STATUS REPORT
ON
GROUNDWATER CONDITIONS IN CAPACITY USE AREA NO. 1
CENTRAL COASTAL PLAIN
NORTH CAROLINA

GROUNDWATER BULLETIN NO. 21

GROUNDWATER SECTION
NORTH CAROLINA
DEPARTMENT OF NATURAL AND ECONOMIC RESOURCES

RALEIGH, NORTH CAROLINA
JUNE 1974

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INTRODUCTION

PURPOSE

The purpose of this report is to provide a review of the status of the Capacity Use Area No. 1 (Fig. 1) in the Beaufort County area, to include the following:

A summary of hydrogeological conditions

Changes in conditions since 1965 resulting from large withdrawals of water from the Castle Hayne aquifer

The scope and effectiveness of existing management

The adequacy of the hydrologic monitoring system

Applicable water resources management measures

PREPARATION OF REPORT

This report was prepared by the staff of the Ground Water Division including H.M. Peek, Division Director; P.F. Nelson, Assistant Division Director; L.L. Laymon, Chief, Regulations and Management Branch; L.A. Register, Regional Hydrologist; and W. J. Jeter, District Hydrologist.

PREVIOUS REPORTS

Many reports have been prepared previously that contain hydrogeologic, geologic or other information pertaining to the Capacity Use Area, many of which are listed in the Bibliography. The reports most pertinent to this report are listed below:

1964 *"Preliminary report on groundwater in Beaufort County with special references to potential effects of phosphate mining", P.F. Nelson and H.M. Peek, N.C. Dept. of Water Resources, Ground Water Circular 2.*

1967 *"Evaluation of potential impact of phosphate mining on groundwater resources of eastern North Carolina". R.J.N. Dewiest, A.N. Sayre, and C.E. Jacob, N.C. Dept. of Water Resources.*

1968 *"Interim report on groundwater conditions in the Beaufort County region, North Carolina," H.M. Peek and P.F. Nelson, 1968, unpublished report.*

1969 *"Effects of large-scale mining withdrawals of Ground Water" Harry M. Peek, Ground Water, Vol. 7, No. 4.*

1971 *"Hydrogeology and effects of pumping from Castle Hayne aquifer system Beaufort County, North Carolina." by Ground Water Division, North Carolina Department of Water and Air Resources; William F. Guyton and Associates, Consulting Groundwater Hydrologists; Leggette, Brashears and Graham, Consulting groundwater Geologists. Harshbarger and Associates, consultants in hydrogeology; and William C. Walton, Consulting Groundwater Hydrologist.*

1973 *"Computer simulation of ground water aquifers of the Coastal Plain of North Carolina, Jabbar K. Sherwani, Report No. 75, University of North Carolina Water Resources Research Institute.*

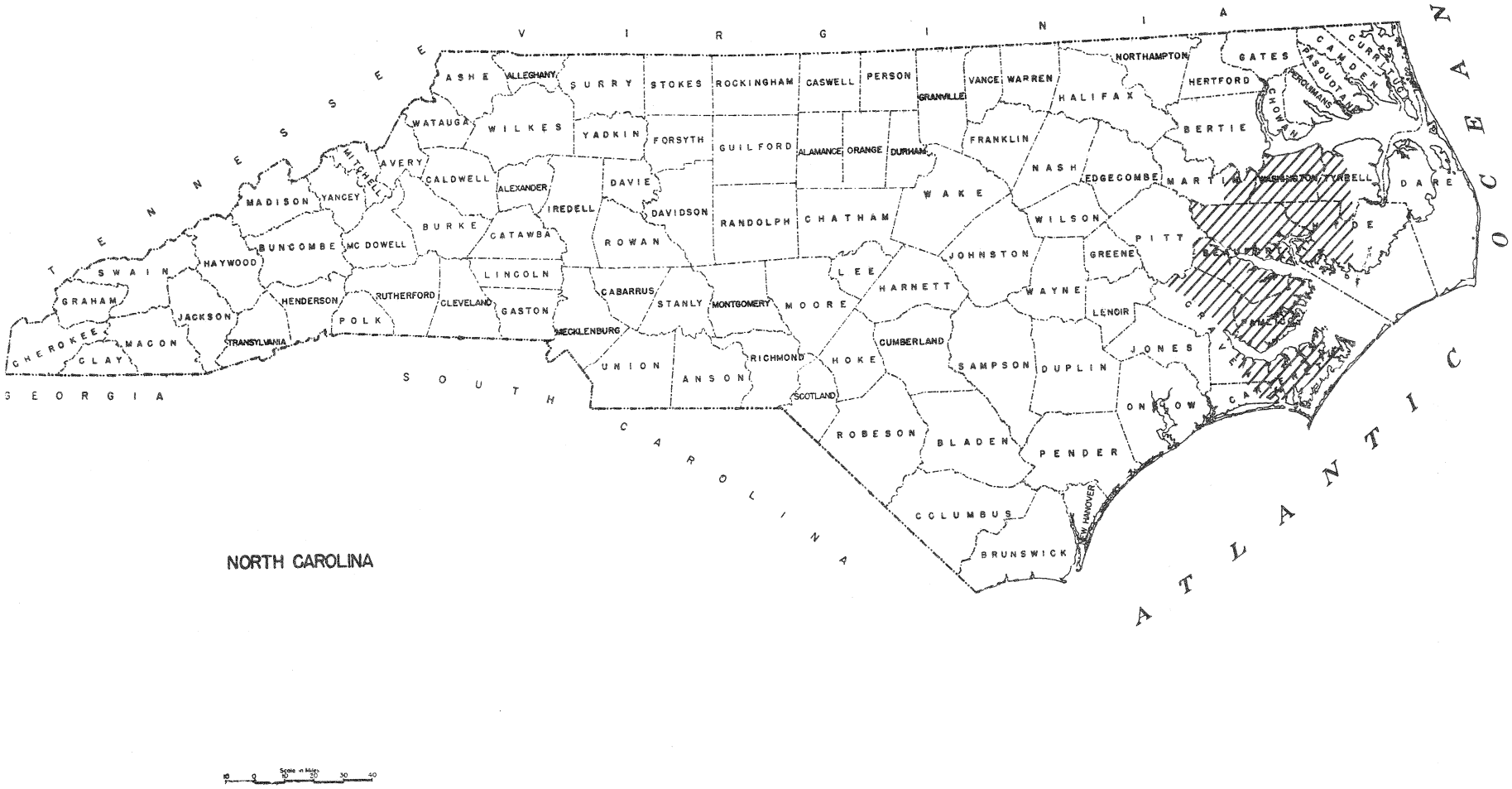
HISTORICAL BACKGROUND OF CAPACITY USE AREA NO. 1

INVESTIGATION AND REPORTS

A study of the hydrogeology of Beaufort County was begun by the Ground Water Division in 1963. After plans for open-pit phosphate mining were announced in 1964, this study was expanded to determine the effects of this activity on the groundwater resources of the area.

Dry open-pit mining of phosphate ore began at Lee Creek in July 1965. As ore lies immediately above the Castle Hayne aquifer, it was necessary to relieve the artesian pressure in the aquifer to permit dry-pit mining. This was accomplished through a system of wells completed in the aquifer around the mine area.

Depressuring the initial pit required pumping of about 65 million gallons of water a day from the Castle Hayne aquifer. This withdrawal resulted in an immediate lowering of the piezometric surface of the aquifer over a large area. Most of the drawdown occurred within a few months after pumping began and created immediate well and pump problems in an area of several hundred



NORTH CAROLINA

FIGURE 1. - INDEX MAP SHOWING CAPACITY USE AREA 1

square miles. Of greater long-range significance, the drawdown created conditions favorable to salt water encroachment. These conditions indicated to the Board of Water and Air Resources that a possible capacity-use situation was emerging, and a team of consultants was employed by the Board to conduct a comprehensive study in 1966. The results of the 1967 study and recommendations in the report led to the passage of the Water Use Act of 1967 by the General Assembly. (N.C.G.S. Chapter 143, Article 21 143-215,11-22)

Under the Water Use Act, a Capacity Use Area is defined as one in which "the aggregate uses of ground water or surface water, or both, in or affecting said areas (1) have developed or threatened to develop to a degree which requires coordination and regulation, or (2) exceeds or threatens to exceed, or otherwise threaten or impair, the renewal or replenishment of such waters or any part of them".

In September 1967, the Board of Water and Air Resources directed the Department to conduct and report upon a Capacity Water Use investigation in Beaufort, Pamlico and Washington counties and parts of Carteret, Craven, Hyde, Martin and Tyrrell counties. A report was submitted in August 1968 recommending that the Board declare a capacity use area.

DECLARATION OF CAPACITY USE AREA AND ADOPTION OF REGULATIONS

After a public hearing in Washington, North Carolina, in October 1968, the Board followed the recommendations in the Capacity Use Study report and on December 18, 1968, declared a Capacity Use Area to include all of Beaufort, Pamlico and Washington counties and part of Carteret, Craven, Hyde, Martin and Tyrrell counties. The total area included is more than 2,500 square miles (Appendix I).

Following the declaration of a Capacity Use Area, the regulations for water management were developed and a public hearing on the regulations was held in Manteo in May 1969. Regulations applicable to Capacity Use Area were adopted by the Board on June 12, 1969. (Appendix II)

WATER USE PERMITS

The regulations adopted by the Board require a Water Use Permit by any person withdrawing more than 100,000 gallons of water per day of ground or surface water. A list of permit holders is shown in Table 1 and the location of withdrawals is shown in Figure 2.

During consideration of the applications of the Texasgulf Company and North Carolina Phosphate Corporation for Water Use Permits, the Board of Water and Air Resources decided that additional studies should be made to determine the effects of pumping large quantities of water from the Castle Hayne aquifer. The Board employed William F. Guyton & Associates of Austin, Texas to conduct the Study with the Ground Water Division. The state and the phosphate companies agreed that a joint study to include consultants of the State and the companies might be a productive effort, and such study was authorized in 1970 and completed in 1971. The report prepared by the study team was entitled "Hydrogeology and effects of pumping from Castle Hayne aquifer system, Beaufort County North Carolina." A Water Use Permit was issued by the Board in January 1972 to the Texasgulf Company with terms based on the conclusions of this report.

WELL CONSTRUCTION PERMITS

The regulations require a permit for all wells constructed other than wells for individual domestic water supplies. Table 2 shows well-construction permits issued since the regulation went into effect.

W.U.Permit No.	Applicant	County	Date Issued	Date of Expiration	WITHDRAWALS (M & D)				SOURCE	
					Surface Water	Ground Water	Total	Purpose	Stream	Aquifer
1	Town of Plymouth	Washington	10/31/69	12/31/74		0.6	.6	Mun.		C.H.
2	N.C. Phosphate Corp.*	Beaufort	11/3/69	8/1/77		2.0	2.0	Exp. Mining		C.H.
3	Texasgulf, Inc.	Beaufort	11/3/69	12/31/74		67.0	67.0	Mining-Proc.		C.H.
4	Weyerhaeuser Co.	Martin	10/31/69	12/31/74	95.0	2.2	97.2	Mfg.	Roanoke	C.H.
5	National Spinning Co.	Beaufort	10/31/69	12/31/74		1.5	1.5	Mfg.		Cret.
6	Weyerhaeuser Co.	Beaufort	10/31/69	12/31/74		5.0	5.0	Irrig.		C.H.
7	Town of Beaufort	Carteret	10/31/69	Invalidated 8/6/70, Reissued as W.U.P. #15						
8	Town of Belhaven	Beaufort	10/31/69	12/31/74		1.0	1.0	Mun.		Yorktown
9	City of Washington	Beaufort	10/31/69	12/31/69	3.0		3.0	Mun.	Thanters Creek	
10	Maola Ice Cream Co.	Beaufort	10/31/69	12/31/74		0.2	0.2	Mfg.		C.H.
11	Town of Aurora	Beaufort	10/31/69	12/31/74		2.0	2.0	Mun.		C.H.
12	Town of Newport	Carteret	12/18/69	12/31/74		2.0	2.0	Mun.		C.H.
13	Weyerhaeuser Co.**	Craven	12/18/69	12/31/74	50.0		50.0	Mfg.	Neuse	
14	Town of Morehead City	Carteret	12/18/69	12/31/74		0.95	0.95	Mun.		C.H.
15	C rolina Water Co.	Carteret	8/17/70	12/31/74		0.5	0.5	Mun.		C.H.
16	NCDA-Tidewater Res. Sta.	Washington	5/13/71	5/1/76		1.5	1.5	Irrig.		C.H.
17	Beaufort Fisheries	Carteret	9/20/73	12/21/78		0.5	0.5	Mfg.		C.H.
18	Weyerhaeuser Co.	Martin	7/19/73	6/30/74		1.5	1.5	Dewatering		W.T.
19	Indian Trace Co.	Pamlico	9/20/73	12/31/78		0.5	0.5	Dom.& Comm.		C.H.
20	Nat.Council-Paper Inc.	Craven	11/15/73	12/31/78	3.0		3.0	Exp. Water Treatment	Neuse	
				TOTAL	151.0	88.95	239.95			

* Permit Revoked and Reissued 7/28/72

** Permit ammended 9/20/73

TABLE 1 - SUMMARY OF WATER USE PERMITS

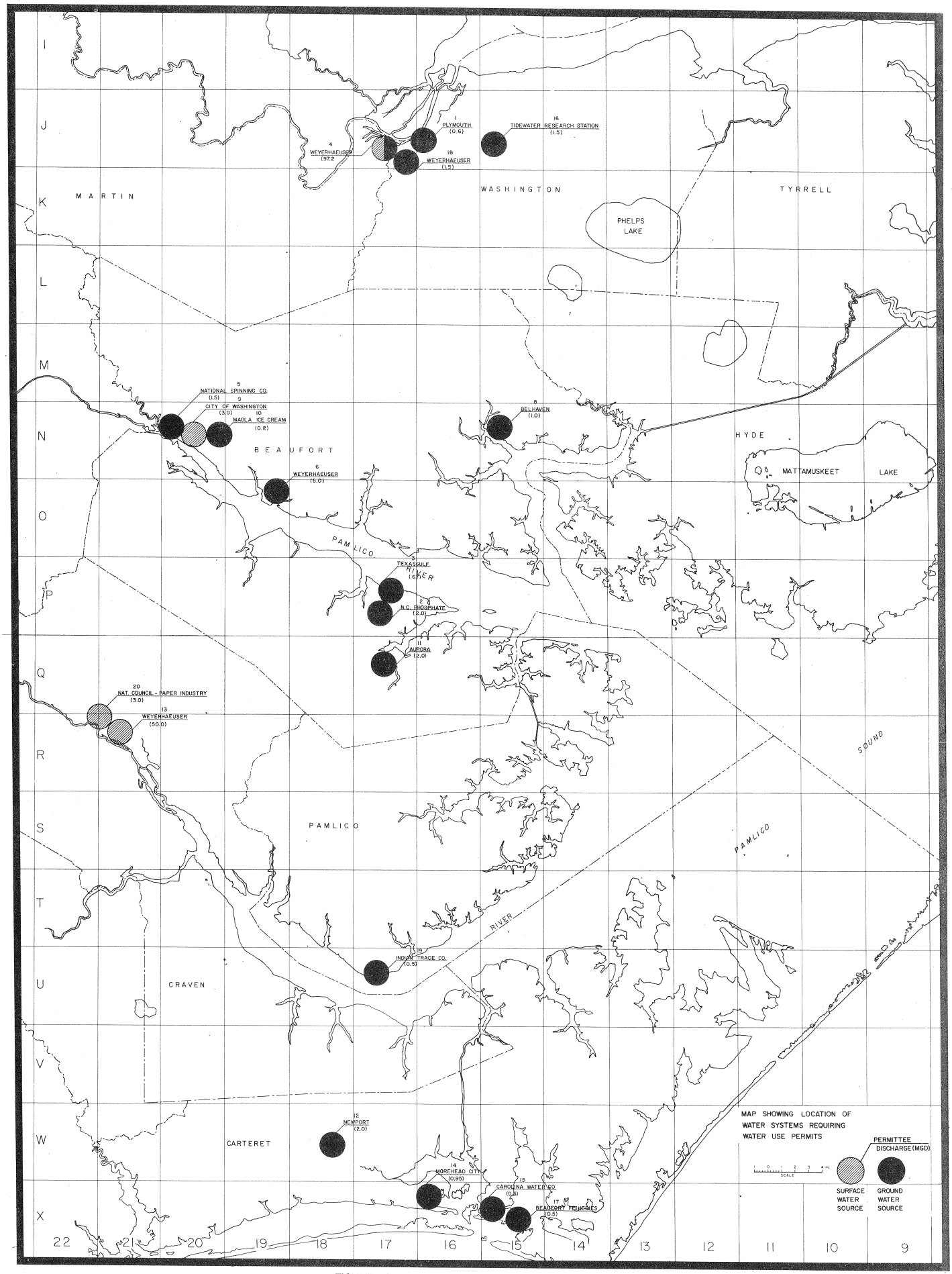


FIGURE 2.- LOCATION OF MAJOR WATER USERS

TABLE 2 - WELL CONSTRUCTION PERMITS ISSUED IN CAPACITY USE AREA NO. 1
JULY 1969 - JUNE 1974

PERMIT NO.	APPLICANT	COUNTY	USE	DATE ISSUED
221	N.C. Phosphate	Beaufort	Mining	10/7/69
222	F.M.C. Corporation	Beaufort	Observation	10/7/69
223	F.M.C. Corporation	Beaufort	Observation	10/7/69
224	F.M.C. Corporation	Beaufort	Mining	10/7/69
225	F.M.C. Corporation	Beaufort	Mining	10/7/69
226	F.M.C. Corporation	Beaufort	Mining	10/7/69
227	F.M.C. Corporation	Beaufort	Mining	10/7/69
234	Weyerhaeuser	Beaufort	Irrigation	10/10/69
276	Town of Vanceboro	Craven	Municipal	1/30/70
280	J. B. Bell	Beaufort	Domestic	2/4/70
300	Texas Gulf	Beaufort	Depressurizing	4/14/70
305	Plymouth Fertilizer	Washington	Industrial	4/16/70
330	Weyerhaeuser	Martin	Industrial	5/27/70
334	Water Resources Institute	Washington	Industrial	6/10/70
355	Northwest Developers	Craven	Public	8/18/70
393	Weyerhaeuser	Beaufort	Irrigation	10/10/71
408	Carolina Pines Const Co.	Craven	Industrial	2/24/71
424	Town of Plymouth	Washington	Public	4/9/71
439	North Carolina State Univ	Beaufort	Research	5/14/71
440	National Spinning Company	Beaufort	Industrial	5/18/71
441	National Spinning Company	Beaufort	Industrial	5/18/71
469	Dolphin Company	Pamlico	Public	8/12/71
474	Town of Plymouth	Washington	Public	8/20/71
480	Town of Jamesville	Martin	Public	9/22/71
530	Weyerhaeuser	Washington	Industrial	1/24/72
557	Texas Gulf	Beaufort	Depressurizing	2/22/72
572	Conner Homes Corporation	Carteret	Public	2/29/72
640	Morehead City County Club	Carteret	Public	4/18/72
641	Morehead City County Club	Carteret	Irrigation	4/18/72
642	Morehead City County Club	Carteret	Irrigation	4/18/72
718	Wellons Enterprises, Inc.	Carteret	Public	5/25/72
726	National Spinning Company	Beaufort	Industrial	6/2/72
733	National Spinning Company	Beaufort	Industrial	6/2/72

PERMIT NO.	APPLICANT	COUNTY	USE	DATE ISSUED
745	Texas Gulf	Beaufort	Public	6/15/72
773	Jasper Tuten	Beaufort	Public	7/5/72
803	Town of Bayboro	Pamlico	Public	8/4/72
892	Duke University	Carteret	Public	10/17/72
896	MERHA LTD.	Washington	Public	10/20/72
909	Henderson's Mobile Home Park	Carteret	Public	10/31/72
963	Town of Bath	Beaufort	Public	12/5/72
982	Sea Gate Development	Carteret	Industrial	12/14/72
988	Town of Columbia	Tyrrell	Public	12/21/72
1045	Shoreline Group	Tyrrell	Industrial	2/13/73
1087	Riverview Crab Company	Pamlico	Public	3/15/73
1107	Teach's Cove Const., Inc.	Pamlico	Depressurizing	4/2/73
1146	Texas Gulf	Beaufort	Public	4/18/73
1169	George Norris	Craven	Depressurizing	5/1/73
1249	Texas Gulf	Beaufort	Public	6/26/73
1263	R. O. Bemish	Carteret	Industrial	6/28/73
1268	Weyerhaeuser	Martin	Public	7/3/73
1280	Bay Hill Corporation	Beaufort	Public	7/9/73
1303	Aviation Fuel Terminals, Inc.	Carteret	Public	7/20/73
1309	Lewis Whitehurst	Carteret	Public	7/26/73
1311	City of Bridgeton	Craven	Public	7/27/73
1314	Indian Trace Company	Pamlico	Public	8/2/73
1326	Harlowe Township	Carteret	Public	8/2/73
1349	Brandywine Bay Associates	Carteret	Public	8/23/73
1407	North Hill, Inc.	Craven	Public	9/27/73
1470	Rich, Rich and Rich	Beaufort	Public	1/14/73
1542	Flanders Filters, Inc.	Beaufort	Industrial	1/24/74
1621	Fred Hollis	Beaufort	Public	4/5/74
1656	Mainsail Point Associates	Pamlico	Public	5/15/74
1684	Town of Chocowinity	Beaufort	Public	6/4/74

WATER RESOURCES MONITORING

The application of water-use regulations and plans for water-resource management requires a comprehensive program of monitoring water use, water levels and water quality. The purpose of a monitoring program is to observe changes in the hydrologic system that may result from natural causes or from man's activities. The recognition of significant trends or changes in the hydrology would necessitate review and possible modification of existing regulations and management procedures.

The monitoring program in the Capacity Use Area includes water levels, water quality and water use. In addition to monitoring by the State, monitoring by individual industries and municipalities is required under the Water Use Permit issued. A substantial system of monitor wells is maintained by the Texasgulf Company and the North Carolina Phosphate Corporation, particularly in the Lee Creek Mine area.

WATER USE MONITORING

Restrictions on withdrawals of water, pumping levels in wells, piezometric surface drawdown and impairment of water quality, and the requirement for reporting on these subjects are based on the limits of the hydrologic system, to meet the demand. A significant increase in withdrawals from a system may require a change in regulations affecting a water-management area or may require changes in the conditions or individual permits. Therefore, it is necessary to maintain an accurate and current inventory of water withdrawals and use.

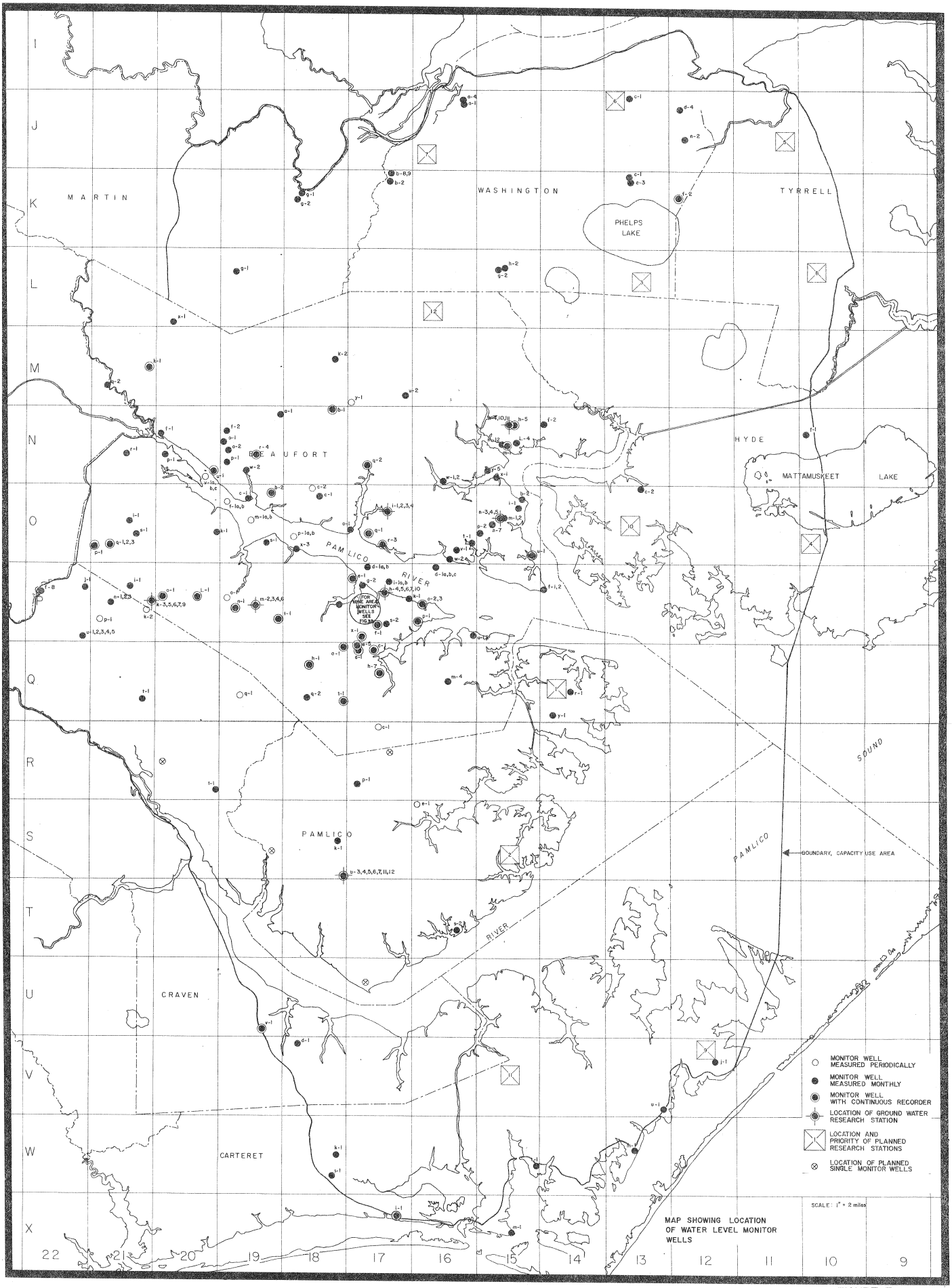
A continuing inventory of water use is maintained in the Capacity-Use Area, facilitated by the requirement that water users apply for well construction permits, and when applicable, water use permits that are

required for new or expanding uses of water. Although permits are not required for domestic wells, a record of each well must be submitted by the drilling contractor, which does provide information on domestic water use. However, the total number of wells constructed in each aquifer in the Capacity Use Area is not known, as most were constructed prior to the requirement for reporting. These must be located and included in the inventory before a realistic evaluation of water use is completed. A summary of reported water use in the Capacity Use Area is included in Table 1 and the location of points of large withdrawals are shown in Figure 2.

WATER-LEVEL MONITORING

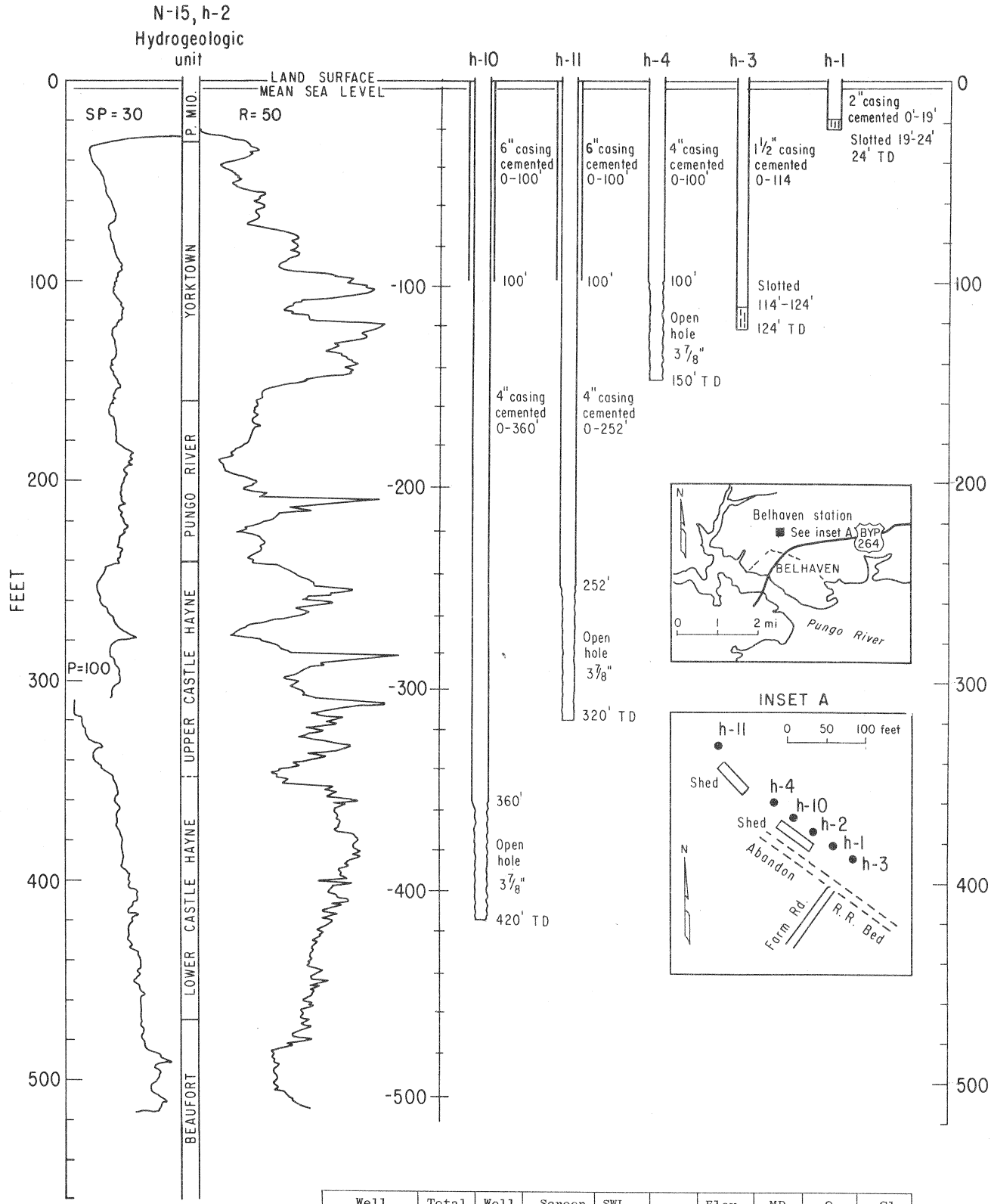
A water-level monitoring program is maintained to provide data necessary for analysis of the response of the aquifer system to changing hydrologic conditions within the Capacity Use Area. The monitoring system consists of more than 200 wells located as shown in Figure 3, and includes wells completed in each aquifer unit. The most comprehensive data are obtained from the monitor stations constructed by the Ground Water Division with one or two wells completed in each of the aquifer units. Diagrams of these stations are shown in Figures 4 - 10. Some of the wells are equipped with graphic or digital continuous recording gages, some are measured monthly and some are measured semi-annually.

The water level data were used to prepare hydrographs that show local, seasonal and long term changes in water levels at specific points for periods up to about ten years. Hydrographs of wells at research stations and other locations are shown in Figure 11-20. Piezometric maps of the upper limestone unit of the Castle Hayne aquifer are prepared semi-annually or



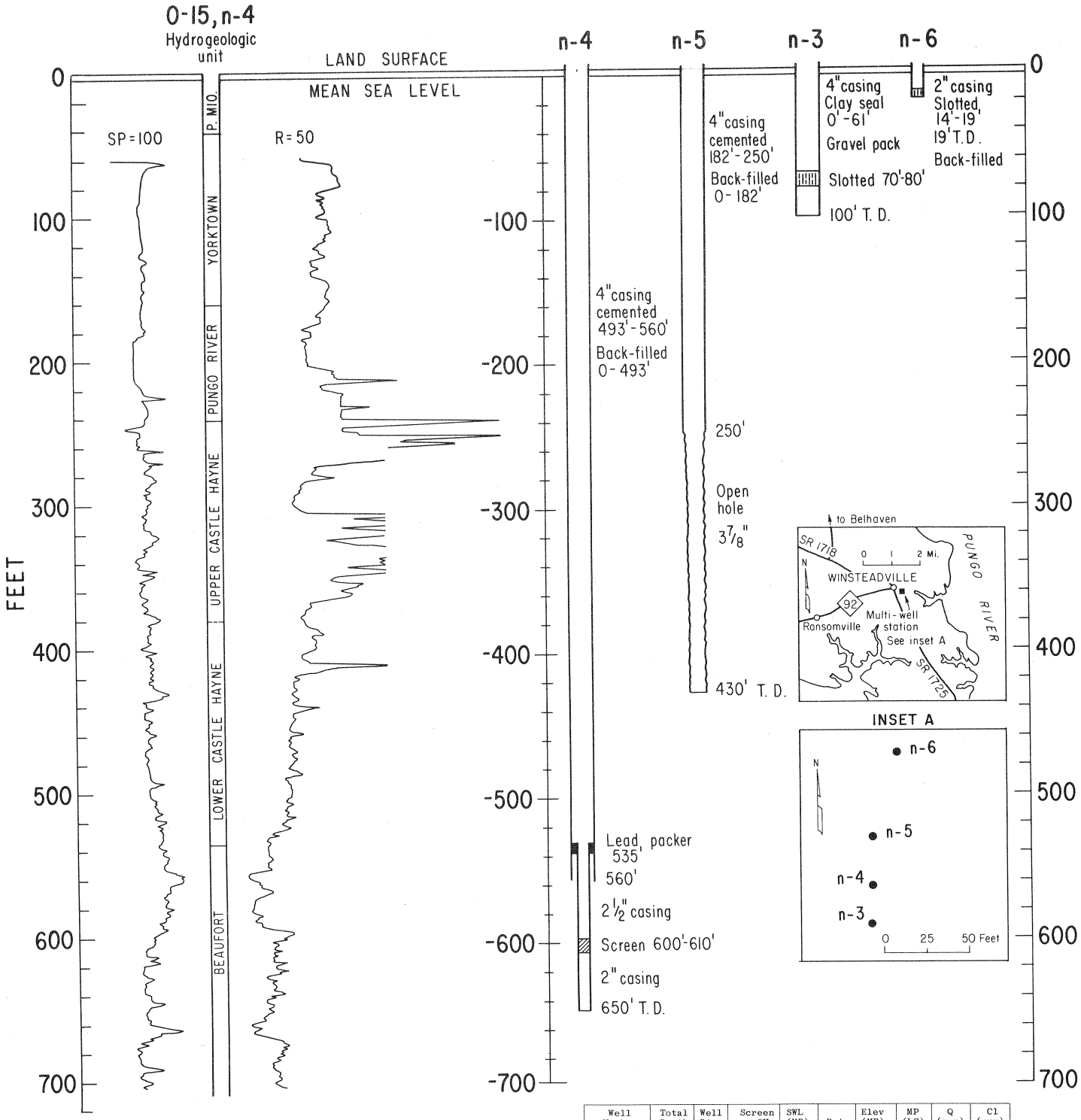
MAP SHOWING LOCATION OF WATER LEVEL MONITOR WELLS

FIGURE 3



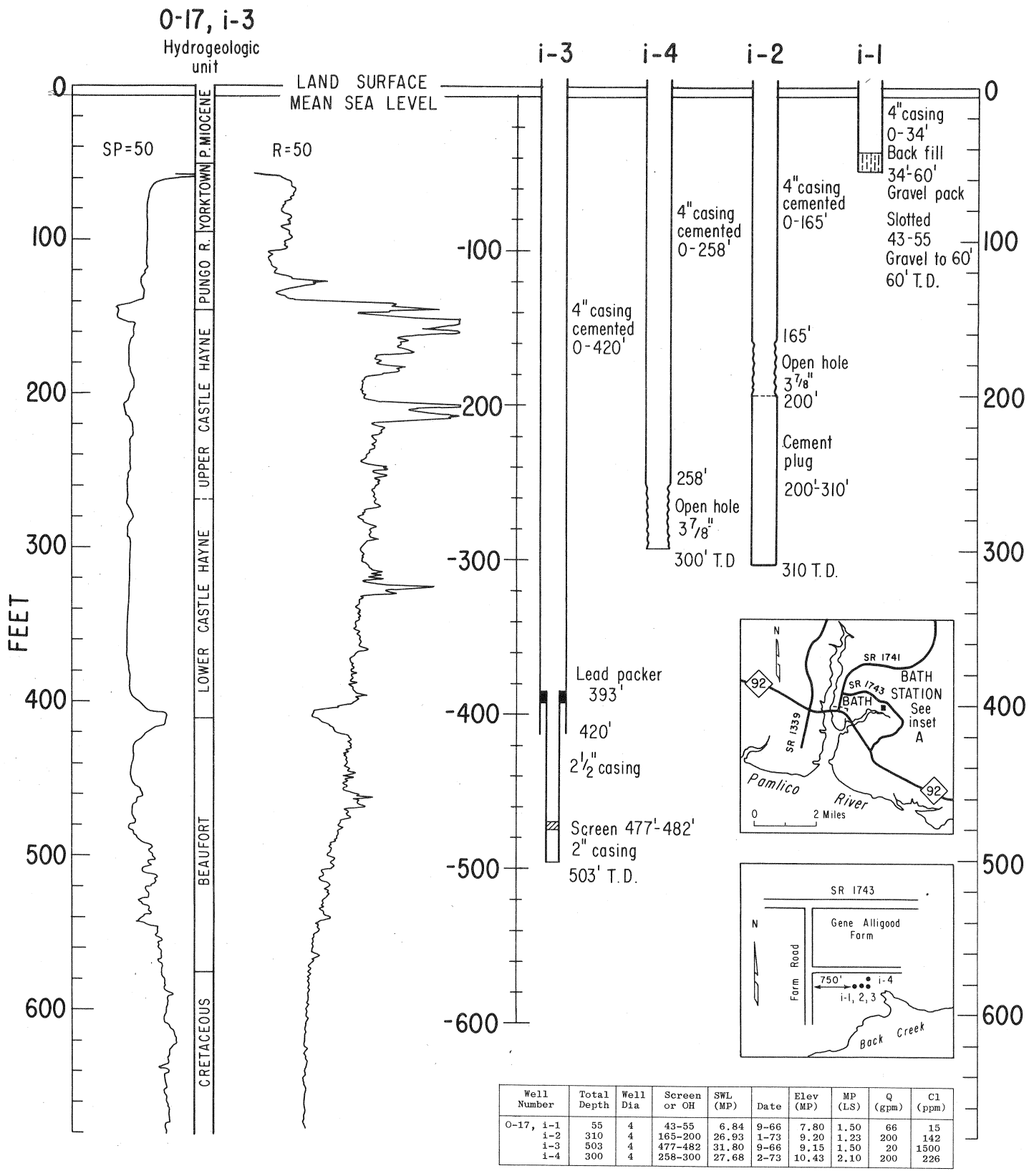
Well Number	Total Depth	Well Dia	Screen or OH	SWL (MP)	Date	Elev (MP)	MP (LS)	Q (gpm)	Cl (ppm)
N-15, h-1	24	2	19-24	5.00	7-66	5.70	1.50	25	20
h-3	124	1½	114-124	5.58	8-66	6.53	1.50	20	--
h-4	150	4	100-150	4.80	8-66	5.72	1.00	60	33
h-10	420	4	360-420	10.50	4-73	6.22	1.80	100	2460
h-11	320	4	252-320	10.27	4-73	6.67	2.27	100	168

FIGURE 4. -- DIAGRAM OF RESEARCH STATION AT BELHAVEN



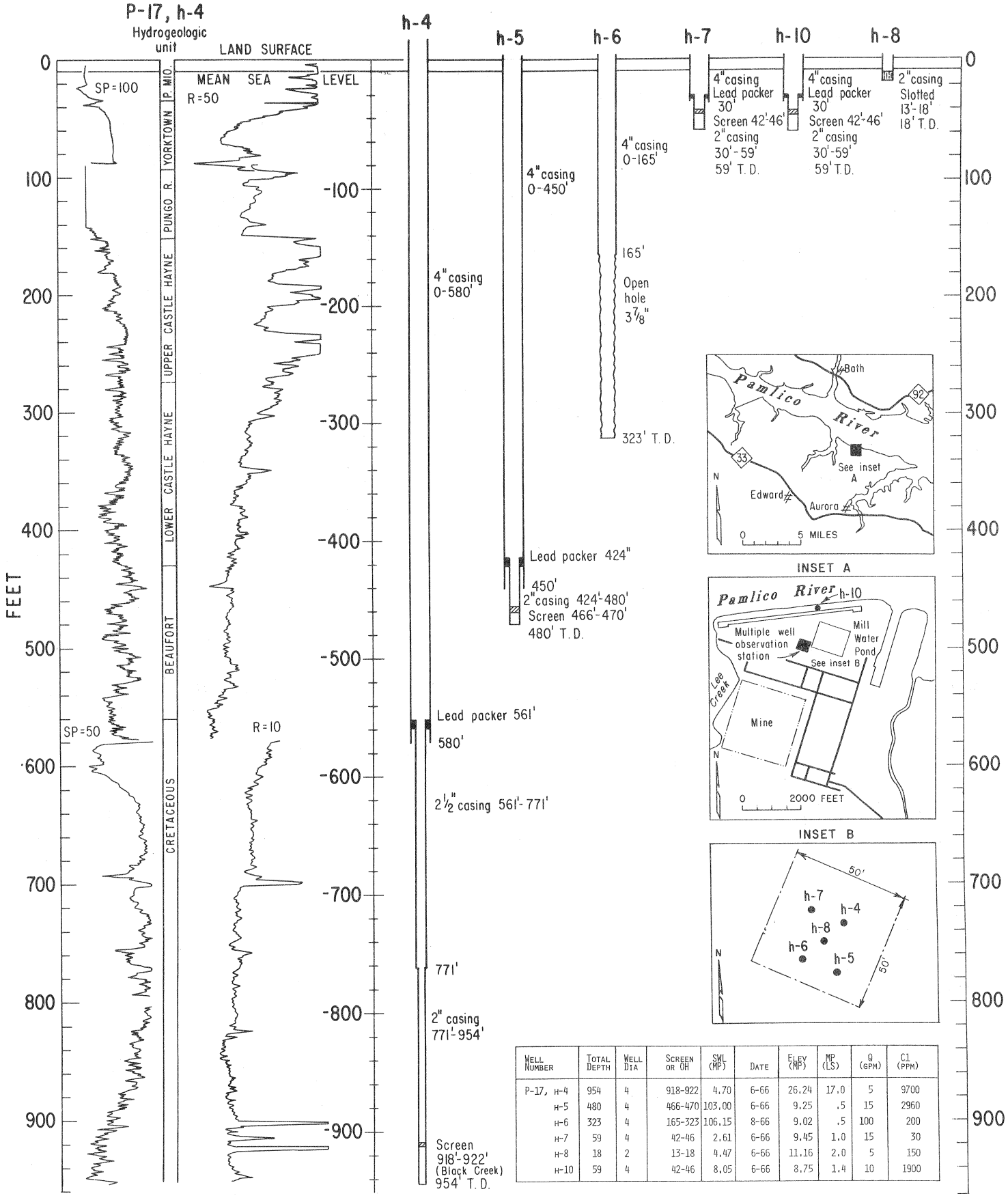
Well Number	Total Depth	Well Dia	Screen or OH	SWL (MP)	Date	Elev (MP)	MP (LS)	Q (gpm)	Cl (ppm)
0-15, n-3	100	4	70-80	3.52	10-66	5.00	2.00	30	30
n-4	650	4	600-610	26.75	11-66	4.00	1.83	19	7480
n-5	430	4	250-430	22.04	11-66	5.47	1.50	42	155
n-6	19	2	14-19	4.16	12-66	3.97	1.90	45	14

FIGURE 5. -- DIAGRAM OF RESEARCH STATION AT WINSTEADVILLE



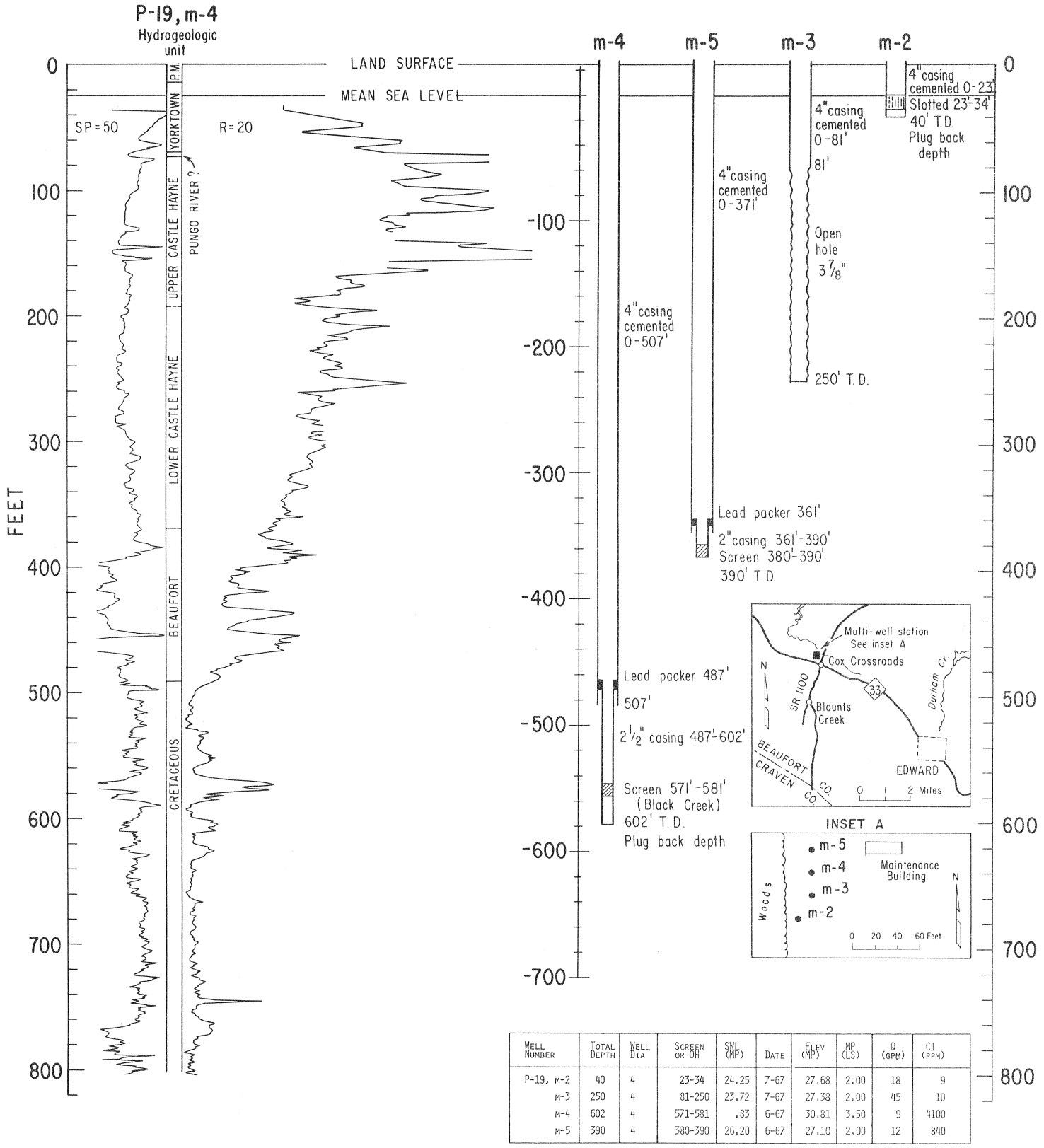
Well Number	Total Depth	Well Dia	Screen or OH	SWL (MP)	Date	Elev (MP)	MP (LS)	Q (gpm)	Cl (ppm)
O-17, i-1	55	4	43-55	6.84	9-66	7.80	1.50	66	15
i-2	310	4	165-200	26.93	1-73	9.20	1.23	200	142
i-3	503	4	477-482	31.80	9-66	9.15	1.50	20	1500
i-4	300	4	258-300	27.68	2-73	10.43	2.10	200	226

FIGURE 6. -- DIAGRAM OF RESEARCH STATION AT BATH



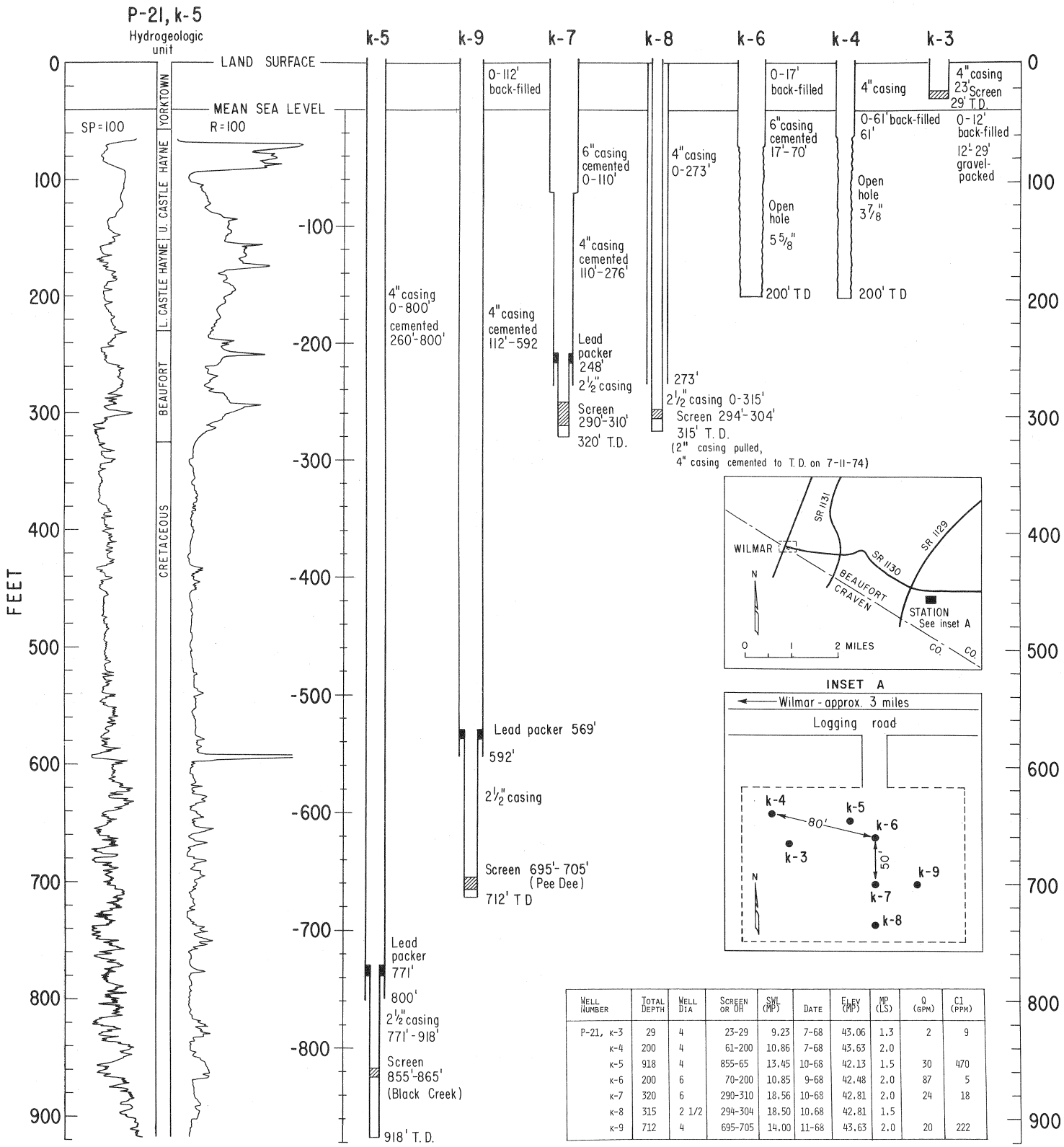
Well Number	Total Depth	Well Dia	Screen or OH	SWL (MP)	Date	Elev (MP)	MP (LS)	Q (GPM)	Cl (PPM)
P-17, H-4	954	4	918-922	4.70	6-66	26.24	17.0	5	9700
H-5	480	4	466-470	103.00	6-66	9.25	.5	15	2960
H-6	323	4	165-323	106.15	8-66	9.02	.5	100	200
H-7	59	4	42-46	2.61	6-66	9.45	1.0	15	30
H-8	18	2	13-18	4.47	6-66	11.16	2.0	5	150
H-10	59	4	42-46	8.05	6-66	8.75	1.4	10	1900

FIGURE 7. -- DIAGRAM OF RESEARCH STATION AT LEE CREEK



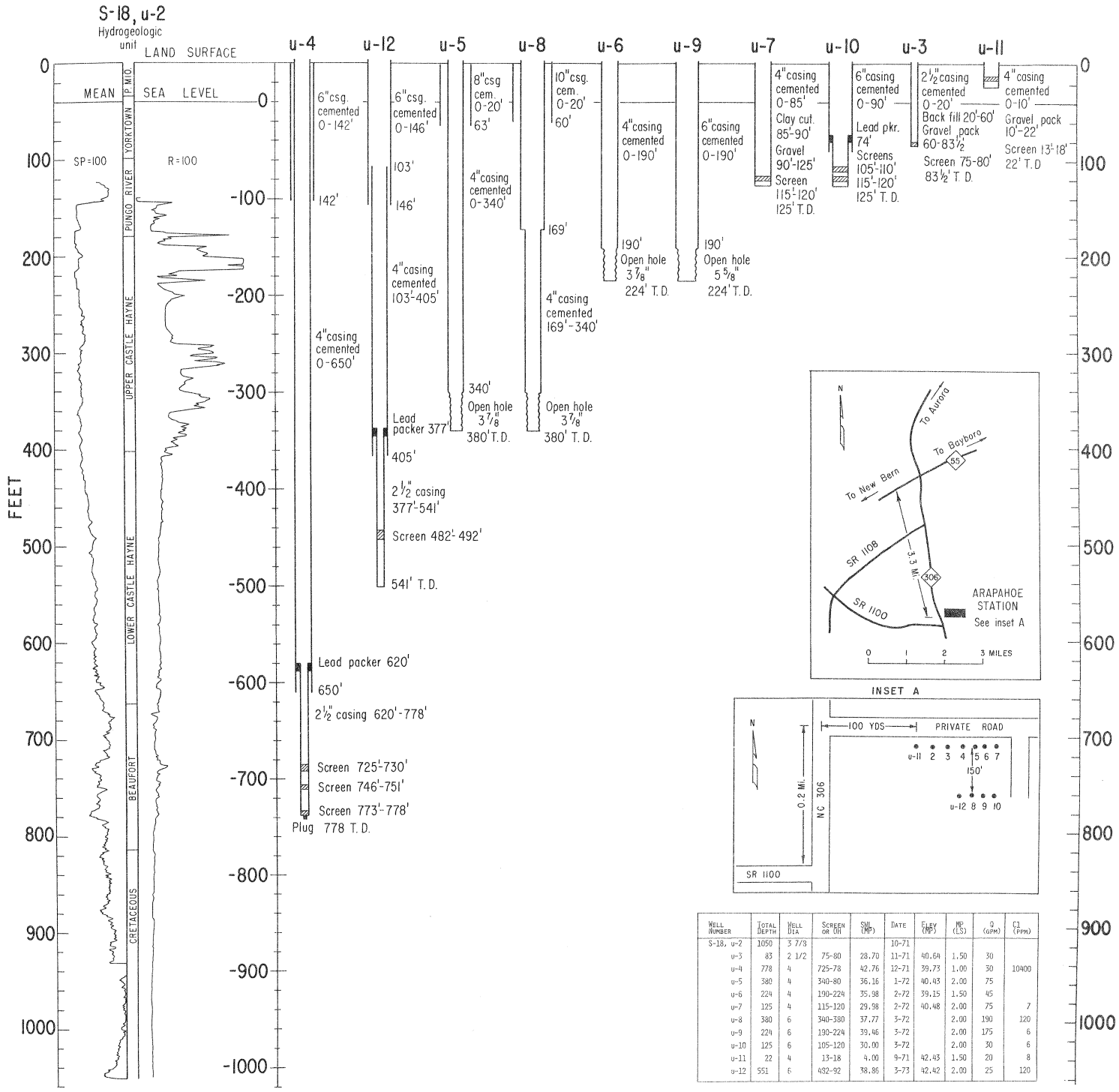
Well Number	Total Depth	Well Dia	Screen or OH	SWL (MP)	Date	Elev (MP)	MP (LS)	Q (GPM)	Cl (PPM)
P-19, m-2	40	4	23-34	24.25	7-67	27.68	2.00	18	9
m-3	250	4	81-250	23.72	7-67	27.38	2.00	45	10
m-4	602	4	571-581	.83	6-67	30.81	3.50	9	4100
m-5	390	4	380-390	26.20	6-67	27.10	2.00	12	840

FIGURE 8. -- DIAGRAM OF RESEARCH STATION AT COX CROSSROADS



WELL NUMBER	TOTAL DEPTH	WELL DIA	SCREEN OR OH	SWL (MP)	DATE	ELEV (MP)	MP (LS)	Q (GPM)	Cl (PPM)
P-21, K-3	29	4	23-29	9.23	7-68	43.06	1.3	2	9
K-4	200	4	61-200	10.86	7-68	43.63	2.0		
K-5	918	4	855-65	13.45	10-68	42.13	1.5	30	470
K-6	200	6	70-200	10.85	9-68	42.48	2.0	87	5
K-7	320	6	290-310	18.56	10-68	42.81	2.0	24	18
K-8	315	2 1/2	294-304	18.50	10.68	42.81	1.5		
K-9	712	4	695-705	14.00	11-68	43.63	2.0	20	222

FIGURE 9. -- DIAGRAM OF RESEARCH STATION AT WILMAR



Well Number	Total Depth	Well Dia	Screen or OH	SWL (MP)	Date	Elev (MP)	MP (LS)	Q (GPM)	Cl (PPM)
S-18, u-2	1050	3 7/8			10-71				
u-3	83	2 1/2	75-80	28.70	11-71	40.64	1.50	30	
u-4	778	4	725-78	42.76	12-71	39.73	1.00	30	10400
u-5	380	4	340-80	36.16	1-72	40.43	2.00	75	
u-6	224	4	190-224	35.98	2-72	39.15	1.50	45	
u-7	125	4	115-120	29.98	2-72	40.48	2.00	75	7
u-8	380	6	340-380	37.77	3-72		2.00	190	120
u-9	224	6	190-224	39.46	3-72		2.00	175	6
u-10	125	6	105-120	30.00	3-72		2.00	30	6
u-11	22	4	13-18	4.00	9-71	42.43	1.50	20	8
u-12	551	6	432-92	38.86	3-73	42.42	2.00	25	120

FIGURE 10. -- DIAGRAM OF RESEARCH STATION AT ARAPAHOE

FIGURE 11. - HYDROGRAPH OF RESEARCH STATION 1, LEE CREEK, N.C.

FIGURE 12.- HYDROGRAPHS OF WELLS AT RESEARCH STATION NO.2, BELHAVEN, N.C.

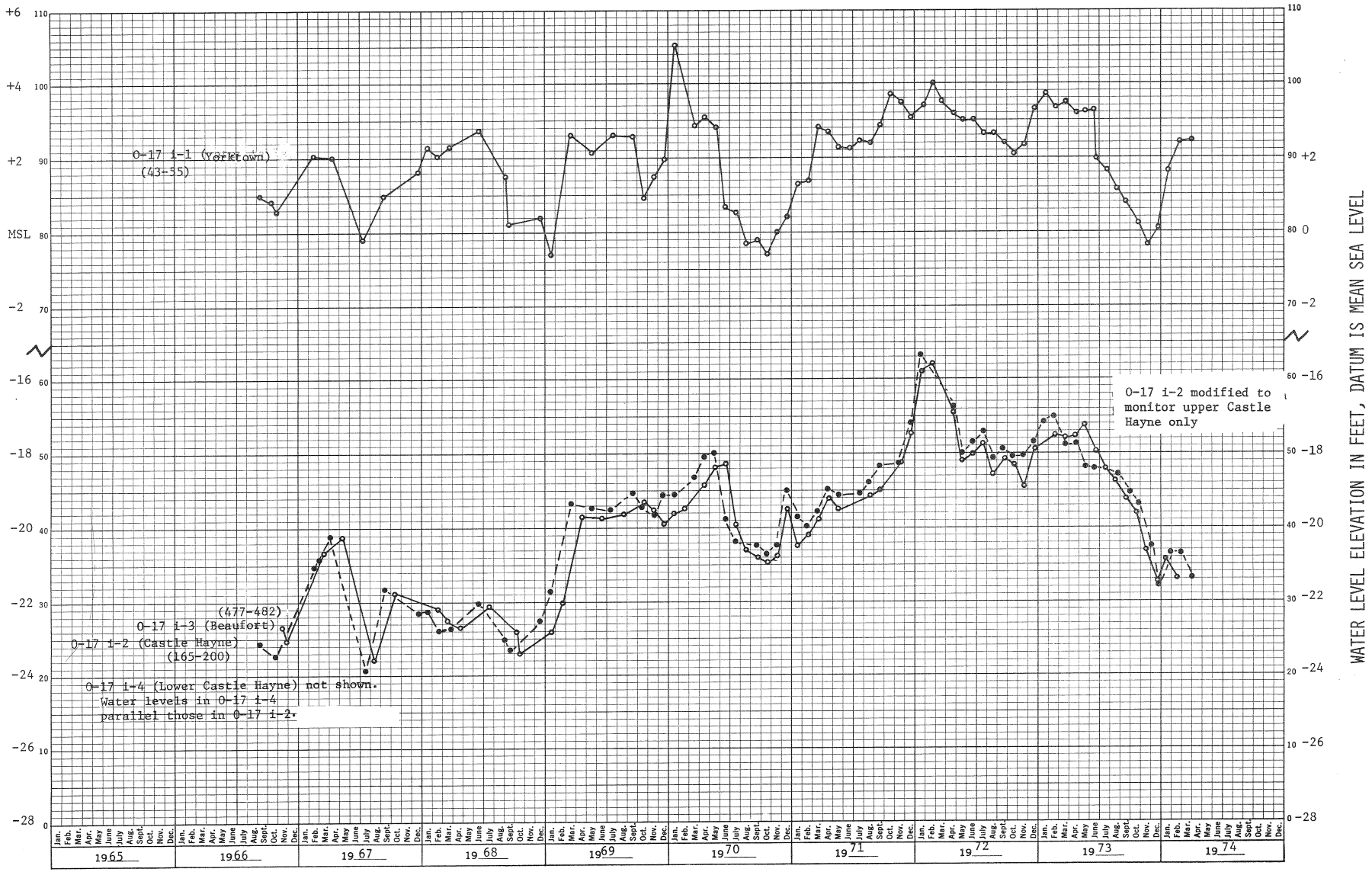


FIGURE 13. - HYDROGRAPHS OF WELLS AT RESEARCH STATION NO. 3, BATH, N.C.

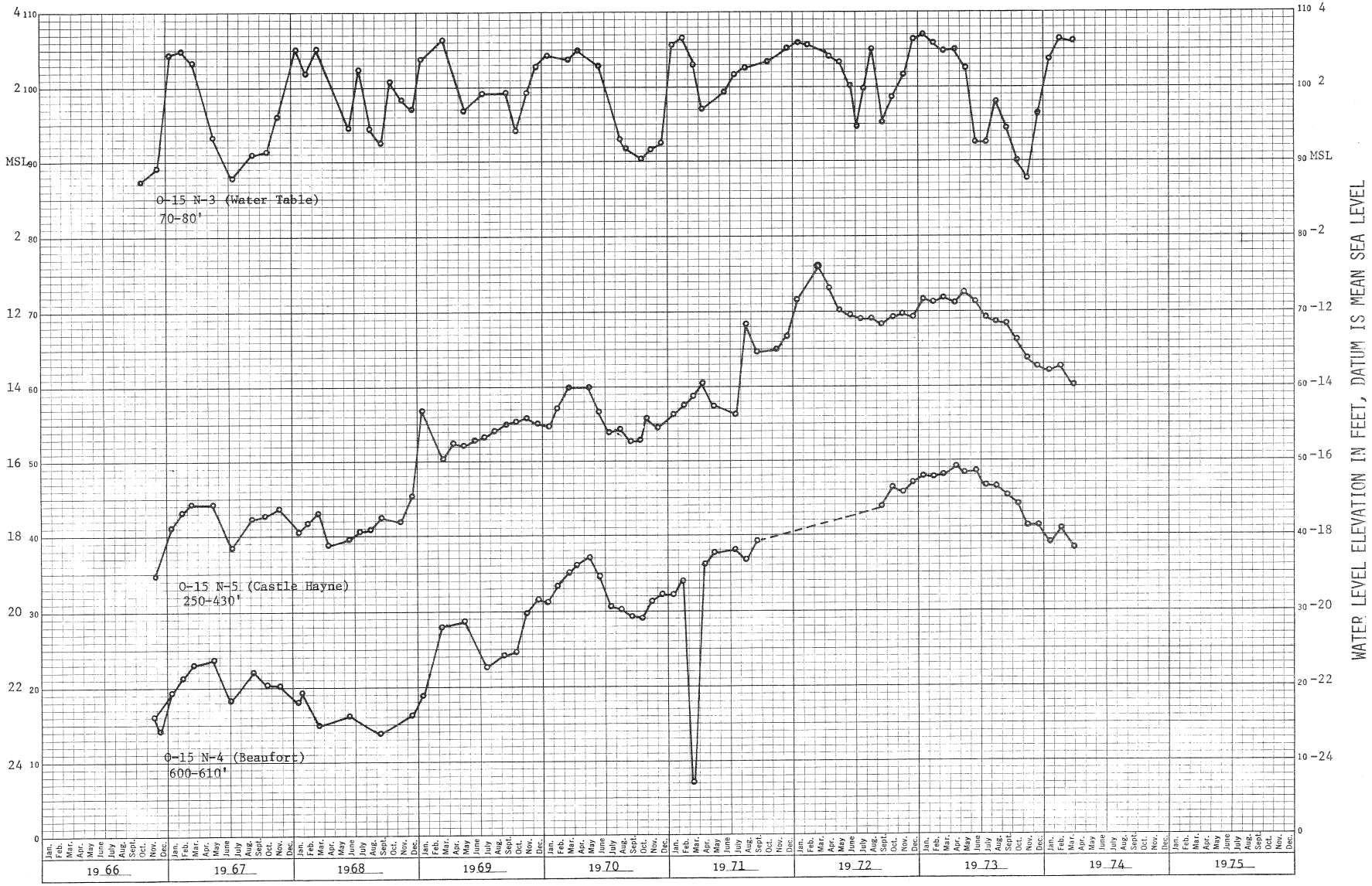


FIGURE 14. - HYDROGRAPH OF WELLS AT RESEARCH STATION NO. 4, WINSTEADVILLE, N.C.

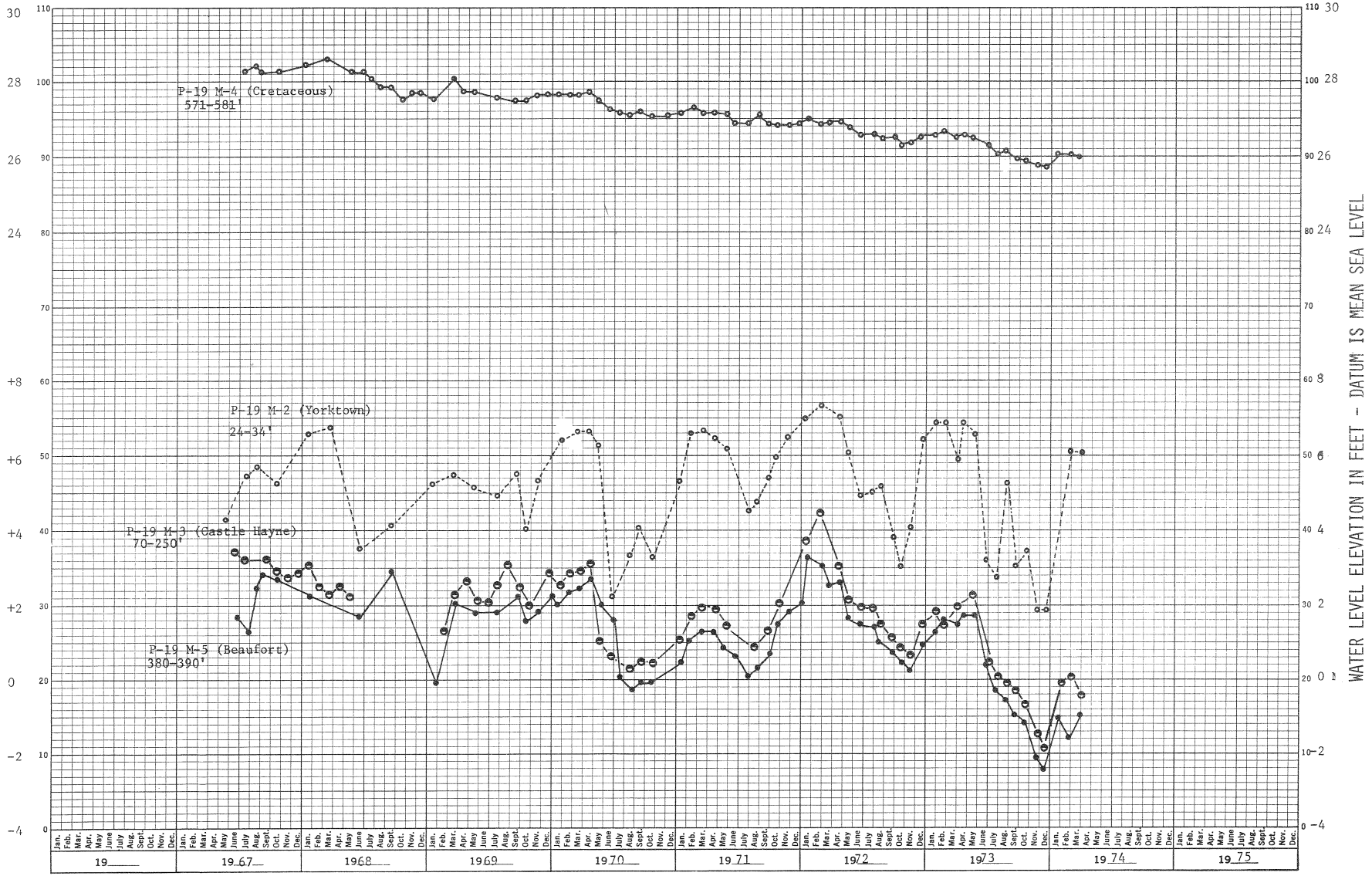


FIGURE 15. - HYDROGRAPHS OF WELLS AT RESEARCH STATION NO. 5, COX CROSS ROADS, N.C.

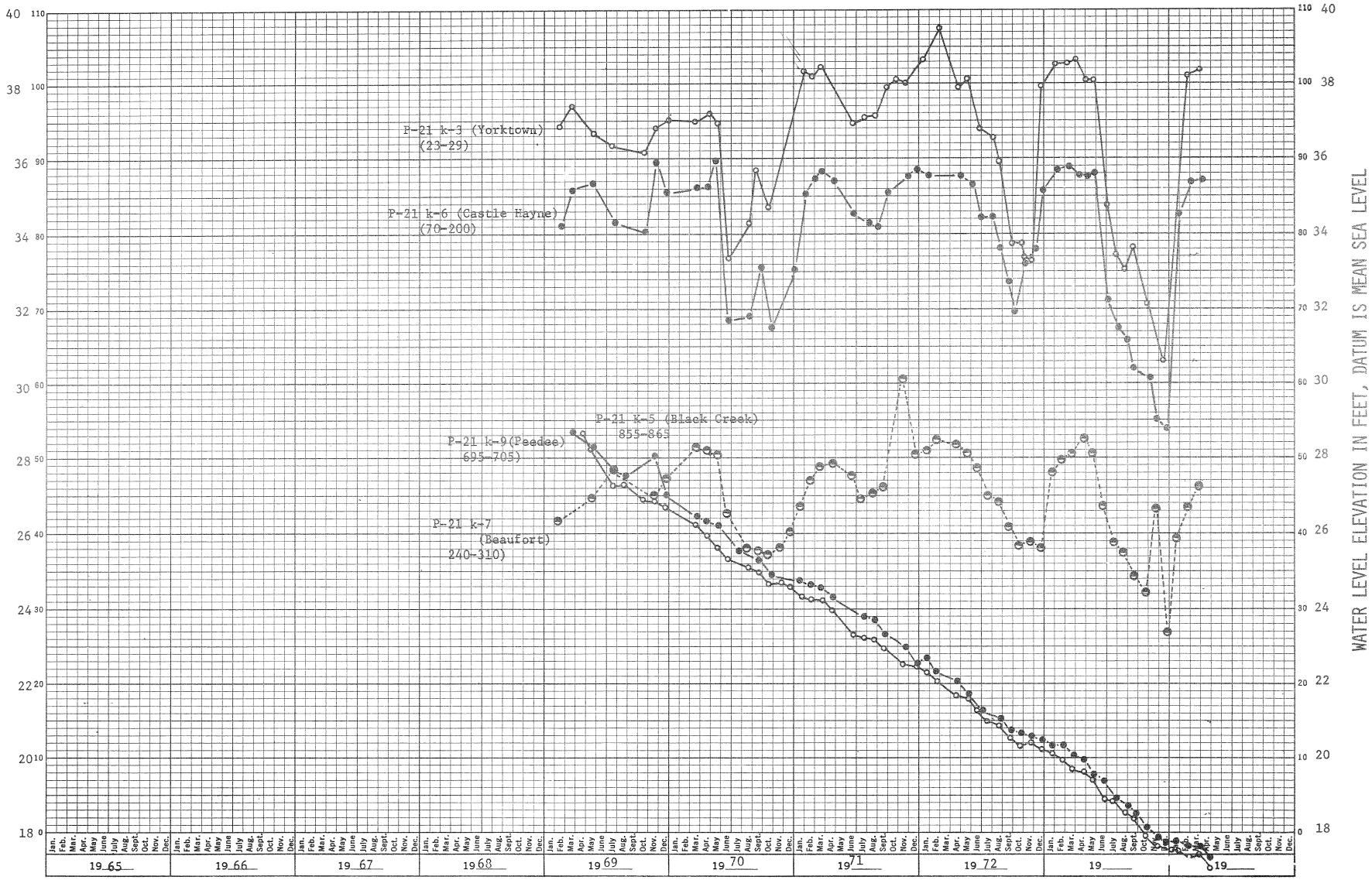


FIGURE 16. - HYDROGRAPHS OF WELLS AT RESEARCH STATION NO. 7, WILMAR, N.C.

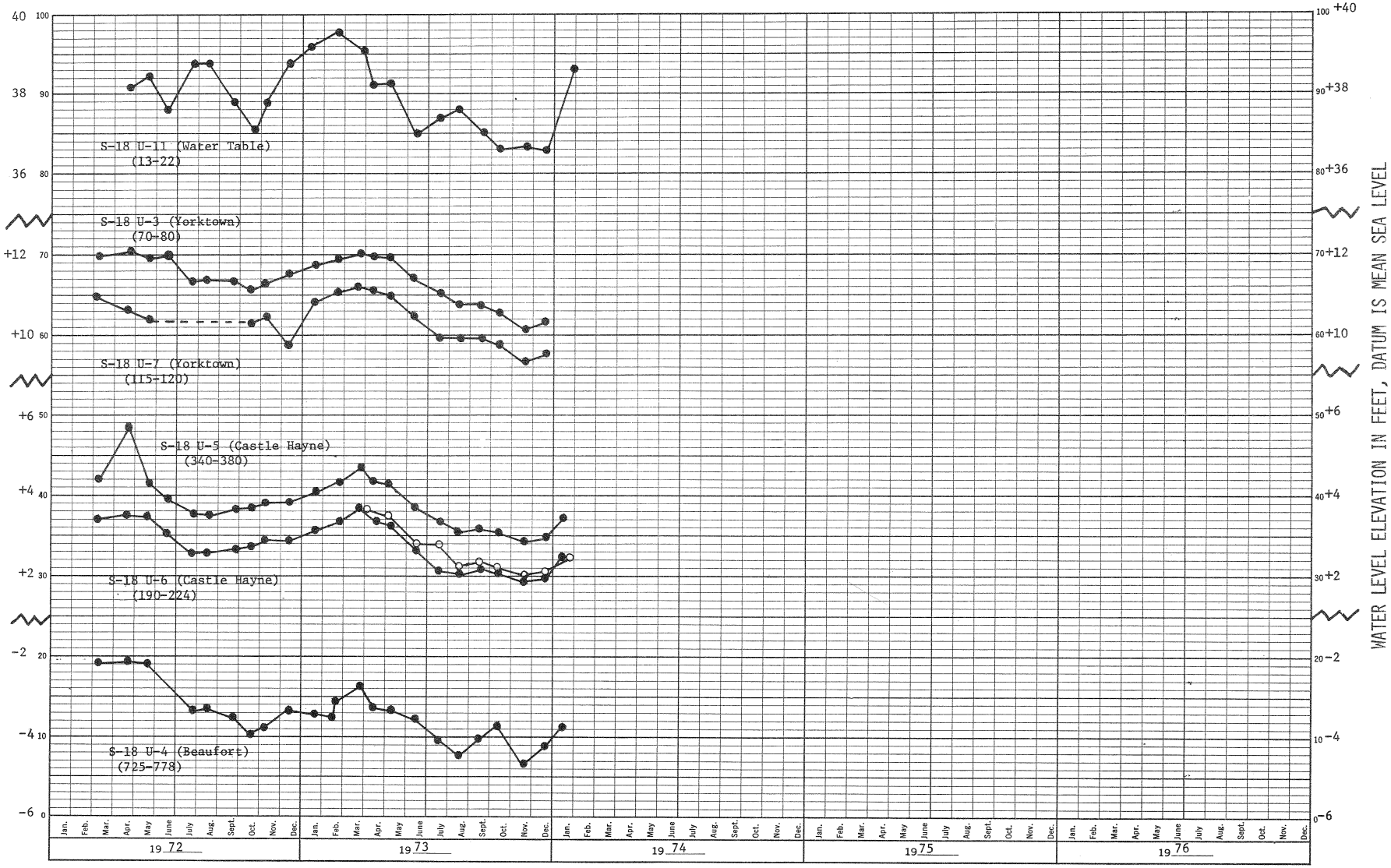


FIGURE 17. - HYDROGRAPHS OF WELLS AT RESEARCH STATION NO. 12, ARAPAHOE, N.C.

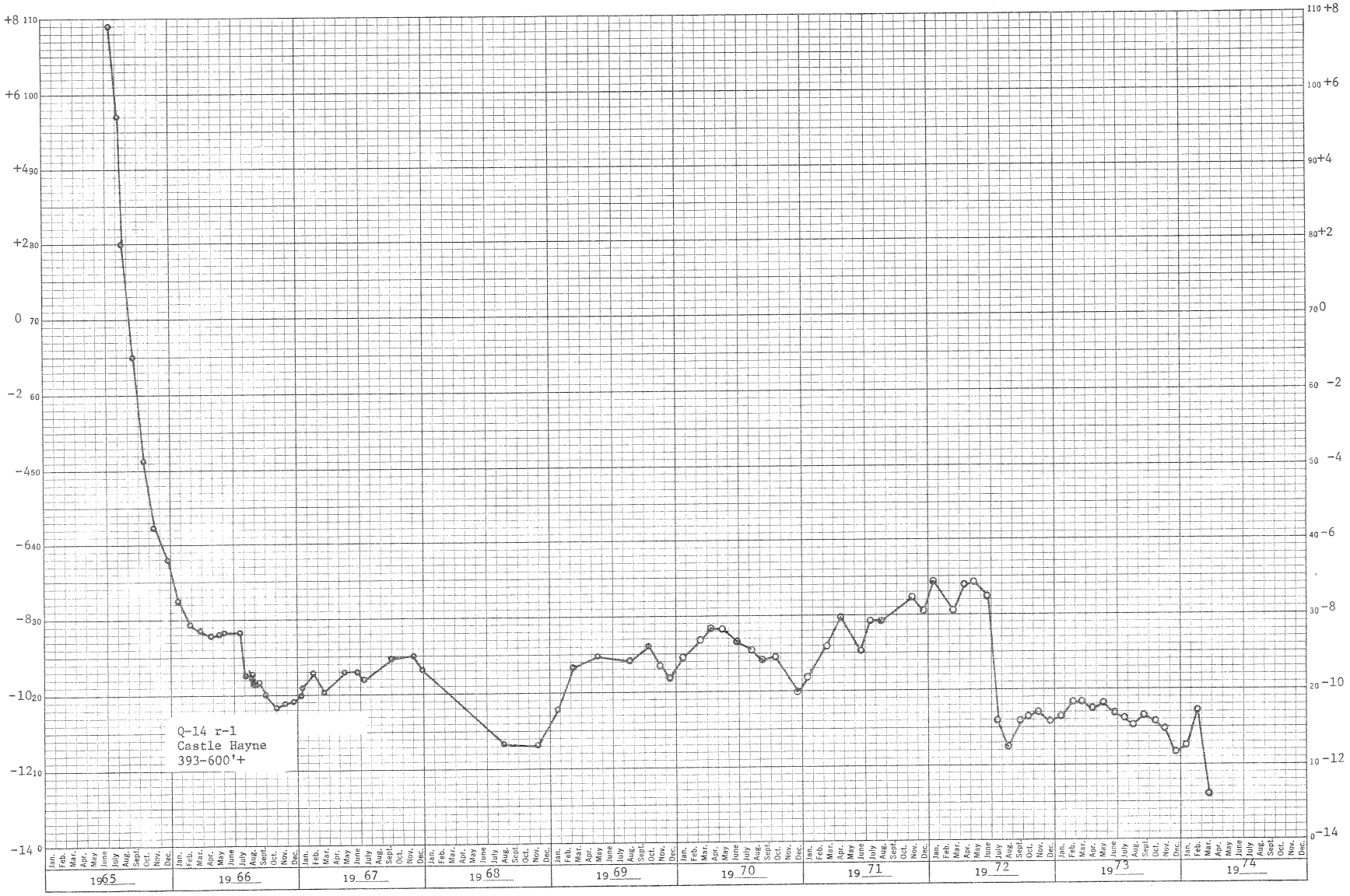


FIGURE 18. - HYDROGRAPH OF WELL Q-14 R-1, LOWLAND, N.C.

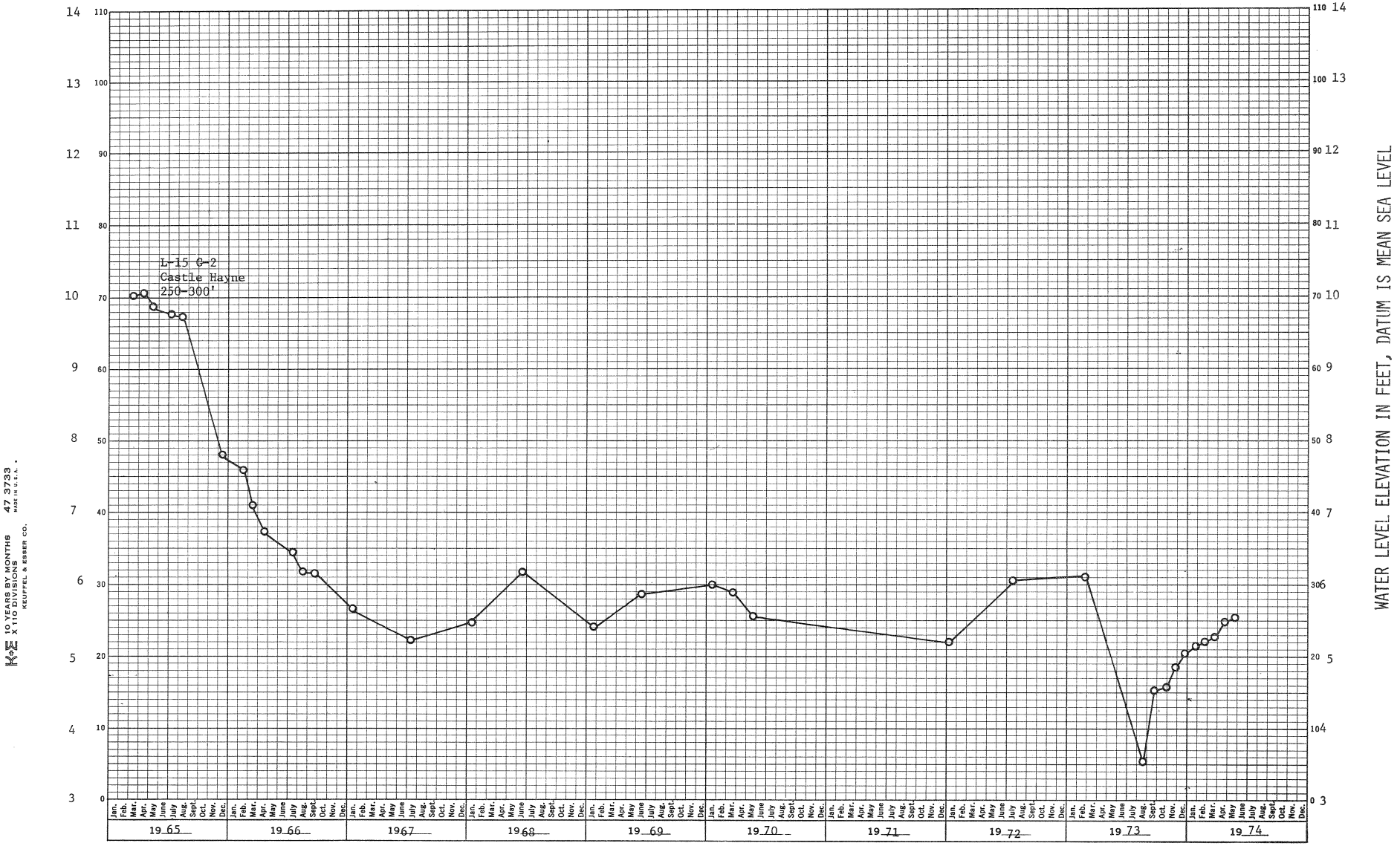


FIGURE 19. - HYDROGRAPH OF WATER LEVEL IN WELL L-15 G-2, WENONA, N.C.

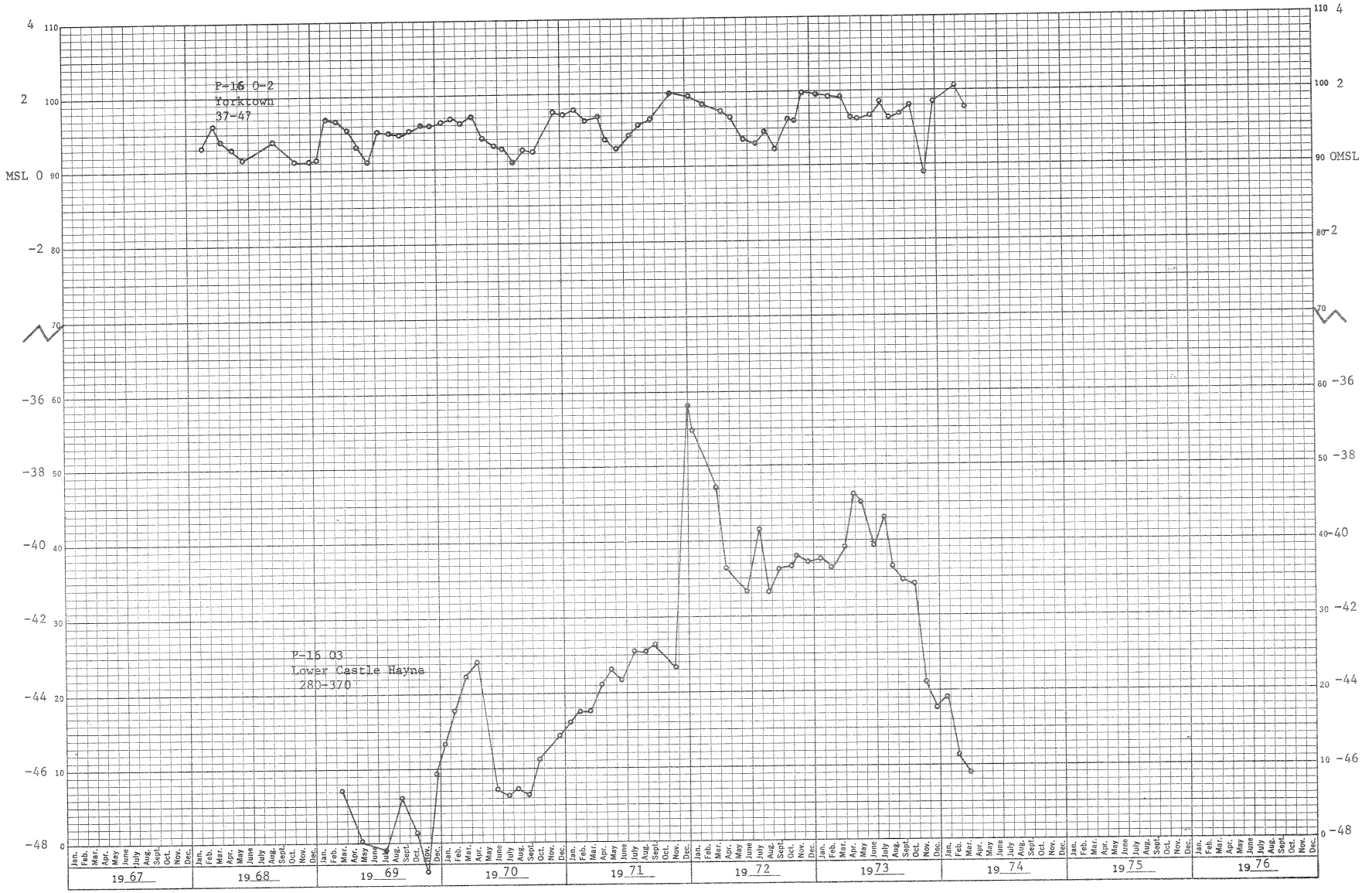


FIGURE 20. - HYDROGRAPHS OF WELLS P-16 0-2 AND P-16 03

more frequently to show the local effects of changes in pumping patterns.

WATER QUALITY MONITORING

Monitoring of water quality is conducted to detect any changes in physical character or concentration of the chemical constituents of the ground waters that are most likely to be affected by stresses imposed upon the aquifer system. In the Capacity Use Area, the primary concern with regard to water quality is the movement of brackish or saline waters into or through the aquifer system. The existing quality monitor-well system has been established to detect and observe changes in concentration of chloride ions in each of the aquifers or aquifer systems of the area. The location of wells monitored by the Ground Water Division are shown in Figure 21. The sampling frequency of the stations is indicated on the map. To supplement the systematic monitoring program, a survey is made periodically to collect samples from a large number of wells in areas where changes in chloride content of the groundwaters are occurring or have been anticipated.

In addition to quality monitoring by the State, Texasgulf has an intensive quality monitoring program in the vicinity of the mine, as required under conditions of the Water Use Permit issued to the company. As shown in Figure 22, the company also maintains additional monitor wells in an area of about 500 square miles surrounding the mine site.

ADEQUACY OF MONITOR SYSTEM

The water use monitoring program requires a detailed inventory, by aquifer, of all water supply wells within the Capacity Use Area. While the existing program is adequate for monitoring the construction of new facilities, many wells constructed prior to the establishment of the

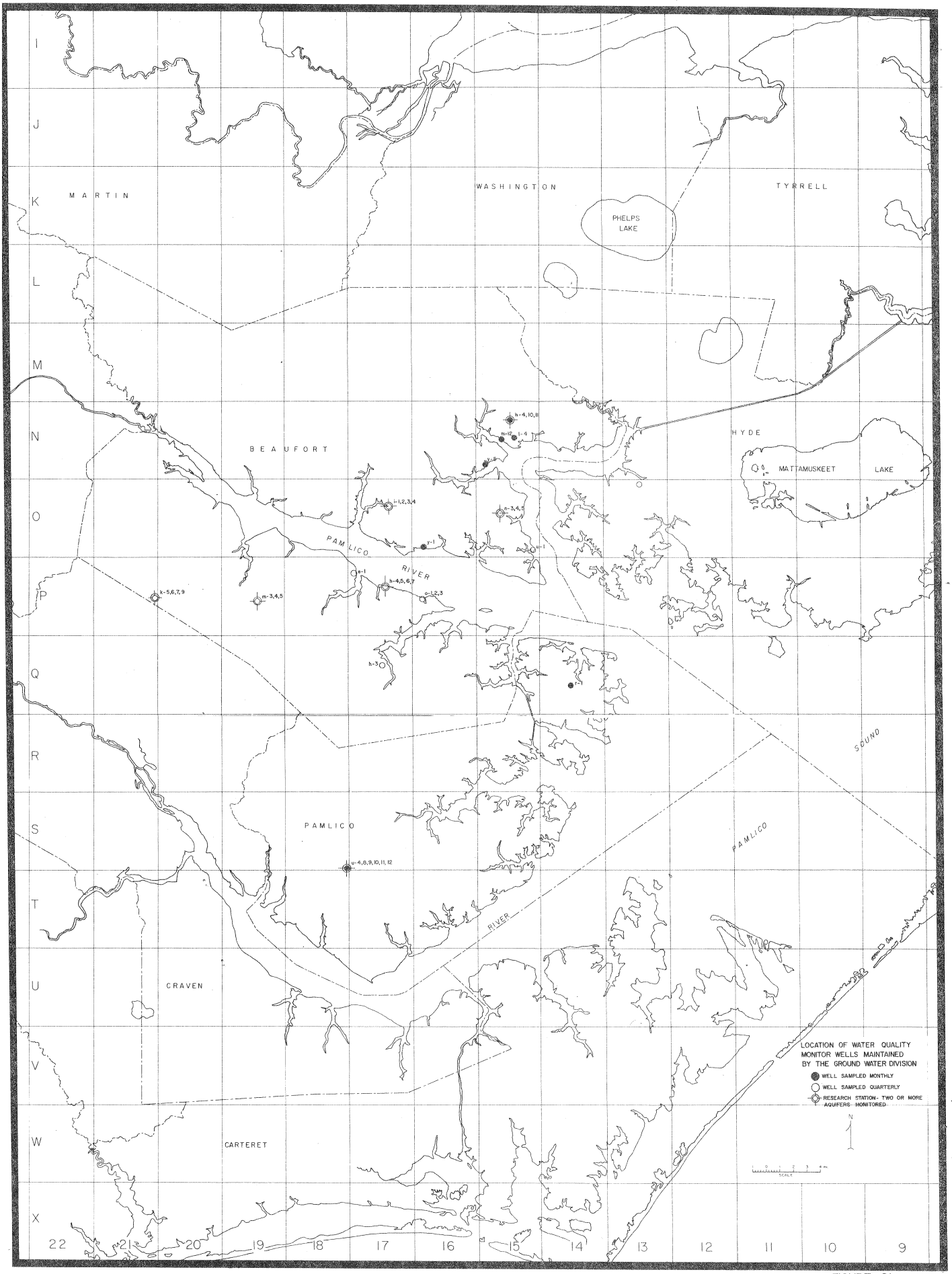

MARTIN
WASHINGTON
TYRRELL
PHELPS LAKE
BEAUFORT
HYDE
MATTAMUSKEET LAKE
PAMLICO RIVER
PAMLICO SOUND
PAMLICO
CRAVEN
CARTERET
h-4,10,11
m-12
i-4
i-1,2,3,4
n-3,4,5
r-1
o-1
q-1
h-4,5,6,7
o-1,2,3
k-5,6,7,9
m-3,4,5
h-3
c-4,8,9,10,11,12
LOCATION OF WATER QUALITY MONITOR WELLS MAINTAINED BY THE GROUND WATER DIVISION
WELL SAMPLED MONTHLY
WELL SAMPLED QUARTERLY
RESEARCH STATION- TWO OR MORE AQUIFERS MONITORED
N
SCALE
I J K L M N O P Q R S T U V W X
22 21 20 19 18 17 16 15 14 13 12 11 10 9

FIGURE - 21

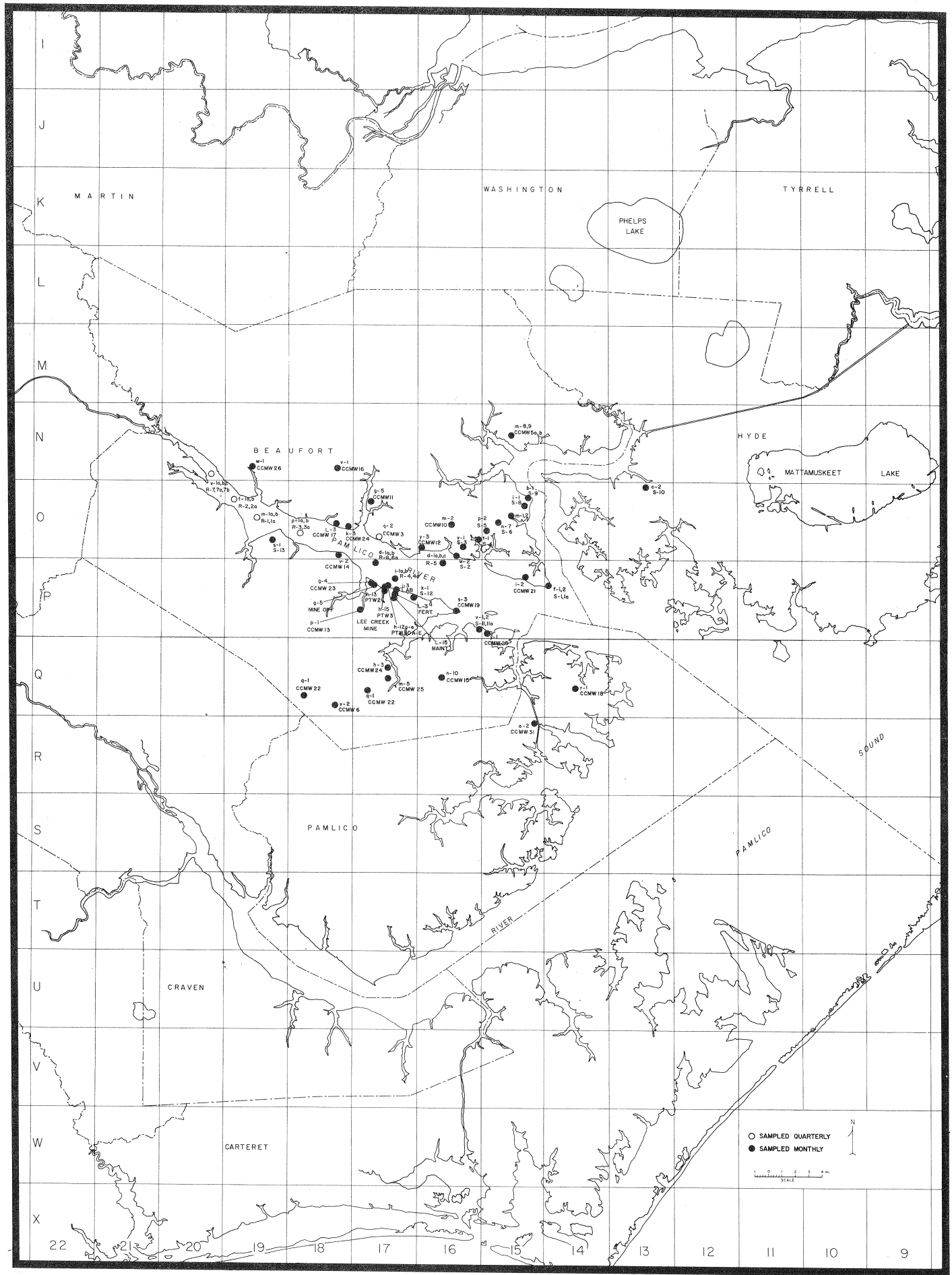


FIGURE 22. - LOCATION OF WATER QUALITY MONITOR WELLS MAINTAINED BY TEXASGULF

Capacity Use Area regulations have not been inventoried. A significant improvement in the program would result from a detailed inventory of irrigation wells with reference to designed yield and periods of use.

The water-level monitoring program,while generally adequate for monitoring the upper unit of the Castle Hayne limestone in the Beaufort County area, needs considerable expansion into the remainder of the Capacity Use Area. Additional control is also needed in the mine area if local effects are to be accurately evaluated. Much additional control is needed on the water table and Yorktown unit so that areas and rates of recharge or discharge can be defined.

The water quality monitoring program is generally adequate for monitoring and mapping chloride distribution within the upper Castle Hayne unit in Beaufort County but does not adequately define water quality throughout the remainder of the Capacity Use Area. Some improvement should be made in sampling techniques to insure optimum consistency in the accuracy of analyses.

Considerably more wells are needed to define the quality of water in the lower Castle Hayne limestone and Beaufort sand units. Locations of proposed water-level and water-quality monitoring stations are shown in Figure 3. Data or existing wells are included in Table 3 and 4. (Back of report).

Summary of Hydrogeologic Conditions

The hydrogeology of the Capacity Use Area has been discussed in considerable detail in the reports mentioned previously, at least to the extent information was available at the time the reports were prepared. Therefore, only a brief summary is included here, based largely on these reports.

Only a limited quantity of new hydrogeologic information has become available since 1971, except at Ground Water Research Station No. 12 constructed near Arapahoe in Pamlico County. A diagram of this station is shown in Figure 10.

HYDROGEOLOGIC FRAMEWORK

The Coastal Plain region is underlain by a "wedge" of sedimentary formations ranging in age from Recent to a Cretaceous or older. These sediments lie unconformably on a "basement" or crystalline rocks that are similar or equivalent to the igneous and metamorphic rocks of the Piedmont region along the western boundary of the Coastal Plain. The wedge of sediments thickens seaward from a thin veeneer along the western boundary to about 10,000 feet at Cape Hatteras, the easternmost land of the State.

In the Capacity Use Area, the sediments consist of sand, silt, clay, shells, limestone and combinations of these lithologies. The thickness ranges from about 1200 feet in the western part to more than 5,000 feet in the eastern part. The sediments may be divided into several hydrogeologic units based primarily on differences in permeability and hydrologic characteristics. Table 5 shows the hydrogeologic units along with the established stratigraphic subdivisions that are based on geologic age. The hydrogeologic units generally coincide with the stratigraphic units

TABLE 5. STRATIGRAPHIC AND HYDROGEOLOGIC UNITS

SYSTEM	SERIES	STRATIGRAPHIC UNITS	HYDROGEOLOGIC UNITS		CHARACTER
QUATERNARY	RECENT PLEISTOCENE	UNDIFFERENTIATED UNNAMED UNIT	POST-MIOCENE UNIT (PM)		SAND, SLIT, SHELLS AND SOME CLAY. THIS UNIT COMPRISES THE UNCONFINED OR "WATER-TABLE" AQUIFER AND INCLUDES SANDS OF THE YORKTOWN FORMATION IN SOME LOCALITIES.
TERTIARY	MIOCENE	YORKTOWN FORMATION	YORKTOWN UNIT (MY)		INTERBEDDED SAND AND CLAY WITH SOME SHELL BEDS. CLAYS ARE GENERALLY SANDY AND COMPRISE CONFINING BEDS OVER MOST OF THE AREA. THE BEDS OF SHELL AND SAND ARE CONFINED AQUIFERS EXCEPT IN THE SOUTH-WESTERN PART OF THE AREA.
		PUNGO RIVER FORMATION	PUNGO RIVER UNIT (MPR)		PHOSPHATE AND QUARTZ SAND, SLIT, CLAY AND LIMESTONE. PERMEABILITY OF THE UNIT IS LOW BECAUSE OF SILT AND CLAY CONTENT AND LAYERS OF DOLOMITIC LIMESTONE. UNIT SERVES AS A CONFINING BED OVER MOST OF THE AREA MAY SERVE AS AN AQUIFER IN SOME LOCALITIES.
	EUCENE	CASTLE HAYNE LIMESTONE	CASTLE HAYNE AQUIFER SYSTEM	UPPER CASTLE HAYNE UNIT (U ECH)	PERMEABLE AND POROUS SHELL LIMESTONE. AN EXCELLENT AQUIFER AND THE MOST PRODUCTIVE UNIT OF THE CASTLE HAYNE AQUIFER SYSTEM.
				LOWER CASTLE HAYNE UNIT (L ECH)	SHELL LIMESTONE INTERBEDDED WITH CALCAREOUS SANDS. A MODERATELY PRODUCTIVE AQUIFER, BUT LESS PERMEABLE THAN THE UPPER CASTLE HAYNE UNIT.
	PALEOCENE	BEAUFORT FORMATION		BEAUFORT UNIT (PB)	FINE GLAUCONITIC SAND, SILTY AND CLAYEY IN PART. INCLUDES SANDS OF THE UPPER PART OF THE PEEDEE FORMATION IN SOME LOCALITIES. THE PERMEABILITY OF THE UNIT IS RELATIVELY LOW AND THE UNIT IS NOT A HIGHLY PRODUCTIVE AQUIFER.
CRETACEOUS	UPPER CRETACEOUS	PEEDEE FORMATION	PEEDEE UNIT (KPD) AND UNDIFFERENTIATED CRETACEOUS UNITS		INTERBEDDED CLAY, FINE SAND AND SILT THAT FORM A CONFINING BED BENEATH THE CASTLE HAYNE AQUIFER SYSTEM.
		BLACK CREEK FORMATION			
		TUSCALOOSA FORMATION			
	LOWER CRETACEOUS	UNNAMED FORMATION			
	BASEMENT				

(FROM "*Report on Hydrogeology and effects of pumping from Castle Hayne Aquifer System, Beaufort County, North Carolina*")

but may be a subdivision of a stratigraphic unit, or may overlap age boundaries in some cases. Cross sections of the hydrogeologic system are shown in Figures 23 and 24. This report is primarily concerned with the Castle Hayne aquifer system and overlying hydrogeologic units.

The Castle Hayne aquifer system is the principal artesian system in the area and the most productive in the State. It extends beneath the Coastal area from Brunswick County to the Albemarle Sound area, and ranges in width from 10 to 60 miles (Figure 25). Areally, the aquifer may be divided into four groundwater basins. The natural movement of water in the aquifer, regionally, is generally from west to east. Within the basins the natural movement is from the upland recharge areas toward the streams, estuaries and sounds. Natural discharge areas include these waters and adjacent land areas.

The Capacity Use Area includes most of the Pamlico River groundwater basin and part of the Neuse River and Roanoke River groundwater basins. Within this area the Castle Hayne aquifer system includes the Castle Hayne limestone, the Beaufort formation and, in places, the upper part of the Peedee formation as indicated in Figures 23 and 24 and Table 5. The Castle Hayne aquifer system has been divided into three hydrogeologic units based on hydrologic character and permeability: The Beaufort unit, the lower Castle Hayne unit and the upper Castle Hayne unit (Table 5).

The top of the aquifer, as shown in Figure 26, ranges from about sea level in the western part of the area, to about 600 feet below sea level in the eastern part. The thickness ranges from about 160 feet in the western part of the area to more than 700 feet in the eastern part. The transmissivity of the aquifer ranges from about 50,000 gallons per day per

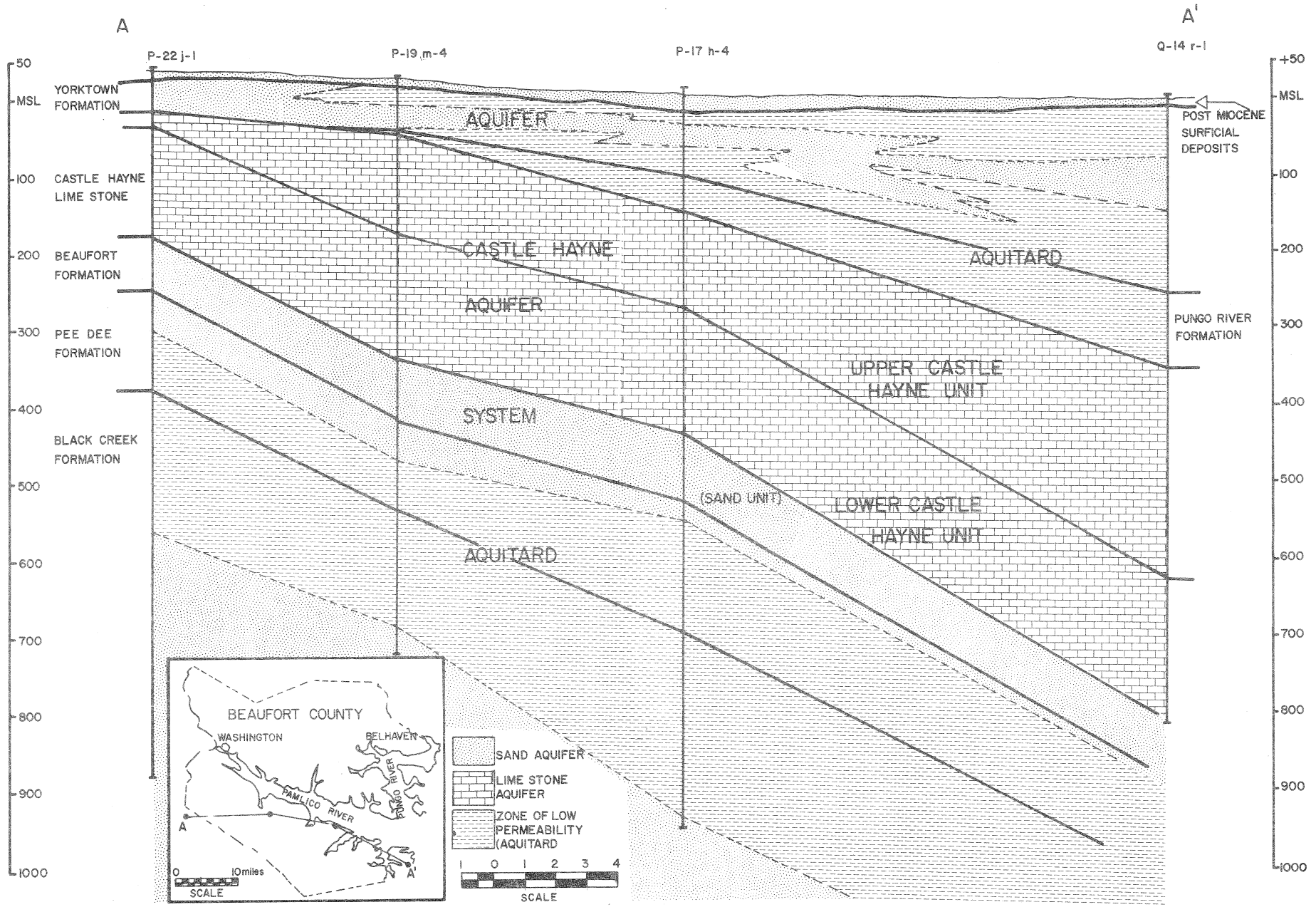


FIGURE 23. - HYDROGEOLOGIC CROSS-SECTION A - A'

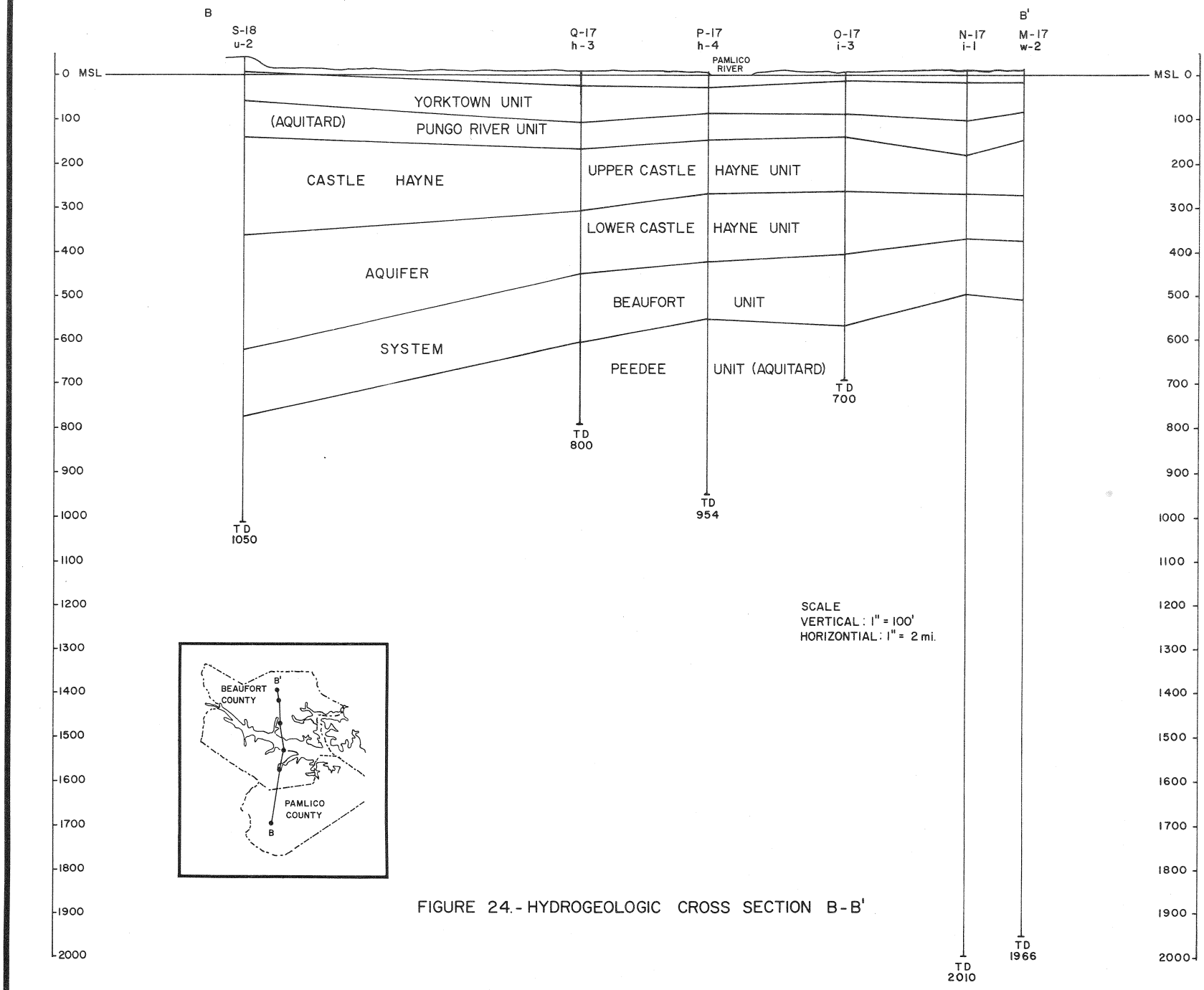


FIGURE 24.- HYDROGEOLOGIC CROSS SECTION B-B'

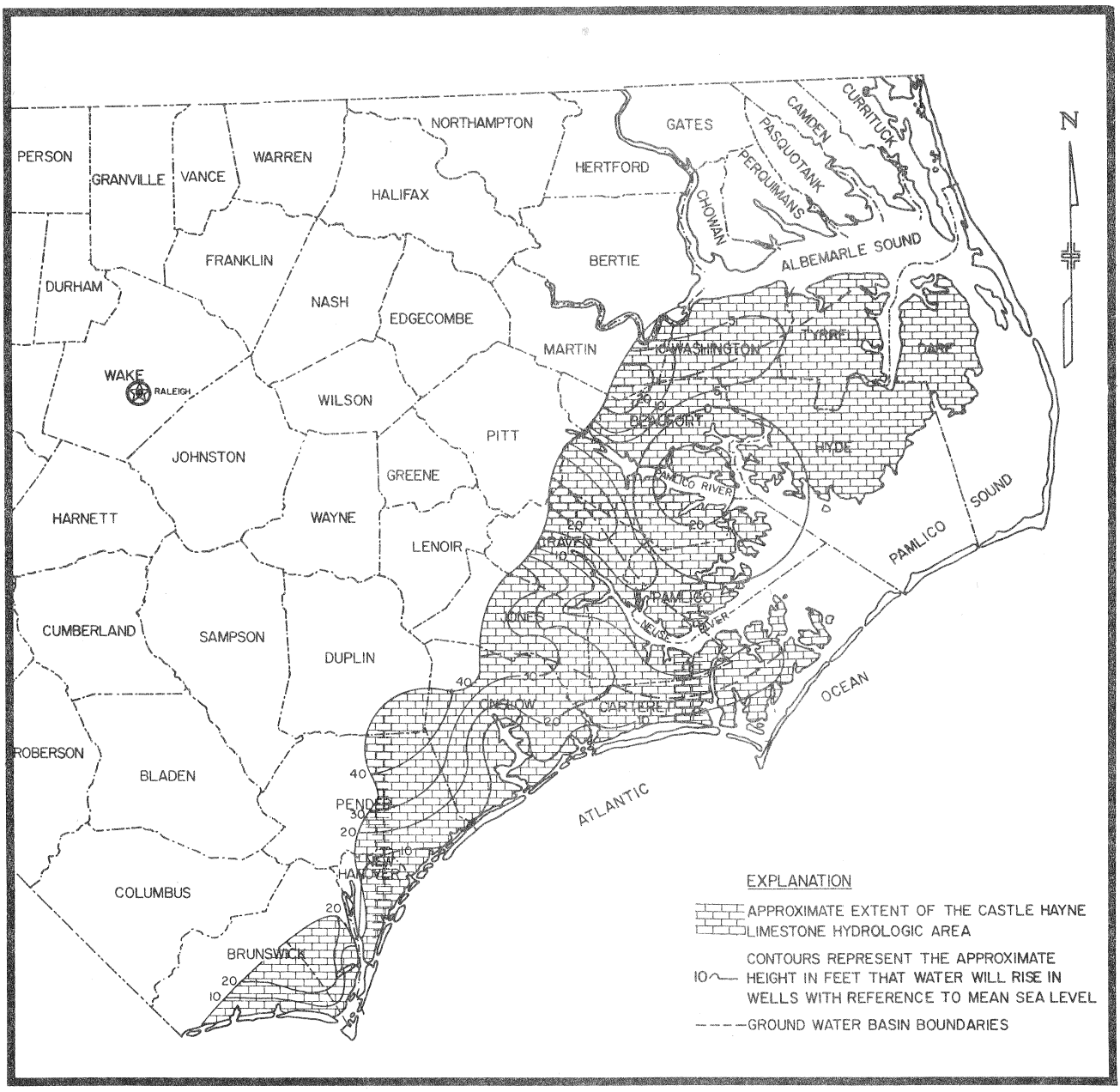


FIGURE 25.--- EXTENT OF THE CASTLE HAYNE AQUIFER SYSTEM

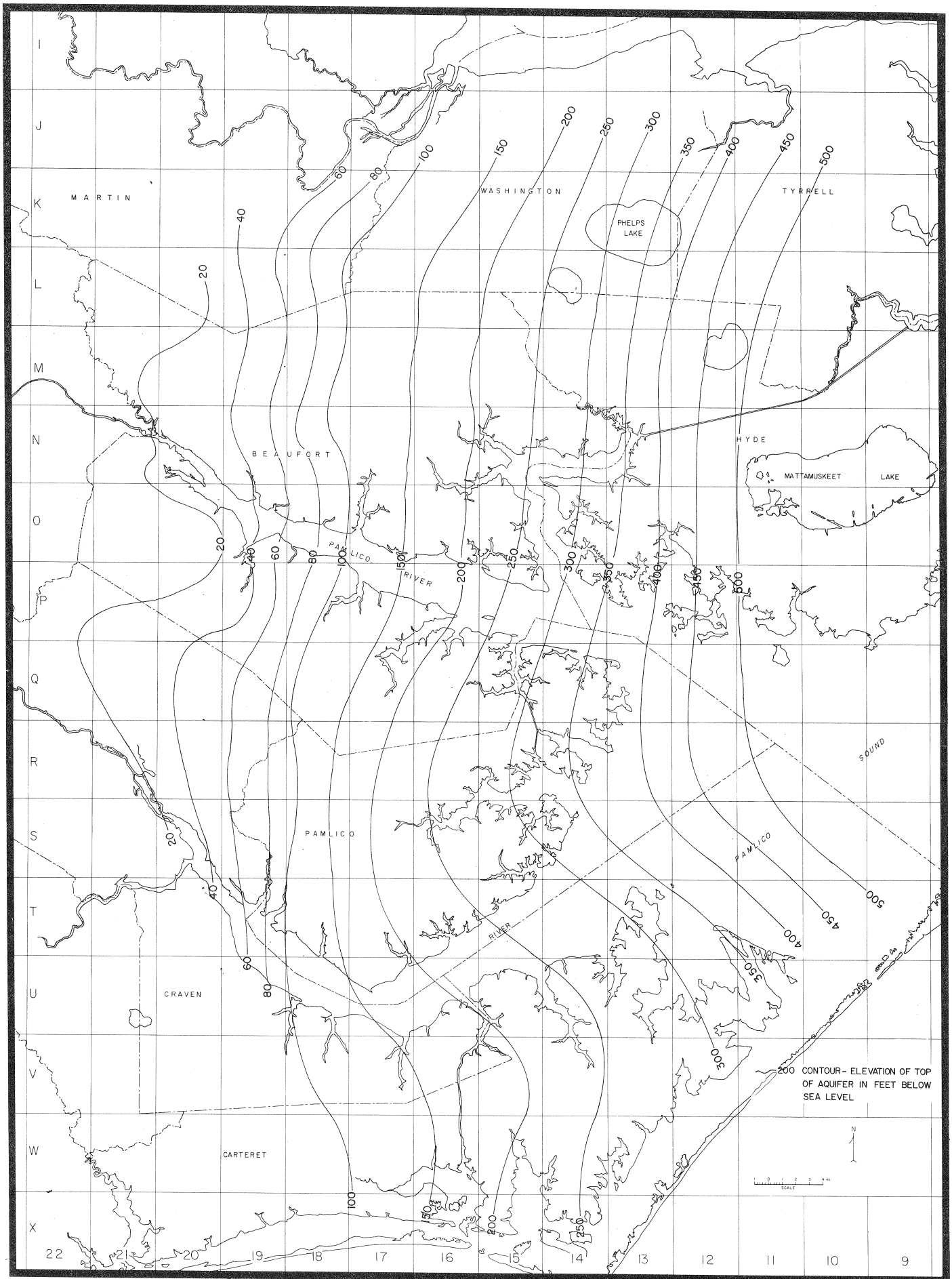


FIGURE 26.- TOP OF CASTLE HAYNE AQUIFER

foot in the western part to 250,000 or more in the eastern part. The coefficient of storage is in the range of 10^{-4}.

The magnitude of the storage capacity of the Castle Hayne aquifer system can be illustrated by comparison with the lakes of the State. The capacity of Lake Mattamuskeet or Lake Phelps is about 6 percent of the capacity of the aquifer that lies immediately beneath the lakes. Compared to the man-made lakes, the estimated capacity of about 75 square miles of the aquifer is more than the total capacity of Badin Lake, Kerr Reservoir, Kerr Scott Reservoir, Mountain Island Lake, and Lake Norman, which is about 4,587,000 acre feet.

The Castle Hayne aquifer system is overlain by the Pungo River hydrogeologic unit, which generally corresponds to the Pungo River stratigraphic unit (Table 5). The Pungo River unit is overlain by the Yorktown unit. In most of the area, these units serve as confining beds above the Castle Hayne aquifer system, although the Yorktown does contain a sand aquifer that extends over most of the area and a permeable limestone aquifer in the eastern part of the region.

The Yorktown unit is overlain by the post-Miocene unit, which consists principally of surficial sands and comprises the water table aquifer.

GENERAL HYDROLOGY

Precipitation in the area is the source of recharge to the Castle Hayne and overlying aquifers. It is estimated that more than 20 percent of the average annual precipitation of 50 inches enters the groundwater reservoir. This represents 350 million gallons per square mile. The water table or non-artesian aquifer serves as the reservoir that sustains stream flow and recharges the artesian aquifers. Recharge to the artesian system occurs where hydraulic head conditions permit; the rate being primarily dependent on head differences

between the water table and the artesian system, vertical permeability of confining beds

Figure 27 shows the piezometric surface of the upper unit of the Castle Hayne aquifer in June 1965, prior to the beginning of very large withdrawals from the aquifer. As may be noted, the contours show two prominent ridges between the Roanoke, Pamlico and Neuse Rivers that represent major recharge areas and form groundwater-basin divides. Natural discharge was occurring in the areas of lower elevation with the principal centers of discharge along the rivers and estauries. In much of the lowlands the piezometric surface was above land surface and flowing wells were common.

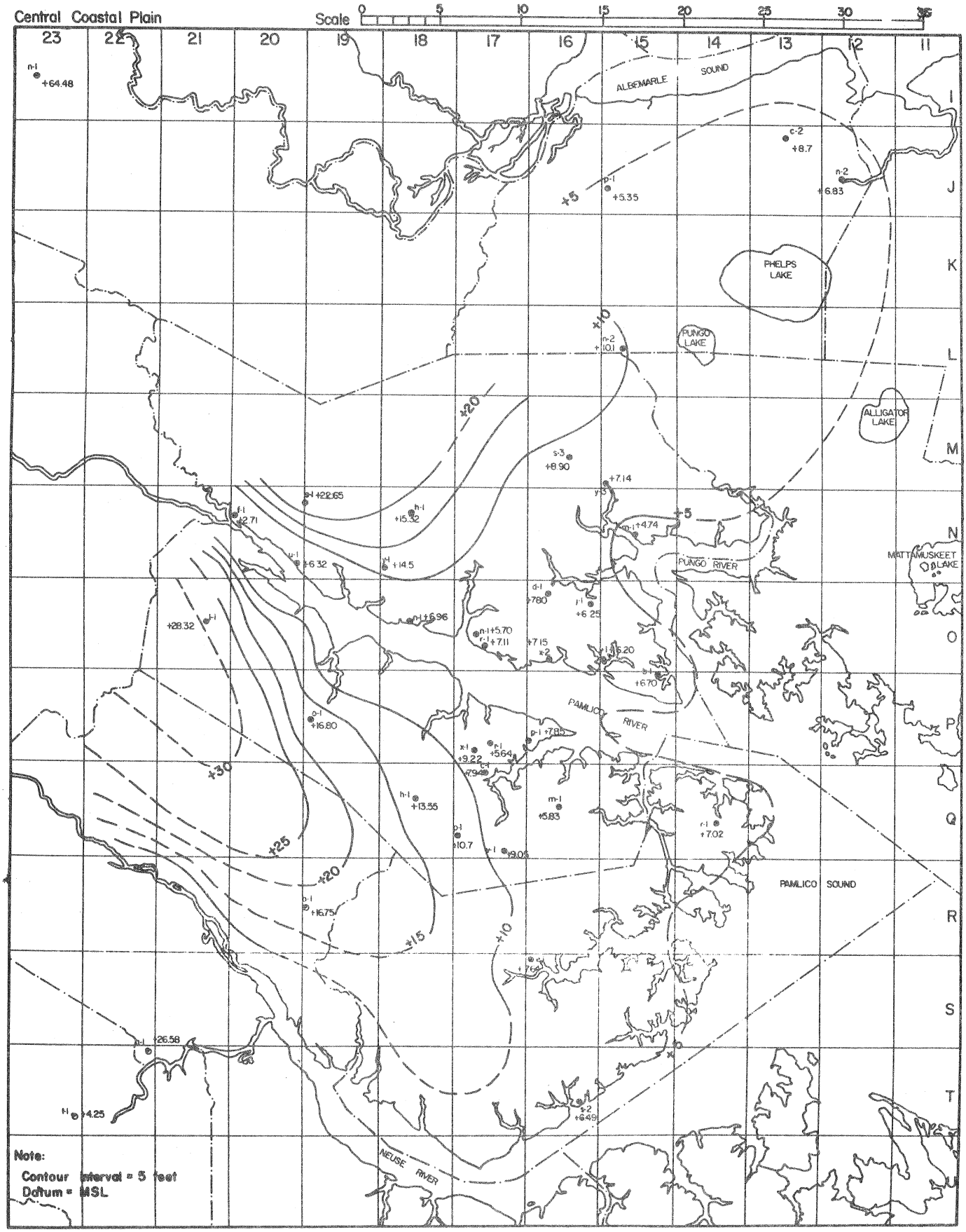
WATER QUALITY

The natural chemical quality of the water in the Castle Hayne aquifer is generally good except where residual or "fossil" seawater has not been completely flushed from the aquifer. Typically, the water is hard but relatively low in other mineral content, although hydrogen sulfide occurs in noticeable amounts throughout the eastern part of the Capacity Use Area. The chloride content is generally low but increases in the direction of natural water movement, and is high in the eastern part of the area where part or all of the aquifer contains residual sea waters. (Figs. 37 and 38)

REVIEW OF EFFECTS OF LARGE WITHDRAWALS FROM THE CASTLE HAYNE AQUIFER, 1965-74

WITHDRAWAL RATES

In July 1965, the Texas Gulf Sulfur Company (now the Texasgulf Company) began withdrawing water from the Castle Hayne aquifer at the rate of more than 60 million gallons per day (MGD) at Lee Creek on the Pamlico River.



Note:
Contour interval = 5 feet
Datum = MSL

FIGURE 27. - PIEZOMETRIC SURFACE OF CASTLE HAYNE AQUIFER - JUNE 1965

This withdrawal was made to permit dry open-pit mining of the phosphate sands that lie immediately above the aquifer in this area. Withdrawals are shown graphically in Fig. 28.

During the initial stages of depressuring, withdrawals from the depressuring wells averaged as high as 70 MGD. After stabilization of the drawdown depression in the piezometric surface, daily withdrawals, averaged monthly, generally ranged from 50 to 56 MGD, but during a few months, the withdrawal rate was less than 50 MGD. The graph shows that an increase in withdrawal rate began in the latter part of 1973. In February 1974, the pumping rate had been increased to more than 60 MGD from the depressuring wells. In addition, about 3.5 MGD was being withdrawn from the service wells at the site.

EFFECTS ON HYDROLOGY

The most immediate and dramatic affect of the large withdrawals was the extensive lowering of the piezometric surface and changes in the pattern of groundwater flow, as illustrated in Figure 29. The piezometric surface was lowered substantially for a distance of 40 miles from the center of pumping. It was lowered more than 5 feet in an area of about 1,300 square miles, and below sea level in an area of more than 800 square miles. Most of the drawdown of the piezometric surface occurred within the first few months of pumping and the configuration of the piezometric surface became relatively stable after about 6 to 9 months; changing in response to changes in pumping rates. After the initial stages of drawdown, when a considerable quantity of water was being removed from storage, the rate of pumping needed to maintain the drawdown configuration decreased.

The lowering of the piezometric surface resulted in immediate water-

FIGURE 28. -- GRAPH OF WITHDRAWLS FROM DEPRESSURING WELLS AT LEE CREEK MINE

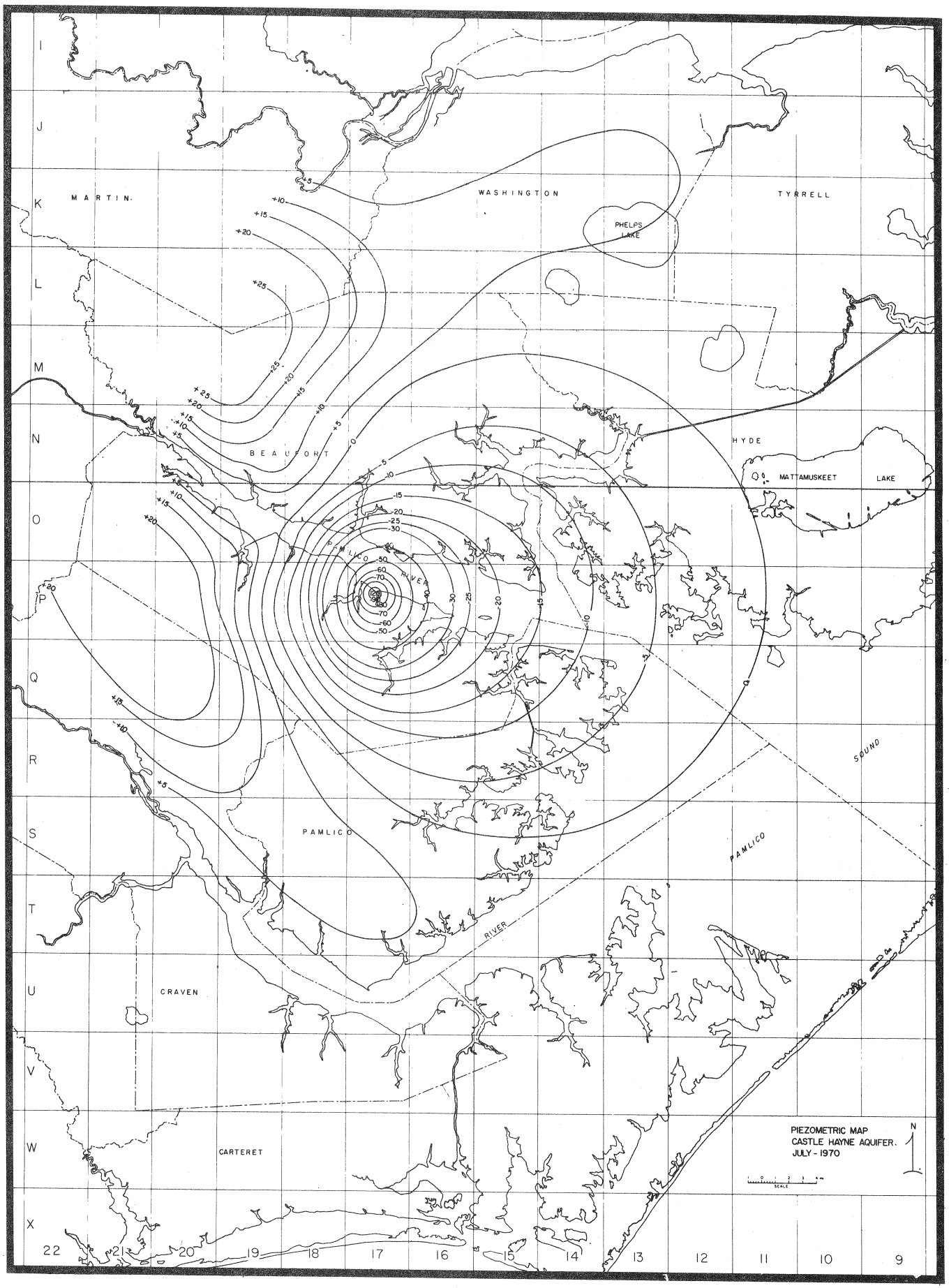


FIGURE 29. - PIEZOMETRIC SURFACE OF CASTLE HAYNE AQUIFER - JULY 1970

supply problems in an area of several hundred square miles. Most wells in the area were equipped with "shallow-well" pumps or flowed under natural artesian head, so that replacement or installation of pumps was necessary to compensate for the lower water levels. The mining company voluntarily bore most of the pump replacement or well construction costs for about 800 wells.

Figure 30 shows the piezometric surface of the upper limestone member of the Castle Hayne aquifer in July 1973. The configuration was about the same as it was in 1970. The net drawdown in the aquifer from the beginning of large withdrawals in 1965 is illustrated in Figure 31. The hydrographs of the wells at research stations and other wells monitored (Figs. 11-20) show that changes in water levels generally reflect the changes in pumping rates.

Since 1972, a sufficient number of observation wells and piezometers has been available to permit relatively detailed mapping of the piezometric surface of the Castle Hayne aquifer in the immediate vicinity of the Lee Creek phosphate mine. Maps prepared from measurements on several dates are shown in Figs. 32-36.

Under the Water Use Permit issued to Texasgulf for depressuring the aquifer, the piezometric surface may be lowered to 120 feet below sea level or more in an area up to 400 acres. The areas where the piezometric surface was below 120 feet, as measured from the piezometric maps, and the pumping rate reported for the particular data are as follows:

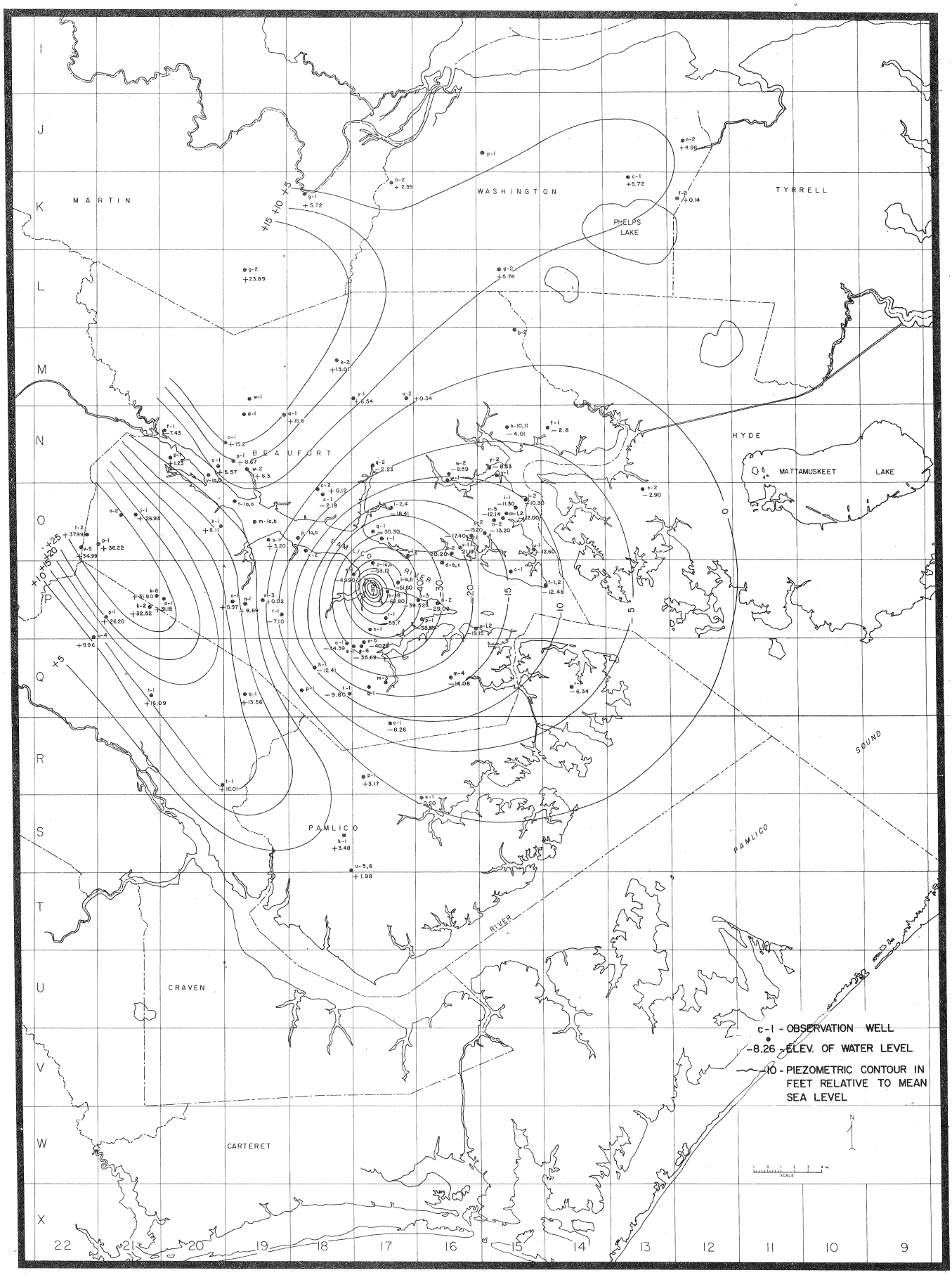


FIGURE 30.- PIEZOMETRIC SURFACE OF CASTLE HAYNE AQUIFER, JULY, 1973

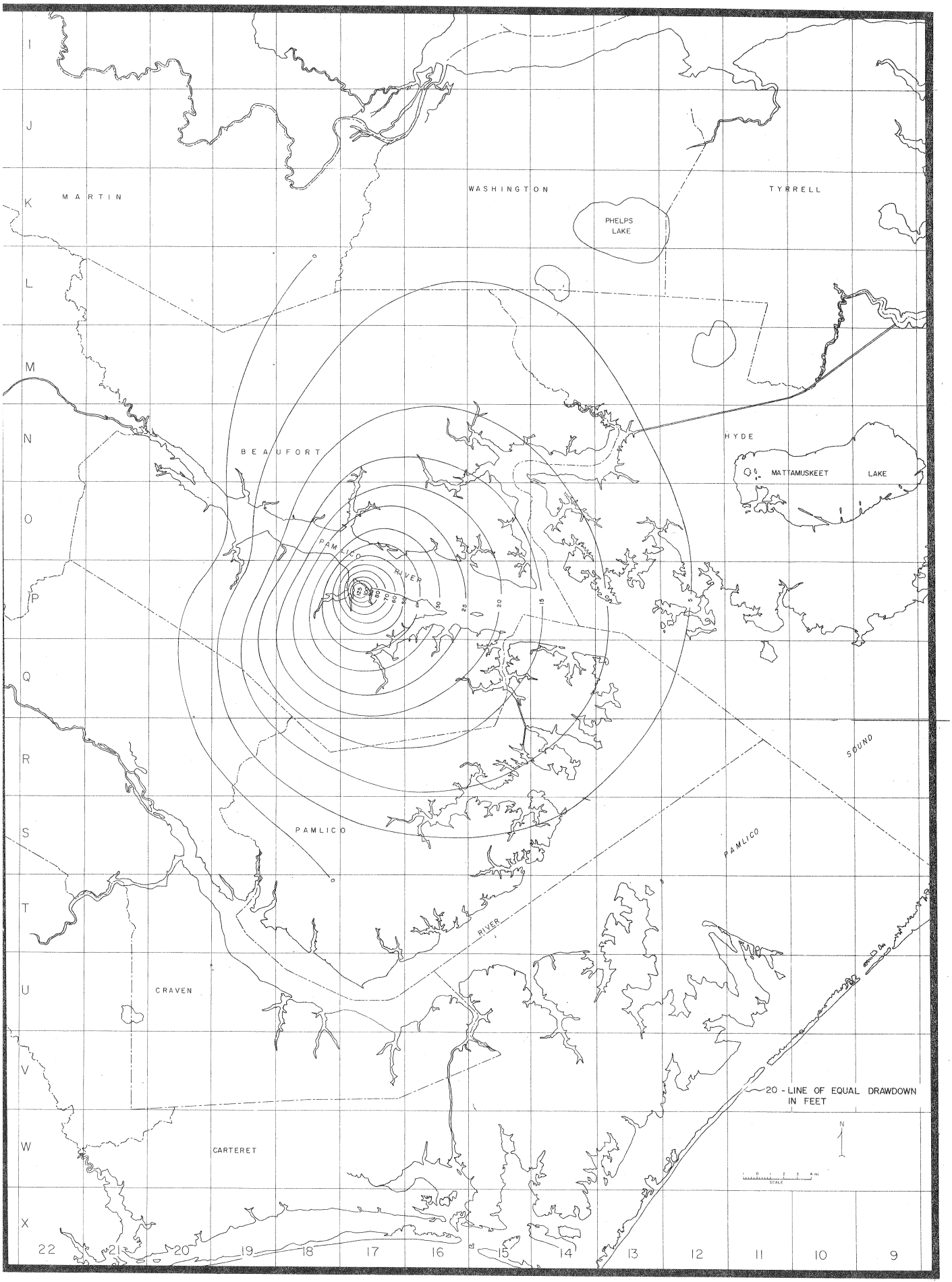


FIGURE 31.- NET DRAWDOWN CASTLE HAYNE AQUIFER - 1965-73

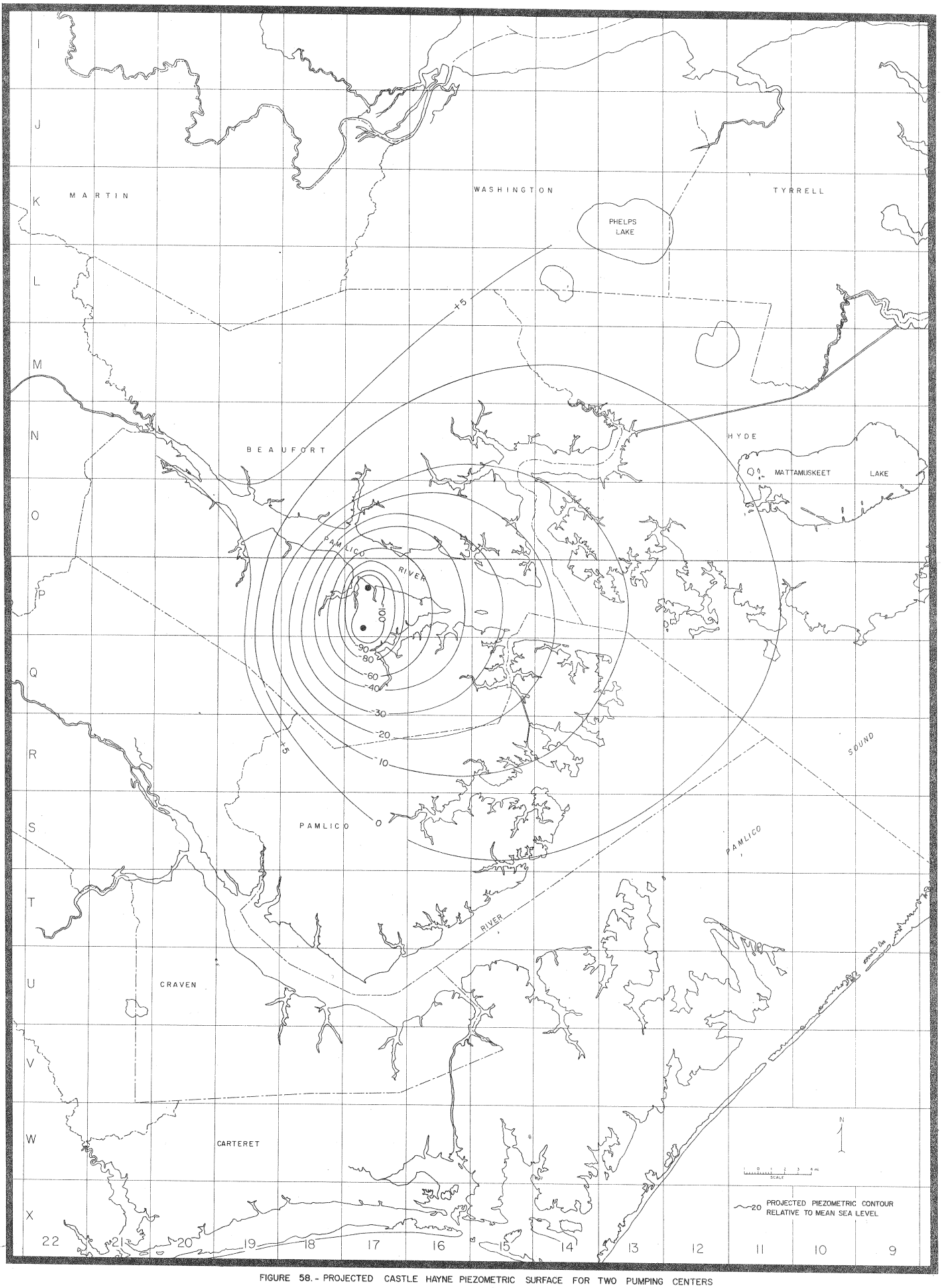


FIGURE 58. - PROJECTED CASTLE HAYNE PIEZOMETRIC SURFACE FOR TWO PUMPING CENTERS

Water use is expected to increase significantly in the Capacity Use Area during the next few years. Expansion of the phosphate industry is anticipated in the near future and the total water requirements are unknown. Mining methods and location will largely determine the effects of these activities. The projected effects on the piezometric surface of the Castle Hayne aquifer by dry open-pit mining at a site a few miles south of the Lee Creek Mine are shown in Fig. 58. The total withdrawal rate is calculated to be about 77MGD, based on a transivissivity of 300,000 gallons per day per foot.

Effective water resource management must include all mangeable aspects of the hydrologic cycle. The Capacity Use Area and adjacent areas offer an ideal opportunity for extensive, effective and positive water resource management, and management measures should be applied to the extent feasible at the earliest date possible.

There are many positive measures that are applicable to the area that will not only protect the hydrologic system, but will significantly increase the total availability of freash water and greatly expand the potential and usability of the system. Some of the more significant measures that should be implemented are described briefly below, and some of which are indicated on the map in Figure 59.

WATER CONSERVATION AND ECONOMICAL USE

In the Capacity Use Area and any water management area, water use for any purpose should be limited to actual needs with respect to both quantity and quality. Each user should make a continuing effort to reduce requirements, particularly for consumptive use. Process waters should be recycled to the extent technically feasible, and the water of lowest quality available that is suitable, or that can feasibly be made

WATER RESOURCE MANAGEMENT

NEED FOR WATER RESOURCE MANAGEMENT

The establishment of the Capacity Use Area was based on the immediate and potential need for water resource management. It is obvious in this area and throughout the Coastal Plain region that the total quantity of water that can be withdrawn from the groundwater reservoirs is limited, and the quantity that may be withdrawn without detriment to the system is considerably less than this at many places. Knowledge of the system is adequate to show that withdrawals by individual users must be limited, the limitations based on productivity of the system at the point of withdrawal, the effects of withdrawals on water quality and other physical aspects of the system and the requirements of other users and prospective users drawing from the system. It appears that future withdrawals of fresh water by individual users other than municipalities should have a maximum limit of 10 MGD or less, as a general rule. Withdrawals within these limits probably comprise more than a reasonable allocation of the resource to an individual user.

Although the Capacity Use Area was established and regulations applicable to water development and use became effective more than 7 years ago, no real water management measures have been implemented. No user has been required to reduce withdrawals, initiate recharge, conduct water conservation measures such as recycling process water, or take any other possible measures to affect water resource management. The only requirements that have been imposed upon water users have been of a monitoring and reporting nature.

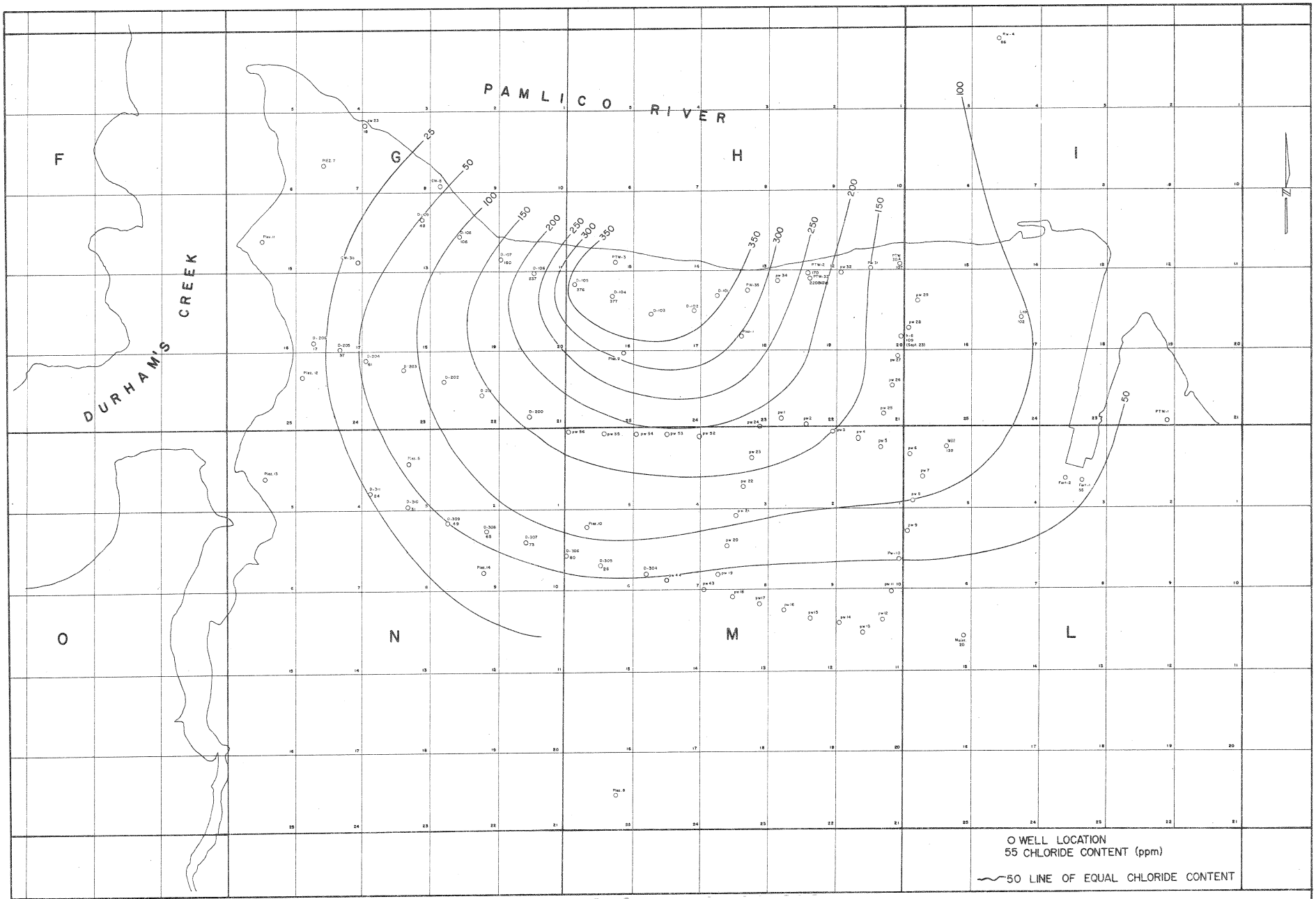


FIGURE 57.-- CHLORIDE CONTENT, UPPER CASTLE HAYNE UNIT
LEE CREEK MINE; DECEMBER 1973

SCALE: 1 inch = 500 ft.

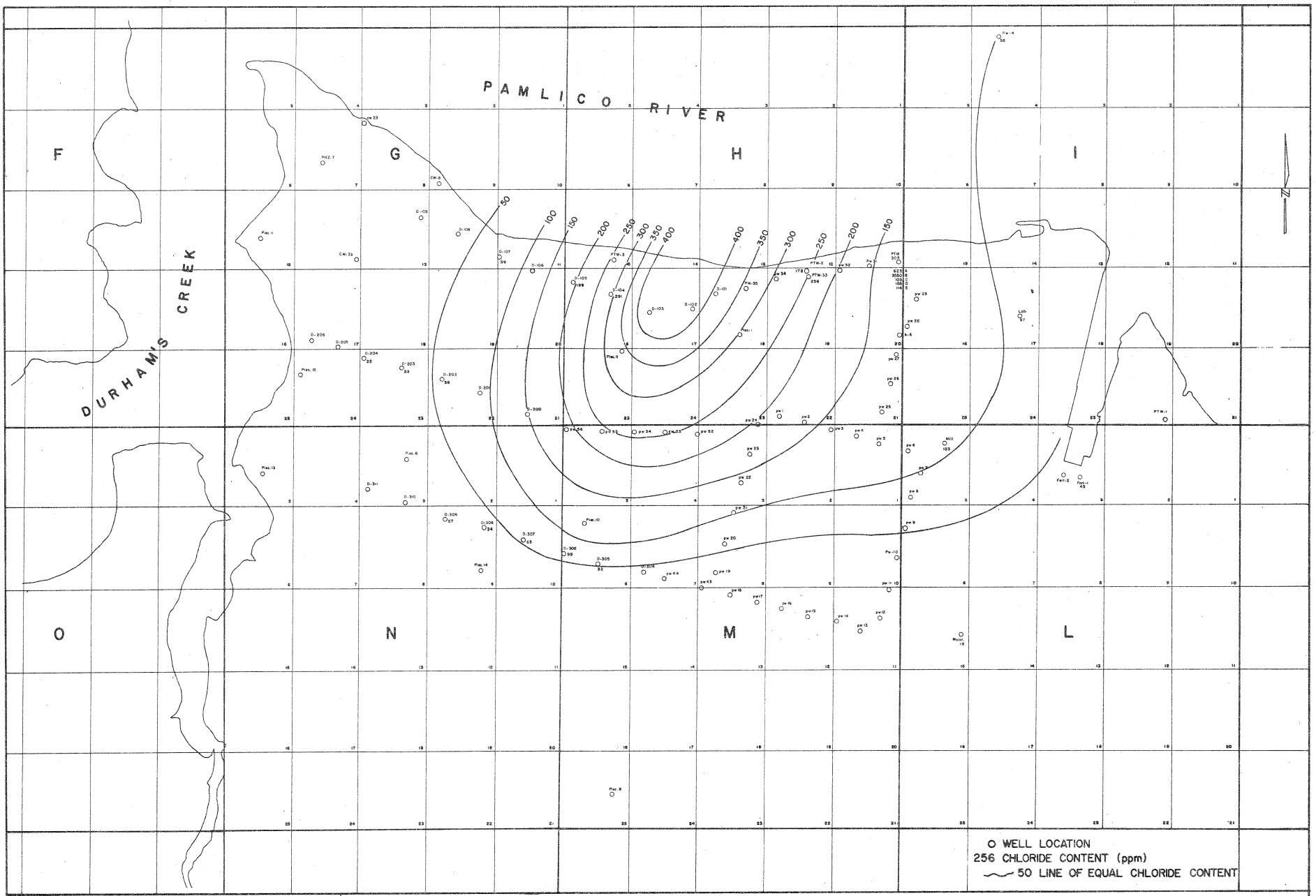


FIGURE 56.-- CHLORIDE CONTENT, UPPER CASTLE HAYNE UNIT
LEE CREEK MINE; JULY 1972

SCALE: 1 inch = 500 ft.

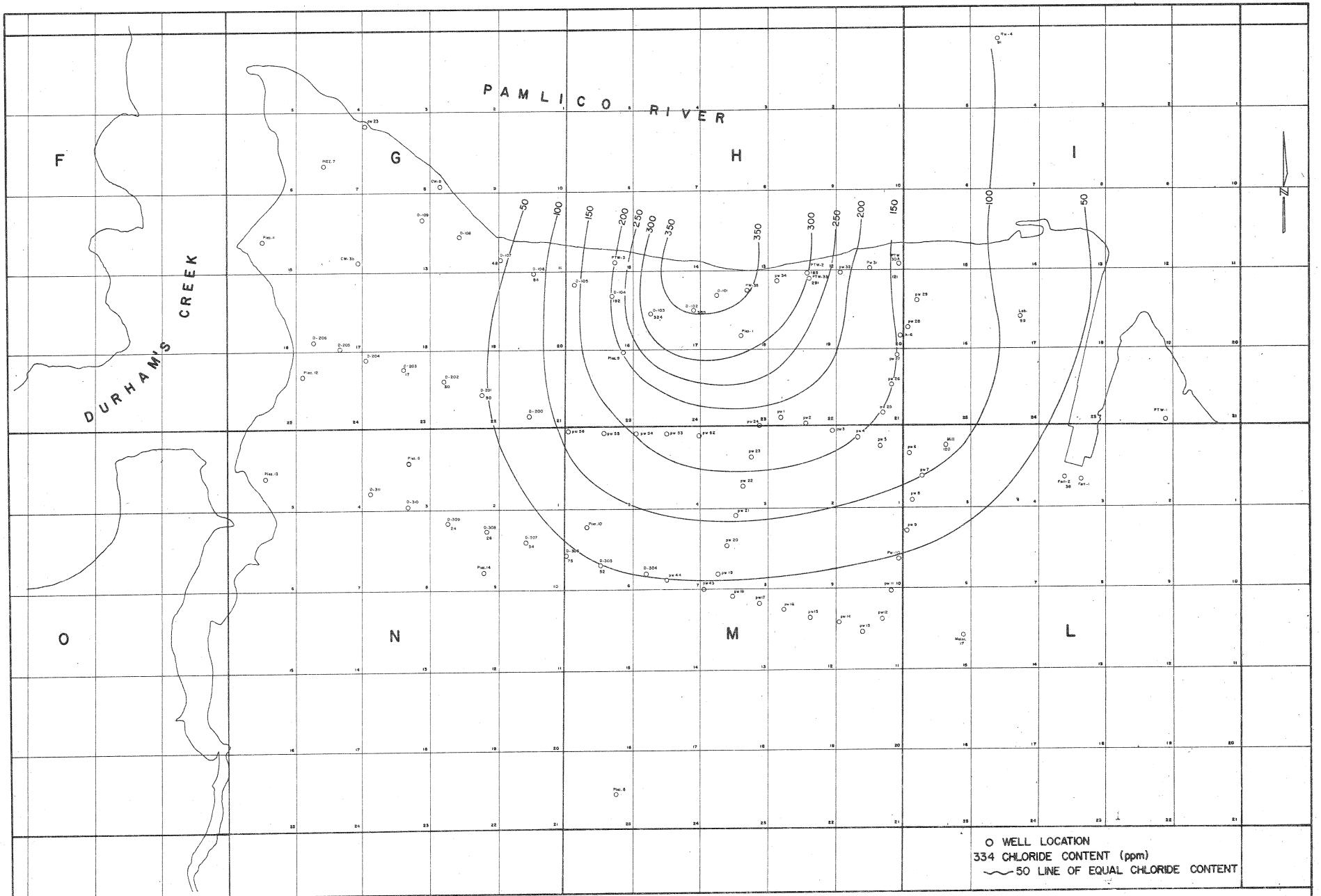


FIGURE 55.-- CHLORIDE CONTENT, UPPER CASTLE HAYNE UNIT
LEE CREEK MINE; JULY 1971

SCALE: 1 inch = 500 ft.

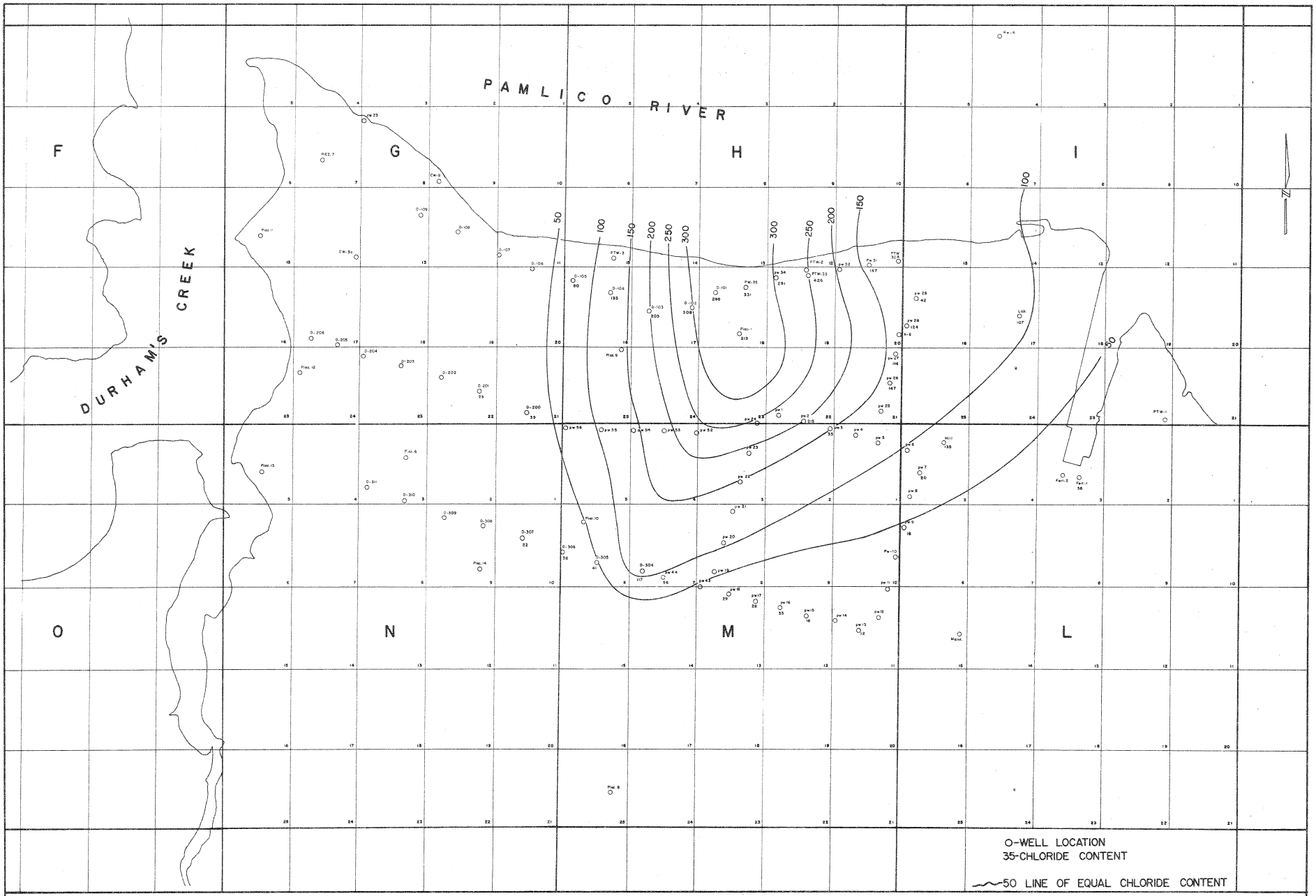


FIGURE 54.-- CHLORIDE CONTENT, UPPER CASTLE HAYNE UNIT
LEE CREEK MINE; JUNE 1970

SCALE: 1 inch = 500 ft.

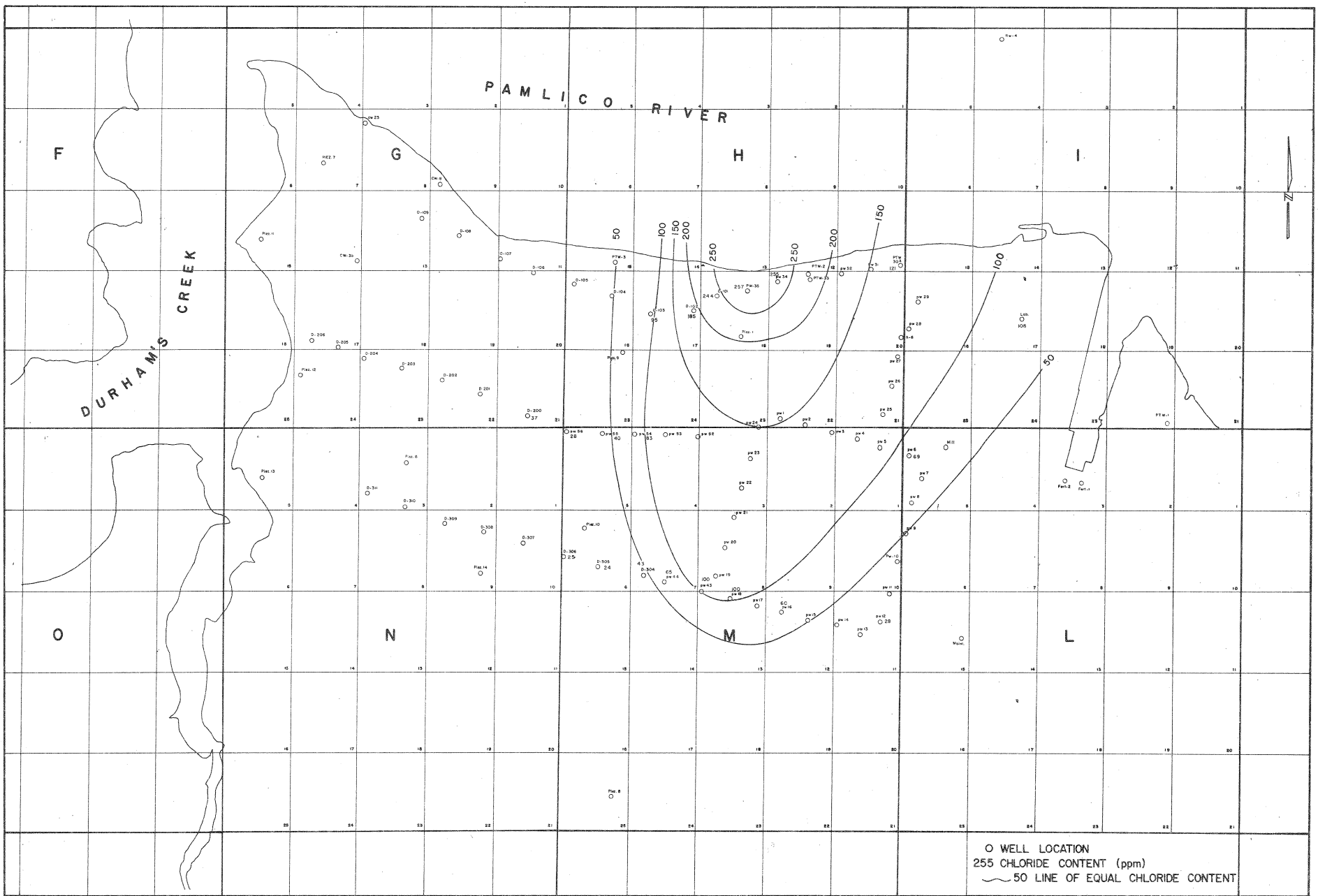


FIGURE 53.-- CHLORIDE CONTENT, UPPER CASTLE HAYNE UNIT
LEE CREEK MINE; AUGUST 1969

SCALE: 1 inch = 500 ft.

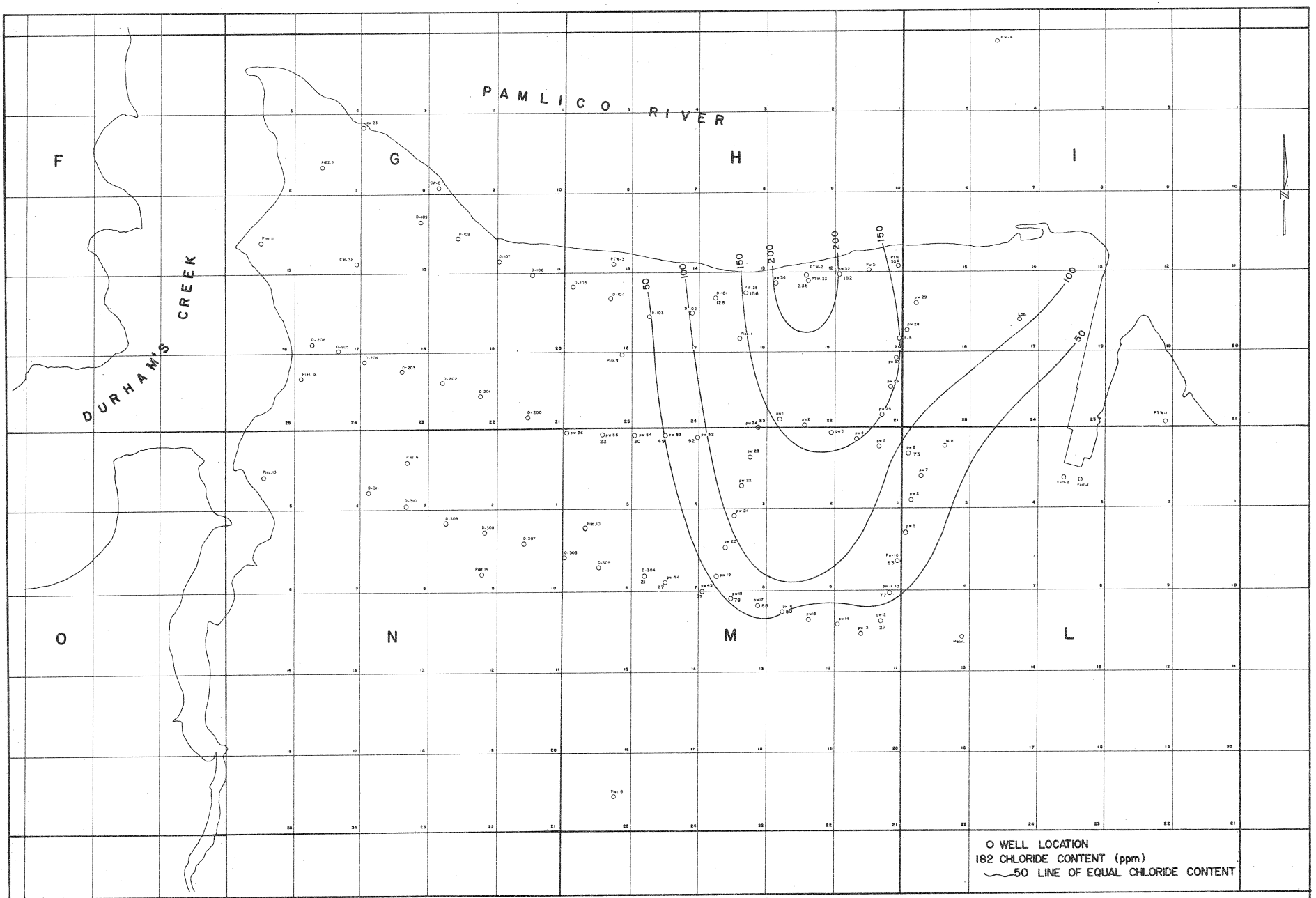


FIGURE 52.-- CHLORIDE CONTENT, UPPER CASTLE HAYNE UNIT
LEE CREEK MINE; JULY 1968

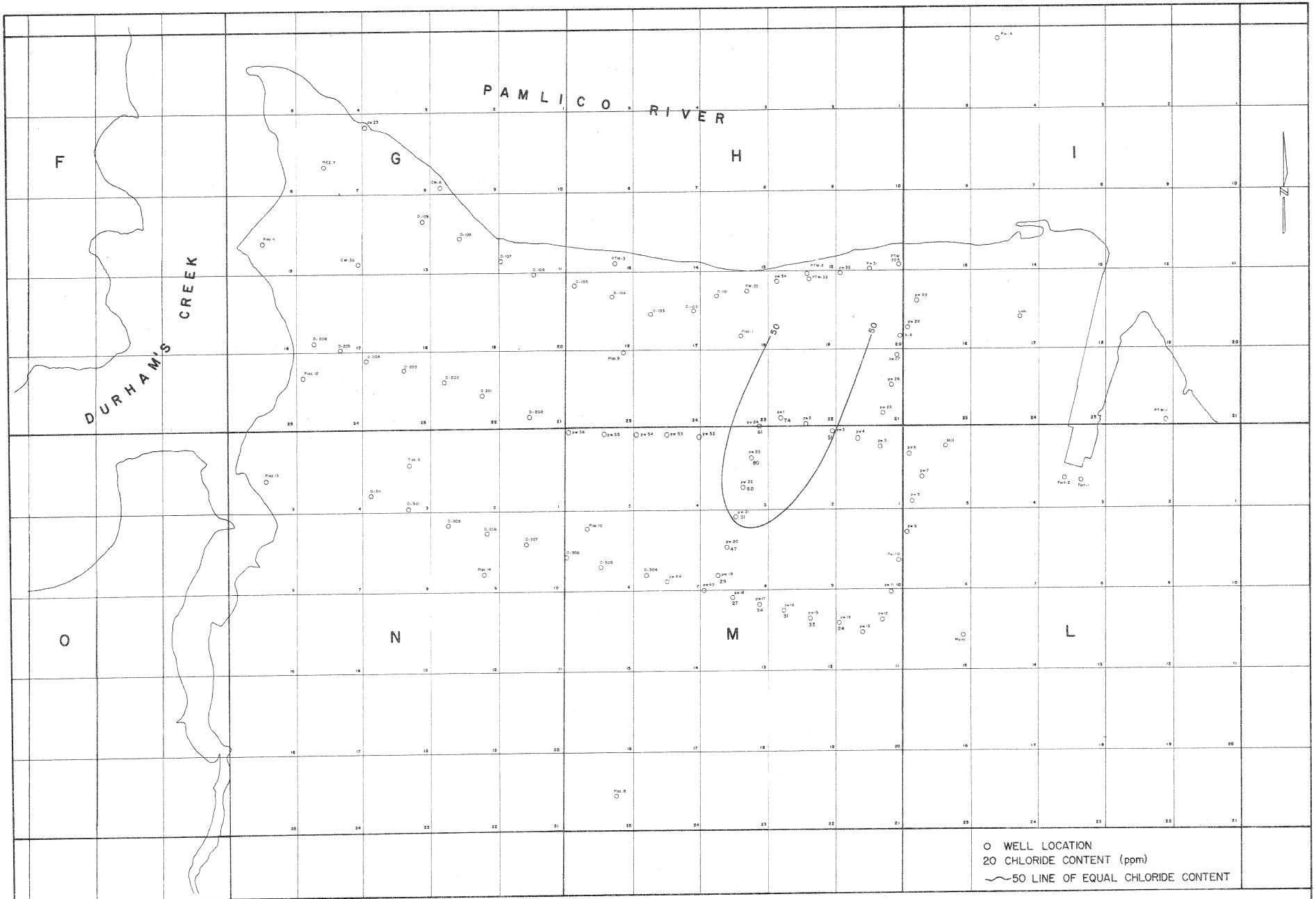


FIGURE 49.-- CHLORIDE CONTENT, UPPER CASTLE HAYNE UNIT
LEE CREEK MINE; OCTOBER 1965

SCALE: 1 inch = 500 ft.

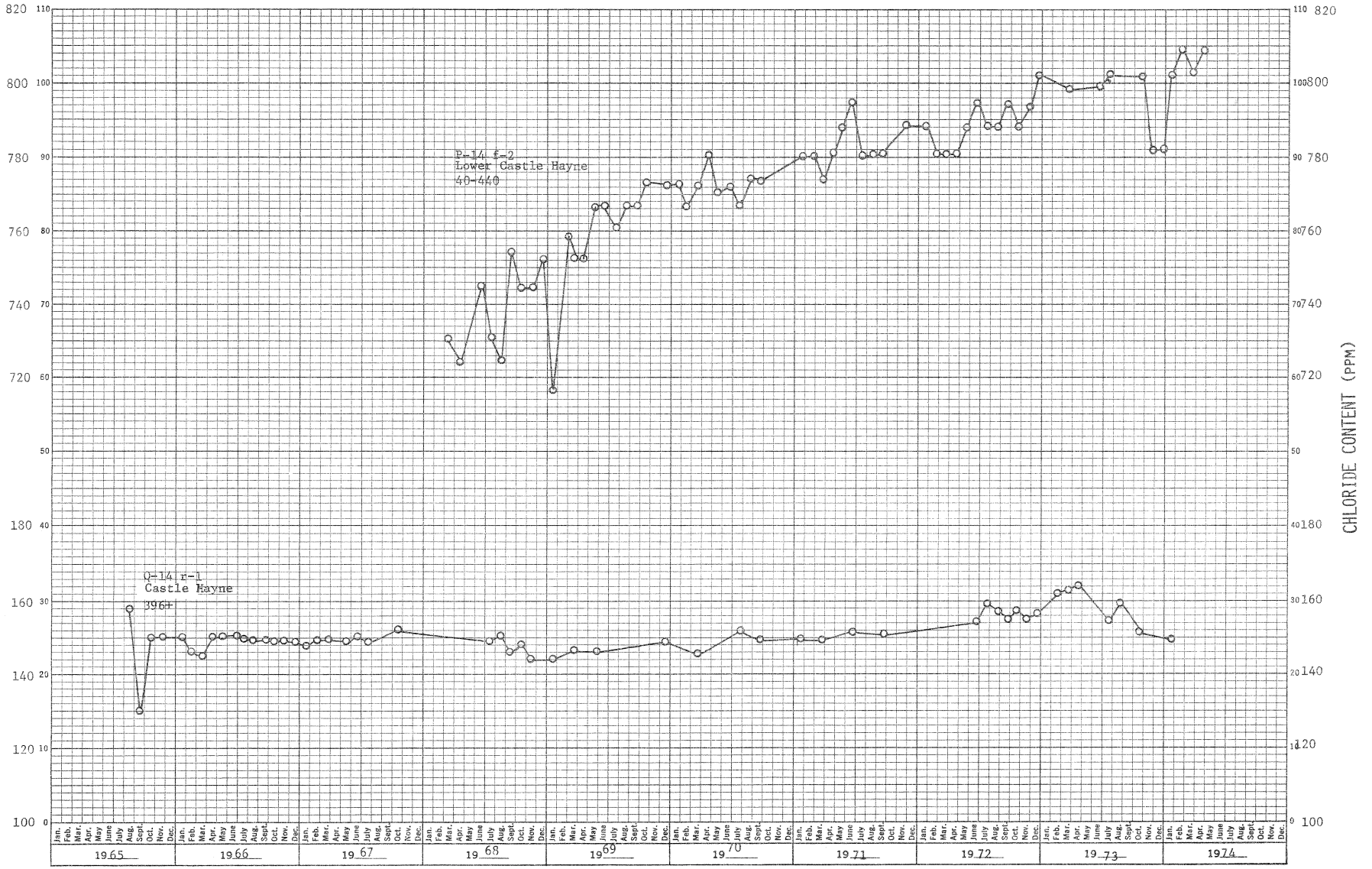


FIGURE 48. - CHLORIDE CONTENT OF WATER FROM WELLS P-14 F-2 AND Q-14 R-1

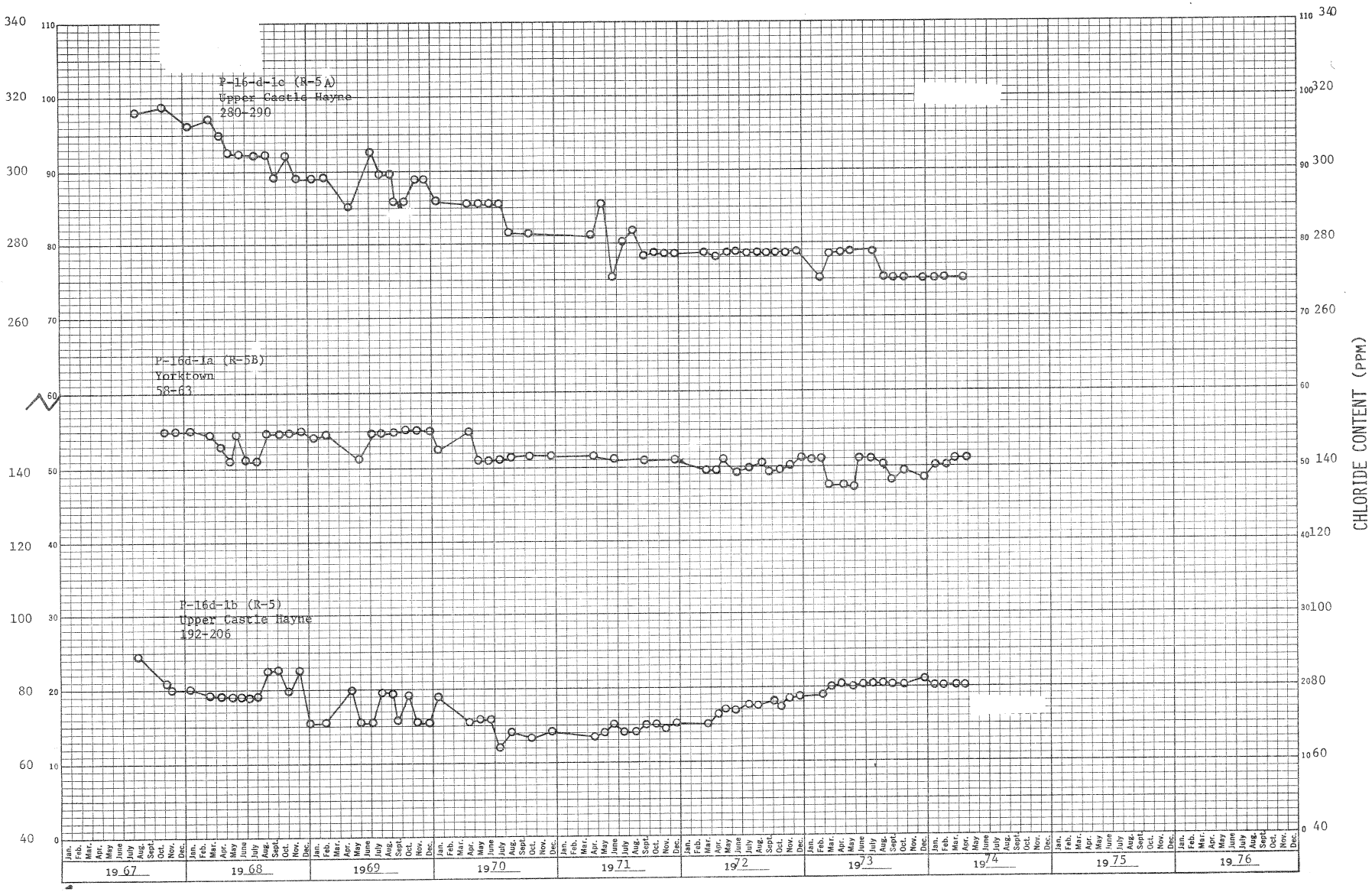


FIGURE 47. - CHLORIDE CONTENT OF WATER FROM WELLS AT SITE P-16,D (TGS R-5)

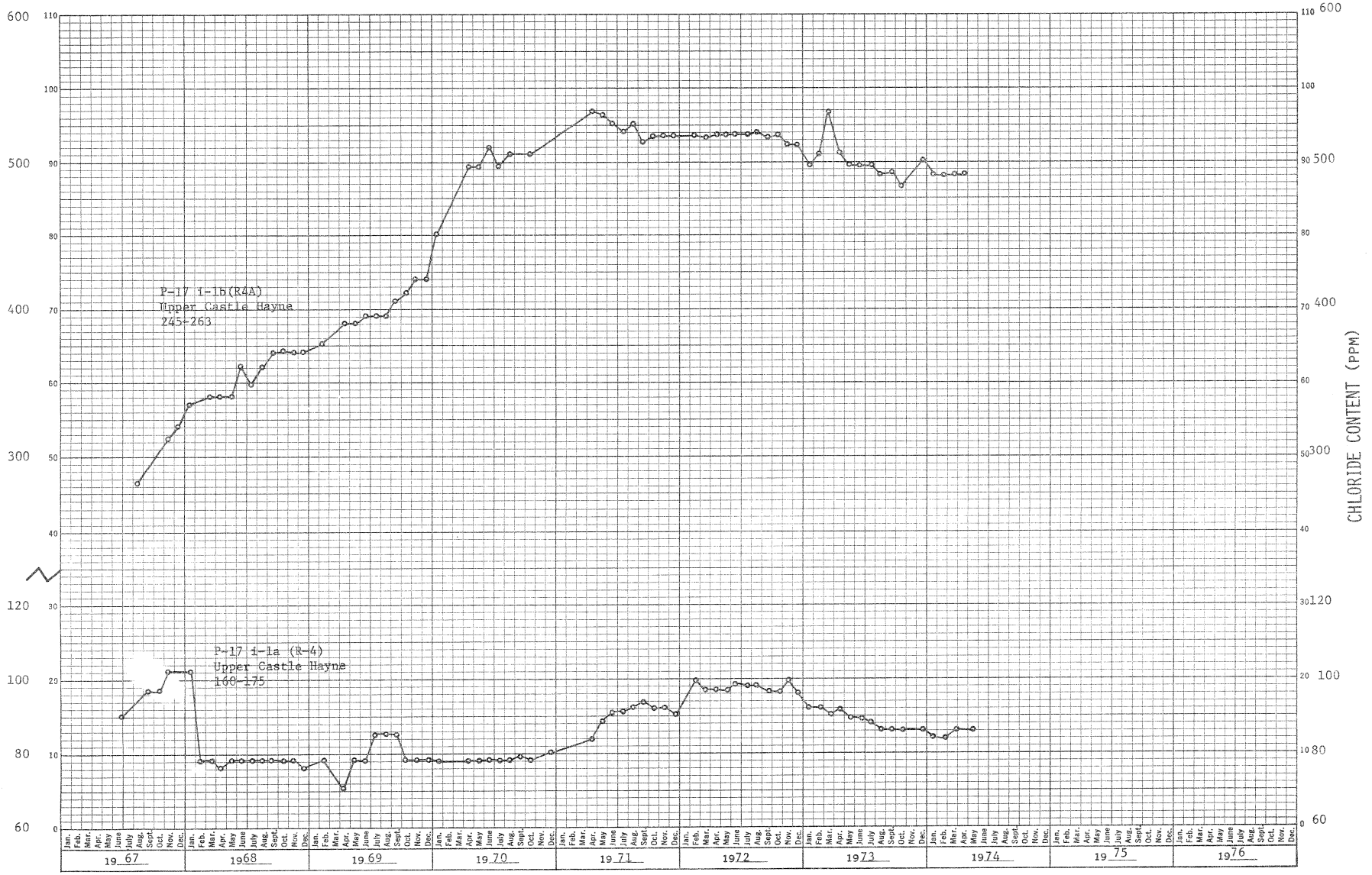


FIGURE 46. - CHLORIDE CONTENT OF WATER FROM WELLS AT SITE P-17, I(TGS R-4)

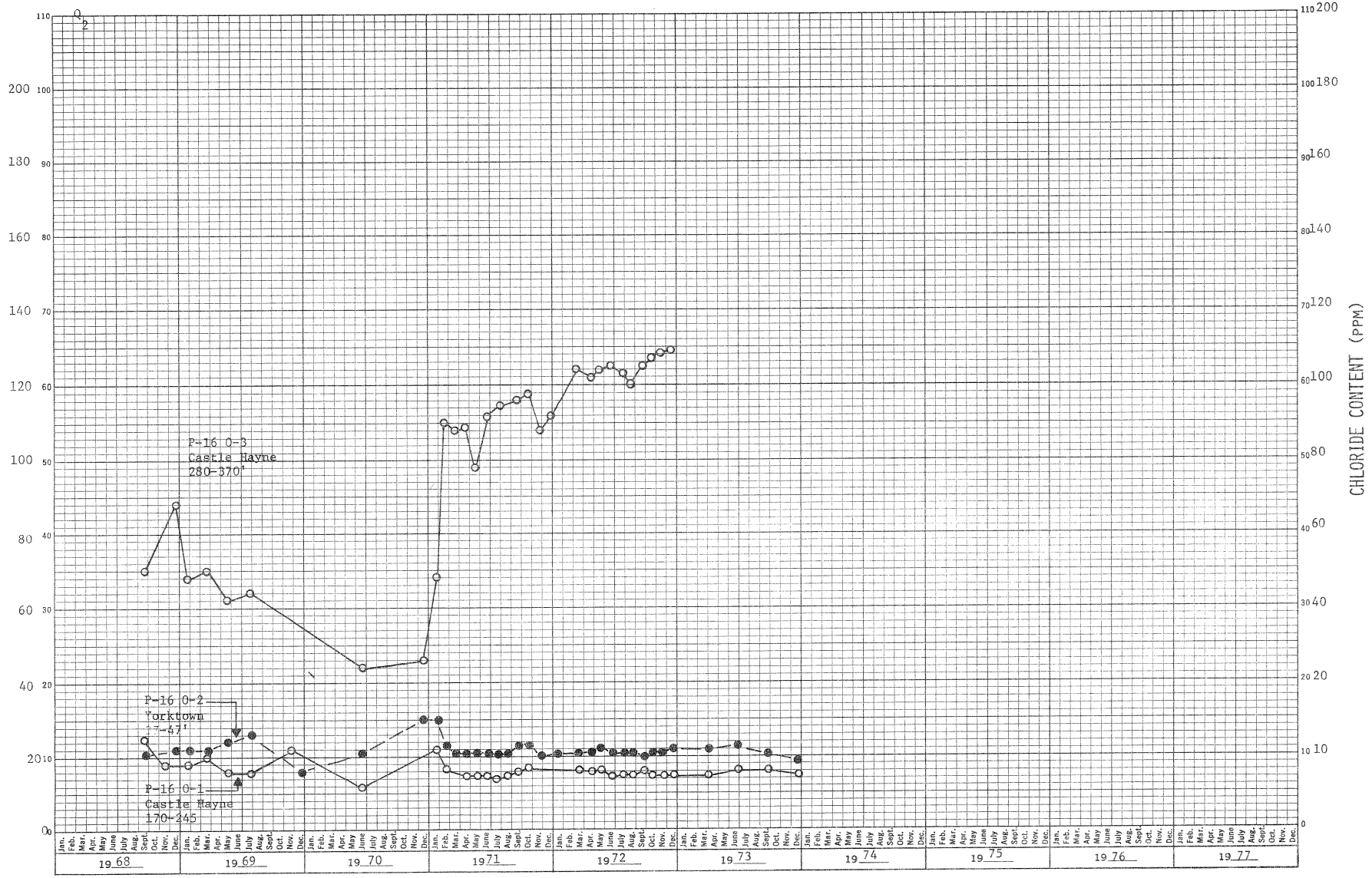


FIGURE 45. - CHLORIDE CONTENT OF WATER FROM WELLS AT SITE P-16,0

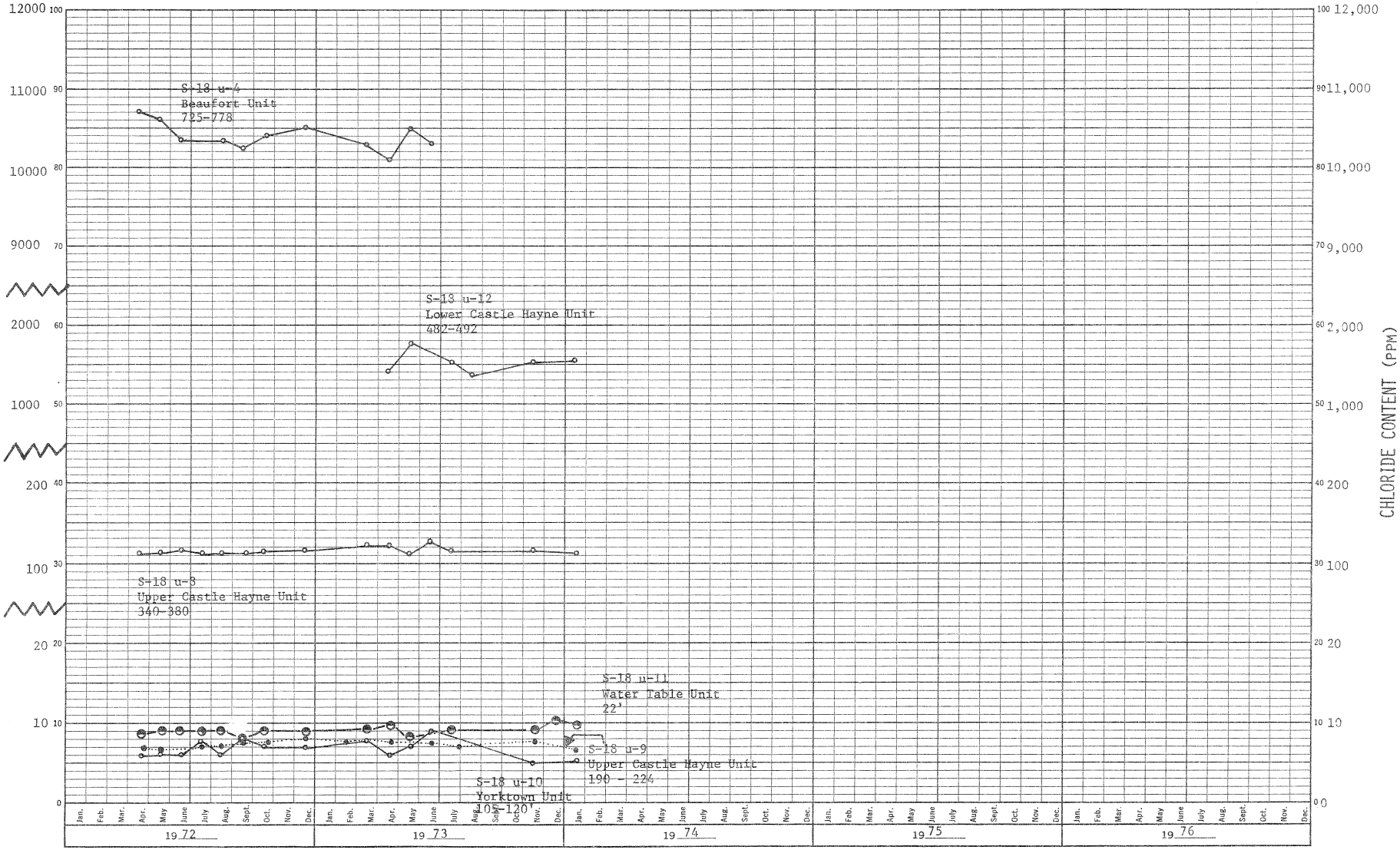


FIGURE 44. - CHLORIDE CONTENT OF WATER FROM WELLS AT RESEARCH STATION NO. 12, ARAPAHOE, N.C.

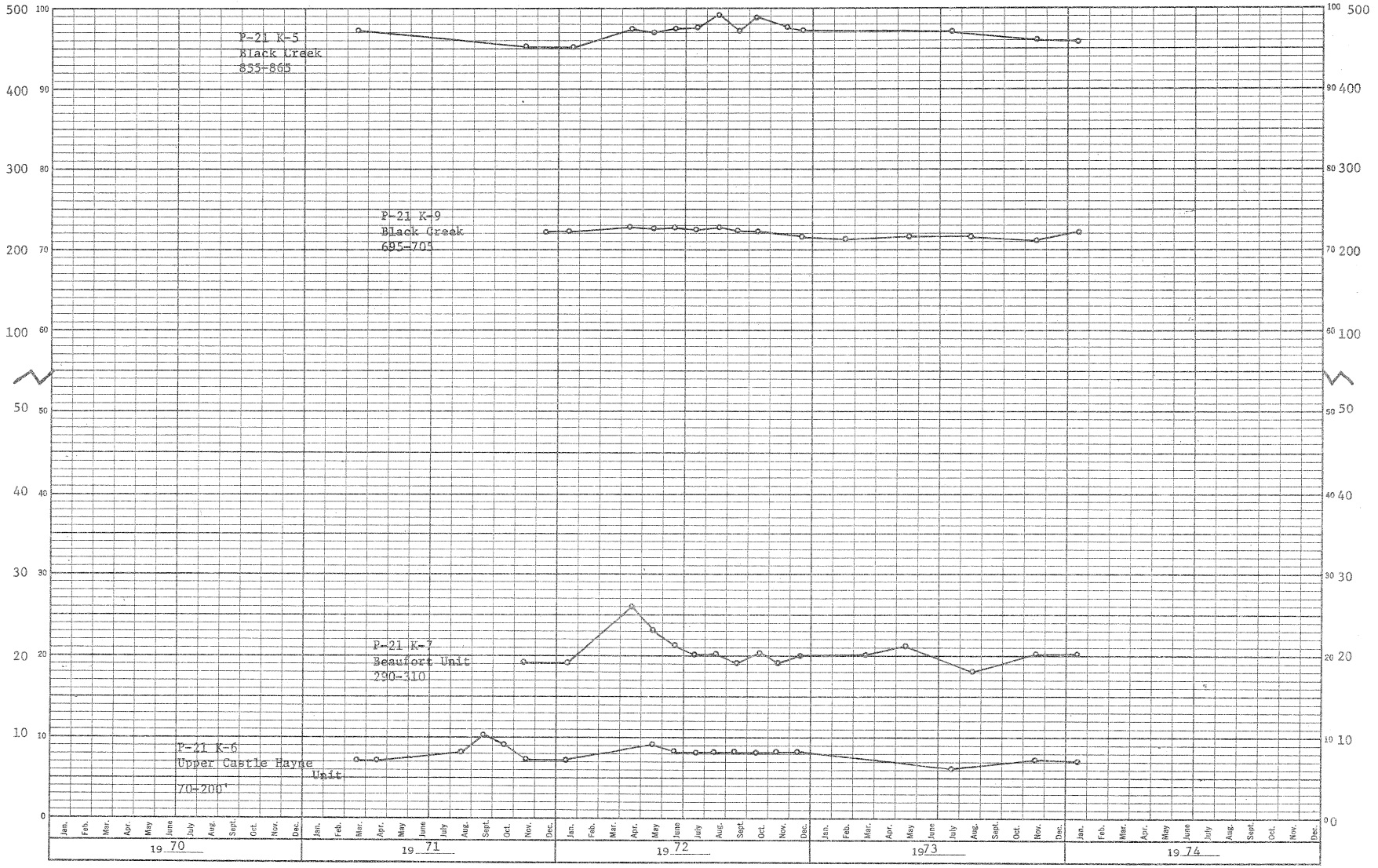


FIGURE 43. - CHLORIDE CONTENT OF WATER FROM WELLS AT RESEARCH STATION NO. 7, WILMAR, N.C.

FIGURE 42. - CHLORIDE CONTENT OF WATER FROM WELLS AT RESEARCH STATION NO. 5, COX CROSSROADS, N.C.

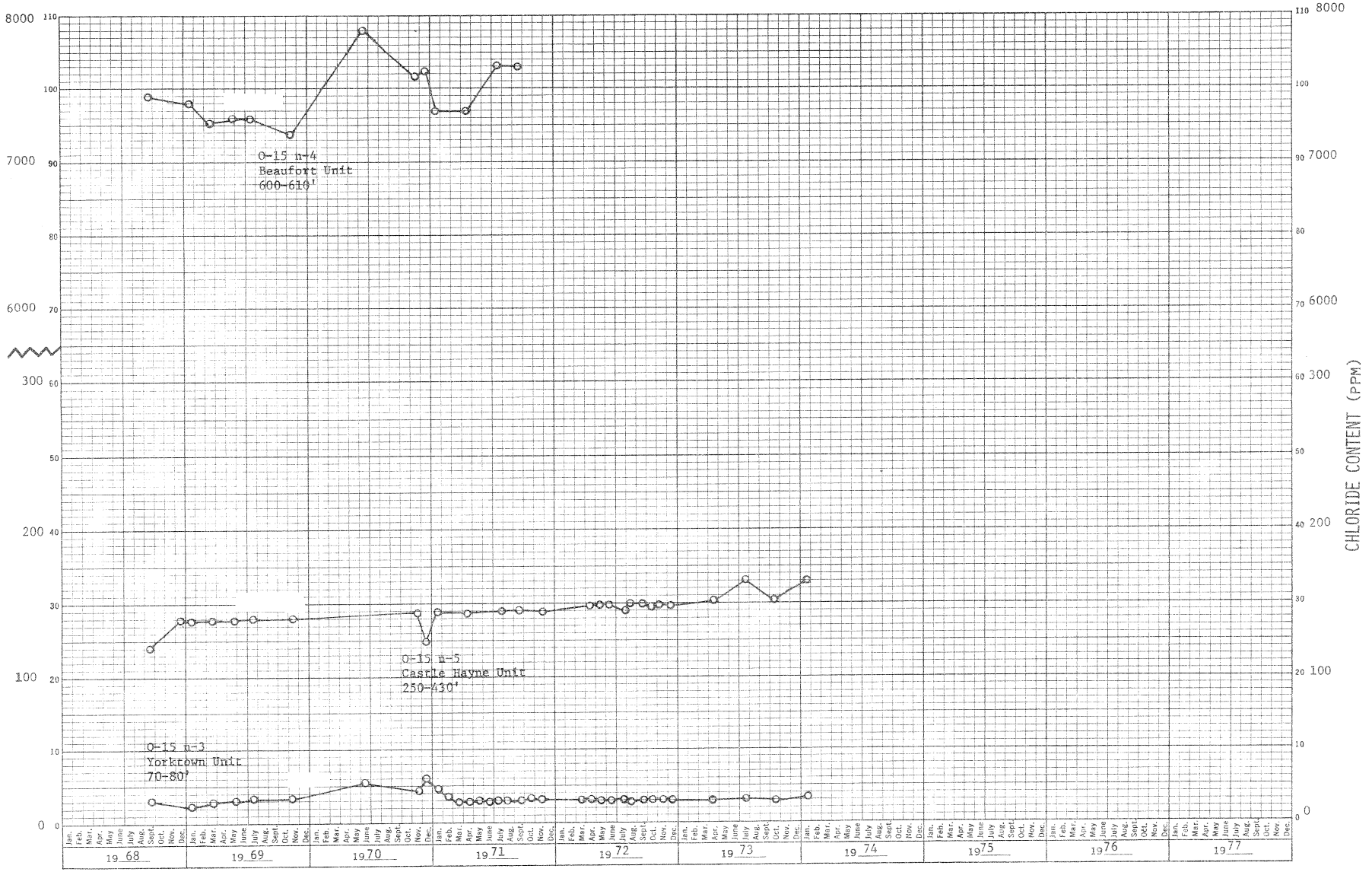


FIGURE 41. - CHLORIDE CONTENT OF WATER FROM WELLS AT RESEARCH STATION NO. 4, WINSTEADVILLE, N.C.

FIGURE 40. - CHLORIDE CONTENT OF WATER FROM WELLS AT RESEARCH STATION NO. 3, BATH, N.C.

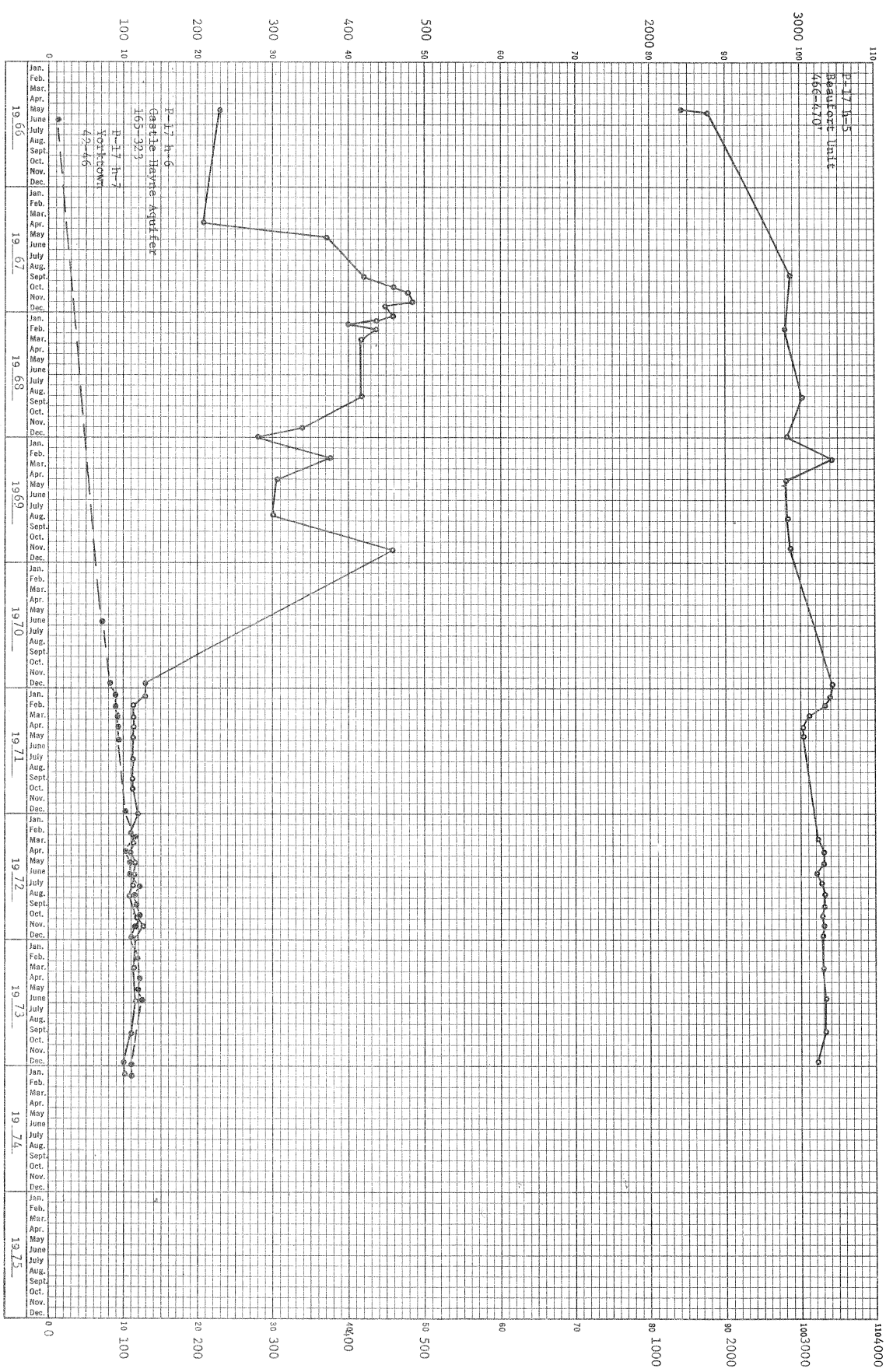


FIGURE 39. - CHLORIDE CONTENT OF WATER FROM WELLS AT RESEARCH STATION NO. 1, LEE CREEK, N.C.

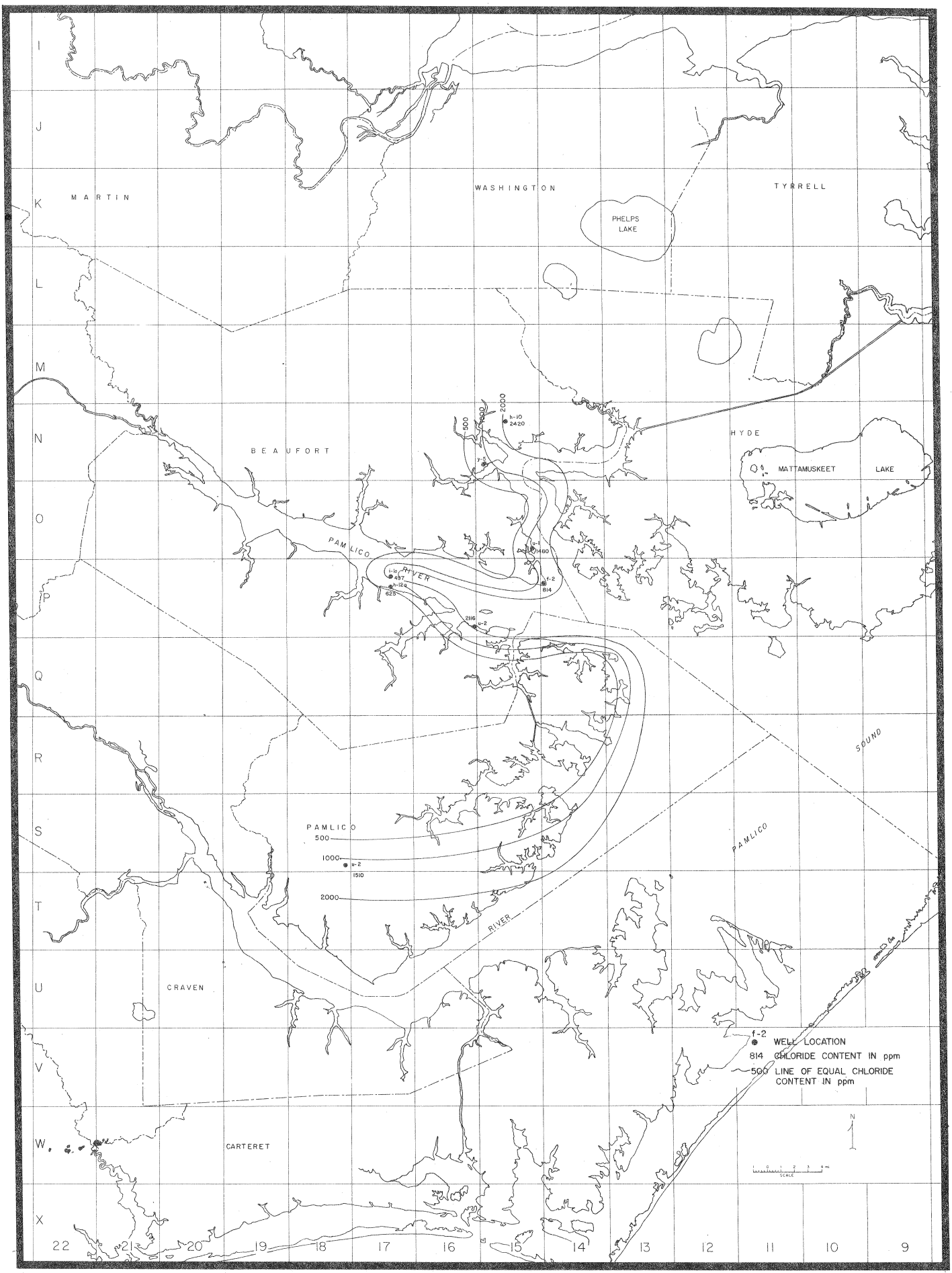


FIGURE 38.- CHLORIDE CONTENT OF WATER IN THE LOWER CASTLE HAYNE UNIT, 1973

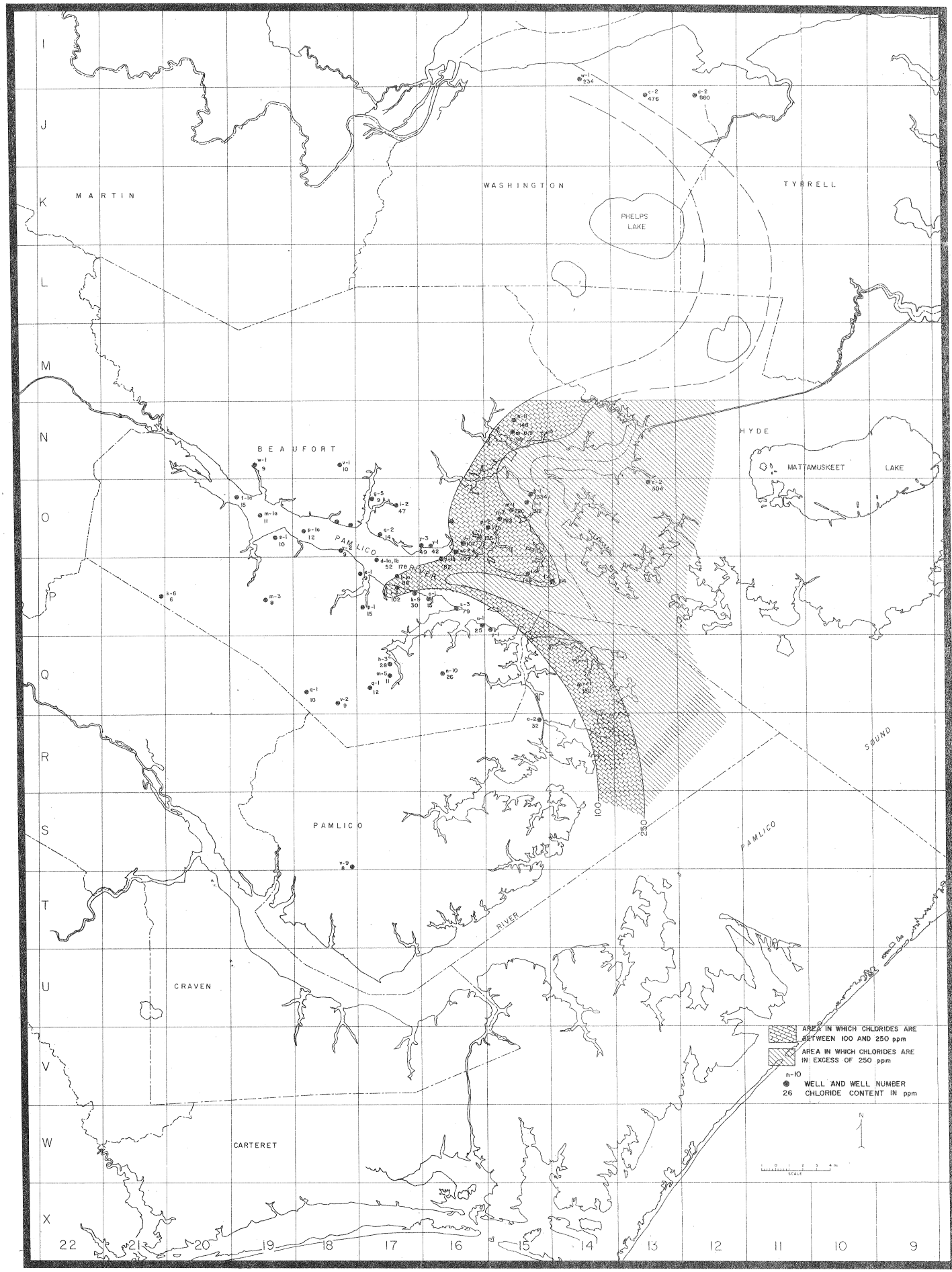


FIGURE 37. -- DISTRIBUTION OF CHLORIDE CONTENT OF WATER IN UPPER CASTLE HAYNE AQUIFER UNIT

depressuring wells were abandoned at the completion of mining in that area. As the pumping center shifted to the west, the graphs show a decrease in chloride due to the reduction of head differential between aquifer units and a corresponding decrease in the migration of water from the lower more saline units into the upper zone.

Increases in the salinity of the upper Castle Hayne unit in the plant area are primarily the result of upward migration of water from the lower units and to a lesser extent from lateral inflow of brackish water within the upper unit from that part of the aquifer underlying the Pamlico River.

Graphs of wells monitoring the lower Castle Hayne and Beaufort units do not show a corresponding decrease in chloride as the distance from the center of pumping increases, as lateral flow from the east and south is more saline and offsets any freshening effect of less saline inflow from the west.

Figure 39 shows the chloride content of water from the Yorktown unit in a well located on the north side of the mine area near the Pamlico River. The increase in chlorides in this well is probably due to recharge from the river as all other recharge to this unit would be from fresh water sources.

fresh water aquifer from three sources. These are (1) lateral movement of saline water that occurs naturally in the aquifer, (2) vertical movement of saline water that occurs naturally in the lower part of the aquifer in some parts of the area, and (3) vertical leakage of saline water from the Pamlico estuary and the sound.

Figs. 37 and 38 show the distribution of chloride content of water in the Castle Hayne aquifer units. Data from the water-quality monitor wells do not indicate any extensive regional changes in salinity of the water. Graphs of chloride content of water from wells at several research stations and some other wells are shown in Figs. 39-48.

Prior to the beginning of pumping at Lee Creek, the chloride content of Castle Hayne aquifer in the mine area ranged from about 30 ppm in the upper limestone unit to about 200 ppm in the lower limestone unit and about 3000 ppm in the underlying Beaufort sand unit.

Periodic analyses of water samples from the depressuring wells made after pumping began show that the chloride content of water in the pumped zone steadily increased with the highest concentrations occurring in wells nearest the center of pumping. The increase in chlorides is caused by the movement of brackish water in the lower limestone and sand units vertically and laterally into the pumped zone in response to the pressure gradient established around the pumping wells. Figs. 49-57 show the distribution of chlorides in the mine area at various times since pumping began. The shifts in the center of the high chloride area reflects shifting of the center of the pumping pattern as the mine face advanced.

Chloride graphs of monitor wells within the plant area show an increase in chloride content from the time pumping began until nearby

Date	Pumping Rate (MGD)	Area 120 ft. below sea level
Feb. 28, 1972	51.5	90 acres
July 5, 1972	54.4	105 acres
Jan. 12, 1973	50.3	110 acres
July 4, 1973	54.5	125 acres
Feb. 27, 1974	63.5	420 acres

As shown by the table and the maps, the piezometric surface was lowered to 120 feet or more below sea level in a total area ranging from 90 acres to more than 400 acres, with pumping rates ranging from about 50 to 63 MGD. At a pumping rate of 50 to 55 MGD, the piezometric surface was lowered to 120 feet below sea level in three separate areas totaling about 25 to 30 percent of the 400 acres permitted. The piezometric surface was actually less than 120 feet below sea level beneath most, if not all, of the active mining area except in February of 1974.

The piezometric maps and pumping data show that the present pattern of depressuring wells is very inefficient, yet it will permit mining by the present method with the piezometric surface lowered to 120 feet below sea level in a area of less than 100 acres. An efficient pattern of depressuring wells could greatly reduce the area of drawdown needed to mine by the present method. It is estimated that the pumping rate could be reduced 20 to 50 percent.

EFFECTS ON WATER QUALITY

Of greater concern than the well problems, the lowering of the piezometric surface created conditions for salt water encroachment into the

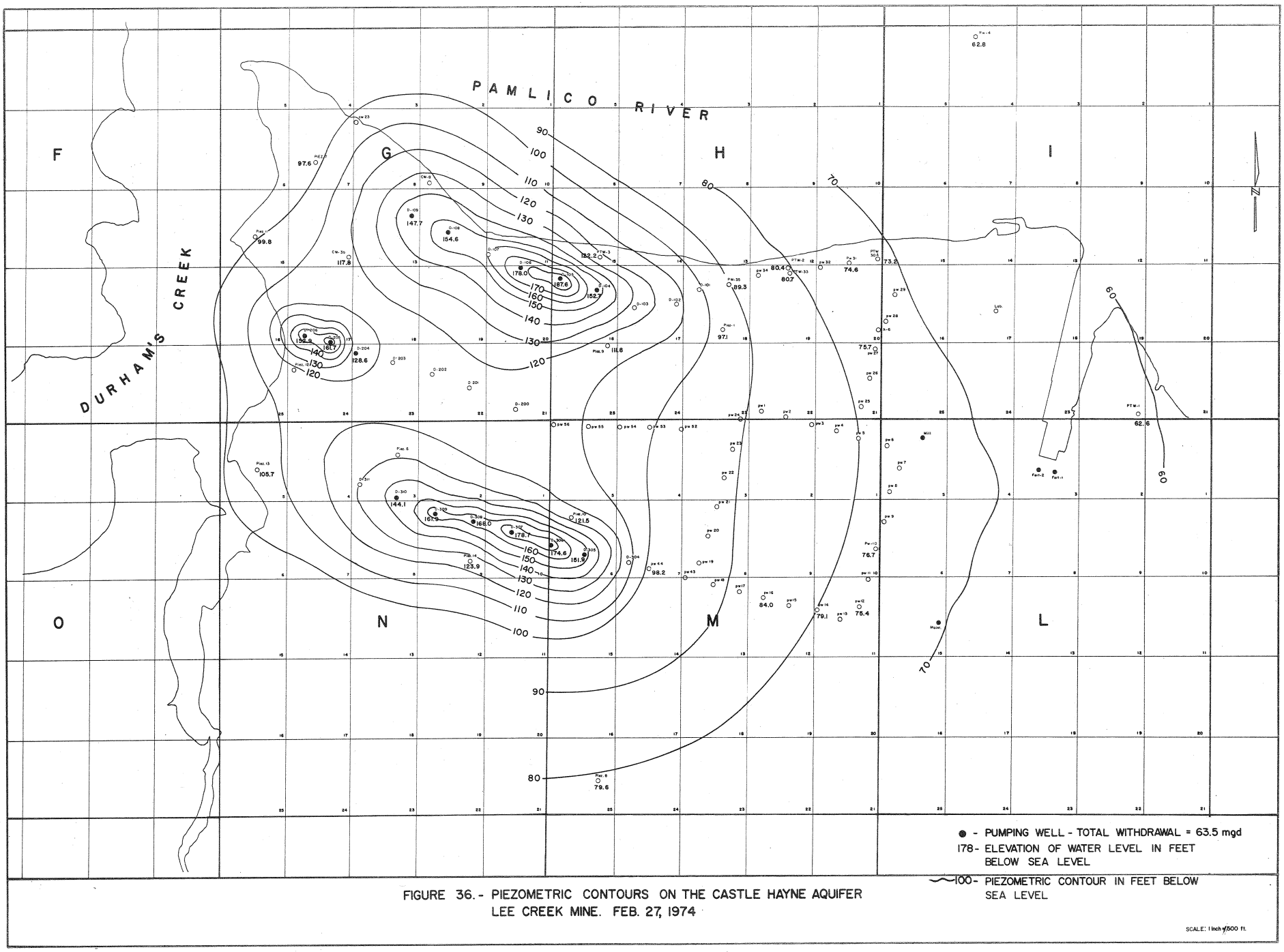


FIGURE 36.- PIEZOMETRIC CONTOURS ON THE CASTLE HAYNE AQUIFER LEE CREEK MINE. FEB. 27, 1974

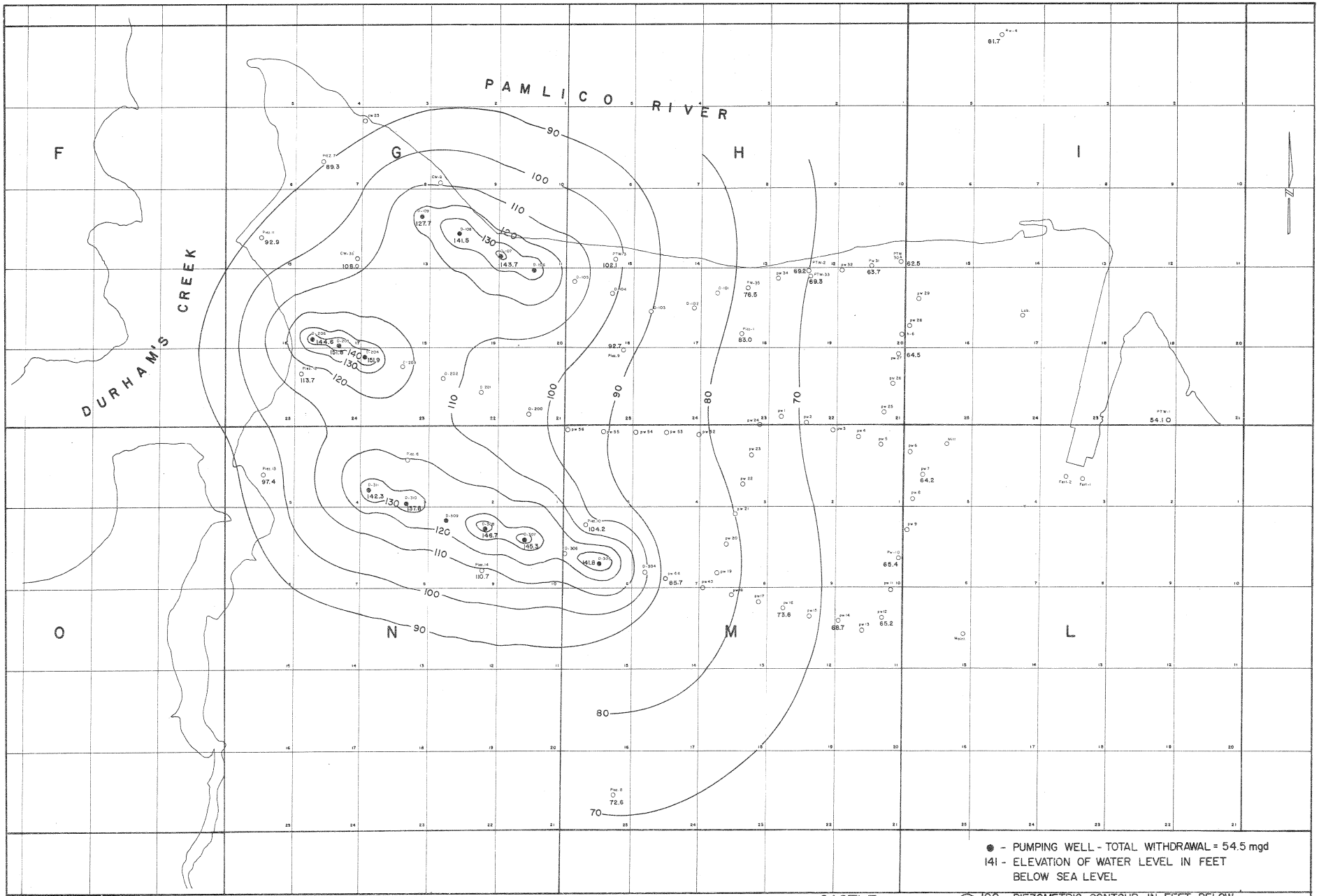


FIGURE 35.- PIEZOMETRIC CONTOURS ON THE CASTLE HAYNE AQUIFER AT LEE CREEK MINE JULY 4, 1973

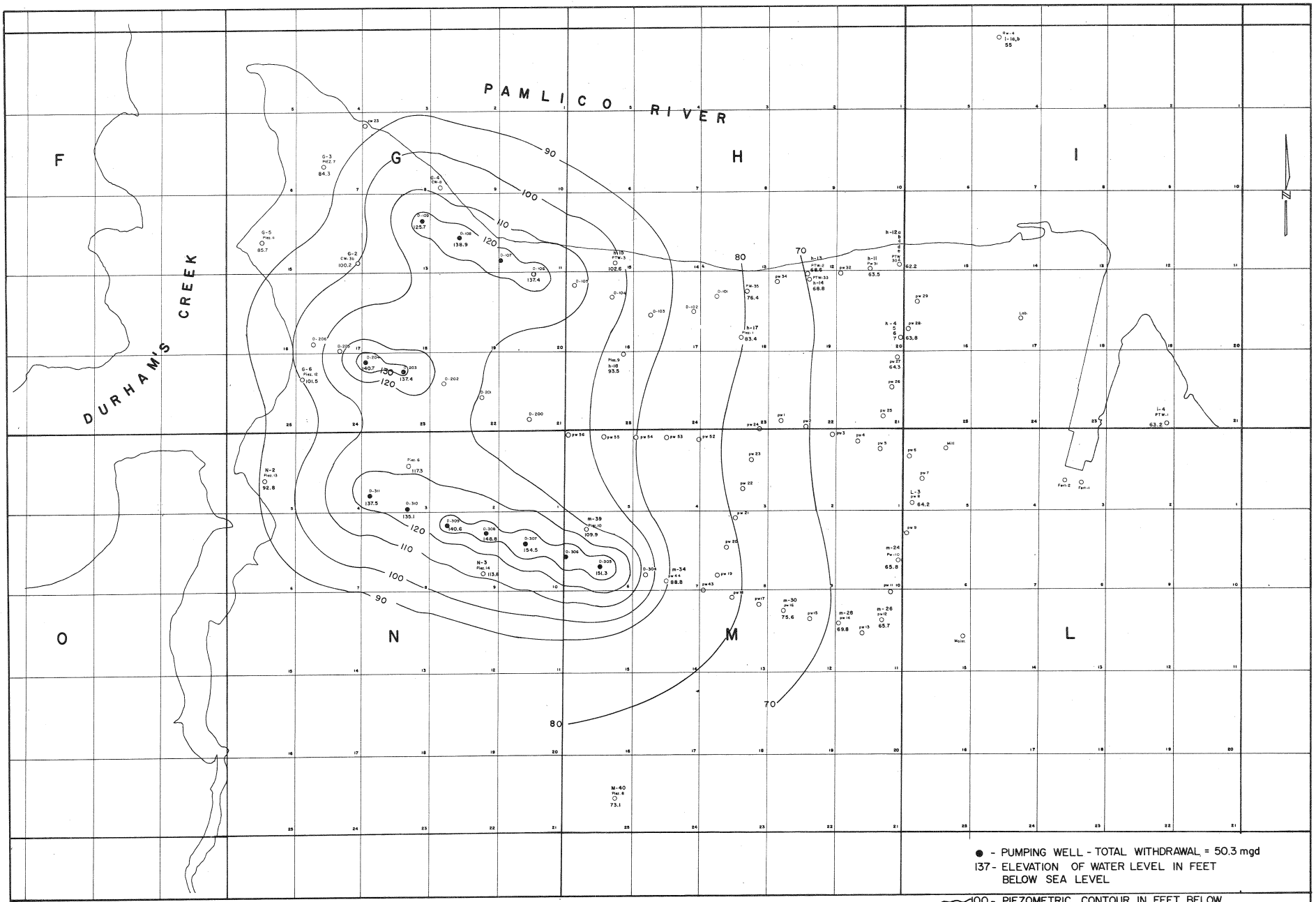


FIGURE 34.- PIEZOMETRIC CONTOURS ON THE CASTLE HAYNE AQUIFER AT LEE CREEK MINE JAN. 12, 1973

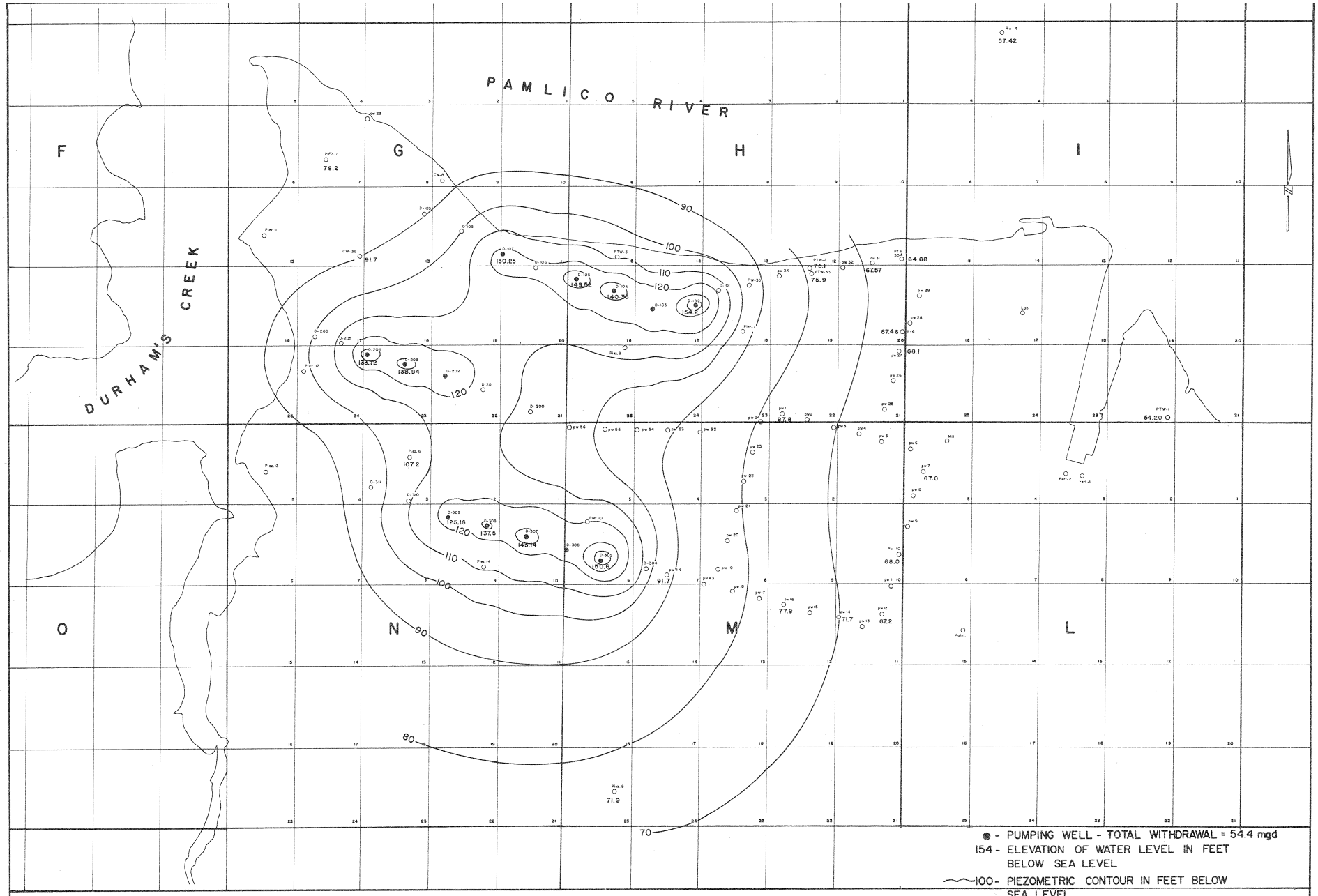


FIGURE 33.- PIEZOMETRIC CONTOURS ON THE CASTLE HAYNE AQUIFER
LEE CREEK MINE. JULY 5, 1972

SCALE: 1 inch = 500 ft.

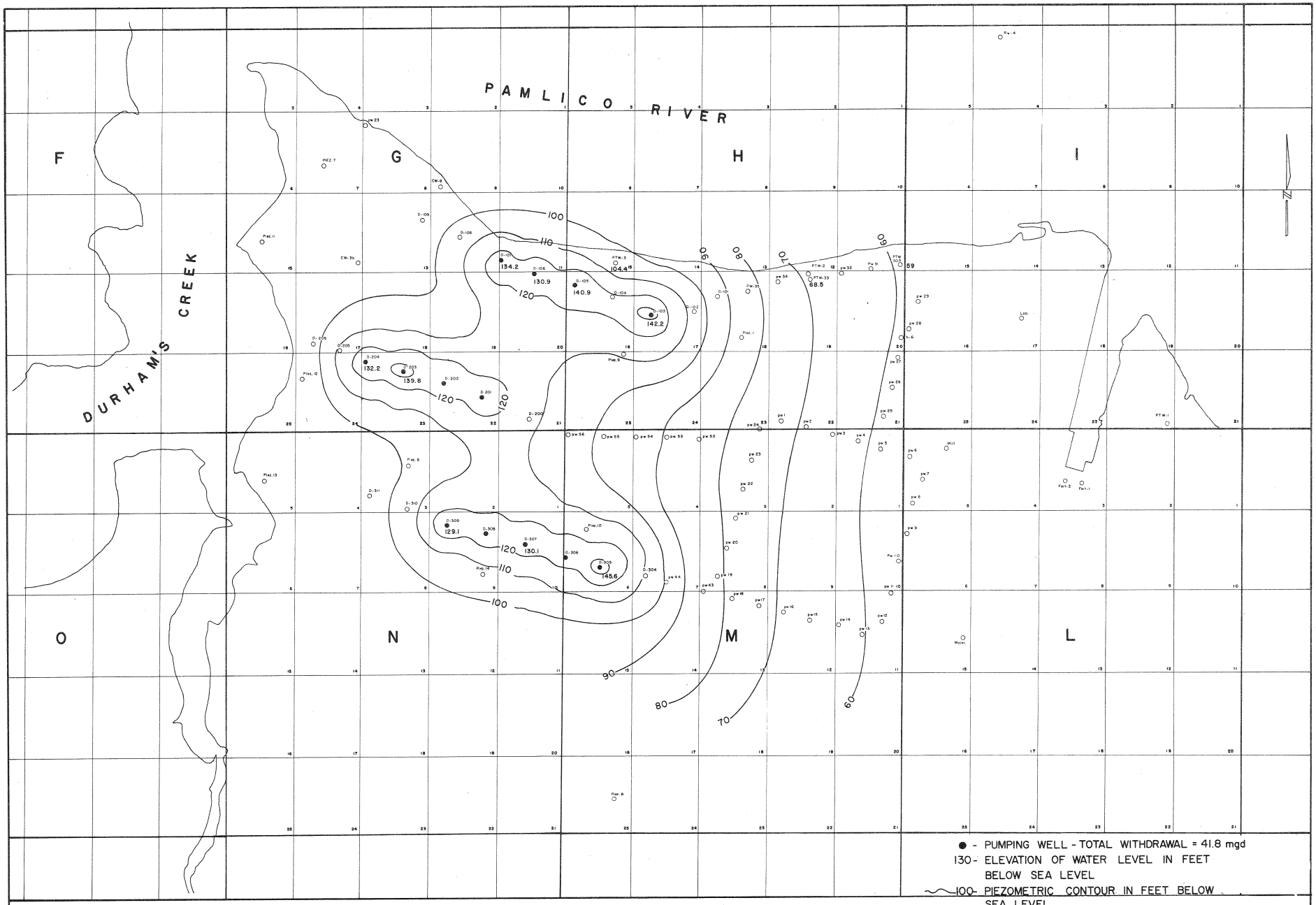


FIGURE 32.- PIEZOMETRIC CONTOURS ON THE CASTLE HAYNE AQUIFER
LEE CREEK MINE. FEB. 28, 1972

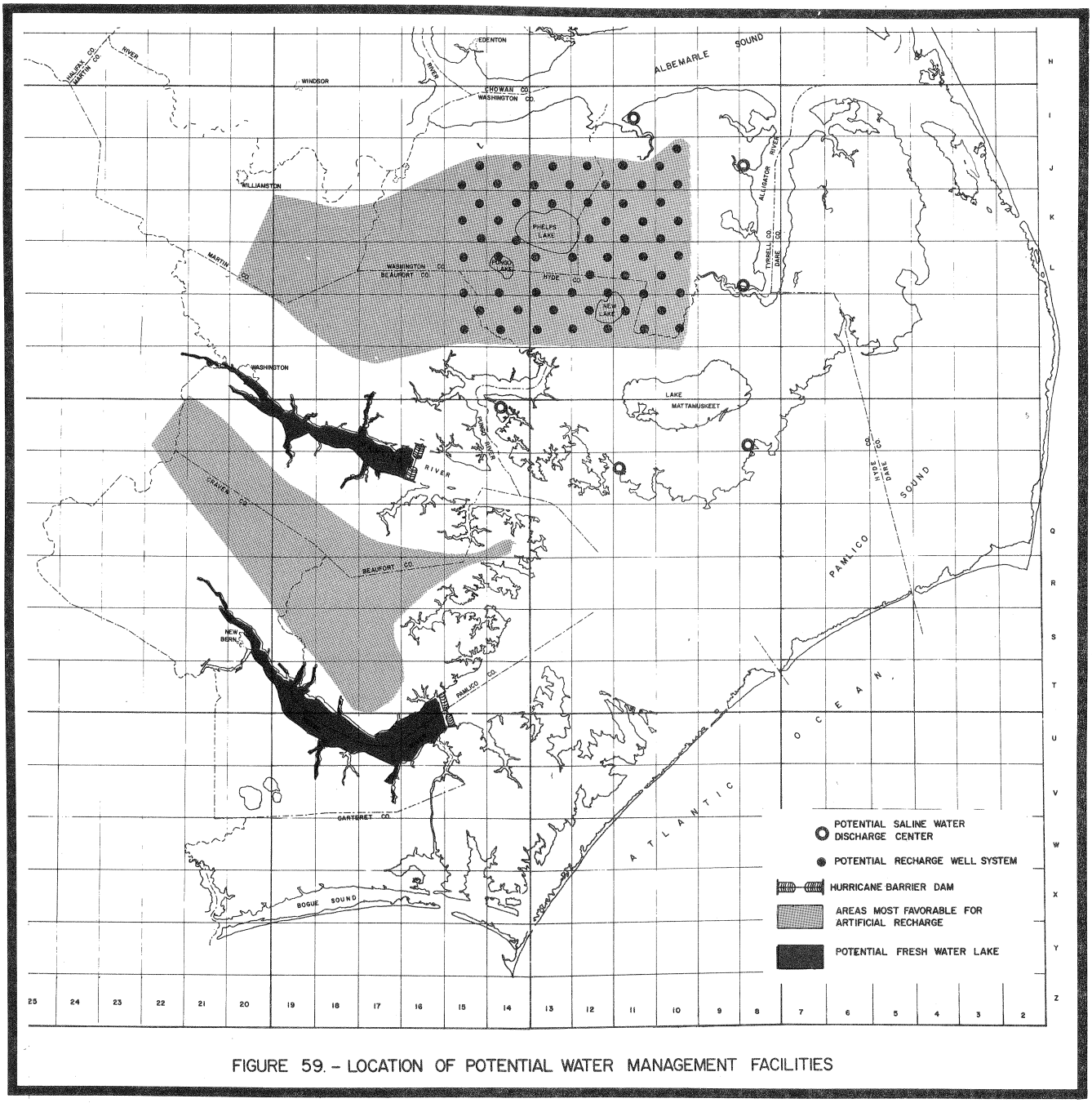


FIGURE 59. – LOCATION OF POTENTIAL WATER MANAGEMENT FACILITIES

suitable for a particular purpose, should be used.

Withdrawals of groundwater from an aquifer system should be made at sites that will provide the best management and use of the system. This will take careful placement of well fields and proper spacing of wells, to the extent practical, and establishment of optimum pumping rates and pumping water levels.

WITHDRAWAL OF BRACKISH WATER FROM THE CASTLE HAYNE AQUIFER

Vast quantities of brackish water are available from the Castle Hayne aquifer system in the Capacity Use Area which is suitable for cooling and other uses in many types of industries with little or no treatment. This is a valuable resource and its utilization should be encouraged. The withdrawal of substantial quantities of brackish water at selected sites also offers an effective means of controlling lateral salt water encroachment into the fresh waters of the aquifer system. The application of the water management technique is illustrated in Figure 60, which shows the projected effects of withdrawal of brackish water on the east side of the Pungo River in Hyde County at the rate of 15 MGD. The changes in the piezometric surface show a reversal in the movement of brackish from the existing conditions. Under the projected condition, the quality of water would be improved by at least a partial replacement of brackish water by lateral movement of fresh water through the aquifer and increased recharge from the overlying fresh waters. The system should be used in conjunction with a system of recharge wells for maximum effectiveness . Several possible or potential sites for saline water discharge centers are shown in Fig. 59.

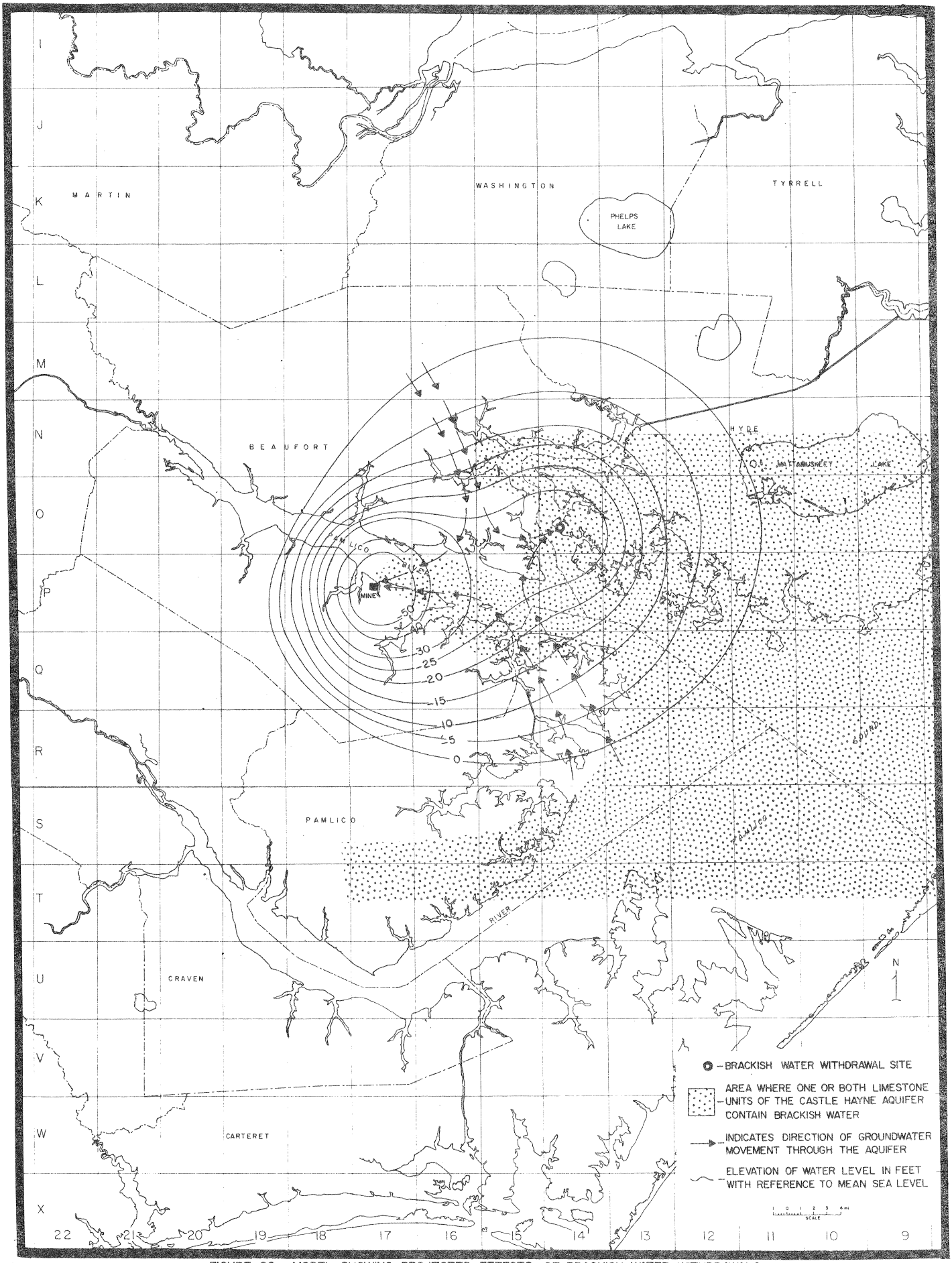


FIGURE 60.- MODEL SHOWING PROJECTED EFFECTS OF BRACKISH WATER WITHDRAWALS

CONTROL AND MODIFICATION OF SURFACE DRAINAGE SYSTEMS

Extensive systems of ditches and canals have been constructed throughout the Capacity Use Area and the entire Coastal Plain. New drainage systems are being constructed or have been planned for most of the freshwater wetlands. In much of the Capacity Use Area, the drainage systems are so extensive and interconnected that separate drainage basins are connected. The purpose of these systems is to improve agricultural conditions by removing flood waters as rapidly as possible and by lowering the water table.

Although the installation of these systems solves certain immediate agricultural problems, it does not comprise water resource management except in a negative sense. In most cases, the drainage systems reduce the total quantity of fresh water available for use. Most, if not all, of the systems have been installed and are being installed without adequate evaluation of their effects on existing hydrologic conditions and changes in hydrologic conditions that are occurring or that may occur. Alternatives to "open-end" drainage systems generally have not been considered.

Systems that are being installed or that were recently installed for draining large wetland and other areas in the Capacity Use Area were planned without recognition of the hydrologic changes caused by large withdrawals from the Castle Hayne aquifer at Lee Creek. For example, the hydrology has been altered in many areas to the extent that natural discharge areas have become recharge areas. Recharge has begun since large withdrawals started, or has greatly increased in more than 2,500 square miles in which the piezometric surface has been lowered significantly. Recharge at a rate of 20,000 to 200,000 gallons per day per square mile has considerably

reduced the quantity of water to be drained from the shallow aquifers.

The elevation of the surface water bodies and the water table are the driving force of the groundwater hydraulic system. Therefore, the lowering of the water table reduces the rate of recharge. For example, the lowering of the water table two feet in an area where the water table is normally four feet higher than the piezometric surface, will reduce the recharge rate by 50 percent. It is obvious that reductions of this magnitude can drastically influence the entire system.

Water resource management requires that any drainage plan be designed with control structures that will maintain the water table at the highest level possible to permit agricultural production. It also requires that existing drainage systems be equipped with structures to accomplish this purpose.

In some areas in the western part of the Capacity Use Area, where the principal uppermost confining beds are relatively near the surface, an alternative to surface drainage may be the deepening of channels to breach the confining beds, allowing vertical drainage from the water table into the artesian system. Pits or large diameter wells might be constructed in lieu of canals in such areas. This would permit salvage of much of the water that would be otherwise lost to the system or downgraded in quality.

In the eastern part of the Capacity Use Area, the water in the shallow aquifer and in the surface drainage systems is a potential source of water for extensive recharge of the Castle Hayne aquifer through a system or recharge wells as discussed elsewhere in this report.

ARTIFICIAL RECHARGE SYSTEMS

The drawdown of the water levels in the Castle Hayne aquifer

resulting from pumping at Lee Creek ranges from 5 to more than 100 feet in an area of more than 1,000 square miles (Fig. 31). In most of this area, natural discharge from the aquifer by upward leakage through the confining beds was occurring before pumping began at Lee Creek, because the piezometric surface was at a higher elevation than the water table or the surface waters. With the reversal in gradient (between the piezometric surface and the water table) since large withdrawals began, recharge is occurring at substantial rates because of the relatively large difference in head. The rate of natural recharge per unit of area is relatively low in much of the area because of the thickness and low vertical permeability of the confining beds, but ranges from about 20,000 to 200,000 gallons per day per square mile.

The potential for artificial recharge in much of the Capacity Use Area is enormous and the opportunity for positive water management is ideal. There is a vast quantity of water in the shallow aquifer and in surface sources that is now considered surplus, particularly in the wetland areas that are being drained by artificial channels, and storage capacity of the Castle Hayne aquifer is extremely large. Recharge well systems would relieve surface drainage problems to a considerable extent, and would not only preclude lateral salt-water encroachment into the aquifer, but would allow replacement of saline water by fresh water in a natural reservoir with a capacity of more than 20 billion gallons per square mile.

In much of the Capacity Use Area where the natural recharge rate is low, conditions are highly favorable for artificial recharge through wells or well systems. The availability of fresh water in the shallow water table aquifer is about 500,000 gallons per day or more per square mile,

and most of this water is presently considered surplus. The elevation of the water table is five feet or more above the piezometric surface of the Castle Hayne aquifer in much of the area. The limestone units of the aquifer has a thickness of up to 500 feet or more with a specific capacity of up to 90 gallons per minute or more per foot of drawdown in a well 24 inches in diameter. Under these conditions, the recharge rate through a 24-inch diameter well could exceed 500,000 gallons per day by gravity flow and several million gallons per day by pumping. The aquifer should readily accommodate all the excess fresh water in the water table aquifer and the surface-water system.

Artificial recharge at a rate of 500,000 gallons per day is about twice the natural recharge rate in the principal recharge areas of the Castle Hayne aquifer, and tens of times greater than natural recharge in most of the area overlain by thick confining beds. Therefore the effects of extensive artificial recharge systems would be spectacular, particularly in the eastern part.

In the areas where most or all of the Castle Hayne aquifer contains brackish or salt water, artificial recharge systems consisting of wells or a combination of recharge wells and salt-water discharge wells can replace the brackish water. Eventually, the fresh water reservoir could be expanded by tens or even hundreds or square miles.

CONSTRUCTION OF STORM BARRIERS IN THE PAMLICO AND NEUSE RIVER ESTUARIES

Studies have already been made by the U.S. Corps of Engineers to determine the feasibility of constructing barrier dams in the estuaries of the Pamlico and Neuse Rivers to reduce the tidal effects of hurricanes and other storms. These structures would also serve as multi-purpose

facilities for water management in the area.

In addition to protection of the estuary areas from tidal flooding and other damaging effects, the barriers would (1) prevent the movement of salt water upstream along the floor of the estuary; (2) create a large freshwater lake, thereby increasing the total availability of freshwater; (3) remove a source of brackish-water recharge to the aquifer system; and (4) provide a source of fresh-water recharge in the estuary. With conversion of the estuary to a freshwater lake, deepening by dredging would increase the recharge rate.

PREVENTION AND CONTROL OF GROUND WATER CONTAMINATION

Studies related to contamination of the groundwaters of the Capacity Use Area other than from natural sources of saline water, have been very limited to date and little information is available on the effects of mans activities on the quality of the groundwaters. Other than salt water encroachment, most problems of groundwater contamination are probably restricted to the water table aquifer. However, the increase in recharge from the water table aquifer to the artesian system has resulted in a corresponding increase in potential for contamination of the waters in the artesian system.

As a part of current studies, an inventory is being made of most significant sources of potential groundwater pollution. The inventory includes industrial chemical wastes and stockpiles; sewage sludge and liquid effluent disposal on land or lagoons; food processing wastes, feedlots and other agricultural activities involving fertilizers, herbicides and pesticides; and concentration of septic tanks. These potential sources of pollution will be monitored to the extent possible

to determine the possible effects and to permit prevention of groundwater pollution. Monitor systems should be installed at any site that may be a significant threat to the quality of the waters.

The potential for contamination of the groundwaters continues to increase . In order to provide protection of the groundwater quality, standards of quality must be established and the groundwaters of the State must be classified according to these standards.

A draft of proposed groundwater quality standards has been prepared and is in review for revision and improvement. In effect, these proposed standards would make placement of wastes or other contaminants on the land dependent upon the suitability of hydrogeologic and related conditions at a particular site.

FINANCING WATER RESOURCE MANAGEMENT

The establishment and operation of extensive water management systems will require a large amount of funds. It appears logical that the necessary management costs should be borne principally by the water users. In order that this may be done equitably, taxation of water users on a graduated scale would be necessary. In addition to providing funds for direct water management purposes, such a tax would be a most effective means of achieving economy in total water use and assuring water conservation.

Water is a valuable commodity, just as any other natural resource, and must be recognized as such in terms of dollars and cents. It cannot continue to be considered a "priceless" resource to be wasted or used without cost, but it must be assigned a fair market value. At this time, a conservative value for uncontaminated fresh water is in the range of 5 to 10 cents per 1,000 gallons at the source.

At the rate of 5 cents per 1000 gallons, the value of a million gallons would be $50.

As there are specific limitations to natural recharge, storage and recovery of groundwater in the Coastal Plain aquifers, limits must be placed on future withdrawals of fresh water at any particular place, based in part on purpose of withdrawal and use. As previously mentioned, the effects of current withdrawals indicate that, as a general rule, withdrawals by individual users should be limited to 10 million gallons per day or less, depending on conditions at the partiuclar location. In most parts of the Coastal Plain, the limit should be less than 5 million gallons per day.

As a starting point for establishing a graduated water use tax, it would be logical to tax withdrawals of more than a few million gallons per day at a rate equal to the assigned value of the water. A tax rate schedule, based on a water value of 5 cents per thousand gallons and taxation of withdrawals exceeding 10 million gallons per day at full value, is given below.

Water Use Tax Schedule

Gallons Per Day (Thousands)	Tax Rate (per 1000 gallons)	Daily Tax Range
1000-2000	$.005	$ .005 - 5
2000-3000	.01	5 - 15
3000-4000	.015	15 - 30
4000-5000	.02	30 - 50
5000-6000	.025	50 - 75
6000-7000	.03	75 - 105
7000-8000	.035	105 - 140
8000-9000	.04	140 - 180
9000-10,000	.045	180 - 225
More than 10,000	.05	225 -

Continuing Investigations

A vast amount of information on the ground water resource of the Capacity Use Area has been and is being obtained through investigations and monitoring activities since 1963. The great majority of the information, however, covers a relatively small part of the Capacity Use Area, principally in Beaufort County. Knowledge of the hydrogeologic and water quality characteristics of the Castle Hayne aquifer is still very limited in most of the area. Information on the overlying hydrogeologic units is much more limited.

The availability of information for evaluating the hydrogeologic systems and the development and refinement of more specific water management plans depends primarily on the installation of the proposed research stations. In addition to these stations, a much more expansive program of installing test and monitor wells is needed to obtain sufficient information to evaluate the hydrogeologic, hydraulic and water quality characteristics of the Pungo River, Yorktown and water table units and to monitor hydrologic changes.

In addition to hydrogeologic exploration, testing, mapping,monitoring and evaluation studies, investigative activities should include demonstration and experimental water-management systems. These should include recharge systems applicable to conditions at various selected sites throughout the Capacity Use Area. Also, at least one or more salt-water discharge centers should be installed, possibly in conjunction with a recharge well system.

With additional data from the investigational and monitoring program, it will be possible to expand and refine the existing digital computer

model for use in refinement of water management plans for the Capacity Use Area. Simulation of salt water encroachment and other aspects of water quality may be possible when adequate data becomes available.

Summary and Conclusions

A Capacity Use Area, comprising Beaufort, Pamlico and Washington counties and part of Carteret, Craven, Hyde, Martin, and Tyrrell counties, was established by the North Carolina Board of Water and Air Resources in 1967 to permit management of the water resources and particularly the Castle Hayne aquifer. The need for management was emphasized by the effects of the withdrawal of 60 MGD of water from the Castle Hayne aquifer at Lee Creek to accommodate phosphate mining which was begun in 1965. These effects include extensive lowering of the piezometric surface and creating conditions favorable for encroachment of saline water into the fresh groundwaters.

A substantial program of monitoring water use, water levels and water quality is conducted in the Capacity Use Area by the State in conjunction with the Texasgulf Company, the North Carolina Phosphate Corporation, the U.S. Geological Survey and others. The data from the monitor program do not show any extensive regional changes in water use, water levels or water quality for the Castle Hayne aquifer since 1970. Some changes in water levels and water quality have occurred in the vicinity of the Lee Creek mine as a result of changing patterns of mining and withdrawals.

A great quantity of information on conditions is available for part of the Capacity Use Area, principally in Beaufort County, however, knowledge is still very limited in a large part of the area. The availability of data for evaluating the hydrogeologic system depends primarily on the

installation of planned research stations and an expansive network of test and monitor wells constructed in the units overlying the Castle Hayne aquifer.

Although the Capacity Use Area was established and regulations applicable to water use and development became effective in 1967, no effective water management measures have been implemented. The Capacity Use Area and adjacent areas do offer an ideal opportunity for extensive, effective and positive water resource management, and such measures should be applied as soon as possible and practical. Management aspects to be considered should include the following:

* A critical review of all Water Use Permits to determine more precisely the actual quantity and quality requirements for each separate use.

* Withdrawals of surface or groundwater from the source of lowest quality available that is adequate and suitable for the particular purpose.

* Recycling and reuse of waters to the extent technically feasible when quantities used exceed 100,000 gallons per day.

* Improvement of water conservation in open pit mining and quarrying by establishing drawdown and withdrawal limits based on technical feasibility.

* Installation of control structures in existing artificial surface drainage systems to provide optimum management of the water and land resources.

* Prohibition of construction of surface drainage systems that do not provide for optimum management of the water resources or that may deplete or have other detrimental effects on the water resources.

* Establishment of groundwater quality standards for the State including the Capacity Use Area.

* Classification of the groundwaters of the Capacity Use Area in accordance with the established quality standards to permit protection from pollution.

* Recruitment of suitable industries that can use large quantities of saline or brackish water for location in Hyde, Pamlico, Tyrrell, Washington, and other counties.

* The installation of demonstration facilities for withdrawal of brackish or saline water from the Castle Hayne aquifer at selected locations in Pamlico, Hyde, Tyrrell and Washington counties.

* Installation of experimental and demonstration facilities for artificial recharge at selected sites in Beaufort, Hyde, Pamlico, Tyrrell and Washington counties as a basis for development of an areal recharge system and conjunctive saline-water discharge system.

* Construction of hurricane and salt-water barriers in the estuaries of the Neuse and Pamlico Rivers.

* Obtaining enabling legislation to permit the levy of a graduated water-use tax in Capacity Use Areas for financing water management activities and facilities.

* Limitation of groundwater use by individual users in a Capacity Use Area to 10 MGD or less, except for municipal or other public supply requirements for domestic use.

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BEAUFORT COUNTY

GWD Grid Coord.	Other Number	Geographic Location	Aquifer Monitored	Interval Monitored	Sample Frequency	Monitored By	Measurments Began
L-20 x-1		Washington	W.T.	0-15	P	GWD	8-70
M-17 u-2	CW 32A	Terraceia	U-Ech	162-225	P	TG	11-69
M-17 y-1		Acre Station	U-Ech	150-170	P	GWD	11-69
M-18 k-2		Pinetown	U-Ech	140-250	P	GWD	1966
M-21 k-1		Washington	Ech-Pb	72-82	R	GWD	11-69
M-21 q-2		Washington	Kpd	150-155	P	GWD	11-69
N-14 f-2	CW 16A	Belhaven	U-Ech		P	TG	6-65
N-15 h-4		Belhaven	My	100-150	P	GWD	1966
N-15 h-5	USGS 75	Belhaven	My		R	USGS-GWD	1966
N-15 h-10		Belhaven	L-Ech	360-420	R	GWD	4-73
N-15 h-11		Belhaven	U-Ech	252-320	R	GWD	5-73
N-15 1-4		Belhaven	U-Ech	233	P	GWD	3-71
N-15 m-1	USGS 15	Belhaven	U-Ech	290-410	R	USGS-GWD	6-65
N-15 m-12		Belhaven	My	60-120	R	GWD	11-69
N-15 x-1	CW 28A	Belhaven	U-Ech	244-247	P	TG	8-66
N-15 y-5		Belhaven	L-Ech	340-400	R	GWD	11-69
N-16 w-1	CW 6A	Yeatesville	Mpr	164-176	P	TG	1-63
N-16 w-2		Yeatesville	U-Ech	200-220	P	GWD	11-69 *
N-17 q-2	USGS 57	Bath	U-Ech	190-204	R	USGS-GWD	1965
N-18 b-1	S-14	Pinetown	U-Ech	136-201	R	TG	4-68
N-19 a-1	CW 23 A	Bunyan	L-Ech	190	P	TG	
N-19 f-2		Washington	W.T.	0-9.5	P	GWD	8-70
N-19 o-1	CW 29 A	Washington	U-Ech	85-105	P	TG	6-65
N-19 o-2	CW 30 A	Bunyan	U-Ech		P	TG	11-69
N-19 p-1	CW 21 A	Bunyan	U-Ech	96-124	P	TG-GWD	1966 *
N-19 r-4	S-16	Bunyan	U-Ech	84-131	R	TG	4-68
N-19 w-2	CW 27A	Broad Creek	U-Ech	84-94	P	TG	

Table 3 - Water-Level Monitor Well Data

BEAUFORT COUNTY

GWD Grid Coord.	Other Number	Geographic Location	Aquifer Monitored	Interval Monitored	Sample Frequency	Monitored By	Measurements Began
N-20 f-1	USGS 14	Washington	Ech		P	USGS-GWD	10-72
N-20 p-1		Washington	Ech	40-69	P	GWD	1965
N-20 u-1	USGS 49	Washington	Ech	124-185	R	USGS-GWD	1964
N-20 v-1a	R 7	Pamlico River	U-Ech	62-74	P	TG	1967
N-20 v-1b	R 7a	Pamlico River	L-Ech	115-125	P	TG	1967
N-20 v-1c	R 7b	Pamlico River	My	44-49	P	TG	1967
N-21 r-1		Chocowinty	U-Ech	90-192	P	GWD	1966
O-15 b-3	S-9	Winsteadville	U-Ech	270-281	P	TG	4-66
O-15 i-1	S-8	Winsteadville	U-Ech	264-282	P	TG	4-66
O-15 m-1	S-7	Winsteadville	U-Ech	245-270	P	TG	4-66
O-15 m-2	S-7A	Winsteadville	U-Ech	365-389	P	TG	1-68
O-15 n-3		Winsteadville	My	70-80	R	GWD	11-69
O-15 n-4		Winsteadville	Pb	600-610	R	GWD	11-69
O-15 n-5		Winsteadville	U-Ech	250-430	R	GWD	11-69
O-15 n-7	S-6	Winsteadville	U-Ech	242-247	P	TG	4-66
O-15 p-2	S-5	Winsteadville	U-Ech	233-248	P	TG	4-66
O-15 u-1		Winsteadville	U-Ech	391-450	R	GWD	11-69
O-16 t-1	S-4	Ransomville	U-Ech	225-230	P	TG	4-66
O-16 v-1	S-3	Burbage X-Rds	U-Ech	216-227	P	TG	4-66
O-16 w-2	S-2	Burbage X-Rds	U-Ech	201-226	P	TG	4-66
O-17 i-1		Bath	My	43-55	R	GWD	1966
O-17 i-2		Bath	U-Ech	165-310	R	GWD	1973
O-17 i-3		Bath	Pb	477-482	R	GWD	1966
O-17 i-4		Bath	L-Ech	258-300	R	GWD	1973
O-17 o-1		Bath	U-Ech	129-147	P	TG	11-64
O-17 q-1	NCP 184	Bath	U-Ech	149-179	R	NCP	7-64
O-17 r-3	CW 33A	Bath	U-Ech	170-250	R	TG	8-69

BEAUFORT COUNTY

GWD Grid Coord.	Other Number	Geographic Location	Aquifer Monitored	Interval Monitored	Sample Frequency	Monitored By	Measurments Began
O-18 c-1	CW 11-A	Bath	U-Ech	117-160	P	TG	1968
O-18 c-2		Bath	U-Ech	123	P	GWD	11-69 *
O-18 p-1a	R-3	Pamlico River	U-Ech	75-152	P	TG	6-67
O-18 p-1b	R-3A	Pamlico River	L-Ech	180-190	P	TG	7-67
O-18 x-3	CW 1B	Core Point	U-Ech	105-112	P	TG	6-65
O-19 b-1	S-17	Goose Creek	U-Ech	85-135	R	TG	4-68
O-19 c-1	CW 22-A	Broad Creek	U-Ech	75	P	TG	7-63
O-19 f-1a	R-2	Pamlico River	U-Ech	58-103	P	TG	7-67
O-19 f-1b	R-2A	Pamlico River	L-Ech	148-162	P	TG	7-67
O-19 m-1a	R-1	Pamlico River	U-Ech	49-90	P	TG	6-67
O-19 m-1b	R-1A	Pamlico River	L-Ech	147-165	P	TG	6-67
O-19 s-1	S-13	Mauls Point	U-Ech	84-122	P	TG	3-68
O-20 k-1	CW 19B	Chocowinty	Ech	65-96	P	TG	1966
O-21 i-1		Chocowinty	Ech	90-166	P	GWD	1965
O-21 p-1		Chocowinty	Ech	61-98	P	GWD	1969
O-21 q-1	USGS Bo191	Wilmar	U-Ech	72-172	R	USGS-GWD	1971
O-21 q-2	USGS Bo192	Wilmar	Wit	7-12	R	USGS-GWD	1971
O-21 q-3	USGS Bo193	Wilmar	My	35-40	R	USGS-GWD	1971
O-21 s-1		Chocowinty	W.T.	O-11.7	P	GWD	1970
P-14 f-1	S-1	Pamlico Beach	Ech	296-300	P	TG-GWD	9-66
P-14 f-2	S-1A	Pamlico Beach	Ech	400-440	P	TG-GWD	9-66
P-16 d-1a	R-5b	Pamlico River	My	58-63	P	TG	8-67
P-16 d-1b	R-5	Pamlico River	U-Ech	192-206	P	TG	8-67
P-16 d-1c	R-5a	Pamlico River	U-Ech	280-298	P	TG	8-67
P-16 o-2		Hickory Point	My	36-47	R	GWD	11-67
P-16 o-3		Hickory Point	U-Ech	280-370	R	GWD	11-67

BEAUFORT COUNTY

GWD Grid Coord.	Other Number	Geographic Location	Aquifer Monitored	Interval Monitored	Sample Frequency	Monitored By	Measurements Began
P-16 p-1	NCP 182	Aurora	U-Ech	180	R	GWD	11-67
P-16 u-1	S-11	South Creek	U-Ech	247-267	P	TG	1-68
P-16 u-2	S-11A	South Creek	L-Ech	447-487	P	TG	1-68
P-17 d-1a	R-6	Pamlico River	U-Ech	140-150	P	TG	9-67
P-17 d-1b	R-6A	Pamlico River	U-Ech	212-222	P	TG	9-67
P-17 e-1		Bonnerton	U-Ech	133-186	R	GWD	5-68
P-17 g-3	Piez 7	Lee Creek Mine	U-Ech	165	P	TG	1970
P-17 g-4	CW 8	Lee Creek Mine	U-Ech		P	TG	
P-17 g-5	Piez 11	Lee Creek Mine	U-Ech	165	P	TG	12-72
P-17 g-2	CW 3B	Lee Creek Mine	U-Ech	138-142	P	TG	5-64
P-17 g-6	Piez 12	Lee Creek Mine	U-Ech	165	P	TG	12-72
P-17 h-4		Lee Creek Mine	Kbc	918-922	R	GWD	5-66
P-17 h-5		Lee Creek Mine	PB	466-470	R	GWD	5-66
P-17 h-6		Lee Creek Mine	Ech	165-323	R	GWD	8-66
P-17 h-7		Lee Creek Mine	My	42-46	P	GWD	8-66
P-17 h-10		Lee Creek Mine	My	42-46	R	GWD	6-66
P-17 h-11	PTW 3.1	Lee Creek Mine	U-Ech		R	TG	5-68
P-17 h-12a	PTW 30A	Lee Creek Mine	L-Ech	300-320	R	TG	5-68
P-17 h-12b	PTW 30B	Lee Creek Mine	Pb	472-492	R	TG	3-68
P-17 h-12c	PTW 30C	Lee Creek Mine	U-Ech	211-216	R	TG	3-68
P-17 h-12d	PTW 30D	Lee Creek Mine	U-Ech	188-193	R	TG	3-68
P-17 h-12e	PTW 30E	Lee Creek Mine	U-Ech	165-175	R	TG	3-68
P-17 h-13	PTW 2	Lee Creek Mine	U-Ech		R	TG	71
P-17 h-14	PTW 33	Lee Creek Mine	U-Ech		R	TG	12-68
P-17 h-15	PTW 3	Lee Creek Mine			P	TG	71
P-17 h-16	Piez 1	Lee Creek Mine	U-Ech	165	P	TG	4-72

BEAUFORT COUNTY

GWD Grid Coord.	Other Number	Geographic Location	Aquifer Monitored	Interval Monitored	Sample Frequency	Monitored By	Measurements Began
P-17 h-17	PW 27	Lee Creek Mine	U-Ech	169-218	P	TG	5-68
P-17 h-18	Piez 9	Lee Creek Mine	U-Ech	165	P	TG	12-72
P-17 i-1a	RW 4a	Pamlico River	U-Ech	160-175	P	TG	7-67
P-17 i-1b	RW 4b	Pamlico River	U-Ech	245-263	P	TG	7-67
P-17 i-4	PTW 1	Pamlico River	U-Ech		R	TG	10-69
P-17 k-1	S-12	Lee Creek Mine	U-Ech	181-200	P	TG	11-69
P-17 l-3	PW-8	Lee Creek Mine	U-Ech	161-230	P	TG	5-68
P-17 m-24	PW 10	Lee Creek Mine	U-Ech	166-225	P	TG	4-72
P-17 m-26	PW 12	Lee Creek Mine	U-Ech	166-228	P	TG	4-72
P-17 m-28	PW 14	Lee Creek Mine	U-Ech	168-226	P	TG	3-68
P-17 m-30	PW 16	Lee Creek Mine	U-Ech	165-225	P	TG	4-72
P-17 m-34	PW 44	Lee Creek Mine	U-Ech	170-215	P	TG	4-72
P-17 m-39	Piez 10	Lee Creek Mine	U-Ech	165	P	TG	12-72
P-17 m-40	Piez 8	Lee Creek Mine	U-Ech	165	P	TG	4-72
P-17 n-2	Piez 13	Lee Creek Mine	U-Ech	165	P	TG	12-72
P-17 n-3	Piez 14	Lee Creek Mine	U-Ech	165	P	TG	12-72
P-17 r-1	NCPB-9	Aurora	U-Ech	150-175	R	NCP	6-65
P-17 s-2		Aurora	My	53-58	P	GWD	1968
P-17 x-1	NCP 169	Aurora	U-Ech	150-175	R	NCP	9-65
P-18 k-3		Edward	W.T.		P	GWD	1970
P-19 m-2		Cox X-Rds	My	23-34	P	GWD	1967
P-19 m-3		Cox X-Rds	Ech	70-250	R	GWD	1967
P-19 m-4		Cox X-Rds	Kbc	571-581	R	GWD	1967
P-19 m-5		Cox X-Rds	Pb	380-390	R	GWD	1967
P-19 n-1	NCP 186A	Cox X-Rds	U-L-Ech	72-271	R	NCPC	3-68
P-19 o-1		Cox X-Rds	U-Ech	64-160	P	GWD	4-64 *

BEAUFORT COUNTY

GWD Grid Coord.	Other Number	Geographic Location	Aquifer Monitored	Interval Monitored	Sample Frequency	Monitored By	Measurements Began
P-19 t-1	NCP 185	Cox X-Rds	U-Ech	120-315	R	NCPC	4-68
P-20 l-1	NCP 188	Big Pocosin	U-Ech	108-220	R	NCPC	4-68
P-20 o-1	NCP 187	Big Pocosin	U-Ech	85-92	R	NCPC	4-68
P-21 i-1		Wilmar	W.T.	0-7.7	P	GWD	9-65
P-21 k-3		Wilmar	Pm	23-29	R	GWD	7-68
P-21 k-5		Wilmar	Kbc	855-865	R	GWD	10-68
P-21 k-6		Wilmar	Ech	70-200	R	GWD	9-68
P-21 k-7		Wilmar	Pb	290-310	R	GWD	10-68
P-21 k-9		Wilmar	Kpd	695-705	R	GWD	11-68
Q-16 m-4	CW 12B	Campbell Creek	U-Ech		P	GWD	5-68
Q-17 c-1	USGS 13	Aurora	U-Ech	160-168	R	USGS-GWD	6-64
Q-17 e-1	NCP 174	Aurora	U-Ech	151-175	R	NCPC	7-64
Q-17 e-5	NCP 170	Aurora	U-Ech	140-170	R	NCPC	7-64
Q-17 h-7	CW 21B	Aurora	U-Ech	200	R	TG	11-65
Q-18 a-1	NCP 173	Edward	U-Ech	125-162	R	NCPC	7-64
Q-18 h-1		Edward	U-Ech	90-150	R	GWD	6-65
Q-18 q-2	CW 5B	Edward	U-Ech		P	TG	6-65
Q-18 t-1	NCP 183	Edward	U-Ech	163-193	R	NCPC	10-64
R-17 c-1		Aurora	Ech	250	P	GWD	1965
V-12 j-1		Atlantic	My	398-408	P	GWD	4-72
V-13 u-1		Stacy	W.T.	11-16	P	GWD	9-73
W-13 m-1		Davis	My	66-71	P	GWD	9-73
W-15 t-1		Bettie	My	117	P	GWD	9-70
W-18 k-1		Newport	Pm	43	P	GWD	9-70
W-18 s-1		Newport	U-Ech	84-149	P	GWD	9-70
X-15 m-1		Beaufort	U-Ech	260	P	GWD	1964

GWD Grid Coord.	Other Number	Geographic Location	Aquifer Monitored	Interval Monitored	Sample Frequency	Monitored By	Measurements Began
BEAUFORT COUNTY							
X-17 i-1	USGS 67	Morehead City	U-Ech	235	R	USGS-GWD	1967
CRAVEN COUNTY							
P-21 k-2		Wilmar	U-Ech	50-150	P	GWD Sec.	12-65
P-21 n-1	USGS CR 464	Wilmar		52-172	R	USGS-GWD	1971
P-21 n-2	USGS CR 463	Wilmar		35-40	R	USGS-GWD	1971
P-21 n-3	USGS CR 462	Wilmar		13-18	R	USGS-GWD	
P-21 p-1		Wilmar	U-Ech	109-180	P	GWD Sec.	1-66
P-22 f-8	USGS CR 465	Vanceboro		15-19	P	USGS-GWD	1971
P-22 j-1	USGS 16	Wilmar	Kpd	320	R	USGS	1-65
P-22 u-1	USGS CR 457	Vanceboro	U-Ech	20-99	R	USGS	1971
P-22 u-2	USGS CR 458	Vanceboro	W T	13-18	R	USGS-GWD	1971
P-22 u-3	USGS CR 459	Vanceboro	W T	13-18	P	USGS-GWD	1971
P-22 u-4	USGS CR 460	Vanceboro	My	25-30	P	USGS-GWD	1971
P-22 u-5	USGS CR 461	Vanceboro	U-Ech	36-122	P	USGS-GWD	1971
Q-19 q-1		Cayton	U-Ech	80	P	GWD	1-66
Q-21 t-1		Vanceboro	U-Ech	36-108	P	GWD	2-66
U-19 v-1		Havelock	W.T.	10-15	P	GWD	9-70
V-18 d-1	USGS 64	Cherry Point	U-Ech	95	R	USGS-GWD	1968
HYDE COUNTY							
N-20 f-1		Fairfield	My	74-79	P	GWD	9-63
Q-13 c-2	S-10	Scranton	U-Ech	382-398	P	GWD-TG	2-66
MARTIN COUNTY							
K-18 g-1		Jamesville	Ech	79-97	P	GWD Sec.	10-65

MARTIN COUNTY

GWD Grid Coord.	Other Number	Geographic Location	Aquifer Monitored	Interval Monitored	Sample Frequency	Monitored By	Measurements Began
K-18 g-2		Jamesville	Pb	168-178	R	GWD	1-67
L-19 g-1		Roberson Store	Pb-Ech	145	P	GWD Sec.	7-65

PAMLICO COUNTY

Q-14 r-1	CW 13B	Lowland	U-Ech	393-600	P-R	GWD-TG	1965
Q-14 y-1	USGS 46	Hobucken	My	219	P	USGS	1965
R-17 p-1		Grantsboro	U-Ech	131-248	P	GWD	12-65
S-16 e-1		Bayboro	U-Ech	300	P	GWD	6-65
S-18 k-1		Grantsboro	U-Ech	180-220	P	GWD	11-71
S-18 u-3		Arapahoe	My	75-80	P	GWD	12-71
S-18 u-4		Arapahoe	Pb	725-778	R	GWD	12-71
S-18 u-5		Arapahoe	L-Ech	340-380	R	GWD	1-72
S-18 u-6		Arapahoe	U-Ech	190-224	R	GWD	2-72
S-18 u-7		Arapahoe	My	115-120	P	GWD	2-72
S-18 u-11		Arapahoe	W.T.	13-18	P	GWD	9-71
S-18 u-12		Arapahoe	L-Ech	482-492	R	GWD	3-73
T-16 s-2		Oriental	My (?)	236	P	GWD	12-61

WASHINGTON COUNTY

J-12 d-4		Creswell	W.T.	4-8	P	GWD	1966
J-12 n-2		Creswell	Ech	380-385	P	GWD-USGS	1958
J-13 c-1		Creswell	My	125-135	P		1962
J-16 a-1		Westover	Pb	300	P		1962
J-16 a-4		Westover	W.T.	15-20	P		1965
K-12 f-2	USGS 65	Lake Phelps	U-Ech	390-400	R	USGS-GWD	1967
K-13 c-1		Cherry	U-Ech	305-365	P		1965

WASHINGTON COUNTY

GWD Grid Coord.	Other Number	Geographic Location	Aquifer Monitored	Interval Monitored	Sample Frequency	Monitored By	Measurements Began
K-13 c-3		Cherry	W.T.	10-15	P		1965
K-17 b-2		Plymouth	U-Ech	168-199	P	GWD	1965
K-17 b-8		Plymouth	U-Ech	165-170	P	GWD	1966
K-17 b-9		Plymouth	W.T.	0-9	P	GWD	1966
L-15 g-2		Wenona	U-Ech	250-300	P	GWD	1965
L-15 h-2		Wenona	My	160-164	P	GWD	1965

BEAUFORT COUNTY

GWD Grid Coord.	Other Number	Geographic Location	Aquifer Monitored	Sample Interval	Sample Frequency	Collection and Analysis by	Chloride Analyses Began
M-21 q-2		Washington	Kpd	150-155	M	GWD	10-68
N-15 h-4		Belhaven	My	100-150	M	GWD	11-68
N-15 h-10		Belhaven	L-Ech	360-420	Q	GWD	3-73
N-15 h-11		Belhaven	U-Ech	252-320	Q	GWD	3-73
N-15 l-4		Belhaven	U-Ech	233	M	GWD	3-71
N-15 m-8	CCMW 5A	Belhaven	U-Ech	250-275	M	TG	11-65
N-15 m-9	CCMW 5B	Belhaven	U-Ech	250-275	M	TG	-66
N-15 m-12		Belhaven	My	60-120	M	GWD	4-68
N-15 y-5		Belhaven	L-Ech	340-400	M	GWD	7-69
N-18 v-1	CCMW 16	Everetts X-Rds	U-Ech	Rptd Ech	M	TG	7-65
N-19 w-1	CCMW 26	Broad Creek	U-Ech	84-94	M	TG	7-67
N-20 f-7		Washington	Kpd	250	M	GWD	4-72
N-20 v-1a	R-7	Pamlico River	U-Ech	62-74	Q	TG	9-67
N-20 v-1b	R-7A	Pamlico River	L-Ech	115-125	Q	TG	9-67
N-20 v-1c	R-7B	Pamlico River	My	44-49	Q	TG	9-67
O-15 b-1	S-9	Winsteadville	U-Ech	270-281	M	TG	4-66
O-15 i-1	S-8	Winsteadville	U-Ech	264-282	M	TG	4-66
O-15 m-1	S-7	Winsteadville	U-Ech	245-270	M	TG	4-66
O-15 m-2	S-7A	Winsteadville	U-Ech	365-389	M	TG	1-68
O-15 n-3		Winsteadville	My	70-80	Q	GWD	12-66
O-15 n-4		Winsteadville	Pb	600-610		GWD	5-67
O-15 n-5		Winsteadville	U-L-Ech	250-430	Q	GWD	6-67
O-15 n-7	S-6	Winsteadville	U-Ech	242-247	M	TG	4-66

Table 4 - Water-Quality Monitor Well Data

BEAUFORT COUNTY

GWD Grid Coord.	Other Number	Geographic Location	Aquifer Monitored	Sample Interval	Sample Frequency	Collection and Analysis by	Chloride Analyses Began
O-15 n-7	S-6	Winsteadville	U-Ech	242-247	M	TG	4-66
O-15 p-2	S-5	Ransomville	U-Ech	233-248	M	TG	4-66
O-15 u-1		Pamlico River	L-Ech	391-450	Q	GWD	6-70
O-16 m-2	CCMW 10	Burbage X-Rds	U-Ech	235	M	TG	12-67
O-16 t-1	S-4	Burbage X-Rds	U-Ech	225-230	M	TG	4-66
O-16 v-1	S-3	Burbage X-Rds	U-Ech	216-227	M	TG	4-66
O-16 w-2	S-2	Burbage X-Rds	U-Ech	201-226	M	TG	4-66
O-16 y-1		Burbage X-Rds	U-Ech	170-230	M	GWD	2-67
O-16 y-3	CCMW 12	Burbage X-Rds	U-Ech	230	M	TG	7-65
O-17 g-5	CCMW 11	Bath	U-Ech		M	TG	2-66
O-17 i-1		Bath	My	43-55	Q	GWD	10-66
O-17 i-2		Bath	U-Ech	165-298	Q	GWD	9-66
O-17 i-3		Bath	Pb	477-482	Q	GWD	10-66
O-17 i-4		Bath	L-Ech	258-300	Q	GWD	-73
O-17 q-2	CCMW 3	Bayview	U-Ech		M	TG	7-65
O-18 k-3	CCMW 29	Whitepost	U-Ech	191	M	TG	3-68
O-18 l-3	CCMW 17	Whitepost	U-Ech	92	M	TG	2-66
O-18 p-1a	R-3	Pamlico River	U-Ech	72-152	Q	TG	6-67
O-18 p-1b	R-3A	Pamlico River	U-Ech	180-190	Q	TG	6-67
O-18 v-2	CCMW 14	Core Point	U-Ech	113-147	M	TG	2-66
O-19 f-1a	R-2	Pamlico River	U-Ech	58-103	Q	TG	5-67
O-19 f-1b	R-2A	Pamlico River	L-Ech	148-162	Q	TG	5-67
O-19 m-1a	R-1	Pamlico Rover	U-Ech	49-90	Q	TG	5-67

BEAUFORT COUNTY

GWD Grid Coord	Other Number	Geographic Location	Aquifer Monitored	Sample Interval	Sample Frequency	Collection and Analysis by	Chloride Analyses Began
O-19 m-1b	R-1A	Pamlico River	L-Ech	147-165	Q	TG	5-67
O-19 s-1	S-13	Mauls Point	U-Ech	84-122	M	TG	3-68
P-14 f-1	S-1	Pamlico Beach	U-Ech	295-306	Q-M	GWD-TG	4-66
P-14 f-2	S-1A	Pamlico Beach	L-Ech	400-440	Q-M	GWD-TG	6-68
P-15 i-2	CCMW 21	Pamlico Beach	U-Ech	350	M	TG	7-65
P-15 y-1	CCMW 20	Spring Creek	U-Ech	260	M	TG	6-68
P-16 d-1a	R-5b	Pamlico River	My	58-63	M	TG	8-67
P-16 d-1b	R-5	Pamlico River	U-Ech	192-206	M	TG	8-67
P-16 d-1c	R-5A	Pamlico River	U-Ech	280-298	M	TG	8-67
P-16 0-1		Ferry LDG-S.	U-Ech	170-245	Q	GWD	2-67
P-16 0-2		Ferry LDG-S.	My	37-47	Q	GWD	11-67
P-16 0-3		Ferry LDG-S.	L-Ech	280-370	Q	GWD	11-67
P-16 s-3	CCMW 19	Hickory Point	U-Ech		M	TG	7-65
P-16 v-1	S-11	South Creek	U-Ech	247-267	M	TG	12-67
P-16 v-2	S-11A	South Creek	L-Ech	447-487	M	TG	12-67
P-17d-1a	R-6	Pamlico River	U-Ech	140-150	M	TG	9-67
P-17 d-1b	R-6A	Pamlico River	U-Ech	212-222	M	TG	10-67
P-17 e-1		Durham Creek	U-Ech	133-186	Q	GWD	4-72
P-17 g-4	CCMW 23	Lee Creek Mine	U-Ech		M	TG	7-65
P-17 g-5	Mine Off.	Lee Creek Mine			M	TG	4-67
P-17 h-4		Lee Creek Mine	Kbc	918-922	M	GWD	4-66
P-17 h-5		Lee Creek Mine	Pb	466-470	Q	GWD	5-66
P-17 h-6		Lee Creek Mine	U-Ech	165-323	Q	GWD	5-66

BEAUFORT COUNTY

GWD Grid Coord.	Other Number	Geographic Location	Aquifer Monitored	Sample Interval	Sample Frequency	Collection and Analysis By	Chloride Analys Began
P-17 h-7		Lee Creek Mine	My	42-46	Q	GWD	6-66
P-17 h-12a	PTW 30a	Lee Creek Mine	L-Ech	300-320	M	TG	1-68
P-17 h-12b	PTW 30b	Lee Creek Mine	Pb	472-492	M	TG	1-68
P-17 h-12c	PTW 30c	Lee Creek Mine	U-Ech	211-216	M	TG	1-68
P-17h-12d	PTW 30d	Lee Creek Mine	U-Ech	188-193	M	TG	1-68
P-17 h-12e	PTW 30e	Lee Creek Mine	U-Ech	165-175	M	TG	1-68
P-17 h-13	PTW 2	Lee Creek Mine	U-Ech	167-213	M	TG	2-70
P-17 h-15	PTW 3	Lee Creek Mine	U-Ech	161-216	M	TG	2-70
P-17 i-1a	R-4	Pamlico River	U-Ech	160-175	M	TG	8-67
P-17 i-1b	R-4A	Pamlico River	U-Ech	245-263	M	TG	8-67
P-17 i-3	TG LAB	Lee Creek Mine	U-Ech	184-264	M	TG	6-66
P-17 k-1	S-12	Lee Creek Mine	U-Ech	204-214	M	TG	3-68
P-17 1-3	TG Fert.1	Lee Creek Mine	U-Ech	190-220	M	TG	6-66
P-17 1-15	TG Maint.	Lee Creek Mine	Ech		M	TG	6-66
P-17 p-1	CMW 13	Bonnerton	U-Ech		M	TG	7-65
P-19 m-3		Cox's X-Rds	Ech	81-250	Q	GWD	4-67
P-19 m-4		Cox's X-Rds	Kbc	571-581	Q	GWD	4-67
P-19 m-5		Cox's X-Rds	Pb	380-390	Q	GWD	6-67
P-21 k-5		Wilmar	Kbc	855-865	Q	GWD	11-68
P-21 k-6		Wilmar	Ech	70-200	Q	GWD	11-68
P-21 k-7		Wilmar	Pb	290-310	Q	GWD	11-68
P-21 k-9		Wilmar	Kbc	695-705	Q	GWD	11-68

GWD Grid Coord.	Other Number	Geographic Location	Aquifer Monitored	Sample Interval	Sample Frequency	Collection and Analysis by	Chloride Analyses Began
BEAUFORT COUNTY							
Q-16 n-10	CCMW 15	Campbell Creek	U-Ech		M	TG	7-65
Q-17 h-3	CCMW 24	Aurora	U-Ech	198-208	M	GWD-TG	10-64
Q-17 m-5	CCMW 25	Aurora	U-Ech		M	TG	11-65
Q-17 q-1	CCMW 9	Aurora	U-Ech	210	M	TG	11-65
Q-18 q-1	CCMW 22	Edward	U-Ech		M	TG	2-66
Q-18 v-2	CCMW 6	Edward	U-Ech		M	TG	7-65
HYDE COUNTY							
O-13 c-2	S-10	Scranton	U-Ech	385-395	Q-M	GWD-TG	2-66
PAMLICO COUNTY							
Q-14 r-1	CCMW 18	Lowland	U-L-Ech	396-747	Q-M	GWD-TG	8-65
R-15 a-2	CCMW 31	Hobucken	U-Ech	377-437	M	TG	6-68
S-18 u-4		Arapahoe	Pb	725-778	M	GWD	4-72
S-18 u-8		Arapahoe	L-Ech	340-480	M	GWD	4-72
S-18 u-9		Arapahoe	U-Ech	190-224	M	GWD	4-72
S-18 u-10		Arapahoe	My	105-120	M	GWD	4-72
S-18 u-11		Arapahoe	Unconfined	13-18	M	GWD	4-72
S-18 u-12		Arapahoe	L-Ech	482-492	Q	GWD	4-72

RESOLUTION OF THE BOARD OF WATER AND AIR RESOURCES DECLARING A CAPACITY USE AREA IN CERTAIN PORTIONS OF EASTERN NORTH CAROLINA

WHEREAS, by resolution of the North Carolina Board of Water and Air Resources dated August 28, 1968, the said Board proposed to declare "a capacity use area" within the meaning and under the provisions of the North Carolina Water Use Act of 1967, as codified in Article 21, Chapter 143 of the North Carolina General Statutes, said area delineated to include all of Beaufort, Pamlico and Washington Counties, and portions of Carteret, Craven, Hyde, Martin and Tyrrell Counties; and

WHEREAS, the North Carolina Board of Water and Air Resources caused a public hearing to be conducted on October 25, 1968, within the relative area, to wit: Washington, North Carolina, in accordance with the procedural and other statutory requirements of the said Water Use Act of 1967; and

WHEREAS, the Board has reviewed all statements, written and oral, made at the public hearing and all other statements, briefs, and other instruments submitted for inclusion into the record of the public hearing, and has carefully considered all other evidence, arguments, reports, and other competent data and information as contemplated by law, with respect to the said Board's proposal to declare "a capacity use area"; and

WHEREAS, the Board has reviewed the pertinent, competent, material, and relevant data, testimony and other evidence on ground water uses and related hydrologic conditions, including the "Report of an Investigation of Water Use in the Beaufort County Area of Eastern North Carolina" dated August 1968, and prepared for distribution by the State of North Carolina Department of Water and Air Resources, and the "Proceedings of Public Hearing Concerning the Declaration of a 'Capacity Use Area' in the Beaufort County Area of Eastern North Carolina" dated October 25, 1968, and published by the North Carolina Board of Water and Air Resources; the said documents being herein incorporated by reference; and

WHEREAS, the North Carolina Board of Water and Air Resources, within its statutory authority, hereby finds that a capacity use area shall be declared within the area hereafter more specifically described for the reason that the aggregate uses of ground water or surface water, or both, in or affecting said area have developed or threaten to develop to a degree which requires coordination and regulation, or exceed or threaten to exceed, or otherwise threaten or impair, the renewal or replenishment of such waters or any part of them;

NOW, THEREFORE, BE IT RESOLVED BY THE NORTH CAROLINA BOARD OF WATER AND AIR RESOURCES that:

(1) The North Carolina Board of Water and Air Resources hereby finds that the following described geographical area be and is hereby declared "a capacity use area" within the meaning and under the provisions of the North Carolina Water Use Act of 1967, and codified as Part II, Article 21, Chapter 143 of the North Carolina General Statutes, and as referred to in the preamble hereof, the said capacity use area being described as follows:

> "That area bounded by a line beginning at the intersection of Highway US 17 and Roanoke River, at Williamston, and running south along Highway US 17 to the Martin-Beaufort County line; thence northwest along the Martin-Beaufort County line to the Pitt County line; thence generally south along the Pitt-Beaufort County line to the Craven County line; thence southwest along the Pitt-Craven County line to the Neuse River; thence southeast along the Neuse River to New Bern; thence south along Highway US 70 to Morehead City and on to Atlantic; thence north along the eastern edge of Cedar Island, across Pamlico Sound, along the eastern edge of Great Island, to the intersection of Highways US 264 and NC 94 near the south shore of Lake Mattamuskeet; thence north along Highway NC 94 to Columbia; thence west along the south shore of Albemarle Sound to the mouth of Roanoke River; thence generally southwest along the south shore of Albemarle Sound to the mouth of Roanoke River; thence generally southwest along Roanoke River to Highway US 17 at Williamston, the beginning."

(2) The North Carolina Board of Water and Air Resources hereby instructs the Director of the Department of Water and Air Resources to prepare proposed water use regulations to be applied in the area hereinabove described; such regulations shall be consistent with the provisions of the Water Use Act of 1967 and commensurate with the degree of control necessary as contemplated by law.

(3) The Board hereby designates six months from the date of this resolution as the period after which no person shall withdraw, obtain, or utilize surface waters or ground waters or both, as the case may be, in excess of 100,000 gallons per day for any purpose unless such person shall first obtain a permit therefor from the Board, as required by Section 5 (a) of the said Water Use Act of 1967.

(4) This resolution declaring and delineating a capacity use area in accordance with the statutory procedures of Part II, Article 21, Chapter 143 of the North Carolina General Statutes, shall be mailed to all persons required by law to receive same, and to all other persons submitting a written request to the North Carolina Department of Water and Air Resources.

This the 18th day of December, 1968.

RESOLUTION OF THE NORTH CAROLINA BOARD OF WATER AND AIR RESOURCES ADOPTING REGULATIONS TO BE APPLIED IN A CAPACITY USE AREA THAT INCLUDES ALL OF BEAUFORT, PAMLICO, AND WASHINGTON COUNTIES, AND PORTIONS OF CARTERET, CRAVEN, HYDE, MARTIN, AND TYRRELL COUNTIES.

WHEREAS, pursuant to the authority of Section 143-215.13 of the North Carolina General Statutes, the North Carolina Board of Water and Air Resources (hereinafter referred to as "Board") declared, on December 18, 1968, the following described territory "a capacity use area" within the meaning of said statutory section:

> "That area bounded by a line beginning at the intersection of Highway US 17 and Roanoke River, at Williamston, and running south along Highway US 17 to Martin-Beaufort counties line; thence northwest along the Martin-Beaufort Counties line to the Pitt County line; thence generally south along the Pitt-Beaufort Counties line to the Craven County line; thence southwest along the Pitt-Craven counties line to the Neuse River; thence southeast along the Neuse River to New Bern; thence south along Highway US 70 to Morehead City and on to Atlantic; thence north along the eastern edge of Cedar Island, across Pamlico Sound, along the eastern edge of Great Island, to the intersection of Highways US 264 and NC 94 near the south shore of lake Mattamuskeet; thence north along Highway NC 94 to Columbia; thence west along the south shore of Albemarle Sound to the mouth of Roanoke River; thence generally southwest along Roanoke River to Highway US 17 at Williamston, the beginning"; and

WHEREAS, the following declaration of the above-described capacity use area by the Board, the Board prepared proposed regulations to be applied in said area, and on May 2, 1969, held a public hearing on said proposed regulations, upon notice and in accordance with the requirements of subdivisions (4) through (6) of Section 143-215.13(c) of the North Carolina General Statutes; and

WHEREAS, upon completion of said hearing the Board considered the submitted evidence and arguments with respect to the proposed regulations; and

WHEREAS, the Board in preparing to adopt the proposed regulations, also considered the following:

(1) The number of persons using an aquifer or stream and the object, extent and necessity of their respective withdrawals or uses;

(2) The nature and size of the stream or aquifer;

(3) The physical and chemical nature of any impairment of the aquifer or stream, adversely affecting its availability or fitness for other water uses (including public use);

(4) The probable severity and duration of such impairment under foreseeable conditions;

(5) The injury to public health, safety or welfare which would result if such impairment were not prevented or abated;

(6) The kinds of businesses or activities to which the various uses are related;

(7) The importance and necessity of the water uses of the area and the extent of any injury or detriment caused or expected to be caused to other water uses (including public use); and

(8) Diversion from or reduction of flows in other water courses or aquifers; and

(9) Other relevant factors; and

WHEREAS, the Board has reviewed all statements, written and oral, made at the public hearing and all other statements, briefs, and other instruments duly submitted to inclusion in the record of the public hearing, and has carefully considered all other evidence, arguments, reports and competent data as contemplated by law with respect to the proposed regulations;

NOW THEREFORE, BE IT RESOLVED BY THE NORTH CAROLINA BOARD OF WATER AND AIR RESOURCES:

(1) That the following "REGULATIONS APPLICABLE IN A DESIGNATED CAPACITY USE AREA THAT INCLUDES BEAUFORT, PAMLICO, AND WASHINGTON COUNTIES AND PARTS OF CARTERET, CRAVEN, HYDE, MARTIN, AND TYRRELL COUNTIES," attached hereto, marked Exhibit 1, and hereby incorporated by reference, are hereby adopted by the North Carolina Board of Water and Air Resources and are declared by the Board to be in full force and effect;

(2) That this resolution and attached regulations shall be published as a part of the Official Regulations of the North Carolina Board of Water and Air Resources, and duly certified copy of this resolution and attached regulations shall immediately be filed with the Secretary of State;

(3) That copies of this resolution and attached regulations shall be mailed forthwith to all persons on the official mailing list of the Board as of this data and to all other persons submitting a written request for same to the North Carolina Department of Water and Air Resources.

Adopted by the Board this 12th day of June, 1969, at its meeting duly called and held at the Dare County Courtroom in Manteo, North Carolina.

STATE OF NORTH CAROLINA
BOARD OF WATER AND AIR RESOURCES
RALEIGH, NORTH CAROLINA

REGULATIONS APPLICABLE IN A DESIGNATED CAPACITY USE AREA THAT INCLUDES BEAUFORT, PAMLICO AND WASHINGTON COUNTIES AND PARTS OF CARTERET, CRAVEN, HYDE, MARTIN AND TYRRELL COUNTIES

I. General Provisions

A. Authority

The Board of Water and Air Resources is required, under the provisions of Part 2, Article 21, Chapter 143, General Statutes of North Carolina (Short Title: Water Use Act of 1967), to adopt appropriate regulations concerning the use of water to be applied in any area that the Board has declared and delineated as a "Capacity Use Area".

B. Declaration and Delineation of Capacity Use Area

The North Carolina Board of Water and Air Resources, on the 18th day of December 1968, delcared and delineated the following described geographical area a capacity use area:

"That area bounded by a line beginning at the intersection of Highway US 17 and Roanoke River, at Williamston, and running south along Highway US 17 to the Martin-Beaufort Counties line; thence northwest along the Martin-Beaufort Counties line to the Pitt-Beaufort Counties line to the Craven County line; thence southwest along the Pitt-Craven Counties line to the Neuse River; thence southeast along the Neuse River to New Bern; thence south along Highway US 70 to Morehead City and on to Atlantic; thence north along the eastern edge of Cedar Island, across Pamlico Sound, along the eastern edge of Great Island, to the intersection of Highways US 264 and NC 94 near the south shore of Lake Mattamuskeet; thence north along Highway NC 94 to Columbia; thence west along the south shore of Albemarle Sound to the mouth of Roanoke River; thence generally southwest along Roanoke River to Highway US 17 at Williamston, the beginning."

C. Purpose

These regulations are intended to provide for the management of water withdrawal and uses in the above-designated Capacity Use Area as needed to conserve water resources in the area, and to maintain conditions that are conducive to the orderly development and beneficial use of these resources.

D. Scope

These regulations establish general and specific requirements that are applicable to all persons who withdraw, obtain or utilize water within the above-designated Capacity Use Area. Special requirements applicable to individual users will normally be included in appropriate Water Use Permits.

E. Rules and Procedures

The Board may establish such rules and procedures as it deems necessary to implement these regulations and the Water Use Act of 1967.

F. Water Management Measures

The Board, in addition to regulatory measures, may promote or sponsor any other reasonable water-management measures that may be necessary, practical, and desirable in the public interest to protect or improve the quantity and quality of the water resources.

II. Requirements Applicable to Persons Withdrawing 100,000 Gallons Per Day or less

A. Permits Required

1. Water Use Permit

None required

2. Well Construction Permit

(a) A Well Construction Permit shall be obtained prior to construction of all wells except those constructed for individual domestic water supplies. (b) Application for a WEll Construction Permit shall be made

on Form GW22, "Application for Permit to Construct a Well", which can be obtained from the Department. The application shall state the purpose of the well, and shall include (1) the proposed location, (2) construction specifications, (3) the estimated withdrawal rate, (4) the location and ownership of all water-supply wells within a radius of 1,000 feet, and (5) such other information as the Board may reasonably deem necessary.

B. Withdrawal and Water-Level Controls Required

None

C. Reports Required

1. Well Record of Well Completion or Abandonment Report

Any person completing or abandoning any well shall furnish the Board, on Form GW-1, a certified record of the construction or abandonment of such well within a period of 30 days after completion of construction or abandonment, as required in the provisions of Article 7, Chapter 87 and Article 38, Chapter 143, General Statutes of North Carolina. The required completion report shall include the location, size, depth, casing record, method of finishing, formation log, static water level, yield data and records of any surveys, geophysical logs, tests, or water analyses. Samples of formation cuttings from all wells shall be furnished to the Board except when the Board specifies that such samples are not required. The required abandonment report shall include the location and method of sealing and plugging.

III. Requirements Applicable to Persons Withdrawing More than 100,000 Gallons Per Day but Less than 1 Million Gallons Per Day

A. Permits Required

1. Water Use Permit

(a) No person shall, after June 18, 1969 (as designated by the Board), withdraw, obtain or utilize surface waters or groundwaters, or both,

in excess of 100,000 gallons per day for any purpose unless such person shall first apply for a Water Use Permit therefor from the Board.

(b) Application for such Water Use Permit shall be submitted on a form approved by the Board. An approved form, entitled "Application for Water Use Permit in a Capacity Use Area", can be obtained from the Department of Water and Air Resources, P.O. Box 9392, Raleigh, N.C. 27603. The application shall describe the specific purpose or purposes for which the water will be withdrawn or used, and shall justify the quantity needed for each purpose. Each application submitted to the Department will be considered and acted upon as soon as practicable. Pending the Board's issuance or denial of a permit, the applicant may continue the same withdrawal or use which existed prior to the date of declaration of the capacity use area.

(c) Water Use Permits shall be issued for a period to be determined by the Board but not to exceed the longest of the following:

(1) 10 years, or

(2) the duration of the existence of the capacity use area, or

(3) the period found by the Board to be necessary for reasonable amortization of the applicant's water withdrawal and water using facilities.

(d) Each Water Use Permit shall be subject to review, modification or renewal by the Board as set forth in Section 143-215.15(c) of the General Statutes of North Carolina (Water Use Act of 1967). Holders of Water Use Permits will be expected to notify the Board of any major changes in usage. Review of Water Use Permits may require the justification of continuing needs and the documentation of all water conservation measures.

(e) Water Use Permits shall not be transferred except with approval of the Board.

(f) Water withdrawn under any Water Use Permit shall be used only for the purpose set forth in the Permit.

2. Well Construction Permit

(a) A Well Construction Permit shall be obtained prior to construction of each well.

(b) Application for a Well Construction Permit shall be made on Form GW22, "application for Permit to Construct a Well", which can be obtained from the Department. The application shall state the purpose of the well, and shall include (1) the proposed location, (2) construction specifications, (3) the estimated wthdrawal rate, (4) the location and ownership of all water-supply wells within a radius of 1,500 feet, and (5) such other information as the Board may reasonably deem necessary.

B. Withdrawal and Water-Level Controls Required

1. Total Quantity

The Water Use Permit issued by the Board shall establish the maximum total quantity that may be withdrawn daily, and may specify the timing of withdrawals.

2. Maximum Withdrawal Rates

Maximum rates of withdrawal of water from individual wells or surface-water intakes may be set forth in the Water Use Permit issued by the Board, when the Board determines that such control is required to conserve water or protect the water quality.

3. Maximum Drawdown Levels

The Water Use Permit may specify the lowest water level that may be produced in any well or wells.

4. Additional Provisions

The Water Use Permit shall be issued subject to such other provisions as the Board deems necessary to conserve or protect the water resources of the Capacity Use Area. The Permit may:

(a) Require that the applicant cooperate with the Department of Water and Air Resources, and with other users of water in the affected area, in determining and implementing reasonable and practical methods and processes to conserve and protect the water resources while avoiding or minimizing effects on the quantity and quality of water available to persons whose water supply has been materially reduced or impaired as a result of withdrawals made pursuant to Water Use Permits.

(b) Require that any portion of the water withdrawn be returned to the source or to any other stream or aquifer as approved by the Board.

(c) Require the holder of a Water Use Permit to obtain the Board's approval of the locations and distribution of individual surface-water intakes and wells, and of the depths, zones, aquifers or parts of aquifers from which withdrawals may be made.

(d) Require that each well or surface-water intake be equipped with an approved metering device that will provide a continuous record of withdrawals within an accuracy of plus or minus five percent.

(e) Require that observation stations or wells be installed and maintained for monitoring water levels and water quality.

C. Reports Required

Each person who withdraws, obtains or utilizes more than 100,000 gallons of water per day but less than 1 million gallons per day shall furnish reports to the Board on (1) well constrcution or abandonment, (2) withdrawals and use, and (3) water levels. Except when otherwise specified by the Board, these reports shall be as follows:

1. Well Record or Well Completion or Abandonment Report

Any person completing or abandoning any well shall furnish the Board, on Form GW-1, a certified record of the construction or abandonment of such well within a period of 30 days after completion of construction or bandonment, as required in the provisions of Article 7, Chapter 87 and Article 38, Chapter 143, General Statutes of North Carolina. The required completion report shall include the location, size, depth, casing record, method of finishing, formation log, static water level, samples of cuttings and records of any surveys, geophysical logs, tests or water analyses, and a description of the proposed device for metering withdrawals. The required abandonment report shall include the location and method of sealing or plugging.

2. Reports of Total Withdrawals and Use

Reports of total daily withdrawals for each calendar month, divided into quantities withdrawn or used for specific purposes, shall be furnished to the Board not later than 15 days after the end of each month. Categories of withdrawal or use shall be reported as follows:

Public Supply Systems

Total withdrawals

Self-Supplied Industries

(a) Processing

(b) Cooling

(c) Other

Agriculture

(a) Irrigation

(b) Other

3. Reports and Records of Withdrawals from Each Source

Monthly reports of daily withdrawals from each well or surface-water

intake shall be furnished to the Board not later than 15 days after the end of each calendar month. Withdrawals shall be measured by a method acceptable to the Board.

4. Reports of Water Levels

Monthly reports of water levels shall be furnished to the Board not later than 15 days after the end of each calendar month, to include the following: (a) the pumping water level for each supply well as measured with a steel or electric tape from a fixed reference point on Friday of each week. The measurements shall be within accuracy limits of plus or minus one percent, (b) The level of each surface water used as a source of supply, as measured from a fixed reference point on Friday of each week.

IV. Requirements Applicable to Persons Withdrawing 1 Million Gallons Per Day or More

A. Permits Required

1. Water Use Permit

(a) No person shall, after June 18, 1969 (as designated by the Board), withdraw, obtain or utilize surface waters or ground waters, or both, in excess of 1 million gallons per day for any purpose unless such person shall first apply for a Water Use Permit therefor from the Board.

(b) Application for such Permit shall be submitted on a form approved by the Baord. An approved form, entitled "Application for Water Use Permit in a Capacity Use Area" can be obtained from the Department of Water and Air Resources, P.O. Box 9392, Raleigh, N.C. 27603. The Application shall describe the specific purpose of purposes for which the water will be withdrawn or used, and shall justify the quantity needed for each purpose. Each application submitted to the Department

will be considered and acted upon as soon as practicable. Pending the Board's issuance or denial of a permit, the applicant may continue the same withdrawal or use which existed prior to the date of declaration of the capacity use area.

(c) Water Use Permits shall be issued for a period to be determined by the Board but not to exceed the longest of the following:

(1) 10 years, or

(2) the duration of the existence of the capacity use area, or

(3) the period found by the Board to be necessary for reasonable amortization of the applicant's water withdrawal and water using facilities.

(d) Each Water Use Permit shall be subject to review, modification or renewal by the Board as set forth in Section 143-215.15(c) of the General Statutes of North Carolina (Water Use Act of 1967). Holders of Water Use Permits will be expected to notify the Board of any major changes in usage. Review of Water Use Permits may require the justification of continuing needs and the documentation of all water conservation measures.

(e) Water Use Permits shall not be transferred except with the approval of the Board.

(f) Water withdrawn under any Water Use Permit shall be used only for the purpose(s) set forth in the Permit.

2. Well Construction Permit

(a) A Well Construction Permit shall be obtained prior to construction of each well.

(b) Application for a Well Construction Permit shall be made on Form GW22, "Application for Permit to Construct a Well", which can be obtained from the Department. The application shall state the purpose of the well, and shall include (1) the proposed location, (2) construction specifications,

(3) the estimated pumping rate, (4) the location and ownership of all water-supply wells within a radius of 2,500 feet, and (5) such other information as the Board may reasonably deem necessary.

B. Withdrawal and Water-Level Controls Required

1. Total Quantity

The Water Use Permit issued by the Board shall establish the maximum total quantity that may be withdrawn daily, and may specify the timing of withdrawals.

2. Maximum Withdrawal Rates

Maximum rates of withdrawal of water from individual wells or surface-water intakes may be set forth in the Water Use Permit issued by the Board, when the Board determines that such control is required to conserve water and protect the water quality.

3. Maximum Drawdown Levels

The Water Use Permit may specify the lowest water level that may be produced in any well or wells.

4. Additional Provisions

The Water Use Permit shall be issued subject to such other provisions as the Board deems necessary to conserve or protect the water resources of the Capacity Use Area. The Permit may:

(a) Require that the applicant cooperate with the Department of Water and Air Resources, and with other users of water in the affected area, in determining and implementing reasonable and practical methods and processes to conserve and protect the water resources while avoiding or minimizing adverse effects on the quantity and quality of water available to persons whose water supply has been materially reduced or impaired as a result of withdrawals made pursuant to Water Use Permits.

one percent.

(b) The level of each surface water used as a source of supply as measured from a fixed reference point on Friday of each week .

(c) The water level in observation wells other than supply wells as measured from a fixed reference point at intervals satisfactory to the Board.

5. Other Reports

The Board may require reports of other data pertinent and necessary to the evaluation of the effects of withdrawals.

Regulation of Other Activities that May Affect the Quantity or Quality of Water in the Capacity Use Area Involving Water Use, Development or Diversion

A. Activities Requiring Prior Approval by the Board

No construction or installation of works of improvement which may significantly affect the quantity or quality of the water resources shall be undertaken without prior approval from the Board. These include, but are not necessarily limited to, the following:

1. Surface Drainage Projects

(a) Any project involving the drainage or diversion of ponded or standing water, except water temporarily impounded as the result of flooding, from an area in excess of five acres.

(b) Application for approval of any such project shall include (1) a description of the area, (2) purpose of the project and method of drainage, and, (3) a general evaluation of the probable effects of the project on the water resources.

2. Subsurface Drainage Projects

(a) Any project involving whe withdrawal or diversion of ground water, except for the purpose of water supply or agricultural use, that will probably result in lowerering existing ground-water levels or artesian

head more than three feet for a period of one year in any area of more than five acres.

(b) Application for approval of any such project shall include a description of the area, purpose of the project and method of drainage, and a general evaluation of theprobable effects of the project on the water resources.

3. Well Mining Projects

(a) Any project involving the removal or extraction of minerals through wells.

(b) Application for approval of any such project shall include (1) a description of the location and extent of the area, (2) methods, procedures and processes of removal or extraction, (3) well-plugging and abandonment procedures, and (4) an evlauation of the effects on the water resources.

4. Excavation Projects

(a) Any project involving the excavation of any land that lies under water.

(b) Any project involving the excavation of any single area in excess of five acres to any depth below the highest natural level of ground water.

(c) Application for approval of any such projects shall include a description of the location and the extent of the area, purpose, depth, and excavation methods.

VI. Nonconsumptive Use Permits

When sufficient evidence is provided to the Board by an applicant for a water use permit that the water withdrawn or used from a stream or the ground is not consumptively used, a permit therefor shall be issued by the Board without a hearing and without the conditions provided for in G.S. 143-215.15(c) to implement the provision of G.S. 143-215.14.

VII. Confidential Information Concerning Formation Cuttings and Methods, Procedures or Processes

At the specific request of any person who is required, pursuant to these regulations, to furnish samples of formation cuttings, or who is required to divulge any methods,

procedures or processes, the Board and the Department shall treat as confidential the information furnished by that person to the Board or the Department concerning such samples of cuttings, methods, procedures or processes.

VIII. Severability

If any provision of these regulations, or the application thereof to any person or circumstances, is held invalid, such invalidity shall not affect other provisions or applications of the regulations which can be given effect without the invalid provision or application, and to this end the provisions of these regulations are declared to be severable.

Adopted by the Board of Water and Air Resources June 12, 1969.