USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Hydrologic Impacts of Improved Irrigation Efficiencies and Land Use Changes:

Focus Category: HYDROL, SW, IG

Keywords: Return flow, Hydrograph analysis

Duration: March/2000 – Feb/2001 (An extension may be requested, depending on the first year results.)

FY 2000 Federal Funds: $31,566

FY 2000 non-Federal Funds: $43,060

Principal Investigator's Name(s) and University:

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Congressional District: 1

Statement of critical regional or State water problems

Traditionally, irrigated agriculture has accounted for more than 80 percent of the consumptive use of water in the Western States. In recent years the demands on this water have increased drastically due to population and industrial growth and due to a greater awareness of environmental and recreational related issues. Thus, water management has become a complex problem incorporating a wide range of multidisciplinary factors. To integrate the impacts of these factors on water availability and quality, development of technologies to conserve and judiciously utilize available water resources is of paramount importance. A current emphasis is to increase irrigation system efficiencies. However, the overall impacts of increased efficiencies are not well defined. Potential hydrologic impacts of increased irrigation efficiencies include increased flood flow probabilities, decreased return flows, lower groundwater recharge rates, and less wetland development.

An enhanced understanding of hydrological processes due to increased irrigation efficiencies and land use changes is desirable. Return flow information and data, in particular, are needed for each basin of Wyoming. Much of the flow in streams passing irrigated lands comes from return flows from saturated lands around the streams in the form of groundwater return flows. This groundwater return flow differs greatly in the amount and timing from surface water return flows. The surface waters return to the stream in a large amount in a very short time. Groundwater return flows, however, are

spread out over a much larger time frame making the return flow amounts much smaller for a given time interval. Increases in irrigation efficiencies may affect streamflows by causing higher spring flows and lower late summer and early fall flows.

Statement of results or benefits

Streamflows that originate in the mountainous areas of Wyoming are receiving increased interest in relation to allocation of water rights, including those for instream flows. The possibility that changes in streamflows may occur due to changes in land use, such as increased urbanization or increased irrigation efficiency, should be considered in water resources management. Where these effects appear likely to occur, procedures to alleviate the problems can be incorporated into management decisions and/or project designs. Changes in the flow patterns of the Salt River could affect the instream flow segment located at the lower end of the Salt River.

Nature, scope, and objectives

The Salt River drainage, located in western Wyoming and known as the Star Valley, is a watershed of approximately 800 mi^2. Historically, Star Valley has been an irrigated agricultural area. Between 1971-74, much of the irrigation was converted from surface to sprinkler systems. After completion, approximately half of the 60,000 irrigated acres were being irrigated with sprinkler systems. Irrigation efficiencies increased by about 50 percent and yields increased by approximately 100 percent. A study was performed in the mid-1980's to investigate the impacts of this conversion on the Salt River flows (Sando et al., 1985). Higher spring flows and lower fall flows were evident as a result of the conversion to the higher efficiency sprinkler systems. Since the previous study, large land use changes are perceived to have occurred in the Star Valley. Many of the farms, especially on the lower end of the Valley, are being subdivided. This trend toward urbanization will change the method and pattern of irrigation and may further change the hydrology of the Salt River.

The major objective of this project is to extend the previous Salt River study to the present and investigate the potential hydrologic impacts of these land use changes. There may also be the possibility of performing a similar study in the Eden-Farson area of Wyoming, where beginning in the late 1980's much irrigation was converted to sprinkler systems as part of a salinity control program on the Colorado River system. A secondary objective is to investigate the feasibility of performing a study of the water quality changes that may have occurred due to conversions to more efficient irrigation systems and land use changes. A final objective is to review the applicability of various watershed models for predicting the hydrologic impacts of improved irrigation efficiency and/or land use changes. If models were readily applicable, then the impacts of various scenarios could be investigated. The latter two objectives are intended to provide only preliminary information and to define the feasibility of future comprehensive studies.

Methods, procedures, and facilities

The Salt River drainage basin (Star Valley) is an agricultural based watershed of approximately 800 mi^2. The Salt River flows into the Snake River, which is a major tributary of the Columbia River Basin. The Star Valley is a narrow valley about 50 miles long and about 15 miles across at the widest point. The main crops are irrigated alfalfa hay and barley grown to support the dairy industry in the valley. The Greys River flows through a narrow drainage of approximately 450 mi^2 to the east and on the other side of the Salt River Mountain Range adjacent of Star Valley. The Greys River drainage is bordered on the east by the Wyoming Mountain Range and is essentially void of agriculture. Thus, the Greys River can be used as a control. Streamflow gaging stations are located on the lower reaches of both the Salt River and Greys River near where they join the Snake River.

Methodology to be used in this project will be similar to that employed in the earlier study. The main variation will be in defining the changes in land use that have occurred in recent years. Sources which will be considered for this information will include the Wyoming Agricultural Statistics annual reports, local building permit requests and taxing information, water right permits through the State Engineer's Office, aerial photographs, and interviews with local residents and State agency personnel.

Analyses will be performed to determine if present flows in the Salt River compare with those in existence in the early 1980's. These will include double-mass analysis of the flows of the Salt River versus Greys River (the valley in which the Greys River is situated is void of agriculture and also has not undergone urbanization). Direct comparison of flows on the Salt River prior to versus after changes in irrigation methodology or land use will not necessarily define the impacts of the changes due to potential climatic differences during the pre- versus post-periods being considered. Double-mass analysis will, however, allow comparisons while accounting for climatic differences since the Greys River flow variations are a result of mainly climate factors. Analysis of annual flood peaks will be accomplished by various hydrologic and statistical tests. These will include a comparison of flood frequency distributions, tests of stationarity, and tests of homogeneity.

Another irrigation project that has undergone considerable conversion from surface to sprinkler irrigation is the Big Sandy Project (the Eden-Farson irrigation project) in the Green River Basin of Wyoming. The Big Sandy Project is a salinity control program for the Colorado River and was initiated in the late 1980's. The feasibility of using the project for a hydrologic analysis similar to that of the Star Valley will be evaluated. Complicating factors in the Big Sandy Project are the presence of reservoir storage and the difficulty in defining a control such as the Greys River for the Star Valley analysis.

Data sources, such as the Wyoming Water Resources Data System (WRDS), will be reviewed for water quality data that might be suitable for analysis of the impacts of irrigation system conversions and land use changes on water quality. Such analyses are being performed on the Big Sandy Unit for salinity control. Monitoring and evaluation

reports were initiated in 1990 for the Big Sandy and show there has been a considerable reduction in the annual salt load.

One issue that needs to be addressed is the compact implications of changes in land use and instream flow water rights. The amount of private land, their locations and the amount of flows from various tributaries combine with other factors to influence the impacts of flow allocations. The difficulty in managing source code and modeling to account for the various factors is apparent from previous studies in Wyoming and elsewhere. An evaluation of data needs of various models versus data availability will be attempted to focus on long-term potentials for conducting scenario analyses of allocation impacts.

Related Research:

As mentioned previously, a study has been conducted in the Star Valley of western Wyoming to define the hydrologic impacts of improved irrigation efficiencies (Sando, 1985 and Sando et al., 1985). The nature of the Salt River drainage basin and the conversion of many of the irrigation systems from surface to sprinkler irrigation provided a unique opportunity to perform the study.

A related return flow study has been performed in Wyoming on an alluvial aquifer subjected to flood irrigation (Wetstein, 1989 and Wetstein and Hasfurther, undated). A water budget analysis, conducted by using the USGS groundwater model "A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model", was performed on the New Fork River valley in western Wyoming. Return flows to the stream, aquifer storage changes, and groundwater inflow minus outflow to the aquifer were analyzed. Results on the return flows indicated that 70 percent of the return flow occurred rapidly while the remainder was released slower, providing additional instream flow during low flow periods.

Models for water accounting have been studied in Wyoming since the early 1990's (Meena, 1993; Williams, 1995; Boyle, 1997; Coleman, 1999). A model entitled WIRSOS (Wyoming Integrated River System Operation Study) has been used for analysis of river basin operation and water rights administration, including evaluation of instream flow permit applications. As recently as 1999, Coleman has presented a number of recommendations to facilitate the application of WIRSOS.

References

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