Boise Mountain Front Recharge: Treasure Valley Aquifer System <u>Groundwater-Flow Model</u>

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Background

One of the more difficult components of a water budget to obtain is flow from an adjacent mountain front into an aquifer, often called mountain front recharge. Measuring mountain front recharge is complicated and expensive, requiring numerous detailed long term measurements that usually are not available.

It may be possible to use an alternate method to estimate the mountain front recharge that would not require the detailed measurements. Carter and Driscoll (2006) developed a relationship between yield efficiency of a watershed and elevation. The total yield of a watershed is defined as the surface and subsurface outflow; yield efficiency is the percentage of annual precipitation partitioned to yield. The premise behind Carter and Driscoll's analysis is that average annual precipitation tends to increase with altitude and evapotranspiration tends to decrease with altitude, thus yield efficiency tends to increase with altitude.

Aishlin (2006) calculated groundwater recharge for the Dry Creek Experimental Watershed in the Boise Front (Figure 1) using a chloride mass balance. She calculated 0.0% to 11% of the annual precipitation was partitioned to aquifer recharge for the entire watershed between June 2004 and June 2005. She was able to determine that higher percentages of precipitation were partitioned to recharge in catchments at higher elevations within the Dry Creek Experimental Watershed.

Kormos and others (2015) estimated bedrock infiltration for one of the Aishlin's higher elevation catchments using the difference between measured stream discharge and modeled soil drainage. Kormos and others (2015) determined that the 95% confidence interval for bedrock infiltration was 34% ±12% (46% to 22%) while Aishlin (2006) arrived at an uncertainty interval for the same catchment of 44% to 17%. Although Aishlin's uncertainty range is the result of an error propagation analysis, I will assume it is equivalent to a 95% confidence interval.

The overlap in the confidence intervals for bedrock infiltration at the same catchment studied by both Aishlin (2006) and Kormos and others (2015) lends credence to the Aishlin's 0.0% to 11% bedrock infiltration calculation for the entire Dry Creek Experimental Watershed.

This technique can be used to infer mountain front recharge from the Boise Front assuming 5.5% is the mean for Aishlin's 0.0% to 11% confidence interval, and assuming that the fraction of precipitation recharging the aquifer for June 2004 through June 2005 is representative for the Treasure Valley Aquifer Model simulation period.

Method

A relationship between elevation and infiltration for the Dry Creek Experimental Watershed can be determined and extended to the Boise Front. This relationship can then be used to estimate mountain front recharge from the Boise Front into the Treasure Valley Aquifer Model. This process will involve clipping the model grid to the cells overlying the Boise Front outside the model boundary as shown in Figure 1. Using the ArcMap "Feature to Point" tool to obtain centroids for all the Boise Front model cells.

The centroids must then be projected onto a 10M DEM using the ArcMap "Zonal Statistics as Table" tool. Obtain the average elevation for all the centroids within the Dry Creek Experimental Watershed and divide the average by 0.055 (5.5% is the assumed mean infiltration fraction obtained by Aishlin). The resulting quotient is a scalar. All the elevations associated with the centroids within Boise Front must be multiplied by the scalar to obtain infiltration fractions for each point. The average of the infiltration fractions from the centroids within the Dry Creek Experimental Watershed should be 0.055.

Clip the PRISM annual precipitation rasters with the Boise Front shape file using the ArcMap "Raster Processing" clipping tool. Then resample the clipped precipitation raster to the same grid as the 10M DEM using the nearest neighbor resampling technique. Project the Boise Front centroids onto the clipped and resampled PRISM annual precipitation raster using the "Zonal Statistics as Table" tool. Multiply the annual precipitation centroids for each calendar year with the infiltration fraction and then sum to obtain the annual mountain front recharge.

The model will have monthly stress periods, therefore to apply the annual mountain front recharge for each model year, the annual mountain front recharge needs to be divided by 365.25 (number of days in a year) and then multiplied by the number of days in each calendar month to obtain the appropriate mountain front recharge for each stress period. Thus the mountain front recharge rate will change annually but be held constant for each year.

Conclusions

A relationship between elevation and infiltration can be used to obtain an estimate of mountain front recharge from the Boise Front into the Treasure Valley Aquifer. The 30 year average (1981-2010) mountain front recharge rate from the Boise Front established using this method is 515 AF. The confidence interval determined by Aishlin's error analysis for the average from 1981 to 2010 is between 0.0 AF to 1,030 AF. This is comparable to previous estimates as shown in Table 1.

Table 1. Estimated mountain front recharge from the Boise Front.

Source	Mountain Front Recharge (AF)
This analysis	515
Petrich and Urban (2004)	905
Urban (2004)	4,300
Newton (1991)	Small
Welhan (2012)	9,000
SPF (2007a)	3,900
SPF (2007b)	5,580

The Welhan (2012) and SPF (2007a,b) are for the Mayfield portion of the Boise Front south and which lies east of the point where the Boise River enters the proposed model domain. To account for the reduced area these estimates pertain to, they have been multiplied by three to scale them to the same length as the other estimates.

The Mountain front recharge rate should be computed annually using the annual PRISM precipitation rasters and held constant for the calendar year. Mountain front recharge is not directly measured, and as such should be an adjustable parameter. A convenient way to adjust mountain front recharge would be to adjust a scalar that is then multiplied with the mountain front recharge rate for each stress period. The scalar should be adjustable from 0.01 through 2.0 to account for Aishlin's confidence interval. If there is interest in including the high estimate by Welhan (2012), the upper range for the scalar should be moved from 2.0 to 17.5.

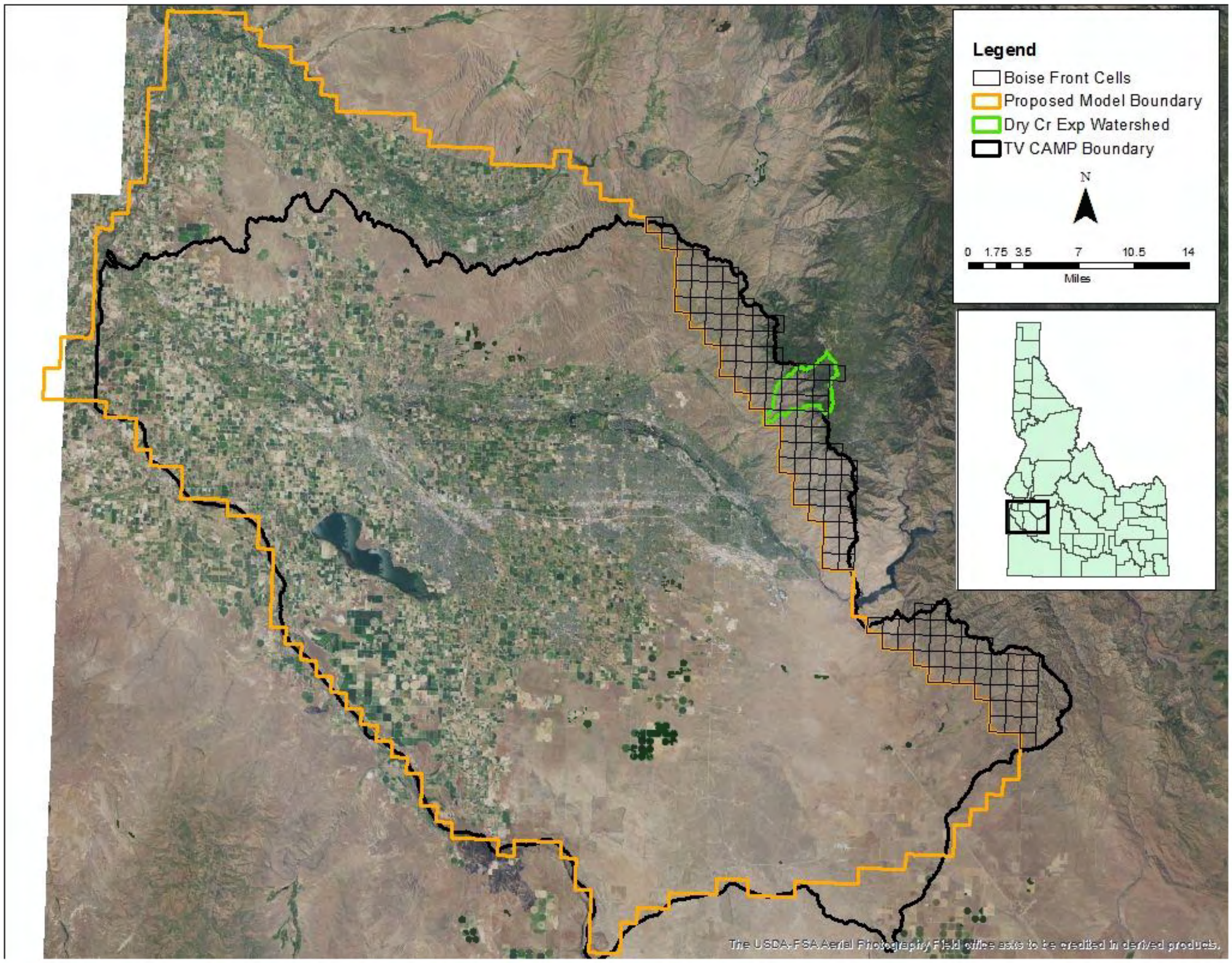

Figure 1. Location and proposed model boundary.

The highest estimates (Welhan (2012), SPF (2007a), and SPF (2007b)) were calculated based on data from the Mayfield portion of the model domain. This may be an indication that the mountain front recharge is higher in this area. Perhaps the mountain front recharge rate in this area should have a separate scalar.

References

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