

RELATION OF GROUND-WATER INFLOW AND OF BANK AND CHANNEL STORAGE TO STREAMFLOW PICKUP IN THE SANTA FE RIVER, FLORIDA

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Work done in cooperation with the Florida Geological Survey

Abstract.—The pickup in flow of the Santa Fe River in the 8-mile reach between gaging stations near High Springs and near Fort White, in north-central Florida, averages about 800 cfs and is provided entirely or almost entirely by ground-water runoff. The magnitude of streamflow pickup in this reach changes slowly, or is almost uniform, except during times of flood. At those times part of the floodwater derived from surface runoff in the region upstream goes into channel and bank storage while passing through this reach. During succeeding periods of resumed base flow, this water drains back into the stream.

Streamflow records for a reach of the Santa Fe River near High Springs, in north-central Florida (fig. 1), show features that are difficult to identify in records for most streams. The flow of the Santa Fe River, a tributary of the Suwannee River, is measured at gaging stations near High Springs and near Fort White; the Fort White station is approximately 8 miles downstream from the High Springs station. Between these stations the stream occupies a channel which has been cut into the highly permeable limestone of the Floridan aquifer. Little or no overland flow enters the river between these stations because all or nearly all the rainfall either returns directly to the atmosphere by evaporation and transpiration or infiltrates the cover of sand and clayey sand that overlies the limestone. A few miles upstream from the gaging station near High Springs, the river, responding rapidly to rainfall, receives overland flow at a high rate during storms and recedes rapidly to a low base flow after storms (Clark and others, 1964, p. 53). The flow of the river at these stations, in a reach of the river that receives no overland flow, is therefore more variable than would otherwise be expected. The result is

that the effects of changing river stages are more apparent in the records from these stations than from most other stations because these effects are not masked by the effects of local overland runoff.

Figure 2 shows hydrographs of the flow at the gaging stations near High Springs and near Fort White and of streamflow pickup between these stations. The pickup was computed by subtracting the flow at the High Springs station from the flow at the Fort White station. As is shown by 30 years of record, the increase in flow between the two stations—the streamflow pickup—averages about 800 cubic feet per second or about 100 cfs per mile of river. As a matter of interest and comparison, this pickup is approximately equal to the flow of Silver Springs, one of the largest springs in the United States, and is only slightly less than the rate of withdrawal of water for all public supplies in Florida in 1960 (MacKichan and Kammerer, 1961, p. 13).

As shown on figure 2 the streamflow pickup, which is largely ground-water inflow, for the most part changes slowly. Similarly, in an earlier study of Pond Creek, in Oklahoma, Clark (1956) found after accounting for the loss of water by evaporation and transpiration from the bottom lands near the creek that ground-water inflow to the creek for the most part changed slowly. Both Pond Creek and the Santa Fe River drain extensive aquifers.

Streamflow pickup does not continue to change slowly, however, during periods when the stage of the river is changing comparatively rapidly. When surface runoff upstream from the gaging station near High Springs raises the river level rapidly, pickup decreases and at times even becomes negative (that is, the stream

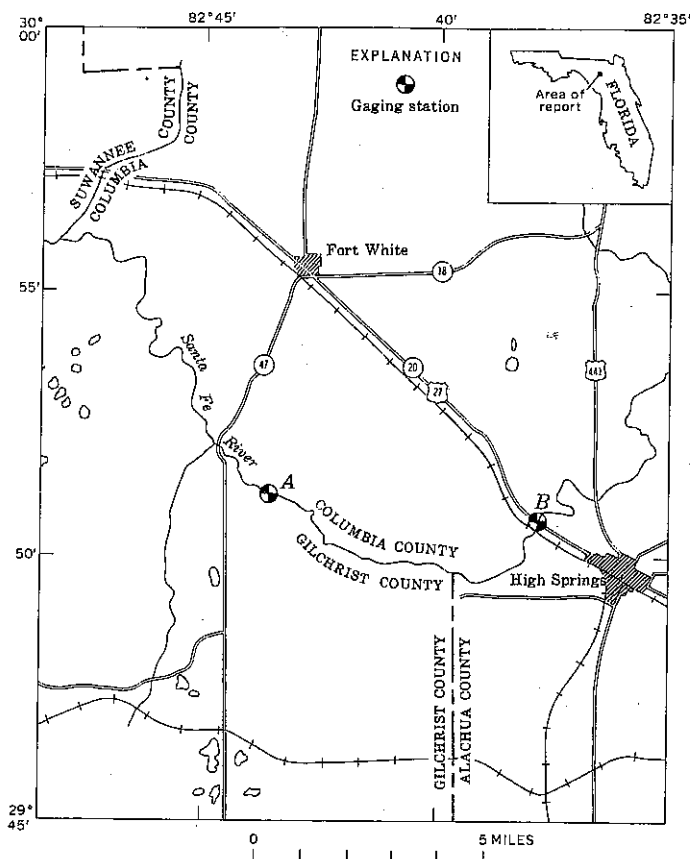


FIGURE 1.—Map showing location of the gaging stations on the Santa Fe River near Fort White and near High Springs in Florida. A, Fort White station; B, High Springs station.

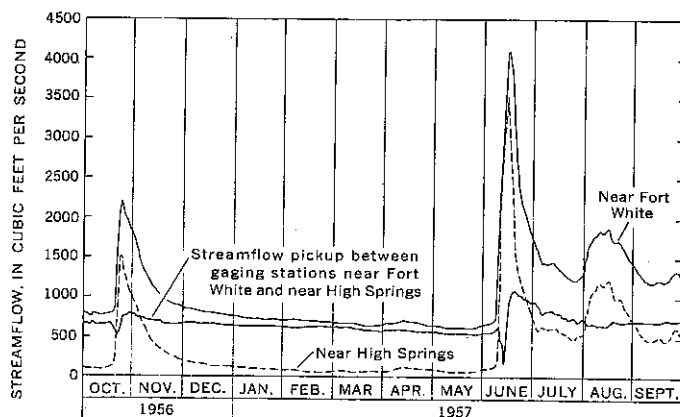
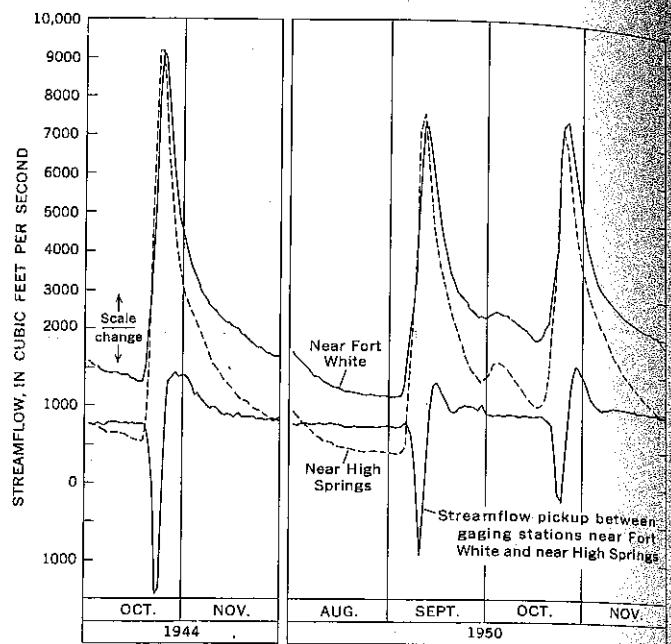
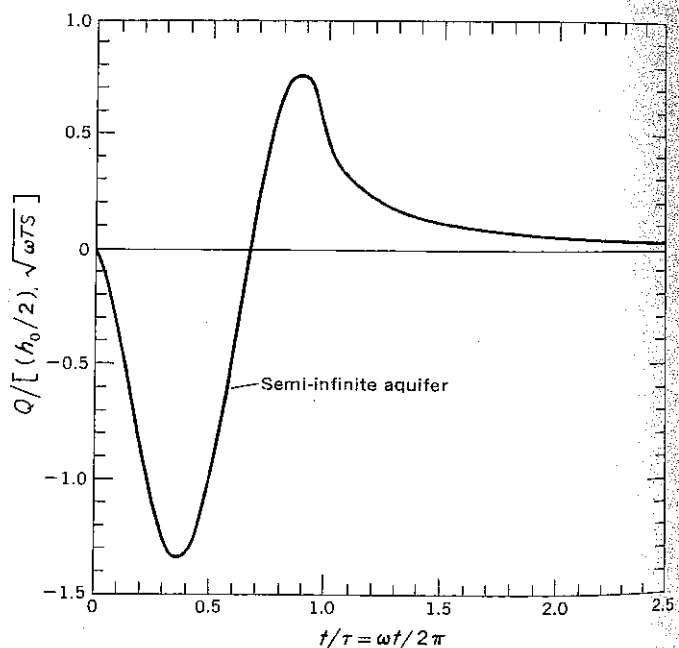


FIGURE 2.—Hydrographs of the Santa Fe River for the 1957 water year, at gaging stations near High Springs and near Fort White, Fla., showing streamflow at these stations and streamflow pickup between the stations.



A



B

FIGURE 3.—A, Hydrographs of the Santa Fe River at gaging stations near High Springs and near Fort White, Fla., showing water discharge at these stations and streamflow pickup between the stations. B, Theoretical ground-water flow from a semiinfinite aquifer into a stream (from Cooper and Rorabaugh, 1963a, fig. 102; 1963b, fig. 53.3).

loses water in the reach between the stations; see fig. 3A). When the river stage subsequently subsides, pickup increases, even reaching for a time a rate higher than its rate before the rise in stage.

The examples of streamflow pickup shown in figure 3A are provided by daily discharge data for periods in 1944 and 1950 when surface runoff from the area upstream from the High Springs gaging station was very high. As can be seen in this figure, streamflow pickup for a few days in October 1944 was negative by almost 1,500 cfs (a decrease in flow of almost 2,300 cfs). Change in the rate of streamflow pickup is attributed to: (1) time of travel of the water between the gaging stations near High Springs and near Fort White, (2) addition of water to, and release from, channel storage, and (3) flow of water into and out of bank storage. As the time of travel between the two stations is only a few hours, it can account for only a small part of the change in the rate of streamflow pickup. Therefore, the remainder must be attributed to changes in channel storage and bank storage—both of which are related to river stage.

The flow of water into and out of bank storage has predictable characteristics. Cooper and Rorabaugh (1963a, b) derived equations for the flow of water into and out of bank storage for a variety of stream-stage hydrographs simulating the passing of a flood and for finite and semiinfinite aquifers. The similarity between the hydrographs of the pickup in the Santa Fe River and of the theoretical ground-water flow into and out of a stream is shown on figure 3. Ground-water flow into a stream, shown on figure 3B, was computed ac-

ording to the formula of Cooper and Rorabaugh (1963a, b) for a semiinfinite aquifer.

Bank storage in the reach of the Santa Fe River consists partly of ground water that would have been discharged into the stream if the river stage had not risen, and at times partly of river water that seeped into the limestone aquifer as a result of the rise in river stage. When the river stage declines after a flood, the water held in channel and bank storage in the reach between the stations is released and pickup within the reach temporarily increases to a rate greater than that before the river rise. Then, unless another rise in river stage intervenes, both the river stage and pickup between stations gradually decline to a level about the same or slightly higher than that before the rise in river stage.

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