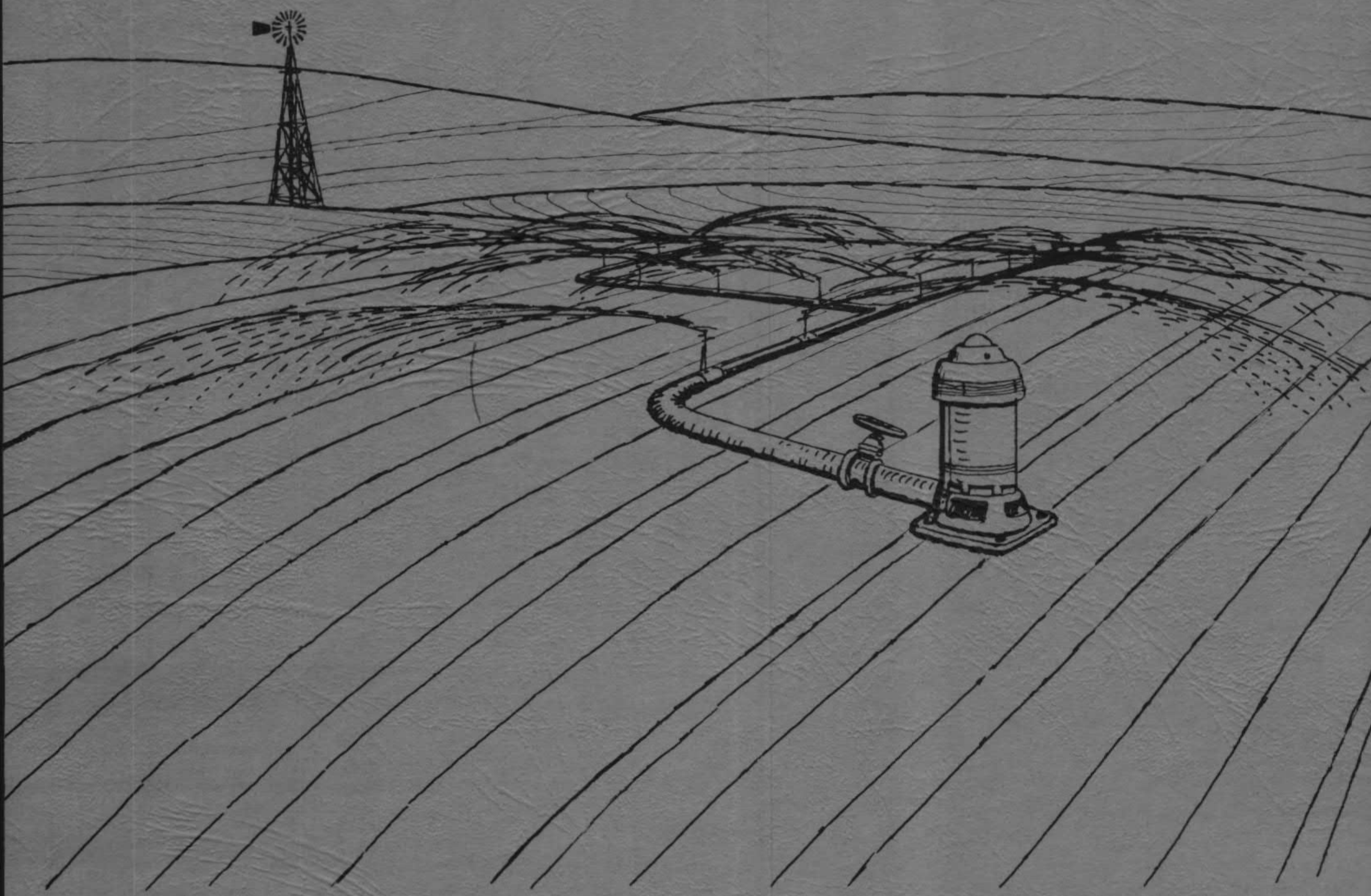
Ground-Water Survey ODESSA-LIND AREA Washington



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Daniel J. Evans, Governor

Department of Water Resources
H. Maurice Ahlquist, Director

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GROUND-WATER SURVEY, ODESSA-LIND AREA, WASHINGTON

By

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Prepared by U. S. Geological Survey

in cooperation with the

Washington State Department of Water Resources

Ground-Water Survey

Odessa-Lind Area

Why This Report Was Written

Since about 1963, there has been a continuing increase in the use of ground water in the Odessa-Lind area, largely for the irrigation of wheat. Although irrigated acreage comprises only a small percentage of this region of predominantly dryland farming, localized areas of water-level decline and well interference were detected as early as 1964 in a preliminary study by A. A. Garrett (Washington Department of Water Resources Water-Supply Bull. No. 31). Pumpage nearly quadrupled from 1963 to 1967, although the number of wells only doubled. This reflected a trend toward use of more powerful pumps for replacement or for installation on new wells (fig. 1).

It became obvious that a continued increase in ground-water pumpage would accelerate the lowering of water levels and enlarge the area affected--perhaps reaching a point in a few years where the cost of pumping water from the increased depth would exceed the additional income from increased crop yield. In addition, the shallower zones of ground water now tapped by many domestic wells would largely be drained.

Thus, a comprehensive cooperative study of the Odessa-Lind area was begun in 1966 by the Washington State Department of Water Resources and the U. S. Geological Survey. The results of this study are presented here, in nontechnical terms, so that those whose property or business is influenced by this ground-water development, as well as other interested citizens of the State, may have a better understanding of the problem in the area.

The problem posed for the Department of Water Resources is how to allow the greatest development of the ground water for the economic benefit of the State's citizens and yet not permit the resources to be endangered through over-development.

Acknowledgments

This present report was prepared under the direct supervision of L. B. Laird, district chief in charge of the U. S. Geological Survey's water resources program in the State of Washington. The writers recognize and appreciate the outstanding cooperation of the farmers and ranchers in the Odessa-Lind area who have made their wells available for periodic observations, borehole surveys, and discharge measurements. We also wish to thank the many drillers for their assistance in this study.

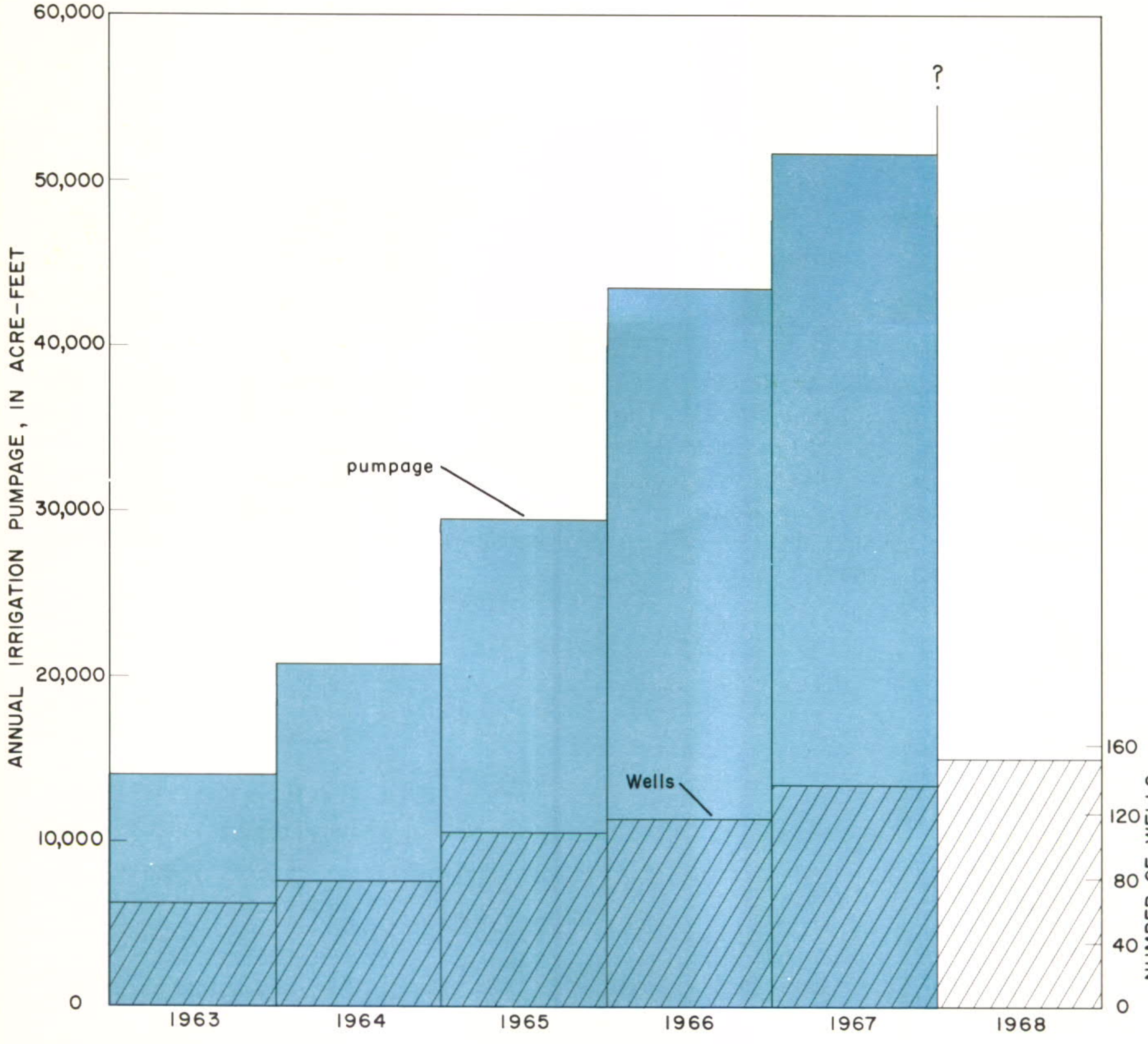
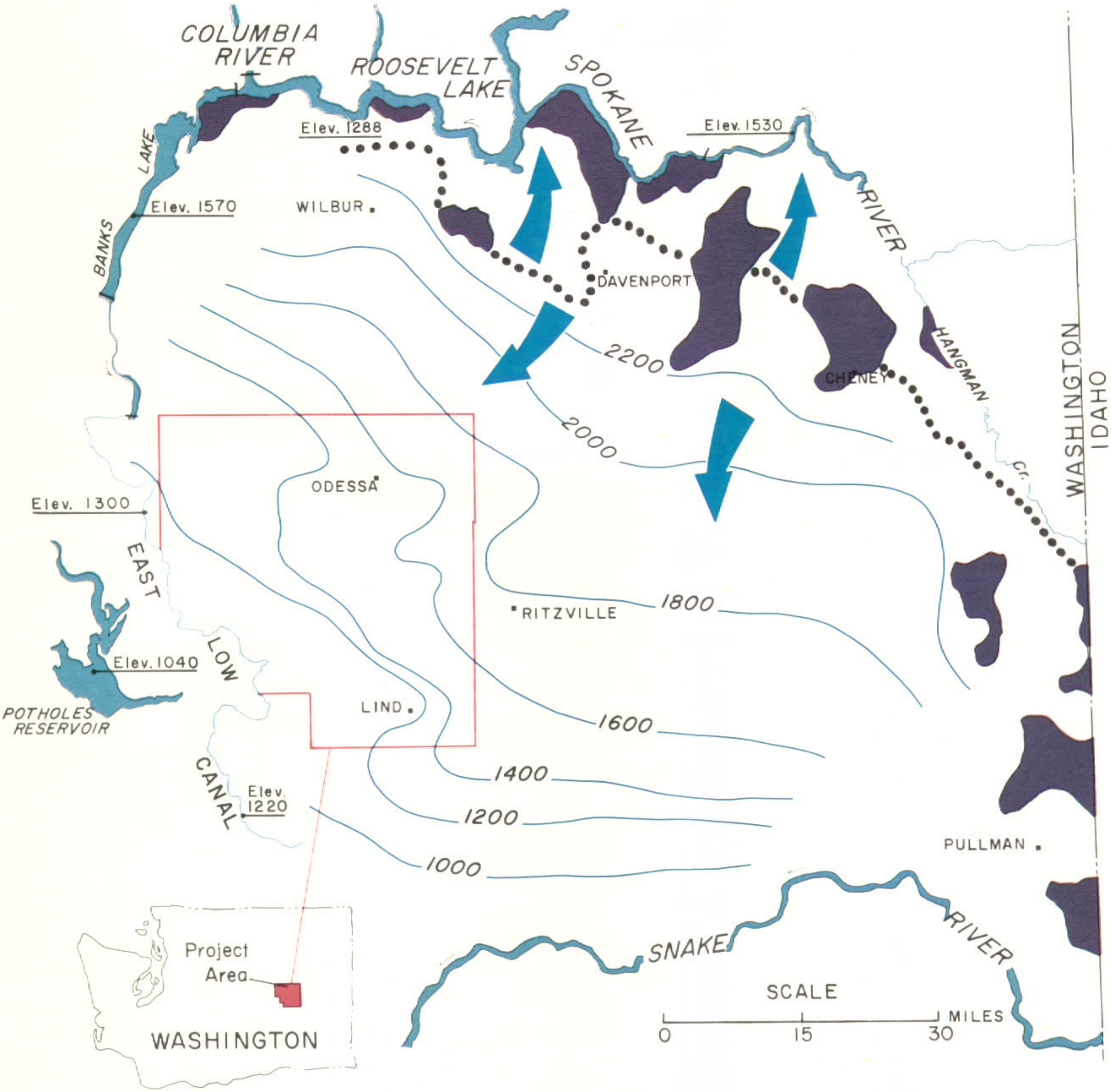


FIGURE 1.--ANNUAL PUMPAGE COMPARED WITH THE NUMBER OF IRRIGATION WELLS, 1963 THROUGH 1967.

Ground-Water Occurrence

The ground water in the Odessa-Lind area is part of a large system that covers much of east-central Washington (fig.2). The ground water moves slowly downgradient toward the southwest and toward the Columbia and Snake Rivers. Nearly all of the ground water in the area shown is derived from precipitation. Contrary to popular belief, surface-water bodies to the north, such as Roosevelt Lake and the Spokane River, cannot be the source of ground water because they are 600 to 900 feet lower than ground-water levels on the plateau just to the south.



EXPLANATION

Basalt – principal source of ground water in east-central Washington

Granite, etc. – impermeable, contains little or no ground-water

Limit of area covered in report

Inferred boundary between areas having a northerly direction of ground-water movement and those having a southerly direction of ground-water movement

1600

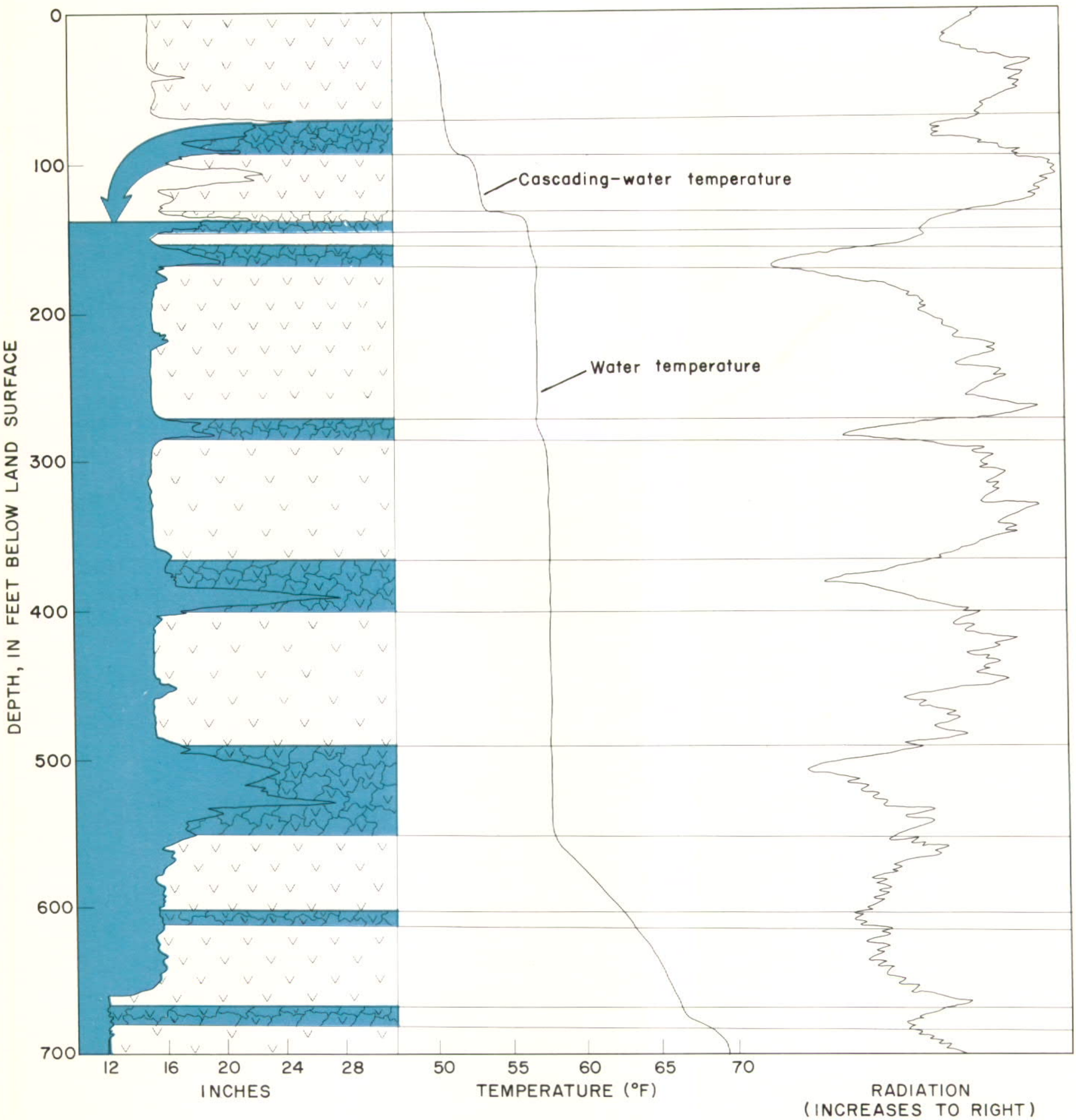
Generalized water-level contours, in feet above mean sea level; arrow shows approximate direction of ground-water movement

FIGURE 2.--REGIONAL MOVEMENT OF GROUND WATER IN EAST-CENTRAL WASHINGTON

Most of the ground water is contained within layered basalt rocks. These layers are generally dense and limit the vertical movement of water. However, between the layers many porous zones occur that contain broken basalt and (or) sediments (fig. 3). These zones permit the movement of the ground water and are the rocks that yield water to most of the large production wells in the area.

Figure 3 illustrates information gained by borehole logging. The porous water-bearing zones are usually identified by the increases in well diameter and by the gamma-radiation logs. Water temperature often offers some clues to the major source of water. Many wells in the Odessa-Lind area have water cascading inside the hole, as shown in the illustration. This allows continuous drainage of the shallower ground-water zones even when the pump is not operating.

Many domestic wells penetrate only shallower ground-water zones while most irrigation wells penetrate deeper zones. Water levels in wells in the shallower or upper zones commonly stand higher than the levels in deeper wells.



HOLE-DIAMETER LOG

Dense parts of basalt flows appear as relatively straight, vertical sections; water-bearing zones (shown in blue) usually appear as broken-out areas.

TEMPERATURE LOG

Temperature generally increases gradually to hole bottom. Water-bearing zones may be indicated by abrupt changes in temperature. This particular well pumps water with a temperature of 66°, indicating that water-bearing zones below 500 feet are the major source of water.

GAMMA-RADIATION LOG

Natural radiation intensity is an indication of rock density; water-bearing zones, being more porous, often have lower radiation than the dense parts of basalt flows.

FIGURE 3.--TYPICAL SET OF BOREHOLE LOGS FROM ONE WELL.

Response of the Ground-Water System to Irrigation Development

The effects of irrigation pumping are observed primarily by water-level measurements spanning a period of time. In the Odessa-Lind area many wells have been measured since 1964 (fig. 4). The frequency of measurement has varied from monthly to twice annually--spring and fall.

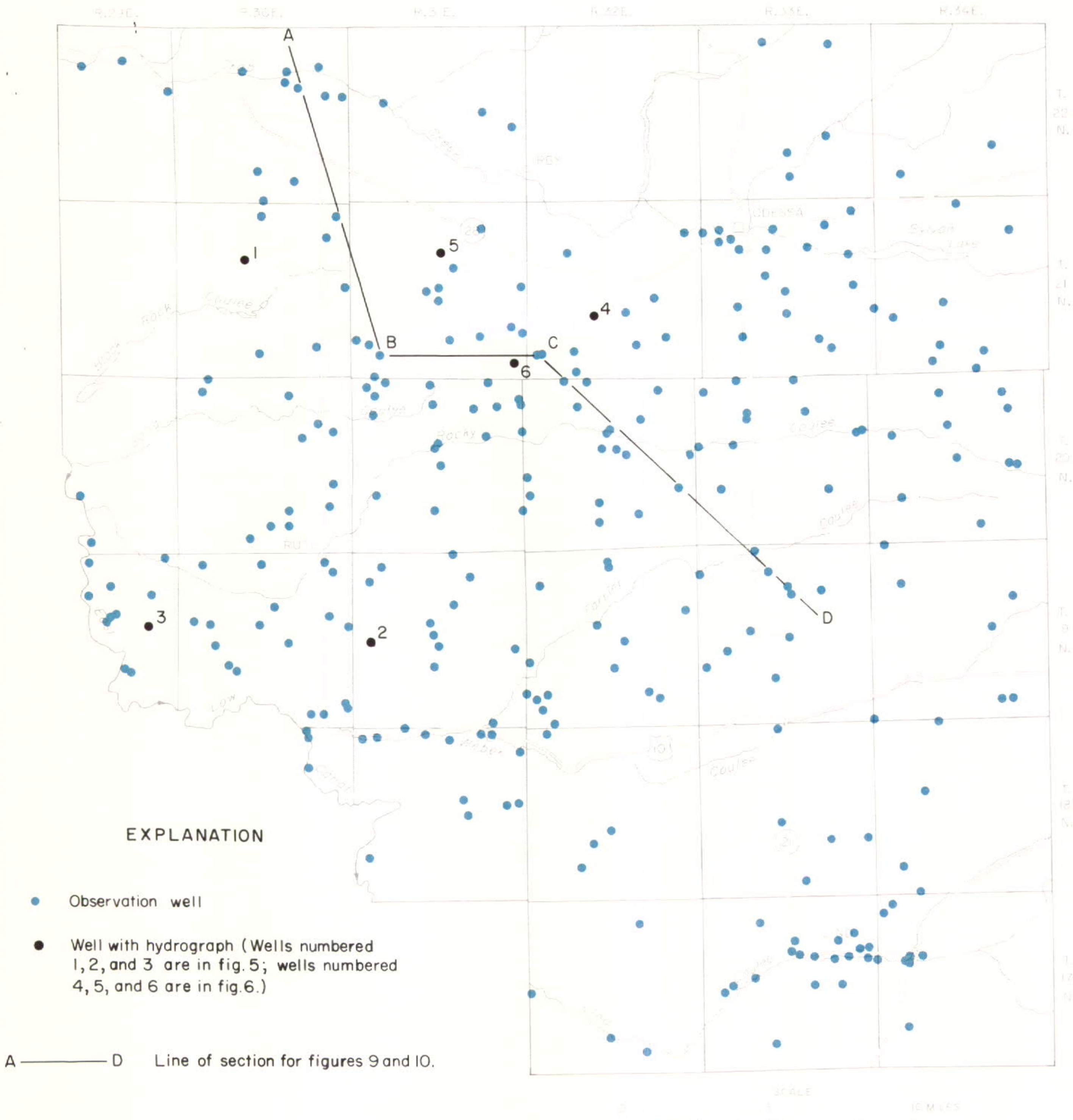


FIGURE 4.--LOCATION OF OBSERVATION WELLS.

Several water-level records extend back to 1940. These older records showed very little variation in water level until the summer of 1967, when the effects of nearby irrigation development caused water levels to decline sharply during the irrigation season (fig. 5).

Periods of light or heavy precipitation since 1940 apparently have had little influence on water-level trends. The ground-water body is so large that variations in the relatively small amount of precipitation reaching the ground water cannot be identified. It's like adding 10 buckets of water to a lake today and 20 tomorrow--you can't tell the difference by the change in lake level.

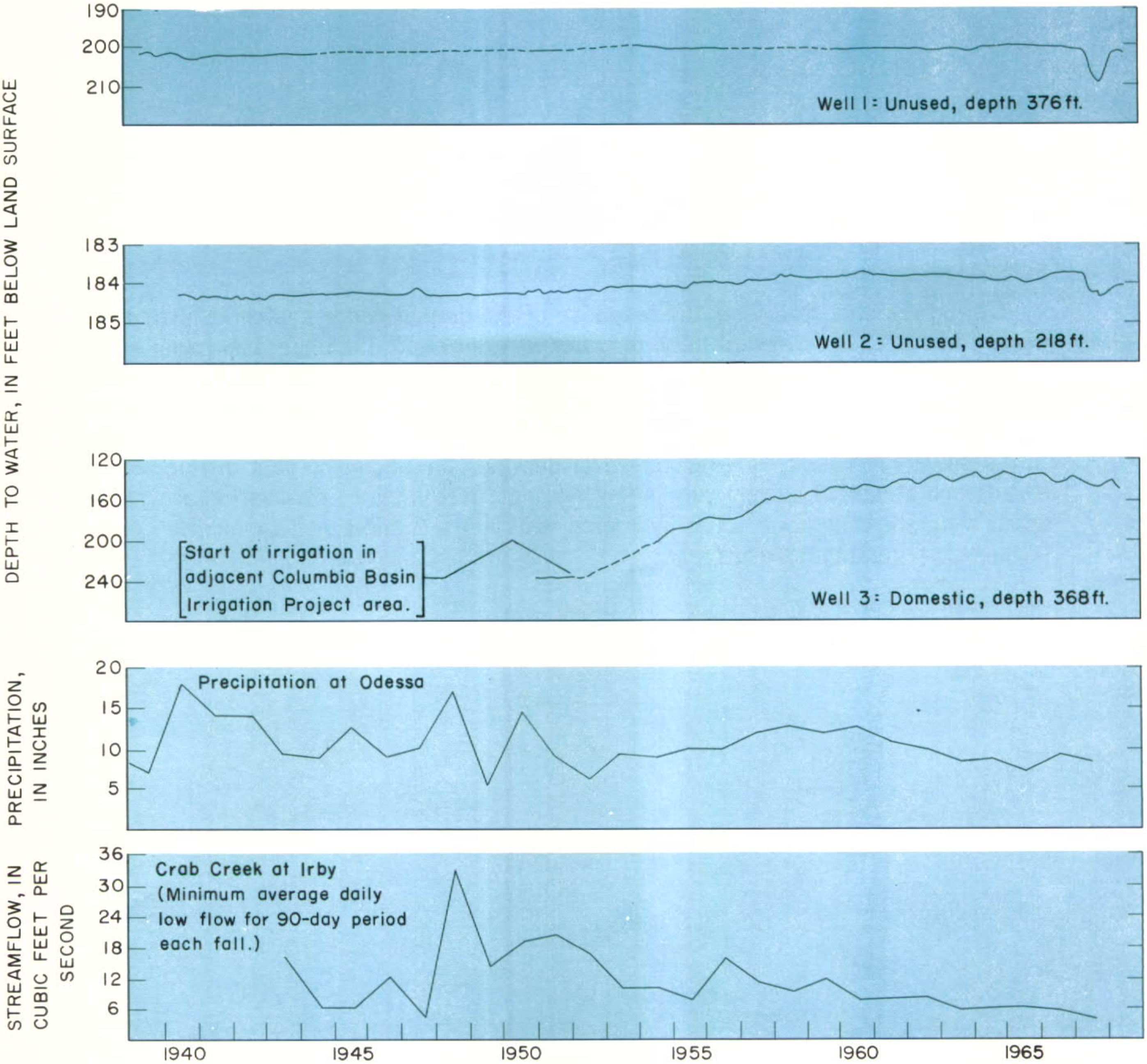


FIGURE 5.--GROUND-WATER LEVELS COMPARED WITH PRECIPITATION AND STREAMFLOW, 1939-68.

During the past few years the response of the ground-water system to irrigation development has been a downward trend of water levels in both the upper and lower water-bearing zones, as illustrated by selected hydrographs in figure 6. Within a particular pumping season, water levels in wells penetrating the lower water-bearing zones (wells 5 and 6, fig.6) drop gradually in response to pumping, reaching a maximum depth late in the summer. Year-to-year water-level declines are occurring over a wide area. The hydrograph of well 4 exemplifies a decline and, in this case, exhaustion of water in an upper water-bearing zone. The hydrographs of wells 5 and 6 reflect similar declines in lower water-bearing zones.

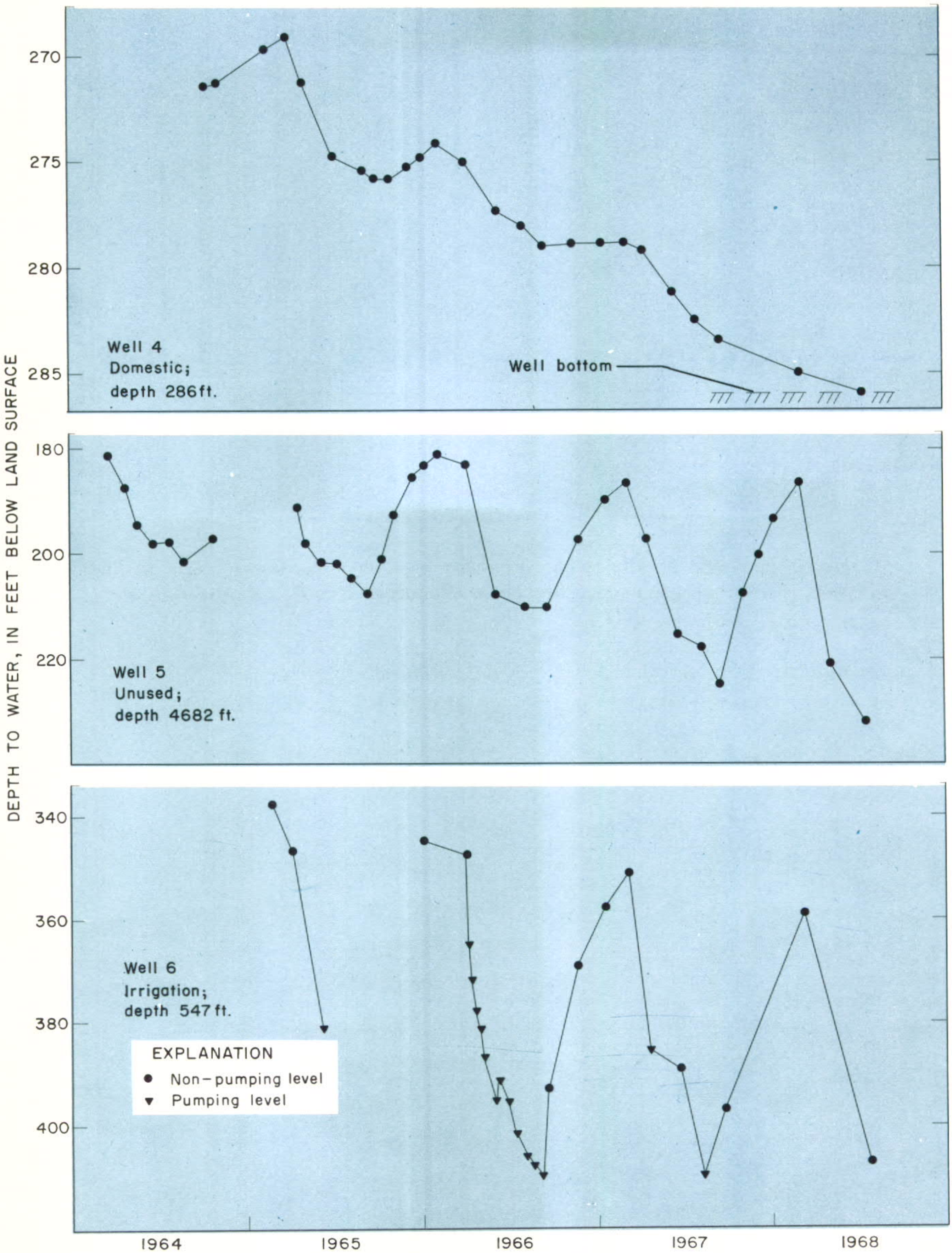


FIGURE 6.-- HYDROGRAPHS OF SELECTED WELLS FOR PERIOD 1964-1968.

As spring water levels decline, maximum pumping lifts likewise tend to increase each summer. The maximum pumping lift observed during 1967 is shown in figure 7.

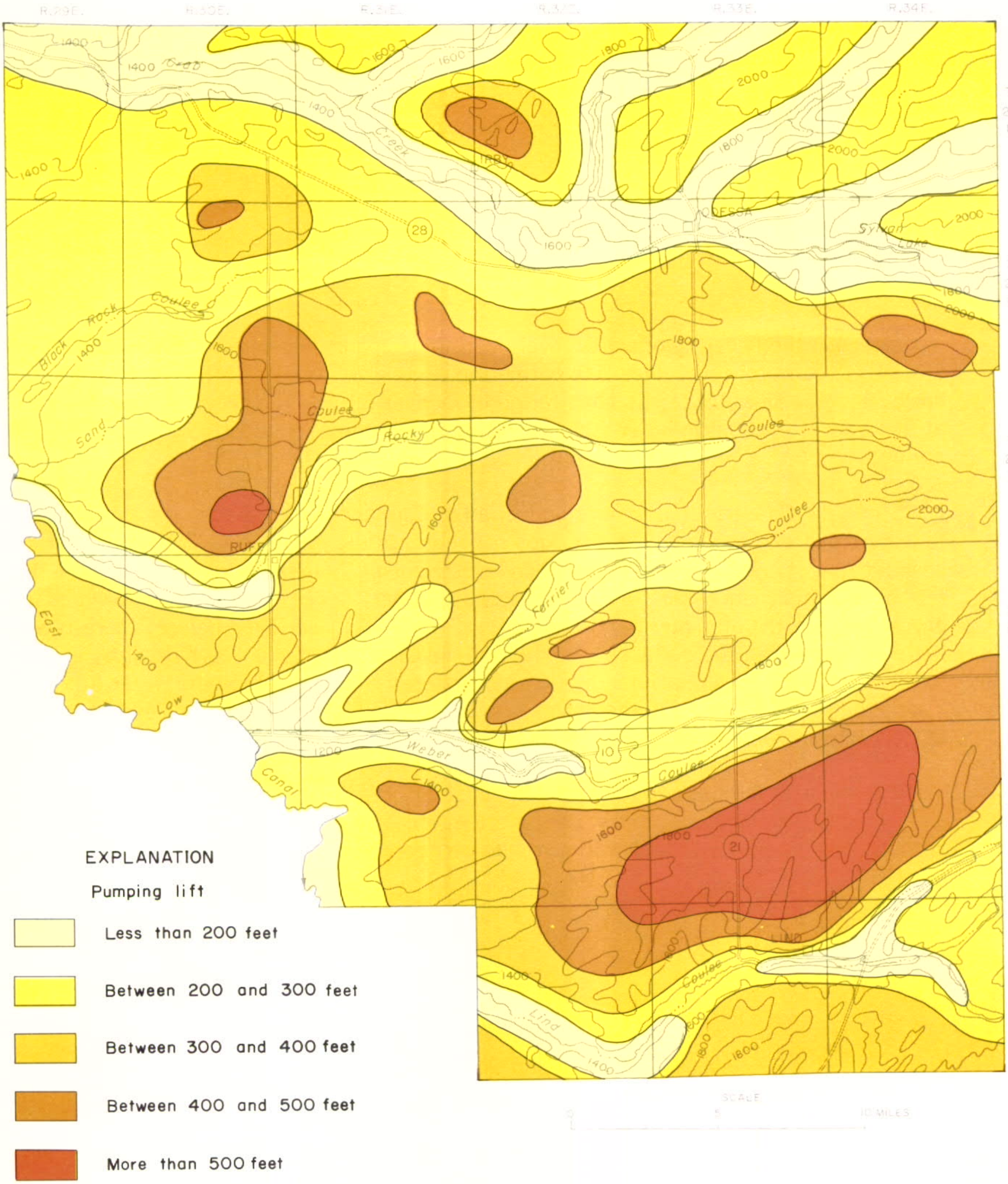


FIGURE 7.--APPROXIMATE MAXIMUM PUMPING LIFT FOR IRRIGATION DURING 1967. (The generalized boundaries between various categories of pumping lift are developed from water-level contours, topography, and maximum depths to pumping level observed in 1967.)

Although the lowering of water levels during each pumping season is widespread (fig. 8), the water level does rise during the winter "off season". In recent years, however, ground-water levels have failed to recover fully to the previous year's level at the start of each pumping season, resulting in a progressive decline from spring to spring.

Since the Odessa-Lind area is part of a large ground-water system it may be difficult to understand why the ground water does not return to the previous year's level after pumping has stopped. In this area ground water simply is being pumped faster than the rate of replenishment. Most of the replacement water, necessary to raise the water level, moves into the area by lateral underground flow. As mentioned before, there is very little recharge from the surface. The lateral movement of ground water is slow, depending on gravity, and is restricted by the rock materials through which the water flows. Thus, the time during which the pumps are turned off is not sufficient for enough water to flow into the area to fill the void created by the previous year's pumping.

If the annual pumpage were to remain constant, the ground-water system would eventually reach a new balance, and water levels would then return to the same level each spring. But an annual increase in pumpage will continue the downward trend of water levels.

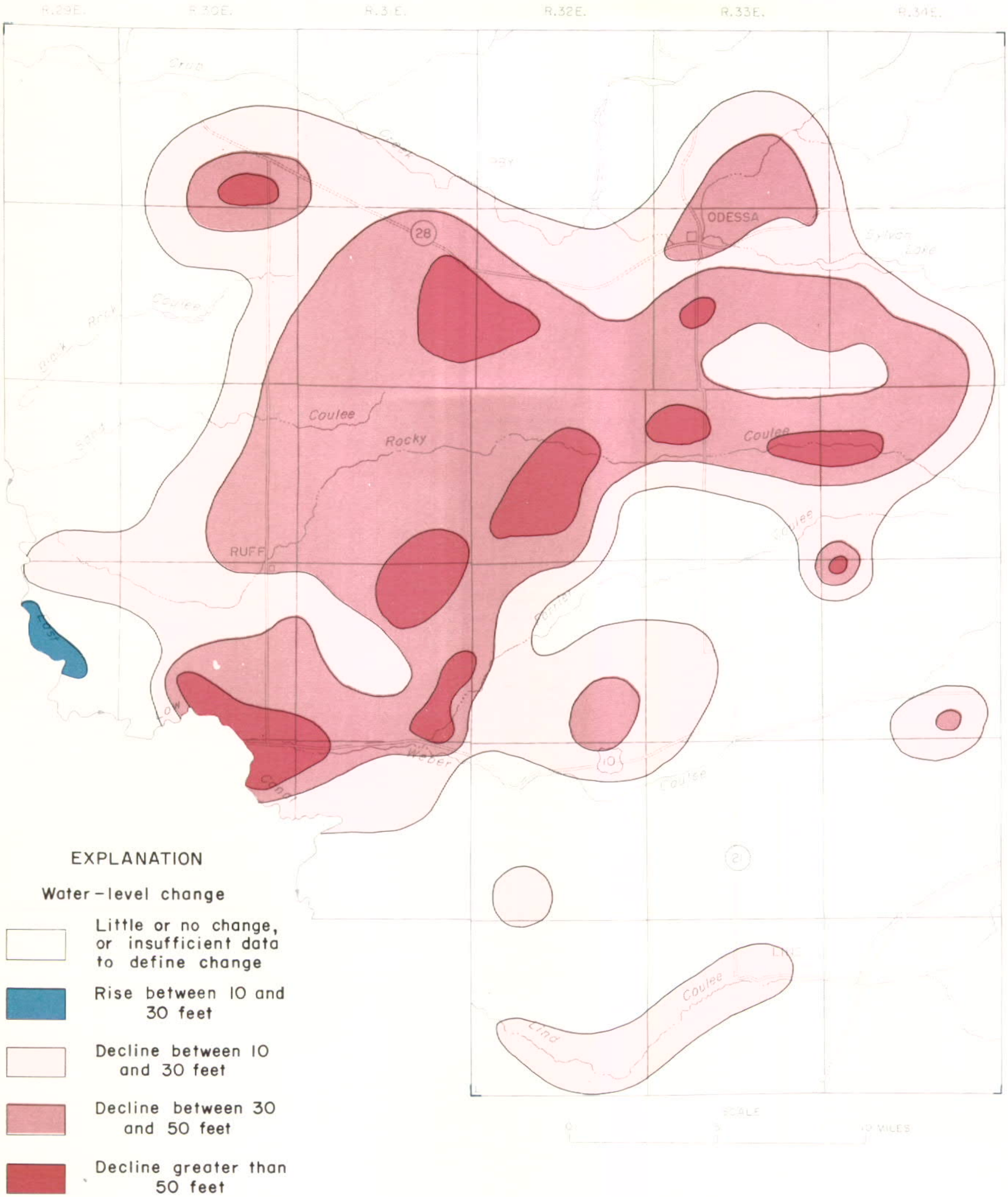


FIGURE 8.--WATER-LEVEL CHANGE IN WELLS PENETRATING THE LOWER WATER-BEARING ZONES, SPRING TO FALL, 1967. During the pumping season, from March to October, static water levels decline gradually near centers of heavy withdrawal, reaching a maximum as depicted. This effect can be expected to intensify and become more widespread as irrigation development increases.

Figures 9 and 10 illustrate the declines in water levels in cross section. It can be noted that only a relatively small decline may have a detrimental effect on wells finished in the upper water-bearing zones. It also is apparent that, in general, the greater the elevation of the land surface, the greater the pumping lifts.

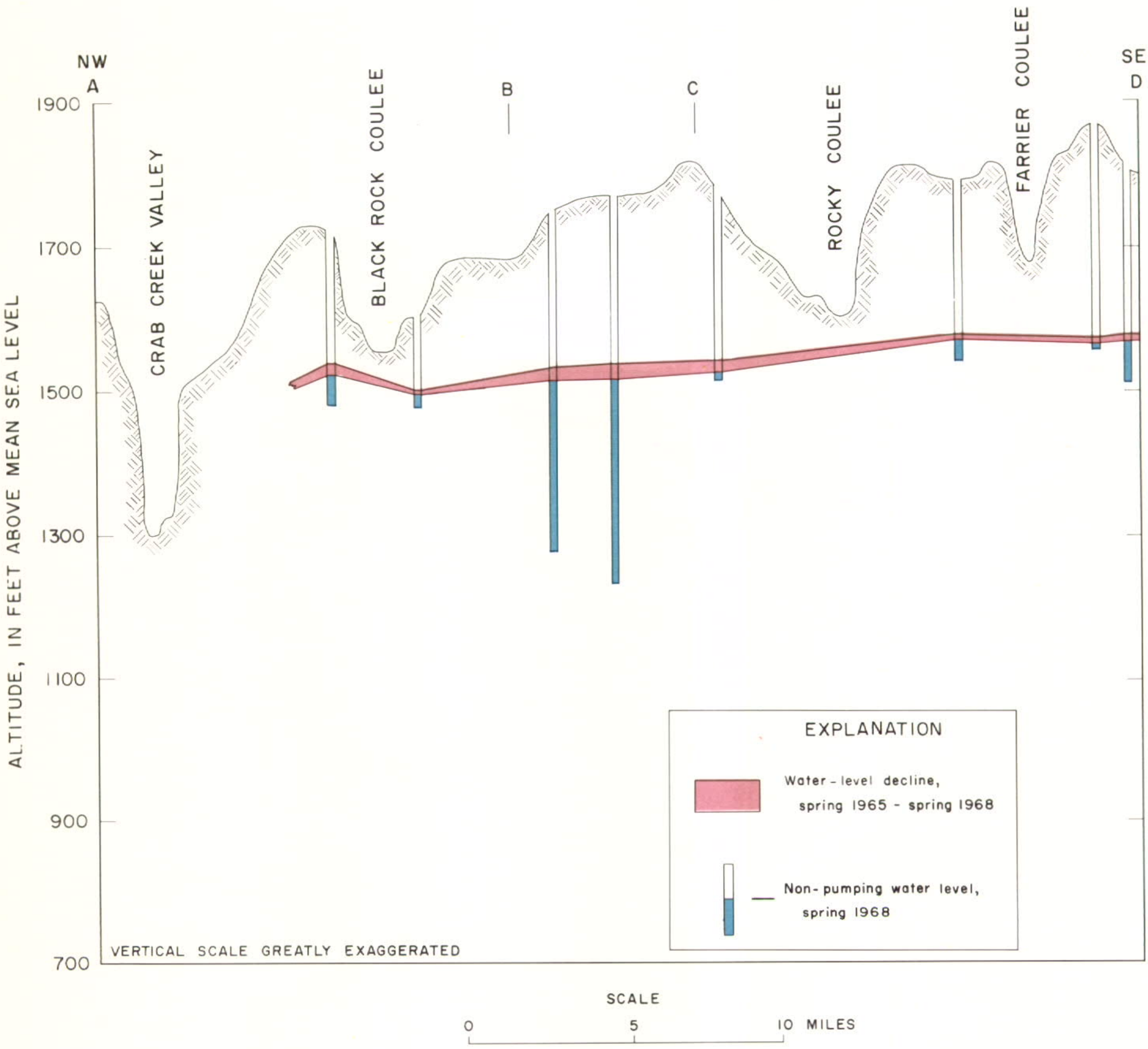


FIGURE 9.-- SIMPLIFIED SECTION SHOWING DECLINE OF WATER LEVEL, 1965-68, IN SELECTED WELLS PENETRATING UPPER WATER-BEARING ZONES. Wells used for control are located near line of section A-D shown in figure 4.

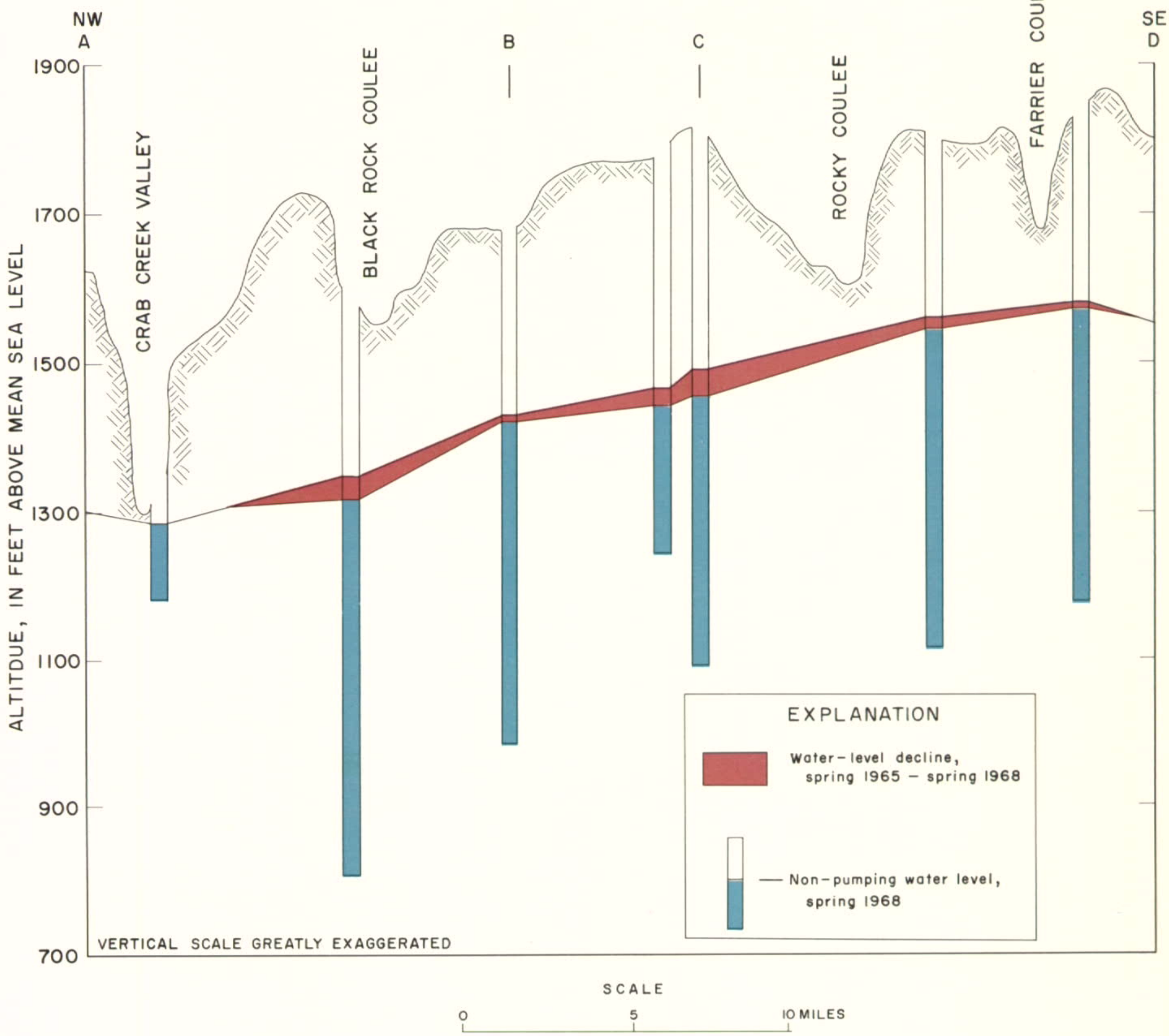


FIGURE 10.--SIMPLIFIED SECTION SHOWING DECLINE OF WATER LEVEL, 1965-68, IN SELECTED WELLS PENETRATING <u>LOWER WATER-BEARING ZONES</u>. Wells used for control are located near line of section A-D shown in figure 4.

Figures 11a, 11b, and 11c following, give an areal representation of water-level changes in the upper water-bearing zones from spring to spring, 1965-68. The increase in area and location of water-level decline in these zones is apparent from the comparison of the three illustrations.

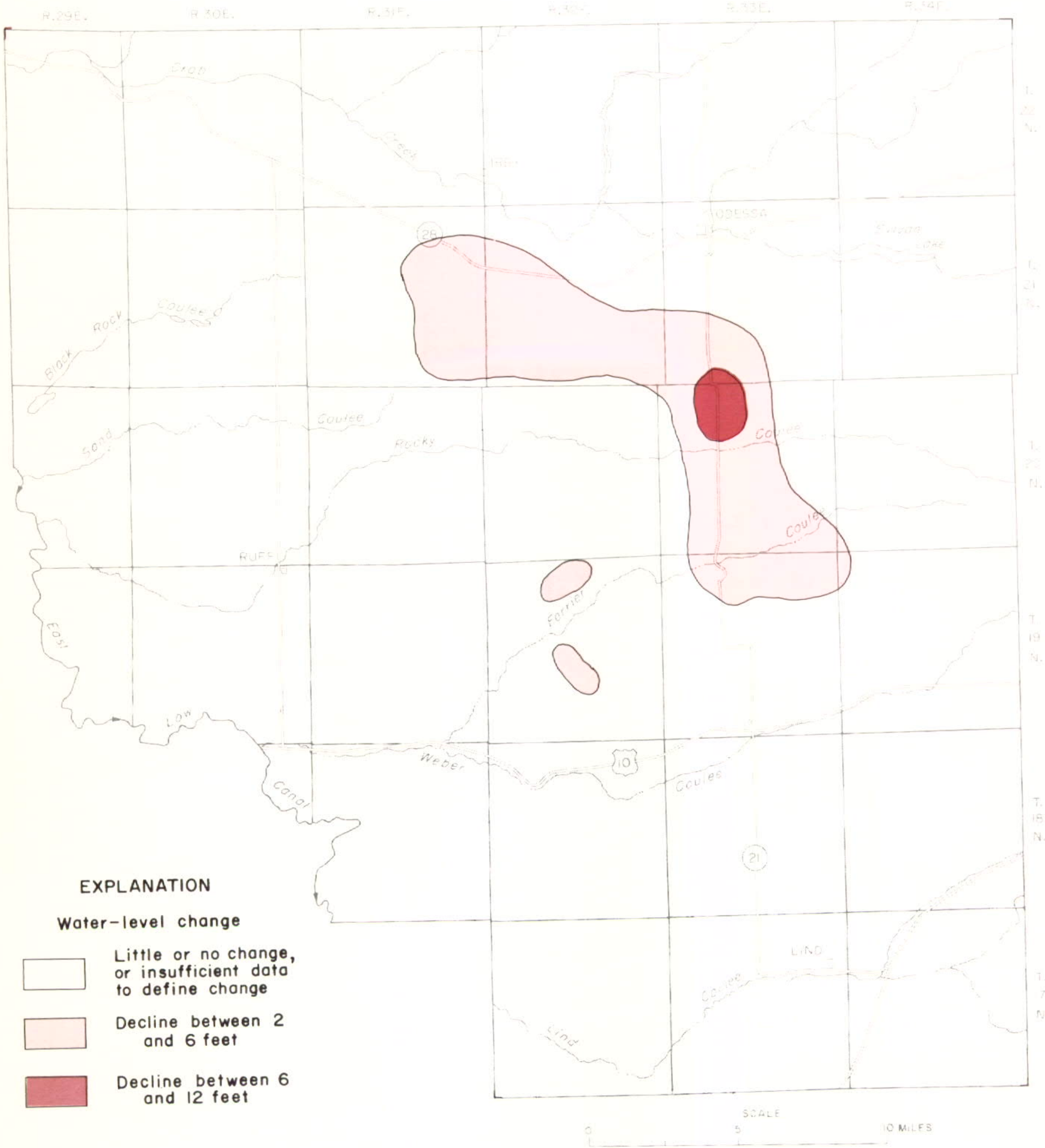


FIGURE 11a.--WATER-LEVEL CHANGE, SPRING 1965 TO SPRING 1966, IN WELLS PENETRATING <u>UPPER WATER-BEARING ZONES</u>.

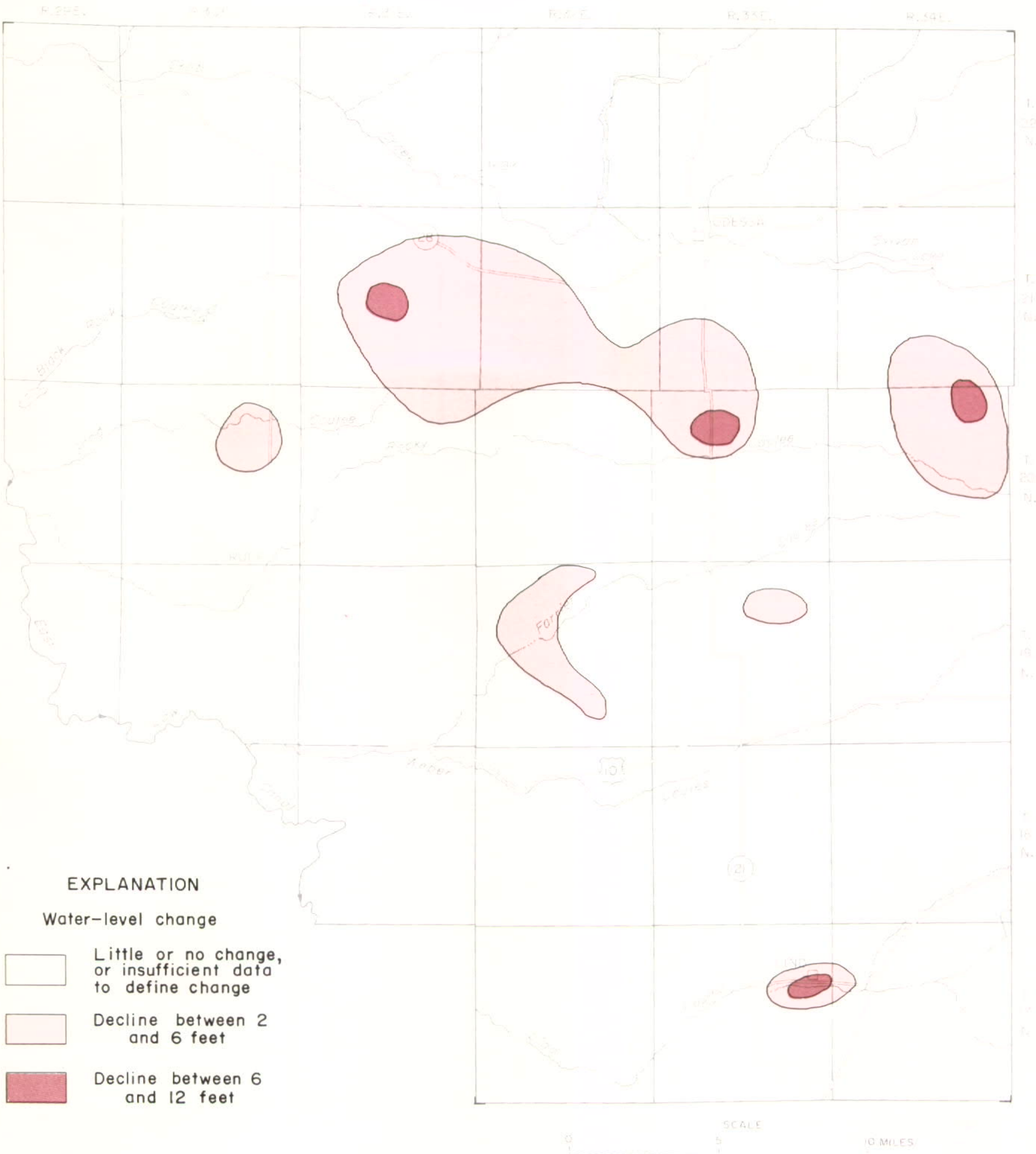


FIGURE 11b.--WATER-LEVEL CHANGE, SPRING 1966 TO SPRING 1967, IN WELLS PENETRATING UPPER WATER-BEARING ZONES.

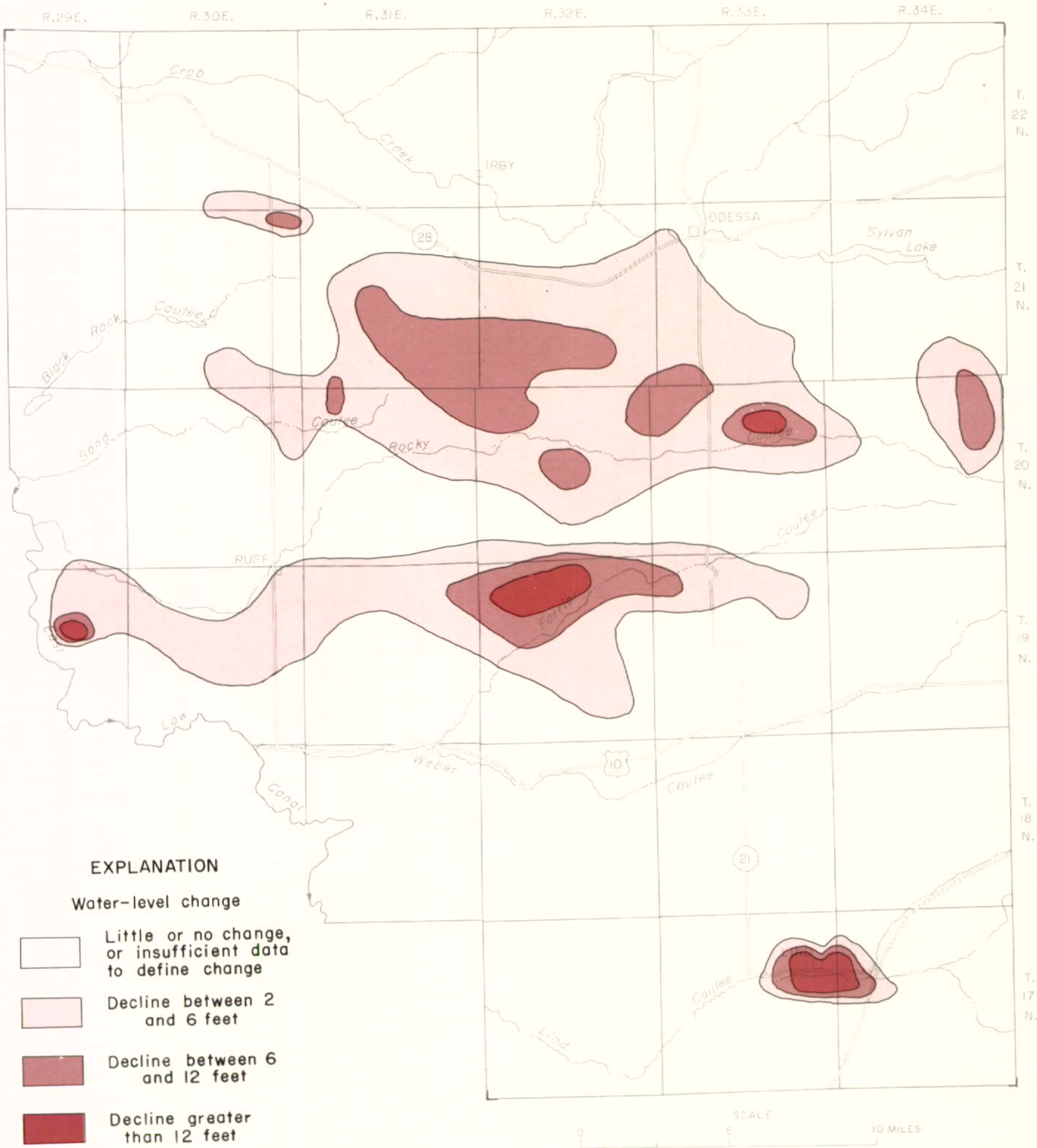


FIGURE 11c. --WATER-LEVEL CHANGE, SPRING 1967 TO SPRING 1968, IN WELLS PENETRATING <u>UPPER WATER-BEARING ZONES</u>.

The following pages present an areal comparison of irrigation pumpage and water-level change in the lower water-bearing zones for 3 years (figs. 12a-b, 13a-b, 14a-b). These maps show the response of the ground-water system to pumpage for the given year. The response within a specific area depends not only on the amount of pumpage in that area, but on the amount pumped from adjacent areas and on the geologic controls on the movement of the ground water, the latter condition being far from uniform.

It should be emphasized that pumpage in areas where there is no decline in water levels still may contribute to the decline in adjacent areas because less water is available to move laterally into the area of decline.

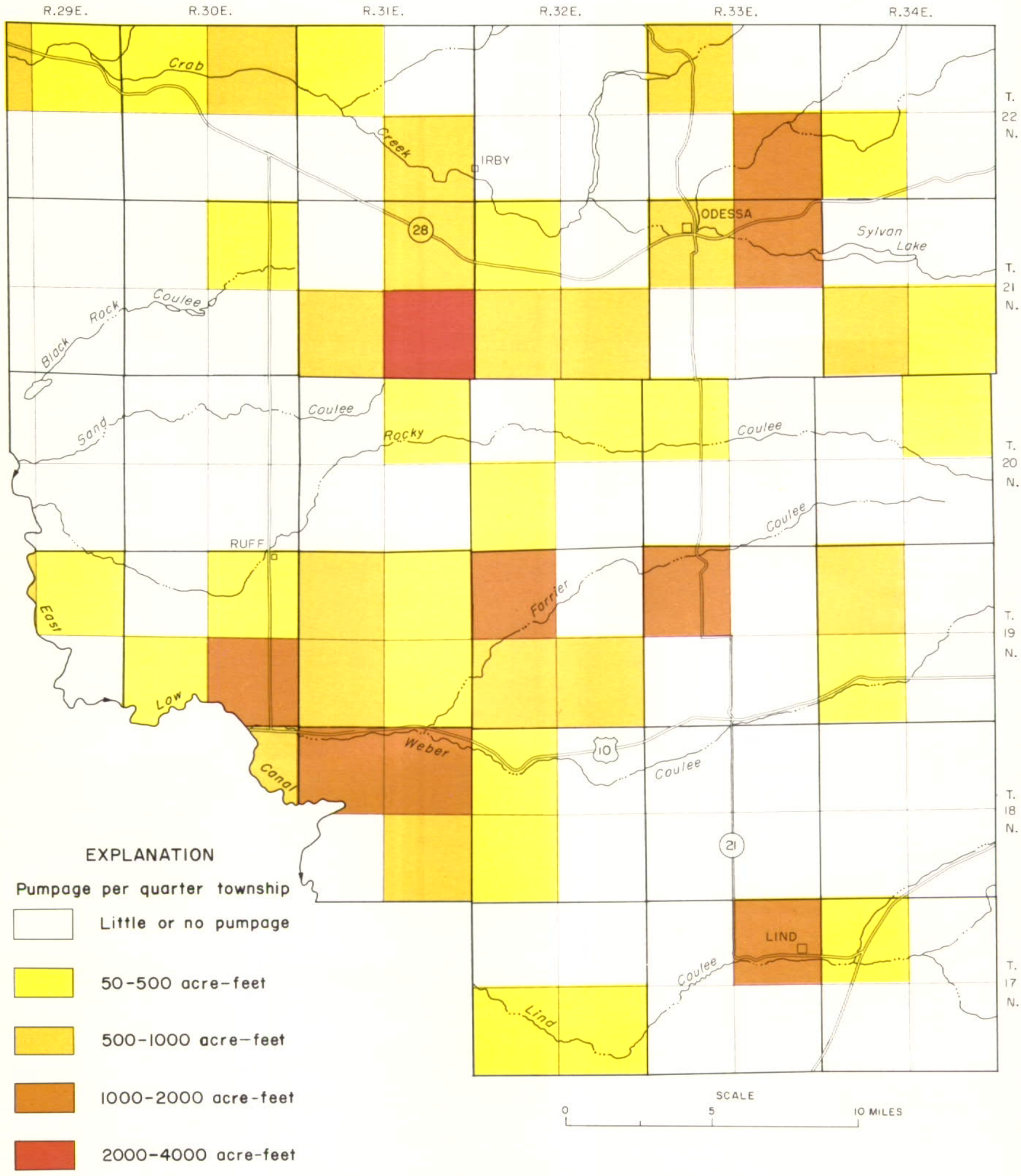


FIGURE 12a.--IRRIGATION PUMPAGE, 1965.

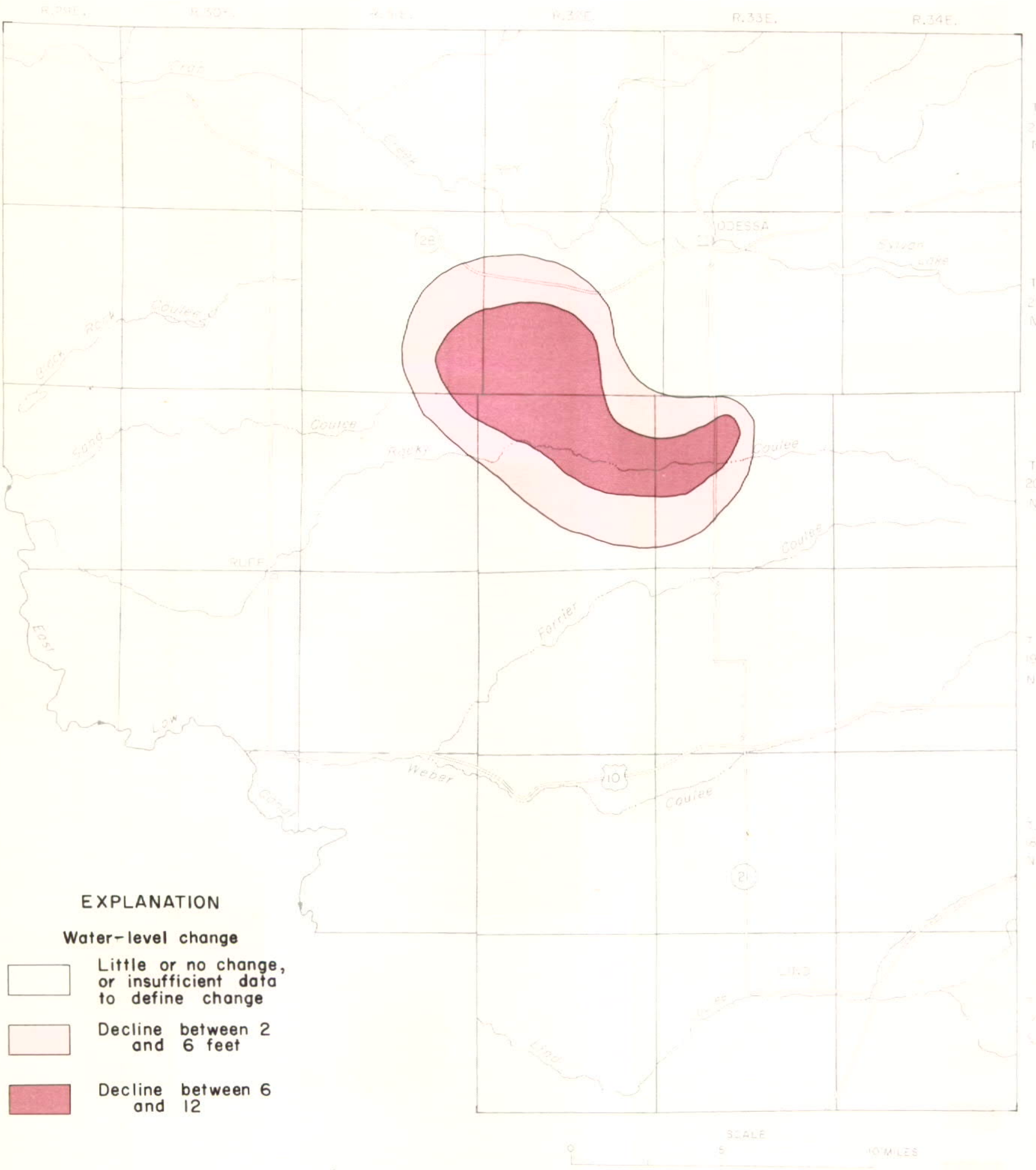


FIGURE 12b.--WATER-LEVEL CHANGE, SPRING 1965 TO SPRING 1966, IN WELLS PENETRATING LOWER WATER-BEARING ZONES.

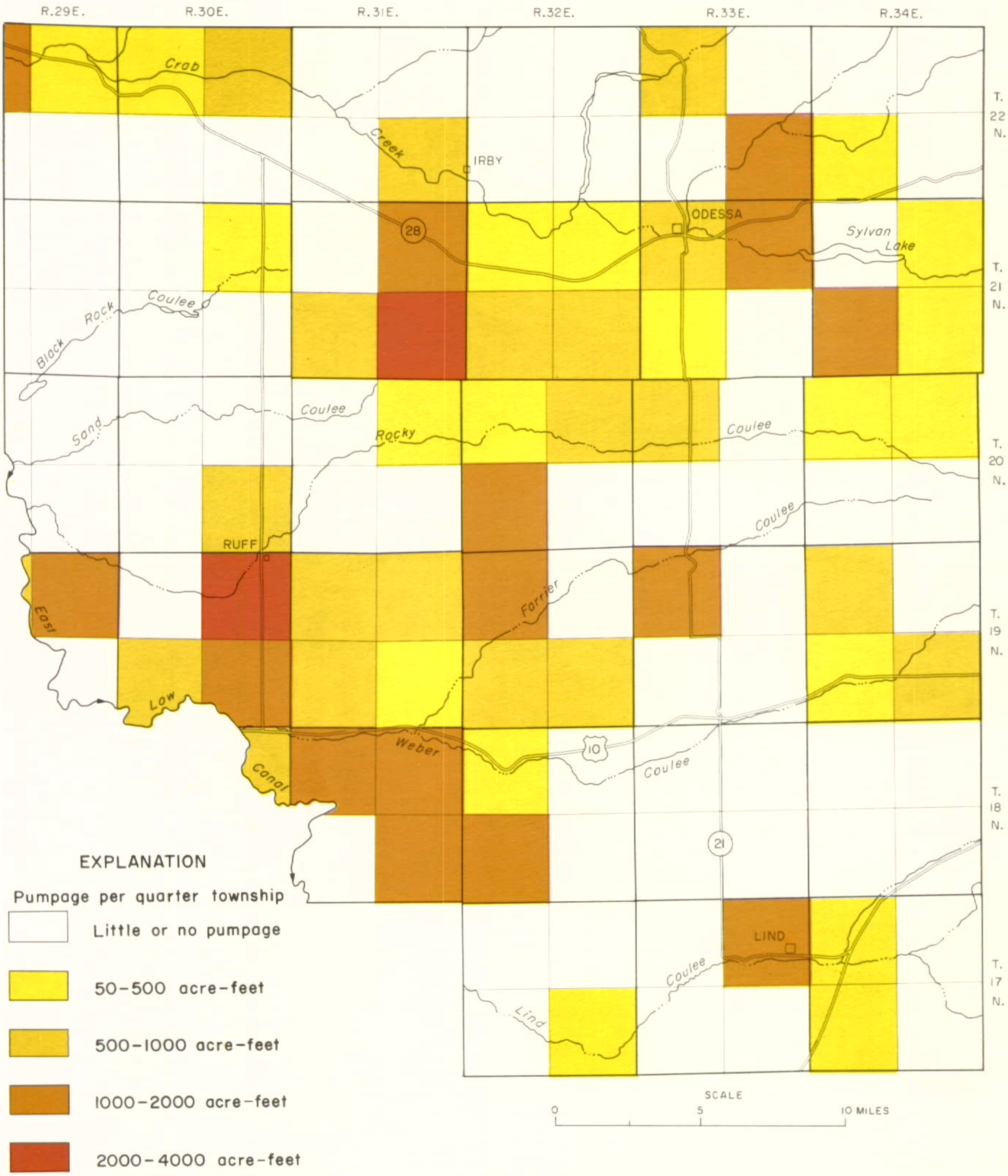


FIGURE 13a.--IRRIGATION PUMPAGE, 1966.

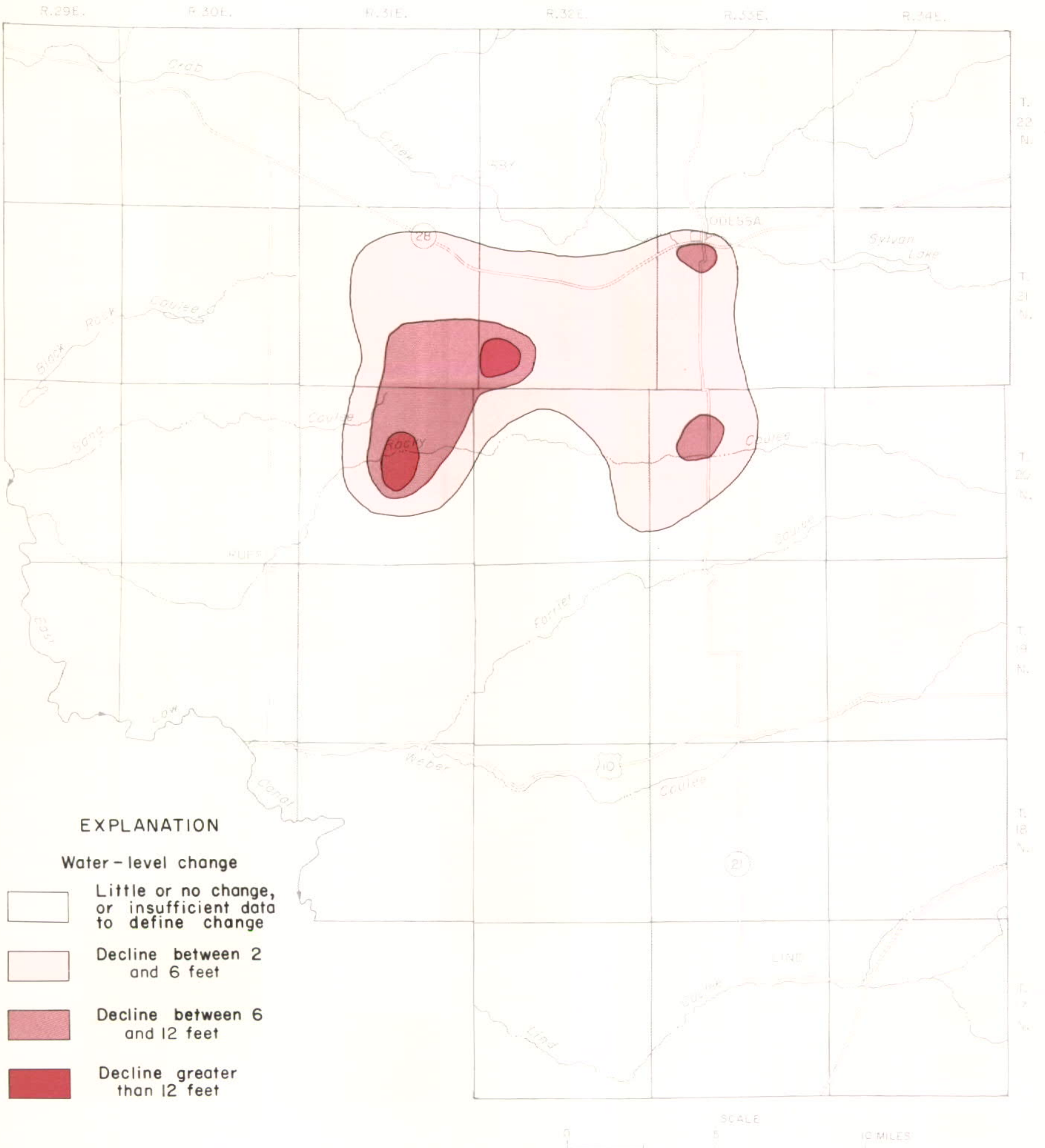


FIGURE 13b.--WATER-LEVEL CHANGE, SPRING 1966 TO SPRING 1967, IN WELLS PENETRATING LOWER WATER-BEARING ZONES.

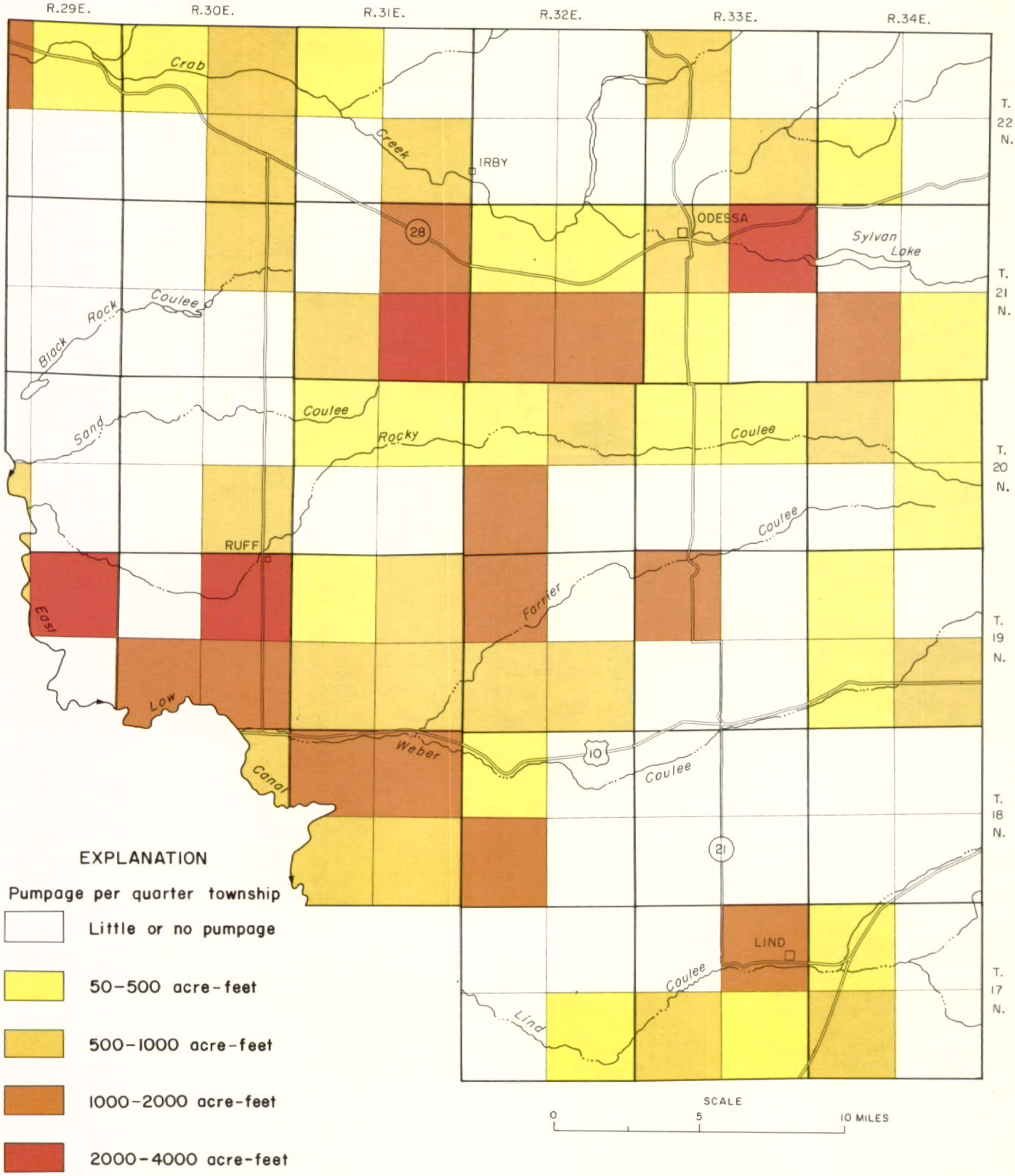


FIGURE 14a.--IRRIGATION PUMPAGE, 1967.

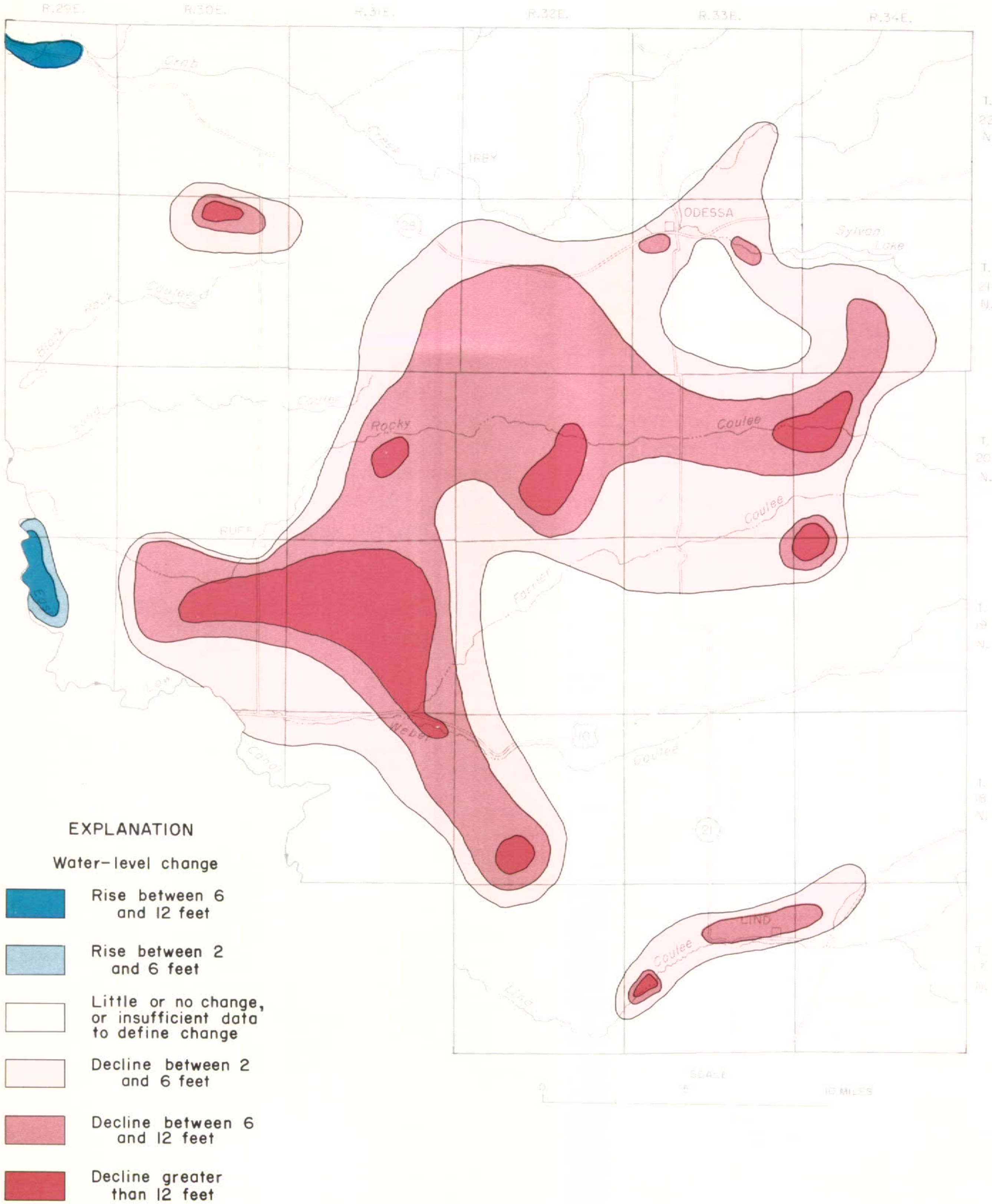


FIGURE 14b.--WATER-LEVEL CHANGE, SPRING 1967 TO SPRING 1968, IN WELLS PENETRATING LOWER WATER-BEARING ZONES.

Summary Statement

The significance of ground water and the farmer's awareness of the importance of that vital resource has rapidly increased during the last few years in the Odessa-Lind area. Large grain yields, once only dreamed of on dryland farms, have become a reality with irrigation. Even at that, ground water cannot meet the demand to irrigate all the suitable lands in the Odessa-Lind area.

As of spring 1968, water levels in the Odessa-Lind area have declined but have not undergone a general decline of great magnitude. Even if the yearly increase in pumping is brought to a halt, however, the established areal trend of declining water levels will continue for several years. If pumping continues to increase, the water-level decline will inevitably accelerate over an area of ever-increasing size. The problem involves not only the areas of declining water levels but adjacent areas as well, as pumping from the nearby lands removes water that might normally flow into the area of decline and lessen lowering of the water level.

The cooperative investigation of the ground-water system in the Odessa-Lind area by the Washington State Department of Water Resources and the U. S. Geological Survey is being continued with the following goals:

1. Monitor the pumpage and response of the system.
2. Amplify present knowledge of the geologic controls on the system.
3. Develop a mathematical model of the system.

The mathematical model is a representation, by computer, of the characteristics of the ground-water system. When the model is tested and verified to produce reliable results it may be used to test many different combinations of pumpage and the response of the ground-water system. Thus, the computer model becomes an excellent management tool for the optimum development and management of the ground-water system.

The cooperative investigation is being pressed forward toward the three goals as rapidly as possible within the limits of funds and manpower. When completed the investigation should provide the Department of Water Resources with facts needed to establish a permanent policy for the optimum development of the ground-water resources in the Odessa-Lind area.