cattle. All cattle improved over the feeder grade of average-good to medium- and low-choice. A few carcasses were graded prime in the control and MGA groups.

The area of the rib eye at the 12th rib of the MGA-fed heifers consistently measured less than the control or Synovex-H heifers and the difference was significant. Back fat thickness varied less with no real difference.

Carcass quality was further analyzed for tenderness, shrink due to thawing and cooking, and for moisture and fat content between samples after cooking. Except for the total moisture, there was a wide variation in measurements within each treatment. An analysis of variance showed no significant difference (at the 5% level) between treatments, with respect to fat content and tenderness. Shear pressures (in lbs-per-square-inch required to cut the meat) were within range for tender meat.

Rib steaks were significantly more tender than the bottom round as determined by the Lee Kramer shear test. Shrink due to cooking and thawing was generally greater in round steak. However, it was found that the control group showed the same amount of cooking shrink in both the ribs and rounds (table 4).

C. A. Perry and D. Addis are Livestock Farm Advisors, Los Angeles and Riverside counties, respectively. H. Strong is Extension Animal Husbandman, Emeritus; R. G. Loy was Assistant Professor, Department of Animal Husbandry; and A. W. Brant is Extension Food Technologist; University of California, Davis. T. M. Little is Biometrician, Agricultural Extension Service, U. C., Riverside.

Assistance in conducting these tests was obtained from: Upjohn Company, Kalamazoo, Michigan; Cattle Feeders of Palo Verde Valley and Alpha Beta Packing Co. of Huntington Beach; and from Dr. George Crenshaw, Extension Animal Health Specialist, and Cheryl Waul, Department of Food Science and Technology, University of California, Davis.

TABLE 3. RATE OF GAIN, FEED CONVERSION AND CARCASS GRADE

	Test 1 January to May, June				Test 2* April to July, September		
	Control	Synovex-H	MGA 1	MGA 1A	Control	Synovex-H	MGA
Number heifers	21.00	21.00	42.00	93.00	46.00	89.00	88.00
Avg. initial wt. lb	667.60	675.20	671.60	568.90	528.20	531.00	534.40
Avg. days on feed	96.00	95.00	88.00	127.00	138.00	124.00	127.00
Avg. sale wt lb	871.90	914.70	874.90	884.70	807.90	826.60	830.80
Avg. daily gain lb	2.13	2.52	2.29	2.49	2.03^{a}	2.38^{b}	2.33^{b}
Feed per 100-lb gain lb	963.90	792.60	857.90	775.80	929.20	836.80	839.20
Daily feed consumption—% of avg. body wt.	2.66	2.51	2.54	2.65	2.82	2.93	2.86
Percent feed efficiency	83.50	106.70	94.90	94.80	77.30	86.10	86.20
In-transit shrink %	3.71	3.68	3.35	4.24	5.14	5.73	4.06
Dressing percentage †	63.36	63.44	63.10	61.85	63.57	64.04	64.33
Percent choice grade	65.00	65.00	80.00	75.00	59.50	48.80	64.10
Avg. grade index ‡	5.15	5.05	5.33	5.14	5.14^{c}	4.41^{d}	5.05^{c}
Rib eye area, sq inch	11.23	11.89	11.36	10.58	11.63^{e}	11.33^{e}	10.84^{f}
Fat thickness, inches	0.36	0.47	0.40	0.49	0.43	0.46	0.49

* Highly significant (P> .01)—Differences are significant if comparable means do not have a common superscript.
† Dressing percentage determined as percent hot carcass weight of sale weight.
‡ Grade Index: Prime 10, 9, 8; Choice 7, 6, 5; Good 4, 3, 2.

TABLE 4. CARCASS QUALITY—LABORATORY DATA OF RIB AND ROUND STEAKS*

	Rib Steak			Bottom Round Steak		
	Control	Synovex-H	MGA	Control	Synovex-H	MGA
Loss during thaw, %	2.3^{a}	1.5^{b}	1.7^{b}	3.2	3.2	4.4
Cooking shrink, %	15.0	14.1	15.1	15.4^{c}	21.8^{d}	21.7^{d}
Moisture content of meat after cooking, %	57.0	59.7	60.6	59.1	58.2	59.5
Fat content, %	12.2	11.0	9.3	9.0	8.9	7.7
Tenderness lbs/sq in pressure	14.2	15.4	13.6	16.9	21.1	18.9
Avg. weight of carcass, lb	512.0	521.0	532.0			
Avg. grade index	5.9	5.6	5.6			

* All values are averages of recorded data.

Significant differences at 5% level: a, b, c, d—differences are significant if comparable means do not have a common superscript:
1) Thaw Loss—
Ribs: MGA and Synovex-H significantly lower than control
Rounds: No significant differences
2) Cooking Shrink—
Ribs: No significant differences
Rounds: MGA and Synovex-H significantly higher than control
3) Moisture Content of Meat after Cooking—
Ribs: MGA significantly higher than Synovex-H or control
Rounds: No significant differences
4) Fat Content—no significant differences
5) Ribs were significantly more tender than rounds, but there were no significant differences within these two groups.

Effects of
on

Ground water recharge through water spreading was studied in the channel of the Santa Ana River, Orange County, where riverbed gravels are apparently an outcrop of the Talbert formation. In sections of the channel where water was ponded, the intake values were reduced to approximately 2% of the intake in a section of the channel where the water was flowing, and which had no surface sediments. The average intake rate of the entire spreading area was about 1.2 acre-feet per day. The intake of the pond was 0.088 acre-feet per day per acre, and the intake of the channel with flowing water was 5.9 acre-feet per day.

THE USE OF UNDERGROUND STORAGE for water has become an operation of major importance in recent years. The problems depend upon the characteristics of the aquifer in which the water is stored, the water source, and the area where the water is spread to recharge the aquifer.

Little can be done to modify the storage aquifer, but information about its properties can be helpful for full utilization. The source of water for such operations is usually fixed and the spreading operation must allow maximum storage at the lowest cost. The usual method of water spreading has been to impound the water in relatively shallow ponds in the recharge area. Deep pits or wells are sometimes used.

This report presents information on infiltration rates of shallow spreading ponds in areas with, and without, surface sediments to show how much the surface sediments affect the spreading efficiency of such ponds.

The data were obtained in cooperation with Orange County Water District from their water spreading operation in the Santa Ana River. The recharge area is the river channel starting at the mouth of the Santa Ana Canyon and extending downstream six miles. The river channel is 500 to 1000 ft wide and has a slope of 17 ft per mile. The riverbed consists of fluviated outwash with a high water conducting capacity. This material is a sub-

Surface Sediments Ground Water Recharge

B. L. GROVER • F. K. ALJIBURY • D. D. BAIER • J. FAIRCHILD

alluvium outcrop of the Talbert formation (or at least is in good hydraulic contact with the Talbert formation), which is believed to be the main artery conducting water into the other formations beneath the southeastern half of the Downey Plain.

The spreading grounds cover approximately 500 acres. The spreading procedure is to run the water down the river channel from point of delivery at the Metropolitan Water District aqueduct at Horseshoe Bend to the Yorba Linda Bridge. Below the Yorba Bridge where the Santa Ana Canyon begins to widen, a series of ponds are used to impound the water in the river channel. In some instances the water passes through control structures in the levees which form the ponds, while in others the water is introduced into the pond at the upper end—with no outlet provided. In the latter instance the excess water moves in a stream past the side of the pond. There is considerable activity in removing silt and sand from the river to lower the channel to improve its flood-control capacity. The water is usually channeled into a narrow stream to pass these operations.

The water is Colorado River water including 700 ppm of dissolved solids made up of bicarbonate, sulfate, and chloride salts of calcium, magnesium, and sodium. The cation percentages are 41% sodium, 33% calcium, 22% magnesium, while the anion percentages are 19% bicarbonate, 56% sulfate, and 24% chloride. Suspended solids amounted to 1.5 ppm during the period of the test.

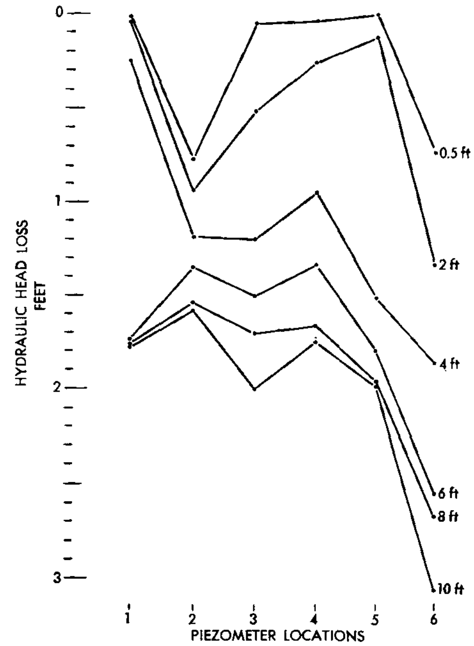
The water is essentially free of sediment but considerable fine sediment is scoured from the channel above the spreading area and from the stream channels between ponds. These sediments reduce the intake rate of the ponds and cause the problem of this investigation. For simplification in this report the entire area between the flood control levees is referred to as the "river channel," and the area of flowing water as the "stream channel."

Sampling sites were located in a stream channel approximately 500 ft below the Santa Fe Railroad bridge, ½ mile downstream from the Jefferson Street bridge, and in one of the large ponds located in the river channel approximately ½ mile downstream from the Anaheim-Olive Boulevard bridge. Piezometers were installed within the limits of the flowing water in the stream channel at six locations equally spaced across the channel at depths of 0.5, 2, 4, 6, 8, and 10 ft at each location. Distribution of hydraulic head loss was measured on three different days from September 28 to October 28, 1962 (see graph). Exact values are listed in the inset because some of the differences are too small to show plainly on the graph. Only one value is given for each piezometer, since the values did not vary significantly over the period of the sampling. The surface of water was used as the reference level at both sampling sites.

Porous medium

The flow of water in a porous medium is described by the equation $V = KI$; where V is the volume of flow through a given area, K is the hydraulic conductivity, and I is the hydraulic gradient. If V is constant, K increases as I decreases. With this relationship in mind, the graph indicates that there are layers of lower conductivity. Two occur near the surface at locations 2 and 6, two others occur between the 4- and 6-ft depths at locations 1 and 6; and another occurs between the 2- and 4-ft depths at locations 3, 4, 5, and 6. None of these layers is as restricting as the surface sediments in the pond, since the head loss is less than unity in all of these examples except the surface at locations 2 and 6. The gradient in the pond sediment is greater than 4 to 1.

Piezometers were installed at three locations in the pond at the same depths as in the stream channel. These locations were distributed across the pond. The readings of head loss were also measured three times over a period of four days, and indicated no differences in any of the readings for a given piezometer. The water in the pond was 1.75 ft deep. The fine sediment was 0.67 ft thick. The head loss was so great that water stood only in the piezometers placed at 0.5 ft and at 10 ft below the bottom of the pond. The piezometers located at a depth of 0.5 ft did not completely penetrate the sediment at the bottom of the pond and all of the head of water ponded on the surface was not dissipated at this depth.



Hydraulic head loss in the gravel of the stream channel where no surface sediments were present. The numbers at the right denote the depths of the piezometers.

The piezometers placed 2, 4, 6, and 8 ft deep did not have water in them. The piezometers 10 ft deep did contain water, but no conclusion could be determined about the shape of the water surface, since the water in the center piezometer stood at a level higher than the bottom of the piezometer placed 8 ft deep. The piezometer placed 10 ft below the sediment surface was apparently in error, but this was not realized until after the end of the study. The head loss was 1.05 ft, 2.25 ft, and 1.19 ft for the three locations down to 0.5 ft; and 11.15 ft and 10.55 ft down to 10 ft.

Infiltration rates were obtained using 6-inch cylinder infiltrometers. The infiltrometers were driven 6 inches into the riverbed or pond sediments at the location of the piezometers. The level of water was maintained slightly below the level of the water outside the infiltrometer to eliminate water flow from inside the cylinder around the bottom and back up on the outside. The data as given in the table

WATER INFILTRATION RATE AVERAGES, SANTA ANA RIVER SPREADING GROUNDS

	ft/day
River	5.9
Pond with sediments	0.088
Pond with sediment removed from inside infiltrometer	5.9

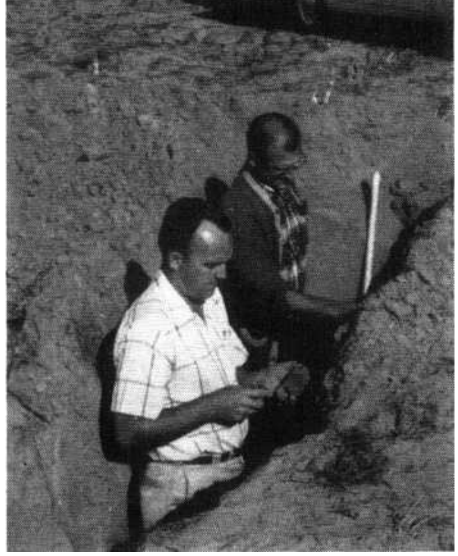
show that the intake rate in the stream channel, where no surface sediments had accumulated, was approximately 50 times as great as it was in the pond. It was also evident that the surface sediment layer is the restricting layer, since the rate of intake in the pond, when the layer of surface sediment in the infiltrometer was removed, was equal to the rate in the channel.

The rate of water delivery to the spreading area was maintained at approximately 300 cubic ft per second during the period of the study. This rate had been maintained for some weeks prior to the study, and thus the average intake rate of the spreading grounds is approximately 1.2 ft per day.

An analysis of the texture of pond sediments was made and the data indicate that the sediments were uniform in texture over the area sampled and also from the top of the layer to the bottom. Averages of all samples showed 5% sand, 60% silt, and 35% clay.

Ponding, and the use of interconnecting stream channels for water spreading, (under the circumstances investigated), greatly increase the area needed for recharging a gravel aquifer. The decrease in intake rate in the pond, as compared with the channel, is due to the surface layer of fine sediments which is formed by the deposition of the fine material which is scoured loose in the flowing stream above the spreading area and between ponds. To insure effective use of the ponds, the water must be desilted at the top of the spreading area and kept free of suspended fine sediments as it is moved from pond to pond in the spreading area. An alternative approach, and probably a more practical one, would be to remove the silt in a single large pond and then spread the water out into small parallel shallow streams so that the water velocity remains low. The low velocity would reduce both the amount of scouring and the amount of sediment—thus keeping the rate of infiltration high. The expense of spreading under this system should also be less than with the present ponding system.

Ben L. Grover was Soil Physicist, Department of Horticultural Science, University of California, Riverside (now at Utah State University, Logan). F. K. Aljibury is Farm Advisor, Orange County. Dwight D. Baier and James Fairchild are with the Orange County Water District. C. E. Houston, U. C., Davis, and A. W. Marsh, U. C., Riverside, assisted in this research.



Observations of soil compaction and water penetration problems in orchard photo above were made possible by backhoe trenching.

BACKHOE *orchard analysis and water*

J. L. MEYER

OBSERVATIONS made possible by excavating with a tractor-mounted backhoe in the Stanislaus area of the San Joaquin Valley indicate that perhaps 10% of the vineyards and orchards are located on nonproductive areas of compacted soil. As much as 25% of the alfalfa acreage is productive for only one to two years because of compaction and poor water penetration.

An increasing number of compaction problems are being recognized on soils that have been thought of as very productive. Hanford sandy loam soils are known throughout the San Joaquin Valley as Class 1, deep permeable soils. Their excellence is recognized by the high crop yields, as well as the ease with which they are cultivated. However, these soils are among those being irreversibly abused with cultivation and land-grading equipment.

Mechanical analyses have shown that these sandy soils, which are most compact in fill areas, could be very effectively used to produce the best adobe bricks. Contrary to public opinion, good adobe bricks contain proportionately very little clay or silt. The Hanford soil mentioned above contains fractions within the textural zone that engineers call excellent for adobe brick production, that is 8 to 10% clay, 75 to 80% sand, 10 to 15% silt, and 1 to 2% organic matter.

When a sandy soil that has been growing pasture or sod crops is suddenly covered by grading to the bottom of a fill, the organic content is relatively high and the size of particles is ideal for adobe brick. If in addition the area is compacted as large land-grading equipment is moved across it, then all elements of adobe brick-making are employed at the surface of the old soil and it is irreversibly compacted.

Blue layers

Furthermore, in a deep fill of 2 to 5 ft, oxygen is often excluded from the old compact soil surface, allowing the anaerobic bacteria to begin to work, and a blue color or gleyed condition develops. The addition of water percolating slowly through the soil excludes even more oxygen and accentuates the blueing or gleying. Existing ferric iron becomes reduced to ferrous iron with the aid of an organic substrate and the iron becomes more soluble and moves down through the profile in this condition with the slowly percolating water. It becomes reoxidized as soon as it reaches a less compact, and consequently less reduced, zone. The ferric iron, having a lower solubility, again is redeposited as ferric oxide or common rust and consequently starts to fill up pores, which reduces and restricts the percolation of water. These rusty lenses are apparent to the naked eye in at least half of the profiles examined. The authors believe that chemical analysis shows that these iron oxide *horizontal* lenses exist in every case of fill compaction in sandy soils. This process probably explains the origin of iron-cemented hardpans.

Deep fills

From county roads, discernible deep fills are often seen (many 20 to 40 years old), that have reduced crop yields. Fills of 2 to 5 ft are compacted to the point that the fill material becomes anaerobic, blue-black in color and often with iron-brown streaks of staining. No roots are found in these layers and bulk densities are high.

Water intake rates are very low in these soils and most often wet layers or perched water tables are found at the interface or