Report as of FY2007 for 2006MT104B: "Student fellowship: Spatial and temporal variation of groundwater and surface water interaction along the Gallatin River, Four Corners Montana"

Publications

Project 2006MT104B has resulted in no reported publications as of FY2007.

Report Follows

Final Report on the Spatial and Temporal Variation of Surface and Groundwater interactions near Four Corners Montana
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Mark Schaffer Department of Earth Sciences Montana State University

Along the West Gallatin River as irrigated agricultural land is converted into residential developments, changes to the hydrologic system are anticipated resulting from the decline in irrigated land. The loss of irrigation along the river has been hypothesized to result in decreased aquifer recharge which will lower stream flows in late summer and fall (Kendy et al, 2006). Managing groundwater and surface water resources conjunctively, possibly by aquifer storage and recovery (injecting surface water into the aquifer for later use), has been proposed as a means of mitigating anticipated stream flow declines.

An understanding of the dynamic relationship between the West Gallatin River and the West Gallatin Alluvial Aquifer is required in order to calibrate future groundwater models which could be used to test theoretical augmentation regimes and manage the ground and surface water conjunctively.

Specific electrical conductance measured in the Gallatin River's channel, streambed, and the aquifer along with discharge and water level measurements indicate that groundwater discharge into the river varied throughout the study area on both the scale of meters and kilometers. In addition, irrigated areas along the river resulted in significant temporary rises in the water table elevations which altered the surface and groundwater exchange on a temporal scale. Included with this general report are selected figures which demonstrate some of these preliminary findings (see Appendix I).

Data collection has been completed for the project. The final product for this analysis will include a statistical analysis of the streambed data along with a geographical analysis of the irrigated area and volumes along the River's flood plain. The data from this project is currently being organized in a data base which will facilitate continued data collection and ease of transfer between interested parties. This data will be analyzed in the context of the effects of the proposed aquifer storage and recovery plans upon river flows and ecologic conditions.

Thorough analysis of the data still remains and the project is anticipated to be completed by December of 2007. In the mean time, preliminary data has been shared with interested parties which including scientist, water users, and planners. Groundwater elevations collected from the monitoring wells installed for this project are available on the internet at the Montana Bureau of Mines and Geology Groundwater Information Center (GWIC) web site. A presentation of this data is planned for the American Water Resource Association Montana Chapter meeting in October of 2007.

References

Kendy, E, Bredehoeft, J.D. 2006. Transient effects of groundwater pumping and surface-water-irrigation returns on streamflow. Water Resources Research Vol. 42, WO8415, doi 10.1029/2005wr004792

Appendix I: Selected figures

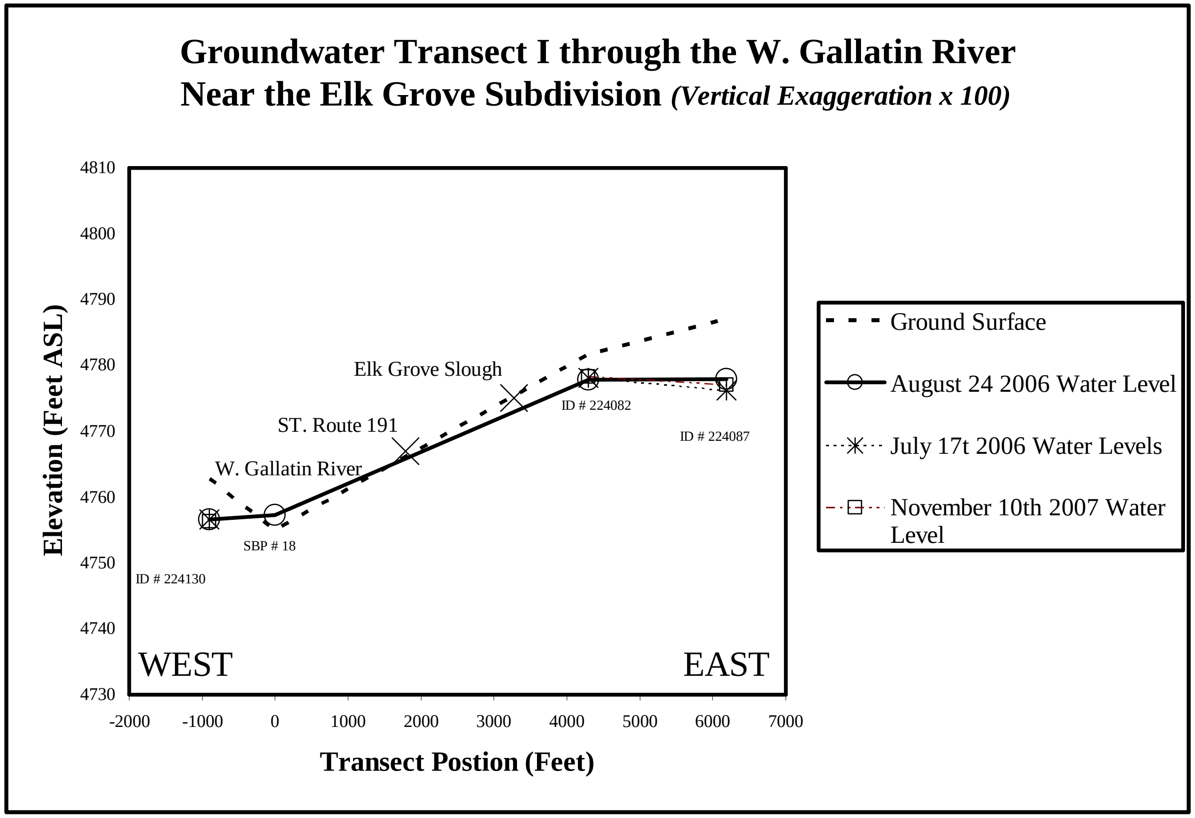

Figure 1. Groundwater elevations measured from monitoring wells and streambed piezometers located north of Axtell Bridge Road near the Elk Grove Subdivision. The potentiometric gradient along Transect I can be classified as flow through, were groundwater flows towards the river from the east but from the river towards the aquifer to the west. In addition, a groundwater divide is evident to the east of the river, the approximate crest of this divide is located below the Elk Grove Subdivision. Groundwater elevations showed little fluctuations from August to November, the greatest fluctuation occurred at well # 224087 below an irrigated field.   Well and piezometer elevation where surveyed with a survey grade GPS unit provided and operated by the Montana Department of Natural Resource Conservation.

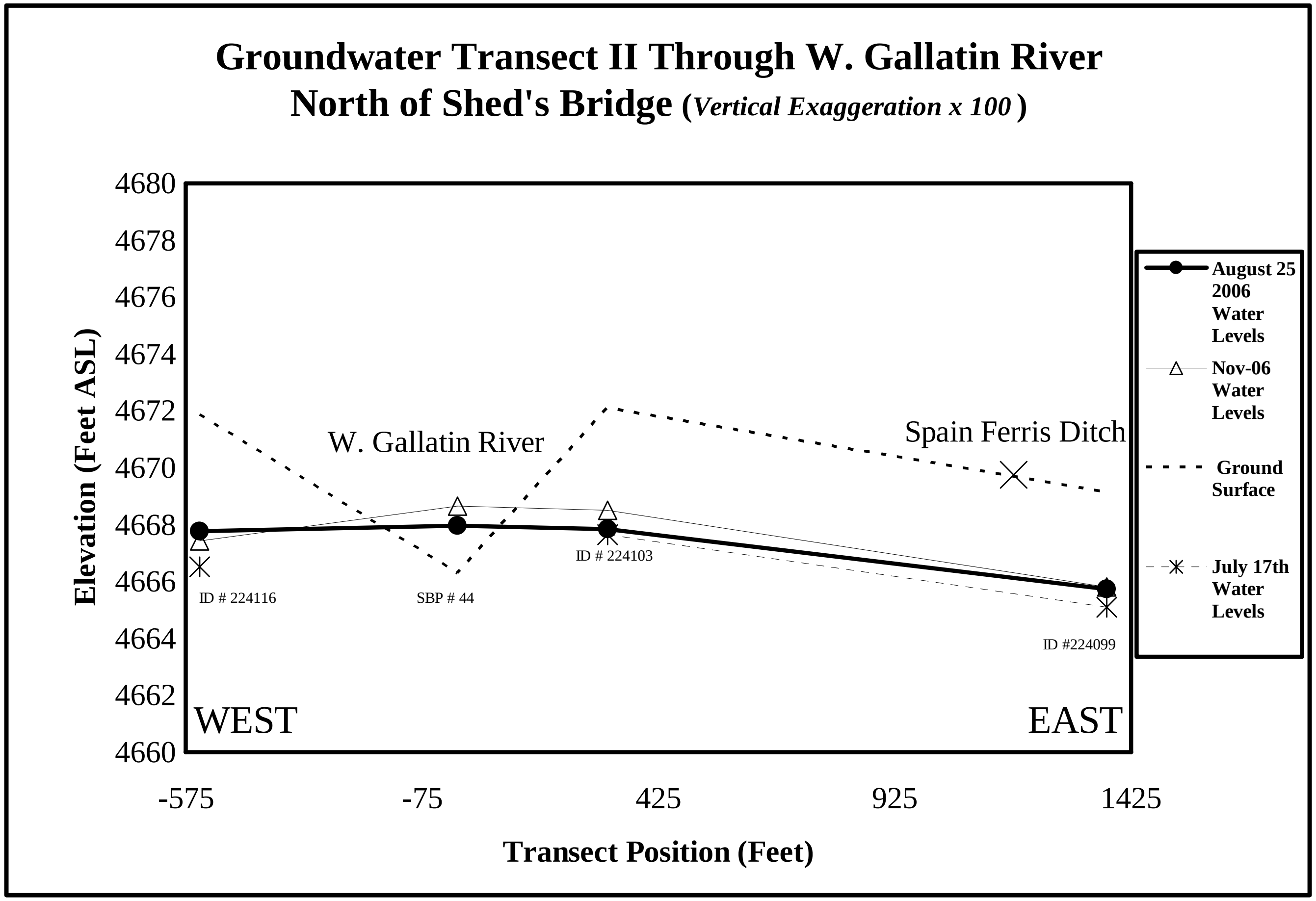

Figure 2. Groundwater water elevations measured from monitoring wells and streambed piezometers north of Shed's Bridge near Four Corners. Potentiometric gradients show water moving from the river channel to both east and west to the aquifer. The greater water level elevations in the river and monitoring wells during July and November correspond to higher stages in the West Gallatin River. Well and piezometer elevation where surveyed with a survey grade GPS unit provided and operated by the Montana Department of Natural Resource Conservation.

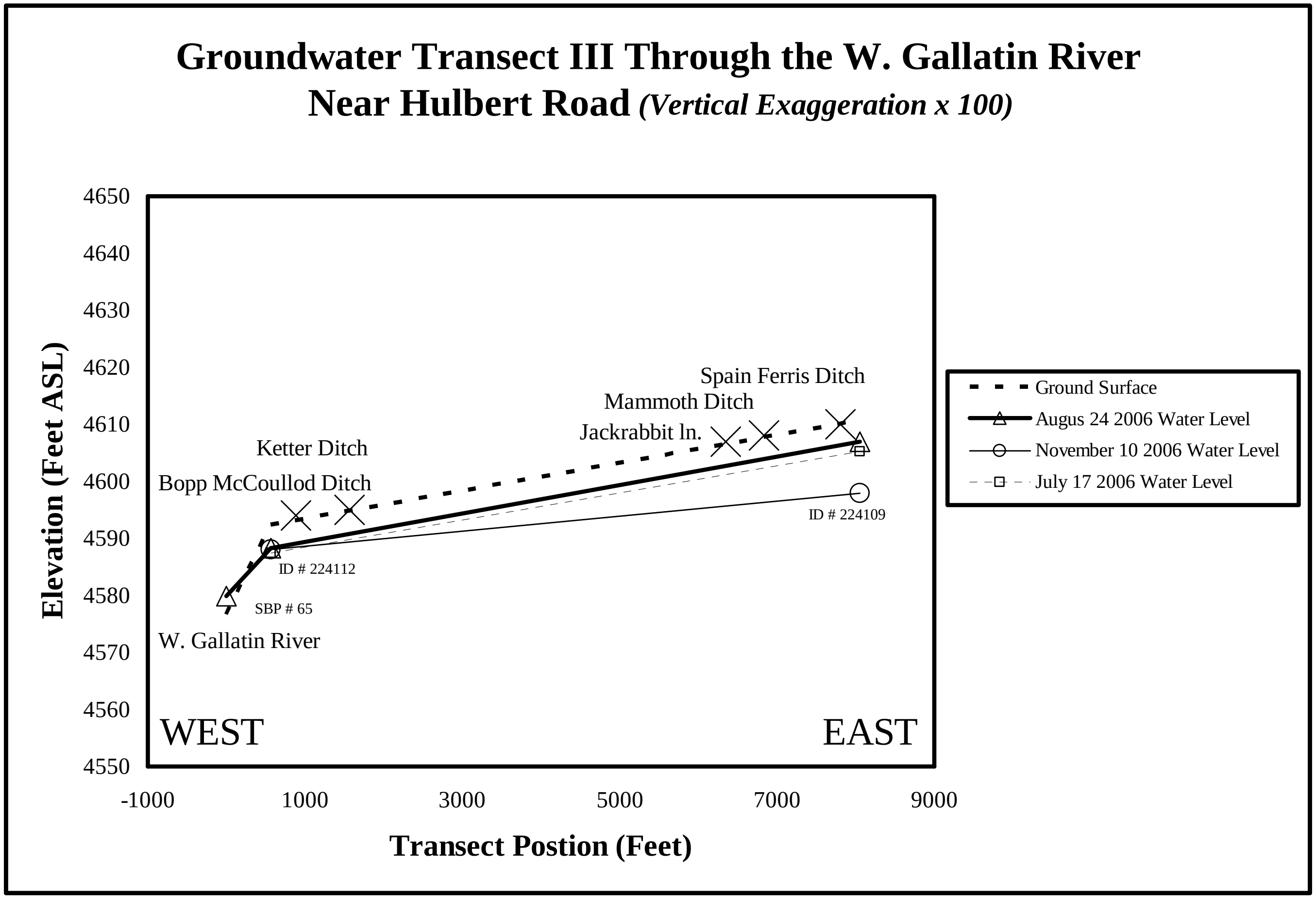

Figure 3. Groundwater elevation measurements measured in monitoring wells and streambed piezometers to the east of the Gallatin River near Hulbert Road. The dramatic fluctuation (> 7 feet) occurred below a flood irrigated field. Groundwater flow towards the river from the east decreased dramatically as the water table elevation declined below the flood irrigated field once irrigation ceased. Well and piezometer elevation where surveyed with a survey grade GPS unit provided and operated by the Montana Department of Natural Resource Conservation.

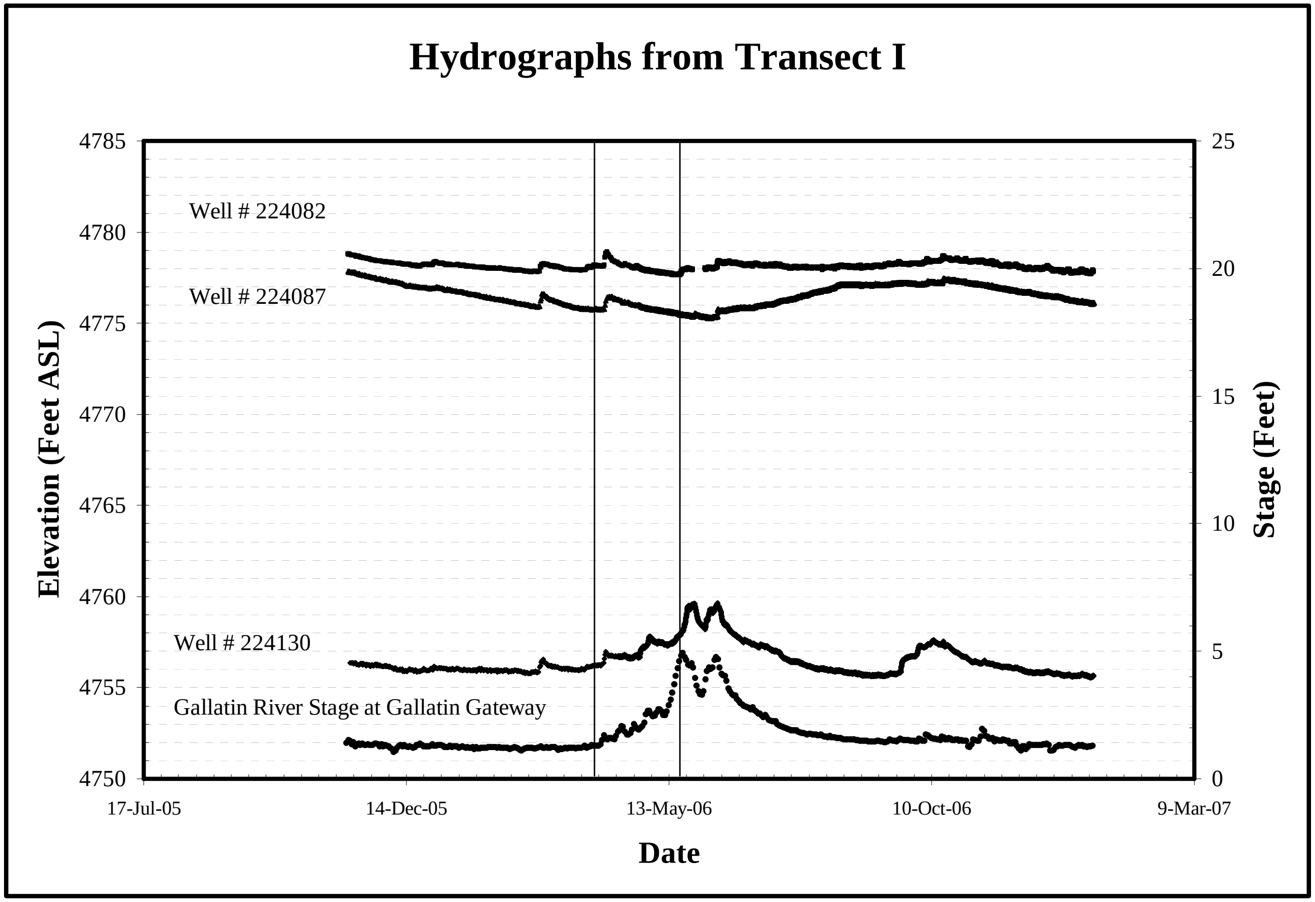

Figure 4. Ground and surface water hydrographs from the West Gallatin River at Gallatin Gateway USGS site and the monitoring wells located along Transect 1 (Figure 1). Water levels to the east of the river in wells 224082 and 224087 show little response to river stage where flow is from these wells to the river, while well 224130 resembles a slightly attenuated and delayed version of the Gallatin Gateway hydrograph. Note well 224087 located below an irrigated pasture, the water table rises during the summer and declines through the winter returning to within a foot of its' pre-rise stage by January 2007.

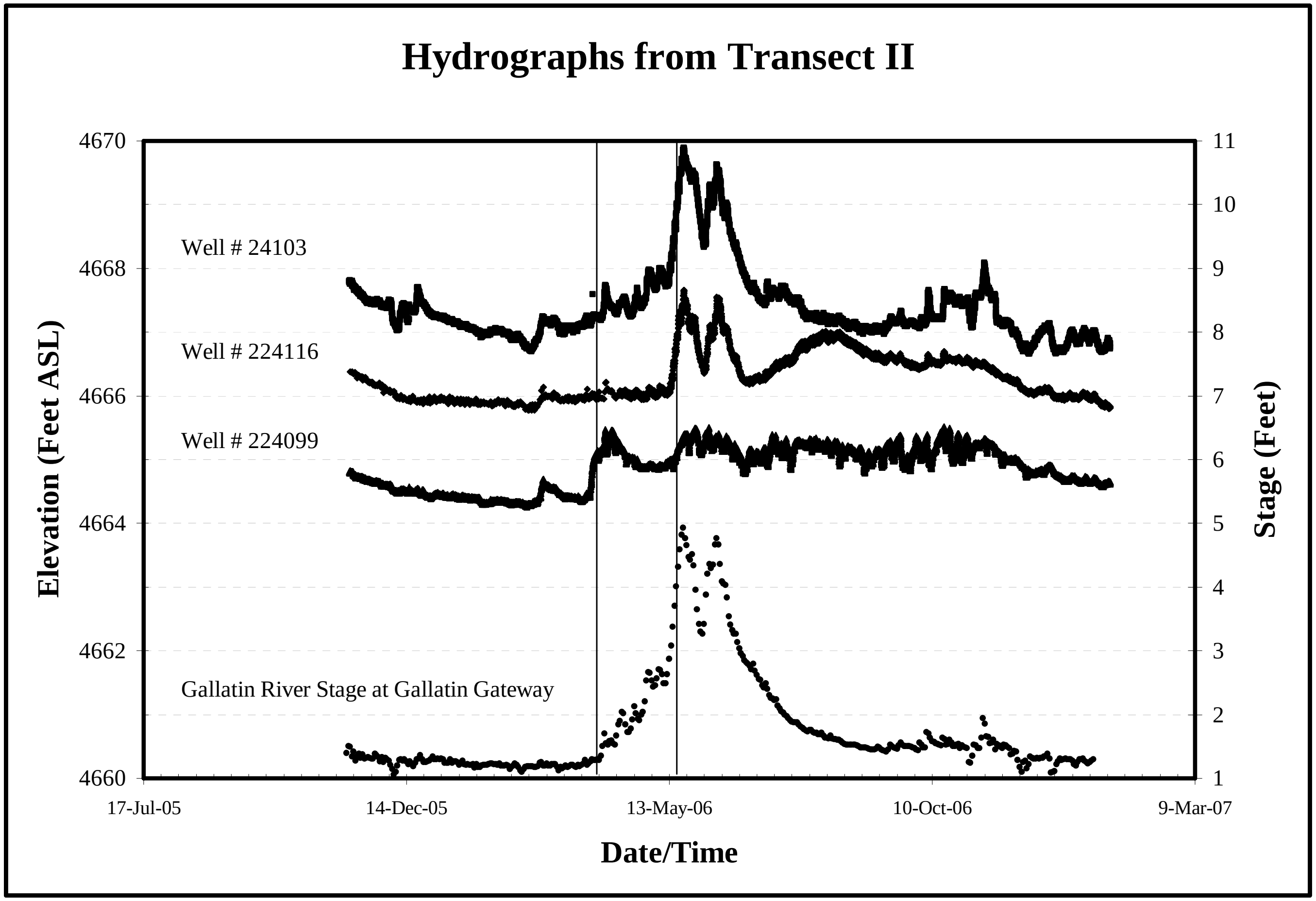

Figure 5. Ground and surface water hydrographs from the West Gallatin River at Gallatin Gateway USGS gauge and the monitoring wells located along Transect II (Figure II). At this transect water leaves the channel to the east and the west, wells 24103 and 224116 respond quickly to changes in the hydrograph, while well 224099 responds to the initial rise but does not exceed 4665 ft despite the rise in river stage. One possible explanation is that the groundwater traveling from the river east discharges into the Spain Ferris Irrigation Canal located between well 224099 and 224116.

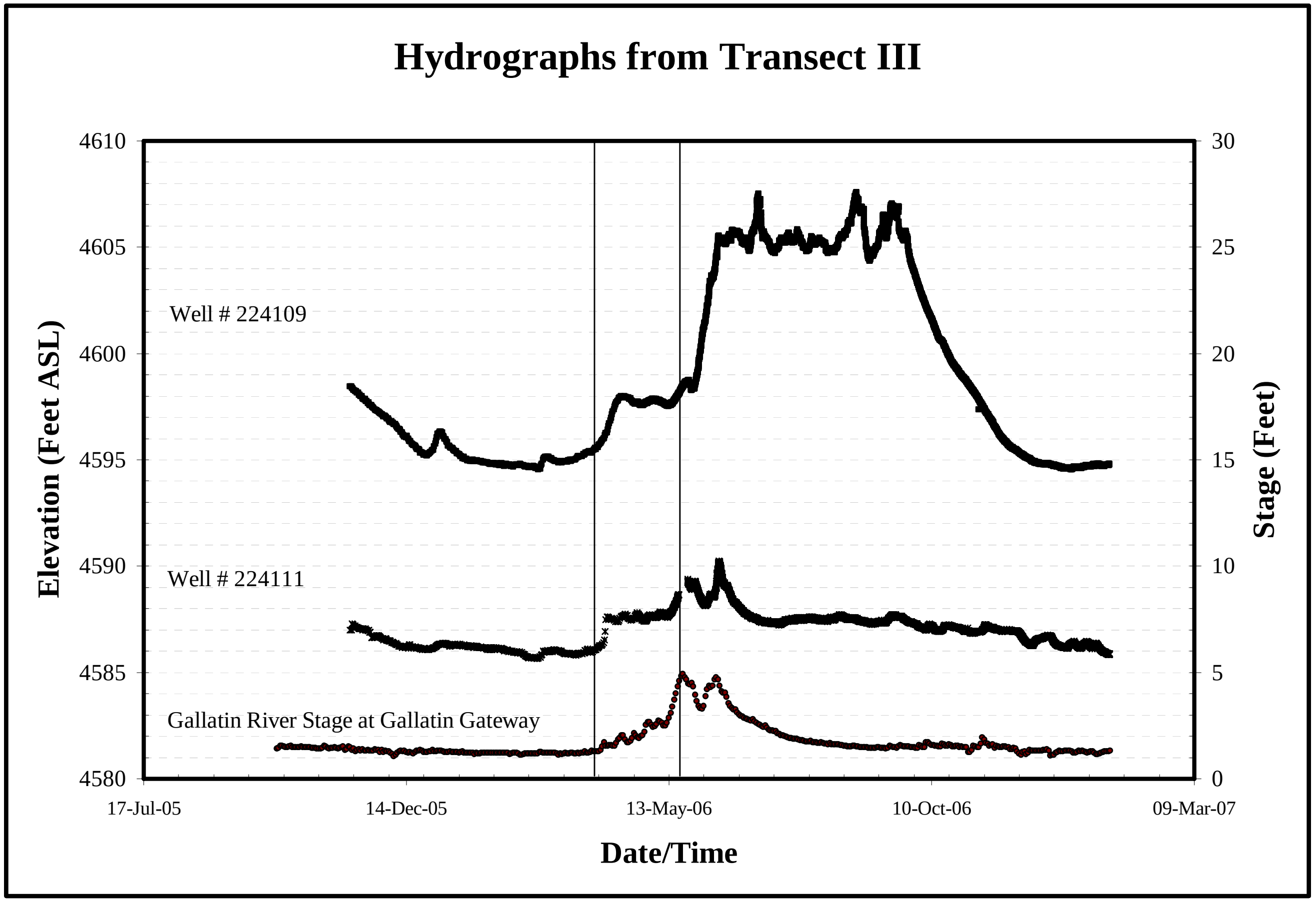

Figure 6. Ground and surface water hydrographs from Gallatin Gateway USGS Gauge and the monitoring wells located along Transect III (Figure 3). Well 224111 initially responds to changes in river stage, however during irrigation season rises despite declines in river stage, indicating that during the winter water flows from the river into the aquifer until groundwater elevations are elevated by irrigation during the summer. Well number 224109, located below a flood irrigated field shows a dramatic rise during irrigation season.

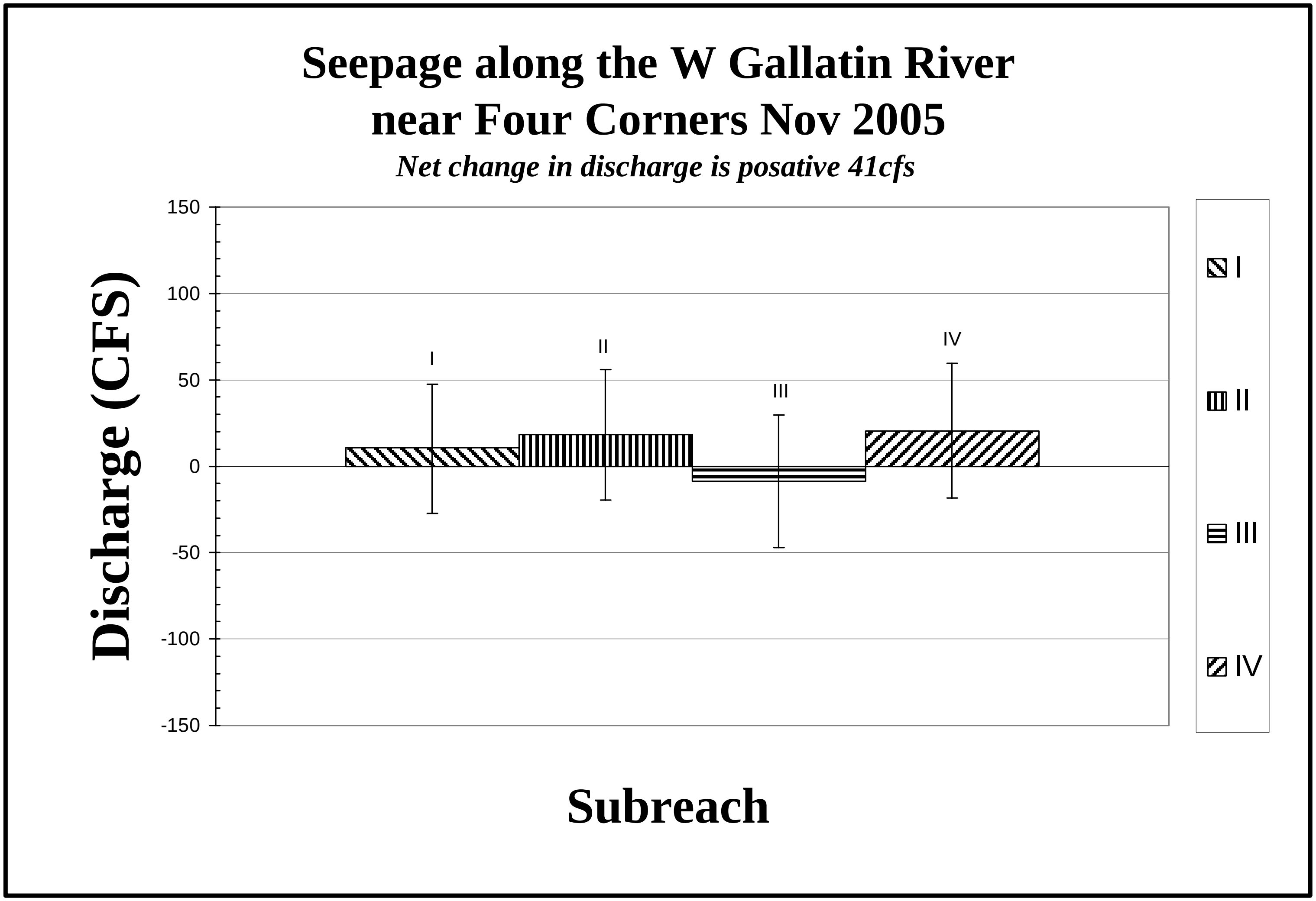

Figure 7. Change in discharge along four consecutive reaches of the West Gallatin River near Four Corners in November 2005. Note the decline in discharge across Reach III located near Shed's Bridge.

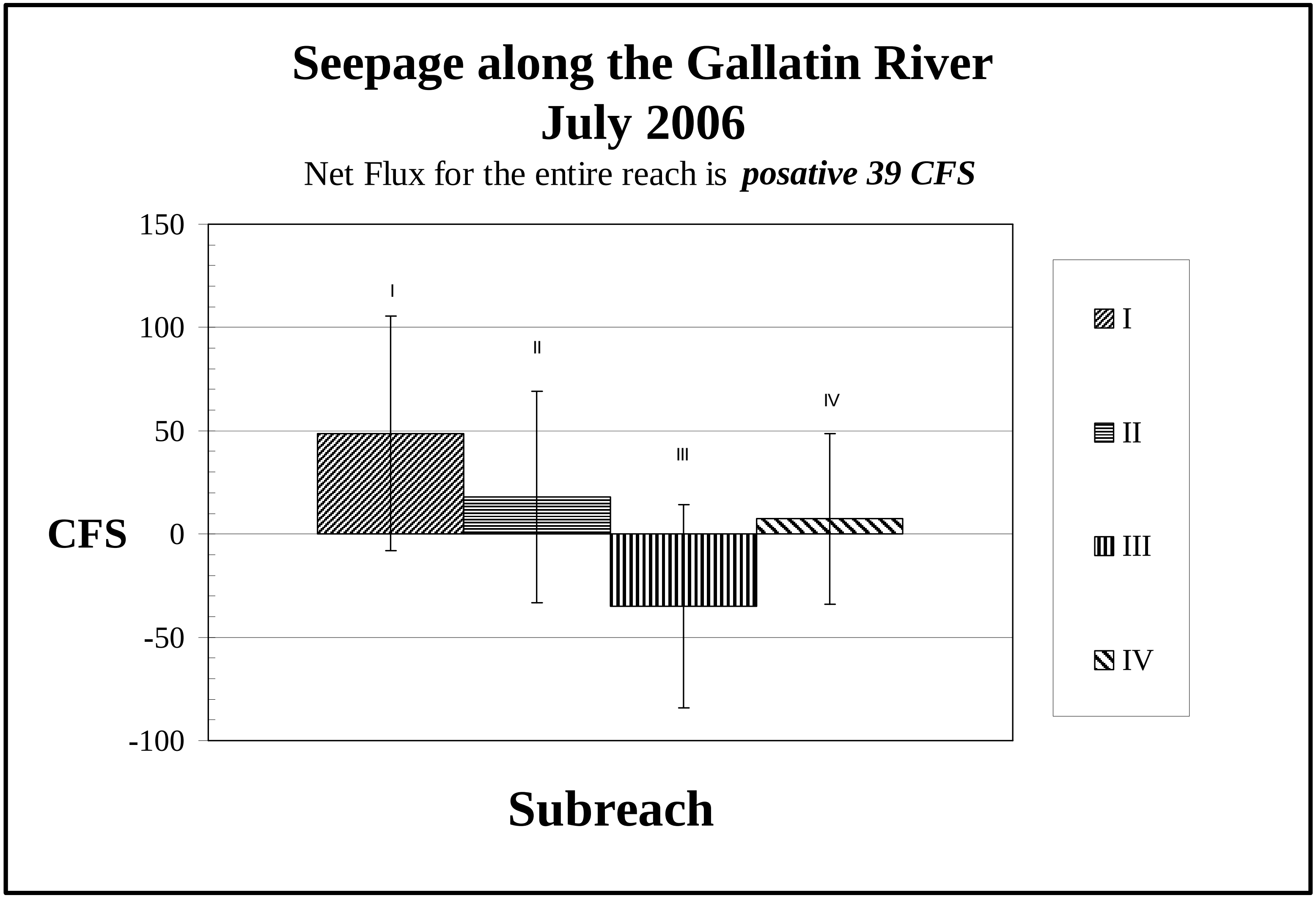

Figure 8. Change in discharge along four consecutive reaches of the West Gallatin River near Four Corners in July 2006. Note the decline in discharge across Reach III located near Shed's Bridge.

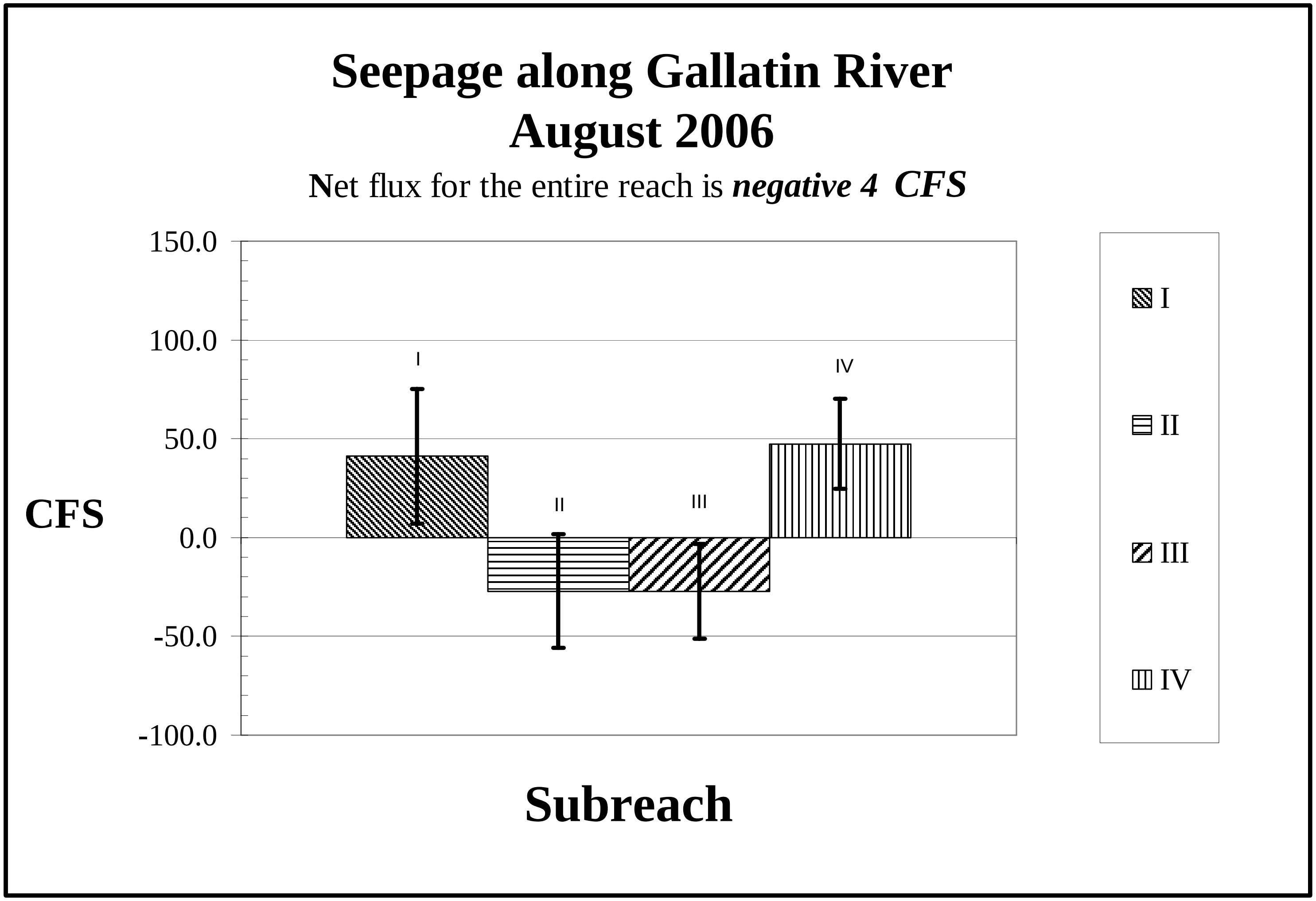

Figure 9. Change in discharge along four consecutive reaches of the West Gallatin River near Four Corners in August 2006. Note the decline in discharge across Reaches III and IV located near Shed's Bridge.

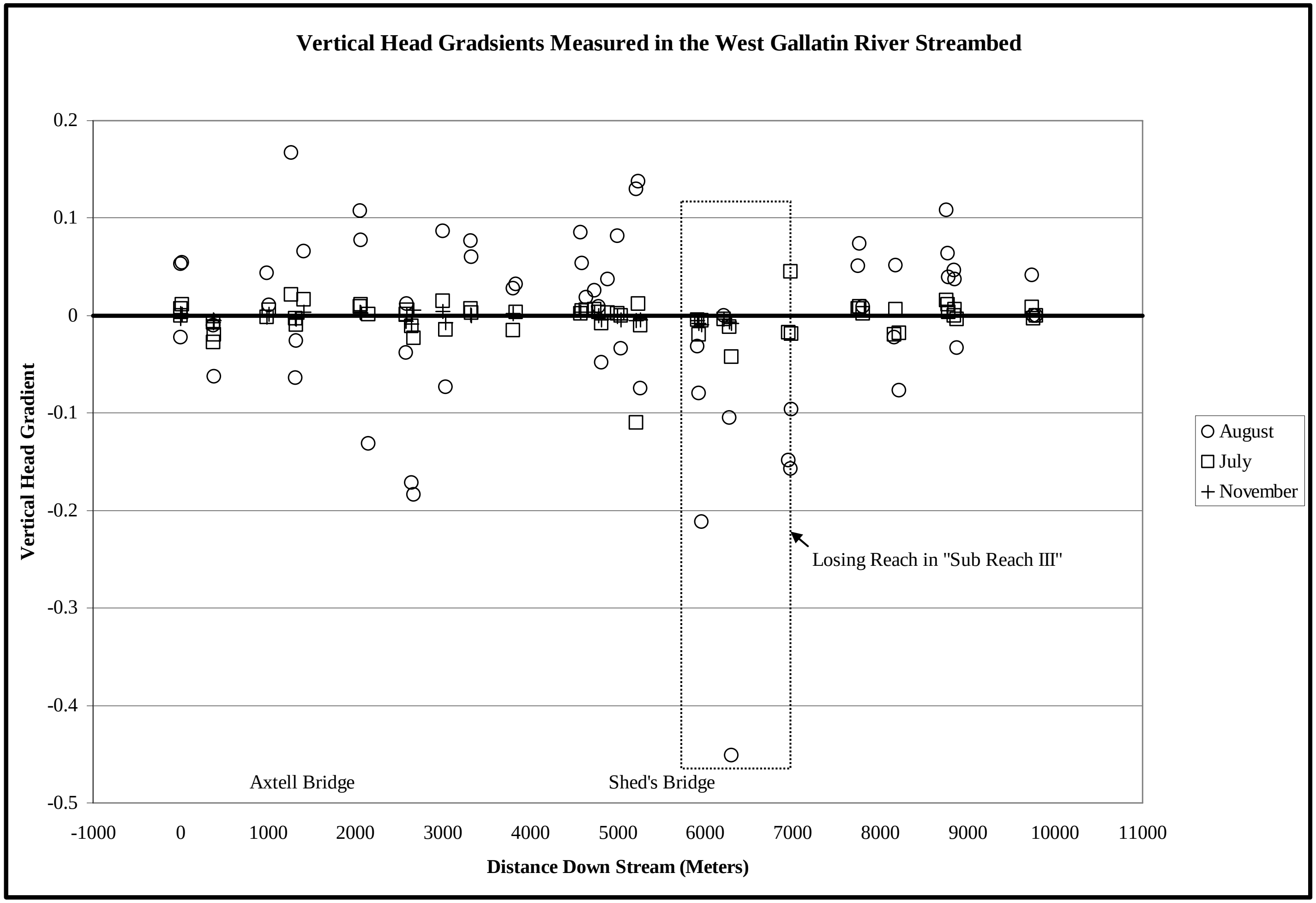

Figure 10. Vertical head gradients measured in streambed piezometers in the West Gallatin Riverbed. Note the absence of upward gradients in Reach III, which showed losses in November, July and August(Figure 7,8,and 9). However in the other reaches (I, II, and IV) which show net gains (Figures, 7, 8, and 9) vertical gradients indicate gains and losses on the scale of meters indicative of hyporheic exchange.

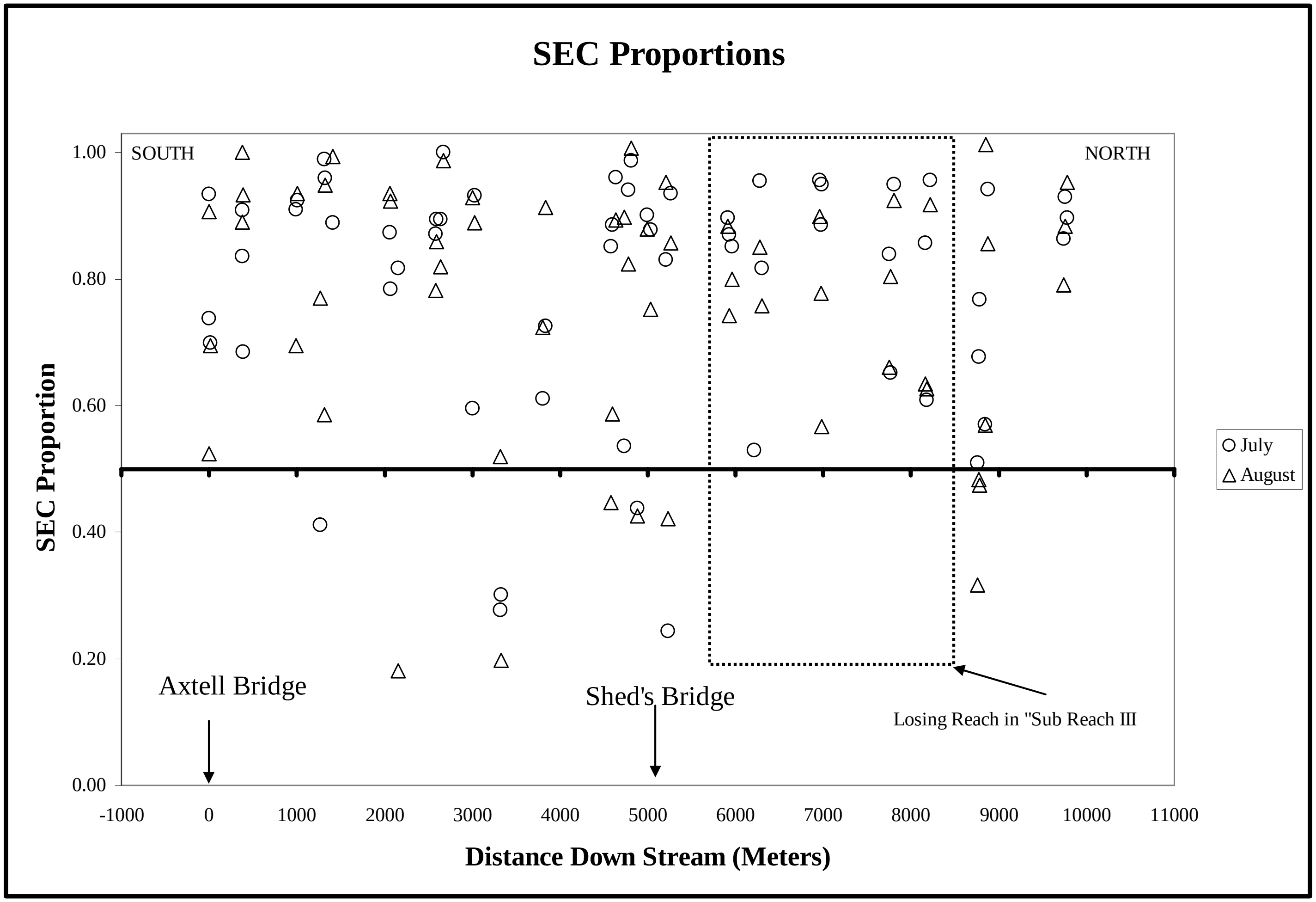

Figure 11. SEC proportions measured in streambed piezometers in the West Gallatin River. The SEC proportion is a measure of the mixing of surface and groundwater, values of 1 are pure river water, values of 0 are pure groundwater, and values greater than 0.5 are more than 50 % river water while values less than 0.5 are more than 50% groundwater. Note the absence of groundwater in Reach III, which shows losses in November, July and August (Figure 7, 8, and 9).

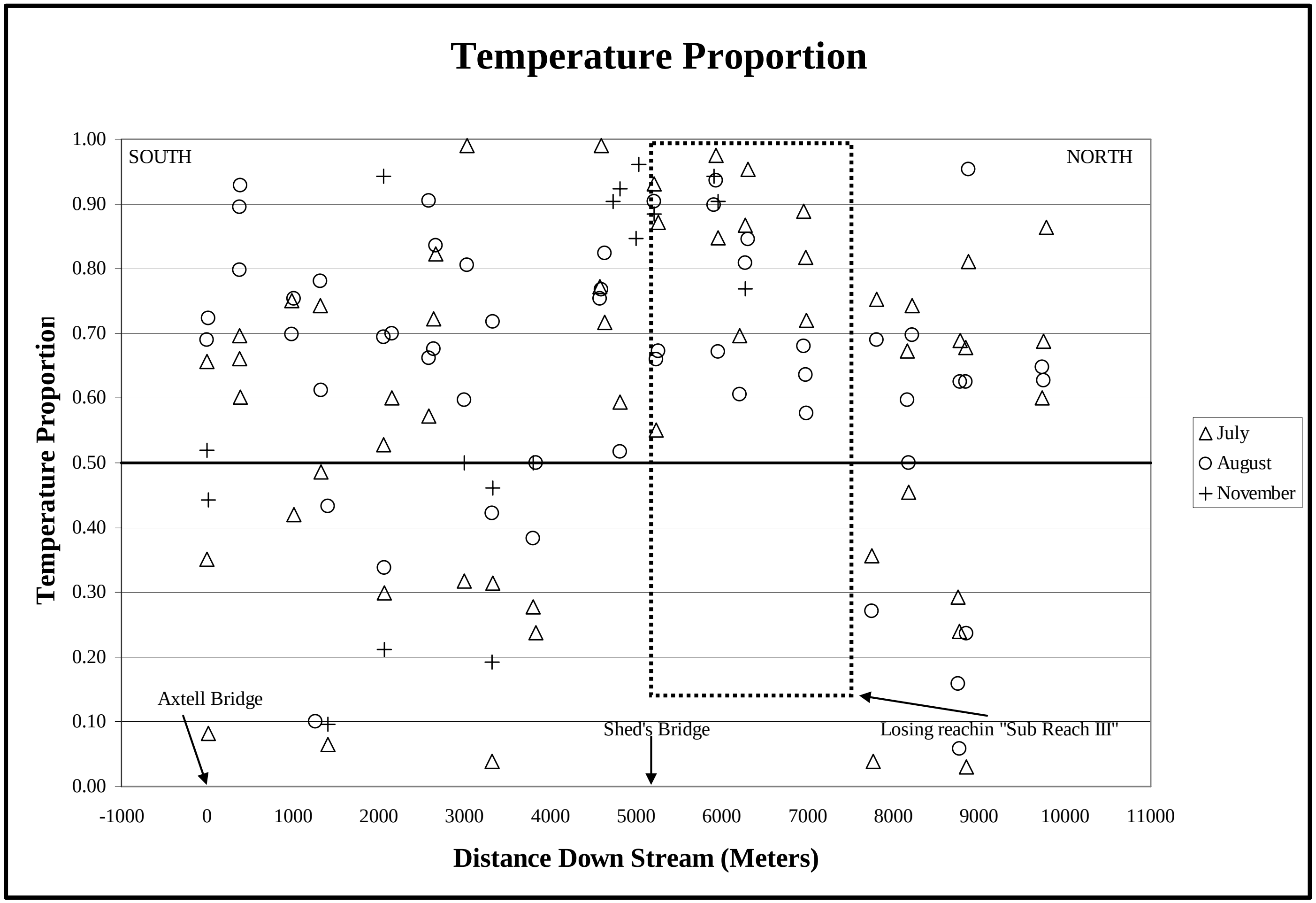

Figure 12. Temperature proportions measured in streambed piezometers in the West Gallatin River. The temperature proportion is a measure of the mixing of surface and groundwater, hyporheic cooling aside, values of 1 are pure river water, values of 0 are pure groundwater, and values greater than 0.5 are more than 50 % river water while values less than 0.5 are more than 50% groundwater. Note the absence of groundwater in Reach III, which shows losses in November, July and August (Figure 7, 8, and 9). The absence of cooling from groundwater discharge and hyporheic exchange has important ecologic implications.