Essaid, H.I., 2015, Modeling the Impact of Irrigation and Irrigation-Related Diversions and Pumping on Streamflow and Surface Water – Groundwater Interactions, 30th Biennial Groundwater Conference & 24th Groundwater Resource Association Annual Meeting, Oct. 6-7, 2015, Sacramento, CA.

Modeling the Impact of Irrigation and Irrigation-Related Diversions and Pumping on Streamflow and Surface Water – Groundwater Interactions

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The watershed-scale impacts of irrigation and irrigation-related surface water (SW) diversions and groundwater (GW) pumping on instream flows and SW-GW interactions are being examined using a coupled SW-GW flow model. The U.S. Geological Survey (USGS) model GSFLOW (Markstrom et al., 2008), an integration of the USGS Precipitation-Runoff Modeling System (PRMS) and the Modular Ground-Water Flow Model (MODFLOW), is being utilized for this effort. Processes represented in this model include: daily rain, snowfall and snowmelt; streamflow, surface runoff, interflow and infiltration; near-surface soil-zone storage and evapotranspiration; and subsurface unsaturated zone and groundwater flow and evapotranspiration. The Upper Smith River watershed, an important agricultural and recreational area in west-central Montana, is being used as the basis for watershed climate, topography, hydrography, vegetation and soil properties. The 640 square kilometer watershed area has been discretized into coincident 200 m by 200 m hydrologic response units (for climate, soil and SW processes) and grid blocks (for GW flow processes). The subsurface GW system is discretized into 6 layers representing Quaternary alluvium, Tertiary sediments and bedrock. The model is being used to first recreate natural, pre-development streamflows and GW conditions in the watershed. The magnitude and timing of changes in streamflows during the irrigation season are being examined for irrigation supplied by SW diversion and/or GW pumping. In both cases, a fraction of the irrigated water generates GW recharge because of imperfect irrigation efficiency. Preliminary simulations contrast a scenario of irrigation supplied only by SW diversion with a scenario of irrigation supplied only by GW pumping. Model results indicate that distributed GW pumping results in less streamflow decrease during the irrigation season than SW diversion for equivalent irrigation applications.

Markstrom, S.L., Niswonger, R.G., Regan, R.S., Prudic, D.E., and Barlow, P.M., 2008, GSFLOW—Coupled ground-water and surface-water flow model based on the integration of the Precipitation-Runoff Modeling System (PRMS) and the Modular Ground-Water Flow Model (MODFLOW-2005): U.S. Geological Survey Techniques and Methods 6-D1, 240 p.

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