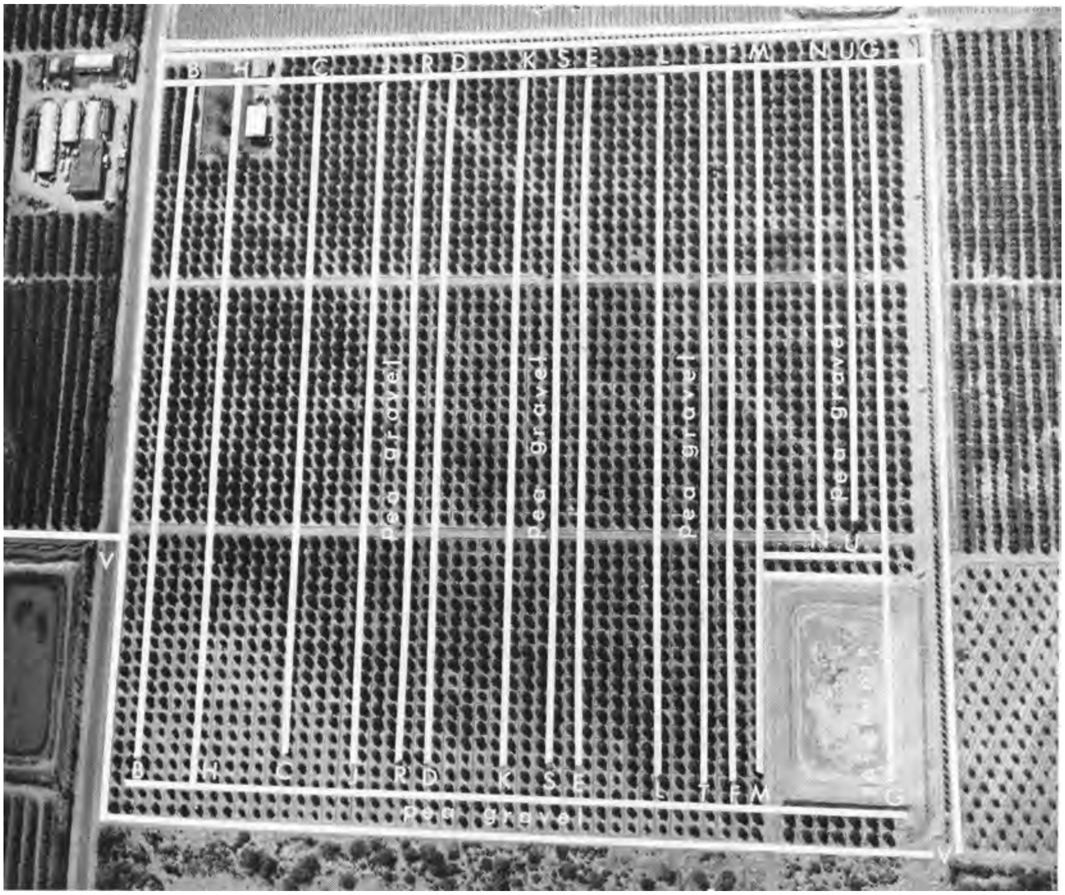


Aerial view of John Jones orchard, Mecca, with drain lines superimposed. Letters are identifying designations assigned by Coachella Valley County Water District.

Pea Gravel For In

D. D. HALSEY · A. W. MARSH

THE AVERAGE WATER application on the 60,000 acres being farmed in Coachella Valley is about seven acre-feet per acre per year. Infiltration rates are high, especially on the high ground. As a result practically the entire valley under canal irrigation has a high water table and must be artificially drained. Tile installations were started in 1949. By 1967 there were approximately 1600 miles of drain tile on farms. An extensive outfall system has been installed and maintained by the Coachella Valley County Water District. Both the water distribution system and the drainage system are almost entirely underground. Problems with poor water infiltration through the usual envelope of sand surrounding the tiles, led to this study of the effectiveness of pea gravel as a tile envelope.

Layouts

In a typical farm tile drainage installation the plan is made jointly by the landowner, the contractor, and the Coachella Valley County Water District. District engineers locate the grade stakes for the installation. A permanent map is made with copies for the contractor and the landowner. Location of lines is based on several considerations. These include the grower's opinion of need, experience on adjacent land, and the location of the point at which the farm drain must connect to the district collector line. There is rarely a detailed survey of the water table. The gap spacing and gravel envelope are not varied to suit particular soils or locations. Most layouts are on some variation of a gridiron system, the laterals being made to conform to tree and vine rows in the many cases where these occupy the land. The laterals generally are oriented with the irrigation run and are approximately parallel to the soil surface. The usual slope is from .1 to .2%.

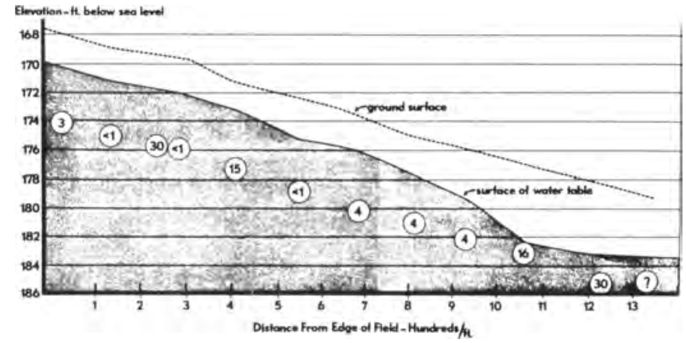
Early installations were entirely without observation wells through which flow could be observed. Consequently, there has been little data on flow rate or its change with time after installation. More recently, as troubles with drain lines were encountered, it became common practice to place an observation well at the upper end of each lateral, at the intersection of the lateral with the base line, and at the intersection of the base line with the district collector line.

Two types of drain tile have been most commonly used. One consists of clay pipe in one-foot sections with butt joints and the other of concrete pipe in two-foot sections with tongue-and-groove joints. The most common tile diameter is 5 inches. Laterals were originally placed as far apart as 300 ft. This distance has since been narrowed to as close as 36 ft in some vineyards. The depth is usually 6 to 7 ft below the soil surface.

A sand envelope at least two tenths of a foot thick has been used around all tile drains. The material used is a gravelly sand taken from high on an alluvial fan. The gravel pit contains layers of fine textured material including very fine sand and silt. Being a "pit run" material, it varies but generally meets the specifications of the Soil Conservation Service which is responsible for making a feasibility report prior to installing drains when Agricultural Conservation Program (ACP) assistance is involved.

As early as 1954 some tile lines were found with appreciable depths of water standing directly over the line although the flow was much less than pipe capacity. Where this was damaging to the crop, the

Envelopes Tile Drains Coachella Valley



Graph 1. Profile of John Jones orchard, Mecca, Feb. 1966 before installation of new tile drains. Circles represent tile drains with top of circle at elevation of the top of the pipe. Figures in circles show flow from end of lateral in gpm/1000 ft of pipe. Water table determined from piezometers set on top of drain in the gravel envelope. Grove had not been irrigated for two months.

remedy was to "split out" the old lines, meaning new laterals were installed midway between the old ones. There are various other difficulties with tile drains, but the problem of water standing over lines has been the most distressing and costly. It has resulted in crop damage to expensive grape and citrus plantings, plus expensive installation of tremendous quantities of tile, occasionally still without achieving adequate drainage.

These tests were established at the John Jones orchard, Mecca, where the typical drainage problems existed. The 40-acre block had been planted to citrus in 1956. It is surrounded on three sides by other plantings and on the fourth by open desert where the water table is close to the soil surface. The soil is gravelly sand with a high infiltration rate. Tile drains were installed here in 1958, 1959, and 1963. The constant subsurface inflow into the property from higher ground, plus the irrigation water applied in a vain attempt to maintain a low salt level, produced more water than the drain lines could remove.

Tree decline

In 1966 the obvious tree decline and wet conditions in the grove caused the grower to buy a ditch digger with which he dug 5-ft-deep ditches between each row of trees and crossing over the tile lines—in the belief that the relatively impermeable strata in the soil prevented movement of water to the drains. However, while the ditches were being dug, it was evident that the water stood at about the same level over the tile lines as at the midpoint between them, and no benefit was achieved by the ditch digging. There was relatively little flow from most laterals, and piezometers set directly on top of the drain pipe in the sandy envelope had several feet of water in them (graph 1).

At the suggestion of the farm advisor, the owner agreed to install four experimental tile lines using a different gravel envelope. Instead of the "pit run" sand which had been used in the nonfunctioning lines, a pea gravel was used. A sieve analysis of these gravels and a typical sample of the soil from this place are shown in graph 2. Selection of this gravel was based on the assumption that the old lines failed because the envelope material used about them was little, if any, more permeable than the soil itself, and that its fine texture allowed it to flow (when under pressure) into the gaps between adjacent joints of the pipe. The pea

"Clean clause" pea gravel (left) used around John Jones tile lines, as compared with standard "pit run" gravel (right) used around old lines which failed.

gravel chosen was of a texture too large to permit flow into the gaps between pipe sections.

Water table

The water-table position on the Jones farm was located with auger holes and the four experimental lines were distributed equidistantly over the 23.5 acre area, which made a spacing of 240 ft. Installation was completed in March of 1966. The flow from these lines was far greater than from any of the old lines (graph 3), and at no time in the year since they have been in place has any water stood over them. They have maintained the general water table at acceptable levels (graph 4) and tree condition has returned to normal. It is interesting to note that the total amount of water removed by these lines has been in excess of the amount of water applied to the grove (graph 5)—resulting from the water-table lowering, and inflow from other properties up the slope.

In addition to the Jones experiment, two other installations have shown similar results. In no case has any water yet been found standing over a pea gravel line. As a result of this one-year favorable performance on ground where the old lines had failed, there has been considerable commerical use of the method. Seventeen miles of pea gravel drains have been installed in the last year in Coachella Valley, so far without evidence of failure. There is a recognized need for long continued observation of these lines to learn whether they might be subject to declining effectiveness with age.

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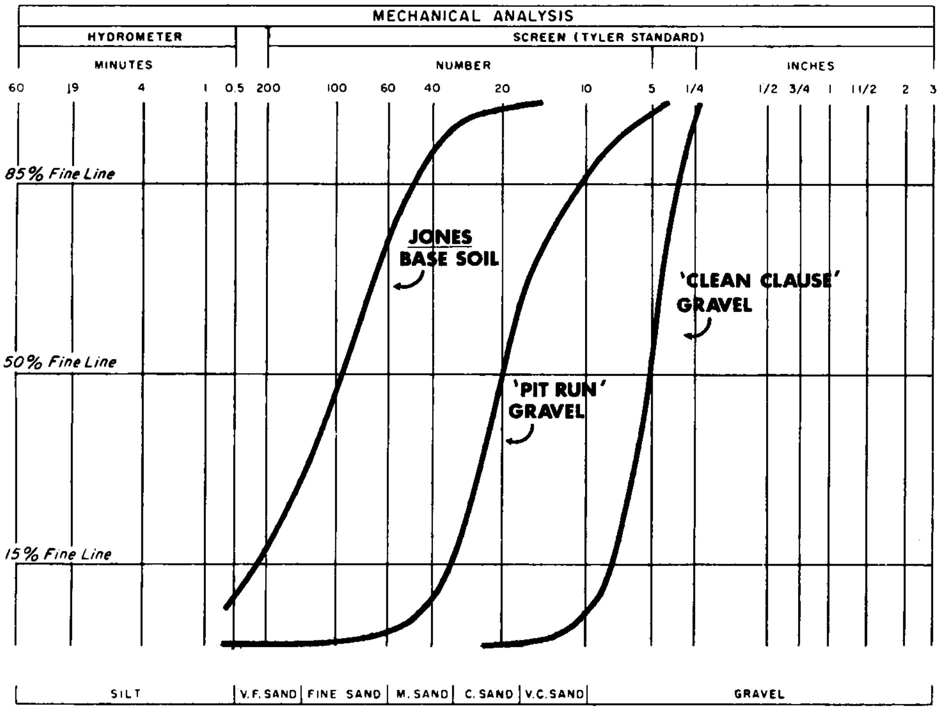
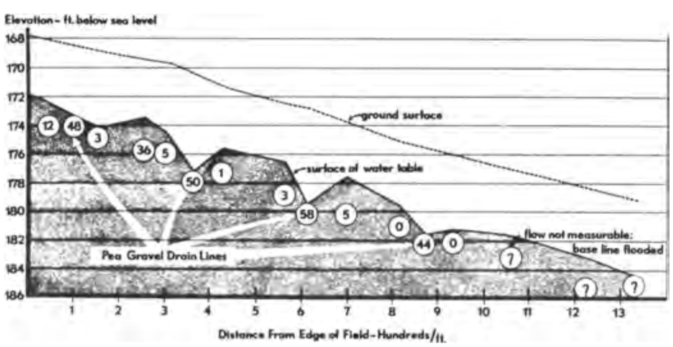
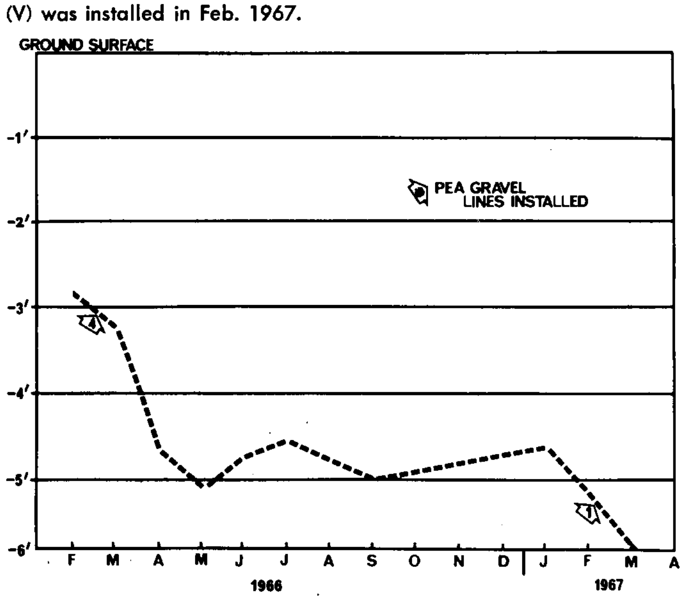
Graph 2. Sieve analysis of base soil, "pit run" gravel and "clean clause" pea gravel from the John Jones ranch, Mecca, sketched on a standard SCS mechanical analysis chart.





Graph 3. Profile of John Jones orchard, Mecca, Oct. 28, 1966, during an irrigation (same methods and notation as in graph 1). New pea gravel lines were carrying most of the water, had no water over them, and had lowered the general water table. (Water flow calculations were made by G. J. Hoffman, U.S. Salinity Laboratory, Riverside.)

Graph 4. Depth of water table below ground surface on John Jones plot, Mecca. Graph shows average of 44 auger holes uniformly distributed throughout the 23.5 acre area. Each hole was located 12 ft away from an old tile line, already in place when the trial was begun. Four pea gravel lines (R, S, T & U) were installed in March 1966, one (V) was installed in Feb. 1967.



Graph. 5. Irrigation water applied, compared with drainage water removed by four pea gravel drain lines from 23.5 acre plot area of John Jones ranch, Mecca.