Visualizing Ground Water and Surface Water Interactions in the Spokane Valley – Rathdrum Prairie

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Background

Surface water and ground water are intimately connected throughout most of the Spokane Valley – Rathdrum Prairie (SVRP). Surface water bodies such as Lake Pend Oreille, Lake Coeur d'Alene, the Spokane and Little Spokane rivers gain water from, and/or lose water to, the underlying SVRP aquifer. The interaction of the surface and ground water has been described in several publications including: Murray (2008), Hsieh et al. (2007), Caldwell and Bowers (2003), Painter (1991), Nace et al. (1970), and Thomas (1963).

Surface and ground water exchange in the basin is important to sustaining both of these resources. Surface water losses provide significant contributions to the aquifer which sustain aquifer water levels and provide water for ground water pumping for municipal and other uses. Seepage to the aquifer from higher elevation lakes and rivers and other recharge also returns to either the Spokane or Little Spokane Rivers at lower elevations, providing additional high quality, cool water contributions to flow in the river. In some locations, and at some times, the aquifer contributions can be a substantial proportion of the total river flow.

Ground water pumping and ground water recharge affect not only aquifer water levels, but also the exchange of water with interconnected surface water bodies. "Interconnected" in this context means that the water table is near or above the bottom of the lake or river, and therefore saturated conditions exist between the surface water and aquifer. When an aquifer is pumped, initially the water comes from water stored in the aquifer. This pumping causes drawdown in aquifer water levels which eventually propagates to interconnected surface water bodies. At this point, the rate of exchange of water between surface and ground water changes in response to the pumping. Losing lakes and rivers will lose more water and gaining lakes and rivers will gain less. The increased losses or decreased gains are both considered surface water depletion. After a sufficiently long period of continuous pumping (different times for different aquifers and locations) the system will approach a new equilibrium where the total depletion of all surface water bodies is the same as the rate of aquifer pumping. Aquifer recharge has the opposite effect of pumping, causing accretion of interconnected surface water bodies.

How to Read the Maps

These maps illustrate the location, timing, and magnitude of the effects of **continuous** ground water pumping and recharge on surface water bodies in the SVRP area. The maps show the areal distribution of the **percentage of pumping or recharge** which appears as depletion or accretion in specific surface water bodies in the SVRP at specific times. Results are presented for six surface water bodies: 1) the

Spokane River above the Spokane gage; 2) the Spokane River between Avista Dam and Deep Creek; 3) the Spokane River below Deep Creek combined with Little Spokane below Painted Rocks gage and Long Lake; 4) Little Spokane River above Painted Rocks gage; 5) Lake Coeur d'Alene; and 6) Lake Pend Oreille.

The accompanying maps show that in locations nearer the surface water body, a larger proportion of pumping or recharge appears as depletion or accretion at earlier times. The proportion not coming from the reach of interest (100 minus percentage shown) originates either from aquifer storage (by lowering the water table) or another surface water body. For example, consider a hypothetical situation where one is interested in estimating the impact of a past or proposed future continuous pumping of 5 cfs at Point E (shown on the pie chart map) in the central Rathdrum Prairie on the Spokane River. Examination of the maps showing capture for the Spokane River above the Spokane gage would indicate that after about one year of continuous pumping, nearly half of the pumping rate (2.5 cfs) would appear as depletion of that reach. After 10 years, however, the situation has approached an equilibrium condition (later times show similar effect) where more than 80% of the pumping (4 cfs) is appearing as depletion of that reach.

A map is also provided that shows the proportion of recharge or stress that affects each reach at steady state (pie charts). Steady state occurs after 5 years or more throughout the aquifer and at that point all aquifer pumping and recharge effects are appearing as river and lake capture. A second map contains superimposed graphs illustrating how capture varies over time at specific locations.

Some of the other lakes surrounding the aquifer are also interconnected with the aquifer, however, aquifer pumping and recharge effects on the seepage from these lakes is thought to be minimal due to lower aquifer transmissivity in these areas (Murray, 2008).

As a whole, the series of maps shows the following general concepts:

- Pumping or recharge at most locations in the aquifer will have the greatest impacts on the Spokane River above the Spokane gage, or Lake Pend Oreille.
- In the portion of the aquifer immediately below Trinity Trough, nearly all pumping or recharge effects are concentrated on that specific river reach because the aquifer is constricted at Trinity Trough and discontinuous at the lower end.
- Near the Little Spokane River pumping or recharge effects are concentrated on the Little Spokane River .
- In most areas of the SVRP, near steady state conditions are reached within about 5 years of the onset of a continuous pumping or recharge activity.

How the Maps were Developed

The maps were created by performing one simulation of the Modflow aquifer model developed by Hsieh and others (2007) for each of the 5268 active cells (1/4 mile square) of the model. In these simulations a recharge of 0.116 cfs was applied, in turn, to each cell and changes to the gains and losses of the six reaches were recorded for various elapsed pumping times. Changes in gains and losses were expressed as a percentage of the recharge rate and these values were mapped to provide the estimates of capture illustrated in the figures. It should be noted that these maps provide an estimate of ground water pumping and recharge impacts on the surface water, but there are uncertainties and limitations associated with the development of the aquifer model, and with its application to estimate capture. A further description of limitations is provided in Johnson, et al. (2008).

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