Drainage Adjacent to a River

investigation on use of pumped well for field drainage of river seepage conducted on farm in Sacramento delta area

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Pumping ground water for relief of drainage problems in agricultural lands is an established practice. However, there are many situations in California where pumping has not been used and where it might—or might not—be the solution to severe drainage problems costing farmers thousands of dollars annually in crops and soil damage.

Because there are many areas along the major rivers in California where seepage is causing damage to adjacent agricultural land a study was made of the possibility of using drainage wells.

The farm selected for the study is located adjacent to the Sacramento River and has long suffered from high water table conditions during periods of high water in the river. The soil conditions are typical of the delta with peat and mineral soils intermixed.

Water can seep from a river in one or more of several ways. In some cases it seeps directly through the levee to the ground surface on the landward side.

In other cases the water moves down through the river bottom soil until it reaches a more permeable stratum—an aquifer—through which it can move laterally out under the land adjacent to the river, and rises to the surface where the soil conditions are favorable. Usually there is artesian pressure—greater water pressure in the permeable aquifers—that forces the seepage to the soil surface. A solution for such a drainage problem requires a detailed investigation to determine the direction of water flow and the location of the underground strata carrying the water out from the river. If a drainage well is to be effective it must be located in such a way that it taps the water in the artesian aquifer.

Conventional surface and subsurface drainage methods—such as open ditches and tile lines—are frequently ineffective in areas of artesian pressure. Many times subsurface water in such areas will rise to the soil surface a few feet away from an open ditch running only partly filled by water.

Two Types of Wells

There are two types of wells which may be used to solve drainage problems. One type is the water table well or gravity well which would be used to remove water from a saturated material lying above confining substrata. The other type of well is the artesian or pressure relief well which has perforations in the confined artesian aquifer. The second type of well operates by lowering the artesian pressure in the aquifer and thereby alleviating the drainage problem.

From preliminary studies it was determined that water on the test farm was flowing from the Sacramento River into an aquifer lying approximately 50′ below the ground surface. The water then moved out from the river through the aquifer and was forced by the pressure to the soil surface at distances of 500′–1,000′ from the river.

Piezometers—installed at many points in the field—enabled the determination of the subsurface water flow and the location of the various strata below the ground surface. The Sacramento River—in the vicinity of the test farm—is subject to tidal fluctuations and the piezometers terminating in the artesian aquifer 50′ below the ground surface indicated that the pressure in the aquifer responded to tidal changes in river level.

A preliminary test was made on the effect of pumping from this aquifer by using two small well points, 1½″ in diameter which were jetted to a depth of 55′–58′ below the ground surface. These wells were equipped with a special well point followed by 5′ of perforated pipe wrapped with screen. It was possible to pump only 20–30 gallons per minute from these two wells for a limited period of time. However, even this small amount of pumping produced some pressure relief in nearby piezometers and indicated the possible success of a larger diameter and larger capacity well.

Accordingly an 8″ diameter well was drilled by a cable tool rig to a depth of 85′. The well was plugged at 77′ and was perforated from that level up to 55′ with vertical perforations. The well log of material was quite similar to those obtained by jetting the piezometers.

Open end piezometers of ½″ pipe were located around the well; five piezometers on each side in the north-south direction and two each in the east-west direction. Each was jetted down into the underlying sand or gravel aquifer. The depths varied between 52′ and 62′. Water level recorders were installed on three of the piezometers to give a continuous record of water pressure fluctuations. To measure the changes in the shallow surface water table, six observation wells were located in the field adjacent to the pumped well. Each observation well was equipped with a continuous water level recorder. Water levels in the river were also measured by a recorder.

After the well had been installed and properly developed a pump was placed on the well and pumped for a period of

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Water level recorder for water table observation.

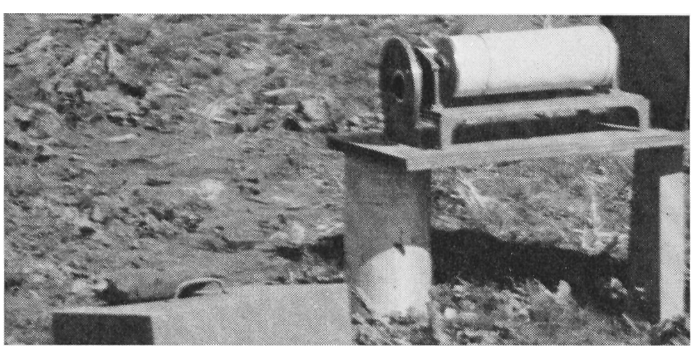
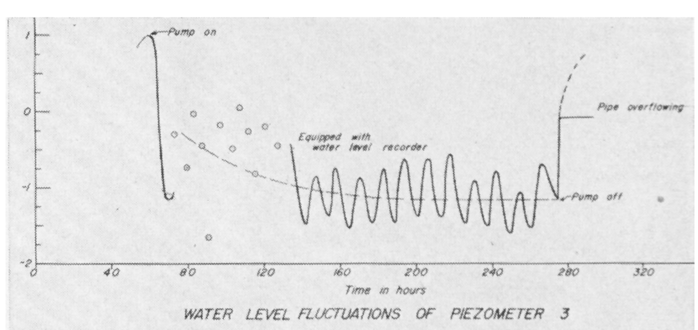


Illustration of the reduction of pressure in an artesian aquifer.



DESERTS

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field crops requiring less frequent irrigation on the fine textured soils. As a result of these conflicting requirements, and because of variations in the relationship between leaching during irrigation and the upward capillary movement of moisture between irrigations—with evaporation and salt accumulation—there is no direct relationship between tile spacing and soil texture. Frequently, more tile is required in light soils than in heavy soils.

Still another problem in tile design is the determination of what maximum flows might be expected. This information is needed so that large enough tile will be used, yet just large enough. Otherwise cost would be higher without better performance. Considerable information has been obtained on this subject in Coachella Valley, and arrangements are being made to obtain similar data elsewhere.

Along with drainage need there is the accompanying problem of removing excessive accumulations of salt. It has been found that there is no good alternative to the construction of essentially level basins with large borders on all sides, and to holding water to a depth of 6″ or so on the surface for considerable periods of time. This leaches the salt downward, and to such depth that it will not later return to the surface.

Other plot work is under way to evaluate effects of deep plowing of a stratified soil on leachability, and when soil amendments are required to correct a sodic soil.

Also, work is under way which will provide better information on the mechanical characteristics of various types of tile, and how those characteristics affect drainage performance. In some instances the effectiveness of tile appears to be decreasing, and studies are in progress to determine why this is so, and how effectiveness can be restored. Fortunately, the problem does not appear to be important at this time.

So far as is known, almost every problem concerned with the drainage of irrigated desert lands of California is under study, has been studied, or will be studied soon.

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Agencies cooperating in the drainage research in one or more of the areas include the Coachella Valley County Water District, the Imperial Valley Irrigation District, the United States Salinity Laboratory, the United States Bureau of Reclamation, the Soil Conservation Service, the United States Department of Agriculture Southwest Irrigation Field Station, the Agricultural Extension Service, the Eastern Municipal Water District, and the Palo Verde Irrigation District.

CORROSION

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ous fertilizers that farmers would likely distribute through their irrigation system, sections of pipe were placed in aerated solutions containing the following nitrogen bearing fertilizers: Calcium nitrate, potassium nitrate, ammonium sulphate, sodium nitrate, ammonium hydroxide and urea. Two levels of nitrogen, roughly 100 and 200 pounds per acre foot, were used. The calcium and sodium solutions remained clear, while the ammonium compounds tended to become murky.

Protective Coatings

Although a protective film of aluminum oxide can form—under favorable conditions—on the pipe surface, aluminum irrigation pipe manufacturers have taken steps to make a more corrosion resistant product. In addition—at times —a protective inner coating of pure aluminum is added. Protective coatings —usually containing zinc or chromate or both—have often been applied to pipe that has already shown a considerable amount of corrosion. When the coatings are applied to old pipe great care must be used to properly clean the pipe prior to the application of the protective material. Any cracks in the coating, or failure to completely cover the entire inner surface of the pipe are potential areas of excessive corrosion.

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RIVER SEEPAGE

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eight days during March 1956. A maximum discharge of 590 gallons per minute was obtained for limited periods of time until the pumping water level reached the bottom of the suction pipe, 62′ below the ground surface.

Artesian Pressure Reduced

Operation of the well was quite effective in reducing the pressure in the artesian aquifer as shown in the graph on page 34. There was an immediate response in water pressure both at the start and stopping of pumping. While it is encouraging to get a pressure relief in the artesian aquifer, of primary importance is what happens in the surface soils where the crops are to be grown. Records obtained from a continuous water level recorder on shallow observation well No. 3—located in the region of the poorest drainage conditions — show that the water table dropped 1.5′ during the pumping period. This is almost directly proportional to the pressure relief recorded in the piezometers about the same distance from the pumped well. The downward trend of the water table of the shallow well was reversed soon after the pumped well stopped. In the next four days the water table rose approximately 0.5′ above the lowest level obtained during the pumping test. There seems no doubt that if the pumping test had been continued for a longer period of time the water level in the surface would have continued to decline. Responses to the pumping in other areas in the field as observed in surface observation wells were not as immediate nor as pronounced as in observation well No. 3. For example, very little change in the surface water levels was recorded in some areas. This is explained by the fact that less permeable layers lie between the surface soil and the artesian aquifer so the relief in artesian pressure was not felt immediately at the surface of the soil because it takes quite a while for the water to drain down out of the surface layers.

The 8″ well was successful in draining an area to a distance of approximately 200′ from the well, and a larger well probably would have done a better job of drainage. However, in this particular case, it is not economical to operate a pumped well for drainage because the water must be pumped again—out of the drainage ditches into the river.

Because the test drainage well was feasible but not economical, a subsurface drainage system was designed and installed. To develop the subsurface drainage system, soil permeability tests were made by sinking a shallow auger hole beneath the soil surface to at least 1′ below the water table. After some initial flushing of the hole it was pumped and the rate of rise of water in the hole was measured.

The rate of water rise is proportional to the soil permeability and a suitable chart can be used to calculate the soil permeability from this rate of rise. The soil permeability can be used to determine the depth and spacing of drains required to drain an area.

Several auger hole tests were made on the test farm and calculations indicated that a spacing of 100′ and an average depth of 5′ for drainage tile would be adequate.

Although the subsurface drainage system was installed on the farm it has not been in operation during periods of high water in the river so it has not been possible to judge the effectiveness of the system.

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