Wood River Valley Aquifer Model
Version 1
Simulated Curtailment of Groundwater Use

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Introduction

The recently completed Groundwater-Flow Model for the Wood River Valley Aquifer System (Fisher et al., 2016) was used to simulate curtailment of groundwater irrigation in the Wood River Valley. The purpose of the simulation is to provide general information regarding the impacts of the consumptive use of groundwater in the Wood River Valley on surface water flow in the Big Wood River and Silver Creek.

The groundwater-flow model was used to simulate curtailment of non-exempt groundwater irrigation in the Wood River Valley. Exempt domestic irrigation, where a domestic well is used to irrigate less than ½ acre, was excluded from the curtailment simulation. Irrigation covered by groundwater rights mitigated with non-use of surface water rights was also excluded from the curtailment simulation. Irrigation within municipal service areas and subdivisions with centralized water systems was included in the curtailment simulation. The exempt and mitigated groundwater use excluded from the simulation comprises approximately 5% of the total consumptive use of groundwater within the model area.

Because a portion of the Big Wood River is perched and the extent of the perched reach varies with time, there is significant non-linearity in the groundwater-flow model. Because of the non-linearity, the use of superposition is not recommended with this model. Therefore, the curtailment simulations were run using 1995-2010 conditions as a baseline. The baseline conditions are equivalent to conditions simulated in the calibrated model (Fisher et al., 2016). Two curtailment simulations were performed. The first simulates curtailment of non-exempt groundwater irrigation during every year of the 1995-2010 period. The second simulates curtailment of non-exempt groundwater irrigation only during 2007, the year with the highest estimated consumptive use of groundwater. The curtailment simulations were performed by adjusting the baseline MODFLOW well file to reduce non-exempt groundwater pumping and associated incidental recharge. The spatial distribution of adjustments to groundwater pumping and incidental recharge is illustrated in Figure 1 through Figure 4. The modified well file for each scenario was generated using the "Wood River Valley Junior Groundwater Tool," with a priority date of January 1, 1890. A copy of the tool is included with the model simulation files at https://idwr.idaho.gov/WaterInformation/Projects/woodriver/. The model version with one time step per stress period, available at https://idwr.idaho.gov/WaterInformation/Projects/woodriver/, was used to perform the baseline and curtailment simulations. Hydrologic responses to the simulated curtailment were calculated by differencing the results of the curtailment simulations from the results of the baseline simulation.

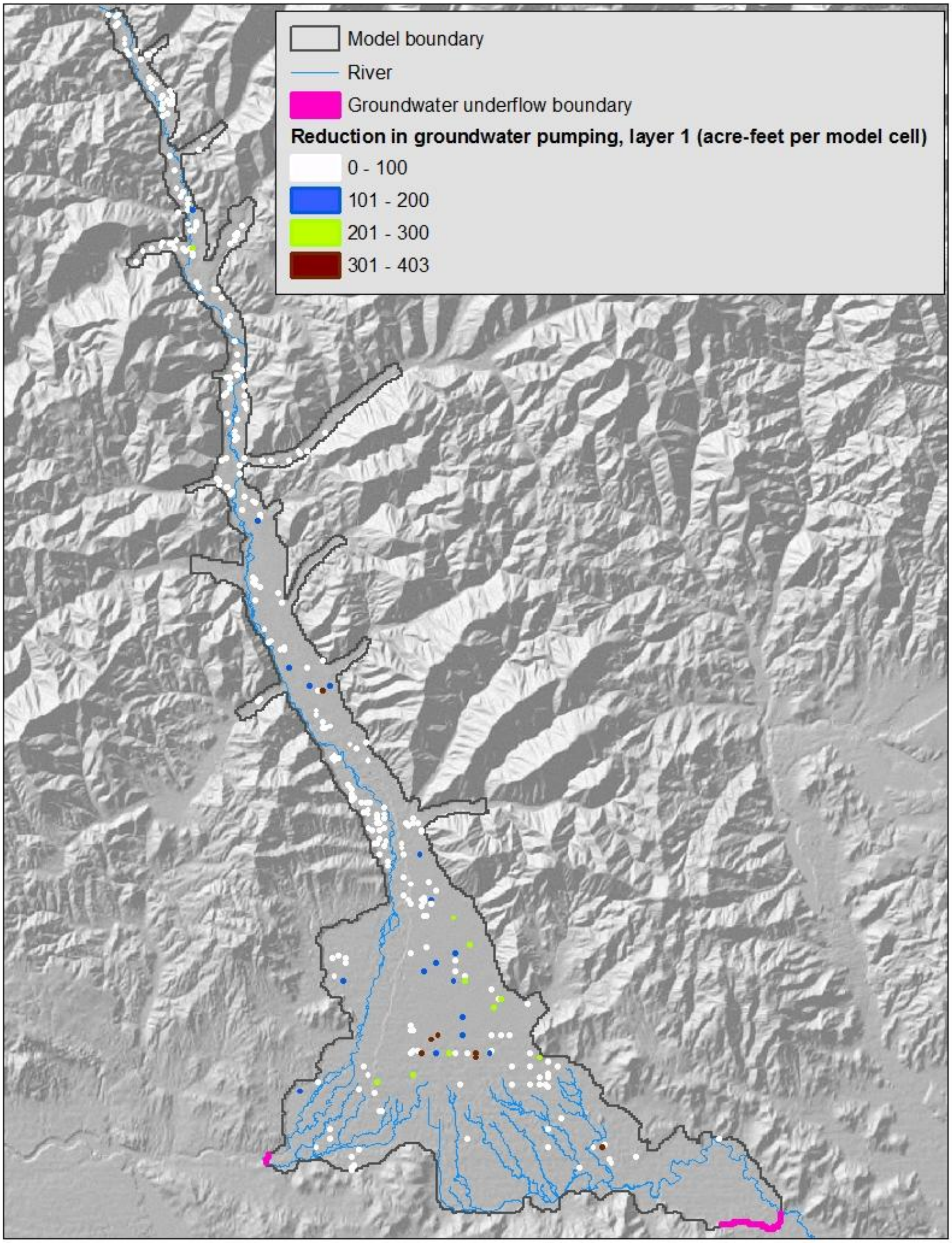

Figure 1. Spatial distribution of simulated reduction in groundwater pumping within model layer 1 (August 2007)

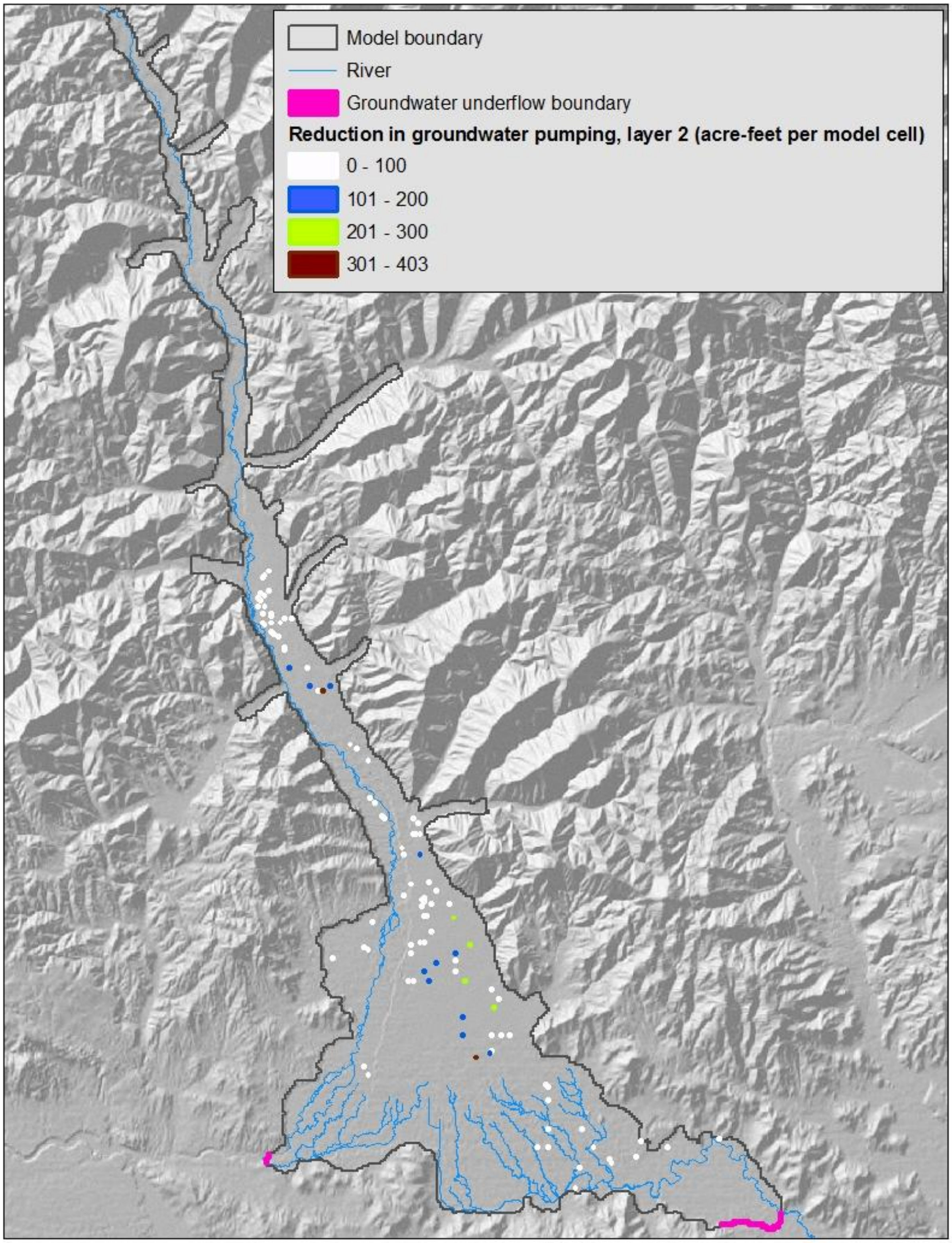

Figure 2. Spatial distribution of simulated reduction in groundwater pumping within model layer 2 (August 2007)

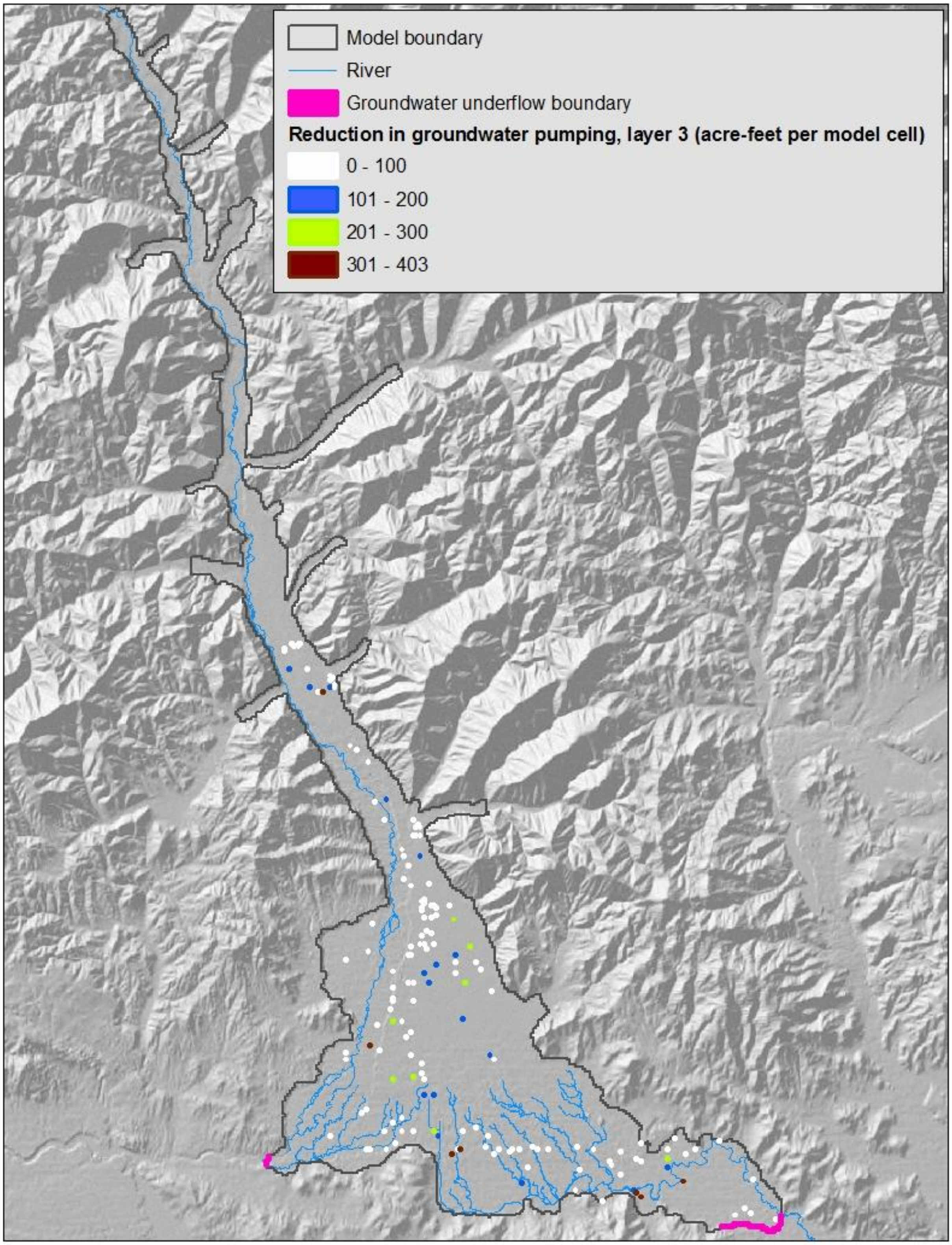

Figure 3. Spatial distribution of simulated reduction in groundwater pumping within model layer 3 (August 2007)

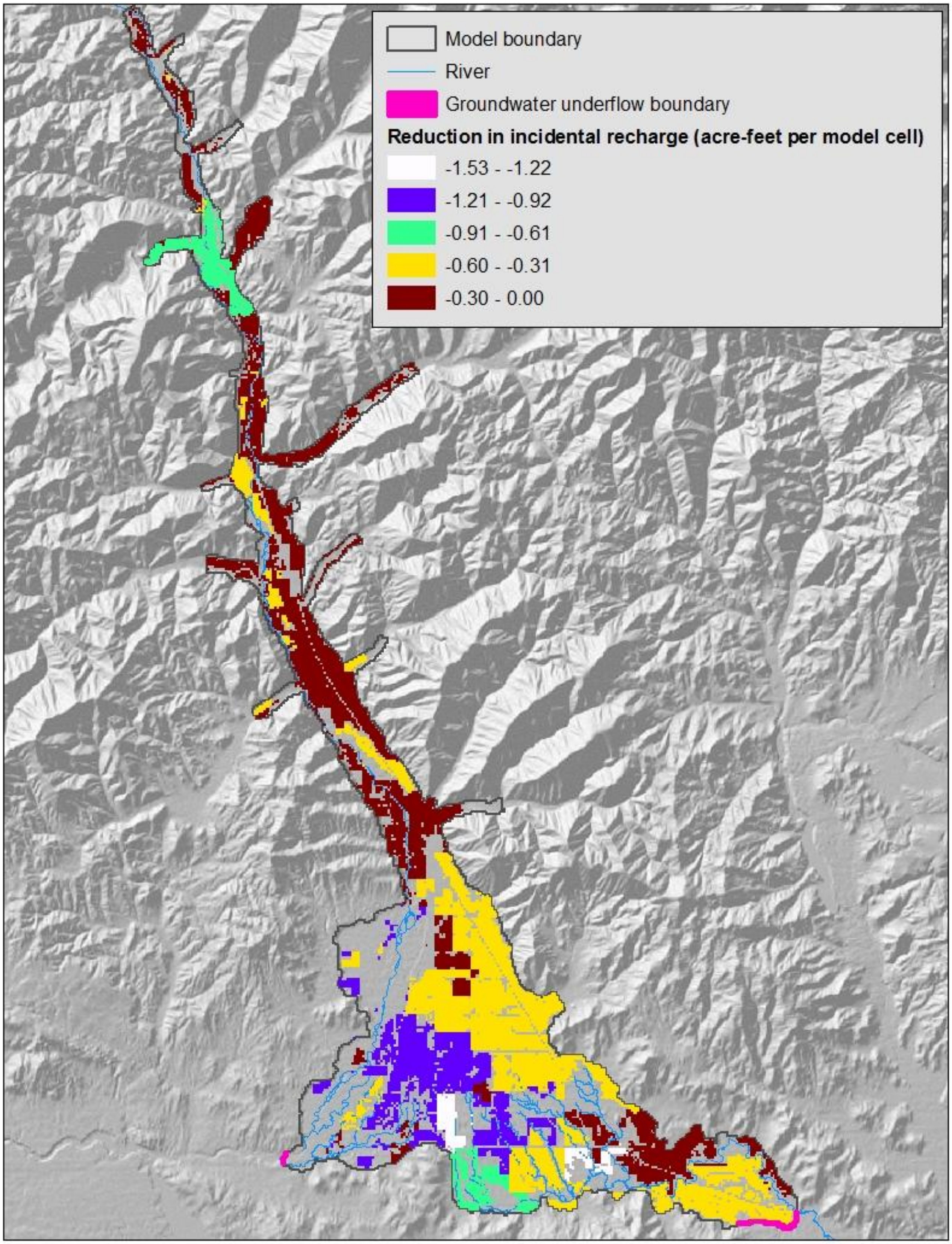

Figure 4. Spatial distribution of simulated reduction in incidental recharge within model layer 1 (August 2007)

Simulated curtailment of groundwater irrigation during 1995 through 2010

The curtailment of groundwater irrigation was simulated by reducing groundwater pumping and incidental recharge. The net change in simulated aquifer stress is equivalent to the consumptive use associated with the curtailed groundwater rights. During 1995-2010, the net annual change in aquifer stress ranged from 15,600 AF in 1998 to 45,500 AF in 2007, averaging 32,400 AF. The total volume of curtailed consumptive use was 518,200 AF over the 16 year period. The net change in aquifer stress varies monthly, as shown in Figure 5. The peak monthly rate was 222 cfs during July 2007. The average rate for 1995-2010 was 45 cfs.

Hydrologic responses to curtailment include changes in aquifer storage, streamflow, and groundwater underflow from the Wood River Valley to the eastern Snake Plain aquifer (ESPA). Aggregate hydrologic responses to curtailment are shown in Figure 5 and Figure 6. The cumulative increase in aquifer storage at the end of the simulation was 24,300 AF, approximately 5% of the curtailed consumptive use. The peak increase in streamflow was 79 cfs in August 2007. The average increase in streamflow for 1995-2010 was 41 cfs, approximately 92% of the curtailed consumptive use. The peak increase in groundwater underflow to the ESPA was 3.5 cfs in February 2003. The average increase in groundwater underflow to the ESPA for 1995-2010 was 1.5 cfs, approximately 3% of the curtailed consumptive use.

Hydrologic responses by river are shown in Figure 7. Aquifer discharge to the Big Wood River and Willow Creek is predicted to increase by up to 34 cfs, with an average predicted increase of 18 cfs. Aquifer discharge to Silver Creek is predicted to increase by up to 46 cfs, with an average predicted increase of 23 cfs. Approximately 65% of the increase in river reach gains is predicted to occur during the irrigation season (April through October) and approximately 35% of the increase is predicted to occur during the non-irrigation season (November through March).

Hydrologic responses at outlet boundaries are shown in Figure 8. Groundwater underflow to the ESPA at the model boundary near Picabo is predicted to increase by up to 3.5 cfs, with an average predicted increase of 1.5 cfs. The predicted change in groundwater underflow at the model boundary near Stanton Crossing is negligible.

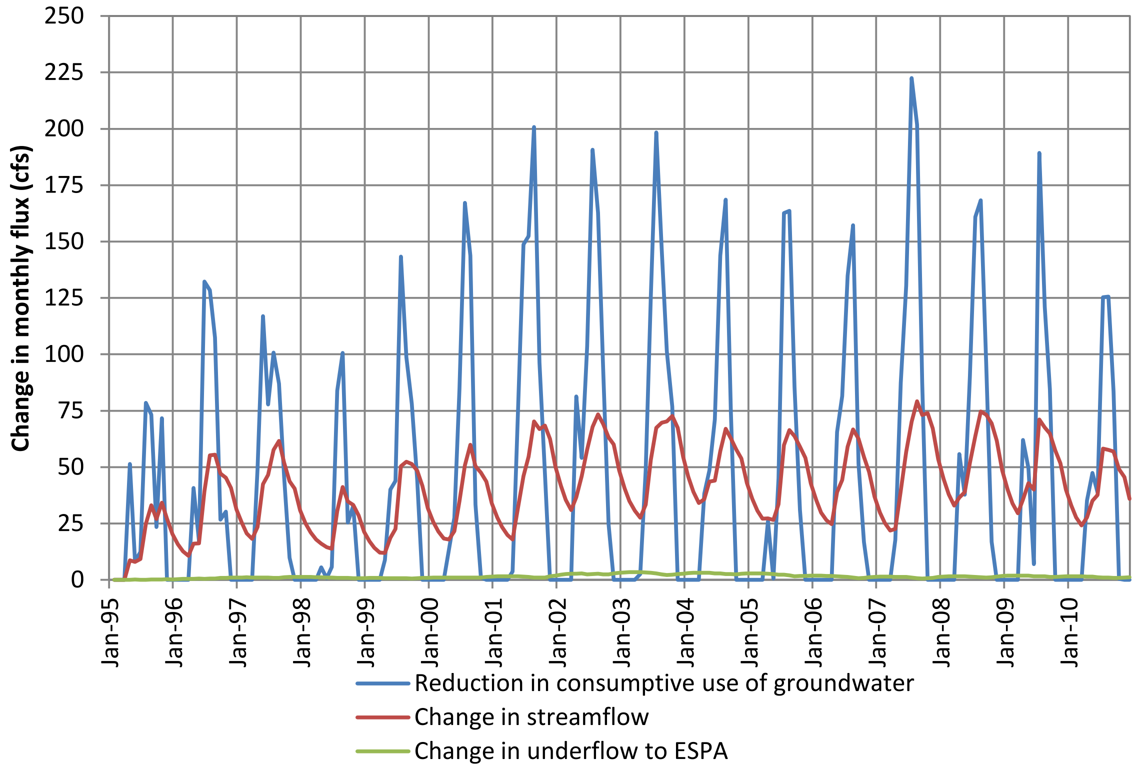

Figure 5. Hydrologic response to simulated curtailment of non-exempt groundwater irrigation (1995-2010)

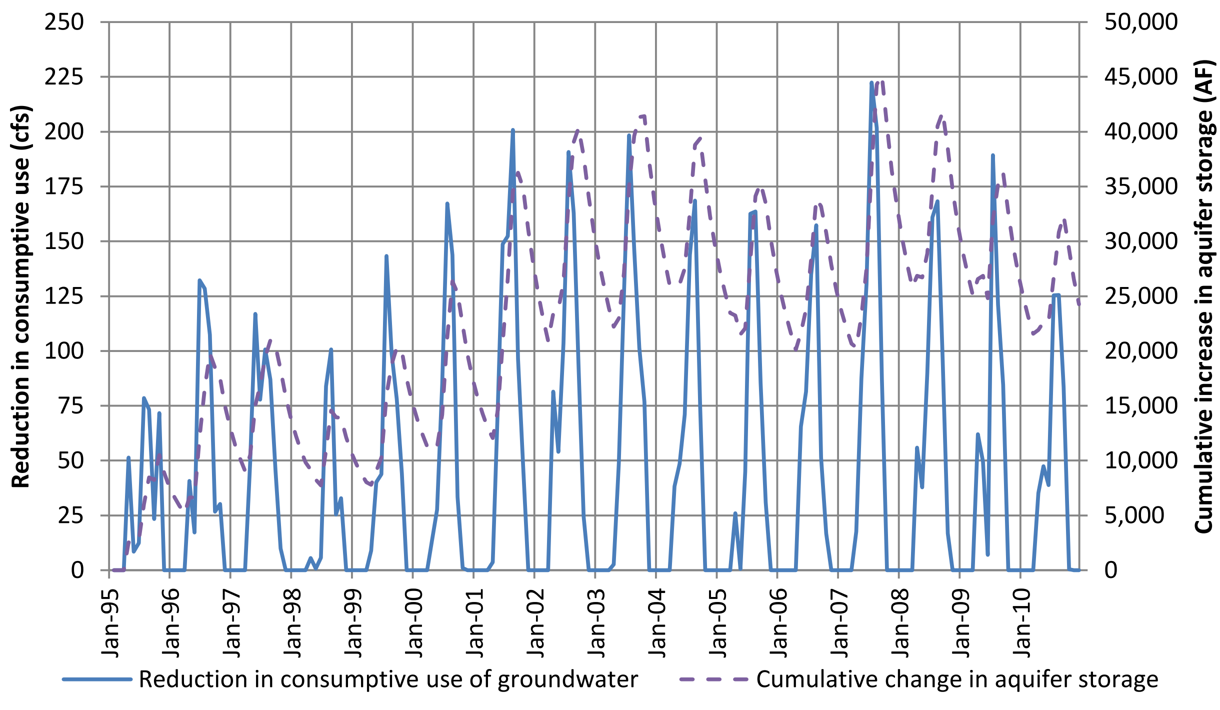

Figure 6. Change in aquifer storage resulting from simulated curtailment of non-exempt groundwater (1995-2010)

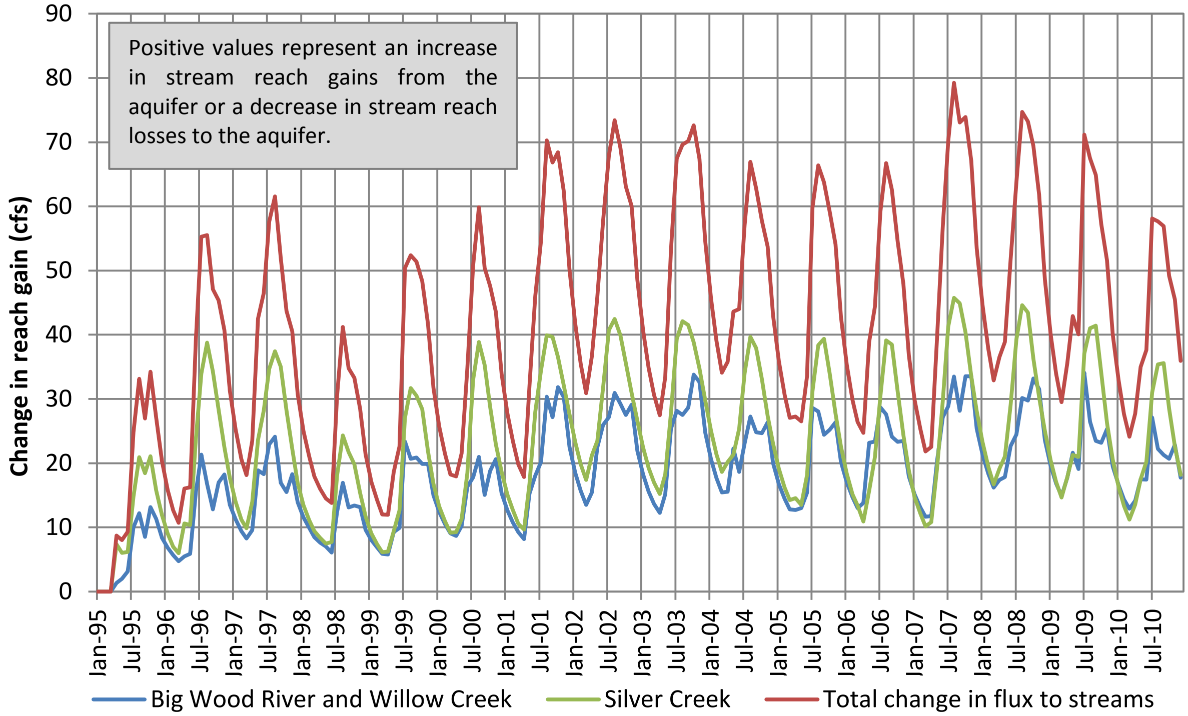

Figure 7. Predicted increase in streamflow in response to curtailment of non-exempt groundwater irrigation (1995-2010)

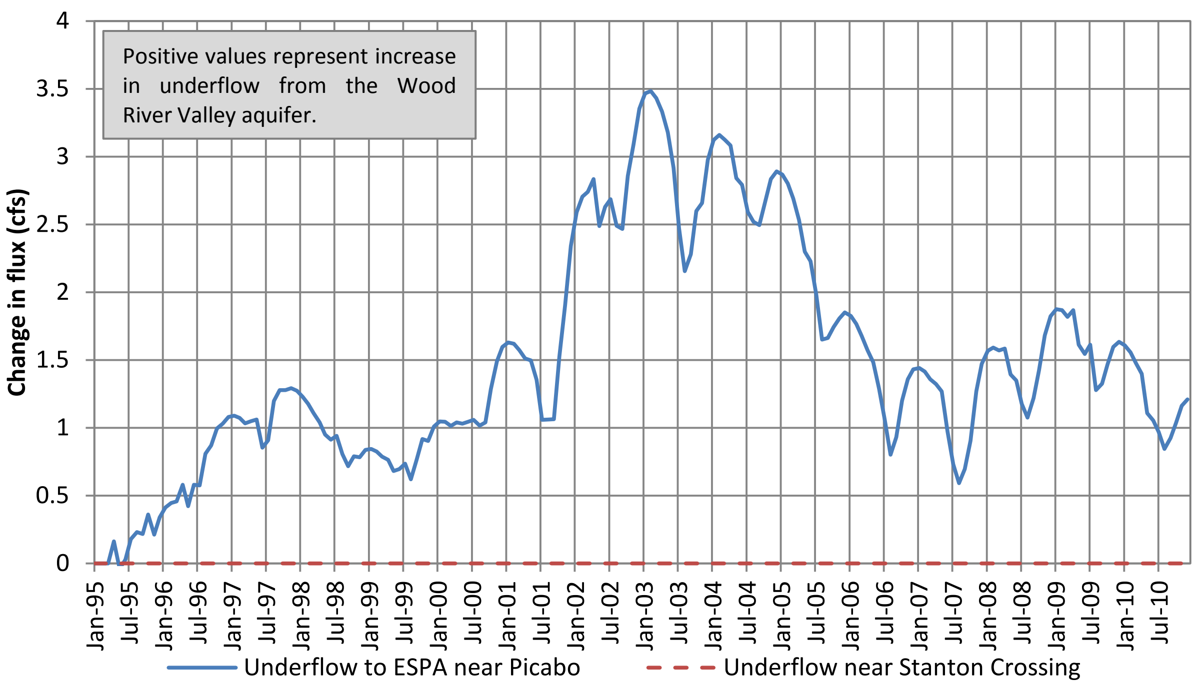

Figure 8. Predicted increase in groundwater outflow in response to curtailment of non-exempt groundwater irrigation (1995-2010)

Simulated curtailment of groundwater irrigation during 2007

Curtailment of non-exempt groundwater during only the year of 2007 was simulated to illustrate the predicted impact of a single year of curtailment during a dry year. During 2007, the net change in aquifer stress was 45,500 AF. The net change in aquifer stress varies monthly, as shown in Figure 9. The peak monthly rate was 222 cfs during July 2007. The average rate for the 2007 irrigation season was 107 cfs.

Hydrologic responses to curtailment include changes in aquifer storage, streamflow, and groundwater underflow from the Wood River Valley to the Eastern Snake Plain Aquifer (ESPA). Aggregate hydrologic responses to curtailment are shown in Figure 9 and Figure 10. The peak increase in streamflow was 71 cfs in August 2007. The peak increase in groundwater underflow to the ESPA was 1.1 cfs in March 2008. During the 2007 irrigation season (April through October), the average increase in streamflow was 47 cfs (approximately 44% of the curtailed consumptive use) and the change in underflow to the ESPA was negligible. During the 2008 irrigation season, the average increase in streamflow was 13 cfs (approximately 12% of the curtailed consumptive use) and the average increase in underflow to the ESPA was approximately 1 cfs. During the 2009 irrigation season, the average increase in streamflow was 3 cfs (approximately 3% of the curtailed consumptive use) and the average increase in underflow to the ESPA was approximately 1 cfs. The cumulative increase in aquifer storage at the end of the 2007, 2008, and 2009 irrigation seasons was 56%, 16%, and 8% of the curtailed consumptive use, respectively.

Hydrologic responses by river are shown in Figure 11. Aquifer discharge to the Big Wood River and Willow Creek is predicted to increase by up to 29 cfs in August 2007. Aquifer discharge to Silver Creek is predicted to increase by up to 42 cfs in August 2007. Approximately 65% of the increase in river reach gains is predicted to occur during the irrigation season (April through October) and approximately 35% of the increase is predicted to occur during the non-irrigation season (November through March).

Hydrologic responses at outlet boundaries are shown in Figure 12. Groundwater underflow to the ESPA is predicted to decline slightly at the end of the 2007 irrigation season because of the reduction in incidental recharge from groundwater irrigation close to the model boundary. As shown in Figure 1 through Figure 4, there is no simulated reduction in pumping from layer 1 and little reduction in pumping from lower layers in the immediate vicinity of the outlet boundary, but there is a reduction in incidental recharge adjacent to the outlet boundary. The reduction in incidental recharge is a negative aquifer stress that propagates to the outlet boundary more rapidly than the positive stress of reducing pumping at more distant locations. Predicted groundwater underflow to the ESPA begins to increase slightly in October 2007 and peaks at an increase of 1.1 cfs in the spring of 2008. The predicted change in groundwater underflow at the model boundary near Stanton Crossing is negligible.

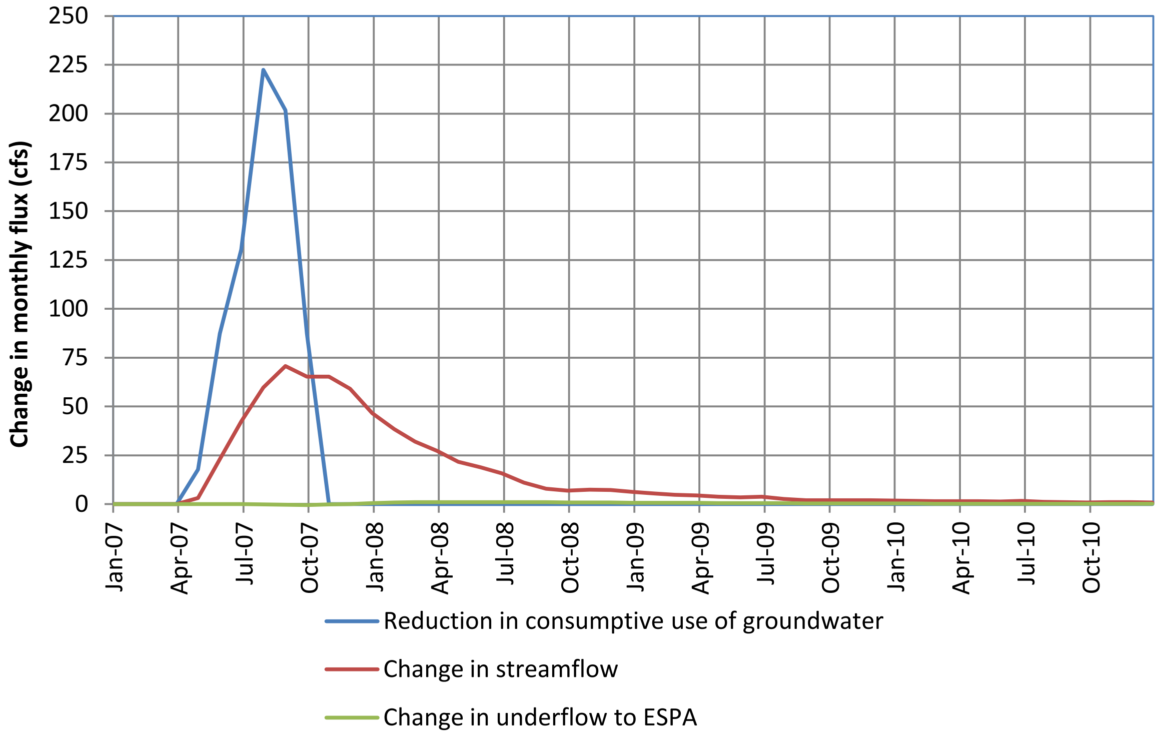

Figure 9. Hydrologic responses to simulated curtailment of non-exempt groundwater irrigation (2007)

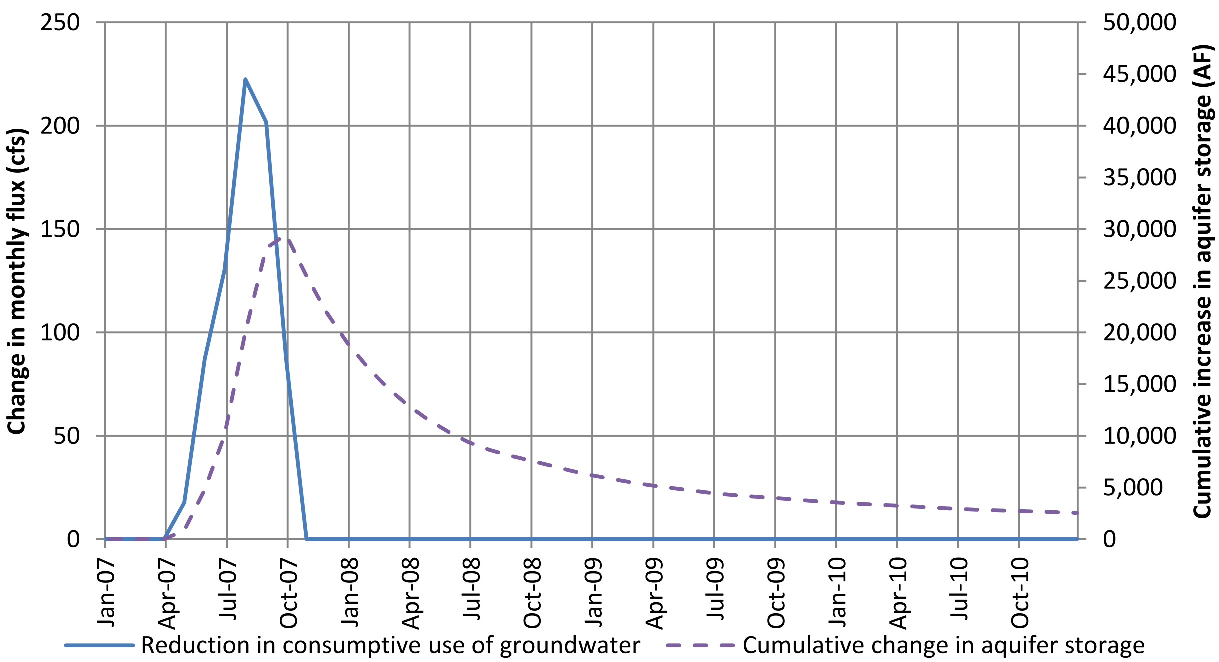

Figure 10. Change in aquifer storage resulting from simulated curtailment of non-exempt groundwater (2007)

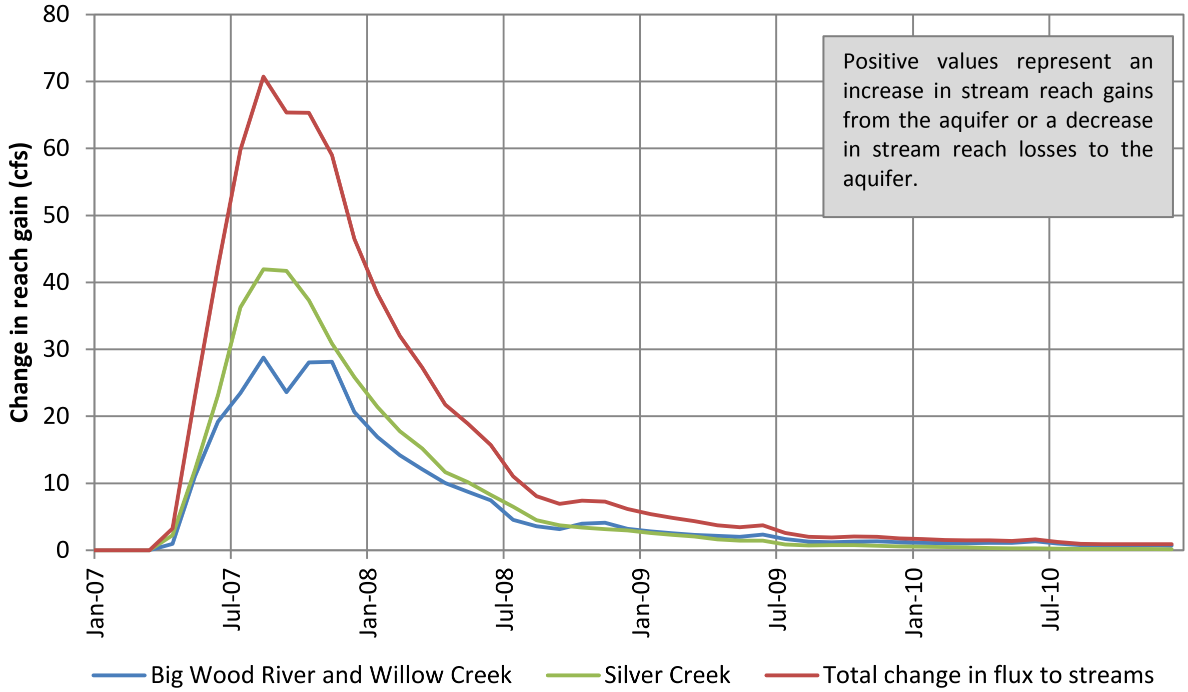

Figure 11. Predicted increase in streamflow in response to curtailment of non-exempt groundwater irrigation (2007)

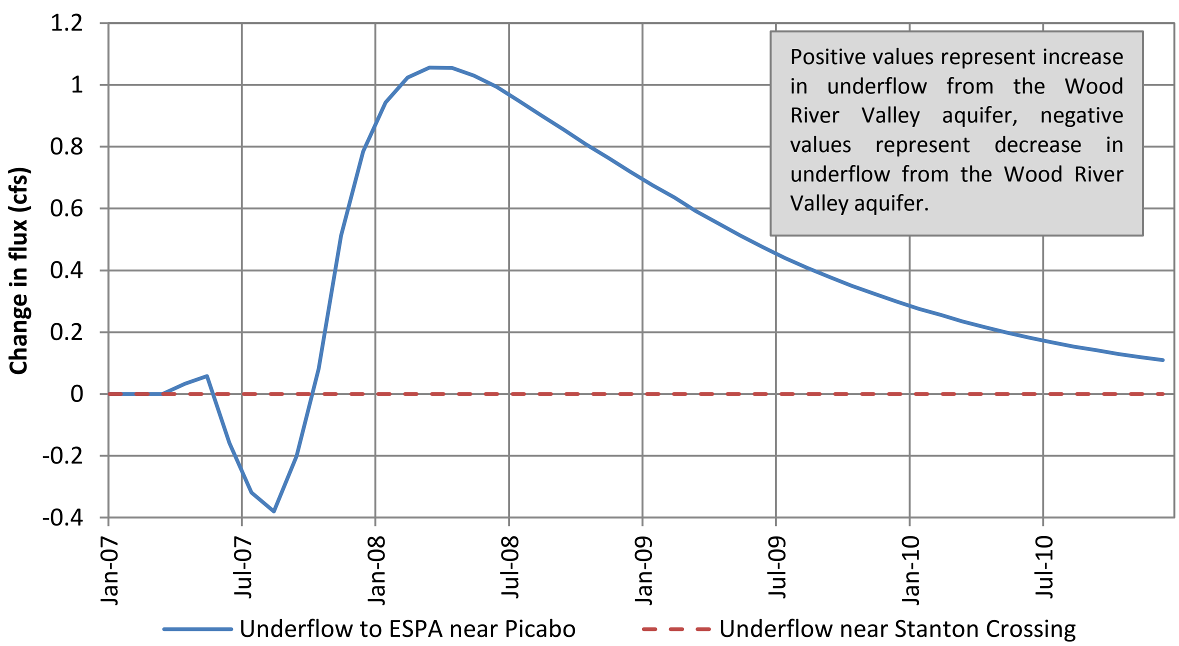

Figure 12. Predicted increase in groundwater outflow in response to curtailment of non-exempt groundwater irrigation (1995-2010)

Limitations of model simulations

The simulations of groundwater curtailment are intended to improve the understanding of groundwater/surface-water interaction within the Wood River Valley on a regional scale. Because historic measurement of groundwater diversions was limited, the majority of groundwater diversions were estimated during development of the groundwater-flow model as described in Fisher et al. (2016) and Sukow (2014). Surface water diversions and surface water priority dates were considered in the calculation of estimated groundwater diversions on mixed source lands, but the spatial resolution of surface water deliveries was generally limited to canal service areas. While the volume of estimated groundwater diversions and the simulated volume of curtailed consumptive use within irrigation entities (Fisher et al., 2016; Sukow, 2014) are reasonable estimates on a regional scale, volumes simulated at a specific well site may not be an accurate estimate of historic use at the local scale. Thus, these simulations are intended to be used to evaluate hydrologic responses to regional groundwater use. The spatial representation of groundwater pumping in these simulations should not be used to evaluate the impacts of a single well.

Prediction of the timing of hydrologic responses to curtailment of groundwater use is constrained to the extent time-series data were available to calibrate the transient groundwater-flow model. Monthly surface water diversion data and evapotranspiration data provided a reasonable estimate of the timing of incidental recharge during the 1995-2010 model calibration period. Monthly reach gains for most river reaches were available for a significant portion of the calibration period, and provide information on the timing of streamflow responses to aquifer recharge and groundwater pumping. Some transient water level measurement data were available during the model calibration period. The Idaho Department of Water Resources has been collecting additional data to improve future versions of the Wood River Valley groundwater-flow model, including additional transient water level data and additional reach gain data for the near Ketchum to Hailey reach of the Big Wood River and Trail Creek. Recalibration of the model with an extended calibration period (1995-2014) will incorporate a significant amount of new data and is expected to further reduce uncertainty in the prediction of timing of hydrologic responses.

Predictive uncertainty of the groundwater-flow model was evaluated by Wylie (2016). The evaluation indicated that model calibration targets reduced predictive uncertainty for both steady state and transient model simulations, but that predictive uncertainty was higher for the transient simulations. While model recalibration with additional data is expected to reduce the predictive uncertainty for transient simulations, the predictive uncertainty evaluation (Wylie, 2016) indicates that the data used to calibrate the current model version did significantly constrain the calibration of aquifer storage properties. Wylie (2016) concluded the predictive uncertainty of the current model version is low enough that the model is an improvement over the use of analytical solutions to predict the impacts of pumping or recharge on stream reaches.

Compared to the recently published groundwater-flow model, previous groundwater-flow models of the Wood River Valley aquifer system were developed for smaller portions of the aquifer and were calibrated to fewer data collected over much shorter time periods (Fisher et al., 2016). Because the recently published model includes the majority of the Wood River Valley aquifer system and incorporates hydrologic and water use data from a 16-year period, which encompassed a variety of climatic conditions, the recently completed model is the best available tool for predicting the hydrologic impacts of reducing the consumptive use of groundwater.

References

Fisher, J.C., J.R. Bartolino, A.H. Wylie, J. Sukow, M. McVay, 2016, *Groundwater-Flow Model for the Wood River Valley Aquifer System, South-Central Idaho*. U.S. Geological Survey, Scientific Investigations Report 2016-5080, 71 p., https://pubs.er.usgs.gov/publication/sir20165080.

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Wylie, A, 2016, *Wood River Valley Aquifer Model, Version 1, Uncertainty Analysis*. Idaho Department of Water Resources, 10 p., https://idwr.idaho.gov/WaterInformation/Projects/woodriver/.