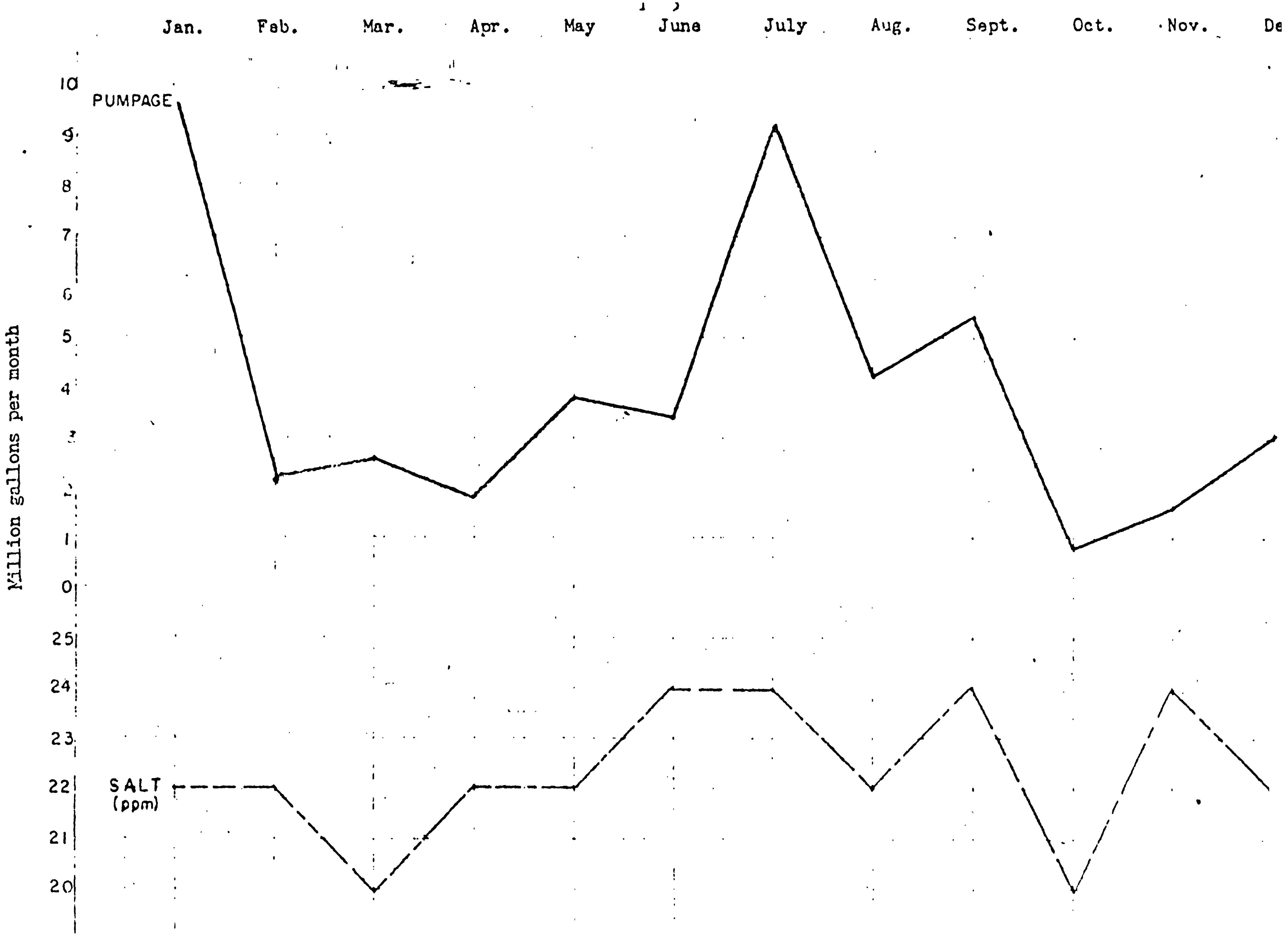


Fig. 9 - Pumpage and chloride content of water from well No. 6. Parris Island. S.C

In Parris Island well #22
BFT Co. #110



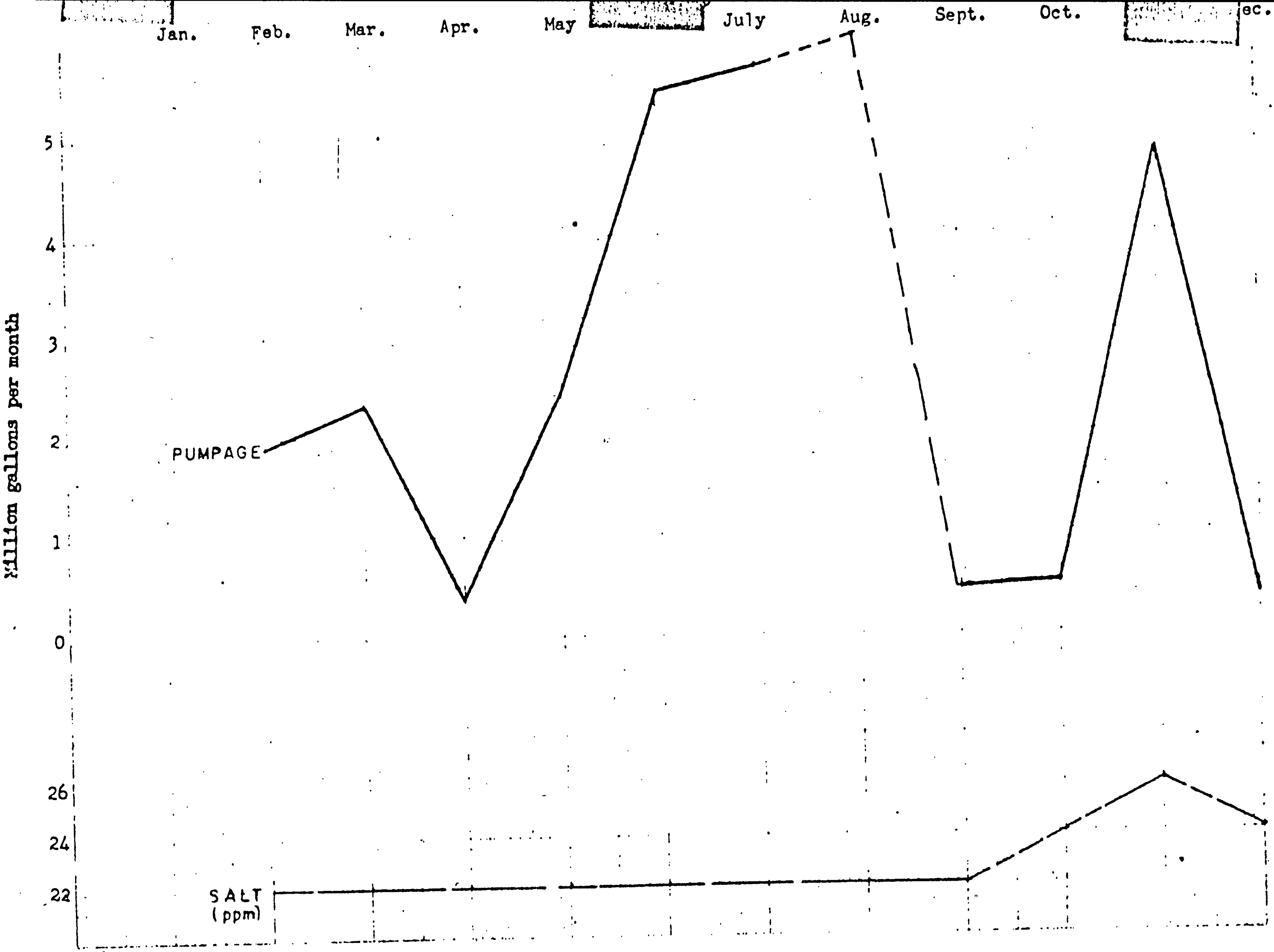


Fig. 11 - Pumpage and chloride content of water from well No. 27. Parris Island .S C.

BPT Co. #117

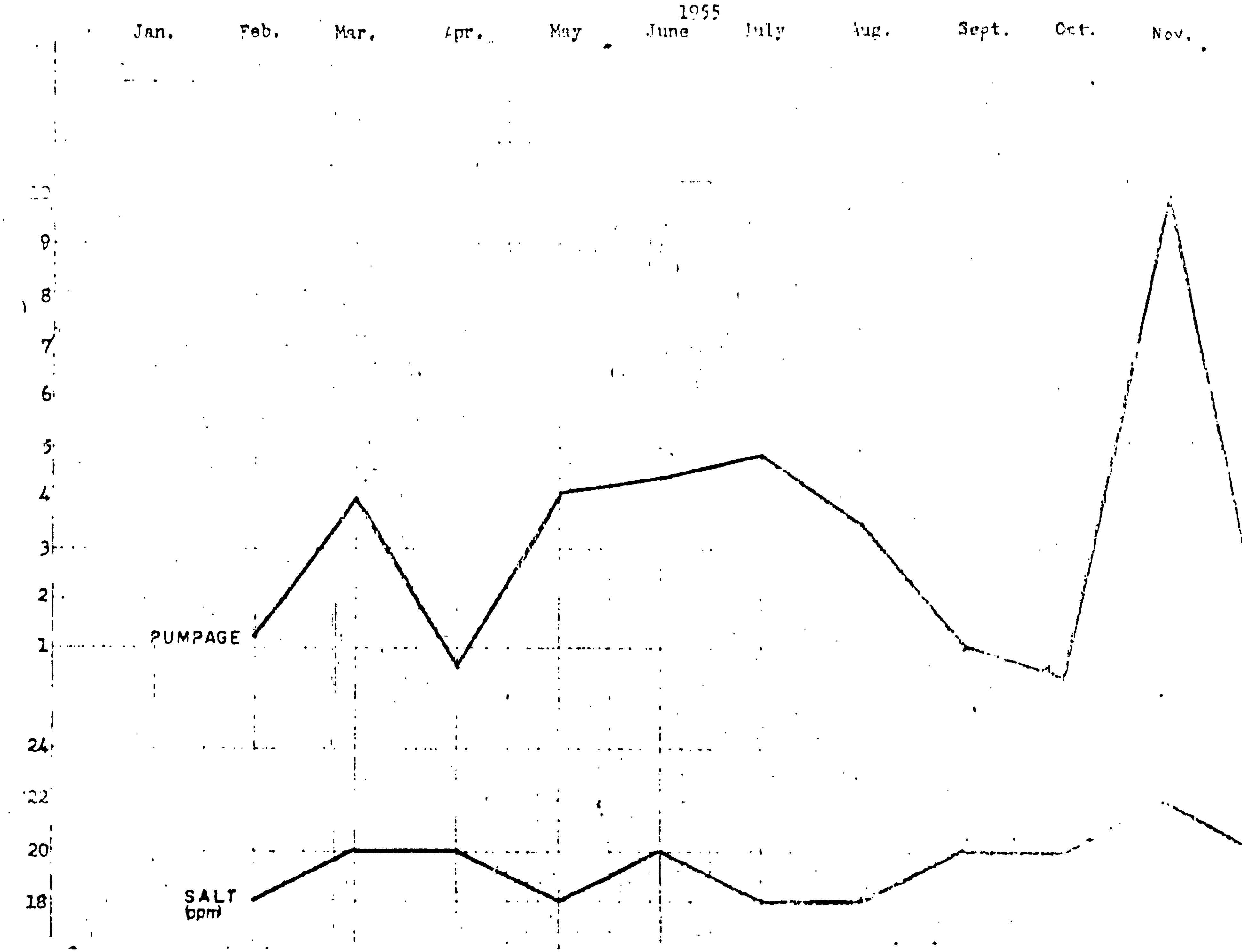


Figure 12. - Pumpage and chloride content of water from well 29, Parris Island, S.C.

chlorides. This tends to substantiate the statement that the chloride content increases with the pumpage, other factors being equal.

Relation between Water Levels and Chloride Content

According to principles developed by several investigators, the contact between fresh and salt water in an aquifer hydraulically connected with the sea is determined approximately by the difference in head between the water in the aquifer and that in the ocean and by the relative specific gravities of the two waters. The fresh water being lighter, will float on salt water. If the average specific gravity of sea water is assumed as 1.025 and that of fresh water as 1.0, then it will require 41 feet of fresh water head to balance 40 feet of sea water and if an aquifer is in contact with the sea at a depth of 40 feet below sea level, then one foot of fresh water head above sea level will be required in order to prevent the movement of salt water into the aquifer.

However, these principles are not strictly valid as they assume a state of hydrostatic equilibrium between fresh and salt water, whereas, in fact, the fresh ground-water is continually in motion, and the two fluids are in dynamic equilibrium.

Figure 14 is a graph of the monthly levels in wells 21 and 23 and the reported chloride content in these wells during the periods October 1951 to May 1952 and March 1953 to January 1956. There is some degree of correlation between the curves but none where the changes of water level and chloride content are small. Of possible significance is the fact, evident from the curves, that the range of water-level and chlorides in the second period of record is about twice that of the first.

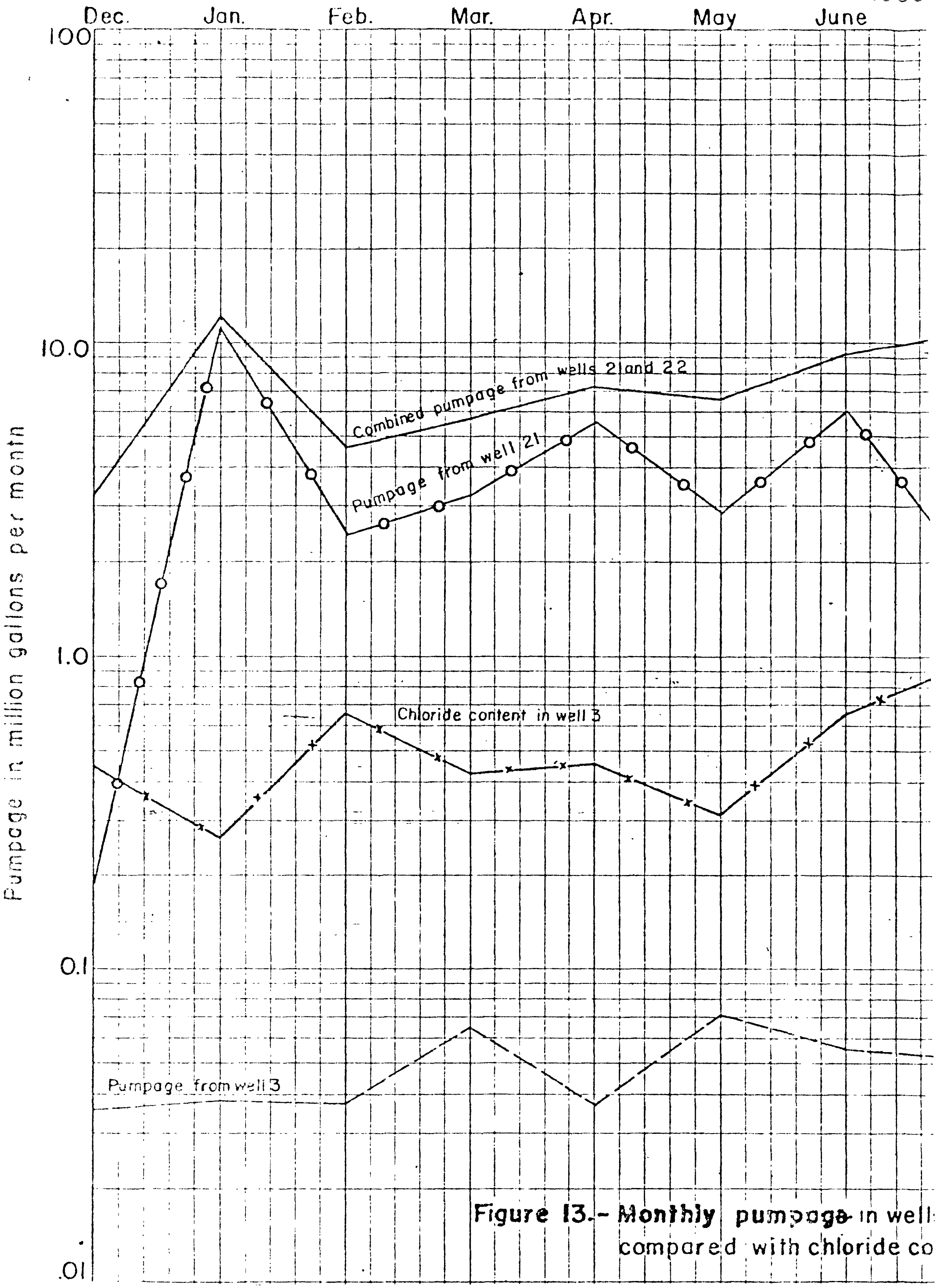
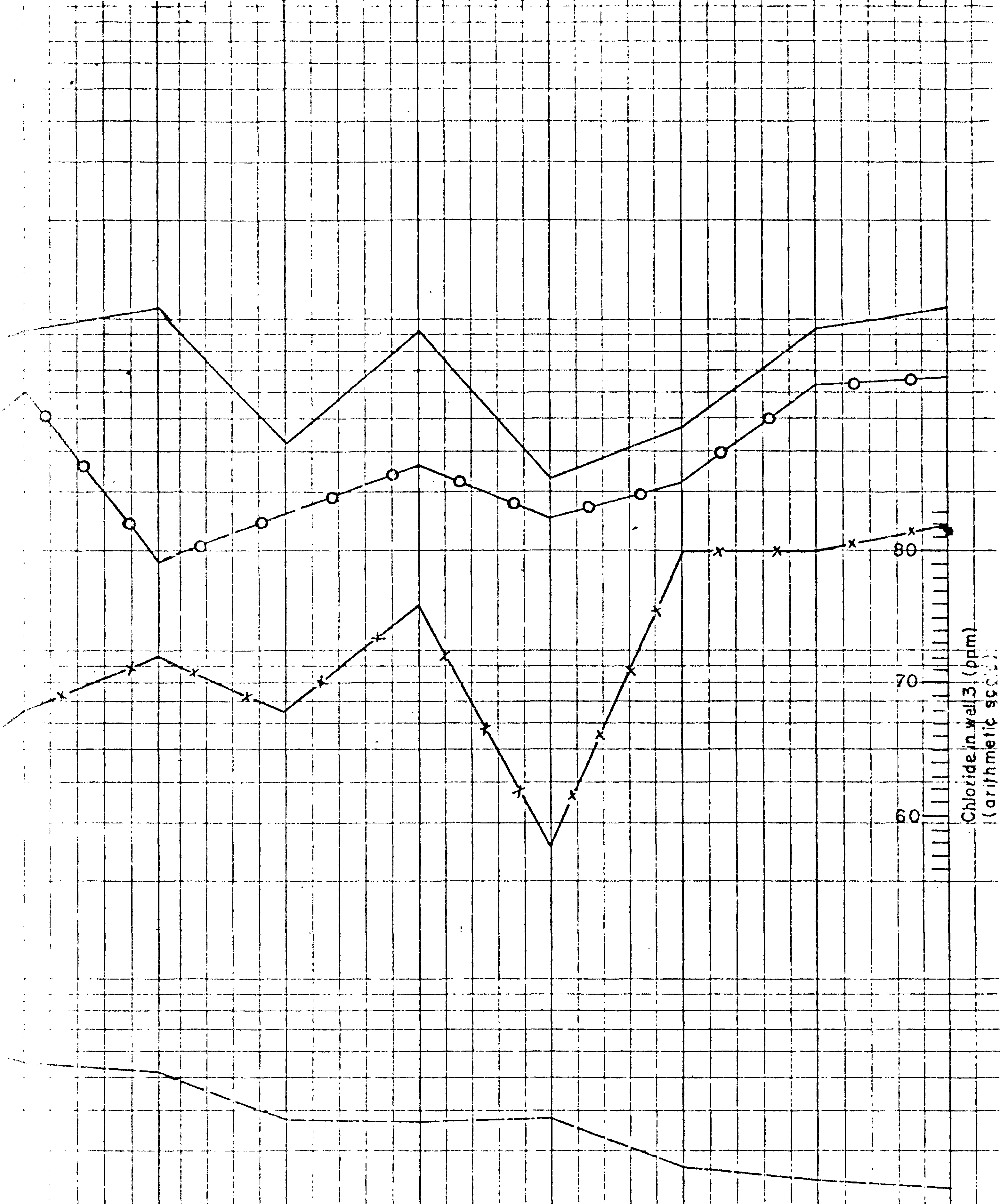


Figure 13.- Monthly pumpage in well
compared with chloride co



in wells 3 and 21 and the combined pumpage from wells 21 and 22,
ride content of water in well 3

Additional Factors Concerning Chloride in Ground Water

Additional facts, pertinent to the problem of chloride content, include the degree of accuracy obtained or refinement used in reporting the chlorides in ground-water. The January monthly report of the Marine Corp Recruit Depot water supply reported a "salt" content of 24 ppm for the water in well 6. The reported duration of pumpage for this well was 124 hours during the month, which is considerably less than the number of hours the well is pumped on an average. When a sample of water from this well was collected on January 27, and analyzed in the U.S. Geological Survey laboratory, the chloride content was only 6 ppm. Similarly the monthly Marine Corp Recruit Depot report for April, 1955 reported the salt content of water from well 26 as 24 ppm. The sample from this well, collected at the same time and analyzed by the U.S. Geological Survey, had a chloride content of only 8.5 ppm. The reason for these discrepancies is not apparent. It may be noted however, that a water sample from well BFT-103, located on the north side of the Naval Air Station and formerly owned by the Trask Plantation, was analyzed by the U.S. Geological Survey laboratory as having 22 ppm of chloride which is of the same magnitude as the salt content reported by the Marine Corp Recruit Depot for the Naval Air Station wells. It is possible that the "salt" content reported by the Marine Corp Recruit Depot does constitute the total salt or salinity of the water rather than just the ~~sodium~~ chloride. However, when the writer checked with the Maintenance Department, he was informed that the water was tested for chloride only.

The wells operated by the City of Beaufort have been reportedly high in chloride——so high in fact that some wells had to be shut down for a period. As indicated in the Lundorff report, this might be expected to occur in the well at the Court House because of its proximity to

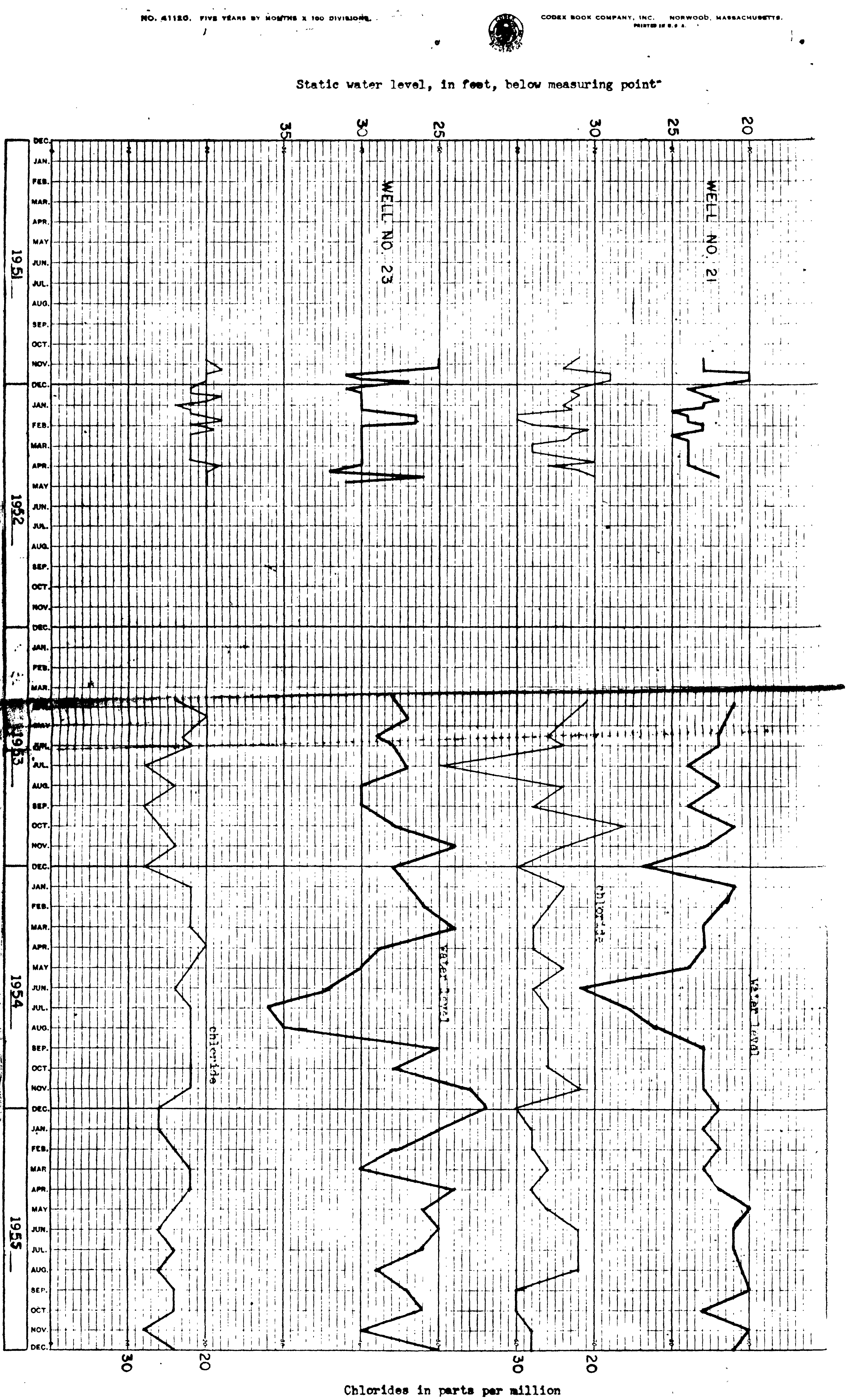


Figure 14.--Water levels and chloride content of water in wells 21 and 23, Parris Island, South Carolina

the salty surface water. But, on occasion, the same difficulty has been reported with city well 5 at Spanish Wells. This well is located in the vicinity of one of the so-called "sinks", mentioned above. Mr. Pickney, a local driller has mentioned the possibly that the high chloride in the well was a result of the discharge of brine effluent from the water softener into the nearby "sink" and the circulation of salty water back into the well. This appears to be a very logical reason for the contamination of this well, and could easily be substantiated by keeping the well in operation and at the same time disposing of the brine backwash in other areas. Another possible cause of the contamination could be a downward seepage of nearby salty surface water through the "sink" and thence to the well.

Quality of Water

Table 4 shows the analyses of water from eight wells in Beaufort County. The water from the deeper aquifers is typically basic, very soft, high in sodium bicarbonate and fluoride, and low in iron. Water from the limestone aquifer is almost neutral, quite hard, and sometimes high in iron or chloride. It is a calcium-carbonate type of water. The temperature of the water from the deep wells on Parris Island is about 103°F. whereas the temperature of the water from the limestone aquifer is usually between 62°F. and 65°F.

SUMMARY AND CONCLUSIONS

The principal aquifer used in the Parris Island area is a gray to white fossiliferous limestone of Eocene to Miocene age which occurs at altitudes of approximately -50 feet. It is approximately 700 feet thick and includes all the calcareous deposits down to and including those of early Eocene time.

Deeper formations in the vicinity of Parris Island proper, contain saline or brackish water down to 2600 feet. But in areas to the northwest from the vicinity of Burton towards Yemassee, it is probable that some of these deeper formations will contain fresh water.

Water levels in the wells on Port Royal Island are affected by tide, barometric pressure and the influence of pumping nearby wells. The maximum recorded range in water level caused by the influence of tide amounted to 4.45 feet. The range of reported water levels due to differences in amount of water pumped amounted to more than 10 feet in the Burton well field. The recovery of water levels in the Burton well field, after shutting down all wells for a period of 12 hours, caused a 1 foot rise in well M-2, approximately one mile west of the Burton wells.

The average piezometric surface in the Burton well field has declined less than 2 feet since 1944. However, there are certain complicating factors involved: (1) Tidal fluctuations in some of the wells are higher than the decline, (2) It has not yet been determined with certainty whether the datum used in determining the altitude of measuring points on wells was mean low water or mean sea level; (3) The distribution of pumping has been changed by the addition of several wells since 1944 although the total pumpage apparently has not increased much (4) The method of measuring water levels by means of an air gage is not sufficiently accurate.

The piezometric surface, as determined in wells extending from the lower part of Hampton County to the lower part of Jasper County and the eastern part of Beaufort County, has apparently declined from 1 to 4 feet. However, the wells are close to the coast and affected by the tide and the wells southwest of Parris Island may be influenced by pumpage from the Savannah area.

Whereas the aquifer in the northwestern part of the area doubtless receives recharge from an area several miles inland, it is possible that local recharge occurs through discontinuities in the confining bed, as, for instance through sinks or through the confining bed itself.

The transmissibility of the limestone aquifer in the vicinity of the Burton well field is approximately 90,000 gpd/ft. It is possible that the transmissibility decreases in the northern or northwestern direction. Accurate data have yet to be obtained in order to determine this possibility. The coefficient of storage is approximately 1×10^{-4}.

The aquifer can be contaminated with salt water by downward seepage, lateral migration, upward movement of underlying waters and leakage through defective wells. Although all of these factors may be more or less operative in this area, those considered to be the ones most likely to cause problems of encroachment are the downward seepage and lateral migration.

Fresh-water aquifers hydraulically connected with salt water bodies will certainly become contaminated when the head of fresh water is reduced to sea level and the gradient between the well and the ocean is in the direction of the well. However, the greatly reduced pumpage in the Jericho well field has apparently had the effect of forming a fresh water barrier between that area of probable contamination and the Burton well field. But it would be wise to maintain a vigilant check on the possibility of contamination reaching the Burton well field from other directions, as for instance in the eastern or northeastern direction towards the town of Burton.

Other factors being equal, the chloride content of the well water appears to vary directly with the amount of water pumped. Discharge of contaminated effluents in the vicinity of pumped wells is also likely to cause high chloride in the pumped water.

Any attempt at this time to estimate the probable safe yield which the principal limestone aquifer could furnish in this area would be at best a slightly less than hazardous guess. The data collected to date are so limited and so subject to error in many respects, that no dependence on such an estimate as a firm figure in warranted.

The net supply of ground-water available for use by the military establishments will be diminished by increasing demands for irrigational use for large truck farms in the vicinity of the Burton Lobeco area. Plans alréady in progress to develop large additional tracts of acreage by supplemental irrigation indicate that larger amounts of ground-water will be used for this purpose in the near future.

As summarised in Table 3, the present supply wells for military establishments in the Parris Island area have a potential yield of 10.2 million gallons per day. However, pumpage from each well has been limited to an arbitrary "safe-yield" which, if all the wells were pumped 24 hours per day, would yield 8.57 million gallons. However, such a rigorous pumping schedule is not ordinarily advisable, so that the total pumpage is 7.16 mgd if the pumps are operated 20 hours per day; 4.29 mgd when operating 12 hours per day and 2.87 mgd when operated 8 hours per day. These figures include pumpage from the deep wells. It appears feasible that additional wells could be added to this system to develop an additional 1500 gpm or a total yield of 8.96 mgd, when operated 20 hours per day and using the deep wells. These figures taken from Table 3, represent the varying amounts of water available as per pumping schedule. However, the reader is cautioned that these figures do not take into consideration such limiting factors as the danger of salt water encroachment.

Table 3. Summary of daily pumpages available from existing and additional wells in the Parris Island area.

Well Field	Rated Yield (gallons per minute)	"Safe-Yield" (gpm)	Total pumpage in million gallons per day when pumps are operated at "safe-yield"[1/] Hours pumped out of each 24: 24 hrs.	20 hrs.	12 hrs.	8 hrs.
Jericho	700	550	0.80	0.67	0.40	0.27
Burton	4200	3400	4.89	4.08	2.45	1.63
Naval Air Station	750	550	0.80	0.67	0.40	0.27
P.I. Deep Wells: Flow	190	190	0.27	0.27	0.27	0.27
or Pump	1450	1450	2.09	1.74	1.04	0.70
Present supply with deep wells flowing	5790	4690	6.76	5.69	3.52	2.44
Present supply with deep wells pumping	7100	5950	8.57	7.16	4.29	2.87
Probable additional supply		1500	2.16	1.80	1.08	0.72
Total supply - deep wells flowing = (A)		6190	8.91	7.43	[illegible]	[illegible]
Total supply - deep wells pumping = (B)		7450	10.73	8.96	5.37	3.59
Pumpage (A) with Jericho shut down		5640	8.12	6.77	4.06	2.71
Pumpage (B) with Jericho shut down		6900	9.94	8.28	4.97	[illegible]

1/ arbitrarily reduced rate, generally about 80 per cent of pump capacity.

BEAUFORT COUNTY
CHEMICAL ANALYSES

BEAUFORT COUNTY

(Results in parts per million except Specific Conductance and pH)

Source of sample	Aquifer Depth (ft.)	Date of sample collection	Silica (SiO_2)	Iron (Fe) a/	Iron (Fe) total	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na & K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	Specific conductance b/	pH
Parris Island BFT-10	2800	Oct. 20/54	18	.09	.10	1.6	.5	Na=486 K=4.9	1170	1.8	58	4.7	2.5	1200	6	1900	8.1
Parris Island BFT-11	2700	Oct. 15/54	19	.10	.20	1.0	.5	Na=412 K=4.4	1000	1.2	10	4.1	1.6	1030	4	1630	8.5
Pritchardville BFT-100	200 to 2352	Oct. 21/53	45	.10	.15	21	10	13	131	7.6	3.5	.5	.6	162	94	243	7.8
Port Royal, S.C., BFT-102	300	April 21/55	12	.00	.09	107	6.5	Na=113 K=1.2	146	18	282	.1	.6	815	294	1170	7.2
Trask Planta. BFT-103	100?	Aug. 27/54		.20	1.9				208	8	22	.1	.0			4130	7.2
Burton - Pines Motor Court BFT-104		Oct. 20/54				37	1.7		121	1	6.2		.5			216	7.3
Beaufort, S.C. BFT-106	81	Mar. 25/55	10	.01	.08	38	2.5	Na= 13 K= .7	114	4.9	24	.0	.0	155	105	274	7.6
Burton well field BFT-114	100	April 21/55	13	.00	.29	44	2.6	Na=4.6 K= .8	147	1.5	8.5	.1	.2	148	120	256	7.5
Beaufort-Mixed finished water from city wells 2, 3, 5.	Well 2- 87 Wells 3&5 165	Dec. 12/51	9.4	.54		40	1.7	16	98	31	20	.2	.3	171	107	294	7.0

a/ In solution at time of analysis

b/ Micromhos at 25°C.

Table 4. Chemical analyses of ground water in Beaufort County, S.C.

With the reservation that the data are not sufficiently reliable or complete, it is estimated that the total supply that might be safely withdrawn from the limestone aquifer is between 3 and 6 million gallons per day. In emergencies, larger supplies can be pumped for short periods. An additional amount of water might be obtained by allowing the deep wells on Parris Island to be pumped for the greater proportion of any 24 hour period.

The above figures are highly conjectural. The aquifer might safely provide more than the amount estimated. On the other hand, such factors as deepening of the Port Royal channel, the increased use of ground-water for irrigation, and the possibilities of contamination by vertical seepage, might singly or collectively limit the safe yield to some lesser amount. Further study should be given to the problem in order to select favorable locations for additional wells. Those areas which, at the present time, appear most favorable are (1) from Burton northwest through Gray's Hill to Garden's Corner, and (2) southwest of the Burton well field on the west side of Broad River and north of Spring Island.