USE OF SNOW SURVEYS TO FORECAST INFLOW TO SNAKE RIVER BETWEEN MILNER AND KING HILL, IDAHO [1]

By

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Snow surveys are widely used to forecast flows in streams to which the snowmelt is directly tributary, and to estimate the magnitude and duration of water supplies fed by such streams. This paper presents a proposed method for using snow survey data to forecast inflow to a rather unique reach of the Snake River (fig. 1) to which the snowmelt is not directly tributary, and within which the largest part of the inflow comes from large springs which drain the Snake Plain aquifer.

The flow of the Snake River at Milner is very small during many years because of storage and diversion for irrigation upstream. The flow of the Snake River at King Hill about 94 miles downstream however, averages about 7,500 cfs (cubic feet per second) more than the flow at Milner. The inflow between these two stations is made up of about 6,000 cfs from large springs along the north side of the river, an estimated 100 cfs of surface waste water from irrigation on the north side of the river, and about 1,400 cfs of return flow from the south side of the river, principally from irrigation. As with flow from the north side, the south side return flow is made up of both underground and surface flow.

The increase in flow of the river as it progresses downstream from Milner to King Hill is illustrated on figure 2. The width of the shading along the river represents the cumulative inflow to that point. The abrupt increases of flow occur at points of entry of spring flow or surface wasteways along the river. Major springs, each of which flow several hundreds of cubic feet per second, include Blue Lakes, Crystal, Niagara, Clear Lakes, Box Canyon, Thousand Springs, and Malad Springs. Principal south side wasteways include Rock Creek, Cedar Draw, Deep Creek, and Salmon Falls Creek. Only Big Wood River and Clover Creek carry water from the adjacent hills directly to Snake River. Big Wood River flow above Malad Springs is not included in the computations of inflow as used here, and flow in Clover Creek is negligible.

The location, magnitude, and uniformity of the inflow combine to make it a resource of great economic value both for hydroelectric power and for irrigation. Consequently, the ability to forecast the magnitude and major variations in this flow would be of considerable value. The factors that control the characteristics of the inflow, however, can only be understood by considering them in relation to the regional hydrologic conditions.

The approximately 1,400 cfs of inflow from south of the river is derived from irrigation water diverted from the Snake River and tributaries to the south below American Falls Reservoir. Nearly all the 6,000 cfs of inflow from north of the river comes from ground water in the Snake Plain aquifer. This aquifer receives its greatest recharge supply from infiltration of irrigation water diverted from the Snake River including Henrys Fork, and from percolation of snowmelt runoff from Snake River and from two groups of streams north and south of the Snake River Plain. The first of these is the Wood River group, which includes the Big Wood and Little Wood Rivers, and Silver Creek, Goose Creek, Rock Creek, and Salmon Falls Creek. The second group is the Lost River group, which includes Big Lost and Little Lost Rivers, Birch Creek, and smaller creeks eastward to Henrys Fork. All the water diverted from the Snake River upstream of Milner and applied for irrigation north of the river is either consumptively used or is returned to the river by surface wasteways or by percolation to the Snake Plain aquifer and subsequently returns through springs. Water diverted and applied to lands between Shelley and American Falls Reservoir, however, is considered herein to return to the American Falls Reservoir reach of the river and not to contribute inflow to the reach between Milner and King Hill.

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[1] Publication authorized by Director, U. S. Geological Survey.

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Thus, there is a relationship between the inflow to the Milner - King Hill reach and the combined recharge elements made up of diversions from the Snake River for irrigation, and snowmelt runoff in the two river groups. For purposes of the remainder of this discussion, all the recharge elements just discussed are combined and are hereafter referred to collectively as diversions onto the Snake River Plain. If these diversions can be forecast by use of snow survey data, then the inflow to the reach can likewise be forecast by its relationship to the diversions.

Figure 3 is a graph showing mean annual diversions onto the Snake River Plain and the mean annual total inflow to the reach. In figure 4, diversions are plotted against inflow and this plot shows that, in general, inflow increases with diversions but at a lesser rate. Before being used on figure 4, the diversions were adjusted somewhat arbitrarily because there is a lag in time between a recognizable diversion event and a corresponding inflow event. Also, it is believed that a shorter lag period exists related to diversions below American Falls Reservoir than for diversions elsewhere onto the Plain. Consequently, the figures used for diversion above Shelley, including the Lost River group, Falls River, Henrys Fork, Teton River, and the Snake River from Heise to Shelley, are the averages of the diversions of the current year and those of the previous year. The figures used for diversions below American Falls Reservoir for the year, including the Wood River Group, Salmon Falls Creek, and the Snake River below Neeley, are the averages of diversions for the 12 months from July of the previous year until June of the current year.

All points on figure 4 are within about 8 percent of the average regression line for the period 1920 to 1966. The standard error is less than 5 percent. Plotting positions on the figure appear to group by years. For instance, the points for the period 1920-41 are all within 3 percent of a regression line drawn through those points. Similarly, points for 3 other periods are all within 3 percent of their respective regression lines.

Changes in regimen in the Snake Plain aquifer appear to explain these groupings. During the period 1920-41, the aquifer was filling as a result of diversions onto the plain. During the same period, consumptive use on newly irrigated lands was reducing recharge from the tributaries bordering the Snake River Plain. During the period 1942-53, the aquifer was full, diversions were large, and effects of pumping ground water from the aquifer were minor. Pumping from the aquifer during the periods 1954-59 and 1960-66. During the period 1960-66, pumping apparently reduced the inflow in the study reach 600 to 700 cfs from the rate reached during 1942-53. The plotting positions for 1965 and 1966 indicate that a new curve to the right of that shown for 1960-66 may now be applicable. From the figure, it can be readily seen that if the diversions can be forecast, then inflow can also be forecast by use of the appropriate curve.

The relations between various segments of the diversions and corresponding data based on snow surveys are shown in figures 5 through 8. In these figures, the April 1 snow survey forecast of runoff from various drainages or river segments, in millions of acre feet, is plotted against the measured mean annual diversion onto the Snake River Plain from related drainages. Accumulated storage on April 1 in principal reservoirs above Lake Walcott is included with the forecasts of the flows of Snake River near Heise and Henrys Fork near Rexburg. Reservoir storage on April 1 is a significant part of the water outlook for the coming season. These plots provide correlations which show how several segments of the diversions compare with flows which are now being regularly forecast by the U. S. Soil Conservation Service. Figures 5 and 6 show some scatter when supplies are ample, and indicate that diversions increase only slightly when the supply is above about 7 million acre-feet. Diversions evidently decline at a faster rate when the supply is less than about 6.5 million acre-feet.

Thus, by use of the curves of figures 5 through 8 a total mean annual quantity of diversion can be forecast from the April 1 snow survey runoff forecast. Entering figure 4 with this diversion quantity, the mean annual inflow to the Milner to King Hill reach of the Snake River may be obtained, which permits forecasting a highly important water supply by means of standard snow survey data from watersheds not apparently directly related to the supply.

As an example of the utility of this procedure, the inflow for 1966 was forecast to be 7,650 cfs before 1966 records were available. Streamflow records recently completed showed the inflow to be 7,480 cfs, which is a close check. April 1,1967 snow forecasts suggest that 1967 inflow will be about 7,750 cfs.

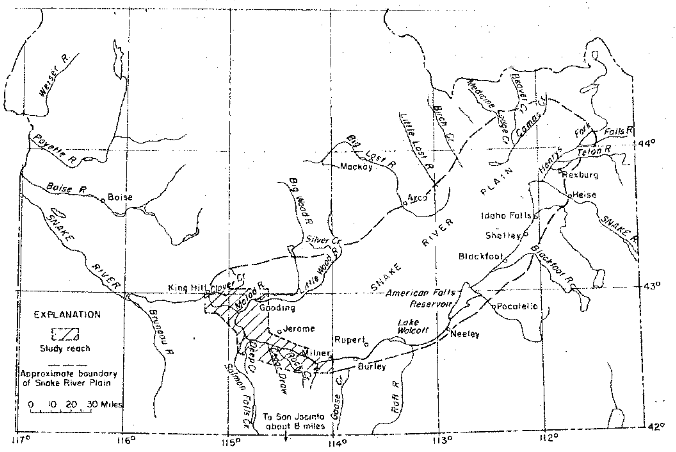
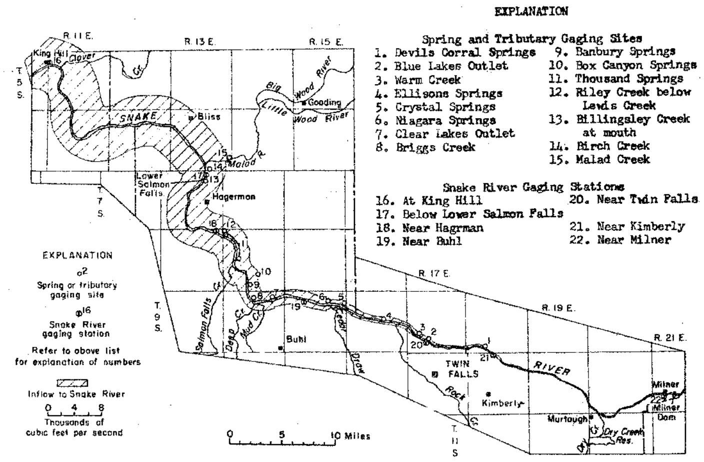


Figure 1. Map of southern Idaho showing the location of the study reach and the Snake River Plain.



EXPLANATION

Spring and Tributary Gaging Sites

1. Devils Corral Springs	9. Banbury Springs
2. Blue Lakes Outlet	10. Box Canyon Springs
3. Warm Creek	11. Thousand Springs
4. Ellisons Springs	12. Riley Creek below Lewis Creek
5. Crystal Springs	13. Billingsley Creek at mouth
6. Niagara Springs	14. Birch Creek
7. Clear Lakes Outlet	15. Malad Creek
8. Briggs Creek	

Snake River Gaging Stations

16. At King Hill	20. Near Twin Falls
17. Below Lower Salmon Falls	
18. Near Hagrman	21. Near Kimberly
19. Near Buhl	22. Near Milner

Figure 2. Map of Snake River between Milner and King Hill showing location of measuring sections and accumulated inflow along the reach.

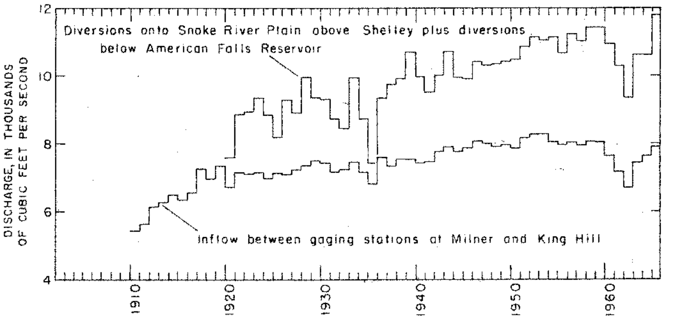


Figure 3. Graph showing diversions onto Snake River Plain and inflow to Snake River between Milner and King Hill.

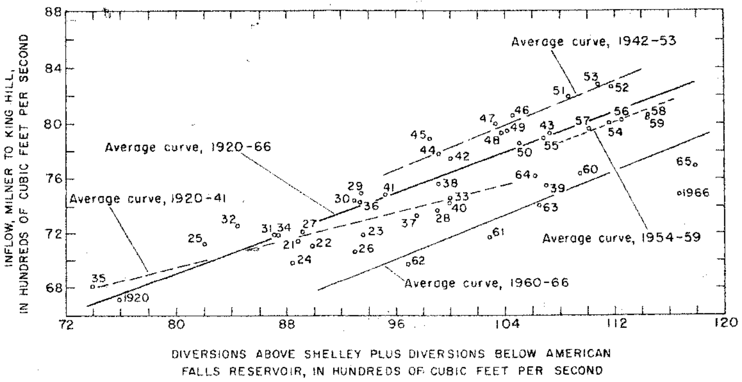


Figure 4. Correlation of diversions onto Snake River Plain with inflow to Snake River between Milner and King Hill.

The shape of the annual cycle of variation of inflow shown on the hydrograph (fig. 9) provides an excellent basis for predicting mean flow for any of the 12 months following the April 1 forecast. The amplitude of the annual cycle for an average year, 1963 for example, departs from other years by only a few percent. By plotting the annual mean inflow on the hydrograph, the monthly discharges can be estimated with considerable assurance.

As demands for use of this large water supply increase, forecasts will become more important. Methods such as the one outlined should prove to be of value to many of the users along the Snake River, and should assist in the wise management of the resource.

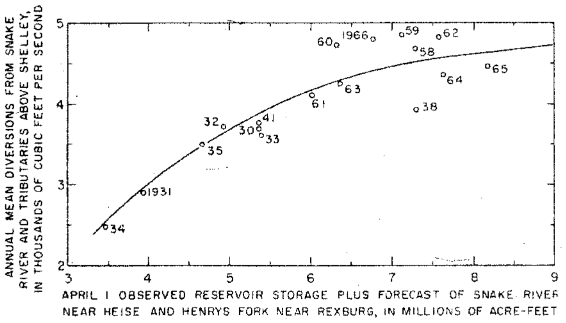


Figure 5. Correlation of annual mean diversions from Snake River above Shelley with the April 1 observed reservoir storage plus forecast flow of Snake River near Heise and Henrys Fork near Rexburg.

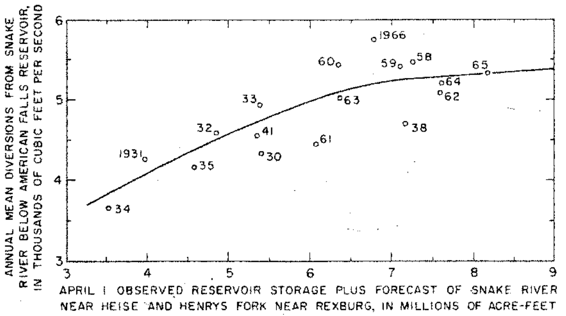


Figure 6. Correlation of annual mean diversions from Snake River below American Falls Reservoir with the April 1 observed reservoir storage plus forecast flow of Snake River near Heise and Henrys Fork near Rexburg.

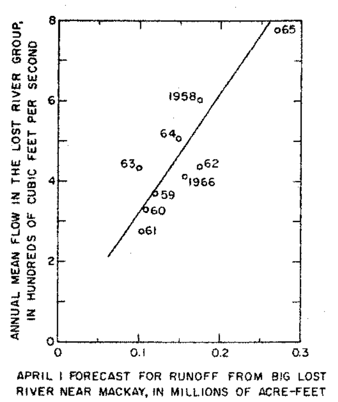


Figure 7. Correlation of annual mean flow in the Lost River group with the April 1 forecast for runoff from Big Lost River near Mackay.

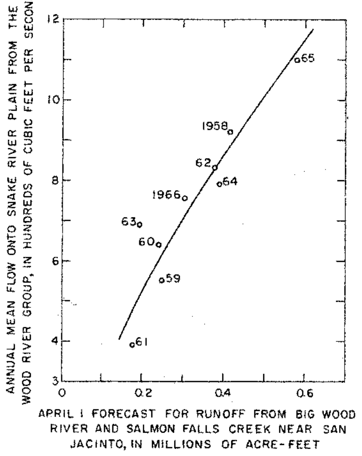


Figure 8. Correlation of annual mean flow onto Snake River Plain from the Wood River group with the April 1 forecast for runoff from Big Wood River and Salmon Falls Creek near San Jacinto.

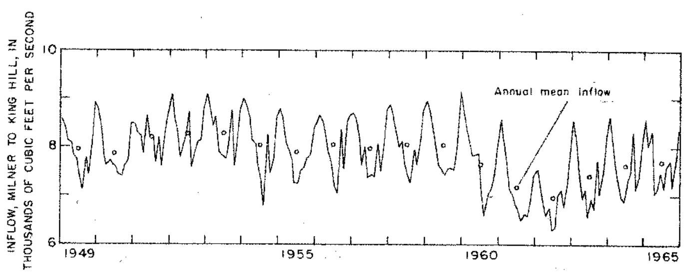


Figure 9. Hydrograph of inflow to Snake River between Milner and King Hill.