The study was designed to evaluate the influence of burning treatments on water infiltration capacities. These treatments (control, light burn, and heavy burn) were replicated on four sites. Light burn treatments were made on areas approximately 10 feet square by igniting an edge of the plot and allowing the fire to move across against the wind. This light intensity burn closely approximated a typical prescribed burn. A heavy burn treatment plot of similar size was ignited simultaneously from all sides and the fire allowed to reach maximum intensity in the plot center.

Seven fusion pyrometers were used to measure the heat generated by each burning treatment. These pyrometers consisted of pure organic compounds, which had definite melting points, painted on small sheets of mica. When inserted vertically into the soil with a flat putty knife, the temperature distribution of the top few inches of soil during burning could be determined by observing the extent of melting of each compound. Surface soil temperatures for the light burn treatments did not exceed 200° F. Maximum temperature at the soil surface for heavy burns ranged from 350° F. to 550° F.

After burning, an infiltrometer plot, one by 2 1/2 feet in size, was installed in the center of each treatment area on each site. A modified North Fork sprinkling type infiltrometer with constant head tank was utilized to conduct infiltration measurements. The twelve infiltrometer plots remained in place for over two years through two overwintering periods. Two infiltration runs were conducted on each plot in the late summer of 1963, and three series of runs were made in both the summers of 1964 and 1965. Infiltration curves were plotted for each run from runoff data programmed into a computer and an incremental digital plotter. Infiltration capacity values were obtained directly from these curves.

RESULTS AND CONCLUSION

Results showed light and heavy burns produced highly significant decreases in infiltration capacities immediately following burning. However, no statistically significant differences due to burning were detected between heavy burn and light burn treatments and controls during the second and third summers.

The restoration of infiltration capacities to nearly normal conditions after an overwintering period can be attributed to freezing and thawing conditions. It was noted in the early spring of 1964 and again in 1965 that the soils on the study area were more loosely textured and porous indicating the effects of frost action. Minimum temperatures during the winter months in this area are sufficiently low to cause freezing and thawing.

Increases in soil pH, carbon, and total nitrogen percentages for the surface two inches of soil were detected immediately following both light and heavy burning treatments. A slight increase in cation exchange capacity was also noted. These increases were still evident two years after treatment but to a lesser extent.

A significant increase in soil bulk density was obtained following heavy burning treatment but not following light burning. This increase, however, was not detected after the first overwintering period. Surface temperatures indicated that the heat generated by the heavy burn treatment was adequate to consume the organic material incorporated in the surface few millimeters of soil. This removal of organic material probably caused a breakdown in soil structure resulting in a more compacted surface soil. Consequently, bulk density samples of the surface one inch of soil would actually include more mineral soil, resulting in a higher bulk density value.

Late fall prescribed burning programs conducted on the Fort Apache Indian Reservation, when followed by an overwintering period with freezing and thawing conditions, therefore, seem to have little or no detrimental effect on infiltration rates.

Another interesting facet of water infiltration into Arizona forest soils was detected during the analyses of study data. Examination of the 96 infiltration curves plotted from the field data showed that 74 had a prominent depression approximately 5 to 15 minutes after the start of water application. This indicated that the infiltration rate reached a minimum value and then increased before a constant capacity was maintained.

The best explanation for this dip in the infiltration curve is soil non-wettability, sometimes known as a water-repellent or hydrophobic soil condition. It has been commonly observed that extremely dry surface soils will temporarily resist wetting at the start of rainfall but will transmit water normally after being moistened. This initial resistance to wetting may be caused by the formation of impenetrable air films at the water-soil interface (Krammes and DeBano, 1965).

Water-repellent soils have received increasing attention in recent years, particularly since they seem to be much more widespread than originally suspected. These soils may have widespread implications for watershed management. They can be a serious problem on steep slopes, where they reduce infiltration of rainwater and cause erosion. But they may also be an asset, for example, in arid regions, where soils might be artifically waterproofed to obtain more water (DeBano, 1969).

The identity of hydrophobic substances in soils responsible for water repellancy have not been established conclusively. It is suspected that oils and resins from organic plant remains may play an important role. The coniferous litter cover and acidic surface soil found in the study area could promote such a condition. Some research has also been published indicating that fire may accentuate a hydrophobic soil condition.

During the past two summers infiltration determinations have been made on ponderosa pine soils near Flagstaff and in the Santa Catalina Mountains northeast of Tucson. Preliminary results show the presence of a dip in the infiltration curves for these two locations which strongly indicates a water repellent-soil condition. Additional field infiltration studies are planned to investigate further the hydrologic importance of this phenomenon.

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THE USE OF A REALISTIC RAINFALL SIMULATOR TO DETERMINE RELATIVE INFILTRATION RATES OF CONTRIBUTING WATERSHEDS TO THE LOWER GILA BELOW PAINTED ROCK DAM

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INTRODUCTION

A rotating disk rainfall simulator developed at the Water Resources Research Center, The University of Arizona, was used in determining relative infiltration rates on approximately 7,000 mi^2 of semiarid subwatersheds of the Lower Gila River in southwestern Arizona. The location of this study area is shown in Figure 1. This hydrologic study was made as a part of the Corps of Army Engineers Environmental Impact Study, in which the senior author served as a consultant.

The unique features of the simulator used will be presented in order to satisfy the claim that it does produce realistic rainfall.

A comparative examination of Gila River flow records at Gillespie Dam approximately 37 miles upstream from Painted Rock Dam, and at the Dome gaging station eight miles above the confluence of the Gila with the Colorado River, indicated that all major flows recorded at Dome gaging station since 1920 resulted from runoff above Gillespie gaging station. These findings have been reported in the *Hydrology Study for the Gila River Below Painted Rock Dam* [1970]. The highest flow at Dome originating from the Lower Basin below Painted Rock Dam was 4820 cfs [*Water Resources Data for Arizona*, 1963] on Sept. 18, 1963. This flow originated

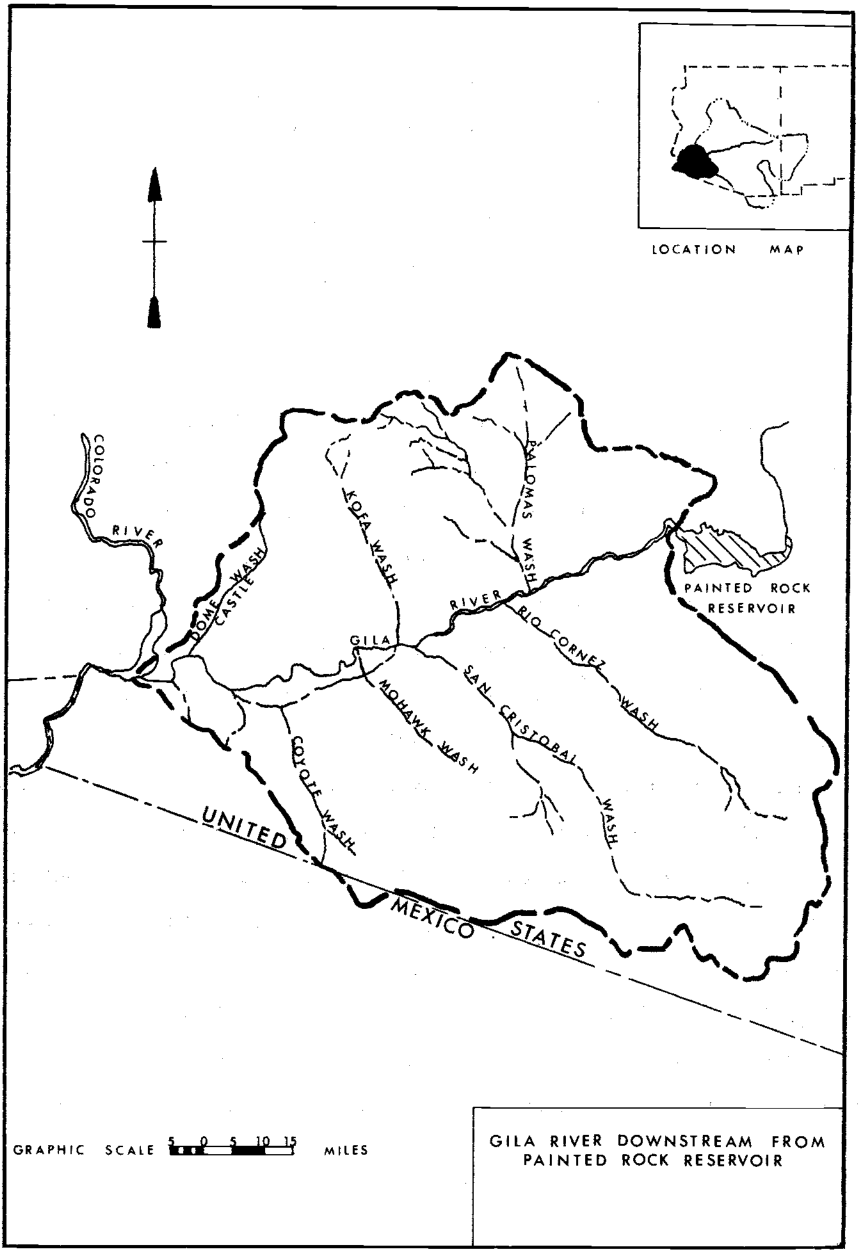

LOCATION MAP
COLORADO
RIVER
DOME
CASTLE
WASH
KOFA WASH
PALOMAS WASH
GILA
RIVER
PAINTED ROCK
RESERVOIR
RIO CORNEZ
WASH
SAN CRISTOBAL
WASH
MOHAWK WASH
COYOTE WASH
UNITED
MEXICO
STATES
GRAPHIC SCALE 5 0 5 10 15 MILES
GILA RIVER DOWNSTREAM FROM
PAINTED ROCK RESERVOIR

FIGURE 1.

from the Castle Dome Watershed. As a result of these observations, the rainfall simulator was used in an attempt to determine why so few floods had occurred from the Gila River Watershed below Painted Rock Dam.

The rainfall simulator was used on reconstituted samples taken from different soil types in the Lower Gila Watershed. The use of the simulator in this manner was not intended to quantify infiltration rates such that they could be used directly in the unit hydrograph for determining peak flows but rather to qualify the relative differences in infiltration rates in the Lower Gila subwatersheds to determine the flood threat indirectly. Funds were not available to take the simulator into the field, hence soil samples had to be taken to the simulator.

ROTATING DISK RAINFALL SIMULATOR

Rainfall simulators used in the past can be divided into two basic types, drip simulators and nozzle simulators. Drip simulators include those that use hanging yarn, glass tubing, hypodermic needles, etc., to form small tips from which drops fall by gravity. The main advantage of drip simulators is in their ability to produce a combination of relatively large drops at a low rate of application. However, impact velocities approaching those of natural rain cannot be achieved unless the drops fall more than 30 feet above the soil [*Mutchler and Hermsmerer*, 1965; *Gunn and Kinzer*, 1949]. Because of this height requirement the drip simulators are not practical for field investigations.

Nozzle simulators produce a drop distribution that includes a large number of drop sizes. If the nozzle is directed downward the pressure can be regulated to give an impact velocity similar to the terminal velocity of raindrops. Increased pressure, however, reduces the size of drops. Thus, in order to obtain realistic sized drops of high velocities, large orifice openings in the nozzles are required, causing excessive application rates. This then is the paradox of the nozzle-type simulator. An attempt to use large nozzles and reduce the intensity has been made in three basic ways: (A) to spray the nozzle over a large area by turning it upward, such as the Type F simulator; (B) to physically move the nozzle back and forth across a plot of suitable size, such as the rainulator developed by *Meyers and McCune* [1958]; or (C) to physically remove a portion of the water from the high capacity nozzle to obtain realistic intensities, as with the rotating disk rainfall simulator first developed as a laboratory model by *Morin, Goldberg, and Seginer* [1967].

During 1968-70, J. Morin, while employed by the Water Resources Research Center, The University of Arizona, developed a field model rainfall simulator based on his earlier laboratory model. This development was a part of a Water Harvesting Research Project sponsored by the Office of Water Resources Research, U. S. Department of the Interior. This field model will be designated as the Rotadisk Rainulator.

The Rotadisk Rainulator utilizes a full-cone-spray type nozzle which is similar in principle to those used by *Bertrand and Parr* [1961], but much larger in capacity. The best nozzle was found to be the Spraying Systems Company Fulljet 1-1/2H30. This nozzle, when elevated 6 feet and operated at pressure of 0.6 atmosphere, will produce an intensity of approximately 60 inches per hour. In order to reduce this intensity to a more realistic value, a slotted metal disk is rotated on a vertical axis beneath the nozzle (Figure 2). Drops from the nozzle reach the experimental plot only when the aperture is under the nozzle. In other positions the water is thrown toward the circumference of the revolving disk, where

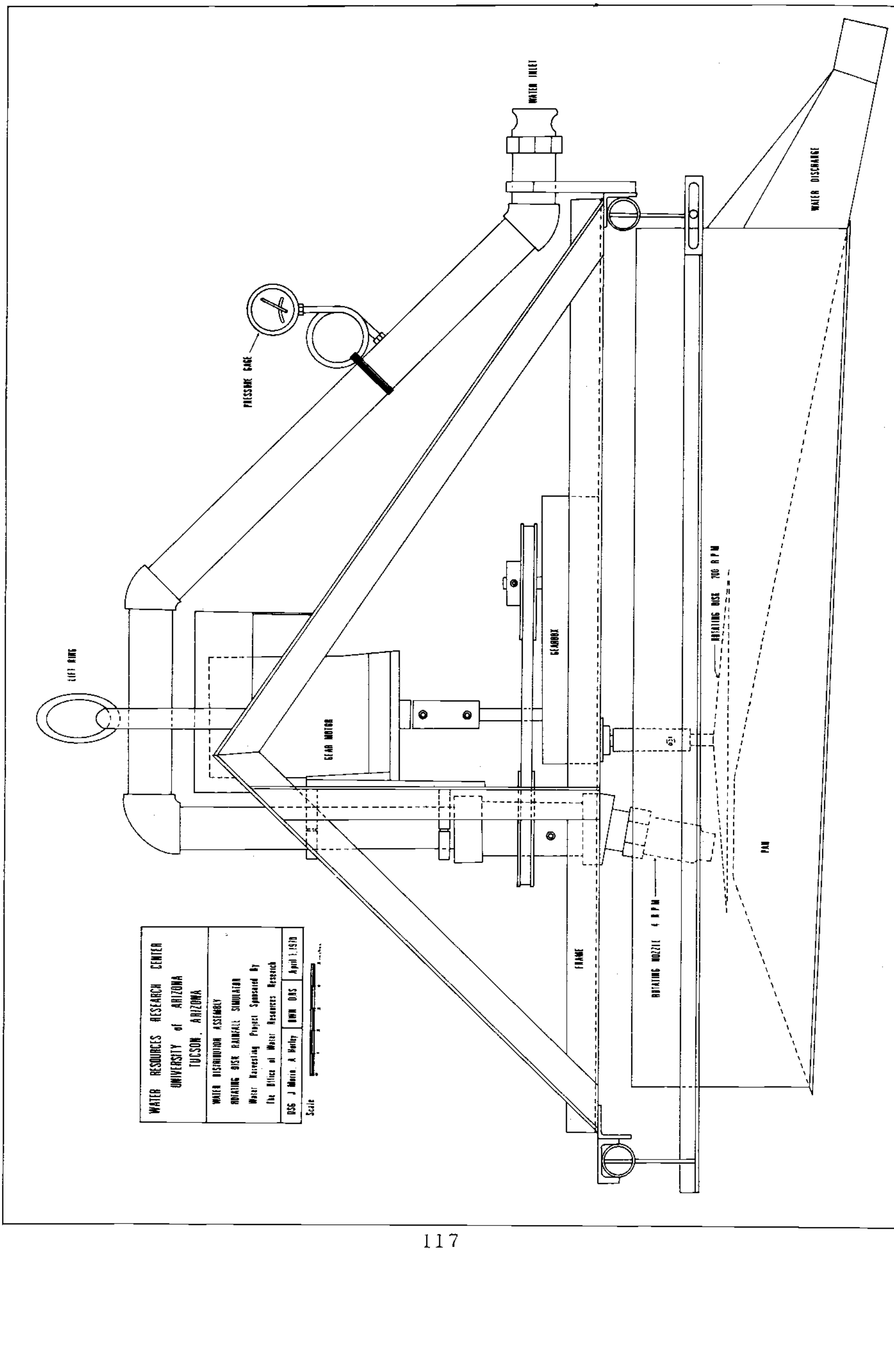

WATER INLET
PRESSURE GAGE
LIFT RING
GEAR MOTOR
GEARBOX
ROTATING DISK 700 R P M
ROTATING NOZZLE 4 R P M
FRAME
PAN
WATER DISCHARGE
WATER RESOURCES RESEARCH CENTER
UNIVERSITY of ARIZONA
TUCSON, ARIZONA
WATER DISTRIBUTION ASSEMBLY
ROTATING DISK RAINFALL SIMULATOR
Water Harvesting Project Sponsored By
The Office of Water Resources Research
DSG J Morin, A Hatley
DWN ONS
April 1, 1970
Scale

FIGURE 2.

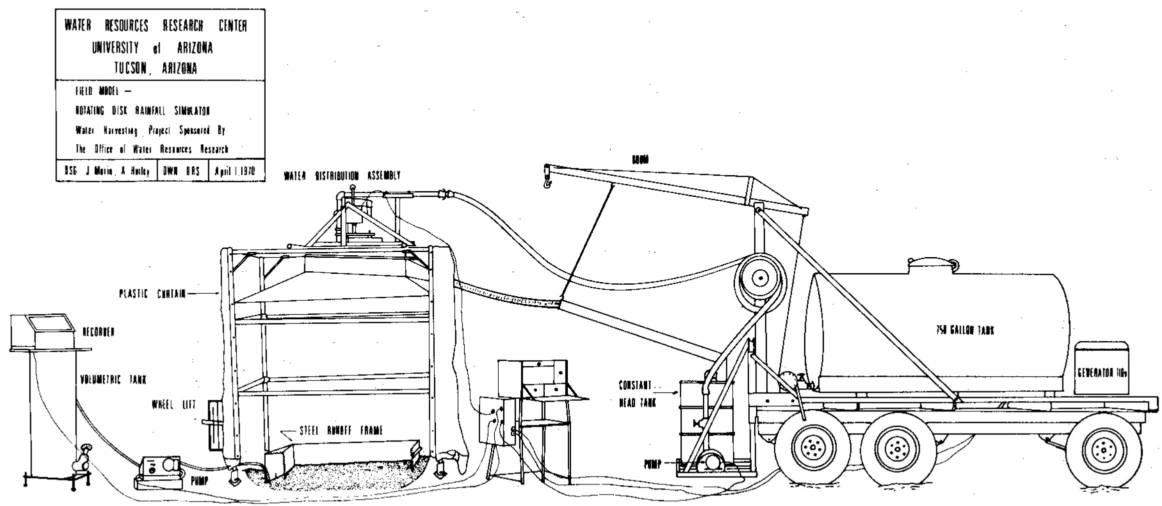
it is drained away by means of a collector pan. The excess water is returned from the pan through a storage tank to the supply pump for reuse. The nozzle on the field model rotates at 4 rpm, which is an improvement over the original laboratory model where the pan containing the soil was rotated. The complete field assembly constructed at The University of Arizona is shown in Figure 3.

The unique feature of the rotating disk rainfall simulator is the rotation of disks with various size openings that makes it possible to produce intensities from close to zero up to the full nozzle capacity. Disks can be changed in less than one minute, making it possible to study the effect on infiltration rates of a series of intensities, such as occur in natural storms.

The disks are shaped to a shallow cone with five-degree side slopes. They are 15 inches in diameter and constructed of 0.020 inch brass sheets. Disks with 5, 10, 15, 30, and 40-degree aperture angles were prepared. Corresponding intensities range from 0.67 in/hr to 6.00 in/hr, when the height is set at 6 feet and the nozzle is rotating at a 10-degree angle from the vertical. The cocking of the nozzle 10 degrees to one side is also an improvement over the original laboratory model, in that better uniformity can be obtained over a larger area. With these improvements the spacial coefficient of variation over a 4.5 ft square plot for the 2.00 in/hr intensity is 9.1 percent.

The rotation of the disk on the field model is fixed at 200 rpm which produces a rain that is visually continuous. There is some pulsation, but it is not much more than would be experienced during an intense natural rainstorm.

The simulator is portable, so that it can be taken into the field to determine the infiltration capacity of the 4.5 ft square plots. Rainfall intensity is checked periodically by covering the surface of the soil in the runoff plot with



WATER RESOURCES RESEARCH CENTER
UNIVERSITY of ARIZONA
TUCSON, ARIZONA
FIELD MODEL —
ROTATING DISK RAINFALL SIMULATOR
Water Harvesting Project Sponsored By
The Office of Water Resources Research
DSG J Morin, A Hurley
DWN BRS
April 1, 1970
WATER DISTRIBUTION ASSEMBLY
BOOM
750 GALLON TANK
GENERATOR 110v
CONSTANT HEAD TANK
PUMP
PLASTIC CURTAIN
RECORDER
VOLUMETRIC TANK
WHEEL LIFT
STEEL RUNOFF FRAME
PUMP

FIGURE 3.

plastic. If care is taken to keep the height of the nozzle at a constant height of 6 feet and if the plot is correctly positioned, the variation in rainfall intensity with time is very small. The coefficient of variation for a given rainfall intensity over nine months of intensive use was found to be approximately 0.8 percent. The reason the uniformity is so good is primarily because the large opening in the nozzle prevents any variation due to plugging.

COMPARISON OF RAINFALL CHARACTERISTICS OF ROTADISK RAINULATOR WITH NATURAL RAINFALL

Rainfall simulator data in the past characteristically have been used primarily for qualitative determinations [*Meyer*, 1965]. Some investigators have tried unsuccessfully to find a good correlation between infiltration rates determined using a simulator, and those determined from hydrograph analysis [*Crawford and Linsley*, 1966]. This is caused in part by the failure of most simulators to adequately duplicate the characteristics of natural rainfall.

Before raindrop characteristics were known, a rainfall simulator that applied both the amount and intensity of a design storm was considered adequate. With increased knowledge of raindrop characteristics came an appreciation of the fact that simulated rainfall should also have a drop size distribution very similar to natural rainfall, with all drops falling at their terminal velocities. This has proven to be absolutely necessary if there is any exposed surface in the plot area covered by the simulator. In both erosion studies and infiltration studies the failure to adequately duplicate drop size distribution and the terminal velocity of natural rainfall can result in gross errors. If there are no exposed surfaces, such as in a dense grass cover, drop size distribution and kinetic energy of the simulator are not important. Under this condition the important factors are the intensity and uniformity of application over the plot. According to a literature survey by *Meyer* [1965], the rainfall parameters which are important in both the erosion of soil and the infiltration rate on exposed surfaces include (A) kinetic energy ($1/2MV^2$), (B) momentum (MV), (C) kinetic energy per unit of drop-impact area ($1/2MV^2/A_d$), and (D) interactions of these variables with rainfall intensity.

A comparison between some of the most widely used simulators and natural rainfall was made by *Meyers* [1965]. This comparison expressed as a percent of natural rainfall as determined by *Laws and Parsons* [1943] is given in Table 1, together with the same data for the Rotadisk Rainulator. The Rotadisk Rainulator provides essentially the same kinetic energy and momentum per unit of rainfall as natural rainfall of 2.0 in/hr. For intensities less than 2.0 in/hr it gives slightly higher kinetic energy, and for intensities higher than 2.0 in/hr it gives slightly lower kinetic energy than natural rainfall as reported by *Laws and Parsons* [1943]. For all intensities above approximately 1.0 in/hr the Rotadisk Rainulator comes much closer to duplicating natural rainfall than has been achieved by other types of rainfall simulators.

THE USE OF THE ROTADISK RAINULATOR ON ACRE PLOTS AT ATTERBURY EXPERIMENTAL WATERSHED

In the spring of 1970 the Rotadisk Rainulator was used to determine the infiltration rate on two one-acre plots, one of which had been treated with sodium chloride in order to increase runoff. These plots are on the Atterbury Experimental Watershed located just east of Tucson. A total of eight runs was made on each of the acre plots, which are covered by a moderate growth of creosote bushes

TABLE 1. COMPARISON BETWEEN VARIOUS RAINFALL SIMULATORS AND NATURAL RAINFALL OF 2.0 INCHES PER HOUR

(The performance of the simulators relative to that of natural rainfall as based on various parameters is presented in percents. After *Meyer* [1965] except for the Rotadisk Rainulator.)

Parameter	Rainfall Simulator			
	Type C	Type F	Purdue Rainulator	Rotadisk Rainulator
Kinetic energy per unit of rainfall ($\alpha\Sigma(pV^2)$)	44	56	77	100
Momentun per unit of rainfall ($\alpha\Sigma(pV)$)	68	76	87	99
Total kinetic energy per unit of total drop impact area ($\alpha\Sigma(pV^2)/\Sigma(p/D)$)	82	72	62	86
Total momentum per unit of total drop impact area ($\alpha\Sigma(pV)/\Sigma)p/D)$)	126	98	70	85
Kinetic energy per unit of drop impact area (by increments) ($\alpha\Sigma(pDV^2)$)	65	70	63	110
Momentum per unit of drop impact area (by increments) ($\alpha\Sigma(pDV)$)	105	97	72	107

α, proportionality factor.

p, portion by weight in a given drop size group

V, terminal velocity

D, drop diameter

Type C, produces a nearly uniform drop size which is much larger than most raindrops. The drops fall from zero velocity for a distance of only 4.3 feet.

Type F, produces a drop-size distribution larger than intense natural rainfall. The drops fall from zero velocity for a distance of only 9 feet.

Rainulator, produces a drop-size distribution slightly smaller than intense natural rainfall. Drop velocities are near terminal velocities except for large drop sizes.

Rotating disk simulator, Nozzle 1½H30; pressure 0.6 atm; angular velocity 30 rpm; aperture angle 10 deg. To obtain 2.0 in/hr with these characteristics an aperture angle of 14 deg is required.

and cacti native to the southwest. The average terminal infiltration rate was found to be 0.29 in/hr on the treated plot and 0.59 in/hr on the control. Owing to the careful selection of infiltration sites, these averages are considered to be weighted averages and therefore representative of the infiltration rates over each of the respective plots. Within a month after the infiltration runs were made using the rainfall simulator, a natural storm occurred in which the rainfall intensity was very uniform for approximately 50 minutes at a rate of 0.37 in/hr. This rainfall intensity produced a fairly constant runoff rate from the treated plot of 0.05 in/hr as determined from the resulting hydrograph. The difference of 0.32 in/hr between these two values represents the natural infiltration rate. The difference between the infiltration rate determined by the simulator and that determined from a natural storm is insignificant in view of the variability involved in determining either rate.

The untreated plot, whose infiltration rate had been determined by the simulator to be 0.59 in/hr, yielded negligible amounts of runoff from the same storm. Therefore, the infiltration based on this natural storm could not be determined. Approximately one week later, during an extended storm period in which 0.87 inches of low intensity rain was obtained, a relatively high intensity shower of approximately 0.57 in/hr occurred for five minutes. This shower produced a flow of approximately 0.01 in/hr on the untreated plot. Thus the infiltration rate as determined from this storm would be 0.56 in/hr. Although the accuracy of this calculation is not as good as that made on the treated plot during the earlier storm, the results do indicate that the infiltration rate as determined by the rainfall simulator in the field is realistic.

THE USE OF THE ROTADISK RAINULATOR ON SAMPLES FROM THE LOWER GILA WATERSHED

A helicopter tour of some of the lower watersheds was made on July 24, 1970 and was supported with limited ground surveys. These surveys showed that large areas of the sub-watershed consisted of similar soil types. The line of demarcation between older and more recent alluvial soil types is in most cases very distinct. Table 2 gives the location of the sampling point and the principal sub-watersheds in which the samples were located. In general, the soil samples taken were representative of the major portions of the watershed in which they were located. The exceptions are noted in Table 2.

A soil analysis was made of each sample in addition to filling a 4" x 12" x 18" pan. These soil-filled pans were then placed under the rainfall simulator. Runoff was collected in graduated cylinders which were photographed every 30 seconds to determine the runoff rate. The results of these infiltration runs and soil analyses are shown in Table 3. Two infiltration runs were made six weeks apart. The length of the run was restricted by the water-holding capacity of the soil. In less than 26 minutes, because of its high infiltration rate, San Cristobal soil was completely saturated. The two infiltration rates made on each soil sample six weeks apart were very close. Only the Kofa samples showed a significant reduction. There were considerable variations in infiltration rates of the soils tested. The reasons for these differences is apparent when the mechanical analysis and exchangeable sodium percentage are compared.

According to the soil classification the Picacho and Castle Dome soils are classified in the Harqua series and are older alluvium soils than are Anthony, Gila, Vienton and Pima series. The Mohave is also an older alluvium soil series, differing only from Harqua series in that it has a lower exchangeable sodium con-

TABLE 2. LOCATION OF SOIL SAMPLES TAKEN FROM PRINCIPAL SUB-WATERSHEDS OF THE GILA RIVER BELOW PAINTED ROCK DAM, JULY 24, 1970

Sub-Watershed	Location	Remarks
Picacho* ($43\ mi^2$)	Two miles west of All American Canal on Picacho Peak Road.	Sample was typical of soil on watershed.
Castle Dome[1] ($410\ mi^2$)	Sampled in R19W, T5S, near the southwest corner of the Kofa Game Refuge, near mountains.	Sample representative of large part of watershed.
Castle Dome[2] ($410\ mi^2$)	Sample taken in Sec. 12, R21W, T7S, near U.S. 95.	Soil typical of large part of the lower watershed.
Kofa ($575\ mi^2$)	Sampled in Sec. 33, R16W, T3S, approximately 20 miles above the confluence with the Gila River.	Representative of bottom land between stream channels.
Palomas ($1260\ mi^2$)	Sampled in Sec. 11, R3W, T6S, located west of Hoodo Wash.	Sample was representative of fairly large area between Palomas Wash area and Kofa Wash area. It is not representative of entire Palomas Wash area.
Ligurta ($30\ mi^2$)	Sample taken in Sec. 3, R20W, T9S, about 200 yards south of the new freeway.	Representative of large area of the watershed.
Coyote ($450\ mi^2$)	Sample taken in Sec. 13 or 24 of R18W, T98, approximately 3 miles south of highway.	Appeared to be representative of lower portion of Coyote Wash area.
San Cristobal -Mohawk ($2520\ mi^2$)	Sample taken in Sec. 2, T9S, R13W, approximately 12 miles from the confluence with the Gila River.	Appeared to be representative of large area in the lower portions of San Cristobal and Mohawk and Rio Cornez basins.
Rio Cornez ($1410\ mi^2$)	Sample taken in Sec. 34, R6W, T9S, approximately 16 miles south of Gila Bend near Highway 85.	Typical of large area in upper Rio Cornez Wash.

*A 43-square mile watershed located in California just west of Yuma. This watershed, which had a recorded flood peak of 37,000 cfs in 1937, was included for comparative purposes.

TABLE 3. ANALYSIS OF SOIL SAMPLES TAKEN FROM PRINCIPAL SUB-WATERSHEDS OF GILA RIVER BELOW PAINTED ROCK DAM, JULY 24, 1970

Sub-Watershed[1]	Mechanical Analysis (percent) Sand	Silt	Clay	Soluble Salts in Saturation Extract (ppm)	Exchangeable Sodium (percent)	Infil. rate after 20 mins (9-24-70)[2]	Infil. rate after 26 mins (11-7-70)	Soil Classification[5]
Picacho[3]	52.4	27.4	20.2	8820	16.7	0.63	0.68	Harqua Sandy Clay Loam
Castle Dome 1	21.8	60.2	18.0	5411	19.6	0.86	0.92	Harqua Gravely Silt Loam
Castle Dome 2	47.5	33.7	18.8	9450	13.0	--	--	Harqua Gravely Loam
Kofa	50.0	42.8	7.2	1498	1.9	2.75	2.11	Gila Loam
Palomas	75.2	17.2	7.6	212	1.0	--	--	Anthony Sandy Loam
Ligurta	60.5	19.9	19.6	4221	5.9	--	--	Mohave Sandy Clay Loam
Coyote	74.7	17.3	8.0	25,025	33.9	1.04	1.08	Anthony Sandy Loam (Saline-Alkali)
San Cristobal	86.5	9.1	4.4	2435	6.4	>3.80[4]	>3.80[4]	Vienton Loamy Sand
Rio Cornez	58.0	38.2	3.8	1365	1.1	--	--	Anthony Sandy Loam
Atterbury[3]	61.7	21.1	17.2	332	5.1	--	1.51	Pima Sandy Loam

[1]For locations see Table 4.

[2]Infiltration rates were made on disturbed but recompacted samples with the rainfall simulator. Rate is in inches/hour.

[3]Analyses of soils from the Picacho, and the Atterbury Experimental Watershed near Tucson, are included for comparison.

[4]Infiltration rate exceeded applied rainfall rate of 3.80 inches/hour.

[5]Classification made by Y. H. Haven, Soil Correlation Specialist, U. S. Soil Conservation Service, Tucson, Arizona.

tent.

An important soil property sometimes overlooked by hydrologists is the Exchangeable Sodium Percentage (ESP). This factor, together with the percentage of clay, is helpful in estimating relative infiltration rates. If more comparative data were available between infiltration rates and chemical analyses of soil, the soil properties could be used even more effectively to predict runoff.

While the clay and silt content of the lower Coyote Watershed is much lower than that of the Picacho and Castle Dome Watersheds, the ESP is very high. This tends to disperse the available clay and produce a relatively low infiltration rate as compared with the Kofa sample with approximately the same clay content. Soils from the San Cristobal Watershed have a moderate value of ESP but very little clay for the sodium to disperse, hence they have a relatively high infiltration rate.

The Picacho Watershed, because of its recorded peak, was included in the analysis for comparative purposes. From the mechanical analysis one would expect similar infiltration rates to that of Castle Dome and Ligurta; however, there was enough difference in clay content to cause a lower infiltration rate. Castle Dome Watershed also has dense single-layer gravel cover, which would cause the infiltration rate to be higher than at Picacho. This difference in surface gravel could not be duplicated in the rainfall simulation tests. If the simulator were taken to the field the effect of the gravel cover could be properly evaluated.

A sample of soil adjacent to the acre plots at Atterbury was placed in a 4" x 12" x 18" pan and included in the infiltration run made on November 7, 1970. (See Table 2.) This was done in order to determine the difference between using a recompacted sample in a small pan and taking the simulator to the field. The average infiltration rate found using the rainfall simulator in the field on an untreated soil, as indicated earlier, was 0.59 in/hr. Thus, the infiltration rate of the recompacted soil in the small pan was approximately 2.5 times the rate in the field. Additional correlation is needed but apparently the infiltration rate of the recompacted sample would be much higher than that obtained when the simulator is used in the field. Therefore the infiltration rates obtained from recompacted soil samples, while suitable for use as a guide for comparative purposes, should not be used directly as being representative of the actual infiltration capacity.

The infiltration rates of the recompacted soil samples supported visual observations of stream channels in ranking the watersheds according to their ability to produce substantial runoff. In making these observations, consideration was also given to the stream gradient.

Picacho Wash has well-defined main channels, indicating substantial runoff from the relatively small watershed. The large number of stream channels is evidence that the infiltration rate of Castle Dome is low enough to produce substantial runoff. Because of slightly flatter gradients than Picacho, the minor channels do not combine into large major channels, except near the lower end of the watershed. This fact would reduce flood flows even if the infiltration rates were the same.

Coyote Wash area shows more evidence of flow than the Kofa Wash area, but less than the Castle Dome Wash area. Numerous small channels exist, indicating substantial runoff.

San Cristobal, Mohawk and Rio Cornez Wash areas show much less evidence of runoff, particularly in the areas away from the mountains. In Mohawk Valley stream channels disappear as they approach a 15-mile-long sand dune area extending along the west side of the Mohawk Mountains. In both the lower portions of San Cristobal and Rio Cornez, main stream channels are nonexistent, even though stream gradients are steeper than 10 feet per mile. In comparison, the gradient of the main channel of the Gila River through the Wellton-Mohawk area is 5 feet per mile. Because of the lack of channels, large areas would have to be covered with sheet flow in order for any substantial amounts of water to reach the confluence with the Gila River.

Palomas Wash Area, as indicated on Table 2, was not properly represented by the soil sample taken. This subwatershed does appear to be a heavy producer. Five drainage channels, extending to the Gila River, each of which are several times larger than the channels from the lower portions of Rio Cornez and San Cristobal, give evidence that the runoff is substantial. During the historical record the broad channel of the Gila River has dissipated any flood flows from this area so that they are insignificant by the time they reach the Dome gaging station.

SUMMARY

Infiltration rates determined using the Rotadisk Rainulator on recompacted samples support the soil analysis and visual surveys in ranking the subwatersheds of the lower Gila in terms of flood threat. This indirect approach was used because rainfall-runoff data on most of the lower Gila subwatersheds or from "similar" watersheds are not available. The rankings revealed that over 50 percent of the subwatersheds have infiltration rates more than five times as high as those of Picacho Wash. With the substantial differences in infiltration

rates and other hydrologic considerations, it is highly unlikely that the Mohawk, San Cristobal and Rio Cornez subwatersheds have or will produce flood peaks comparable with the high flood peaks of Picacho Wash, even though these watersheds are much larger. Castle Dome, Coyote, Kofa and Palomas Watersheds would be ranked between Picacho and Mohawk-San Cristobal-Rio Cornez Watersheds in flood producing capability. Any future hydrologic studies in the area should reflect these large differences in infiltration rates of individual watersheds. These rankings support the flood frequency analysis which indicates the flood threat from subwatersheds along the lower Gila is much lower than previously had been projected.

Additional soil samples and infiltration data using the recompacted samples should greatly strengthen the above arguments. However, the results at Atterbury Experimental Watershed indicate that it should be possible to determine the actual infiltration capacities of different soil and vegetative types with reasonable accuracy when the Rotadisk Rainulator is taken into the field. This information would be even more valuable to hydrologists than data from the recompacted samples.

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