

**HYDROLOGY  
and WATER  
RESOURCES  
in ARIZONA  
and the  
SOUTHWEST**

PROCEEDINGS OF THE 1973 MEETINGS  
OF THE  
ARIZONA SECTION—  
AMERICAN WATER RESOURCES ASSN.  
AND THE  
HYDROLOGY SECTION—  
ARIZONA ACADEMY OF SCIENCE

MAY 4-5, 1973, TUCSON, ARIZONA

USE OF STOCK PONDS FOR HYDROLOGIC RESEARCH  
ON SOUTHWEST RANGELANDS <sup>1/</sup>

J. R. Simanton and H. B. Osborn <sup>2/</sup>

INTRODUCTION

The Walnut Gulch Experimental Watershed in southeastern Arizona is operated by the USDA, ARS Southwest Rangeland Watershed Research Center in Tucson. Hydrologic research on the 58-square-mile rangeland watershed includes the following: estimates of rainfall amounts, intensities, and variability based on records from 95 recording rain gages; estimates of runoff based on continuously recording water level recorders at 11 concrete flume-weir measuring structures, 12 livestock watering ponds, 6 V-notch weirs, 2 Venturi-type flumes, and 2 n-flumes; and, fluvial sediment samples with cableway, wading, and pumping samplers. Sediment deposition is estimated from pond surveys.

In this paper, the use of livestock watering ponds as a relatively inexpensive method of comparing rainfall amounts with runoff sediment volumes is discussed.

CLIMATE

The climate of Walnut Gulch is semiarid, with the rainfall biseasonal and monsoon in type. The annual rainfall distribution is characterized by a strong summer maximum and a weaker winter maximum. The summer rains are usually short-lived, high-intensity, air mass thunderstorms occurring in late afternoons and evenings from June through September. The winter rains are usually prolonged, low-intensity frontal storms occurring from December through February. The average annual precipitation is about 13 inches, of which 70% falls during the summer. Summer thunderstorms produce nearly all of the annual watershed runoff.

WATERSHED DESCRIPTION

There are 19 livestock watering ponds on Walnut Gulch. Semiarid rangeland wildlife also use the ponds as a source of water. Without disturbing either livestock or wildlife, Southwest Watershed Research

- 
1. Contribution of USDA, ARS Soil, Water, and Air Sciences.
  2. Research hydrologic technician and research hydraulic engineer, Southwest Rangeland Watershed Research Center, Tucson, Arizona.

Center hydrologists use the ponds as an inexpensive source of rangeland hydrologic records. Twelve of the ponds have been instrumented with continuously recording water level recorders. Materials and labor for instrumenting a typical stock pond cost about \$410. These ponds drain watersheds with widely different soils and covers and represent a wide variety of rangeland combinations. Also, the pond drainage areas are grazed at different intensities. Several of the watersheds are heavily grazed; others receive little or no pressure from livestock (all pond drainage areas have been heavily grazed at one time or another).

In this study, records from 5 of the 12 stock ponds were analyzed. Four of the 5 have the longest continuous records (over 10 years), and the fifth was of interest because its watershed was root-plowed and reseeded.

In addition to the installation of water level recorders, topographic surveys are made of each pond to determine its storage capacity. These surveys provide a sediment accumulation record for each pond, as well as a means to quantify the rainfall-runoff relationship for each watershed.

The vegetation on Walnut Gulch consists mainly of grass and brush. Brush dominates on the lower 2/3 of the watershed, and grass dominates on the upper 1/3. Predominant brush species are spreading creosotebush (Larrea divaricata), whitethorn (Acacia constricta), and american tarbush (Flourensia cernua). Grass species include black grama (Bouteloua eriopoda), blue grama (Bouteloua gracilis), sideoats grama (Bouteloua curtipendula), and tobosa (Hilaria mutica). Vegetative covers on the different pond drainages are grouped as brush, grass, or brush-grass, based on visual observations. Soils are generally deep, well drained, poorly developed, medium to moderately coarse textured gravelly loams.

The five ponds selected for analysis are referred to hereafter as Pond No. 1, 7, 14, 20, and 23 (Figure 1). Pond drainage area, vegetative cover, principal soil type, percent slope, and years of record for each pond are listed in Table 1. The two listings for pond 1 represent the watershed condition before and after root plowing in the spring of 1971. At that time, the pond drainage was reseeded to sideoats grama and blue grama, but these grasses had not become completely established after 2 seasons.

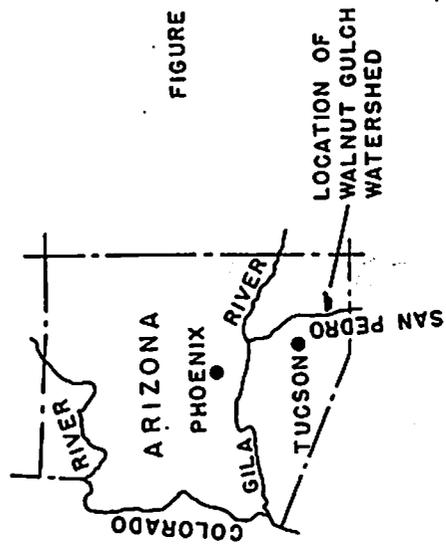
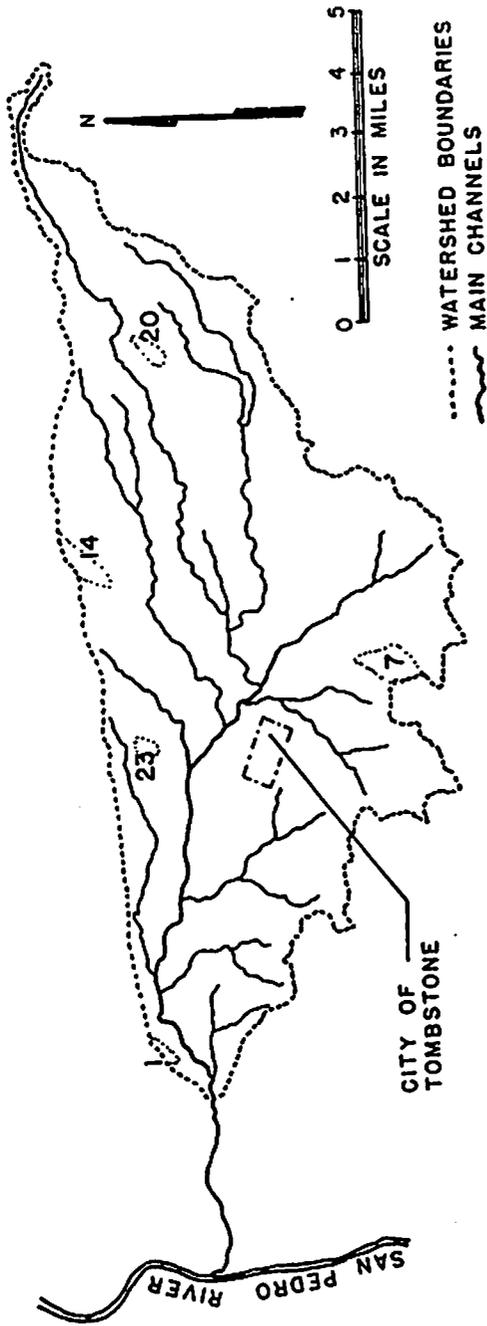


FIGURE 1. THE WALNUT GULCH WATERSHED.

TABLE 1. Description of 5 selected Walnut Gulch Stock pond watersheds.

Pond	Drainage Area(Acres)	Vegetation	Soil*	Slope(%)	Years of Runoff Record
1	109	Brush	Rillito-Karro	3-15	5
1	109	Ripped, reseeded to grass	do	3-15	2
7	253	Brush-grass	Rillito-Cave	3-30	12
14	372	Grass	Hathaway-Bernadino	8-15	10
20	142	Grass	do	8-15	14
23	108	Brush	Rillito-Laveen	3-15	13

\*All soils listed are gravelly loams.

#### RAINFALL-RUNOFF RELATIONSHIPS

Runoff from various sized semiarid watersheds has been related to many different variables. Kincaid and Williams (1966) reported that runoff volume decreased significantly as crown cover increased on 6-x12-foot plots. Osborn and Lane (1969) found that total precipitation was the primary variable for determining runoff volume from very small semiarid rangeland watersheds (0.6 to 11 acres). Reich and Hiemstra (1965) reported that for watersheds larger than one square mile, runoff peaks were best correlated with maximum 30-min. rainfall depth.

Runoff volumes for the 5 selected stock ponds were related to total storm amounts and maximum 15-minute depths, assuming a linear relationship (Figs. 2 and 3). From the figures and the correlation coefficients, there is a suggestion that the runoffs from the watersheds of about 100 acres and less are more highly correlated to total storm rainfall than to maximum 15-min. depth; and, that the runoffs from the watersheds of about 250 to 350 acres are more highly correlated to maximum 15-min. depth. If true, the most likely explanation is that

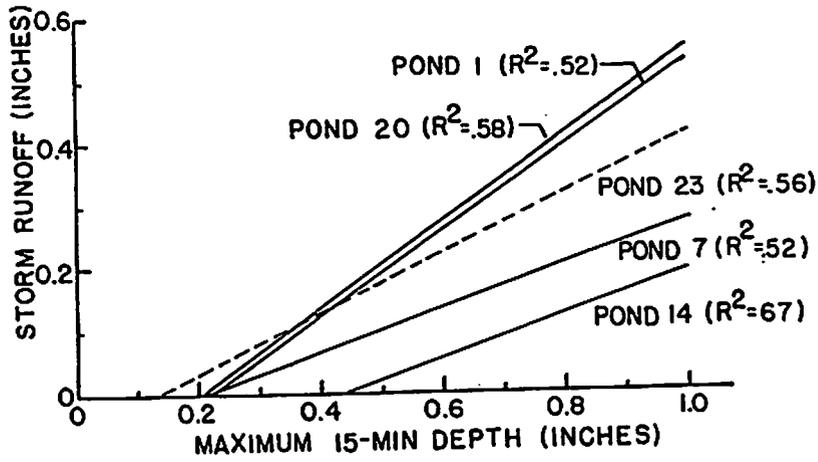


FIGURE 3. Storm runoff versus maximum 15-min. rainfall depth for 5 selected Walnut Gulch stock pond drainages.

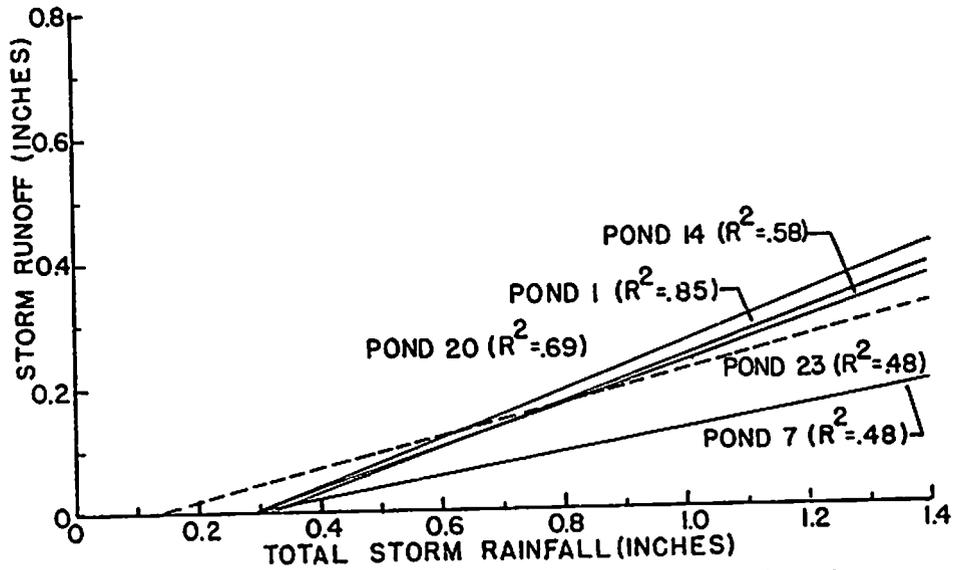


FIGURE 2. Storm rainfall-runoff relationship for 5 selected Walnut Gulch stock pond drainages.

storm rainfall is more variable over the larger watersheds, and therefore more poorly correlated to runoff than for the very small watersheds. However, a more detailed analysis when more data are available from all 12 instrumented stock ponds will be necessary to verify this suggested relationship.

Mass curves of accumulated summer rainfall and runoff indicate some differences in rainfall-runoff relationships between the 5 stock pond drainages (Fig. 4 and Table 2).

TABLE 2. Relationships between rainfall and runoff for 5 selected Walnut Gulch stock pond drainages.

Pond	Drainage Area (acres)	Years of Record	Ave. Summer Rainfall (Inches)	Ave. Summer Runoff (Inches)	Runoff/Rainfall
1	109	1966-70	9.42	0.90	.10
1	109	1966-72	9.50	1.11	.12
7	253	1962-71	8.83	.33	.04
14	372	1960-68	7.71	.78	.10
20	142	1962-71	9.07	.83	.09
23	108	1961-72	7.54	.70	.09

Except for pond 7, about 10% of the summer rainfall, on the average is measured as runoff into stock ponds. Runoff from the drainage above pond 7 is about 1/2 that of the other 4 watersheds. This indicates that, although the intense highly variable thunderstorm rainfall generally tends to mask differences in rainfall-runoff relationships caused by differing watershed characteristics, in some cases, these differences make meaningful differences in the rainfall-runoff relationship. Possible explanations for the lower runoff volume from the drainage above pond 7 are: This watershed has the densest brush-grass cover of any of the 5 ponds and has recovered the most from earlier over-grazing; the relatively complex soil and rock surface may be more porous than that of other pond drainages; and, the watershed is grazed more lightly than the other watersheds.

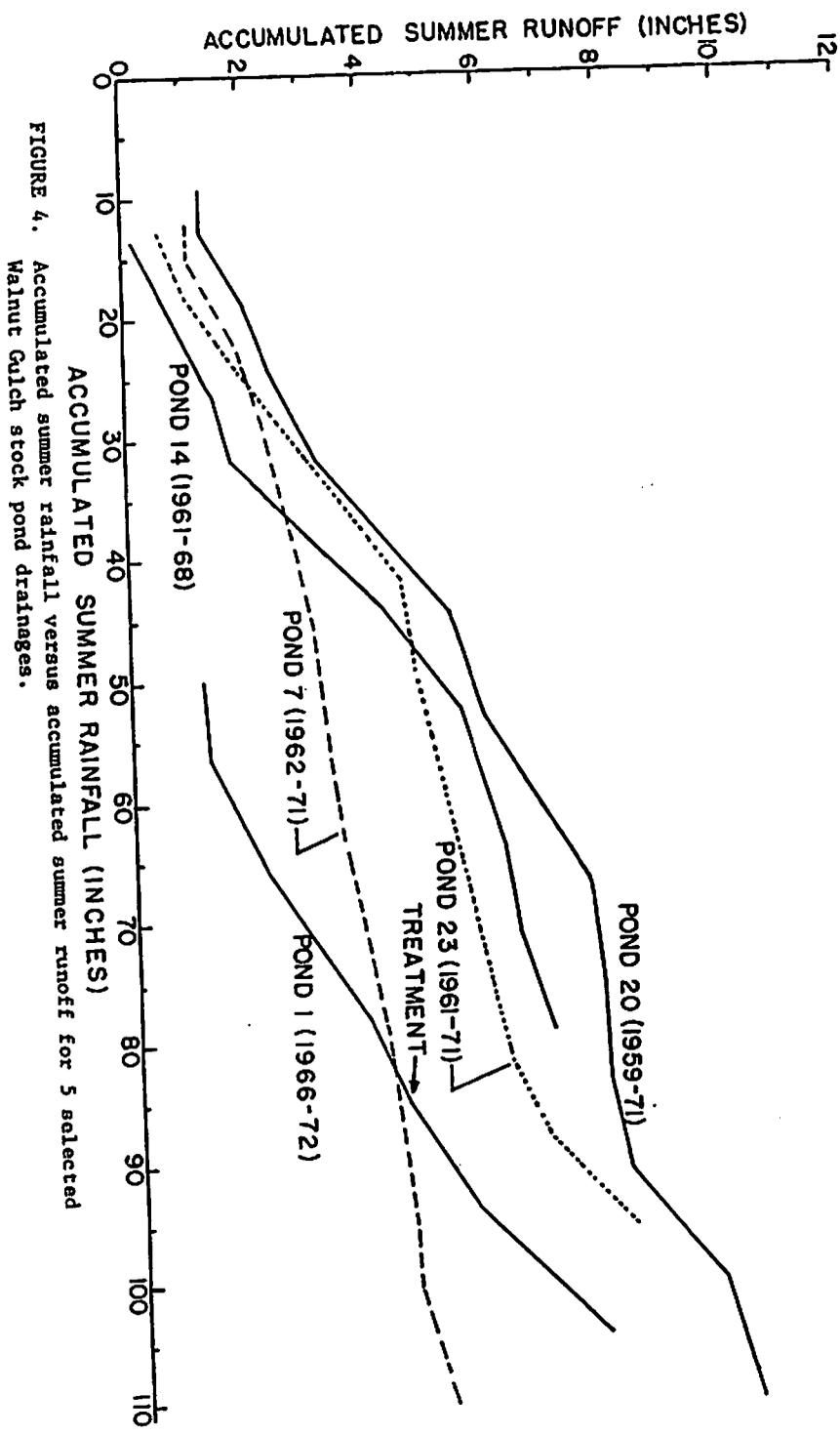


FIGURE 4. Accumulated summer rainfall versus accumulated summer runoff for 5 selected Walnut Gulch stock pond drainages.

Several investigators, including Renard (1970), have reported decreasing water yield per unit area with increasing watershed size for the ephemeral streams of the Southwest. Primarily because of the record from pond 7, but also because of natural rainfall variability and the short records, this effect is not apparent in the analysis (Fig. 5 and 6). Obviously, more quantitative descriptions and longer records are needed to derive rainfall-runoff relationships for the stock pond drainages on Walnut Gulch.

Runoff from the pond 1 watershed increased after the 1971 root plowing and reseeding (Fig. 7). However, the most intense storm rainfall (2.5 inches in 30 minutes) for the period of record occurred in 1972, so the indicated increase in runoff rate per unit area indicated in Figure 7 is misleading. However, the record does not suggest that ripping decreased runoff as might have been expected.

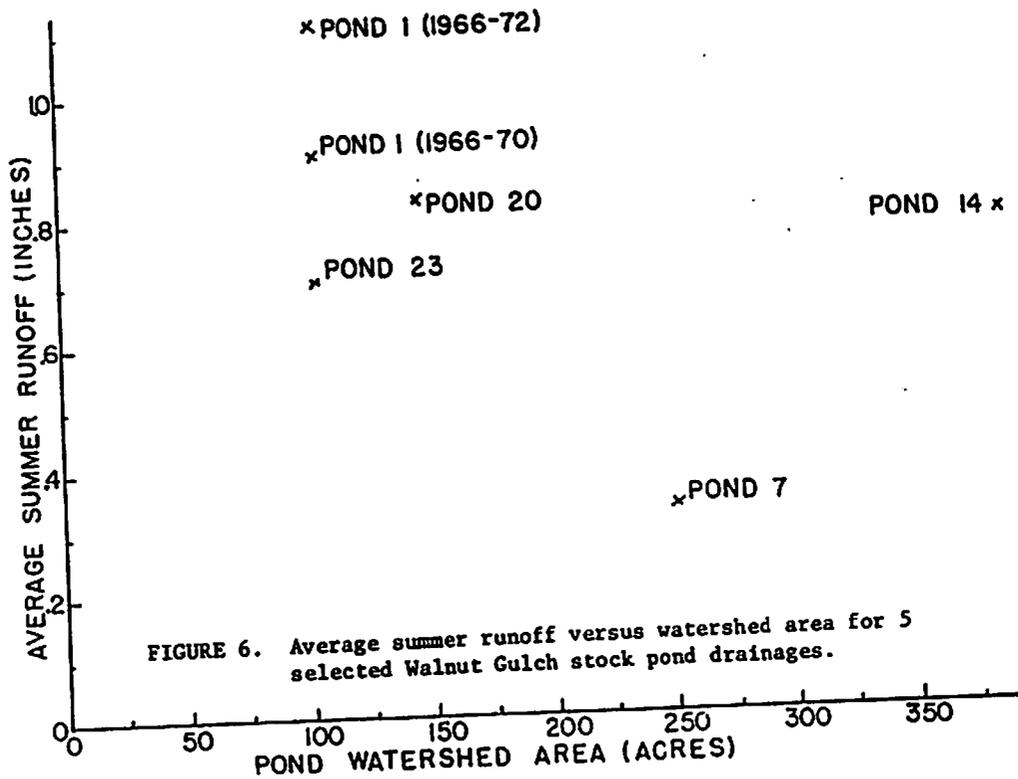
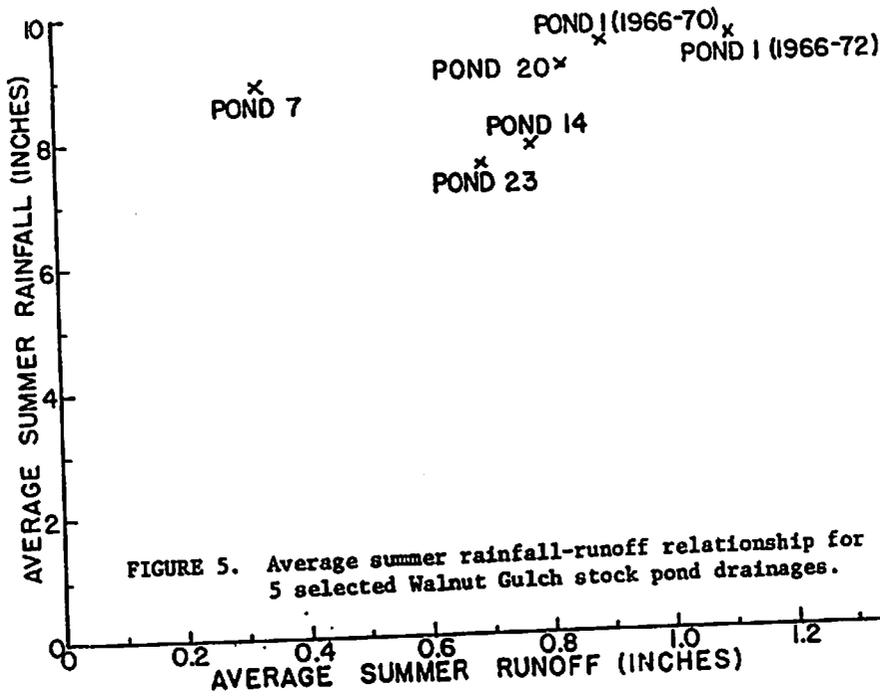
#### SEDIMENTATION

The principal purpose for instrumenting the stock ponds on Walnut Gulch was to estimate sediment production from very small (less than one-square-mile) rangeland watersheds. The results to date have not been very satisfactory because of a variety of instrumentation and surveying problems and because of the natural variability of thunderstorm rainfall. For example, on several occasions sediment has been removed from ponds before a survey could be made, thus losing one or more years of record. However, most of the problems that have plagued early evaluations have been corrected, and records from all 12 ponds should yield better results in the future.

Sediment yields were estimated from the records available and from surveys at ponds 1, 7, 14, and 23 for various periods (Table 3).

TABLE 3. Sediment yields for 4 selected Walnut Gulch Stock Pond Drainages:

Pond	Years	Ave. Summer Runoff (Inches)	Sed. Yield (ac-ft/mi <sup>2</sup> /yr.)	Sed. Yield per 1" of Runoff (ac-ft/mi <sup>2</sup> /yr.)	Cover
1	1966-70	0.90	0.33	0.37	brush
1	1971-72	1.64	.54	.33	seeded to grass
7	1962-72	.33	.14	.42	brush grass
14	1960-68	.78	.31	.40	grass
23	1961-71	.70	.41	.59	brush



Sediment yields from watersheds of ponds 1 (before treatment) 7, and 14 all averaged about 0.4 ac-ft/mi<sup>2</sup>/yr/inch of runoff. Sediment yield from pond watershed 23 was about 50% greater than that from the other 3 pond watersheds. The watershed above pond 23, which has been heavily grazed in the past, is highly eroded and almost devoid of grass. Again, however, the available data are insufficient to reach definite conclusions.

There was no significant change in sediment yield from the pond 1 watershed after the 1971 treatment, although higher sediment yield rates generally are expected for exceptional events such as the storm in 1972. The watershed was root plowed along the contour and left heavily furrowed and pitted, which may explain why the sediment yield from the watershed was less than expected. This low yield may be only temporary, or if the grass becomes well established and grazing is deferred, the sediment yield may remain low. Again, analyses of current and future data collected from all 12 stock pond drainages should answer this question.

#### SUMMARY

Stock watering ponds in the Southwest can be instrumented to provide valuable hydrologic information, particularly for rainfall-runoff relationships and sediment yields. On the Walnut Gulch Experimental Watershed in southeastern Arizona, 12 such stock ponds have been instrumented. Because of a variety of problems, analyses based on early records are inconclusive, but future records should provide valuable information in hydrologic research on the semiarid rangelands of the Southwest.

#### REFERENCES CITED

- Kincaid, D. R. and Williams, G. Rainfall effects on soil surface characteristics following range improvement treatments. J. Range Mgmt. 19(6):346-351, 1966.
- Osborn, H. B. and Hickok, R. B. Variability of rainfall affecting runoff from a semiarid rangeland watershed. Water Resources Res., AGU, 4(1):199-203, 1968.
- Osborn, H. B. and Lane, L. J. Precipitation-runoff relationships for very small semiarid rangeland watersheds. Water Resources Res., AGU 5(2):419-425, 1969.
- Reich, B. M. and Hiemstra, L. A. V. Tacitly maximized small watershed flood estimates. J. Hydr. Div., ASCE, Vol. 91 (HY-3): 217-45, 1965.
- Kenard, K. G. The hydrology of semiarid rangeland watersheds. U.S.D.A. pub. ARS-41-162, 26 pp., 1970.

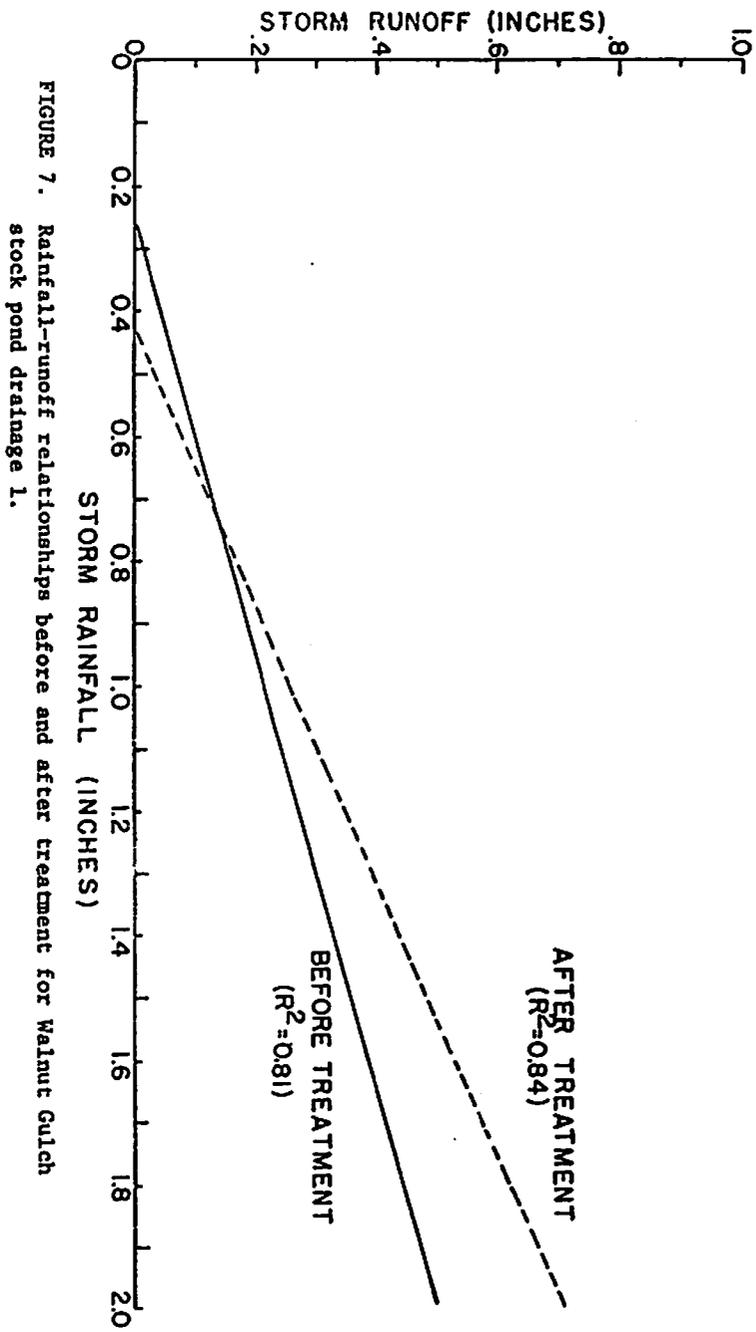


FIGURE 7. Rainfall-runoff relationships before and after treatment for Walnut Gulch stock pond drainage 1.