POTENTIAL EFFECTS OF WITHDRAWALS FROM THE CASTLE HAYNE AQUIFER FOR EXPANDED PHOSPHATE MINING IN BEAUFORT COUNTY NORTH CAROLINA

BY

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INTRODUCTION

Dry open-pit mining of phosphate sands was begun in Beaufort County, North Carolina in 1965 by Texasgulf Inc. (TGI). Since that time, withdrawals of water from the Castle Hayne aquifer at the mine site near Aurora have continued at a rate ranging from about 50 million gallons per day (MGD) to more than 65 MGD. The resulting effects and projected effects of this withdrawal have been described in several reports, as indicated in the Bibliography. Projections of the long-range effects of withdrawals from the aquifer were made in a 1971 report prepared jointly by the State and independent consultants employed by the State, TGI and North Carolina Phosphate Corporation (NCP).

In the spring of 1975, an informal technical committee was formed to evaluate the effects on the Castle Hayne aquifer of an additional open-pit phosphate mine proposed by NCP at a site about 3 miles southeast of TGI mine. This committee includes all but one of the members of the Committee that prepared the joint report of 1971. In addition, it includes a groundwater consultant for the FMC Corp. The committee consists of the following persons:

M.L. Brashears, Groundwater Consultant for Texasgulf, Inc.

W.F. Guyton, Groundwater Consultant for Dept. of Natural & Econ. Res.

details in this report.

For reference, the cross section in Fig. 1 shows the principal hydrogeologic units. These include the three units of the Castle Hayne aquifer; the Pungo River unit, which is the phosphate ore body as well as a significant aquitard; the Yorktown unit, which serves both as an aquifer an an aquitard; and the post-Miocene unit which comprises the water-table aquifer.

Fig. 2 shows the depth to the top of the Castle Hayne aquifer system, which ranges from less than 20 feet below sea level in the western part of the area to about 600 feet in the eastern part of the area. In the area of open pit mining and proposed mining the top of the aquifer is about 110 to 150 feet below sea level. Dry open pit mining requires lowering the potentiometric surface of the aquifer to near the top of the aquifer.

Figure 3 shows the potentiometric surface of the Castle Hayne aquifer in June 1965, prior to the beginning of pumping at the TGI Lee Creek phoshphate mine. Figure 4 shows the potentiometric surface in January 1973 when the withdrawal rate was about 54 MGD at Lee Creek. Fig. 5 shows the potentiometric surface in January 1975 when the withdrawal rate was about 64 MGD.

Fig. 6 shows the potentiometric surface in July 1975 when the pumping rate was about 65 MGD. This map is significant because it includes new water level control points at Lake Mattamuskeet and near Columbia, which greatly changes the configuration of the 5-foot contour in that area. The configuration indicates substantial recharge in the Lake Phelps-New Lake area.

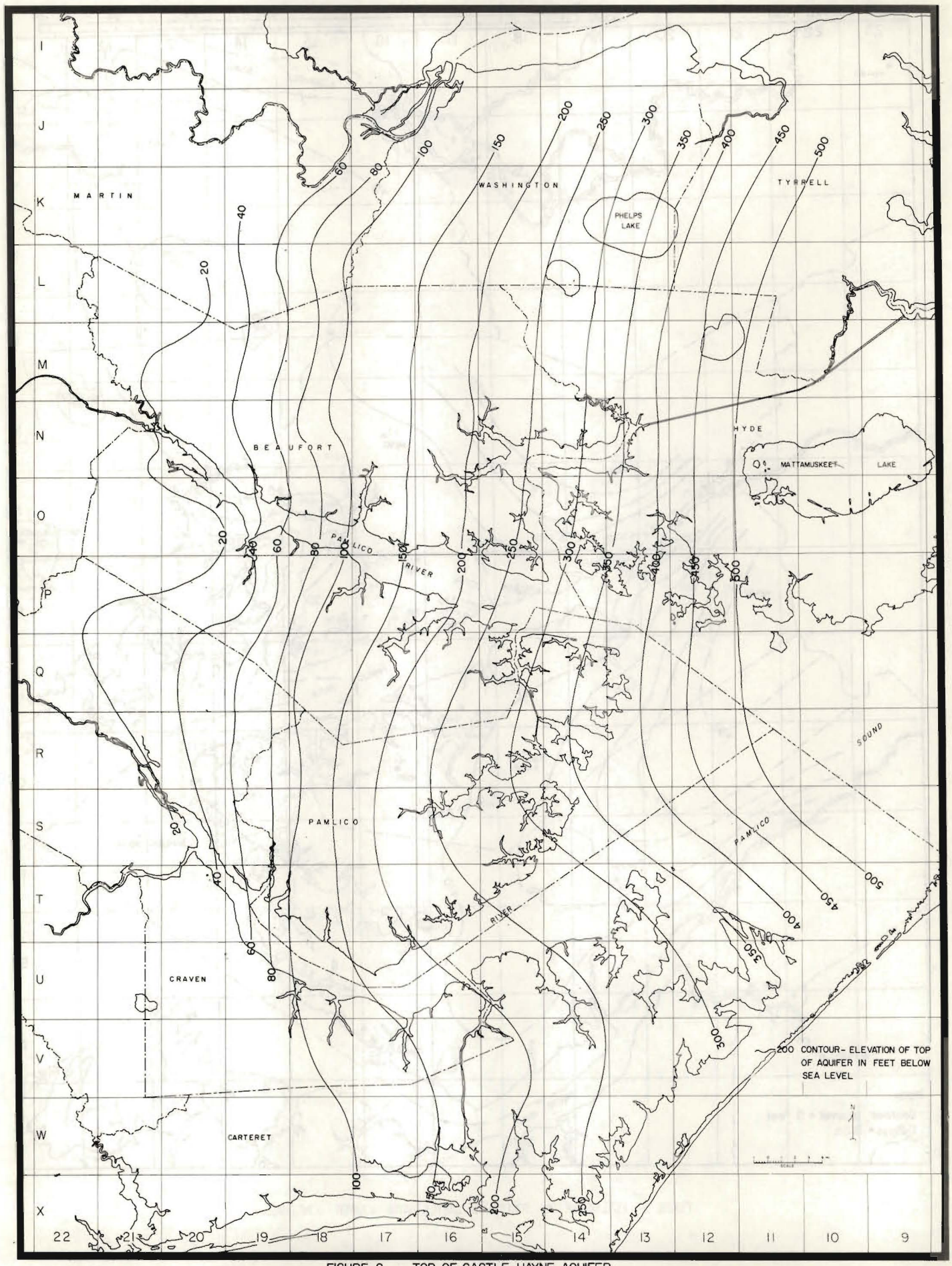

FIGURE 2 - TOP OF CASTLE HAYNE AQUIFER

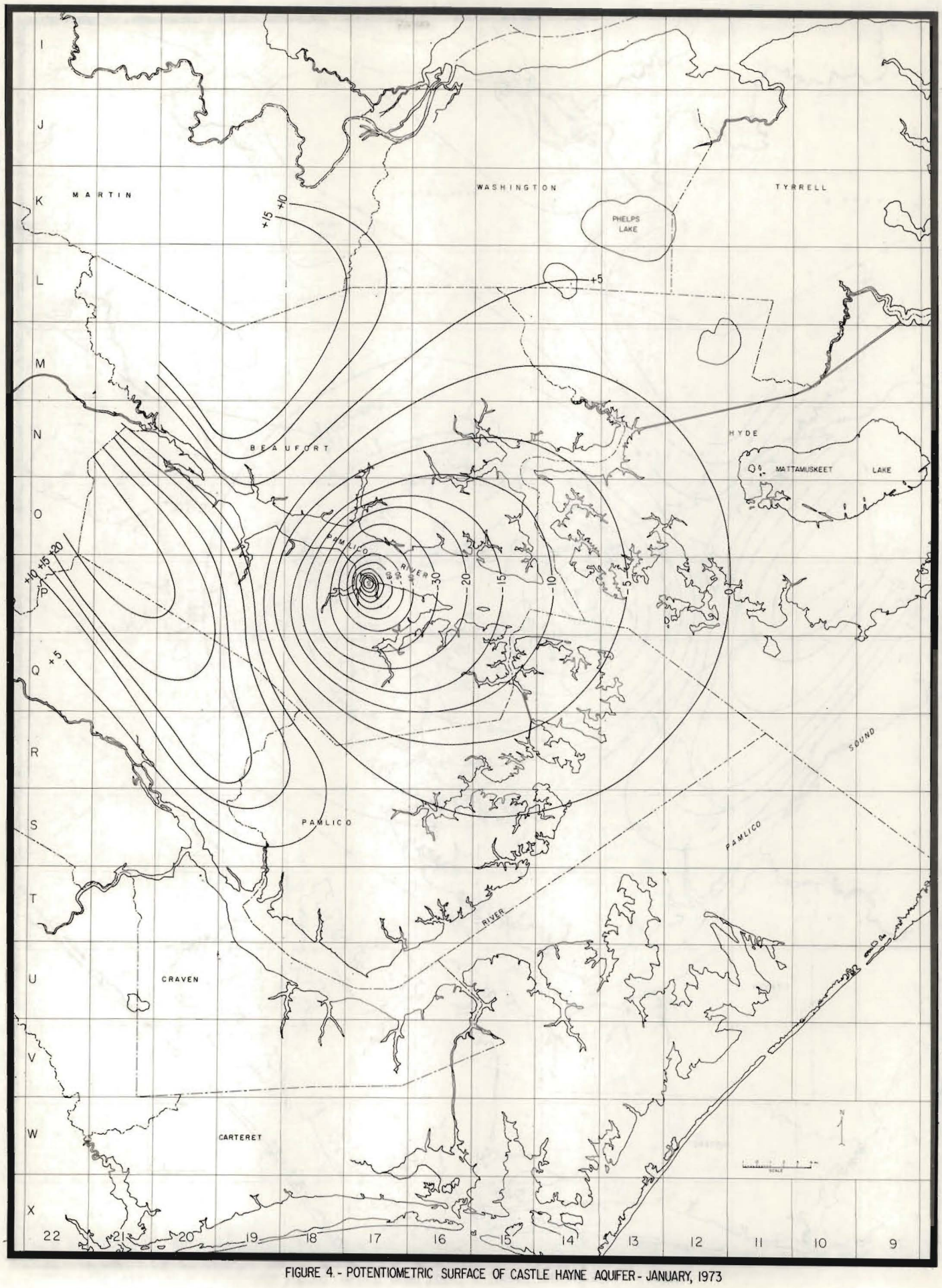

FIGURE 4.- POTENTIOMETRIC SURFACE OF CASTLE HAYNE AQUIFER- JANUARY, 1973

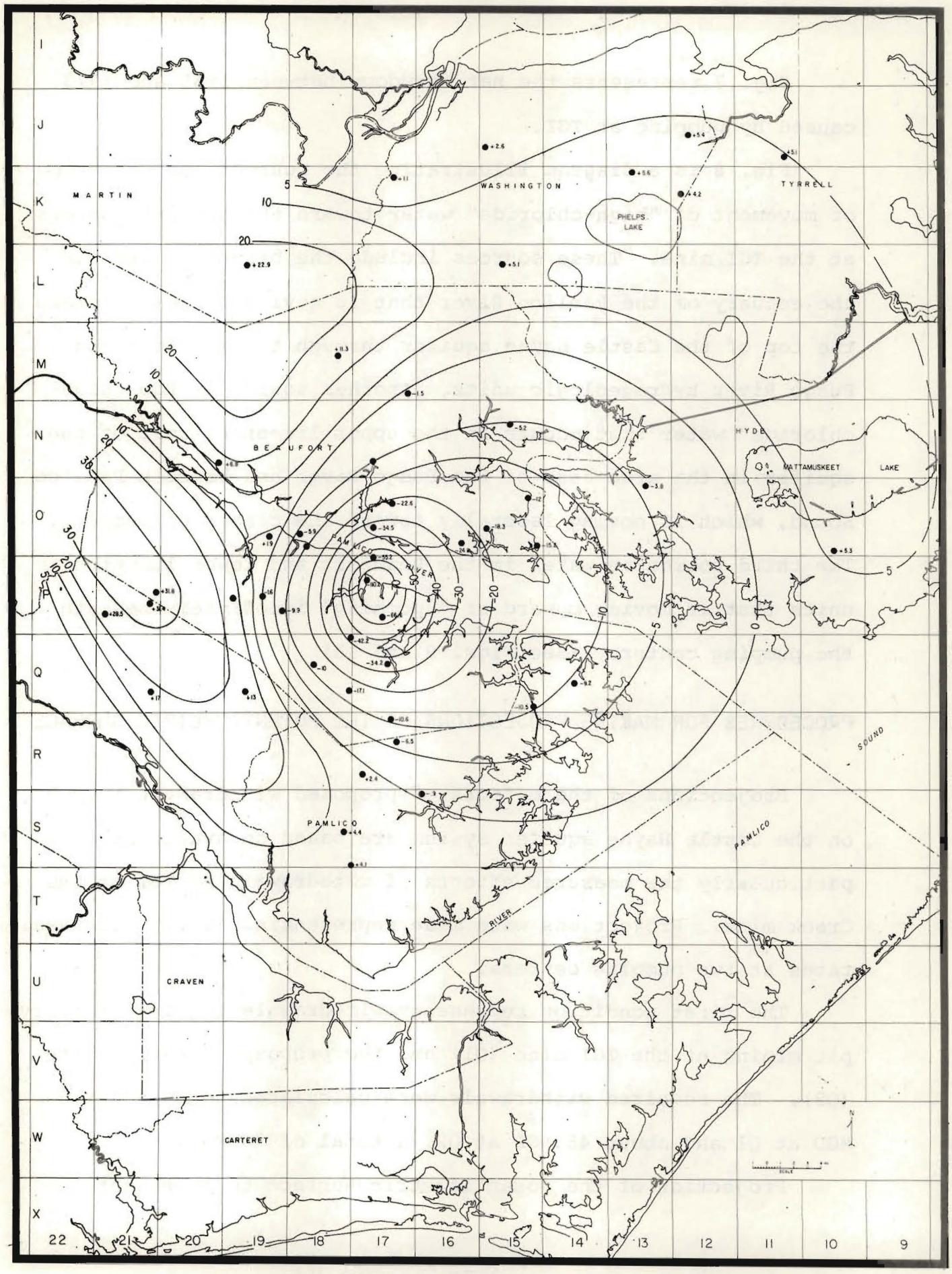

FIGURE 6.- POTENTIOMETRIC SURFACE OF CASTLE HAYNE AQUIFER - JULY, 1975

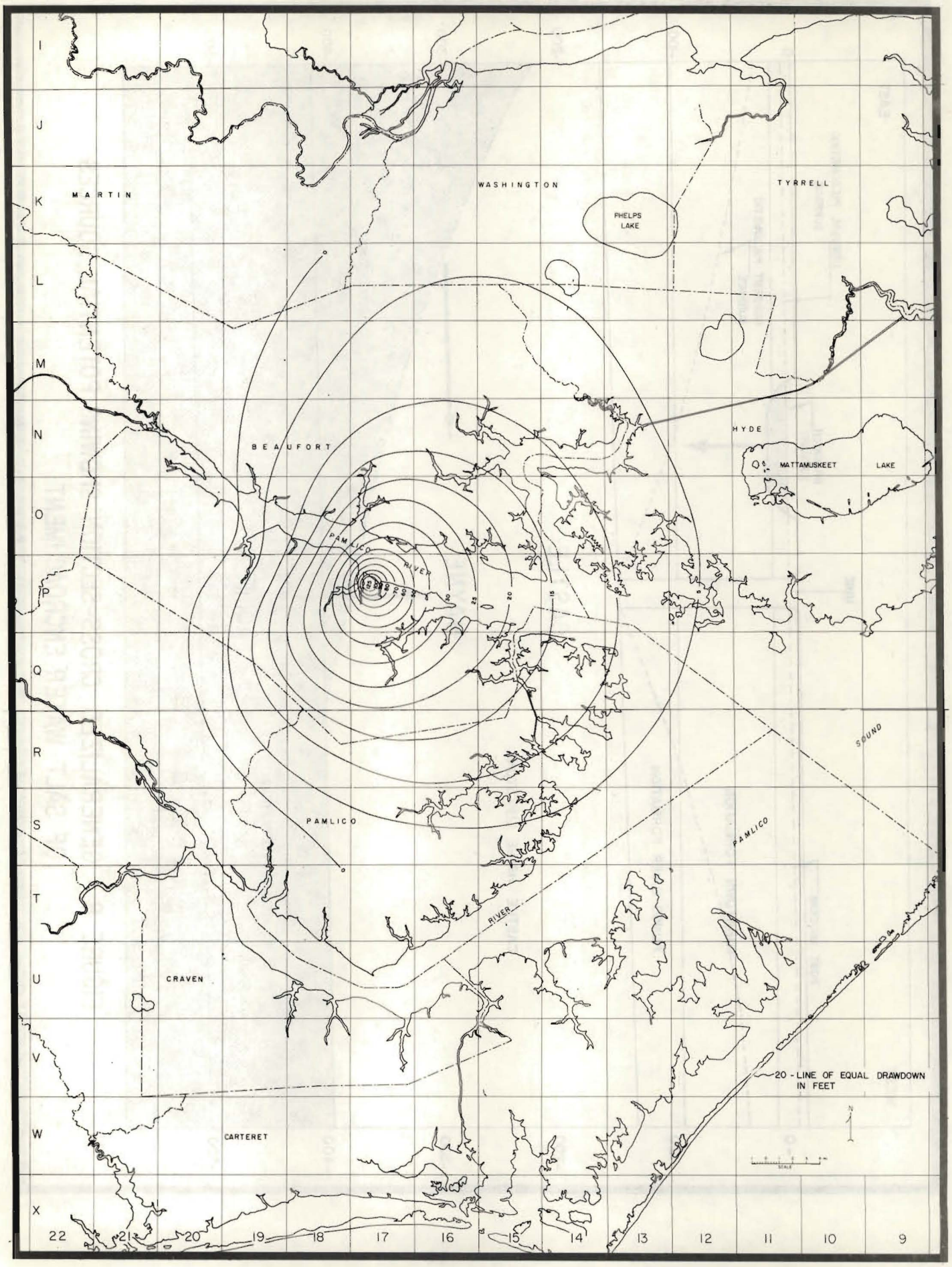

FIGURE 7 - NET DRAWDOWN OF POTENTIOMETRIC SURFACE OF CASTLE HAYNE AQUIFER- 1965-73

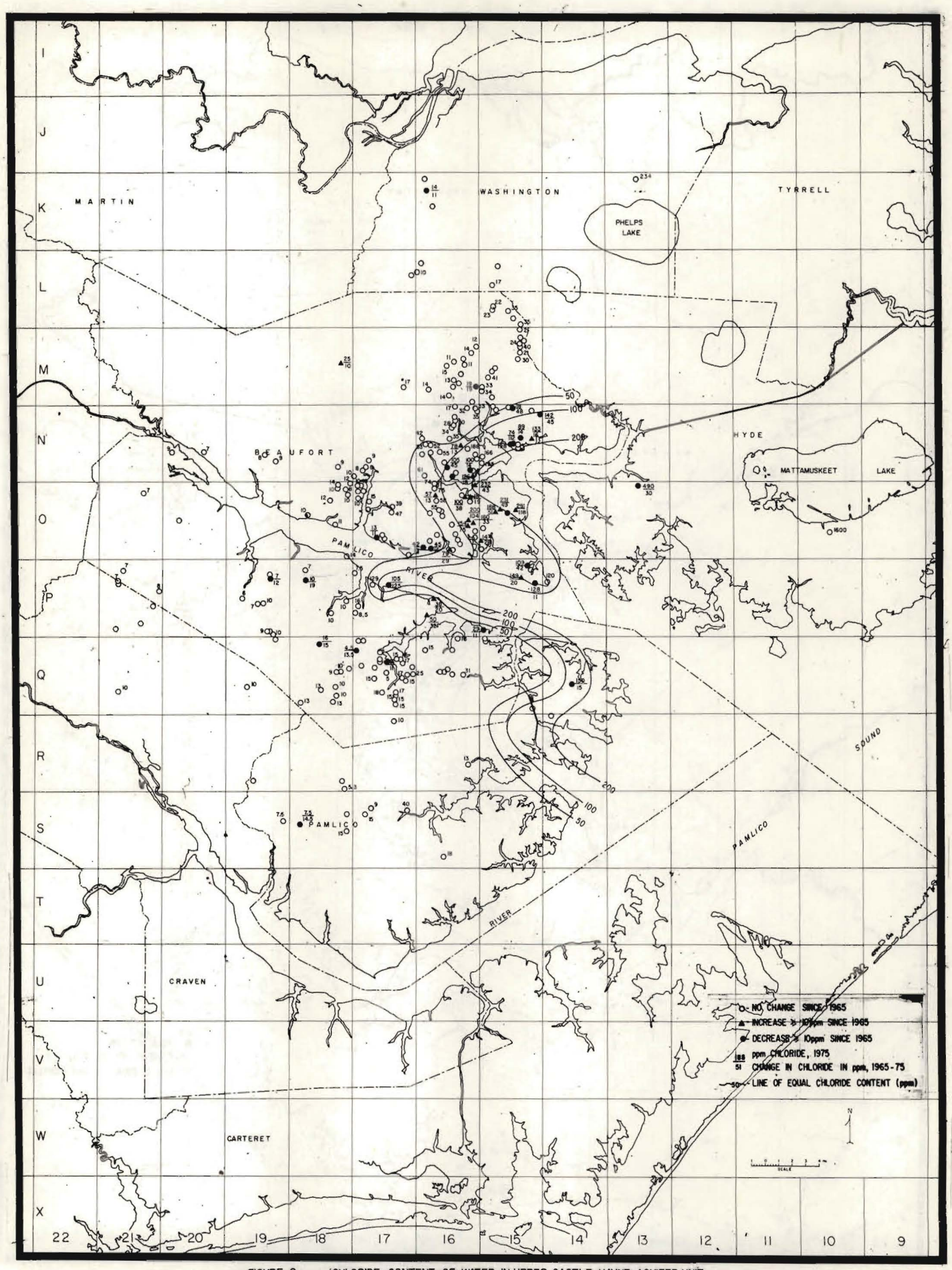

FIGURE 9.- CHLORIDE CONTENT OF WATER IN UPPER CASTLE HAYNE AQUIFER UNIT, JANUARY-FEBRUARY 1975 AND CHANGES SINCE 1965.

these withdrawals (Fig. 11) was accomplished by constructing a map of the net drawdown between June 1965 and January 1973, as shown in Fig. 7. This drawdown map was adjusted proportionally to represent withdrawal rates of 45 and 33 MGD at Q1. A composite of these drawdown maps was constructed, with the 33 MGD drawdown map centered at Q1 and the 45 MGD drawdown centered at Q2. The potentiometric map was constructed by subtracting the composite drawdown map from the 1965 potentiometric map.

The second condition represents withdrawal of 64 MGD at Q1 and 45 MGD at Q2 for a total withdrawal of 109 MGD (Fig. 12). This map was constructed by subtracting the 45 MGD drawdown map centered at Q2 from the January 1975 (64 MGD) potentiometric map.

The third condition represents a withdrawal of 64 MGD at Q1 and 54 MGD at Q2. The projected potentiometric map of a total withdrawal of 118 MGD (Fig. 13) is a composite of the potentiometric map of January 1975 and the potentiometric map of January 1973 centered at Q2.

Drawdown maps in Fig. 14, 15, and 16 represent the differences in the potentiometric surface of January 1975 and the projected potentiometric maps. Projections of lateral movement of "high-chloride" water through the upper Castle Hayne unit of the aquifer were made by using the transmissivity and permeability values determined from the potentiometric maps along approximately the same flow line in each case. Porosity values were taken from the 1971 joint report.

Projection of downward movement of high-chloride water from

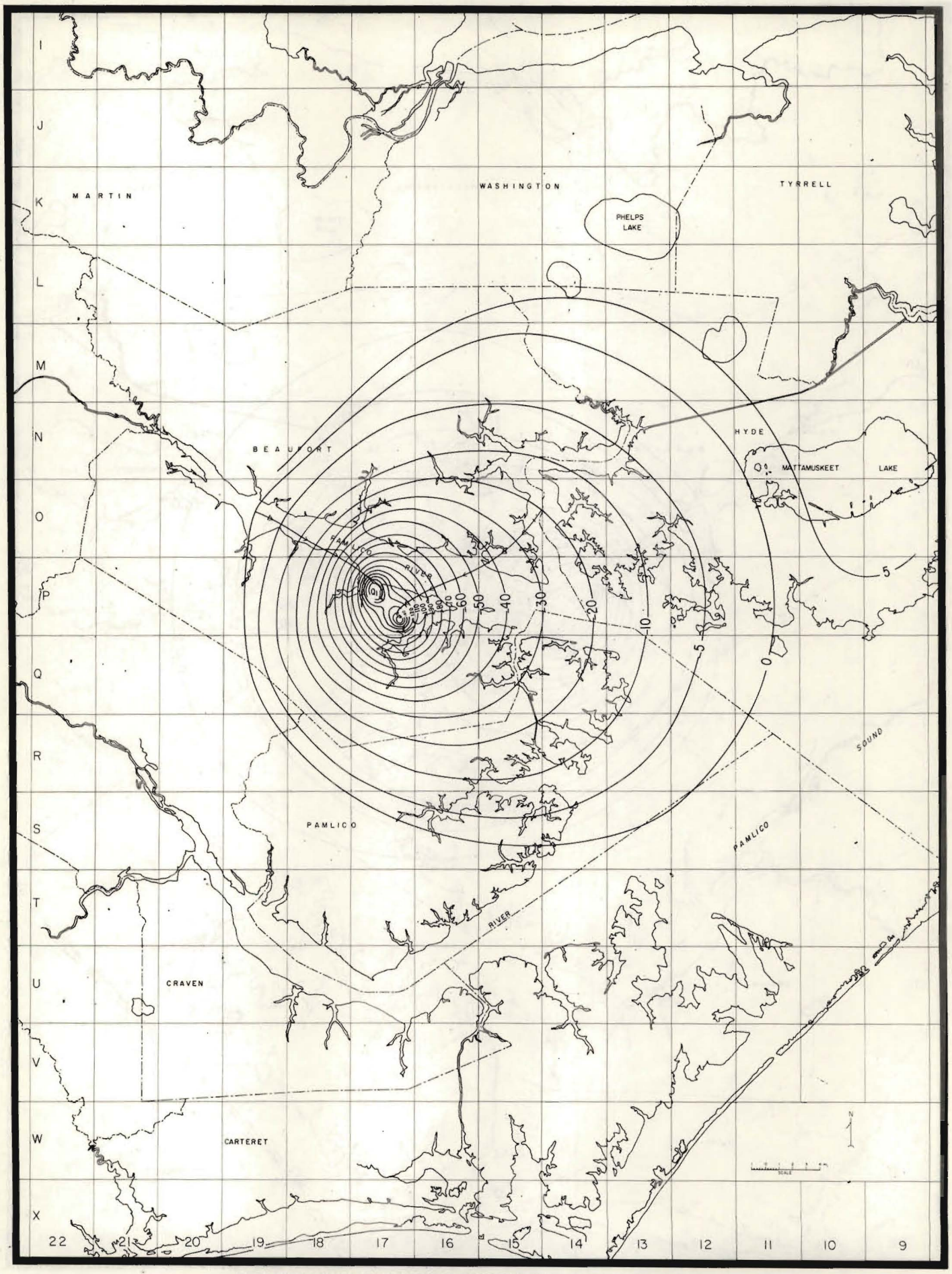

FIGURE 12.- PROJECTED POTENTIOMETRIC SURFACE FOR TOTAL PUMPAGE OF 109 MGD

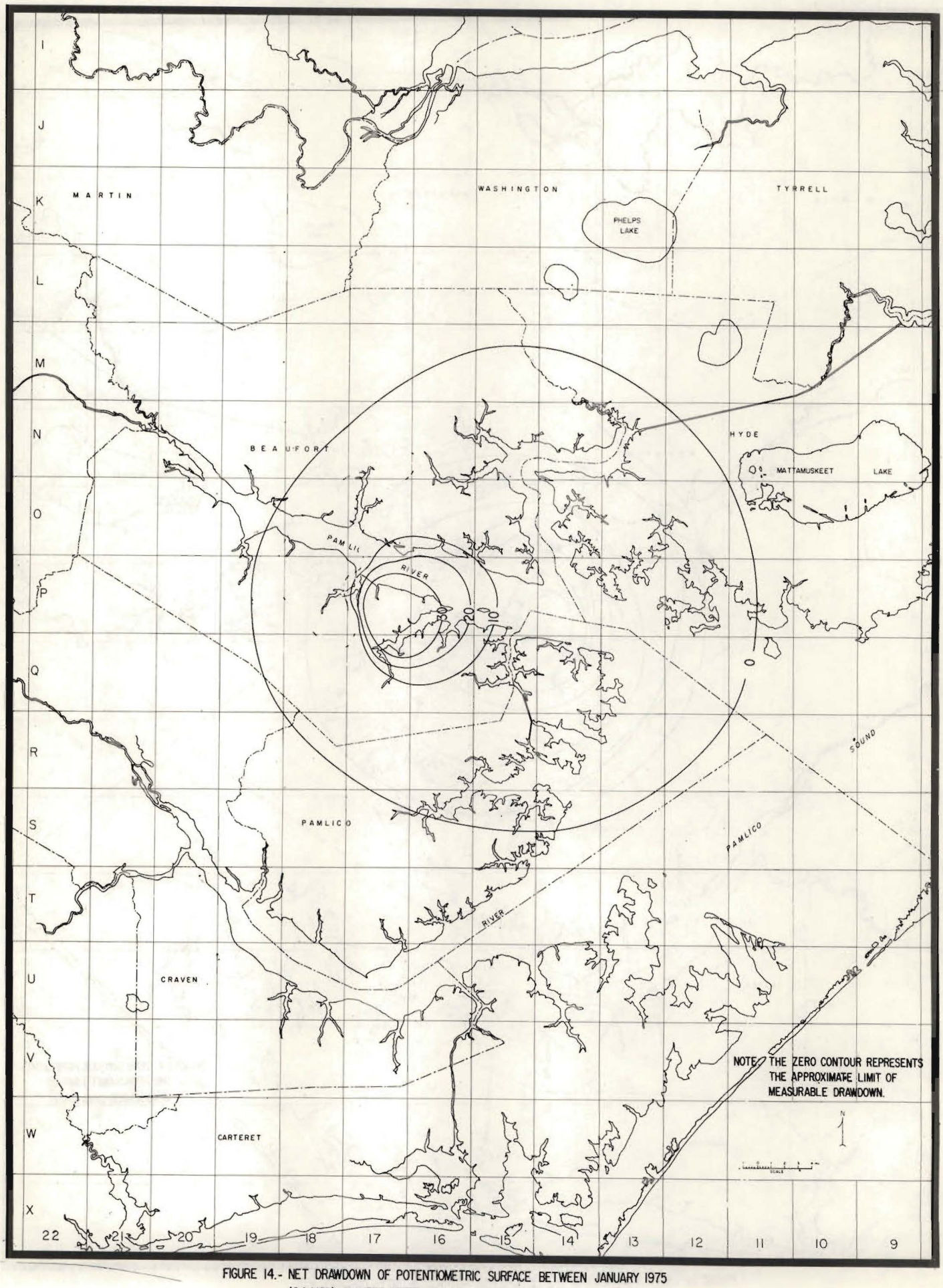

FIGURE 14.- NET DRAWDOWN OF POTENTIOMETRIC SURFACE BETWEEN JANUARY 1975 (64 MGD) AND PROJECTED 78 MGD

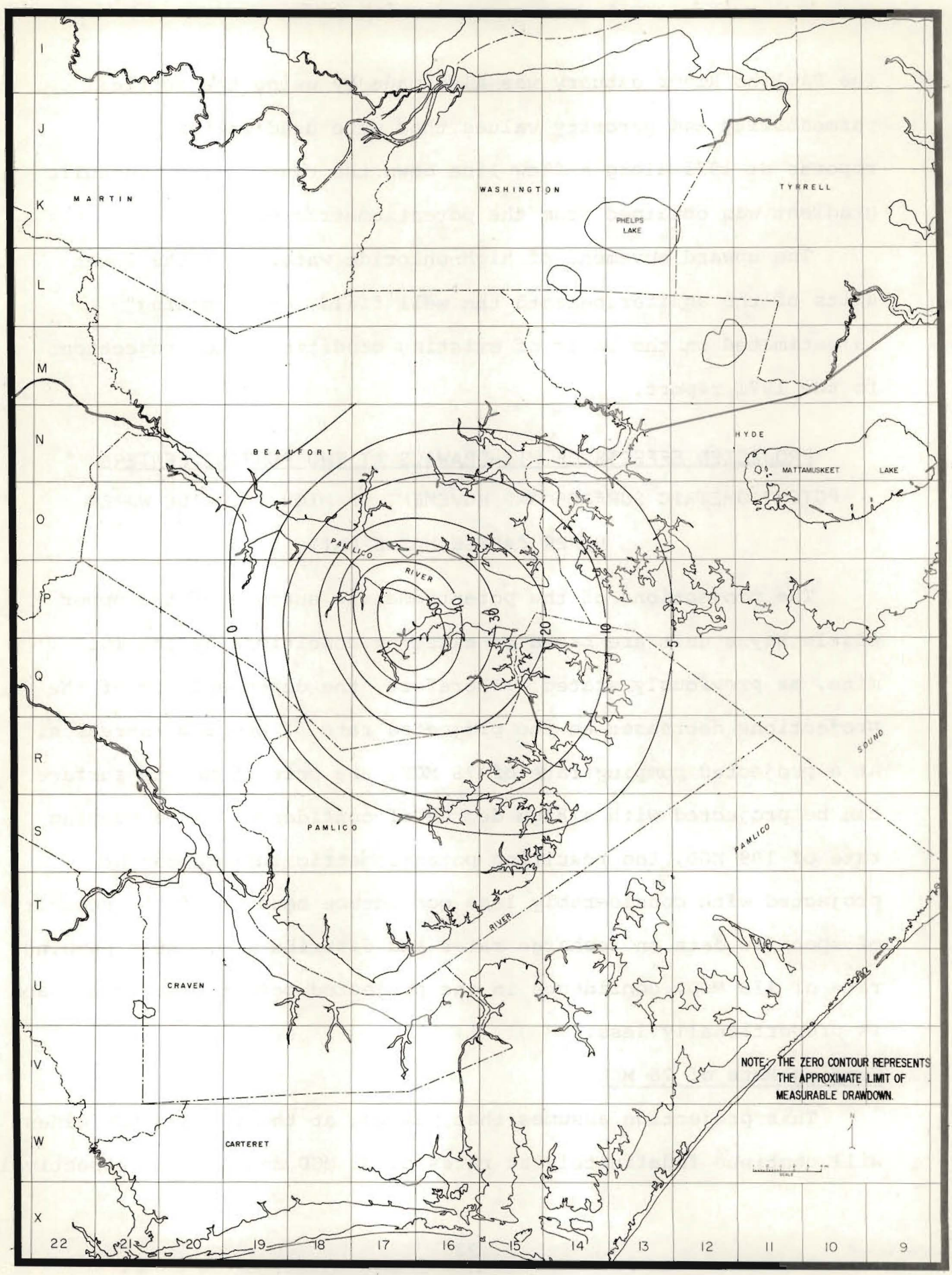

FIGURE 16.- NET DRAWDOWN OF POTENTIOMETRIC SURFACE BETWEEN JANUARY 1975 (64 MGD) AND PROJECTED 118 MGD

The effects on the potentiometric surface may be seen by comparing Fig. 5 and 11. The net drawdown caused by increasing the total withdrawal in the mine area from 65 MGD to 78 MGD is shown in Fig. 14. The area in which the drawdown is more than 10 feet is approximately 92 square miles. The area in which some drawdown occurs is more than 1000 square miles.

The lateral movement of high-chloride water through the aquifer from the Belhaven area along the selected flow line (See Fig. 11) is shown in Fig. 17. The rate of travel would be about 2.1 miles in 100 years.

The calculated time for downward movement of estuarine water to the top of the aquifer is shown in Fig. 18. The shortest time would be about 500 years.

It is estimated that upconing would be expanded to an area of 8 - 10 square miles because of the two pumping centers.

Pumping Rate of 109 MGD

This projection assumes that pumping at the TGS and NCP mines will continue indefinitely at the rate of 64 and 45 MGD respectively. The effects on the potentiometric surface are shown in Fig. 12. The net drawdown caused by increasing the total withdrawal in the area from 64 to 109 MGD is shown in Fig. 15. The area in which the drawdown is more than 10 feet is about 300 square miles, and more than 5 feet in an area of about 575 square miles. Some additional drawdown will occur in an area of more than 1100 square miles.

Lateral movement of high cloride water through the aquifer

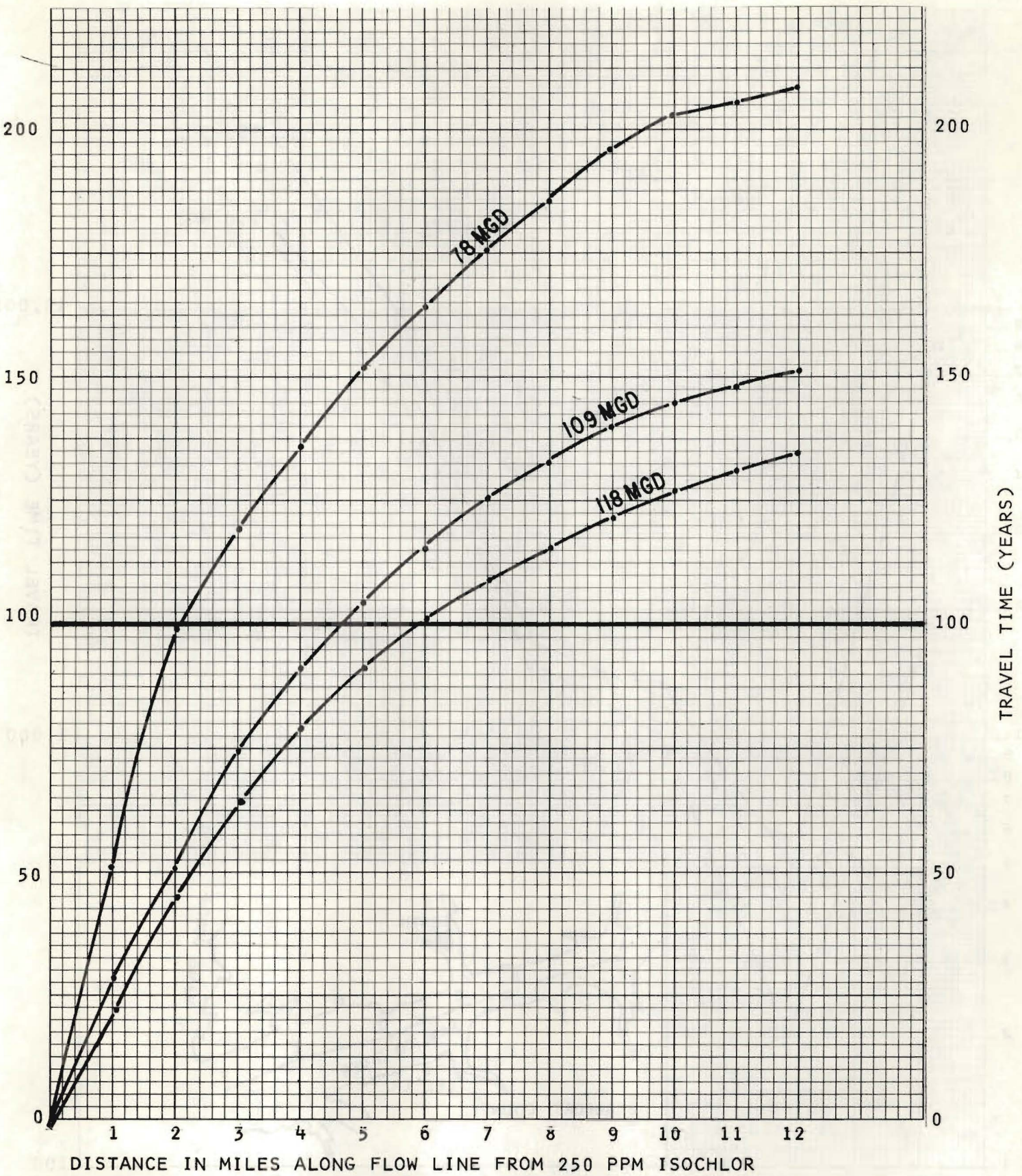

FIGURE 17. - PROJECTED RATES OF LATERAL MOVEMENT OF HIGH CHLORIDE WATER

EFFECTS ON OTHER HYDROGEOLOGIC UNITS

The potentiometric surface of the Beaufort sand unit should be very similar to the upper Castle Hayne unit, although the existing configuration has not been mapped in detail. Lateral movement of water through the unit will be extremely slow, and any changes in chloride content will be proportionally slow. Upconing from this unit will occur beneath the pumpimg centers.

The potentiometric surface of the lower Castle Hayne unit will be approximately the same as the upper unit. Movement of water through this unit will be very slow, but will cause changes in chloride content of the water.

The potentiometric surface of the Pungo River and Yorktown units will show the same general configuration as that of the upper limestone unit. The additional drawdown caused by pumping 109 MGD or greater may be significant at some places. The chloride content of the water in these units is expected to increase beneath salt-water bodies, so that thewater from wells pumping from these units near the estuary may eventually show an increase in chloride content.

EFFECTS OF PUMPING ON OTHER USERS

Domestic Users

The projected increases in pumping will affect domestic users over a large area, as indicated by the net drawdown projected in Fig. 14, 15, and 16. The differences in the

extremely slow rates. The total rise in chloride content in milligrams per liter (mg/l) will amount to a few tens to a few hundreds in 100 years. The chloride content will decrease in many wells.

Wells completed in the upper Castle Hayne unit, in the area where upconing will occur, may have a substantial increase in chloride content in a relatively short time. However, the areas of potential upconing contain few domestic wells.

Municipal Users

The projected increase in pumping is expected to have a significant effect on only a few existing municipal water supplies. The Town of Aurora will be substantially affected by any large increase in pumping. The additional drawdown at a pumping rate of 78 MGD will be about 10 feet. This additional drawdown and the proximity to the NCP pumping center will result in a greater pumping level in the municipal wells and may result in an increase in chloride content of the water from upconing. At a pumping rate of 109 MGD the drawdown will be about 30 feet, so that the potential for upconing of salt water beneath the municipal wells will be greatly increased.

The Town of Bath will be affected very little at a pumping rate of 78 MGD. At a pumping rate of 109 MGD, the effects may be similar to those expected at Aurora, but on a smaller scale.

The Town of Bayboro will have only a small increase in drawdown at a pumping rate of 78 MGD. At a pumping rate of 109 MGD, the drawdown will be several feet, but this should have very little

extensive droughts, when a regional drawdown may be created by irrigation wells, some upconing may occur in the future.

When the TGI pumping first lowered the water levels in irrigation wells in 1965, pumps were required on previously flowing wells, "shallow-well" pumps had to be replaced on others, and some wells had to be redrilled. Since adjustment for this initial effect, no problems with irrigation wells have been reported.

SUMMARY

A large quantity of data on the aquifer systems of Capacity Use Area 1 has been accumulated since 1964. Several reports have been prepared evaluating these data and the effects on the aquifer systems of large-scale pumping by TGI that began in 1965. The purpose of this report is to show the projected effects of expansion of dry open-pit phosphate mining proposed by NCP on the Castle Hayne and related aquifer systems.

Projections were made on the effects of total pumpage at two mine sites of 78, 109 and 118 MGD. These projections are based on available data and previous evaluation. The conclusions resulting from these projections are essentially the same as conclusions presented in the joint report of 1971.

The pumping rate of 78 MGD represents the minimum rate that will permit dry-pit mining with two pits at the proposed spacing of about 3 miles. Drawdown caused by the increase in pumping above the present 65 MGD would be 10 feet or more in an area of about 100 square miles. Lateral movement of high chloride water through

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