# Drainage in Irrigated Deserts

## efficient design, installation, and maintenance of drainage systems essential to avoid crop damage by high soil salinity

**Arthur F. Pillsbury**

**Subsurface drainage** is vital in irrigated desert areas and much research on the problem has been and is being done in the Coachella, the Imperial, and the Palo Verde valleys of California. The problems are complex, and not susceptible to simple easy solution.

When a new water supply is imported to an area—or where irrigation is expanding—drainage problems are apt to arise. In the Coachella Valley, for instance, early studies indicated the probability of drainage problems when Colorado River water was imported through the All-American canal system. Because of that probability, cooperative research was initiated in 1945, three years before the first Colorado River water was used for irrigation in the Coachella Valley. By 1948, new methods and refinements of old methods had been applied to studying the potential drainage problem, and the type of drainage that could be used to remedy the problem had been evaluated. As a result, the Valley was prepared when drainage need arose. Since then, work has continued to improve drainage design criteria, and to find the most efficient way of reclaiming the large acreage of land that had been saline or saline-sodic since before irrigation began. In other desert areas the work has involved problems of maintenance and adequacy of drainage systems already installed.

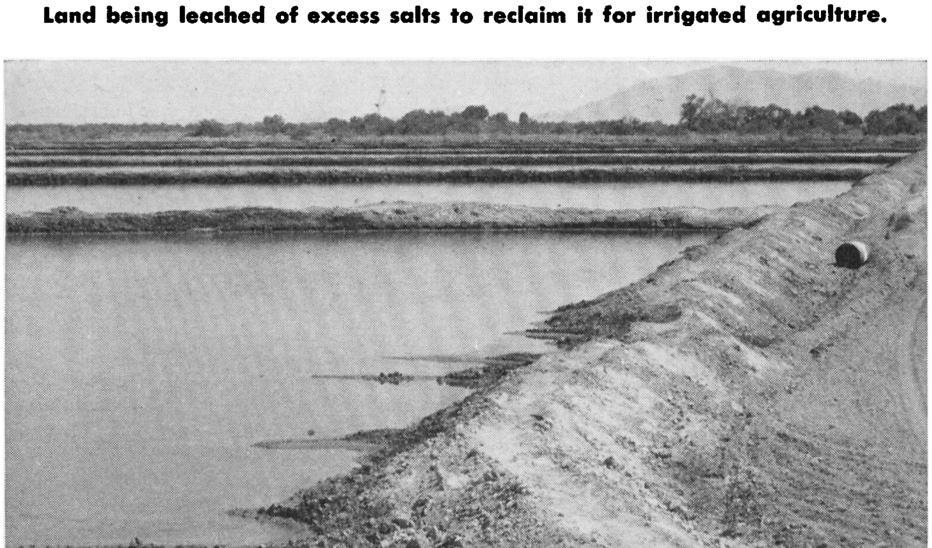
To evaluate the potential—but then nonexistent—drainage problem in the Coachella Valley the first effort was the installation of 2″ diameter observation wells on a two-mile grid pattern over the floor of the Valley. Core samples, obtained during drilling, provided information on the stratification existing in the soil. The wells have been useful for periodic observation of the water table, provided a means of making chemical analysis of the ground water.

Next step in evaluating the potential drainage problem involved the jetting of 3/8″ piezometers into the soil on a quarter mile or closer grid pattern. This step provided the necessary detail to the water table observations. By installing batteries of piezometers to different depths—between the limits of 10′ and 150′, for example—information on vertical and hydraulic gradients of the ground water was obtained.

In areas where the water table was still at appreciable depth, or where fluctuations were small, water level readings were made rather infrequently. Where a drainage problem was becoming imminent, readings were frequent.

For some years the Coachella Valley County Water District has been notifying farmers when the water table under their land was within 10′ of the surface, thus giving the farmers time to take remedial measures before harm is done. The water table information permits the management of the District to plan and install a collector system.

**Land being leached of excess salts to reclaim it for irrigated agriculture.**



There are a number of methods used for subsurface drainage. Some areas pump from a network of wells which can supplement the irrigation supply and provide very satisfactory drainage. More commonly, subsurface soil conditions are such that pumping can not be employed. Then, drainage must be by means of a network of ditches, networks of tile drains, or both.

Evaluation of the most efficient kind or kinds of drainage for a particular area has been one of the important phases of the drainage research. In the Coachella Valley a number of test wells were installed, both as a technique for evaluating the proper kind of drainage, and to provide better data on the most effective type of well where pumping is feasible.

Another problem, particularly for tile drainage, is the establishment of good design standards. In humid regions it is desirable to install tile quite shallow, from 2′–5′ below the surface, which is deep enough to provide a dry surface for tillage, an aerated root zone, but shallow enough to provide maximum benefits from subirrigation. In arid and semi-arid regions the important factor is to put the drains deep enough so that salts will not accumulate at the surface. Greater depth makes possible wider spacing. Yet, the deeper the tile is placed, the more expensive trenching and placing become. Therefore, tile depth is at best a compromise. As a general rule, most satisfactory depth seems to be somewhere between 6′ and 8′ below the surface in the desert areas.

Another problem on which considerable information has been accumulated pertains to tile spacing. With a given amount of water to be drained away, spacing can be greater with coarse textured permeable soil than with fine textured less permeable soil because the water can move through the former so much more readily.

In actual practice, the amount of water to be drained depends upon the deep percolation from irrigation. There is generally more deep percolation through the coarse textured permeable soils than through the tighter fine textured soils. In addition there is a tendency to plant specialty crops requiring frequent irrigation on the coarse textured soils and

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## 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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