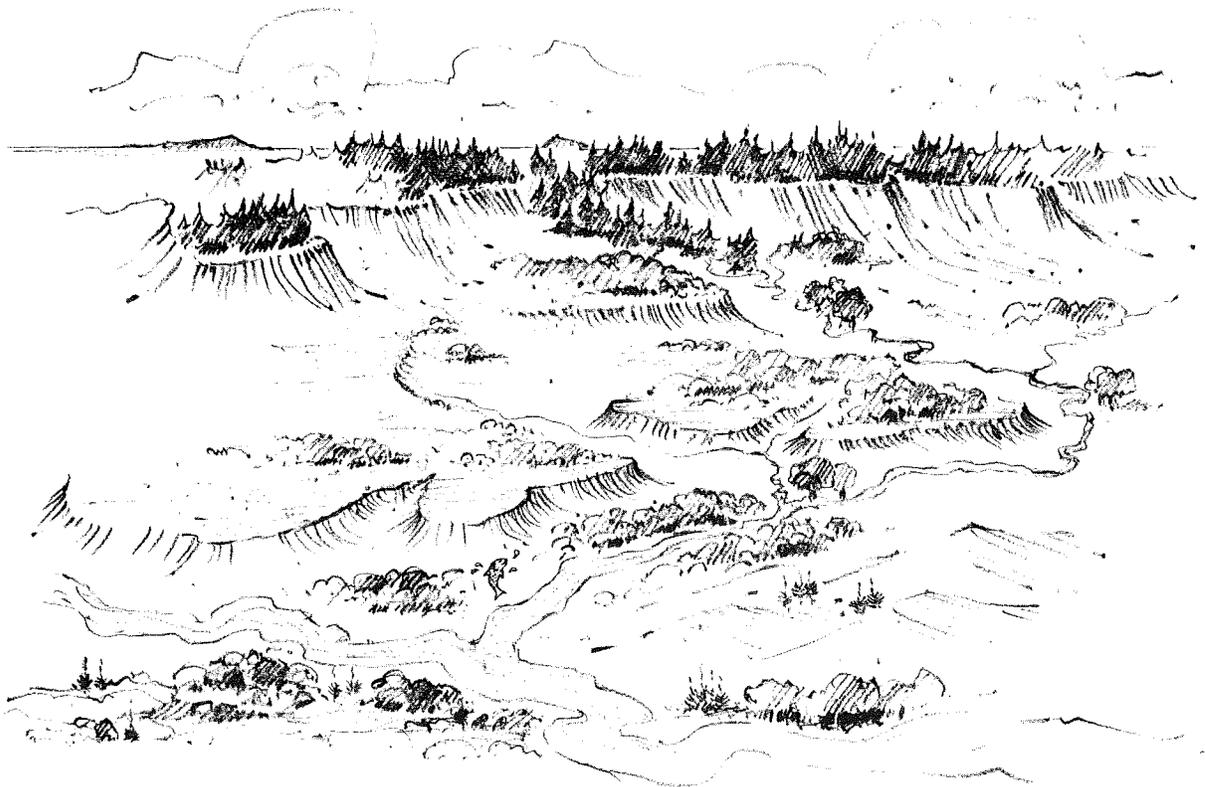


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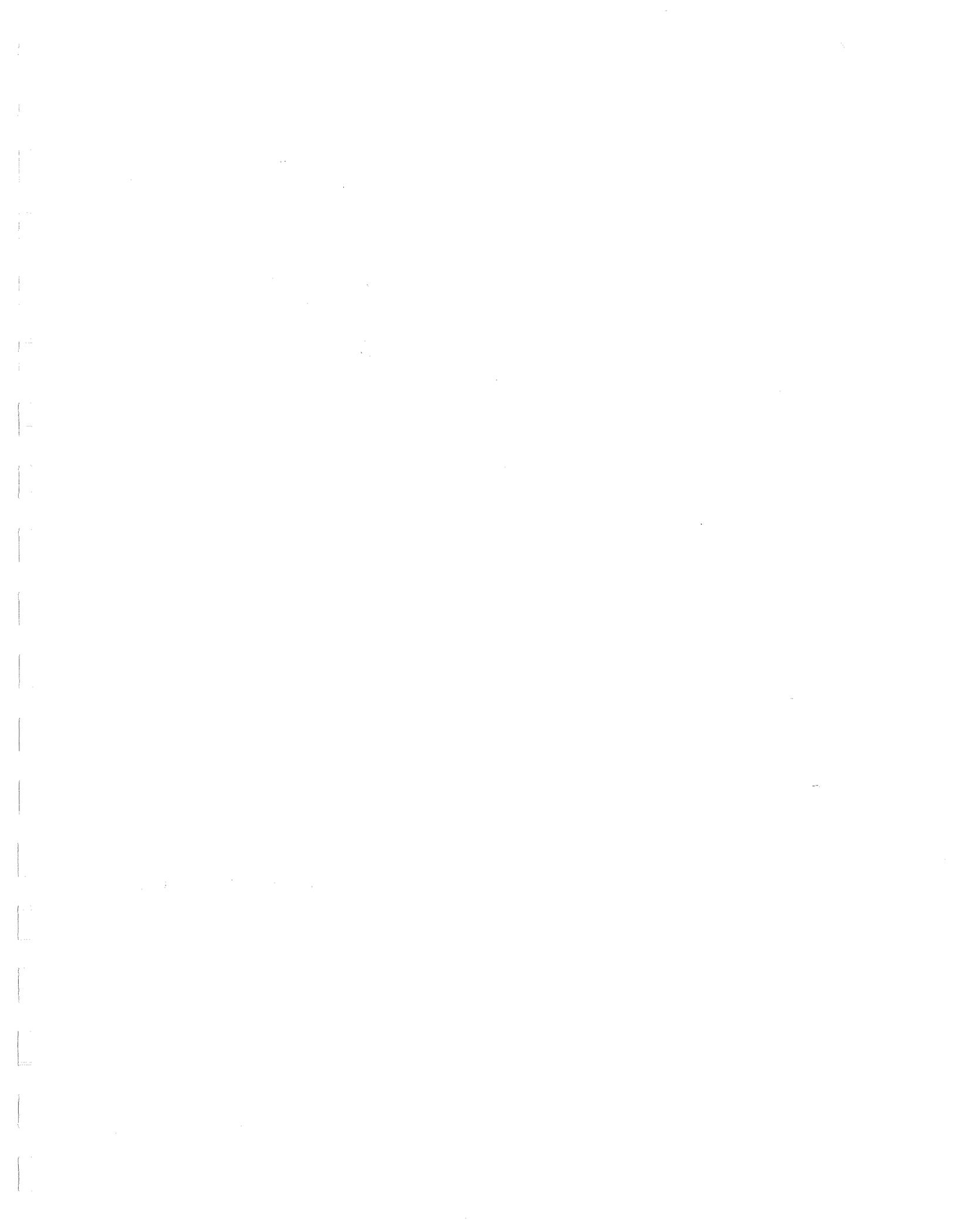
ANTICIPATED CHANGES IN THE FLOW REGIMEN CAUSED BY THE ADDITION OF WATER TO THE EAST VERDE RIVER, ARIZONA

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ABSTRACT

The East Verde River drains about 320 square miles of granitic and sedimentary rocks in northwestern Gila County, Ariz. The river heads in the Mogollon Rim and flows southwestward to discharge into the Verde River. The average annual streamflow from October 1961 to September 1964 was about 850 acre-feet near the head and about 13,500 acre-feet near the mouth. The streamflow increased from 1.2 cfs (cubic feet per second) near the headwaters of the river to 4.7 cfs near the mouth, or about 3.5 cfs from the head to the mouth during low-flow periods; the maximum decrease during a sustained low-flow period was 0.5 cfs.

About 30 cfs of water is to be added to the river near the head of the East Verde River basin. The expected losses of the added water to seepage into the ground and evapotranspiration are small. The geometry of the river channel is not expected to change, and the erosion along the river course is not expected to increase markedly.

INTRODUCTION

The study of the East Verde River basin defines the present hydrologic regimen, insofar as present data allow, and anticipates the effect on the regimen of an addition of about 30 cfs (cubic feet per second) of water at the head of the basin to the natural flow of the river. The additional water will be transported from a reservoir 20 miles northeast of Pine on East Clear Creek.

The East Verde River drains about 320 square miles of heavily wooded land in northwestern Gila County and is typical of many small

tributary streams heading in the Mogollon Rim region of central Arizona. The river heads at an altitude of 7,300 feet in the Mogollon Rim about 15 miles north of Payson, flows 43 miles southwestward, and discharges at an altitude of 2,500 feet into the Verde River a few miles south of Childs.

The basic data used to appraise the present stream regimen were provided by three stream-gaging stations, three partial-record sites, and a field reconnaissance of the drainage basin. The gaging stations have been operated since the fall of 1961 and are referred to in this report as the Pine, Payson, and Childs gages. The Pine gage is near the headwaters of the river, the Childs gage is near the mouth, and the Payson gage is 10-1/2 miles upstream from the Childs gage (fig. 1). The partial-record sites are numbered from 1 to 3 in downstream order.

PHYSICAL ENVIRONMENT OF THE EAST VERDE RIVER DRAINAGE BASIN

The East Verde River flows southwestward toward the Verde River from a headwaters area in the escarpment of the Mogollon Rim. The Mogollon Rim is a serrated cliff that extends northwestward across the State and separates the plateaus to the northeast from the basins and ranges to the southwest. The altitude of the plateau north of the rim in the area of the East Verde River is slightly more than 7,000 feet; the plateau slopes northward and is underlain by sedimentary rocks. South of the rim are many ridges and mesas at an altitude of about 5,000 feet. The ridges and mesas are separated by 200- to 500-foot-deep canyons. The area south of the rim is underlain by granitic, sedimentary, and volcanic rocks.

The upper 12 miles of the 43-mile-long East Verde River channel is on gently dipping sedimentary rocks, which consist chiefly of limestone and sandstone. The lower 31 miles is on crystalline granitic rocks and, to a minor extent, on semiconsolidated beds of sand and silt (fig. 1). In places the river flows on bedrock, and in other places the river channel and flood plain are underlain by deposits of unconsolidated sand and gravel that probably are not more than 30 feet thick.

The topography of the drainage basin is rugged, and the river is in a steep-walled V-shaped canyon incised several hundreds of feet below the tops of ridges and mesas in the basin. The flood plain generally is less than 200 or 300 feet wide; the gradient is about 410 feet per mile in the upper 5 miles and about 70 feet per mile in the lower 38 miles. Because the deeply incised steep-walled canyons are composed of rocks that are

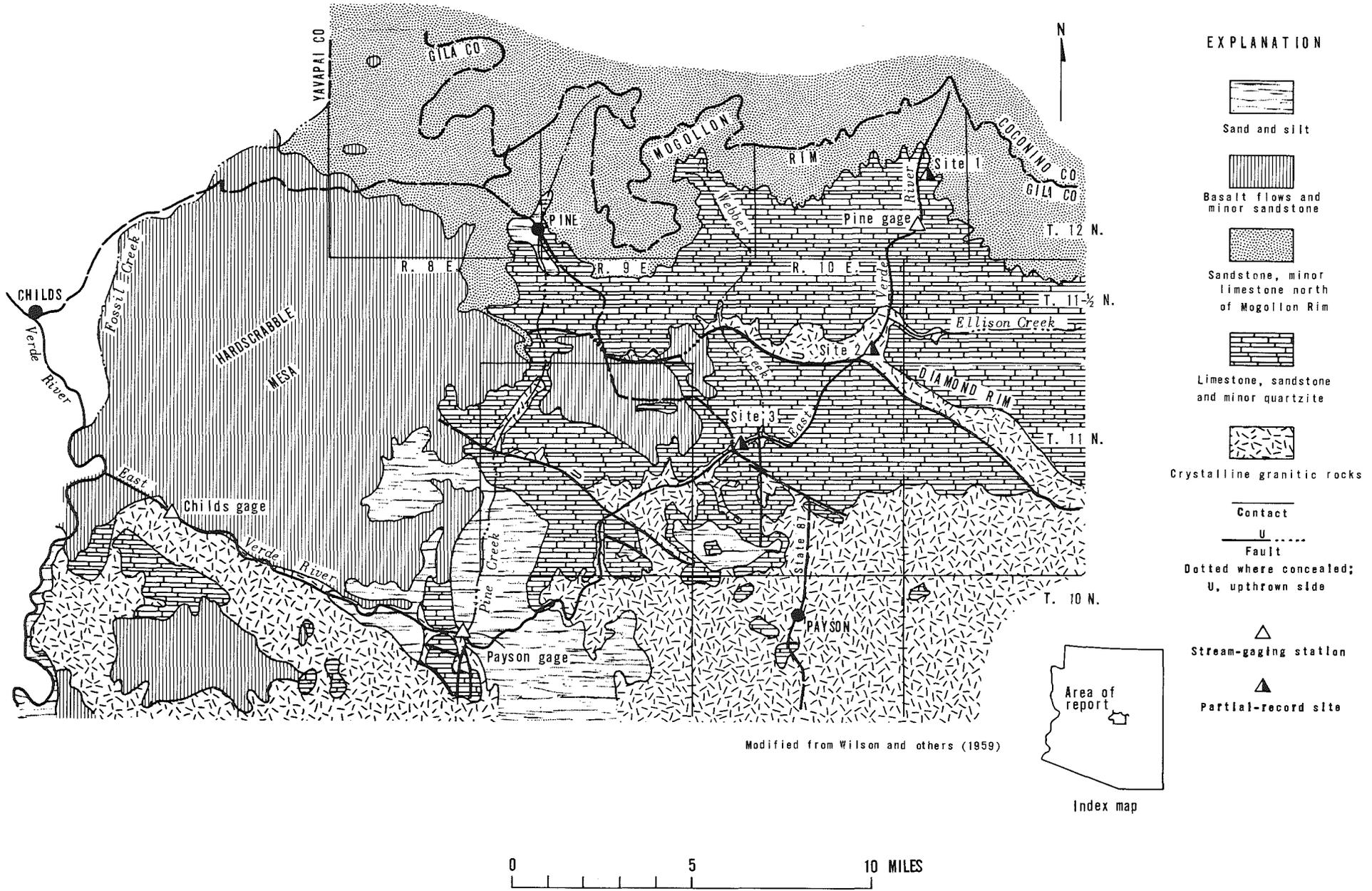


Figure 1.--Rock types, location of gaging stations, and partial-record sites.

resistant to erosion, the river's course is stable, and little material is eroded during periods of low flow.

The vegetation in the East Verde drainage basin changes from chaparral at the mouth of the river to pine at the head of the river. About 50 percent of the drainage basin is covered by chaparral, 25 percent by pinyon and juniper, and 25 percent by white and ponderosa pine.

HYDROLOGIC SYSTEM

The surface-water and ground-water drainage divides of the East Verde River coincide, except along the Mogollon Rim. The Mogollon Rim is the surface-water divide; the ground-water divide is 2 to 3 miles north of the escarpment of the rim. Ground water flows southward from the escarpment area along the rim and feeds the many springs (Feth and Hem, 1963) that emerge on the steep slopes below the rim. Thus, the area of ground-water contribution to the East Verde River is slightly larger than the 320 square miles of the surface-water drainage basin.

The flow of the East Verde River is dependent on precipitation within the bounds of the ground-water divide. Precipitation occurs as rainfall in the summer and as snowfall and rainfall in the winter. The normal annual precipitation in the drainage basin ranges from 20 inches at the Childs gage to 35 inches in the highest parts of the Mogollon Rim area; slightly more than half the precipitation—12 to 23 inches—falls from October through April (University of Arizona, 1965). The normal annual precipitation at the U.S. Forest Service ranger station in Payson is 20.6 inches. The annual precipitation at the ranger station during the period when data were collected for this study was 19.5 inches in 1961, 16.7 inches in 1962, 20.7 inches in 1963, and 16.8 inches in 1964. The total amount of precipitation that falls on the drainage basin is slightly more than 400,000 acre-feet per year. The average annual discharge into the Verde River is about 13,500 acre-feet, which is equivalent to slightly more than 3 percent of the mean annual precipitation.

The amount of precipitation that is converted into runoff in the East Verde drainage basin is dependent mainly on the degree of prior saturation of the rocks in the northern part of the basin. When these rocks are saturated to levels above the tributary streams, most of the precipitation that infiltrates into the ground will appear in nearby springs and will accumulate as flow in the tributary streams. When the rocks are not saturated and the regional ground-water levels are low, the spring flow

and tributary flow will decrease. Thus, even if there were no use by plants, tributaries, such as Ellison Creek, Webber Creek, and Pine Creek, would not flow as much in response to rainfall in dry seasons as they would in wet seasons.

The average annual streamflow for 3 water years, October 1961 to September 1964, was 850 acre-feet at the Pine gage, 9,200 acre-feet at the Payson gage, and 13,500 acre-feet at the Childs gage. During the 3 years of record, eight peaks of more than 30 cfs occurred at the Pine gage, seven peaks of more than 400 cfs occurred at the Payson gage, and nine peaks of more than 300 cfs occurred at the Childs gage. The maximum peaks were 264 cfs at the Pine gage, 9,950 cfs at the Payson gage, and 11,400 cfs at the Childs gage. The surface-water drainage areas upstream from the gaging stations are 7 square miles for the Pine gage, 272 square miles for the Payson gage, and 320 square miles for the Childs gage. During the period of record, there was always streamflow at the Payson and Childs gages; however, periods of no flow occurred in the summer at the Pine gage.

Streamflow increases from the Pine gage to the Childs gage except during hot, dry periods when natural losses and diversions are large. The average annual increase in streamflow per unit increase in drainage area is 32 acre-feet per square mile between the Pine and Payson gages and 90 acre-feet per square mile between the Payson and Childs gages. The average precipitation over both drainage areas is nearly uniform; the reason for the disproportionate increase in streamflow is not known, but it may be due to a more efficient transport of rainfall and snowmelt from Hardscrabble Mesa to the river and, to a lesser extent, to the many diversions above the Payson gage.

Water is diverted from the East Verde River for domestic, agricultural, and recreational purposes. Most of the diversions are upstream from the Payson gage. The amount of water diverted probably reaches a maximum during the summer and sometimes exceeds the flow at the Payson gage. The total amount of streamflow diverted is not known, and much of the water diverted is returned to the river. As much as 3 cfs was measured at a diversion about 3 miles above the Payson gage.

Streamflow gains and losses during periods of low flow.-- The streamflow of the East Verde River is evaluated by an accumulative plot of the average gains and losses between successive gaging stations and partial-record sites. The average gains and losses are computed from 30 sets (U. S. Geological Survey, 1963) of streamflow measurements, each set made on the same day during periods of low flow. The measurements were

selectively made during periods of no, or very minor, surface runoff from snowmelt or rainfall.

An average of about 0.6 cfs of streamflow is lost by seepage into the ground between site 1 and the Pine gage, and about 4.1 cfs is gained below the Pine gage (fig. 2, curve A). The greatest streamflow gain per mile of river channel is between the Pine gage and site 2. Flow from Ellison Creek to this reach is the cause of the gain. The average net gain of streamflow between site 1 and the Childs gage is 3.5 cfs. Because gains and losses of streamflow are regulated partly by manmade diversions, the average net streamflow gain of 3.5 cfs for the river is lower than the natural gain would be if no streamflow were diverted by man.

For the period of record, the average low flow at site 1 was 1.2 cfs, and the average low flow at the Childs gage was 4.7 cfs. The average gain in low flow of 3.5 cfs between site 1 and the Childs gage was about three times the average flow of 1.2 cfs at site 1.

The maximum measured net loss of streamflow during the period of record is shown in curve B (fig. 2). The measurements were made on June 18, 1963, and were preceded by a 2-month dry period. A gain of 0.6 cfs was measured between the Pine gage and site 2, but from site 1 to site 3 the river lost 0.6 cfs. A gain of 0.1 cfs was measured in the lower 30 miles from site 3 to the Childs gage. Natural losses and diversions exceeded inflow, causing a net loss of 0.5 cfs.

The records that form the basis for this report do not include any data for prolonged periods of drought. The streamflow loss along the East Verde River during a prolonged drought, when precipitation is not sufficient to maintain channel saturation, probably would be more than the maximum loss observed during the period of record.

Evapotranspiration losses from the East Verde River are not expected to differ in the same proportion as the variation in streamflow; the streamflow is confined to the channel, which has very small storage capacity along the entire length of the river, and there is usually sufficient water available to satisfy the demands of vegetation regardless of the amount of streamflow. The difference in seasonal evapotranspiration losses is shown by the correlation of seasonal streamflow at site 1 and at the Pine gage (fig. 3). Downstream from the Pine gage, the variation in unmeasured diversions was great enough to distort graphs designed to show the seasonal correlation. Although the correlation of streamflow at the downstream stations was poor, the trend was similar to that between site 1 and the Pine gage. The average streamflow from April through August, when evapotranspiration is high, is about 0.3 to 0.4 cfs lower than in September

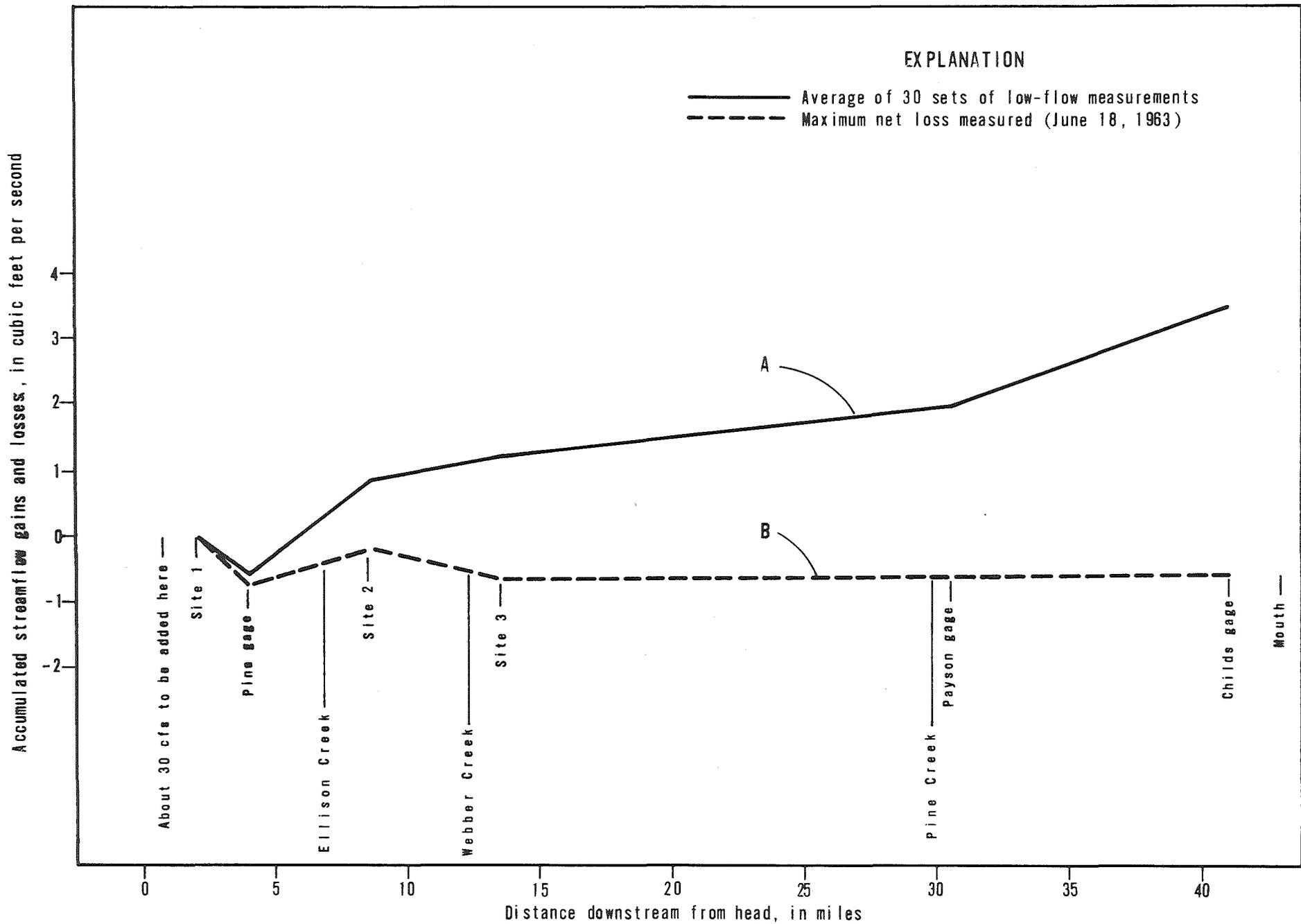


Figure 2.--Average and maximum net streamflow gains and losses.

through March, when evapotranspiration is low (fig. 3). The streamflow difference between periods of high and low evapotranspiration is constant for the range of streamflow measured. Evapotranspiration losses, therefore, do not differ significantly despite rather large variations in streamflow and are not expected to increase significantly with the addition of water at the rate of about 30 cfs.

Physical changes of the river system due to the addition of water. --Addition of water to the East Verde probably will not change the channel course nor increase degradation of the channel. The river is entrenched deeply in bedrock, which is resistant to erosion; in the past, peak flows far greater than the amount of flow to be added have not changed the river course. Therefore, the river course is expected to remain stable. The water introduced into the river at the head of the basin will be free of sediment and will have high sediment-carrying and scouring capacities. Some degradation of the channel probably will take place in the unconsolidated alluvial areas as the river channel adjusts to the flow conditions. Degradation of the channel will be limited by the erosion-resistant bedrock, and adjustment of the channel to the added flow probably will be minor. Deposition or channel filling along the East Verde is expected to be minor, because of the present relatively steep gradient and the high scouring capacity of the river.

SUMMARY AND CONCLUSIONS

The average streamflow in the East Verde River increased from 1.2 cfs near the headwaters to 4.7 cfs near the mouth, or 3.5 cfs from the head to the mouth during low-flow periods; the maximum measured decrease during a sustained dry period was 0.5 cfs.

Evapotranspiration losses do not change significantly despite rather large variations in streamflow, because the flow is confined in the channel and the channel is usually saturated. Losses due to seepage into the ground are minor because the rocks along the stream generally are saturated and contribute to the streamflow.

About 30 cfs of water is to be added to the river near the head of the East Verde River basin from the East Clear Creek reservoir. The expected losses of the added water to evapotranspiration and seepage into the ground are small. The geometry of the river channel is not expected to change, and the erosion along the river course is not expected to increase markedly.

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