NM 65-C (N

ED 28

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Albuquerque, New Mexico

A progress report on the Malaga Bend Experimental Salinity Alleviation Project, Eddy County, New Mexico

By

E. R. Cox and J. S. Havens

Prepared in cooperation with the Pecos River Commission

Open-file 65-35

November 1965

Contents

Illustrations

(All illustrations in pocket)

Tables

(All tables at back of report)

A progress report on the Malaga Bend Experimental Salinity Alleviation Project, Eddy County, New Mexico

By

E. R. Cox and J. S. Havens

Abstract

At Malaga Bend on the Pecos River in Eddy County, New Mexico, a brine aquifer about 195 feet below the stream channel has a pressure head about 10 feet above the river bed. This aquifer normally discharges about 430 tons of dissolved minerals daily into the river of which about 370 tons was sodium chloride.

The Malaga Bend Experimental Salinity Alleviation Project, authorized by the U.S. Congress in 1958, Public Law 85-333,is an attempt to determine if the salinity content of the Pecos River below Malaga Bend can be decreased by reducing the inflow of saline water into the river at Malaga Bend by pumping from the brine aquifer.

Construction for the project was supervised by the Bureau of Reclamation, and the collection of data and its interpretation were the responsibility cooperatively of the U. S. Geological Survey and the Pecos River Commission.

Construction for the Malaga Bend Experimental Salinity Alleviation Project began in 1962 and was completed in 1963. An old observation well was rehabilitated to be used for the pumping of brine from the aquifer and an 8-inch asbestos-cement plastic line was built to the Northeast Depression located about 1 1/3 miles southeast of the brine well.

The Northeast Depression had been selected as the most suitable place to store the brine after a study had been made of several other sites including the possibility of underground storage. The floor of the depression and part way up the sides was compacted to retard brine leakage from the depression.

The pump was started at noon July 22, 1963. The brine was pumped at about 550 gpm from July 22, 1963, to noon November 22, 1963, at about 325 gpm from noon November 22, 1963, to noon March 23, 1964, and at about 450 gpm thereafter.

The sodium chloride load in the river at Malaga Bend began to decline in early August 1963. The average gain in chloride load between Fishing Rock Crossing (at the upper end of Malaga Bend) and Pierce Canyon Crossing (downstream from Malaga Bend) declined from 258 tons per day in July 1963 to 66 tons per day in August 1964, about 75 percent.

A problem has developed in connection with possible leakage of brine from the Northeast Depression. Leakage was indicated by increases in the chloride content of water in three observation wells near the depression. During the year August 1963-July 1964, inflow to the depression was about 700 acre-feet, evaporation was about 304 acre-feet, and change in storage accounted for 288 acre-feet. Leakage from the depression, therefore, was about 108 acre-feet or about 15 percent of the total inflow to the depression.

The stage at which brine would spill from the Northeast Depression (23.3 feet) would be reached late in 1967 at a pumping rate of 460 gpm if leakage is disregarded. At a stage of 20 feet, the yearly evaporation would be as much as the yearly pumping at a rate of 300 gpm.

Evaluation of the factors that control the leakage from the Northeast Depression, the quantities of brine involved and the direction and rate of its movement must await the collection and analysis of additional data. It is possible that other storage must be found.

Introduction

The purpose of this report is to present and evaluate all pertinent data through 1964 for the Malaga Bend Experimental Salinity Alleviation Project. The objective of the project is to determine the effect on the quality of water in the Pecos River by the removal through pumping of ground-water brine discharging to the river.

Studies indicated that the discharge of the brine to the river could be reduced substantially by pumping at least 300 gpm from a well completed in the brine aquifer at a depth of 195 feet below the river (Hale, Hughes, and Cox, 1954, p. 36). The disposal of the brine pumped from a well at Malaga Bend was a problem that required considerable study. A cursory examination indicated that the brine could be diverted to a nearby natural depression for disposal where it would evaporate leaving a solid salt residue.

The possibility of using the Queen Lake Depression, near Malaga Bend, for a disposal area for brine was considered. Large quantities of brine, however, would leak from Queen Lake at moderate and high lake stages without expensive artificial treatment of the lake floor (Cox and Havens, 1961, p. 52-53).

A large salt lake about 5 miles north of Malaga Bend used by a potash company for disposal of brine from their processing plant was considered as a disposal area for brine from Malaga Bend. The potash company that owns the lake, however, after careful consideration, declined a request to store brine from Malaga Bend in their lake.

Consideration was given to storage of the brine in plastic-lined ponds near Malaga Bend. This plan was too expensive for funds available for the project.

The feasibility of injecting brine from Malaga Bend into a deep-lying aquifer, the Delaware Mountain Group of Permian age, was investigated. From 300 to 600 gpm of brine probably could be injected into the Delaware under gravity flow, but chemical reactions between the two brines would probably form chemical precipitates that might clog an injection system without expensive treatment (Cox and Kunkler, 1962, p. 66-67).

Because large surface disposal areas for brine were either not watertight under natural conditions or not available and underground storage was not feasible, the Pecos River Commission selected the Northeast Depression as the brine-disposal area. The Northeast Depression is large enough to provide storage to evaluate the effects of pumping from the brine aquifer to reduce brine discharge to the river. Funds were available to treat part of the depression to reduce leakage.

Construction for the Malaga Bend Experimental Salinity Alleviation Project, authorized by the U.S. Congress in 1958 (Public Law 85-333), began in 1962 with the rehabilitation of an old observation well to be used for pumping brine. Construction was completed in 1963. At noon July 22, 1963, pumping of brine began at a rate of about 550 gpm. Data were collected before and after pumping began.

This progress report compares the data on the salt content of the river above and below Malaga Bend, before and after pumping the ground-water brine, to determine the effectiveness of the pumping on reducing the salt content in the Pecos River water. It also describes the problem of disposing of the pumped brine and the new problem that has developed in connection with apparent leakage from the present disposal lake in the Northeast Depression. Evaluation of the factors that control this leakage, the quantities of brine involved and the direction and rate of its movement must await the collection and analysis of additional data.

Construction for the project

The main parts of the Malaga Bend project were constructed under three contracts administered by the U.S. Bureau of Reclamation. The first contract involved a brine-production well. An old test well, 16.133 (USGS 8), drilled in 1939 was rehabilitated by pulling the old 8-inch steel casing and reaming the well to 16 inches in diameter to a depth of 195 feet, at the top of the brine aquifer at Malaga Bend. Twelve-inch plastic casing was cemented in the new well and the well was drilled 11 inches in diameter below the plastic casing to a depth of 223 feet. An 8-inch steel pipe about 43 feet long with the bottom 20 feet slotted with $\frac{1}{4}$-inch by 4-inch slots was placed in the well as a liner. Gravel was placed between the liner and the walls of the well. After completion, the well yielded 600 gpm of brine with a drawdown of about 42 feet during a 24-hour test.

The second contract involved the brine-disposal system for the project. This included: (1) An embankment to raise the land surface at the production well even with the nearby terrace to protect the well from large floods in the Pecos River; (2) furnishing and installing a pump, pumphouse, and brine meter; (3) an 8-inch, asbestos-cement pipeline from the well to the brine-disposal area (the Northeast Depression); and (4) drilling and casing 10 observation wells around the brine-disposal area.

The pump was a 5-inch submergible type capable of pumping 450 gpm against a head of 160 feet of water. It had a Monel metal shaft and corrosion resistant nickel alloy diffusers and impellers. The electric motor was 60 cycle, 440 volt, three phase, and rated at 40 horsepower. The pump was installed at a depth of 175 feet below land surface. The submergible pump failed in April 1964 and was replaced with a turbine pump. The pump failure apparently was not caused by contact with the brine.

The pumphouse is an 8-foot square metal prefabricated building mounted on a concrete floor. The building may be lifted from the floor to service the pump and the well. The meter is a 6-inch Sparling salt-water type with a dial that registers discharge from 90 to 900 gpm and a totalizer that registers in thousandths of an acre-foot up to 1,000 acre-feet. The discharge indicator oscillated and was not dependable. A new meter head was installed in August 1963, but that indicator also oscillated. In August 1964, the meter failed completely and was returned to the factory for repair. A new meter was installed in January 1965; the discharge indicator oscillates only slightly.

The pipeline extends 10,456 feet from the blowoff structure, adjacent to the pumphouse, to the venting structure at the edge of the Northeast Depression. The pipeline rises continually throughout its length and is buried to a depth of at least 2 feet. The pipe is 8 inches in diameter, asbestos-cement type with an epoxy coating inside the pipe. The epoxy coating was provided at no cost by the manufacturer for experimental purposes. The blowoff structure is at the lower end of the pipeline and has a valve with which to drain the pipeline. The venting structure is an open concrete box where gases associated with the brine escape to prevent accumulation in the uppermost part of the pipeline. A 6-inch diameter, plastic pipe, joined in 30-foot lengths, extends from the venting structure to the bottom of the Northeast Depression. This plastic pipe lies on the ground surface and lengths can be removed as the depression fills.

The observation wells were drilled near the Northeast Depression to obtain water-level and quality-of-water data to help evaluate the effectiveness of the depression as a disposal area for brine. Some wells drilled prior to 1962 also are used for measuring water levels and collecting water samples. The wells were reamed to 6 inches in diameter and drilled to a depth 20 feet below the top of the water-bearing zone. They were equipped with 2-inch diameter plastic casing that was slotted opposite the water-bearing zone, and were gravel packed. That part of the casing above land surface is steel pipe. The locations of observation wells used in this study are shown in figure 1.

Figure 1 (caption on next page) belongs near here.

Logs of wells drilled near the Northeast Depression in 1962 are shown in table 1.

The third contract involved clearing and compacting the floor and lower slopes of the Northeast Depression and fencing the entire disposal area. Lack of funds would not permit clearing or compacting the remaining part of the depression. The bottom 52.8 acres (to altitude 2,938 feet) was cleared and plowed to a depth of 18 inches. Brine was used to bring the soil to optimum moisture content. The upper 18 inches was compacted to at least 98 percent of maximum density. Then the compacted area was covered with 6 inches of soil to prevent drying of the compacted layer.

The Bureau of Reclamation established a grid system in the depression, locations and altitudes of the observation wells, and topography of the depression after the compaction had been completed.

Figure 1.--Map showing locations of wells, depressions, pipeline, and river-sampling sites in the Malaga Bend area, Eddy County, N. Mex.

In addition to the three contracts administered by the Bureau of Reclamation, miscellaneous items were constructed by the Geological Survey from project funds. These items were: (1) Roads to the observation wells; (2) a fence around a weather station near the Northeast Depression; (3) an evaporation pan; (4) two sets of staff gages in the depression; and (5) markers to measure the thickness of salt crust in the depression. The Geological Survey provided weather instruments other than the evaporation pan.

The weather station is in a swale so that it is similar to the Northeast Depression in altitude and exposure to prevailing winds. The altitude at the center of the Northeast Depression is about 2,929 feet and at the weather station about 2,933 feet. Instrumentation includes a recording rain gage, a wedge-type rain gage, an anemometer, a hygrothermograph, a maximum-minimum thermometer, and a recording evaporation pan. The evaporation pan consists of a 4-foot diameter open pan (standard class A land pan) connected by 1-inch diameter galvanized pipe to a covered reservoir 5.65 feet in diameter with twice the open pan capacity. A $\frac{1}{4}$-inch copper tube soldered in the cover of the closed pan provides venting and an opening for the recorder float line. Both pans are set on 2-inch by 4-inch wooden support which allows about 4 inches for air circulation beneath the pans. A weekly recorder, calibrated in thousandths of a foot, is connected to a 12-inch plastic float in the closed pan.. (See fig. 1A.)

Figure 1A (caption on next page) belongs near here.

Figure 1A.--View of evaporation pan and the weather station near the Northeast Depression.

Figure 1A.--View of evaporation pan and the weather station near the Northeast Depression

Methods of investigation

Data on ground-water levels, streamflow, and quality of water have been collected in the Malaga Bend area for many years. Part of these data were collected during previous investigations for the Malaga Bend project and part were collected as basic data on the quality and quantity of streamflow. No attempt is made in this report to present all data available before pumping of brine began at Malaga Bend. Only those data that compare with data collected after pumping began are presented.

Hydrologic data were collected before pumping began to determine natural conditions for comparison with data collected at a later date. Water-level recorders were installed on 10 wells in the Malaga Bend area (fig. 1). Water samples were collected at regular intervals from 17 wells around the Northeast Depression and from 4 sites on the Pecos River. In addition, the Malaga Bend reach of the river (Fishing Rock Crossing to near well USGS 11, fig. 1) was sampled at 4 sites for a 24-hour period July 16-17, 1963. Miscellaneous streamflow measurements were made at all the sampling sites and the streamflow was either measured or estimated at the time each sample was collected.

Water samples have been collected weekly from the Pecos River at Fishing Rock Crossing, near well USGS 11, and at Pierce Canyon Crossing since July 26, 1963, and at Lower Wading Station since March 13, 1964, to determine the effects of pumping on the mineral load in the river. Staff gages were installed at Fishing Rock Crossing and near well USGS 11, and ratings were made from discharge measurements so that chloride load in the river could be determined for each sample collected. The Malaga Bend reach of the river was sampled at 3 sites for a 24-hour period in August 1964 to determine changes in the chloride load in the river since the similar test in July 1963 before pumping began.

In addition to nearly continuous water-level data from the recorder wells,,water levels have been measured monthly since November 1962. Additional water-level measurements are made in 17 wells around the Northeast Depression when water samples are collected. Therefore, water levels are measured semimonthly in these 17 observation wells.

Continuous data on evaporation, precipitation, temperature, and relative humidity have been collected from recording instruments at the weather station near the Northeast Depression since pumping began. Water for the evaporation pan is air-lifted from well 19.421. Water levels in the closed pan are determined at midnight to the nearest thousandth of a foot from the recorder chart and multiplied by three to give daily evaporation. The water level in the open pan is measured with a hook gage in a stilling well in the pan weekly or after filling the pans. The anemometer dial is read at the same time to the nearest tenth of a mile of cumulative miles of wind movement. Non-recording, wedge-type rain gages were set up in the Northeast Depression and near the pumphouse. A microbarograph is in the pumphouse.

The project area has been visited by Geological Survey personnel at least weekly since pumping began. During each visit, the weekly recorders on observation wells and weather instruments are serviced, the weekly water samples are collected from the Pecos River, and the brine meter and the electric meter are read. Also, the staff gages in the Northeast Depression are read, the water level in the pumped well is measured, and weather observations are made. Personnel from Red Bluff Water Power Control District visit the area at least weekly to check on the operation of the pump. At that time, the brine meter and the electric meter are read. The Red Bluff district is responsible for the operation and maintenance of the pumping plant, pipeline, and brine-storage area.

The pumping rate was reduced from 550 to 325 gpm on November 22, 1963, and increased to 450 gpm on March 23, 1964, to observe effects due to different pumping rates (table 2).

Well-numbering system

The system of numbering wells in this report is that used by the Geological Survey and the State Engineer in New Mexico. The well number locates the well to the nearest 10-acre tract in the land net. The series of numbers corresponds to the township, the range, the section, and the tract within the section as shown in figure 2. The letter "a" is added to the well number to designate

Figure 2 (caption on next page) belongs near here.

the second well in a 10-acre tract. Because most wells in this project area are in T. 24 S., R. 29 E., the numbers denoting the township and range are omitted for wells in that township. Field numbers also have been added in this report for some wells drilled during earlier investigations. Wells whose numbers include "USGS" in parentheses are observation wells drilled with cable-tool drills under contract with the Geological Survey.

Figure 2.--System of numbering wells in New Mexico.

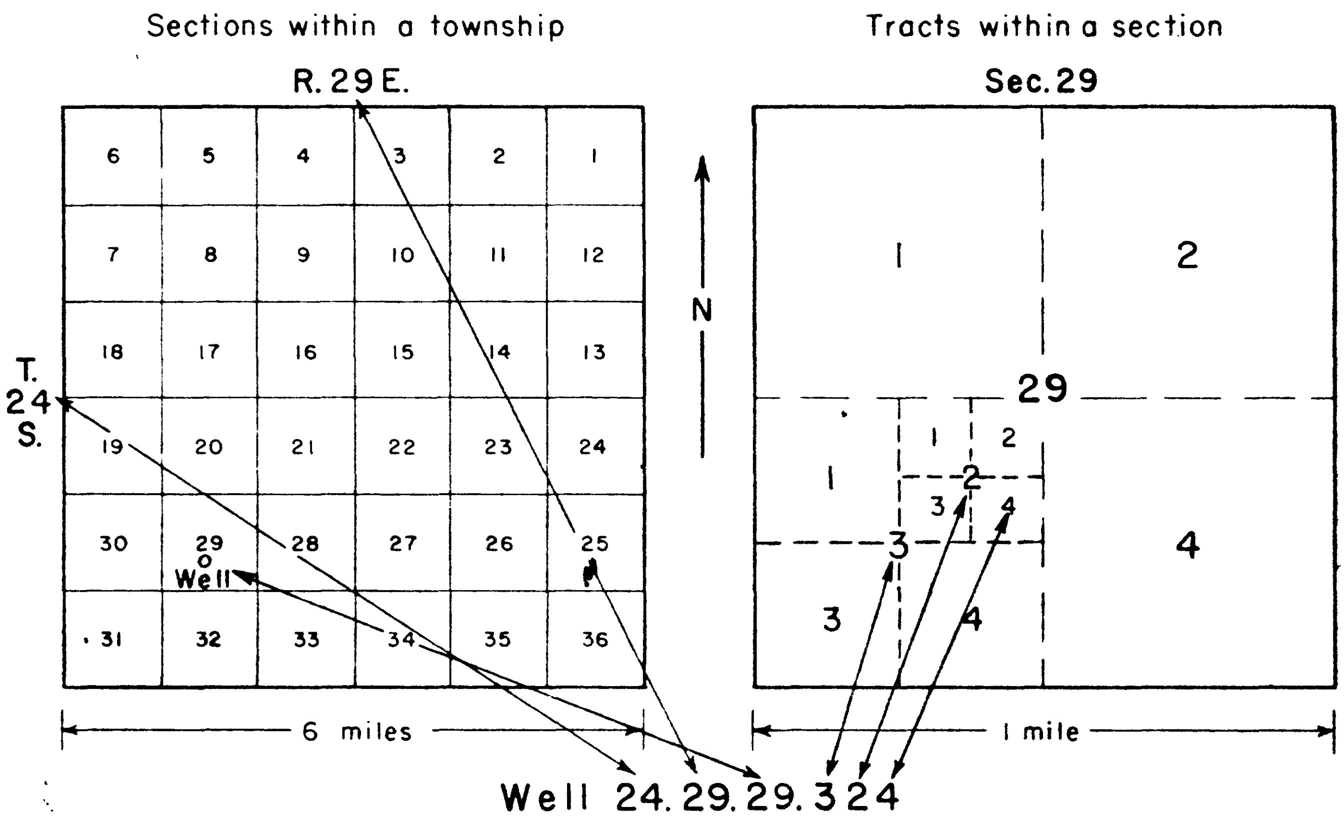


Figure 2.--System of numbering wells in New Mexico

Occurrence of water in the Malaga Bend area

The Rustler Formation of Late Permian age and alluvium of Quaternary age contain water that affects the Malaga Bend Experimental Salinity Alleviation Project. Two zones of the Rustler contain water. Saturated brine occurs at the base of the Rustler just above salt of the Salado Formation of Late Permian age under sufficient pressure to rise through the overlying rocks and discharge into the Pecos River at Malaga Bend. Higher in the Rustler the Culebra Dolomite Member contains confined water. Test wells penetrated little or no water other than in these two zones of the formation. The Culebra has slumped because of solution and is not continuous at all places in the Malaga Bend area, especially in the depressions.

The alluvium contains either confined or unconfined water where it is thick enough to extend into the zone of saturation. It contains water at Malaga Bend, Queen Lake, and nearby depressions. The brine aquifer, the aquifer in the Culebra, and the aquifers in the alluvium are connected hydraulically, at least locally. Leakage from the Northeast Depression will probably move through alluvium and solution channels in the Culebra to the Pecos River.

The piezometric surface of the brine aquifer was almost level at an altitude of about 2,900 feet at Malaga Bend before pumping began. For example, the piezometric surface on July 19, 1963, was at altitude 2,899.7 feet in wells 16.133 (USGS 8) and 17.444 (USGS 11), at altitude 2,900.0 feet in well 16.311 (USGS 1), and at altitude 2,900.3 feet in well 16.323 (USGS 7). The piezometric surface was higher in wells a few miles from Malaga Bend. It was at altitude 2,905.0 feet in well 24.28.24.211 (USGS 2) on July 19, 1963, and at altitude 2,923.4 feet in well 8.111 (USGS 3) on July 18. The piezometric surface of the brine aquifer may be lower than is shown by water levels in wells 24.28.24.211 (USGS 2), 8.111 (USGS 3), and possibly 16.311 (USGS 1) and 16.323 (USGS 7) because the casings may have holes that permit water from the alluvium or Rustler Formation to enter the wells.

The piezometric surface of water at the base of the alluvium was at altitude 2,899.0 feet in well 16.133a (USGS 10) on July 19, 1963. This water is saturated with sodium chloride from the brine aquifer and its piezometric surface is slightly lower than that of the brine aquifer.

The water level in well 30.421a (USGS 14) was at altitude 2,892.6 feet on July 19, 1963. This well is finished in collapse breccia near Queen Lake.

The piezometric surface of the brine aquifer was lower in the Queen Lake Depression than that at Malaga Bend before pumping began. The piezometric surface in well 30.421 (USGS 12) was at altitude 2,884.9 feet on July 19, 1963.

The unconfined water in alluvium and the confined water in the Culebra Dolomite Member of the Rustler Formation sloped toward the Pecos River at Malaga Bend and near the Northeast Depression before pumping began. The unconfined water formed a mound under Malaga Bend where the alluvium is recharged by irrigation water (fig. 3).

Figure 3 (caption on next page) belongs near here.

Figure 3.--Map showing the configuration of the piezometric surface in alluvium and the Culebra Dolomite Member of the Rustler Formation in the Malaga Bend area, Eddy County, N. Mex., before pumping of brine began.

A previous investigation showed that the Pecos River gained about 430 tons of dissolved minerals daily between the Malaga and Pierce Canyon Crossing gaging stations. Of this amount, about 370 tons was sodium chloride. (Hale, Hughes, and Cox, 1954, p. 14-15.) The average gain in chloride load of the river between the two gaging stations for water years 1952-64 (October 1, 1951-September 30, 1964) ranged from 213 to 272 tons per day (fig. 4) and averaged 248 tons per day during

Figure 4 (caption on next page) belongs near here.

the period. A large part of the gain in mineral load between Malaga and Pierce Canyon Crossing gaging stations occurs between Fishing Rock Crossing and Lower Wading Station (fig. 1).

The reach of the river between Fishing Rock Crossing and the site near well USGS 11 was sampled at 2-hour intervals for 24 hours July 16-17, 1963. The chloride load of the river during this period is shown in figure 5. The average gain in chloride load between Fishing Rock Crossing

Figure 5 (caption on next page) belongs near here.

and near well USGS 11 during this period was 168 tons per day. The average gain in chloride load from near well USGS 11 to Pierce Canyon Crossing during a similar 24-hour period in March 1962 was 49 tons per day. The sum of these averages gives an average gain in chloride load from Fishing Rock Crossing to Pierce Canyon Crossing of 217 tons per day. Average gains in chloride load between sampling sites from Fishing Rock Crossing to Reed's Pump are listed in table 3.

Figure 4.--Graph showing gain in chloride load of the Pecos River between Malaga and Pierce Canyon Crossing gaging stations, October 1951 to September 1964.

Figure 5.--Graphs showing chloride load of the Pecos River around Malaga Bend, July 16-17, 1963, and August 12-13, 1964.

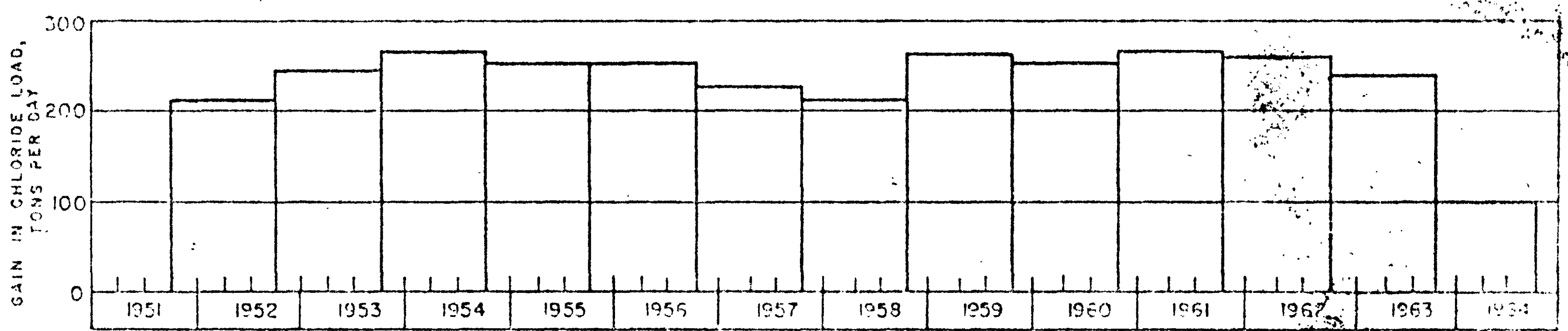


Figure 4.--Graph showing gain in chloride load of the Pecos River between Malaga and Pierce Canyon Crossing gaging stations, October 1951 to September 1964

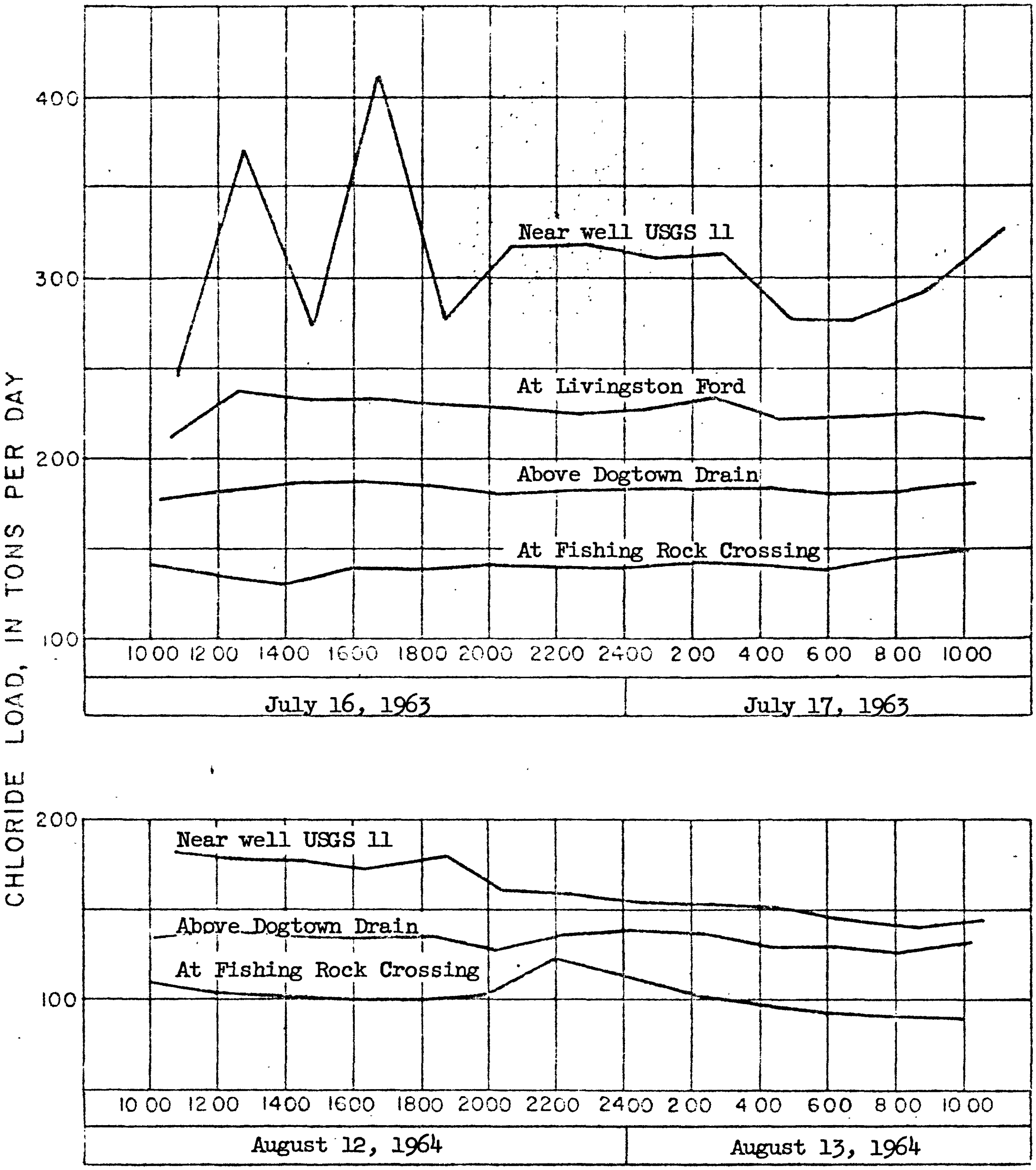


Figure 5.--Graphs showing chloride load of the Pecos River around Malaga Bend, July 16-17, 1963, and August 12-13, 1964.

Effects of pumping

Pumping from well 16.133 (USGS 8) affected the piezometric surface in wells 17.444 (USGS 11), 16.311 (USGS 1), and 16.323 (USGS 7) in the brine aquifer at Malaga Bend almost identically. (See figs. 6, 7, and 8.) These wells are within 0.5 mile of the pumped well. The large

Figure 6 (caption on next page) belongs near here.

Figure 7 (caption on next page) belongs near here.

Figure 8 (caption on next page) belongs near here.

fluctuations in August 1963 are caused by frequent pump stoppages due to electrical problems. The changes in water level on November 22, 1963, and March 23, 1964, are due to changes in pumping rate. The large change in water level in April 1964 resulted when the submergible pump failed and was replaced. The small fluctuations are due mostly to changes in barometric pressure.

The pumping effects in wells that tap the brine aquifer greater distances from the pumped well are shown in figures 9 and 10. Well

Figure 9 (caption on next page) belongs near here.

Figure 10 (caption on next page) belongs near here.

24.28.24.211 (USGS 2) is about 2.6 miles and well 8.111 (USGS 3) is about 1.8 miles from the pumped well. The fluctuations of water levels in these wells are similar to but smaller than those in the wells nearer the pumped well. The large rise in water level in well 24.28.24.211 (USGS 2) in September 1964 was due to recharge by rain water running into nearby sinkholes.

Figure 6.--Graph showing fluctuations of water level in well 17.444 (USGS 11).

Figure 7.--Graph showing fluctuations of water level in well 16.311 (USGS 1).

Figure 8.--Graph showing fluctuations of water level in well 16.323 (USGS 7).

Figure 9.--Graph showing fluctuations of water level in well 24.28.24.211 (USGS 2).

Figure 10.--Graph showing fluctuations of water level in well 8.111 (USGS 3).

Pumping brine from well 16.133 (USGS 8) also affected water levels in the alluvium at Malaga Bend. Before pumping began, brine moved into the alluvium because the brine aquifer had a higher hydraulic head, but after pumping began the gradient was reversed and water moved from the alluvium into the brine aquifer. Figure 11 shows the pumping

Figure 11 (caption on next page) belongs near here.

effects in well 16.133a (USGS 10), finished at the base of the alluvium near the pumped well. The fluctuations of water level in this well are similar to but smaller than those in wells in the brine aquifer. The rise in water level in July, August, and September 1964 was probably due to recharge by irrigation water and precipitation.

Water levels in shallow wells that penetrate only the upper part of the alluvium at Malaga Bend may have been affected by pumping from the brine aquifer. The decline of water levels in shallow wells in the alluvium at Malaga Bend (fig. 12) may be seasonal declines and the

Figure 12 (caption on next page) belongs near here.

water levels may be affected only slightly by pumping from the brine aquifer. Part of the decline of water level in shallow well 16.323a is probably due to leakage through holes in the casing to well 16.323 (USGS 7) which taps the brine aquifer. These two wells consist of casings one inside the other in the same hole. Part of the decline in shallow well 16.311a may be due to leakage of water from the alluvium into well 16.311 (USGS 1) through holes in the casing. Well 16.311 (USGS 1) and 16.311a, however, are not in the same hole. Apparently, water levels in wells 16.431, 16.324, and 17.444a have not been affected by pumping from the brine aquifer.

Figure 11.--Graph showing fluctuations of water level in well 16.133a (USGS 10).

Figure 12.--Graphs showing fluctuations of water levels in shallow wells in alluvium at Malaga Bend.

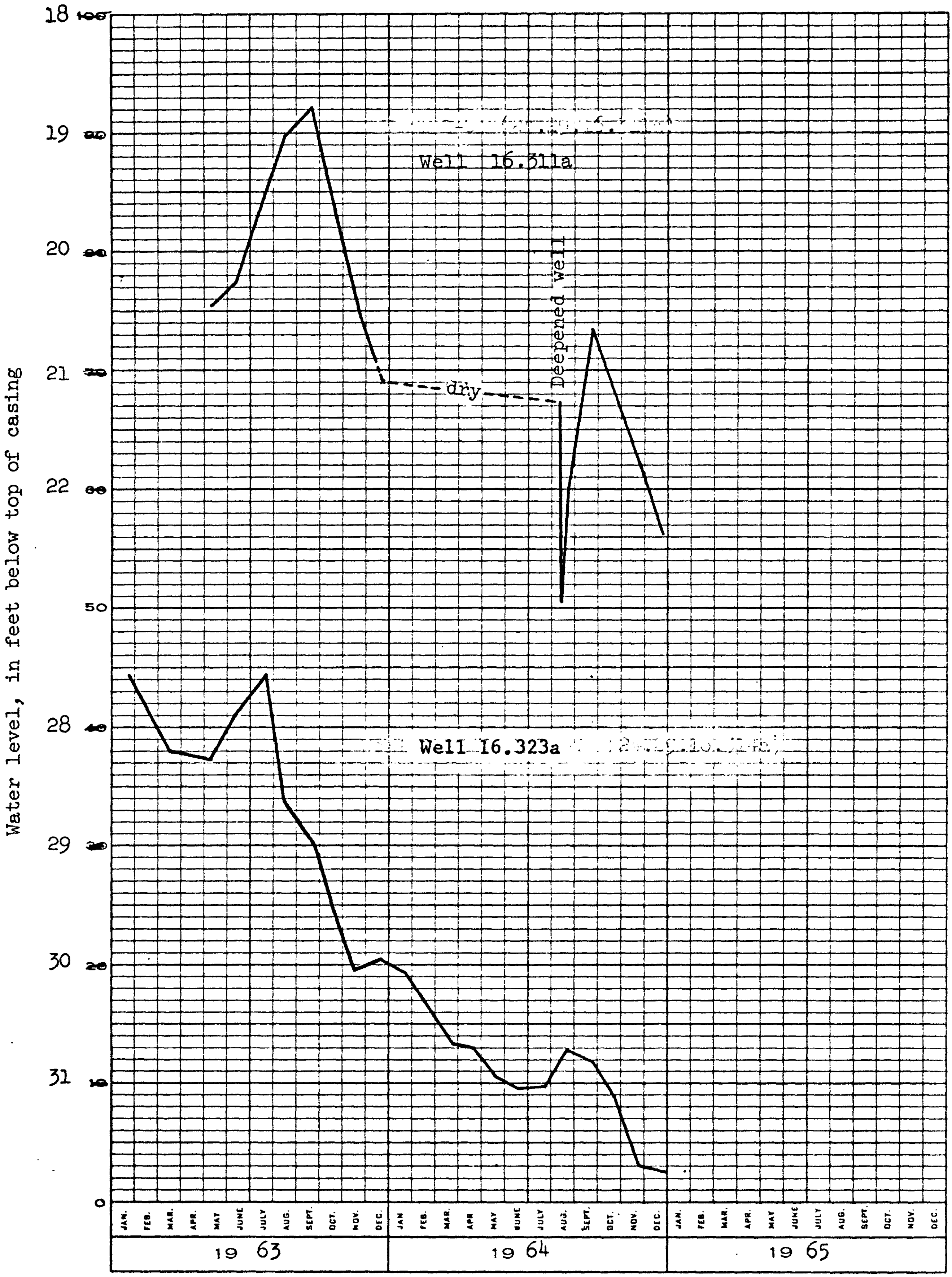


Figure 12.--Graphs showing fluctuations of water levels in shallow wells in alluvium at Malaga Bend

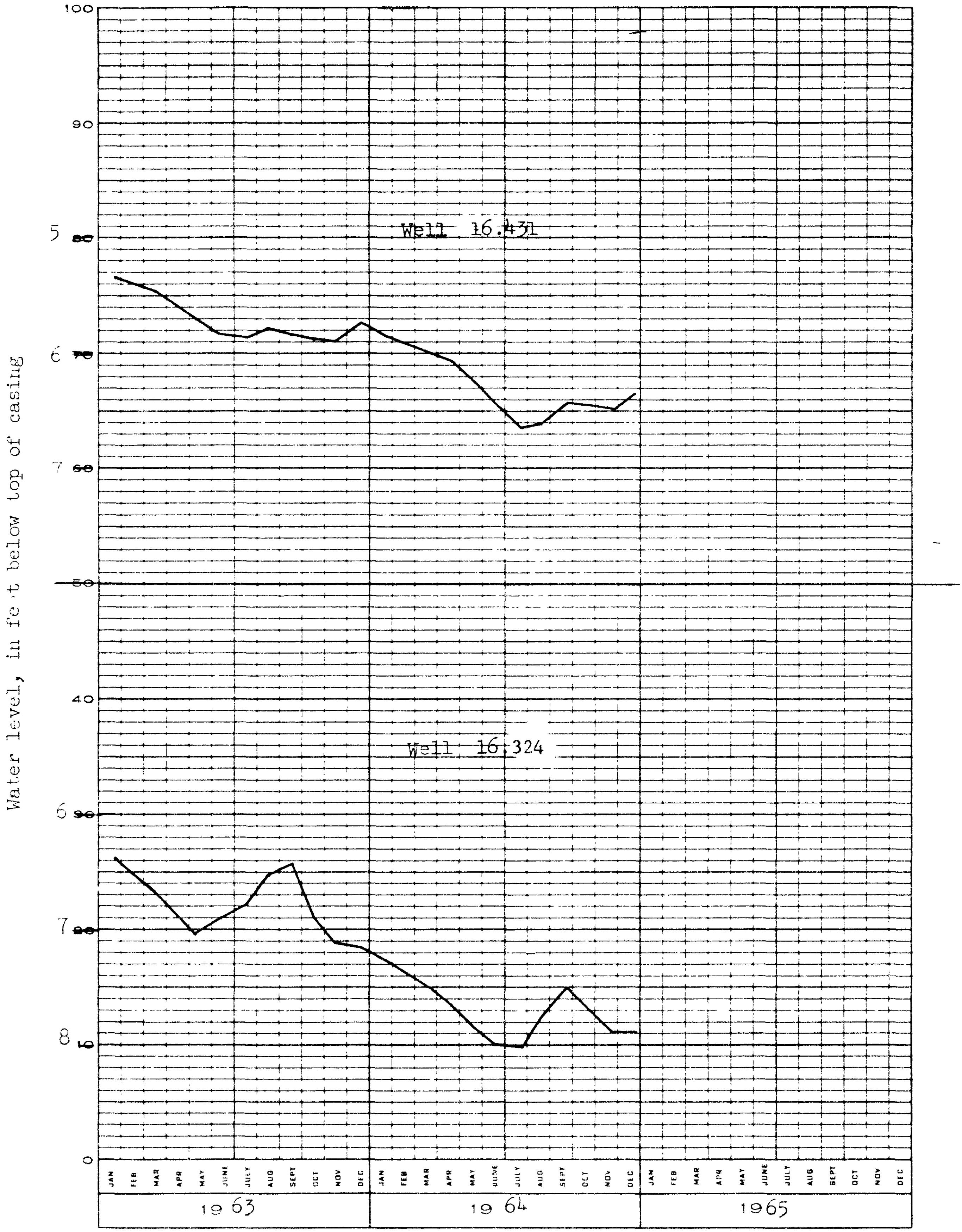


Figure 12.--Graphs showing fluctuations of water levels in shallow wells in alluvium at Malaga Bend - Continued

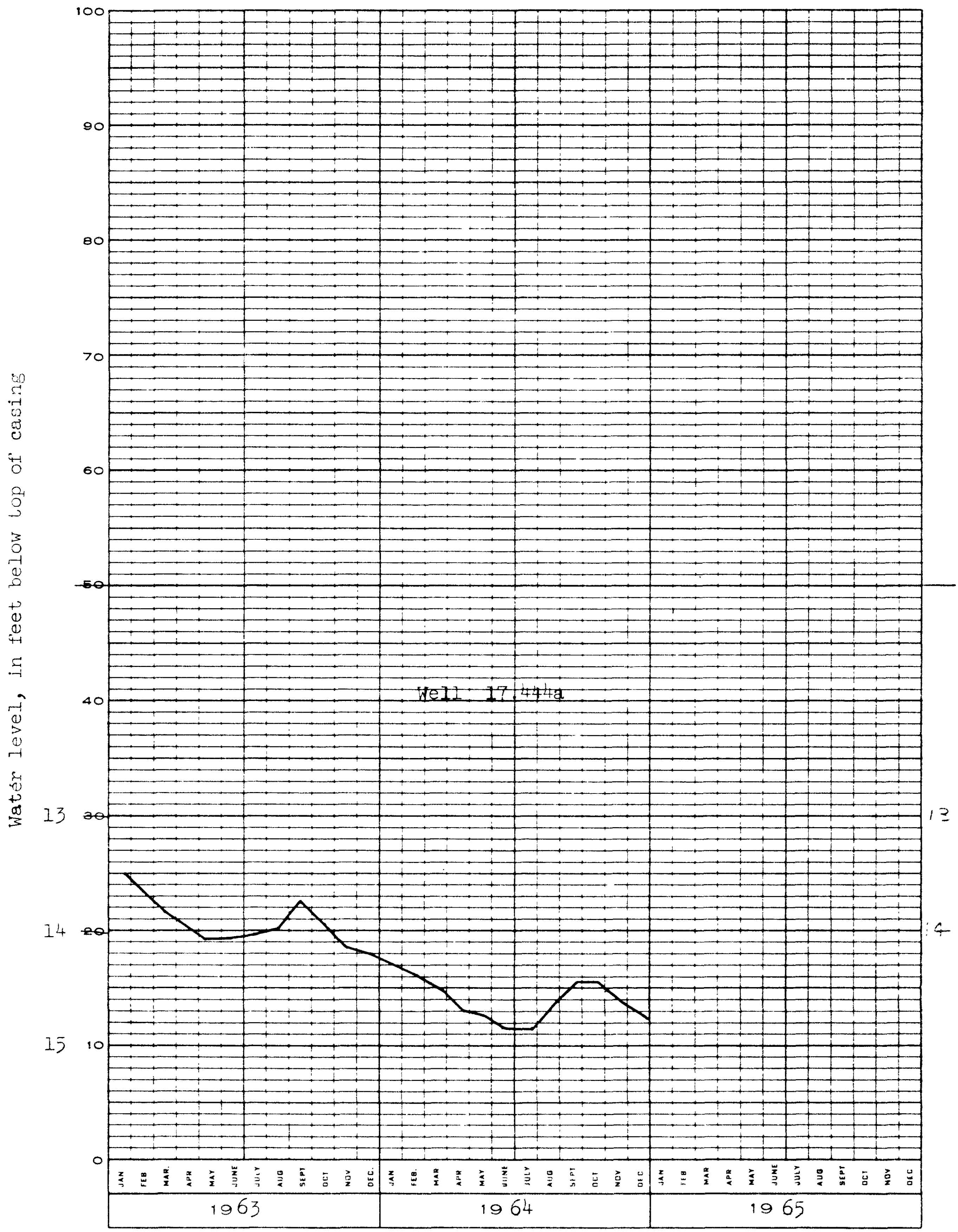


Figure 12.--Graphs showing fluctuations of water levels in shallow

wells in alluvium at Malaga Bend - Continued

The pumping of brine from well 16.133 (USGS 8) does not seem to have affected water levels in any aquifer other than the brine aquifer and the alluvium at Malaga Bend. Of interest is the fact that the water level in well 30.421 (USGS 12) near Queen Lake has not been affected by the pumping even though this well is finished in brine at the base of the Rustler Formation. The brine aquifer near Queen Lake, therefore, is not connected with the brine aquifer at Malaga Bend.

Lowering the piezometric surface of the brine aquifer at Malaga Bend by pumping had reduced the head of the brine aquifer about 8 feet in well 17.444 (USGS 11) by July 1964, (fig. 6). Before pumping began the piezometric surface of the brine aquifer was at altitude 2,899.7 feet. The bottom of the river near well 17.444 (USGS 11) is at altitude 2,888.9 feet; or the head of the aquifer was 10.8 feet above the bottom of the river before pumping began. The head of the brine aquifer, therefore, was still almost 3 feet above the river at the lower end of Malaga Bend after a year of pumping.

The Pecos River gained about 430 tons of dissolved minerals daily between the Malaga and Pierce Canyon Crossing gaging stations before pumping of brine from well 16.133 (USGS 8) began on July 22, 1963. The average gain in chloride load in the river from Fishing Rock Crossing to Pierce Canyon Crossing was 217 tons per day. The gain in chloride load in the river between Fishing Rock Crossing and Pierce Canyon Crossing has been reduced since pumping began (fig. 13).

Figure 13 (caption on next page) belongs near here.

The gain began to decline in early August 1963 and has generally continued to decline since that time. The fluctuations in the gain are probably caused by natural fluctuations in the chloride load upstream from Malaga Bend and by errors in sampling, measuring, and laboratory determinations. Also, no correction was made for lag effects between the two sites.

The reach of the river between Fishing Rock Crossing and the site near well USGS 11 was sampled at 2-hour intervals for 24 hours August 12-13, 1964, to compare with similar data collected July 16-17, 1963, before pumping began (fig. 5). The average gain in chloride load between Fishing Rock Crossing and the site near well USGS 11 was 168 tons per day July 16-17, 1963, and 59 tons per day August 12-13, 1964. The gain was about 65 percent less August 12-13, 1964, than July 16-17, 1963. The average gain between Fishing Rock Crossing and Pierce Canyon Crossing in July 1963 was 258 tons per day and in August 1964 was 66 tons per day (fig. 13); or the gain was about 75 percent less in August 1964 than in July 1963.

Figure 13.--Graph showing gain in chloride load between Fishing Rock Crossing and Pierce Canyon Crossing, July 1963 to August 1964.

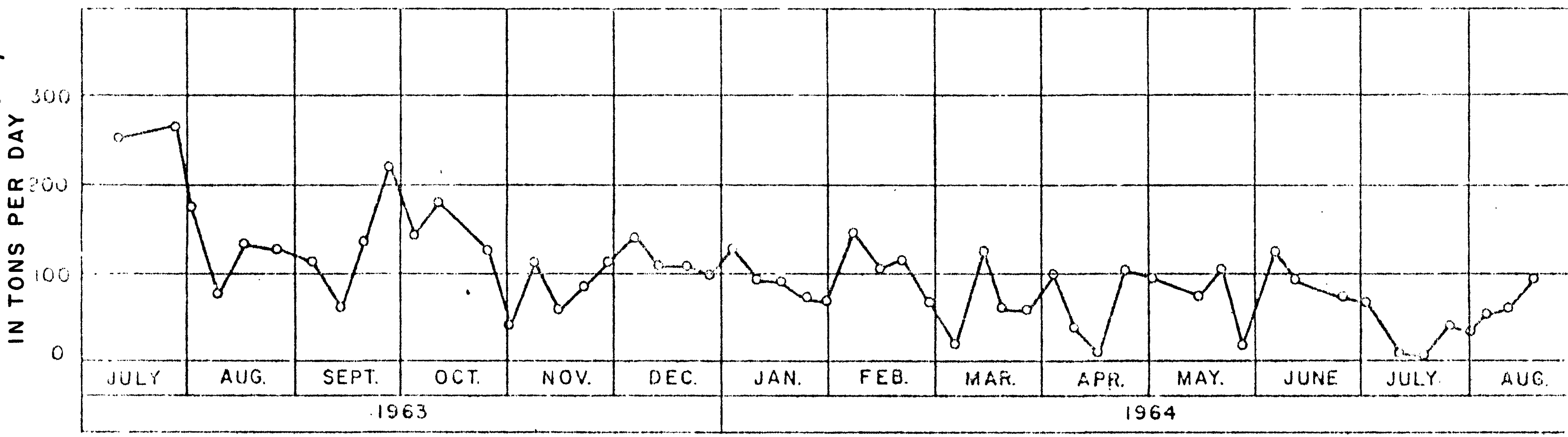


Figure 13.--Graph showing gain in chloride load between Fishing Rock Crossing and Pierce Canyon Crossing, July 1963 to August 1964

The average gain in chloride load between the Malaga and Pierce Canyon Crossing gaging stations declined from an average of 248 tons per day for water years 1952-63 to 101 tons per day for water year 1964 (fig. 4).

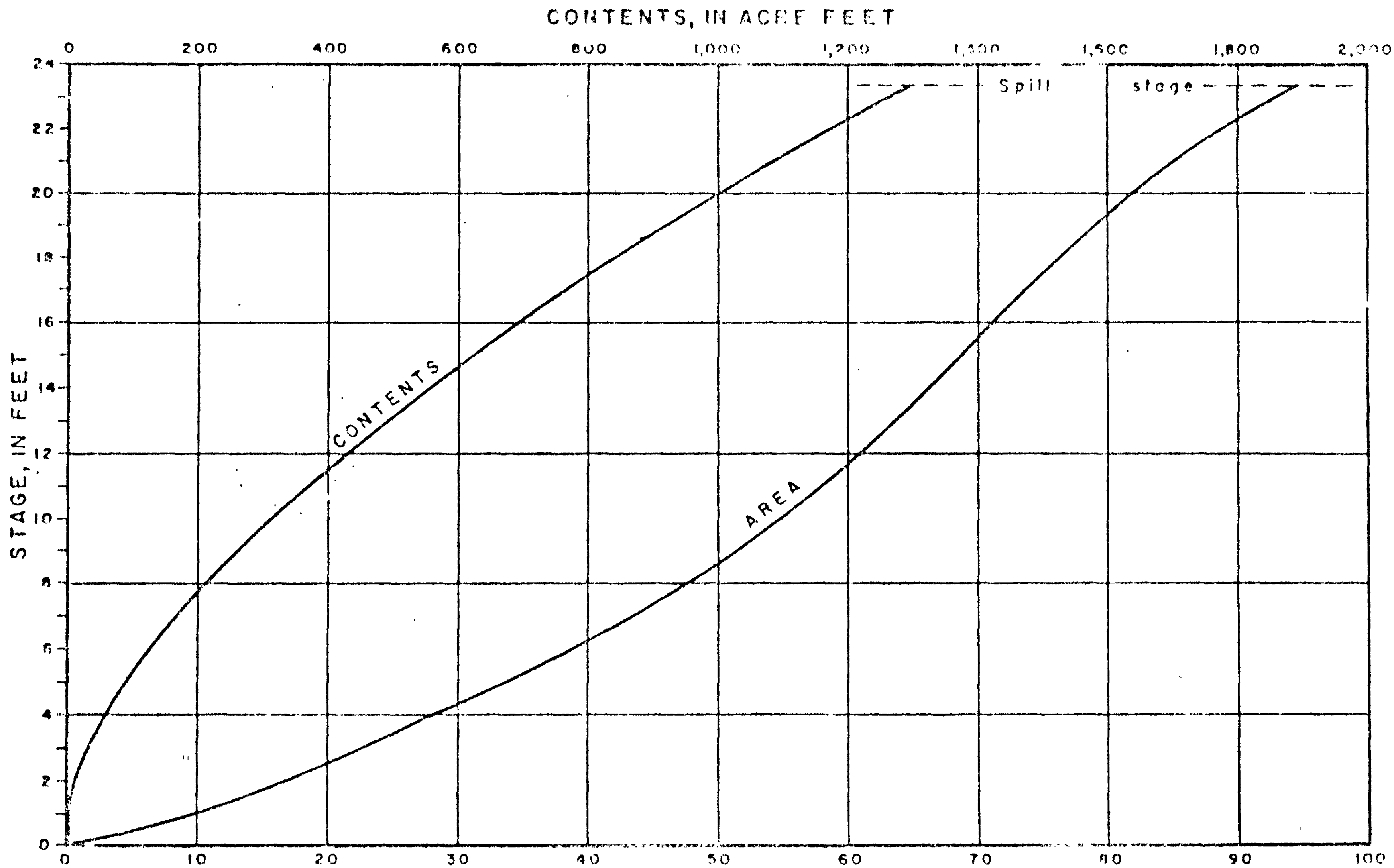
Northeast Depression

The Northeast Depression has a storage capacity of about 1,300 acre-feet. The bottom of the depression (after compaction) is at altitude 2,928.7 feet and the low point on the rim is at altitude 2,952.0 feet. Brine would spill from the depression at gage height 23.3 feet (fig. 14). The maximum area for brine storage is

Figure 14 (caption on next page) belongs near here.

94 acres. The bottom 52.8 acres, to altitude 2,938.0 feet (gage height 9.3 feet), was cleared and compacted to retard leakage.

Figure 14.--Graphs showing contents and area of the Northeast Depression.



Based on topography by U. S. Bureau of Reclamation, 1953

Figure 14.--Graphs showing contents and area of the Northeast Depression

Precipitation of salt

Salt began to precipitate in the Northeast Depression immediately after pumping began. Within a week, a dense hard crust that could support a man had formed on the bottom of the depression. A scum that quickly develops into thin rafts forms on the surface of the brine pond. When these rafts become heavy enough, they sink and accumulate. The salt precipitate is composed of twinned, cubic, halite crystals as much as half an inch across. Most of the crystals, however, are less than a quarter of an inch across.

The salt accumulates thickest on objects such as sticks, clods of dirt, markers, and gages in the depression. This is because wave action alternately wets the objects with brine and exposes them to the atmosphere. Salt also accumulates near the shore of the pond by the same action.

Loose salt crystals accumulate by wave action in sheltered areas forming pockets of salt sand.

Fresh water entering the brine pond from runoff dissolves salt from the crust. After heavy rainstorms, the brine pond is muddy and has a much different appearance than after long dry periods when the pond is relatively clear.

Algae

In July 1964, the brine in the Northeast Depression began to have a slightly pink color. Microscopic examination of the water showed red, yellow, and colorless algae. The types of algae in the water were not identified. In September 1964, the brine was diluted by runoff and the algae disappeared.

Leakage from the depression

One of the most important parts of the study is to determine leakage from the depression. Brine that leaks from the depression would probably follow the path of movement of ground water in the area. Ground water moves in directions perpendicular to the water-table contours (fig. 3) from the Northeast Depression eastward, southeastward, or southward toward the Pecos River. Leakage probably would move in these directions to the river. Leakage possibly could move in other directions because a mound of brine would build up under the depression and create a gradient in all direction.

Brine leaking from the Northeast Depression and moving toward the Pecos River could be detected in observation wells that ring the depression (fig. 1). Leakage from the depression would result in a rise in the water level and an increase in chloride content of water in the wells. Figure 15 shows the water level and chloride content of

Figure 15 (caption on next page) belongs near here.

water in wells near the Northeast Depression.

Leakage from the Northeast Depression would be expected to appear first in wells 20.322, 20.431, and 29.213 because these wells are nearest the depression and in the path of most likely movement of leakage. The water levels in these wells have not risen consistantly to indicate leakage, but rises that have occurred could be attributed to recharge from precipitation. The chloride content has consistantly increased since May 1964 in wells 20.431 and 29.213 and since June 1964 in well 20.322 indicating probable leakage from the depression (fig. 15).

Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression.

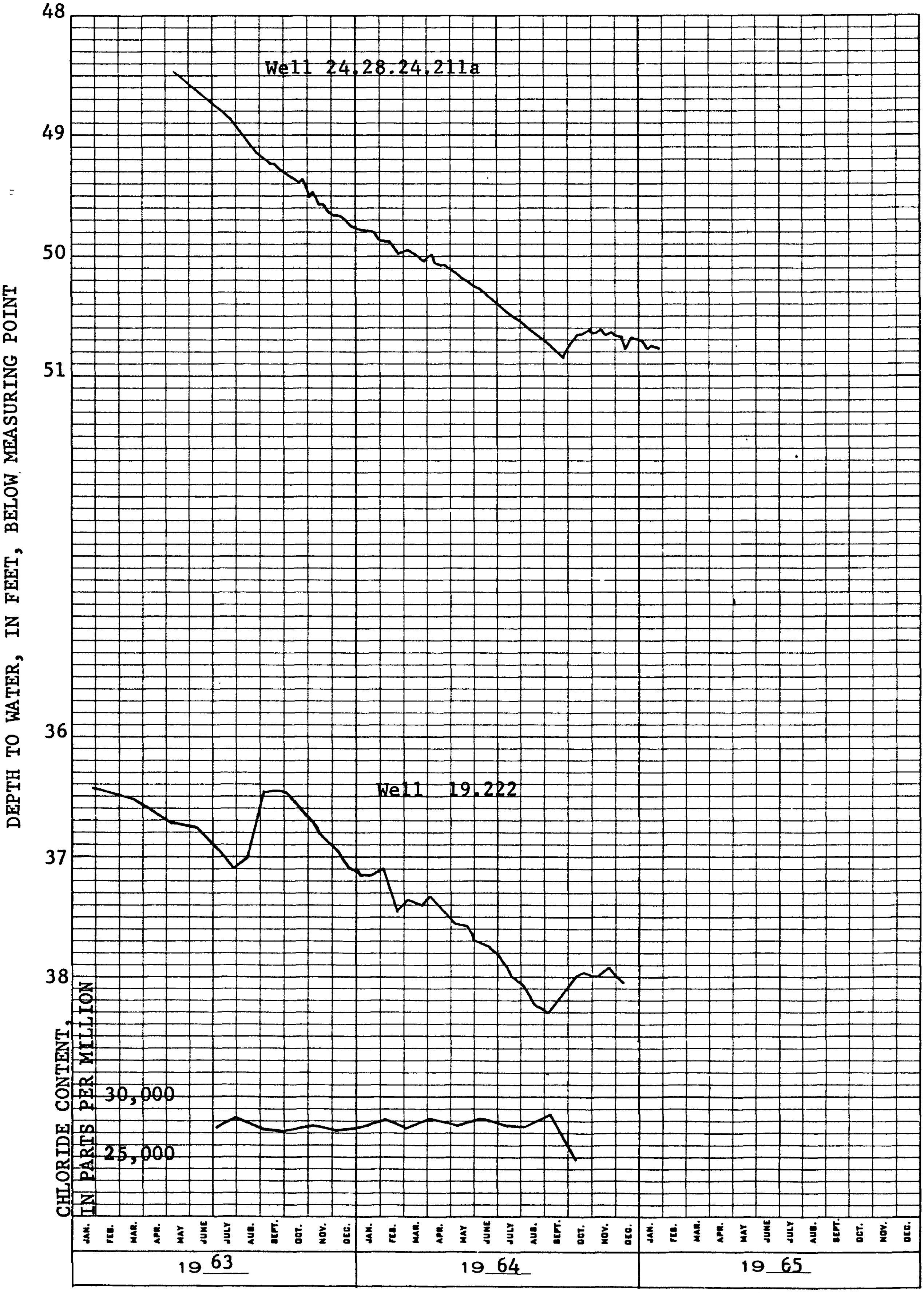


Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression.

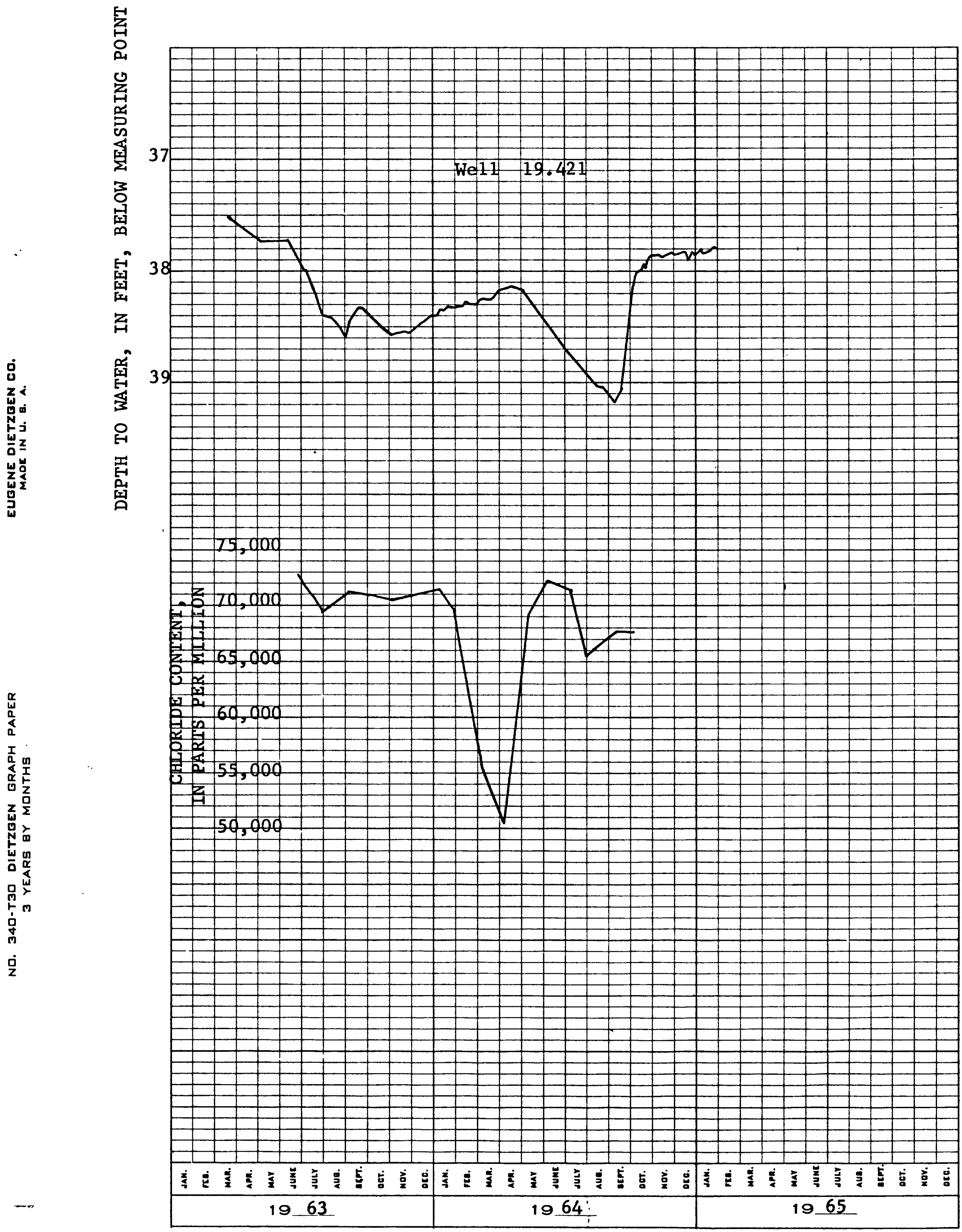


Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression - Continued

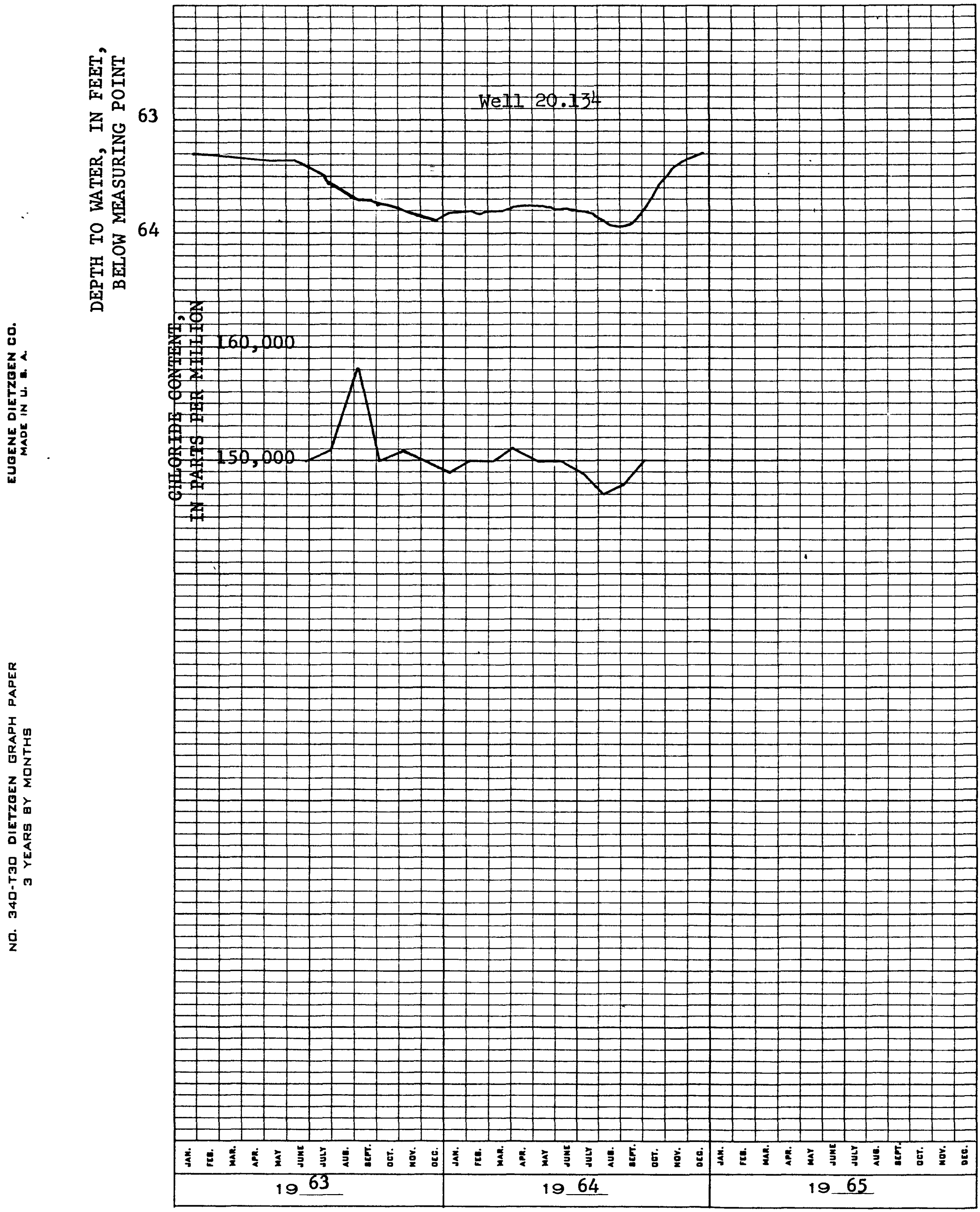


Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression - Continued

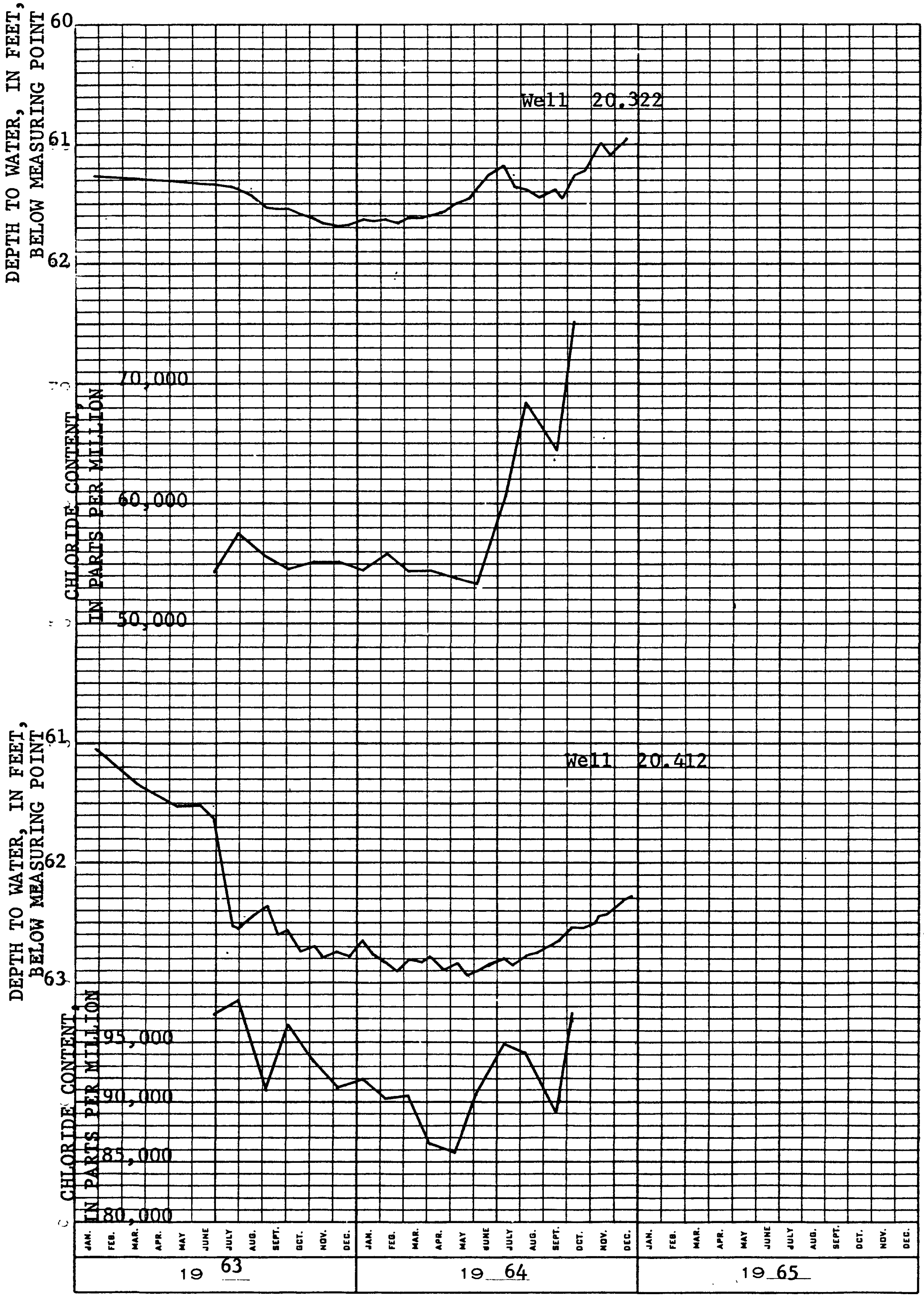


Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression - Continued

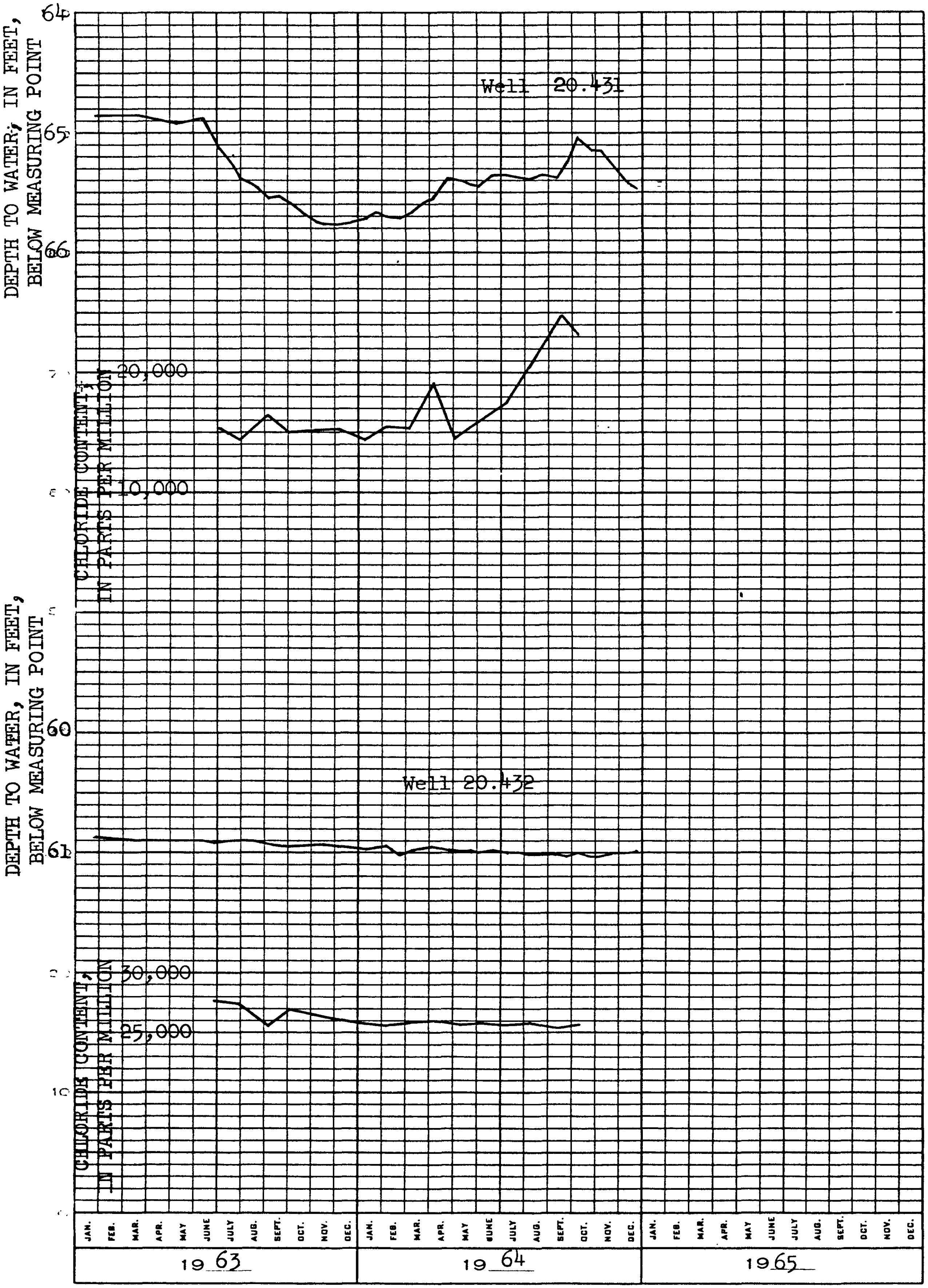


Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression - Continued

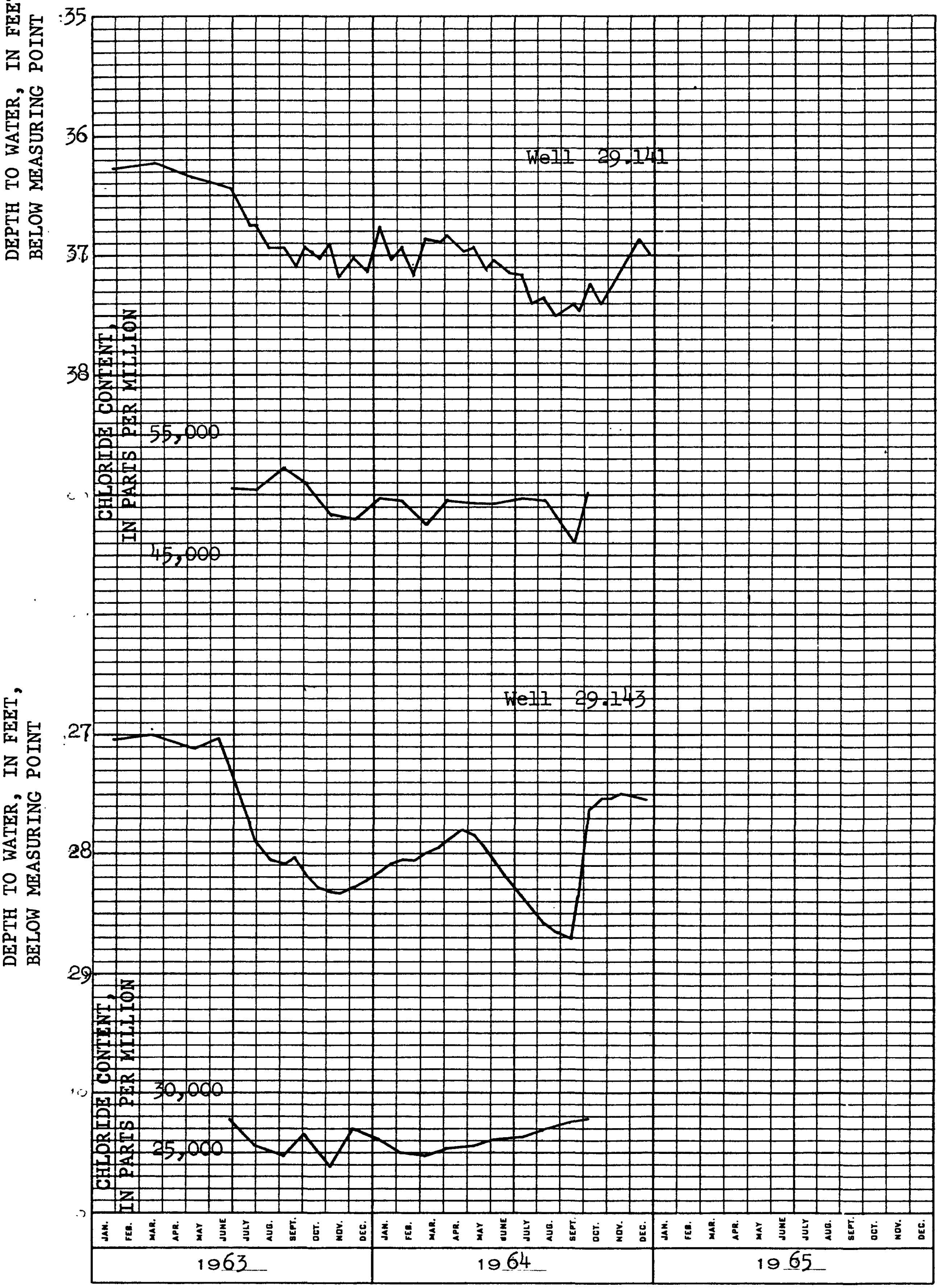


Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression - Continued

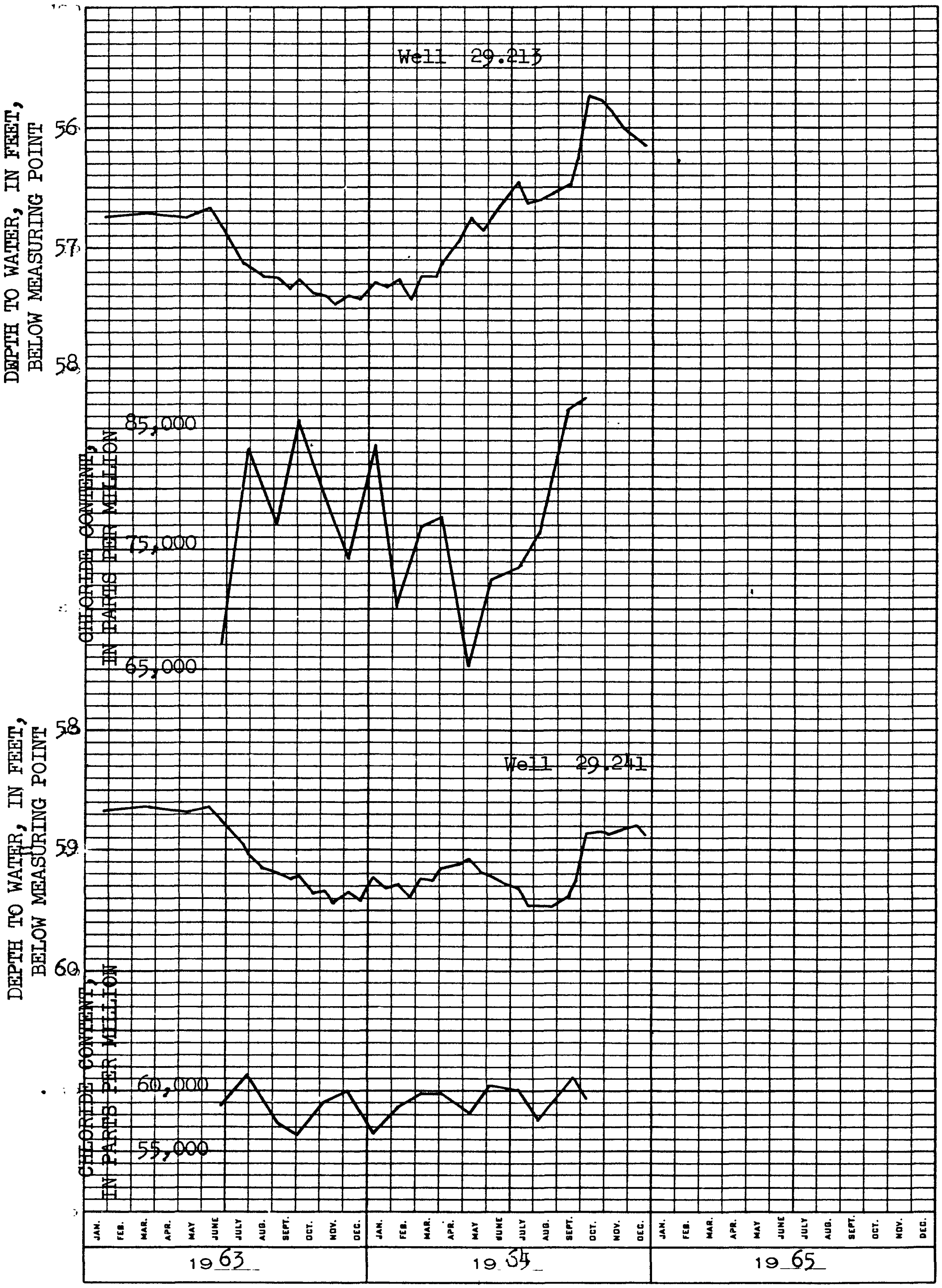


Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression - Continued

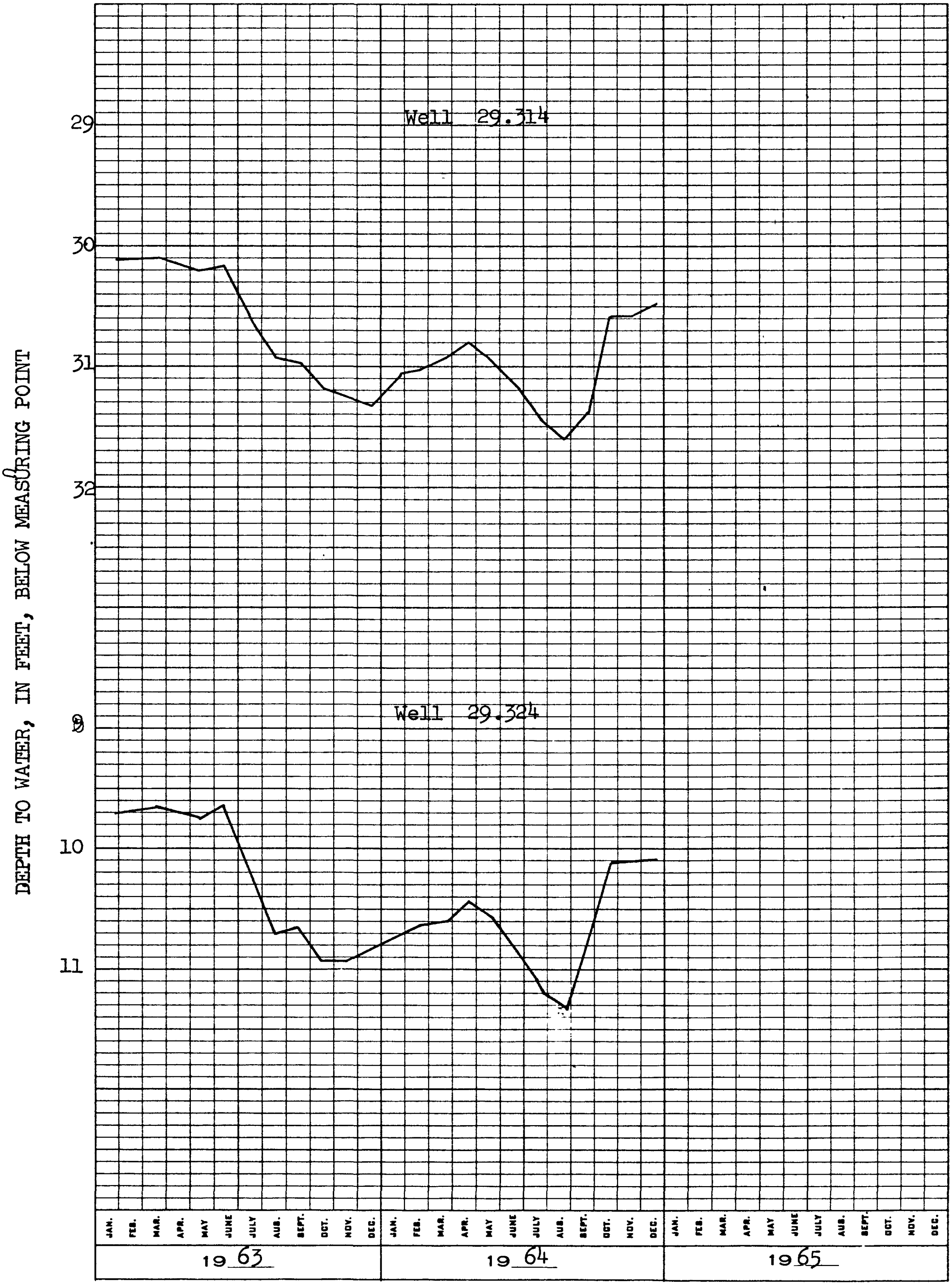


Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression - Continued

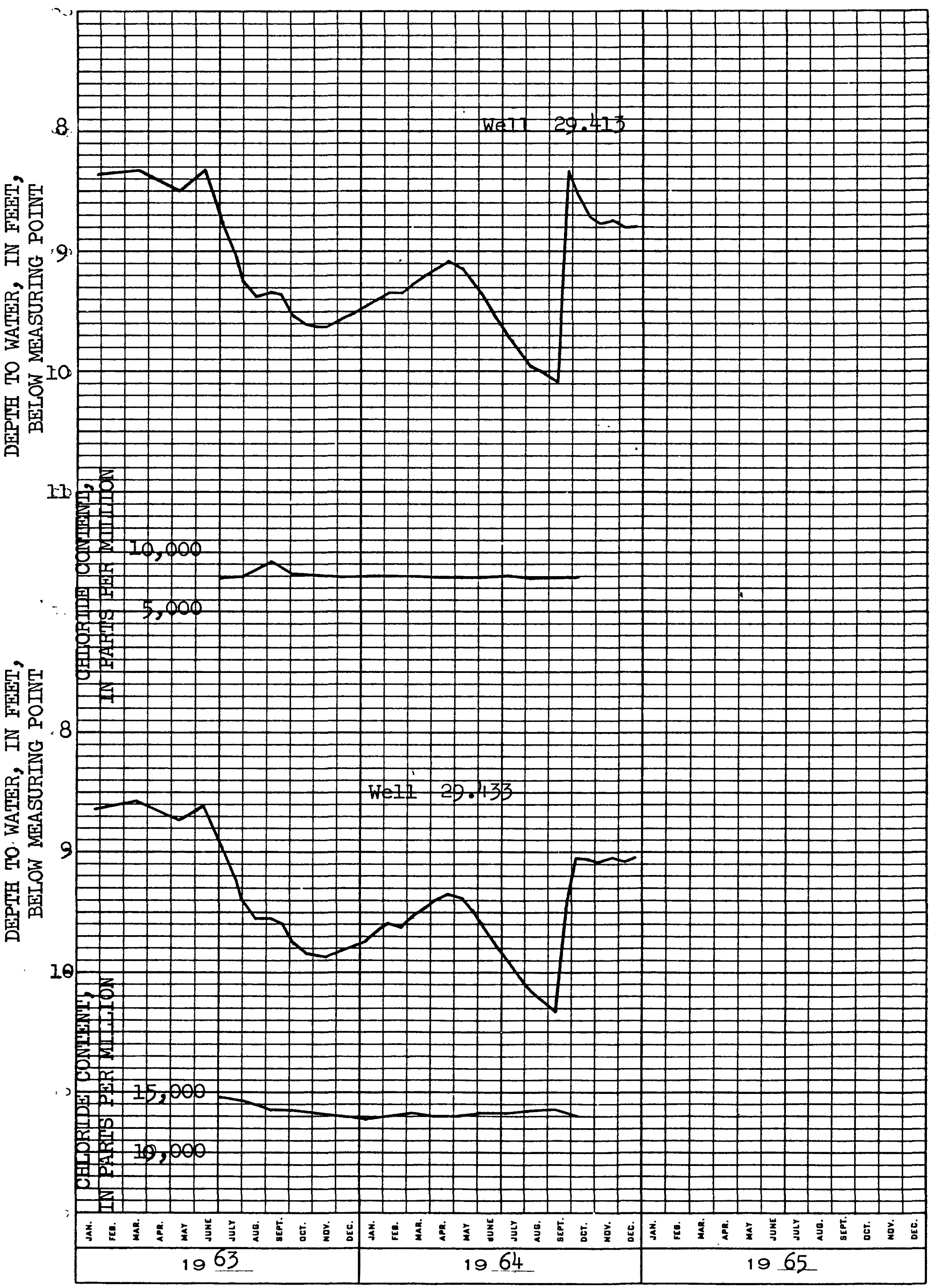


Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression - Continued

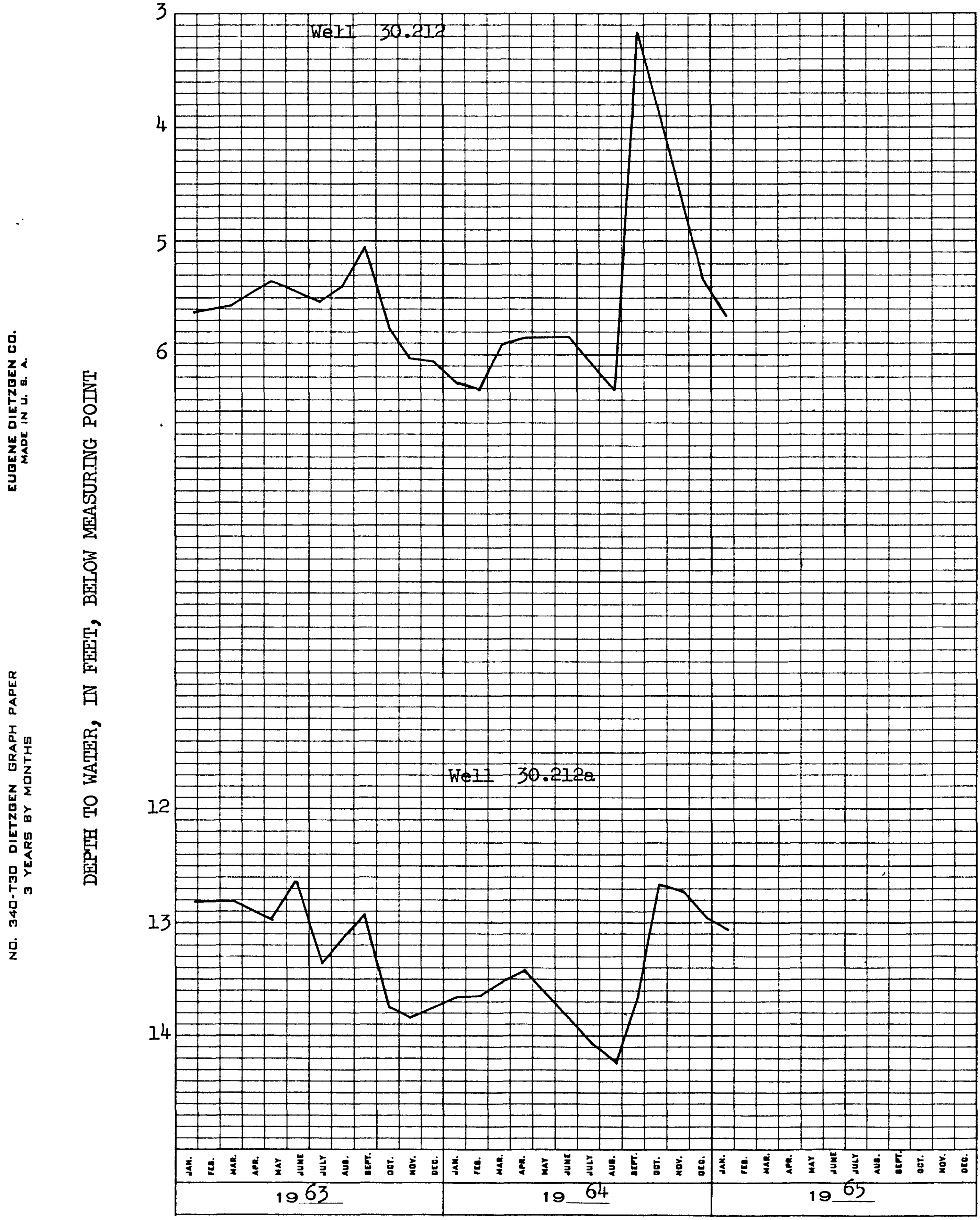


Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression - Continued

Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression - Continued

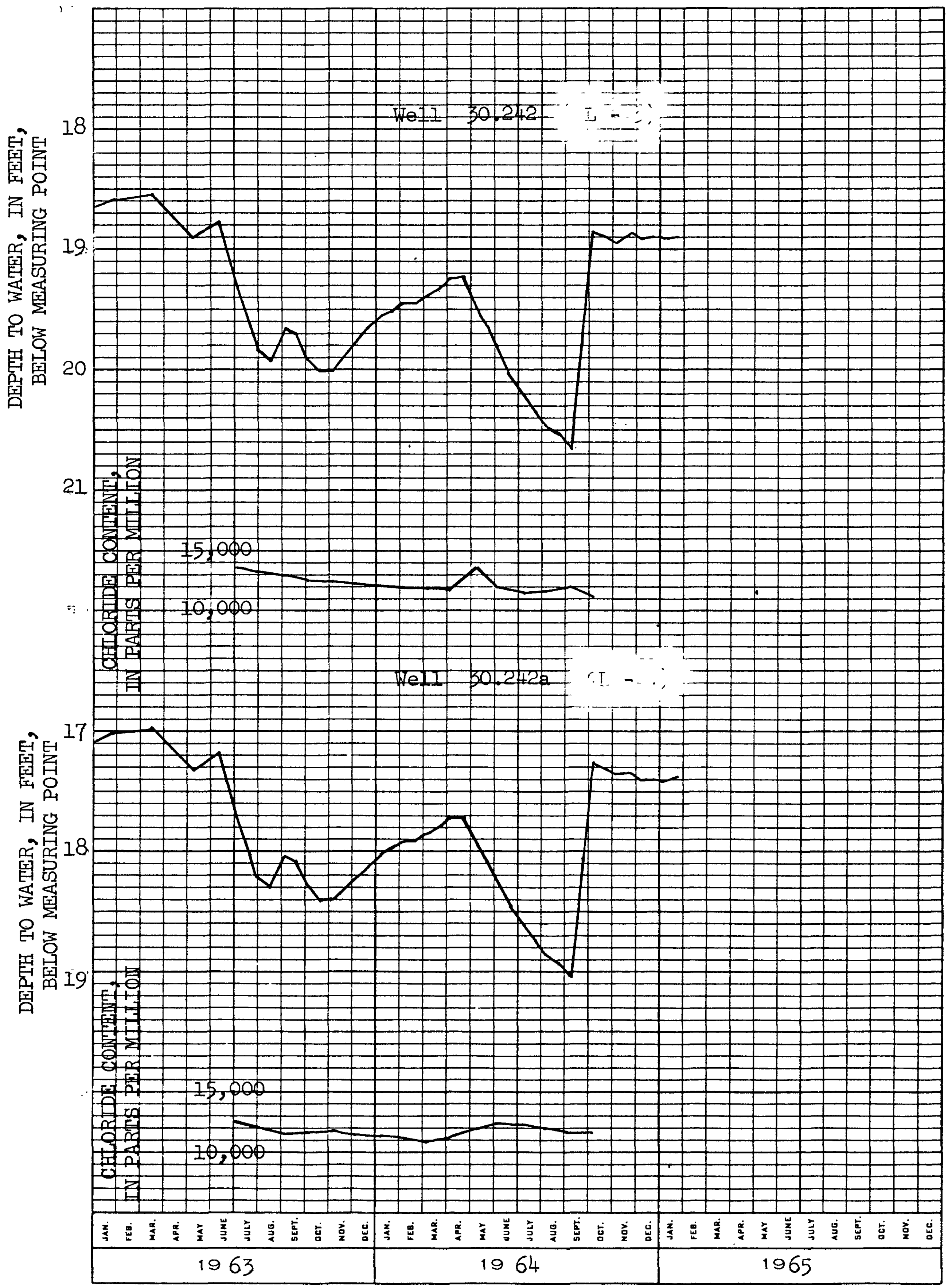


Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression - Continued

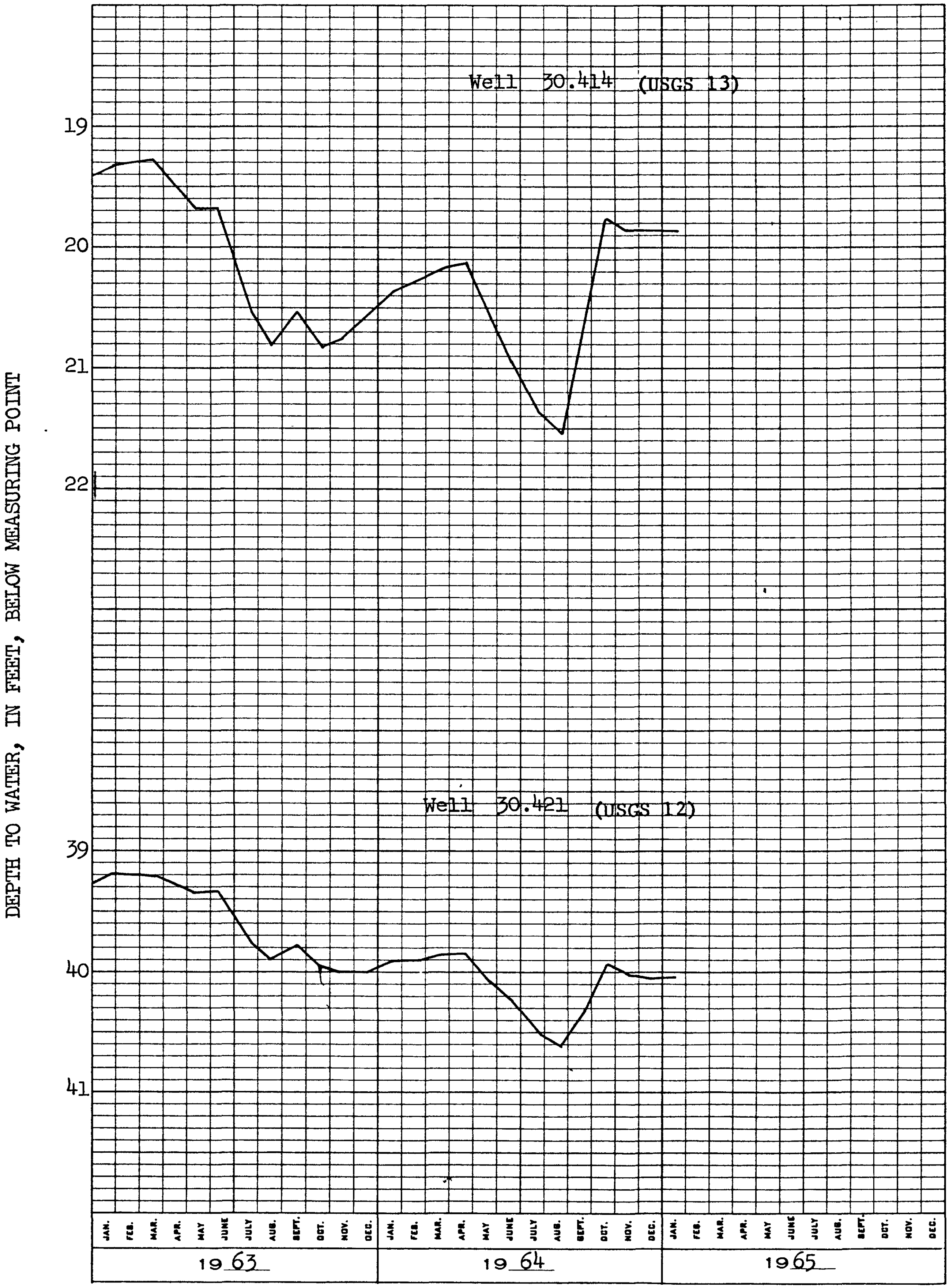


Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression - Continued

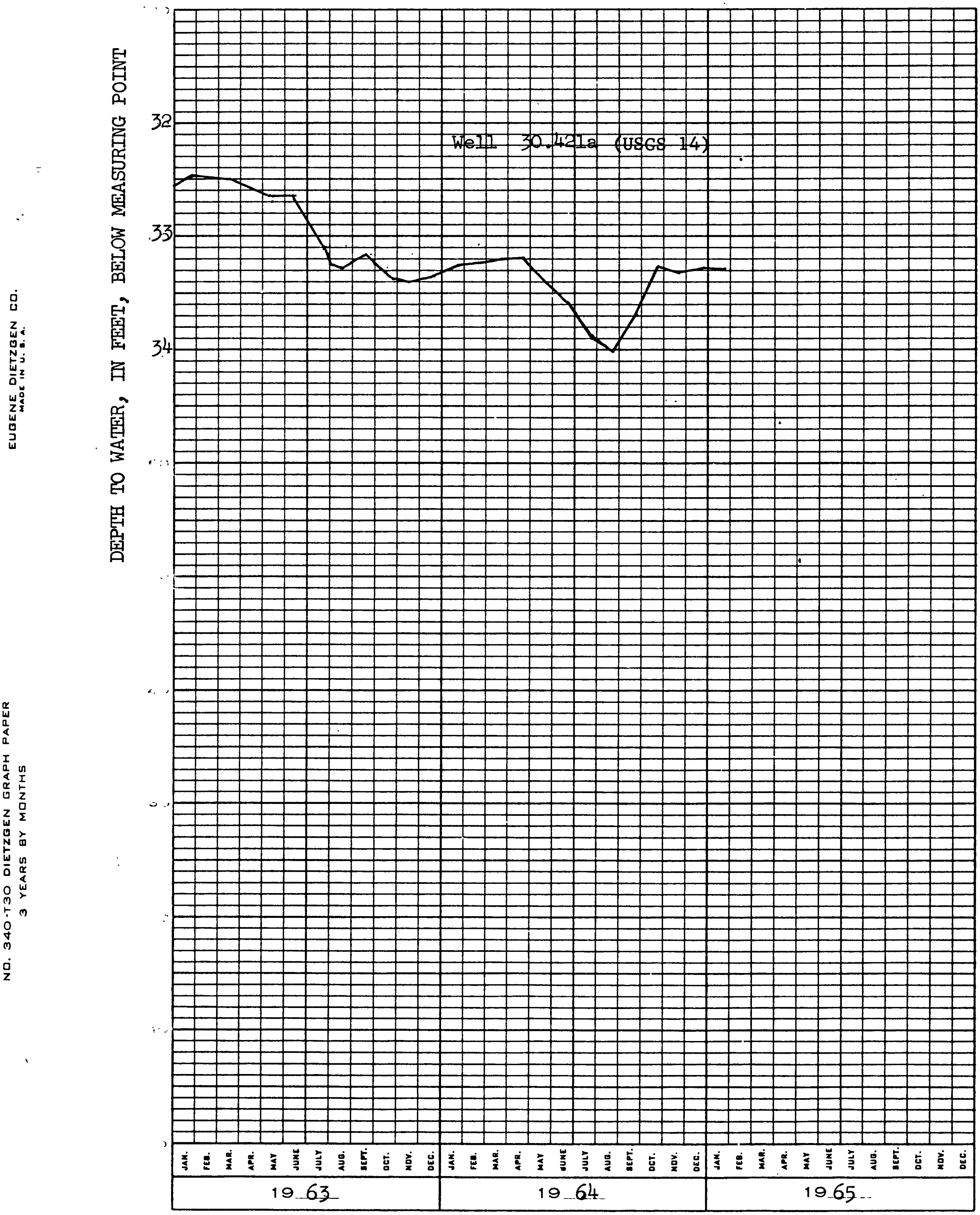


Figure 15.--Graphs showing fluctuations of water level and chloride content of water in wells near the Northeast Depression - Concluded

The amount of leakage from the Northeast Depression can be estimated by accounting for the inflow to the depression. The inflow is the brine pumped plus runoff into the brine pond. The outflow is evaporation plus leakage from the depression. The difference between the inflow and the outflow is the amount of brine in storage in the depression. The leakage can be estimated because all the other factors can be either measured or closely approximated.

During the period July-December 1963, about 335 acre-feet of brine was pumped into the depression and about 13 acre-feet of runoff entered the depression; hence, the inflow was about 348 acre-feet. The pumpage was metered and the runoff determined from rainfall data. The evaporation was about 72 acre-feet and about 228 acre-feet of the inflow remained in storage. The evaporation was determined by applying the measured evaporation from a pan to the average area of the lake surface; a coefficient of 0.9 was used from the pan to the lake.

Ordinarily, a coefficient should be applied to correct from evaporation of fresh water to evaporation of brine. The water from well 19.421 used in the evaporation pan is not fresh water, on the contrary it is a brine, although not as concentrated a brine as that being evaporated in the depression. During the summer, salt crystals precipitate in the open pan. Consequently, the water is saturated with sodium chloride much of the year and no coefficient for salinity was used.

A coefficient of 0.6 to 0.8 is used in larger bodies of water, but in the Northeast Depression, a shallow lake with a comparatively high water temperature, a coefficient nearer unity was used. During early periods of observation when leakage through the compacted area was probably small, a coefficient of 0.9 gave leakage estimates of 10 percent or less. Evaporation and rainfall are shown in table 4. The change in storage in the depression was determined by the change in gage height for the period and its relation to the contents of the depression (fig. 14). A total of 300 acre-feet of inflow, therefore, can be accounted for as evaporation or change in storage. The leakage for the period July-December 1963 was about 48 acre-feet, or about 14 percent of the total inflow.

Similarly, during the period July 1963-June 1964 the pumpage was 644 acre-feet and the runoff about 23 acre-feet for a total inflow into the depression of about 667 acre-feet. Evaporation was about 261 acre-feet and change in storage 285 acre-feet. Leakage, therefore, was about 121 acre-feet, or about 18 percent of the total inflow, table 5. During July 1964 the water in the depression rose above the compacted area. For the period July 1963-December 1964 the pumpage was 1,020 acre-feet and the runoff about 39 acre-feet for a total inflow of about 1,059 acre-feet. Evaporation was about 451 acre-feet and change in storage was 390 acre-feet. Leakage was about 218 acre-feet or about 21 percent of the total inflow into the depression.

The rate of leakage from the Northeast Depression has increased since July 1964 because the surface of the lake has been above the compacted area. The salt crust may become thicker in future years, however, and may retard leakage. But it seems more likely that leakage will increase as the lake covers more of the uncompacted area.

Capacity of the depression

The Northeast Depression cannot be used for storage of brine continually at a pumping rate of 460 gpm unless leakage is large. The stage at which brine would spill from the depression (23.3 feet) would be reached late in 1967 at a pumping rate of 460 gpm if leakage is disregarded (fig. 16). At a stage of 20 feet and an average

Figure 16 (caption on next page) belongs near here.

annual evaporation rate of 6 feet, the brine would cover about 82 acres and evaporation would be about 500 acre-feet per year. About 300 gpm (484 acre-feet per year), therefore, could be pumped into the depression until the salt crust became thick enough to force brine to spill from the depression. A stage of 20 feet would be reached about October 1966 (fig. 16) at a pumping rate of 460 gpm, if leakage is disregarded. The rate of leakage from the depression, however, affects the estimates of future lake stages. For example, if 450 gpm were pumped into the depression and 150 gpm (33 percent) leaked from the depression, the lake stage would be the same as if 300 gpm were pumped into the depression with no leakage.

Figure 16.--Graphs showing actual and projected stages of the lake in the Northeast Depression.(from July 1964).

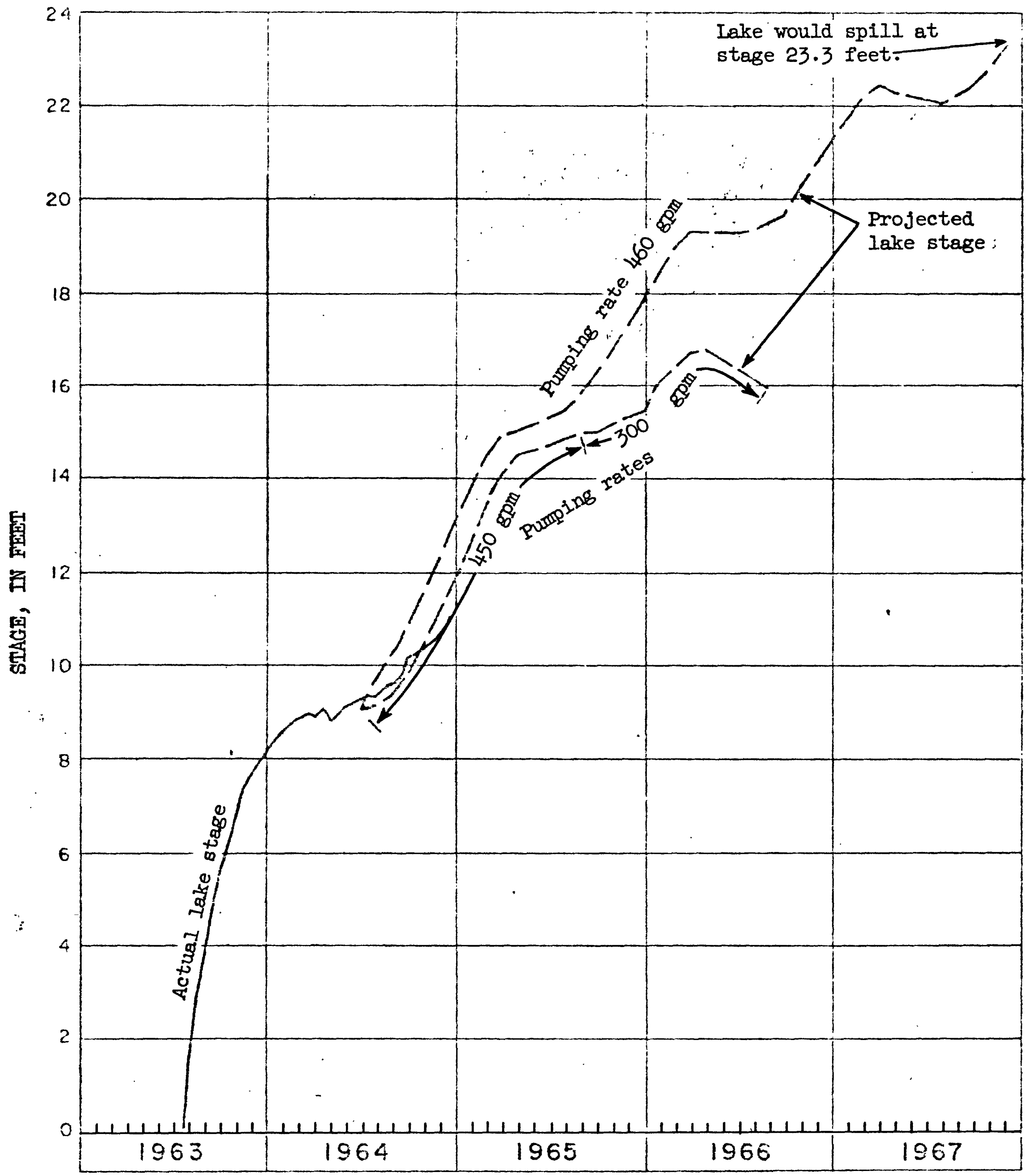


Figure 16.--Graphs showing actual and projected stages of the lake in the Northeast Depression (from July 1964).

Additional disposal

If the pumping rate is reduced to insure the continual use of the Northeast Depression as a disposal area, the quality of the water in the river will not be improved as much as it will be if the present pumping rate is maintained. For this reason, additional disposal areas are mentioned here in case it is desirable to continue to pump at a rate of 450 gpm and the lake stage rises to the capacity of the Northeast Depression. Also, if the salt is of commercial value, another disposal area could be used while salt is harvested from the Northeast Depression.

A depression in the S$\frac{1}{2}$ sec. 29, T. 24 S., R. 29 E., (fig. 1), here called the Southeast Depression, probably could be used as a disposal area for brine. By constructing a dike about 20 feet high and about 500 feet long across a gap in the southeast corner of this depression, it would have a storage capacity at least as large as that of the Northeast Depression (1,300 acre-feet). The Southeast Depression would have a maximum storage area of about 200 acres and a maximum depth of about 20 feet.

Disposal ponds to store a thousand acre-feet of brine could be constructed on a flat between the road and the river in the SE$\frac{1}{4}$ sec. 20, T. 24 S., R. 29 E. The ponds could be made by erecting embankments and lining the interior areas with plastic or compacted clay. If the ponds were 10 feet deep and covered a total area of 100 acres, 1,000 acre-feet of storage would be provided.

The Queen Lake Depression could be used as a disposal area if the bottom and sides of the depression were treated to reduce leakage (Cox and Havens, 1961, p. 53) and runoff from the drainage area west of Queen Lake were diverted away from the depression. Also, disposal ponds might be constructed on the floor and terraces in the Queen Lake Depression.

References cited

Cox, E. R., and Havens, J. S., 1961, Evaluation of the Queen Lake Depression, Eddy County, New Mexico, as a storage basin for brine: U.S. Geol. Survey open-file report, 110 p., 11 figs., 3 tables.

Cox, E. R., and Kunkler, J. L., 1962, Feasibility of injecting brine from Malaga Bend into the Delaware Mountain Group, Eddy County, New Mexico: U.S. Geol. Survey open-file report, 69 p., 5 figs., 2 tables.

Hale, W. E., Hughes, L. S., and Cox, E. R., 1954, Possible improvement of quality of water of the Pecos River by diversion of brine at Malaga Bend, Eddy County, New Mexico: Carlsbad, Pecos River Comm., New Mexico and Texas, 43 p., 8 pls., 5 figs., 7 tables.

Table 1.--Logs of test wells near the Northeast Depression

Test well 19.244 Drilled December 11-13, 1962

Material	Thickness (feet)	Depth (feet)
Silt, brown; dry, loose; contains numerous caliche pebbles ----------------------------	10	10
Conglomerate, dry, hard; cuttings very fine ---	25	335
Dolomite, shaly, tan; moderately hard, dry; cuttings platy and powdery -----------------	17	52
Shale, reddish-brown, some greenish-gray; damp to dry; moderately firm --	8	60
Gypsum, selenite and alabaster; white, colorless, and pink; dry ------------------------	8	68
Siltstone, gray; dry; moderately soft ---------	1	69
Clay and gypsum, clay reddish brown, gypsum mostly platey pink and white selenite; moderately firm------------------------------	20	89
Siltstone, light greenish-gray; moderately soft to soft, slightly damp-----------------	60	149

No water struck at 149 ft. Hole not cased. Filled up.

Test well 19.421 Drilled December 15-17, 1962

Material	Thickness (feet)	Depth (feet)
Silt and very fine-grained sand, dry, loose, brown; contains caliche pebbles from 9-14	14	14
Sand, fine- and very fine-grained, dry, loose, brown; contains caliche pebbles	5	19
Sand, clayey, brown; fine- to medium-grained with some coarse fragments; damp	5	24
Sand and caliche, clayey, light-brown; damp	10	34
Clay, silty, reddish-brown; moderately soft; contains caliche pebbles; damp	18	52
Culebra Domomite Member of Rustler Formation, dolomite, moderately hard, broken, gray, green, and tan; contains clay and calcite crystals; has many solution openings	20	72

Water-bearing zone 52-72 ft.

Well gravel packed 16-72 ft.

Depth to water 37.26 ft below land surface at completion; 2-in. casing set to 70 ft.

Table 1.--Logs of test wells - Continued

Test well 20.134 Drilled December 7-11, 1962

Material	Thickness (feet)	Depth (feet)
Silt, brown, dry, loose; contains occasional pebbles	6.5	6.5
Caliche, gray, tan and white; moderately hard to hard; cuttings ground up finely	12.5	19
Sand, brown; dry, loose, fine-grained	9	28
Clay, reddish-brown; moderately soft; dry to damp	6	34
Conglomerate, hard cemented gravel and sand	29(?)	63(?)
No recovery; 6-inch cavities at 64 and 74 ft	9	72
Culebra Dolomite Member of Rustler Formation; dolomite, gray to tan; hard, sandy and shaley at places, broken, jointed; some evidence of solution action and secondary deposition	11	83
Shale and dolomite breccia, gray to greenish-gray, silty; contains some solution pits	3	86
Shale, greenish-gray; silty, firm; contains a few fragments of dolomite	1.5	87.5
Shale, reddish-brown; firm, contains streaks of green shale	2.5	90
Gypsum, gray; dense, crystalline	2	92

Water-bearing zone 72-86 ft.

Well gravel packed 45.5-92 ft.

Depth to water 61.75 ft below land surface at completion; 2-in. casing set to 93 ft.

Table 1.--Logs of test wells - Continued

Test well 20.322 Drilled October 24-31, 1962

Material	Thickness (feet)	Depth (feet)
Silt, brown, loose; dry with caliche pebbles ----	4	4
As above, but some dark-brown clay and quartzite pebbles --	3	7
Conglomerate, quartzite and limestone pebbles, and sand ---------------------------------------	11	18
Silt and very fine-grained sand, yellow to brown, well-sorted (siltstone of Rustler Formation); poorly consolidated ---------------	32.5	50.5
As above, slightly damp -------------------------	22	72.5
Limestone or dolomite, yellow with black spots; hard, crystalline -----------------------------	3	75.5
Limestone (limy dolomite?); cavernous with solution channeling and secondary calcite; somewhat soft and granular --------------------	4.2	79.7
Culebra Dolomite Member of Rustler Formation; dolomite, greenish-white, hard, somewhat fractured; vuggy, manganese stains in fracture planes --	1.3	81.0
Dolomite, hard ----------------------------------	2.0	83.0
Dolomite, cavernous; grading to clay ------------	0.8	83.8

Table 1.--Logs of test wells - Continued

Test well 20.322 - Concluded

Material	Thickness (feet)	Depth (feet)
Clay, yellow, tough, slightly calcareous --------	0.9	84.7
Dolomite, rotten; some gypsum, white crystalline appearance ------------------------	.1	84.8
Siltstone, deep-red-brown; soft, sandy ----------	10.7	95.5

Water-bearing zone 74-83.3 ft.

Well gravel packed 62-80.

Depth to water 60.18 ft. below land surface at completion; 2-in. casing set to 94 ft.

Table 1.--Logs of test wells - Continued

Test well 20.412 Drilled November 1-14, 1962

Material	Thickness (feet)	Depth (feet)
Caliche or conglomerate and calcareous cement	4	4
Sandstone; silty and sandy siltstone; soft	3	7
Conglomerate; hard, poorly consolidated, calcareous; caving	7	14
Clay, sandy, light-brown to yellow; contains fine-to very-fine sand	4	18
Sand, fine, red, silty and clayey	6	24
Sandstone, red; fine to medium; contains some clay and a few caliche pebbles; damp	15	39
Sandstone, poorly indurated; caving, with clay stringers; damp from 61.5-62.0 ft.	40	79
Shale, red and blue; some red sand and silt; some iron stains	6.3	85.3
Saline water below 79 feet (Depth to water 76 ft below land surface)		
Shale, yellow, hard, some blue shale; yellow sand partings on bedding planes	1.2	86.5
Shale, blue to greenish-white and yellow, with iron-stained yellow sand; contains some hard rock fragments	2.1	88.6

Test well 20.412 - Concluded

Material	Thickness (feet)	Depth (feet)
Clay, silty, yellow-green; some yellow sand stringers	3.9	92.5
Sand, medium, yellow, unconsolidated or very poorly consolidated; may contain more water -- A little harder at 102.	9.5	102.0

Water-bearing zone 79-102 ft.

Gravel packed 72-102 ft.

Depth to water 59.21 ft below land surface at completion; 2-in. casing set to 105.5 ft, surface casing still in hole.

Table 1.--Logs of test wells - Continued

Test well 20.431 Drilled October 3-10, 1962

Material	Thickness (feet)	Depth (feet)
Silt and sand, fine; contains caliche pebbles -------------	0.5	0.5
Caliche, gray to tan; hard ----------------------	1.5	2
Sand and caliche pebbles ------------------------	6	8
Conglomerate, limestone -------------------------	5.5	13.5
Dolomite, white to brown, multicolored, jointed, limy; contains solution pits; brecciated at places --	16.5	30
Sand, fine- to medium-grained, yellow-brown; poorly indurated damp -------------------	2.5	32.5
Conglomerate or breccia contains few sandy veins and small dolomite fragments; moderately well-cemented ---------------------------------------	1.0	33.5
Sand, yellow; poorly consolidated ---------------	4.0	37.5
Conglomerate, poorly consolidated; contains sand stringers; clayey and silty --------------------	0.5	38.0
Sand, yellow; fine to medium, angular to subangular; poorly consolidated ----------------	5.0	43.0
Clay, loose; dolomite pebbles; contains some gray shale --	1.0	44.0
Shale, red, calcareous; contains a few calcareous nodules and streaks of light yellow-green siltstone; damp --------------------------------	5.5	49.5

Testwell 20.431 - Continued

Material	Thickness (feet)	Depth (feet)
Culebra Dolomite Member of Rustler Formation;		
dolomite, limy, porous and vuggy in part -----	0.5	50.0
Shale, red and green ------------------------------	.5	50.5
Dolomite, limy, vuggy, cavernous; contains many solution channels, secondary crystals, and some stylolites --	8.5	59.0
As above and some manganese dioxide(?) black spots --	1.0	60.0
Dolomite, limy, cavernous, brecciated in appearance ------------------------------------	3.5	63.5
Dolomite, limy, cavernous, vuggy, surrounding large (1 to 2 in.) fragments of gray, white, very slightly calcareous clay (weathered dolomite?) ------------------------------------	2.5	66.0
Show of water 65-65.5		
Depth to water 63.75 ft below land surface		
As 63.5-66 -------------------------------------	4.0	70.0
Clay, red ---------------------------------------	.2	70.2
Dolomite, limy, very porous; many solution channels ------------------------------------	1.3	71.5
Domomite, light-greenish-white, chalky (as "clay" 63.5-70); small vugs, some filled with calcite crystals; solution channeling in part of section ------------------------------------	6.0	77.5

Test well 20.431 - Concluded

Material	Thickness (feet)	Depth (feet)
Clay, yellow; soft; contains iron stains ----------	0.2	77.7
Dolomite, as 71.5-77.5 ---------------------------	5.3	83.0
No record ---	1.0	84.0

Water-bearing zone 65-84 ft.

Well gravel packed 54-84 ft.

Depth to water 63.66 ft. below land surface at completion; 2-in. casing set to 84.5 ft.

Table 1.--Logs of test wells - Continued

Test well 20.432 Drilled October 16-22, 1962

Material	Thickness (feet)	Depth (feet)
Silt, brown, loose, contains caliche and quartzite pebbles; dry	4	4
Caliche(?)	6	10
Conglomerate, weathered(?)	2	12
Conglomerate, hard; quartzite and limestone pebbles with sandy matrix	11	23
Sand, light-reddish-brown; fine to very fine, unconsolidated	6	29
Sand, fine to medium; loose	5	34
Sand, fine to medium; a little finer than 24-34 ft; caving	8	42
Conglomerate, hard, and fine to coarse sand and gravel; contains quartzite, chert, and rounded petrified wood pebbles; calcareous cement	4	46
Clay, medium red-brown, slightly calcareous; damp	10.5	56.5
Trace of water at 56.5 ft.		
Sand, red, fine	1	57.5
Sand, red and medium, fine; some red-brown clay	10	67.5
Sand	1	68.5
Clay, bedded with yellow, iron-stained sand in cracks	.5	69.0

Table 1.--Logs of test wells - Continued

Test well 20.432 - Concluded

Material	Thickness (feet)	Depth (feet)
Sand --	0.5	69.5
Clay bedded with sand ------------------------	.5	70.0
Sand and clay --------------------------------	3.5	73.5
Possibly more water at 73.5 ft.		
Sand --	.3	73.8
Clay, sandy ----------------------------------	.4	74.2
Clay and soft sandstone;		
half clay and half sandstone ----------------	.2	74.4
Sand and clay, reddish-brown ------------------	3.1	77.5

Water-bearing zone 56.5-77.5 ft.

Well gravel packed 17-61 ft.

Depth to water 59.35 ft below land surface at completion; 2 in. casing set to 73 ft.

Table 1.--Logs of test wells - Continued

Test well 29.141 | Drilled December 3-5, 1962

Material	Thickness (feet)	Depth (feet)
Silt and very fine-grained sand, loose, brown; contains occasional caliche pebbles from 10 to 15 ft; dry	14	14
Sand, very fine-grained, contains silt; same as 0-15 ft., but coarser	5	19
Sand, tan, loose, very fine-grained; contains gypsum crystals	5	24
Silt, clayey, tan, soft, friable	10	34
Clay, silty; moderately soft, greenish-gray; contains some water	5	39
Clay, silty, reddish-brown, moderately soft; moist to wet	5	44
Sand, very fine-grained; contains some loose, light-gray to white, well-sorted silt; dry	7	51
Clay, reddish-brown, silty, soft; contains numerous gypsum crystals (selenite); dry to damp	3	54
Clay, reddish-brown, silty, moderately soft; contains some sugary gypsum (alabaster)	5	59
Clay, brown, silty, soft; wet (from seep at 35-45 ft), not as wet, 65-71 ft	12	71

Table 1.--Logs of test wells - Continued

Test well 29.141 - Concluded

Material	Thickness (feet)	Depth (feet)
Culebra Dolomite Member of Rustler Formation;		
dolomite, hard, gray, broken; contains numerous solution openings; saturated --------------------	5(?)	76(?)
Clay, brown, silty, soft; wet ---------------------	1	77
No recovery - probably broken dolomite ------------	15	92

Water-bearing zone 71-92 ft.

Well gravel packed 54-90 ft.

Depth to water 37.92 ft below land surface at completion; 2-in. casing set to 90 ft.

Table 1.--Logs of test wells - Continued

Test well 29.143 Drilled December 5-7, 1962

Material	Thickness (feet)	Depth (feet)
Silt, brown; dry, loose; contains caliche pebbles	4	4
Caliche, tan to white; moderately hard; dry	5	9
Dolomite, hard, broken, gray to white; contains calcite	15	24
Gypsum, white; powdery cuttings (silt and clay clay sized); dry	18	42
Culebra Dolomite Member of Rustler Formation, dolomite, hard, broken, brown to gray; contains solution pits	7	49
Dolomite, clayey, brown to tan; moderately hard to moderately soft; contains solution pits and secondary calcite crystals	5	54
Clay and shale, limy, greenish-gray, moderately hard	1	55
Shale, reddish-brown; contains some gypsum; moderately soft	1	56
Gypsum, gray, crystalline, massive	4	60
Clay, siltstone, and gypsum; clay is gray and reddish-brown; siltstone is gray; gypsum is white alabaster and white and colorless selenite	2	62

Water-bearing zone 42-55 ft.

Well gravel packed 33-62 ft.

Depth to water 25.91 ft below land surface at completion; 2-in. casing set to 62 ft.

Table 1.--Logs of test wells - Continued

Test well #29.213 Drilled November 15-23, 1962

Material	Thickness (feet)	Depth (feet)
Sand, soft, silty, clayey; contains a few pebbles-	5	5
Conglomerate (limestone); alternating hard and soft; matrix is coarse sand at 11 ft; some solution channeling; possible secondary calcite at 10.5-11 ft., very friable; pebbles more siliceous downhole --	10.5	15.5
Sand, red and yellow, medium to fine-grained ----------------------------------	6.0	21.5
Sand, red, fine; contains silt and clay stringers; damp ---------------------------------	6.5	28
Shale, red; damp ----------------------------------	1.0	29
Sand, red, loose and caving; contains red clay stringers ------------------------------------	12.5	41.5
Shale, red, silty; contains limestone pebbles, a few quartzite pebbles, and white limy streaks ---	8.5	50
Sand, brown, very fine, and loose; well-sorted, rounded to sub-rounded; contains some clay; dry -	6.5	56.5
A little water at 55-56 ft? (Perched)		
Shale, silty, reddish-brown, firm, brecciated; contains quartz pebbles and fragments of limestones; slickensides and possible fault gouge at 58.5; dry to damp ------	6.5	63

Table 1.--Logs of test wells - Continued

Test well 29.213 - Concluded

Material	Thickness (feet)	Depth (feet)
Clay and siltstone, reddish-brown; very sandy; [softer]; contains a few dolomite fragments	11	74
Gypsum, white, massive; may contain a little water	1.5	75.5
Shale, reddish-brown, gypsiferous; contains dolomite fragments; slickensides 79-80 ft; damp	5	80.5
Culebra Dolomite Member of Rustler Formation, dolomite, jointed, honey-combed, gray to tan; contains solution channels	20.5	101

Water-bearing zone 80.5-101 ft.

Gravel packed 61.5-101 ft.

Depth to water 56.67 ft below land surface at completion; 2-in. casing set to 100 ft.

Table 1.--Logs of test wells - Continued

Test well 29.241 Drilled November 26-30, 1962

Material	Thickness (feet)	Depth (feet)
Sand, gravel, and soil, grading to moderately well-cemented conglomerate	15	15
Conglomerate, well-cemented; hard drilling	15	30
Siltstone, yellow-brown; contains a little very fine sand	10	40
Siltstone, and yellow and red-brown shale; section is a transition zone	2	42
Shale, red-brown; silty and sandy in part, becoming sandier toward 60 ft	18	60
Sand, bright yellow; medium- to coarse-grained; clay or shale, red and greenish-white; slightly damp	3	63
Sand, yellow, and shale red; damp	2	65
Sand, yellow; contains some medium- to coarse-grained black fragments; contains yellow clay; damper toward 90 ft	25	90
Shale, red-brown, purple, and pink	4.5	94.5
Shale, limy, variegated red, purple, pink, and yellow; very shattered and fractured; water-bearing zone 95-98 ft; dry ~~from~~ 98-100 ft	9.5	104.0
Siltstone, yellow-green	.3	104.3

Table 1.--Logs of test wells - Concluded

Test well 29.241 - Concluded

Material	Thickness (feet)	Depth (feet)
Limestone, granular appearance, mauve or "magenta" in part, light yellow-brown or greenish-yellow, in part	0.7	105.0
More water; formation blows much air at 106 ft.		
Siltstone, variegated, predominantly red; contains sugary-textured, limy material; yellow and greenish-white clay, 110 - 115 ft.	10.0	115

Water-bearing zone 95-98 ft. and 106 - 115 ft.

Well gravel packed 56.5-115. ft.

Depth to water 60.24 ft. below land surface at completion; 2-in. casing set to 114 ft.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage, Malaga Bend Experimental Salinity Alleviation Project July 1963

	Pumpage data					Water level		Evaporation depression			
[illegible]	Time	Pipeline meter (acre-ft)	Power meter (kwhr) (x 160)	Pumping rate (gpm)	Pressure at pump head (psi)	USGS 8 (feet below lsd)	USGS 11 (feet below lsd)	Stage (feet)	Area (acres)	Capacity (acre-ft)	Remarks
	1603	053.037				22.79	4.79				
22XX)	1200	053.037	0014.9			22.81					(Pump on 1200
22XX)	1305	053.118	0015.0								(Pump off 1247-1319
)	1651	053.479		560		54.57					(
	1215	055.455	0020								
	1319	057.988	0026.2	543	50	58.38		0.62	7.6	2.9	
	1309	062.805	0037.5	543	49	59.07	11.49	1.04	11.4	6.8	
	1505	065.429	0043								
	1455	067.781	0049	543				1.30	13.3	10.0	
	1615	070.319	0055					1.44	14.1	12.0	
	0955	072.080	0059.5	543	47			1.58	14.9	14.0	
	1140	074.646	0065.5	543		59.91		1.72	15.6	16.3	Oil on brine surface in well USGS 8

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project ____August____ 19 63__

Day	Brine pump data					Water level		Northeast Depression			Remarks
	Time	Brine meter (acre-ft)	Power meter (kwhr) (÷100)	Pumping rate (gpm)	Pressure at pump head (psi)	USGS 5 (feet below MP)	USGS 11 (feet below LSD)	Stage (feet)	Area (acres)	Capacity (acre-ft)	
1											
2	1000	078.783	0075.3			26.70	9.40	1.86	16.6	18.2	Pump off 0400
3	1515	078.898									Pump on 1410. Pump off 1900 8/3/63
4											
5	1127	079.294	0076.5	555	35	54.05	7.60	1.98	17.3	20.4	Pump on 1126. Pump off 1320-1339 8/5/63
6	1515	082.108	0083								
7	0940 1050	083.967 084.001	0087.3	550	42						Brine meter off 0943-1049
8	0930	086.302	0093								
9	1650	089.446	0100.5	558	40	59.17	11.76	2.40	19.7	27.8	
10											
11	1200	093.796	0110		40						
12	1445	096.491	0117	543	39	59.61	12.10	2.67	21.2	33.5	
13	1425	098.823	0122		40						Pump off 1355-1415
14	0932	100.567	0126.5	546	38			2.82	22.0	37.0	Pump off 0800-0930
15											
16	1544	106.057	0139.5	552	38	59.82	12.05	3.01	23.2	41.5	
17											Pump off 1400
18											
19											
20	1950	108.378	0144		40						Installed new switch and auto re-closers 8/20. Pump on 1950
21											Pump off 1300
22	1135	110.077	0149		40						Pump on 1135
23	1544	112.883	0155.2	554	40	56.57	10.42	3.18	24.2	45.5	Installed larger heater 8/22
24	1505	115.250	0161		40						
25											
26											
27											
28											
29	1410	127.290	0189		40						1.10 inch rain in depression 2300 8/29-0200 8/30
30	1526 1542	129.824 000.009	0194.9	554	34	58.63	11.77	3.91	28.2	64.8	New brine-meter head. Meter off 1531-1537
31											

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero stage height in the depression is altitude 2,928.63.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project September 19 63

	Pumpage data					Water level		Northeast Depression			
Day	Time	Brine meter (acre-ft)	Power meter (kwhr) (160)	Pumping rate (gpm)	Pressure at pump head (psi)	USGS 8 (feet below MP)	USGS 11 (feet below LSD)	Stage (feet)	Area (acres)	Capacity (acre-ft)	Remarks
[illegible]	1510	007.233	0212								
[illegible]	1100	009.242	0216.5	554	36	58.84					
[illegible]	1545	012.160	0223.4	550	38						
[illegible]	1321	016.756	0234.0	537	36	58.97	11.83	4.40	30.8	79	Brine sampled. Temp. 70°F
[illegible]	1440	031.420	0268								
[illegible]	1620	034.010	0274.5	554	40	59.02	11.91	4.80	33.0	92	
[illegible]	1458	043.546	0297.3	546	40	59.22	12.04	5.00	34.2	99	
[illegible]	1415	048.315	0308		40						
[illegible]	1245	050.578	0313.2	545	40	59.30	12.08	5.14	35.0	103	
[illegible]	1440	060.456	0336		40						
[illegible]	1310	067.540	0363.0	545	40	59.31	12.19	5.46	36.6	115	

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,9[illegible]8.[illegible]8.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project ____October____ 19 63

Day	Time	Pumpage data: Brine meter (acre-ft)	Pumpage data: Power meter (kwhr) (160)	Pumpage data: Pumping rate (gpm)	Pumpage data: Pressure at pump head (psi)	Water level: USGS 8 (feet below MP)	Water level: USGS 11 (feet below LSD)	Northeast Depression: Stage (feet)	Northeast Depression: Area (acres)	Northeast Depression: Capacity (acre-ft)	Remarks
1	1530	77.433	0378.0	545	40	59.56		5.62	37.3	121	
2											
3	1230	81.973	0386		40						
4	1658	84.830	0393.4	550	39	59.52	12.37	5.77	37.8	126	Brine sample: T=70°F
5											
6											
7											
8											
9											
10	1230	98.846	0426		40						
11	1454	101.483	0432.5	550	40	59.86	12.45	6.04	39.4	137	
12											
13											
14	1405	108.657	0449		40						(Pump off 1410 to 1555 to put flume on end discharge pipe in NE depression
15											
16											
17	1510	115.790	0465		40						
18	1540	118.247	0471.9	547	40	59.78	12.48	6.33	40.8	147	Brine sample: T=70°F
19											
20											
21											
22											
23											
24	1115	132.242	0504		40						
25	1418	134.930	0511.0	545	40	59.95	12.64	6.61	42.1	161	
26											
27											
28											
29	1700	144.796	0534		40						
30											
31								6.83	42.9	171	

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,926.68.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project November 1963

Day	Pumpage data					Water level		Northeast Depression			Remarks
	Time	Brine meter (acre-ft)	Power meter (kwhr) (150)	Pumping rate (gpm)	Pressure at pump head (psi)	USGS 8 (feet below MP)	USGS 11 (feet below LSD)	Stage (feet)	Area (acres)	Capacity (acre-ft)	
1	1032	151.340	0549.7	543	39	60.29	12.82	6.85	42.9	172	
4								6.96	43.4	175	
7	1445	166.122	0584		40						
8	1418	168.462	0590	538	39	60.09	12.75	7.08	43.8	181	Brine sample: T=70°F
14	1525	182.926	0624		40						
15	1510	185.280	0629.9	534	40	60.02	12.82	7.35	44.8	193	
19	1116	194.450	0651.5	539	39		12.98	7.47	45.4	199	
20-21 22 XX	1143	201.655	0668.4	535	40	60.34	14.25	7.58	45.7	203	Brine sample: T=70°F. Reduced pumping rate to 325 gpm at 1210-1227
	1240			325	89	42.01	13.79				
23	1050	203.093	0673		91						
26	1028	207.337	0687.9	325	92	39.70	10.68	7.62	45.8	205	
28	1425	210.426	0698		92						
29	1230	211.697	0703.1	310	95	38.72	10.51	7.65	46.1	207	

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,928.86.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project December 1963

Day	Pumpage data					Water level		Northeast Depression			Remarks
	Time	Brine meter (acre-ft)	Power meter (kwhr) (160)	Pumping rate (gpm)	Pressure at pump head (psi)	USGS 8 (feet below MP)	USGS 11 (feet below LSD)	Stage (feet)	Area (acres)	Capacity (acre-ft)	
1											
2											
3											
4	1520	218.955	0728.4	325	96			7.74	46.7	212	
5	1320	220.259	0733		95						
6	1425	221.724	0738.1	311	98	38.43	10.13	7.77	46.8	213	
7											
8											
9											
10											
11											
12	1045	230.043	0767		97						
13	1316	231.617	0772.9	311	97	39.09	10.34	7.90	47.0	217	
14											
15											
16											
17											
18	1315	238.523	0798.0	309	100			7.99	47.5	222	
19											
20	1427	241.214	0808.2	292	101	37.11	10.07	8.02	47.6	223	Adjusted pumping rate to 309 gpm
20XX 21	1445			309	84	42.52					Pressure gage sticking
21 22											
23											
24											
25											
26	1140	249.609	0838		89						Installed new pump-head pressure gage
27	1228	251.126	0844.1	330	92	39.67	10.46	8.16	48.3	229	
28											
29											
30											
31											

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,[illegible]8.68.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project January 1964

Day	Pumpage data: Time	Pumpage data: Brine meter (acre-ft)	Pumpage data: Power meter (kwhr) (160)	Pumpage data: Pumping rate (gpm)	Pumpage data: Pressure at pump head (psi)	Water level: USGS 8 (feet below MP)	Water level: USGS 11 (feet below LSD)	Northeast Depression: Stage (feet)	Northeast Depression: Area (acres)	Northeast Depression: Capacity (acre-ft)	Remarks
1	1030	258.213	0869		93						
2											
3	1417	261.273	0880.3	325	93	39.35	10.56	8.26	48.6	234	
4											
5											
6											
7											
8											
9	1125	269.656	0910		93.5						
10	1508	271.309	0916.5	325	95	39.16	10.29	8.36	48.9	238	
11											
12											
13											
14											
15											
16											
17	1417	281.290	0952.4	325	96	38.98	10.37	8.44	49.3	243	
18	1350	282.675	0957		96						
19											
20											
21	1458	286.980	0973.1		97						
22											
23	1345	289.726	0983		97						
24	1450	291.188	0988.6	318	98	39.20	10.65	8.54	49.6	247	
25											
26											
27											
28											
29											
30	1415	299.611	1019		98						
31	1440	301.047	1024.9	318	99	39.24	10.65	8.60	49.8	251	

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,9[illegible]8.68.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project February 19 64

Day	Pumpage data					Water level		Northeast Depression			Remarks
	Time	Brine meter (acre-ft)	Power meter (kwhr) (160)	Pumping rate (gpm)	Pressure at pump head (psi)	USGS 8 (feet below MP)	USGS 11 (feet below LSD)	Stage (feet)	Area (acres)	Capacity (acre-ft)	
1											
2											
3											
4											
5											
6	1345	309.445	1056		98						
7	1510	310.943	1061.7	318	99	39.28	10.64	8.66	50.0	254	
8											
9											
10											
11											
12	1420	317.969	1087								Installed new pump-head pressure gage
13											
14	1312	320.735	1097.8	320	95	39.06	10.46	8.75	50.3	258	
15											
16											
17											
18											
19											
20	1455	329.479	1129.9	355	92	41.70	11.01	±8.77	50.4	259	
21											
22	1425	332.529	1140		93						
23											
24											
25											
26											
27											
28	1258	341.493	1172.4	339	94	40.91	11.05	±8.85	50.8	265	
29	1435	343.095	1178		94						
30											
31											

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,908.68.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project March 19 64

Day	Time	Pumpage data: Brine meter (acre-ft)	Pumpage data: Power meter (kwhr) (160)	Pumpage data: Pumping rate (gpm)	Pumpage data: Pressure at pump head (psi)	Water level: USGS 8 (feet below MP)	Water level: USGS 11 (feet below LSD)	Northeast Depression: Stage (feet)	Northeast Depression: Area (acres)	Northeast Depression: Capacity (acre-ft)	Remarks
1											
2											
3											
4											
5											
6	1510	352.151	1210.4	339	95	40.75	10.93	±8.88	51.0	266	Wind 15-20 mph from W
7	1530	353.682	1215		95						
8											
9											
10											
11											
12											
13	1445	362.592	1247.9	339	96	40.64	10.84	±8.96	51.3	269	Wind 10-15 mph from SW
14	1525	364.129	1253		96						
15											
16											
17											
18											
19											
20	1453	373.102	1285.7	339	96	40.94	11.17	8.97	51.3	269	Flat calm at depression
21	1550	374.649	1291		96						
22											
23	1223	377.432	1301.3	450	71	49.77					Increased pumping rate to 450 gpm at 1214
24	1318	379.505	1307.3	450	70	50.54					
25											
26											
27	1325	385.507	1325.1	450	71	50.73	12.23	8.94	51.2	267	Wind 5-10 mph from S
28	1435	387.586	1331		71						
29	1607	389.695	1337.5	450	70						
30											
31											

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,920.68.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project April 1964

Day	Pumpage data					Water level		Northeast Depression			Remarks
	Time	Brine meter (acre-ft)	Power meter (kwhr) (160)	Pumping rate (gpm)	Pressure at pump head (psi)	USGS 8 (feet below MP)	USGS 11 (feet below LSD)	Stage (feet)	Area (acres)	Capacity (acre-ft)	
1											
2											
3	1545	399.641	1377.0	450	72	50.80	12.30	8.99	51.5	272	
4	1455	401.285	1382(?)		73						
5											
6											
7											
8											
9											
10	1552	413.323	1408.0	445	73	50.49	12.16	9.02±	51.6	274	
11	1625	415.340	1414		72						Removed discharge box in depression
12											
13											
14											
15											
16											
17	1445	427.027	1449.6	442	73	50.24	12.32	9.07	51.8	276	
18	1500	429.003	1455		73						
19											
20											
21											
22											
23											
24	1605	438.513	1484.8	0	0	26.37	8.86	9.02±	51.6	274	Pump off about 1200
25											Pulled submersible pump
26											
27											
28											
29											Installed turbine pump
30	1315	438.651	1485	515	39						Started pump at 1205
31											

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,928.68.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project ______ May ______ 19 64

Day	Pumpage data					Water level		Northeast Depression			Remarks
	Time	Brine meter (acre-ft)	Power meter (kwhr / 160)	Pumping rate (gpm)	Pressure at pump head (psi)	USGS 8 (feet below MP)	USGS 11 (feet below LSD)	Stage (feet)	Area (acres)	Capacity (acre-ft)	
1	1452	440.930	1489.1	513	40	45.31	13.30	8.80	50.6	261	
2	1325	443.096	1483		40						
3											
4											
5											
6	1410	452.386	1510		40						
7											
8	1422	456.980	1518.2	517	38	47.67	13.08	8.84	50.8	264	
9											
10											
11	1355	463.808	1531		39						
12											
13											
14											
15	1610	473.135	1547.7	514	39	47.81	11.23	8.96	51.2	271	(Reduced pumping rate to 454 gpm at 1650
16	1415	474.593	1551		54						(473.203 acre-ft, 1547.8 kwhr/160; 51 psi
17											
18											
19											
20	1328	482.678	1568.3		54						(Raised impellers at 1410=482,737 acre-ft
21	1125	484.484	1571.8	461	36						(1568.5 kwhr/160; 36 psi
22	1445	486.854	1575.9	468	36	44.12	12.70	9.04	51.7	274	
23											
24											
25											
26											
27											
28											
29	1435	499.361	1598.6	470	36	44.37	12.91	9.11	52.1	279	
30											
31	1430	505.630	1610		36						Reduced pumping rate with impellers-pressure 40 psi

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,928.68.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project June 1964

Day	Pumpage data					Water level		Northeast Depression			Remarks
	Time	Brine meter (acre-ft)	Power meter (kwhr) (÷ 160)	Pumping rate (gpm)	Pressure at pump head (psi)	USGS 8 (feet below MP)	USGS 11 (feet below LSD)	Stage (feet)	Area (acres)	Capacity (acre-ft)	
1	1230	507.459	1613.3	461	39	43.49		9.14±.01	52.2	279	
2											
3											
4											
5	1513	515.800	1629.0	455	40	43.53	12.84	9.17	52.3	281	
6											
7	1305	519.652	1636		39						
8											
9											
10											
11	1625	527.981	1652		39						
12	1400	529.808	1655.3	460	38	43.75	12.93	9.18	52.4	282	
13											
14											
15											
16											
17	1315	539.821	1674.3		39						
18											
19	1520	543.957	1682.2	460	40	43.35	12.58	9.22±.02	52.5	283	
20	1415	545.885	1685		39						
21											
22											
23											
24	1210	553.846	1700		38			9.26	52.6	286	
25											
26	1410	558.090	1708.5	461	40	43.60	12.84	9.27	52.6	286	
27											
28											
29											
30	1350	566.203	1723.7		40						
31											

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,928.63.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project ______July______ 19 64

Day	Pumpage data					Water level		Northeast Depression			Remarks
	Time	Brine meter (acre-ft)	Power meter (kwhr) (160)	Pumping rate (gpm)	Pressure at pump head (psi)	USGS 8 (feet below MP)	USGS 11 (feet below LSD)	Stage (feet)	Area (acres)	Capacity (acre-ft)	
1											
2	1400	570.302	1731.4	460	40	43.57	12.78	9.28	52.8	283	
3											
4	1450	574.471	1749		40						
5											
6											
7											
8	1215	582.394	1754		40						
9	1200	584.420	1757.7		40						
10	1335	586.605	1761.8	460	40	43.83	12.96	9.29	52.8	284	
11											
12											
13											
14											
15											
16	1020	598.551	1784		40						
17	1435	600.960	1788.6	460	40	43.68	12.91	9.31	52.8	285	
18											
19											
20											
21											
22											
23	1505	613.223	1811.7		40						
24	1410	615.173	1815.1	460	40	43.58	12.87	9.32	52.9	286	
25											
26											
27											
28											
29	1515	625.434	1834		40						
30	1440	627.407	1838.3	455	40	43.54	12.81	9.36	53.0	288	
31											

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,920.68.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project August 1964

Day	Pumpage data					Water level		Northeast Depression			Remarks
	Time	Brine meter (acre-ft)	Power meter (kwhr) (160)	Pumping rate (gpm)	Pressure at pump head (psi)	USGS 8 (feet below MP)	USGS 11 (feet below LSD)	Stage (feet)	Area (acres)	Capacity (acre-ft)	
1											
2											
3											
4											
5	1525	639.576	1861.5		40						
6											
7	1330	643.436	1869.7	455	40	43.55	12.77	9.39	53.1	290	
8											
9											
10											
11											
12	1415	653.460	1888		40						
13											
14	1550	-	1895.9		40	43.35	12.61	9.45	53.3	293	(Brine meter stopped--Cleaned and oiled; still eccentric. Set at 657.171 at 1553
15											
16											
17											
18											
19	0950	666.657	1914.1	455	41						Meter seems to be functioning
20	1230	668.884	1918.4		41						
21	1525	671.150	1922.8	455	40	43.27	12.63	9.54	53.5	299	
22											
23											
24	1415	677.042	1944.0?		41						(Meter not operating continuously; lost about 1 acre-ft since 8/20/64.
25											
26	1550	680.884	1942.0		40						
27											
28	1430	684.808	1949.4	432?	40	43.39	12.74	9.58	53.6	302	Meter probably wrong; eccentric
29											
30											
31	1445	690.856	1961		40						(Pump off from 1515 to 1605 to remove brine meter

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,920.63.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project September 19 64

Day	Time	Pumpage data: Brine meter (acre-ft)	Pumpage data: Power meter (kwhr) (160)	Pumpage data: Pumping rate (gpm)	Pumpage data: Pressure at pump head (psi)	Water level: USGS 8 (feet below MP)	Water level: USGS 11 (feet below LSD)	Northeast Depression: Stage (feet)	Northeast Depression: Area (acres)	Northeast Depression: Capacity (acre-ft)	Remarks
1											
2											
3											
4	1450		1976.1		40	43.38	12.70	9.60	53.7	302	
5											
6											
7	1535		1987.8		40						
8											
9											
10											
11	1520		2003.2		40	43.42	12.76	9.63	53.8	304	
12											
13											
14											
15	1425		2018.4		40						
16											
17											
18	1315		2029.8		40	43.34	12.62	9.83	54.4	316	Rainfall 0.72 in. 9/11-9/18
19											
20											
21											
22	1625		2045.5		40						
23											
24											
25	1405		2056.8		40	43.28	12.64	10.12 10.15	55.4 55.4	331 333	Rainfall 1.32 in. 9/18-9/25
26											
27											
28											
29	1145		2068		40						
30											

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,926.68.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project October 19 64

Day	Pumpage data					Water level		Northeast Depression			Remarks
	Time	Brine meter (acre-ft)	Power meter (kwhr) (160)	Pumping rate (gpm)	Pressure at pump head (psi)	USGS 8 (feet below MP)	USGS 11 (feet below LSD)	Stage (feet)	Area (acres)	Capacity (acre-ft)	
1											
2	1505	-	2084.0		39	43.55	12.86	10.20	55.6	336	
3											
4											
5											
6	1130	-	2099		40						
7											
8											
9	1440		2111.0		40	43.51	12.81	10.22	55.7	337	
10											
11											
12											
13	1425		2126		40						
14											
15	1025		2133.4		40	43.64	12.93	10.26	55.8	339	
16											
17											
18											
19											
20	1250		2153		40			10.31	55.9	342	Pump off 1325-1445
21											
22	1410		2160.8		40	43.61	12.93	10.33	56.0	343	
23											
24											
25											
26											
27	1500		2180		40						
28											
29											
30	1300		2191.4		40	43.63	12.97	10.42	56.3	348	(Computed pumpage from power records 9/28-10/30 65.8 acre-ft
31											(Brine meter still off for repairs

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,988.63.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project November 19 64

Day	Pumpage data					Water level		Northeast Depression			Remarks
	Time	Brine meter (acre-ft)	Power meter (kwhr) (160)	Pumping rate (gpm)	Pressure at pump head (psi)	USGS 8 (feet below MP)	USGS 11 (feet below LSD)	Stage (feet)	Area (acres)	Capacity (acre-ft)	
1											
2	1425		2203		40						
3											
4											
5											
6	1100		2218.1		40	43.80	13.07	10.46	56.4	350	
7											
8											
9											
10	1325		2234		40						
11											
12											
13	1345		2245.6		40	43.77	13.13	10.54	56.7	354	
14											
15											
16											
17	1410		2261.2		40						
18											
19											
20	1045		2272.5		39	43.96	13.28	10.62	56.9	358	
21											
22											
23											
24	1440		2288.8		40						
25											
26											
27	1420		2300.2		40	43.82	13.23	10.72	57.3	364	(Computed pumpage from power records 10/30-11/27 58.0 acre-ft
28											(Brine meter still off for repairs
29											
30											

Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,923.68.

Table 2.--Monthly data on pumpage, water levels in wells, and reservoir storage,

Malaga Bend Experimental Salinity Alleviation Project December 19 64

Day	Pumpage data: Time	Pumpage data: Brine meter (acre-ft)	Pumpage data: Power meter (kwhr) (160)	Pumpage data: Pumping rate (gpm)	Pumpage data: Pressure at pump head (psi)	Water level: USGS 8 (feet below MP)	Water level: USGS 11 (feet below LSD)	Northeast Depression: Stage (feet)	Northeast Depression: Area (acres)	Northeast Depression: Capacity (acre-ft)	Remarks
1	1415		2315.8		40						
2											
3											
4	1440		2327.4		39	44.11	13.51	10.77	57.4	368	
5	1455		2331.5		39						
6											
7											
8											
9								10.83	57.6	372	
10											
11	1125		2354.1		39	44.02	13.35	10.86	57.8	373	
12											
13											
14	1200		2365.8		40						
15											
16											
17											
18	1447		2381.9		39	44.18	13.60	10.93	58.0	377	
19											
20											
21	1500		2393.6		39						
22											
23											
24	1404		2405.0		38	43.96	13.38	11.03	58.4	383	
25											
26											
27											
28											
29	1420		2424.5		39						(Computed pumpage from power records 11/27-12/31 70.6 acre-ft
30											
31	1548		2432.7		39	44.07	13.53	11.11	58.7	388	(Brine meter still off for repairs

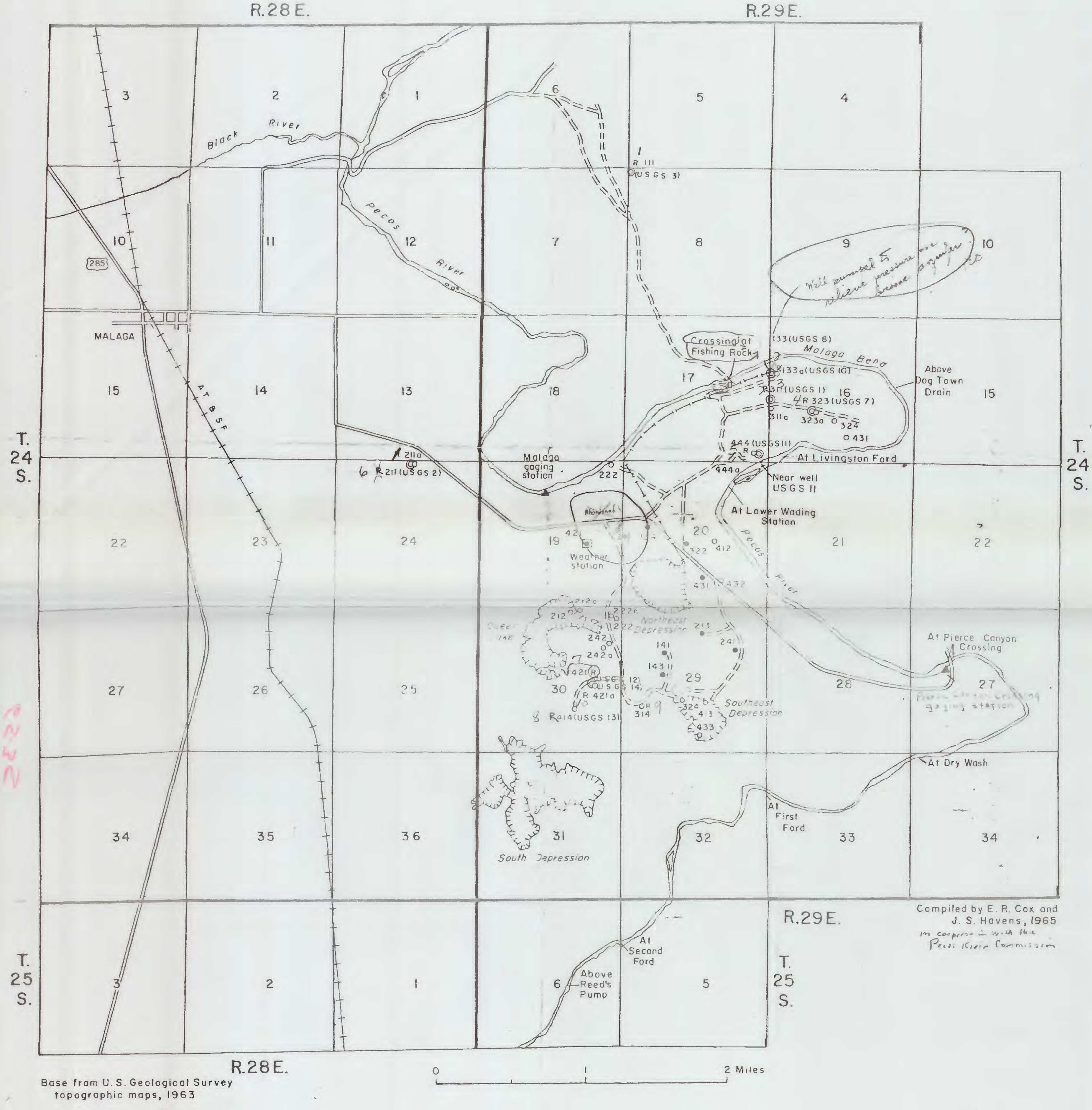
Time is Mountain Standard Time.
Land surface at well USGS 11 is 15.6 feet above the riverbed at the lower end of Malaga Bend.
Zero gage height in the depression is altitude 2,928.63.

Table 3.--Average gain in chloride load between sampling sites from Fishing Rock Crossing to Reed's pump.

<table>
<tr><th rowspan="2">Between sampling sites</th><th colspan="3">Gain in chloride load</th></tr>
<tr><th>March 13-14
1962</th><th>July 16-17
1963</th><th>August 12-13
1964</th></tr>
<tr><td>At Fishing Rock Crossing – Above Dogtown Drain</td><td></td><td>43</td><td>34</td></tr>
<tr><td>Above Dogtown Drain – At Livingston Ford</td><td></td><td>41</td><td rowspan="2">25</td></tr>
<tr><td>At Livingston Ford – Near Well USGS 11</td><td></td><td>84</td></tr>
<tr><td>Near Well USGS 11 – At Pierce Canyon Crossing</td><td>49</td><td></td><td></td></tr>
<tr><td>At Pierce Canyon Crossing – At Dry Wash</td><td>26</td><td></td><td></td></tr>
<tr><td>At Dry Wash – At First Ford</td><td>28</td><td></td><td></td></tr>
<tr><td>At First Ford – At Second Ford</td><td>16</td><td></td><td></td></tr>
<tr><td>At Second Ford – Above Reed's pump</td><td>16</td><td></td><td></td></tr>
</table>

Table 4.--Evaporation and climatological data, Malaga Bend, Eddy County, N. Mex., Aug. 1963-July 1964

Month	Average air temperature (°F)		Average relative humidity (percent)		Precipitation				Evaporation		Remarks
					At Northeast Depression	At Well USGS 8	At Weather station				
	Max.	Min.	Max.	Min.	(in)	(in)	(in)	(ft)	Net (ft)	Gross (ft)	
1963											
Aug.	94	67	69	28	1.17	2.08	1.69	.141	.564	.705	
Sept.	89	60	83	32	.64	.47	1.00	.083	.450	.533	
Oct.	84	48	74	29	.04	.21	.11	.009	.423	.432	
Nov.	68	35	70	28	.02	.05	.03	.002	.402	.404	
Dec.	53	25	85	44	.29	.27	.26	.022	.156	.178	
1964											
Jan.	59	23	59	19	Tr.	0	Tr.	Tr.	.297	.297	
Feb.	57	21	74	24	0	.01	.02	.002	.288	.290	
Mar.	71	35	47	12	.64	.56	.64	.053	.561	.614	
Apr.	82	45	40	9	0	0	0	0	.978	.978	
May	91	58	56	17	.19	.35	.68	.056	.927	.983	
June	96	62	65	19	.95	-	.57	.048	.882	.930	
July	100	70	60	19	0	-	.26	.021	.945	.966	



EXPLANATION

o 222

Well finished in alluvium.

• 431

Well finished in Culebra Dolomite Member of Rustler Formation.

R 211
◎ (USGS 2)

Well finished in brine aquifer.

NOTE: "R" by well symbol indicates recorder on well. Number is well location within a section.

Near well USGS 11

River sampling site.

▲

Gaging station

Pipeline

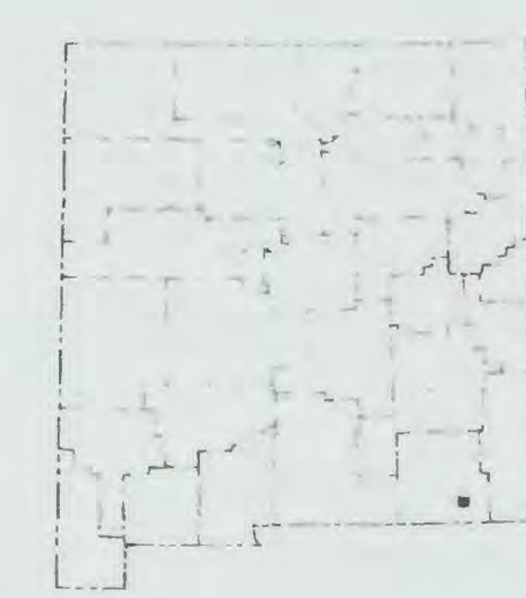


Figure 1.--Map showing locations of wells, depressions, pipeline, and river-sampling sites in the Malaga Bend area, Eddy County, N. Mex.

65-35

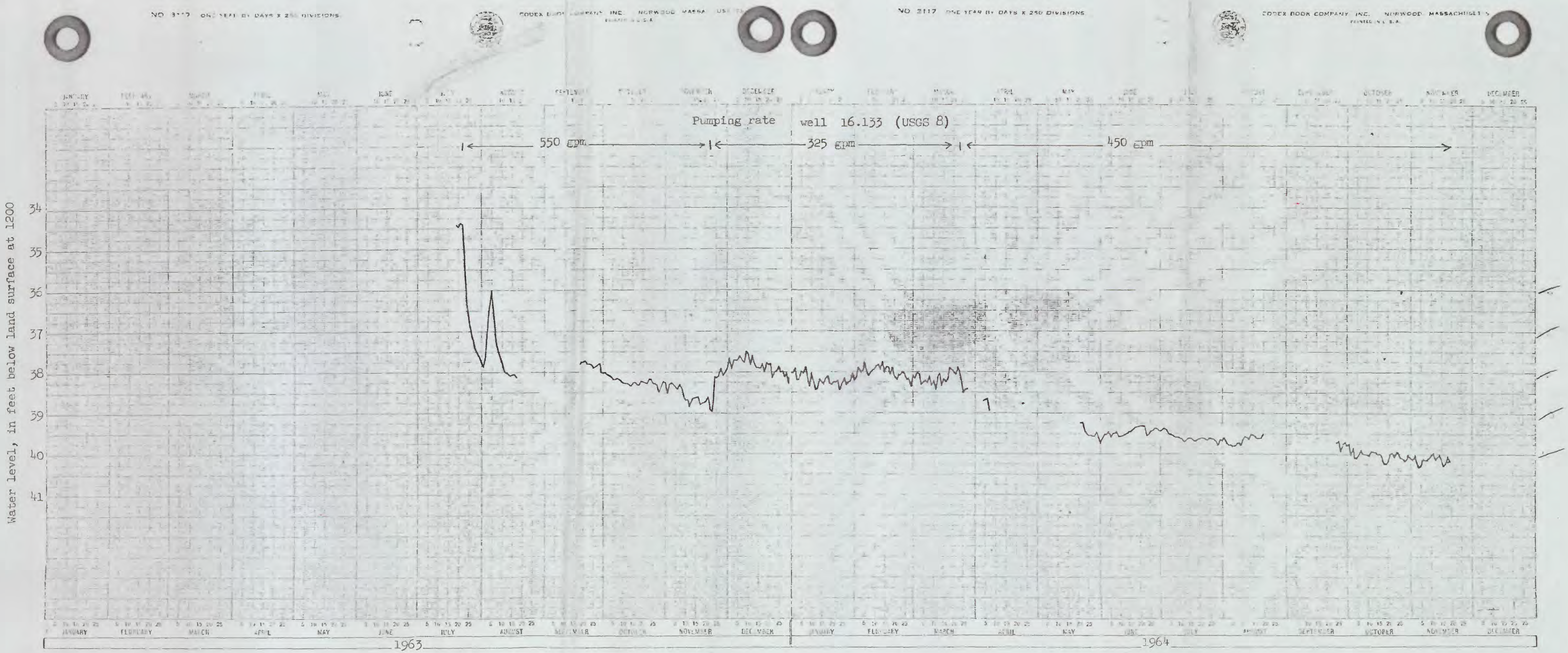


Figure 10.--Graph showing fluctuation of water level in well 8.111 (USGS 3)

65-35

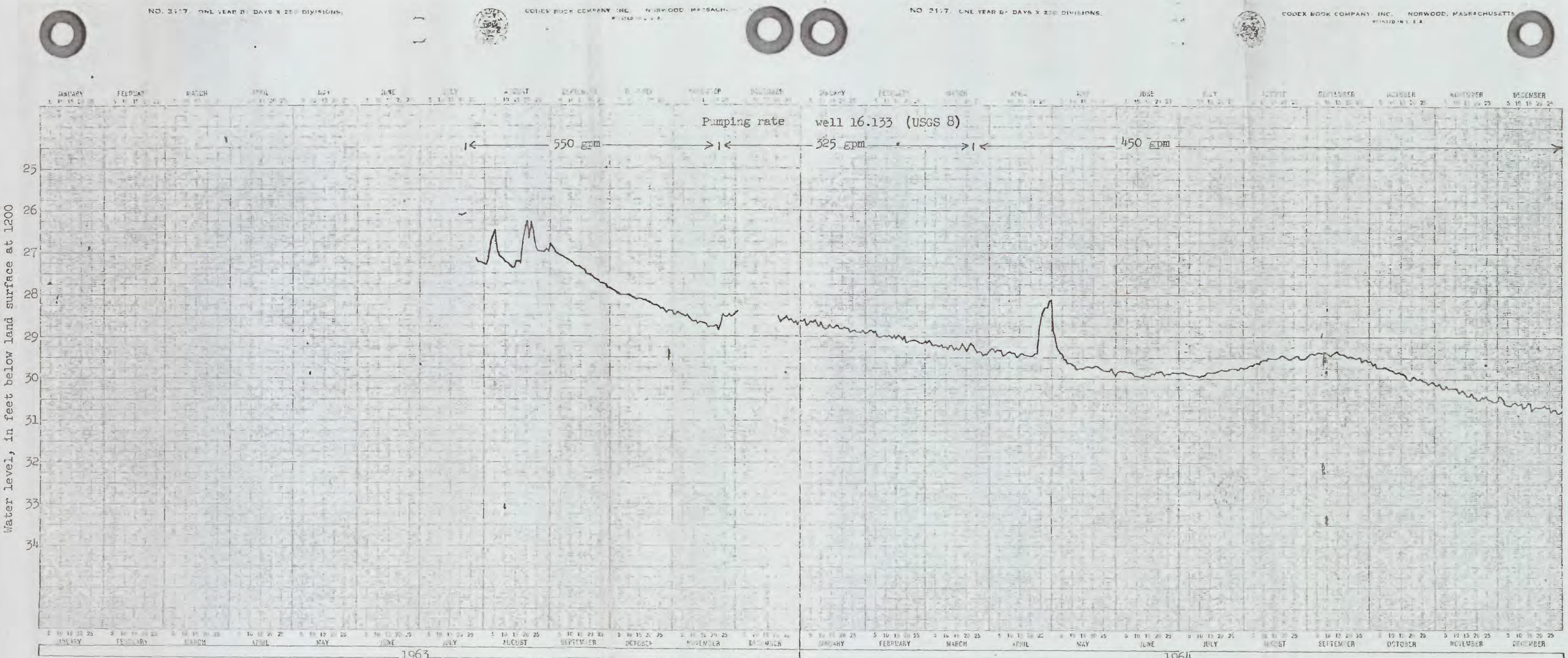
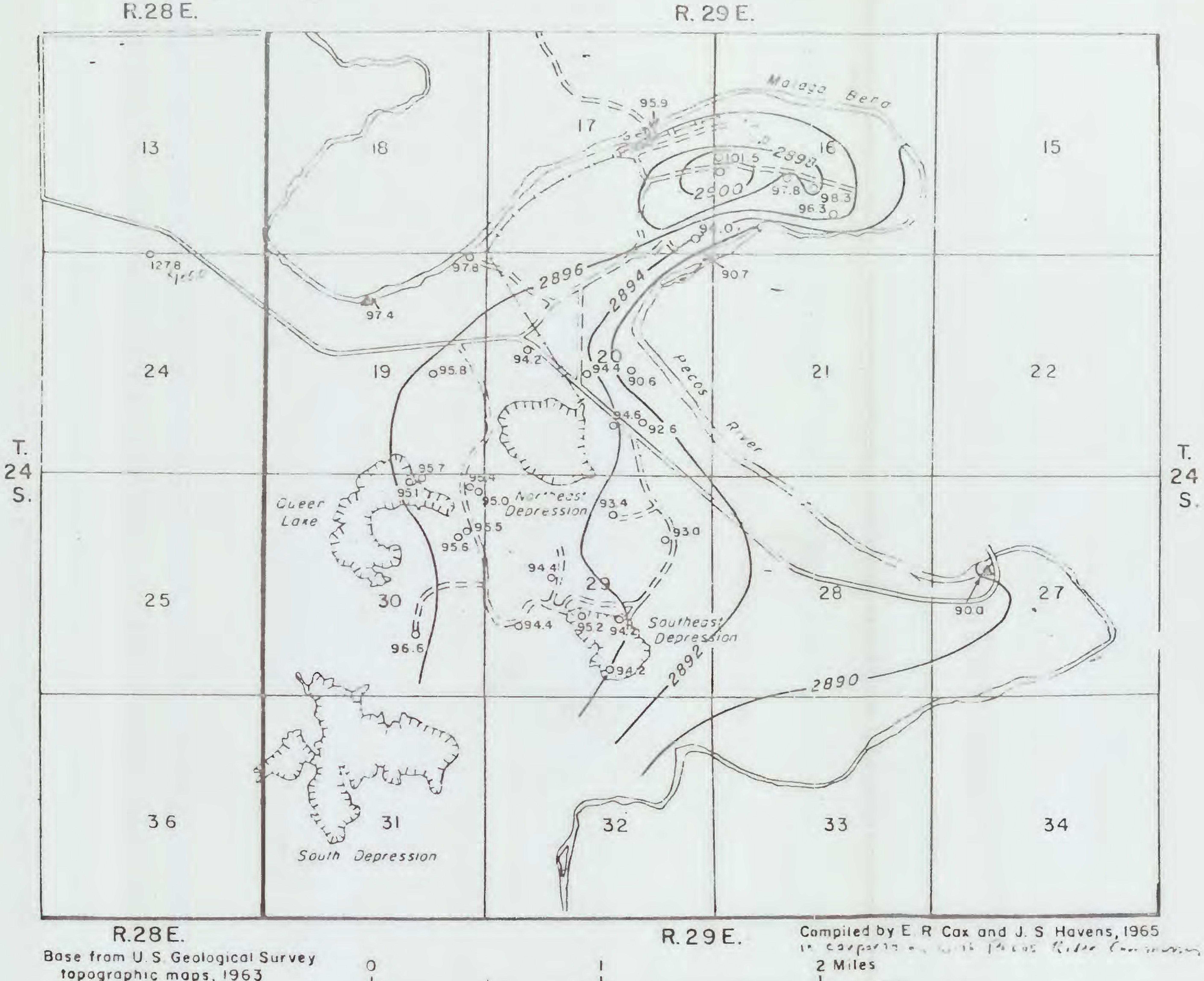


Figure 11.--Graph showing fluctuation of water level in well 16.133a (USGS 10)



EXPLANATION

o 95.8
Well

Number denotes altitude of water level above 2,800 feet.

← 90.0

Altitude of the river surface above 2,800 feet.

—2896—

Piezometric ~~Water-table~~ contour ~~on~~ July 19, 1963. Interval is 2 feet. Number denotes altitude of water table.

▲

Gaging station

Pipeline

Figure 3.--Map showing the configuration of the ~~water-table~~ Piezometric surface in alluvium and the Culebra Dolomite Member of the Rustler Formation in the Malaga Bend area, Eddy County, N. Mex. before pumping of brine began,

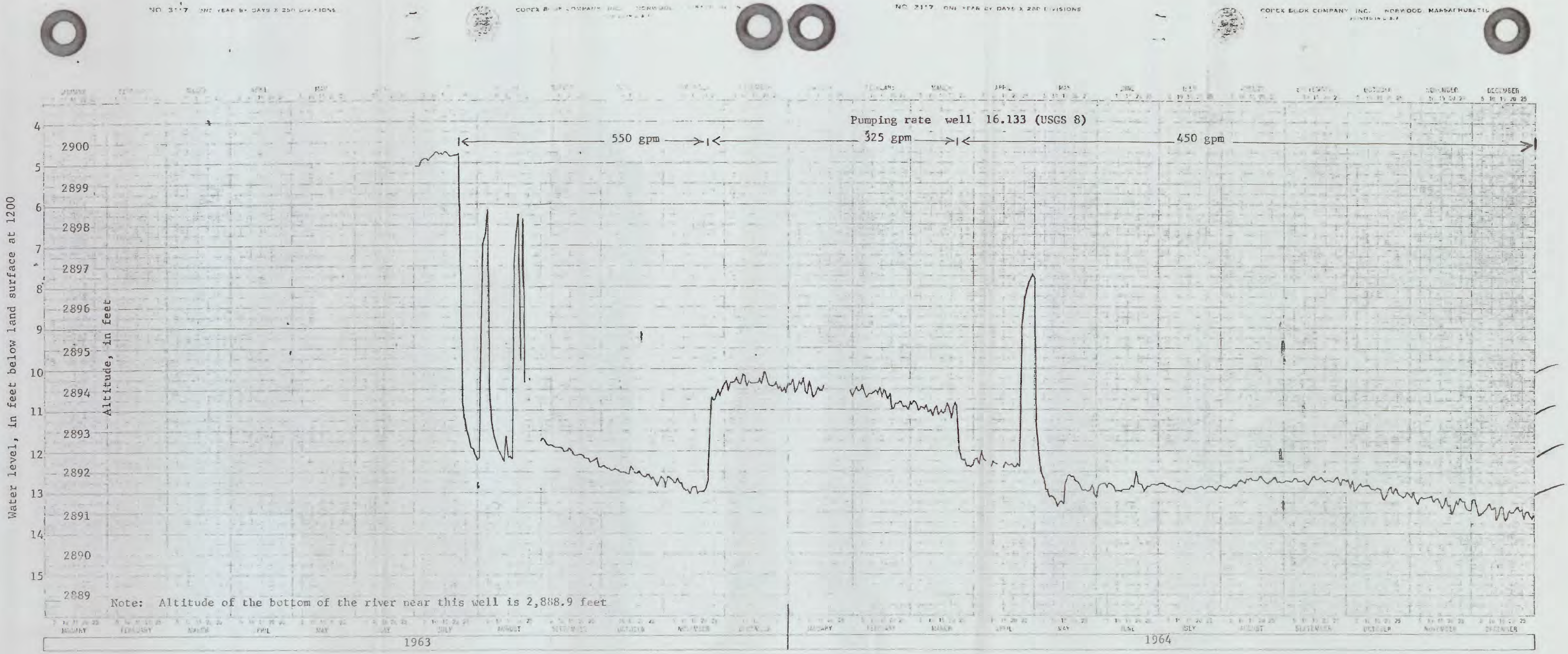


Figure 6.--Graph showing fluctuation of water level in well 17.444 (USGS 11)

65-35

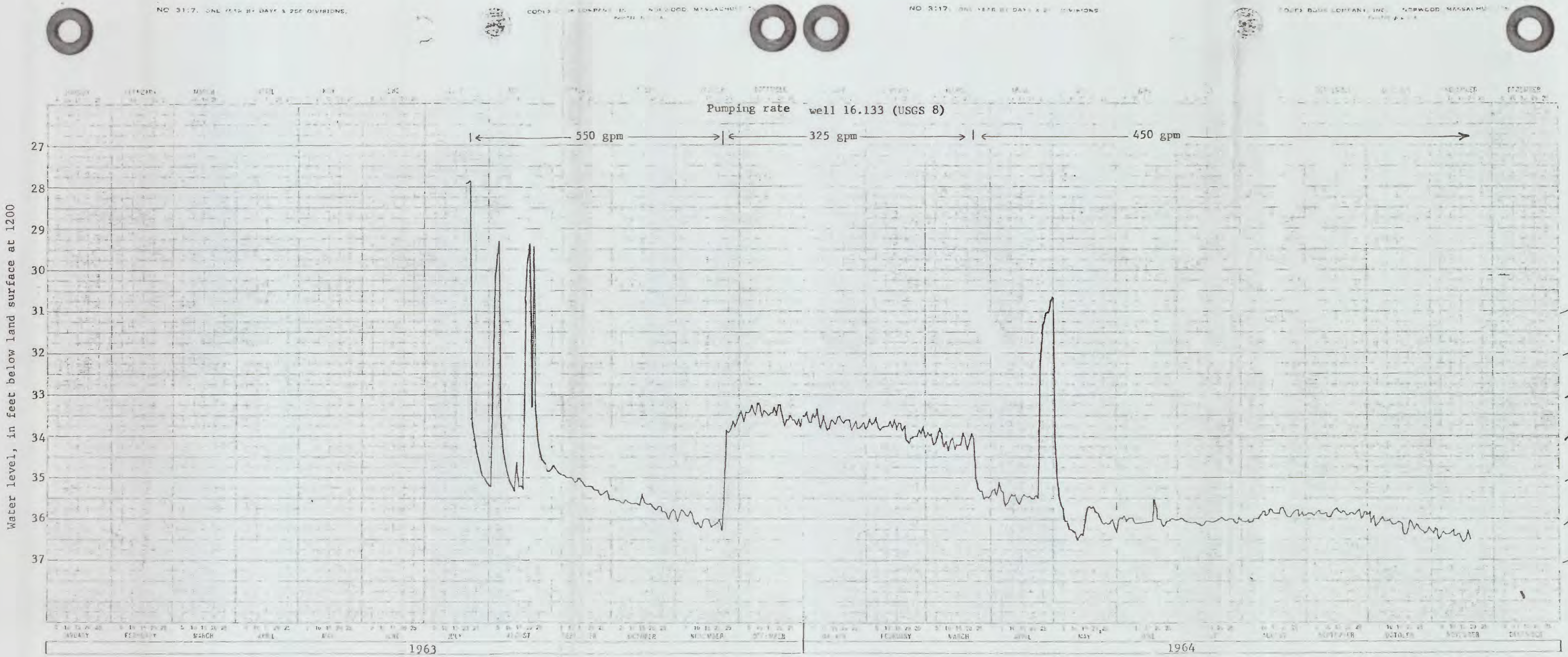


Figure 7.--Graph showing fluctuation of water level in well 16.311 (USGS 1)

65-35

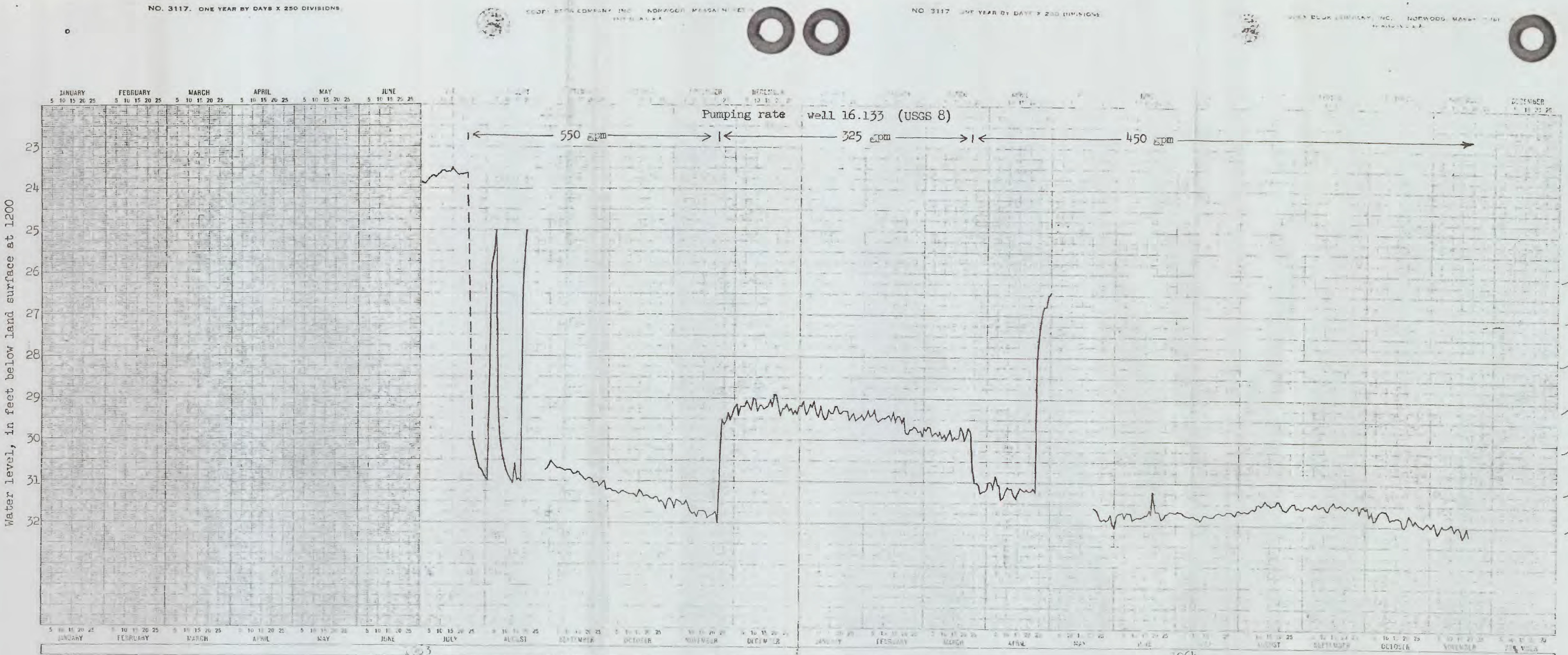


Figure 8.--Graph showing fluctuation of water level in well 16.323 (USGS 7)

65-35

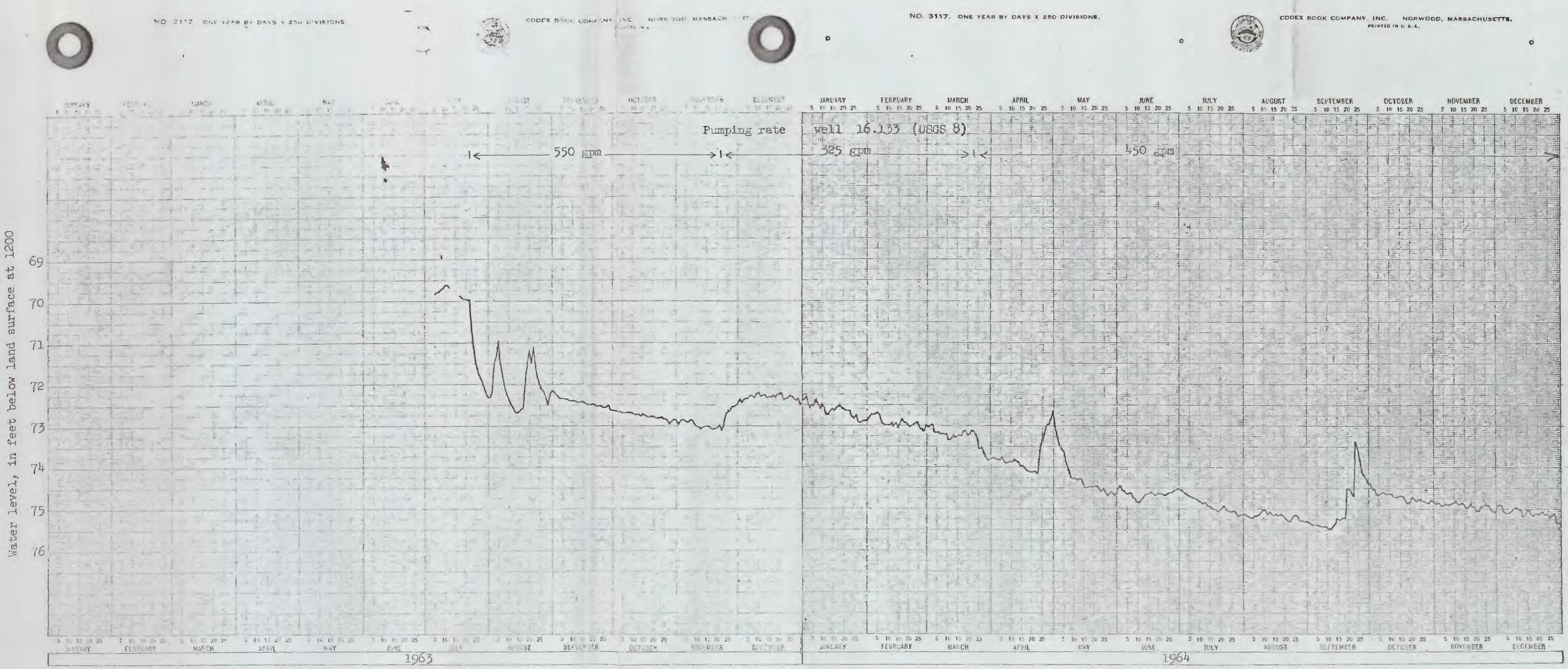


Figure 9.--Graph showing fluctuation of water level in well 24.28.24.211 (USGS 2)