Wood River Valley Model; Previous work

J.R. Bartolino, USGS

Groundwater levels and maps

Chapman (1921) created the earliest ground-water level map of the Wood River Valley: it shows June 1921 conditions in the Bellevue fan area below Bellevue. A report by Stearns and others (1938) contains a small-scale groundwater-level map of 1928-30 conditions in the eastern Snake Plain and selected tributaries including the Bellevue fan area below Bellevue and Camas Prairie. Subsequent groundwater-level maps of all or parts of the Wood River Valley were prepared by Smith (1959), Castelin and Chapman (1972), Moreland (1977), Brockway and Grover (1978), Luttrell and Brockway (1984), Frenzel (1989), Wetzstein and others (1999), and Skinner and others (2007). Small-scale groundwater-level maps that include the Wood River Valley include those by Mundorff and others (1964), Maupin (1992), Berenbrock and others (1995), and Briar and others (1996).

Water budgets

Eight previously published studies have developed water budgets for all or part of the Wood River Valley: Smith (1959), Castelin and Chapman (1972), Brockway and Grover (1978), Luttrell and Brockway (1984), Brockway and Kahlown (1994), Frenzel (1989), Wetzstein and others (1999), Bartolino (2009), and Loinaz (2012). These water budgets are not directly comparable because they differ in areal extent, time period, manner in which budget components were combined, and whether they address groundwater and surface water or ground-water systems exclusively. Bartolino (2009) summarized the study area, hydrologic system, and time period for these water budgets, except for Loinaz (2012).

Hydrogeologic frameworks

The earliest publications on the geology of the study area focus on the mining of precious metals discovered in the area in 1864 (Spence, 1999). These early reports include Eldridge (1896), Lindgren (1900), and Umpleby and others (1930). Although the geology of the study area is described in these reports, no mention is made of water resources.

The earliest papers that discuss groundwater in the Wood River Valley are those of Chapman (1921) and Stearns and others (1938); however, Smith (1959) made the first detailed study of the Wood River Valley aquifer system in the Hailey and the Bellevue fan areas. In characterizing the aquifer system, Smith (1959) made multiple-well aquifer tests at five sites and constructed geologic sections of the aquifer in the area of four USGS streamflow-gaging stations then in operation in the lower valley. Smith (1960) also analyzed groundwater underflow at 27 streamflow-gaging stations in the Malad River basin above its confluence with the Snake River. For each streamflow-gaging station included in this latter report, Smith (1960) described the geology (including a geologic section) and made an estimate of probable groundwater underflow beneath the stream channel.

Geologic cross sections of parts of the Wood River Valley aquifer system are found in several reports starting with Smith (1959) and Smith (1960). Schmidt (1962) described the Quaternary geologic history and processes that formed the Bellevue fan south of Hailey and the western part of the Camas Prairie. This work has served as the basis for all subsequent descriptions of the Quaternary rocks of the study area although later authors have expanded and refined Schmidt's original description.

Castelin and Winner (1975) constructed four geologic sections of the area between Hailey and the North Fork of the Big Wood River on the basis of well-driller reports and a single

seismic refraction survey at their northernmost section across the Big Wood River above the confluence with the North Fork.

Moreland's (1977) report contains four geohydrologic sections, descriptions of the lithology of 10 test holes drilled for the study, maps of the extent of the confining unit separating the confined and unconfined aquifers, and estimates of transmissivity (using single-well, specific capacity methods) from about 70 well-driller reports.

Luttrell and Brockway (1984) included two generalized geologic sections plotted along the axis of the Wood River Valley from above Ketchum to below Bellevue. These sections were compiled from well reports.

Frenzel's (1989) report on the water resources of the Wood River Valley contains an east-west geologic section of the aquifer system near Glendale Road constructed from seismic refraction data. This report also includes estimates of hydraulic conductivity (using single-well, specific capacity methods) at six wells using pumping data from well reports and Smith's (1959) multiple-well aquifer tests.

Brockway and Kahlown (1994) compiled hydrogeologic information from previous authors in preparation for constructing a groundwater-flow model of the Wood River Valley aquifer system south of Hailey; the model is described in Wetzstein and others (1999). The Wetzstein and others (1999) report updated the hydrogeologic framework described in Brockway and Kahlown (1994) by incorporating additional data from well-driller reports. Brown (2000) "synthesize[ed] and highlight[ed] the methods and findings" of the reports by Brockway and Kahlown (1994) and Wetzstein and others (1999).

Various geologic maps of the study area have been compiled, including regional-scale geologic maps (Worl and others, 1991; Link and Rodgers, 1995), a geologic terrane map (Worl

and Johnson, 1995b), and a sedimentary unit map (Link and others, 1995b). The Link and Rodgers (1995) map includes three northeast-trending geologic sections that cross the Wood River Valley: (1) 2 mi north of Ketchum, (2) 1 mi north of Hailey, and (3) 1 mi north of Bellevue. These sections emphasize the regional structure and in places extend to depths of as much as 2 mi below land surface. Recent mapping products of the area by the Idaho Geological Survey include a surficial geologic map (Breckenridge and Othberg, 2006) and 1:24,000-scale geologic maps that include the Magic Reservoir East quadrangle (Kauffman and Othberg, 2007), the Gannett quadrangle (Garwood and others, 2010), and the Picabo quadrangle (Garwood and others, 2011). The map by Garwood and others (2010) includes the subsurface extent of the Pleistocene basalts and a geologic section across the Bellevue fan. Currently (2013), the Idaho Geological Survey is finalizing maps of the Bellevue and Seaman's Creek 1:24,000-scale quadrangles for ultimate inclusion into a geologic map of the Fairfield 1:100,000-scale quadrangle. Skinner (2013) describes a debris-flow hazard assessment for the area burned in the summer 2013 Beaver Creek fire. Two maps of the Wood River Valley describe earthquake hazards: Weppner and others (2013a) mapped the expected intensity of ground shaking and Weppner and others (2013b) mapped liquefaction susceptibility.

Modeling

Brockway and Grover (1978) developed the first groundwater-flow model of the Wood River Valley aquifer system using a 2-D finite-difference model code developed by de Sonneville (1972) and Newton (1978). Because the model code could only represent a single layer, separate models were developed for the confined and unconfined aquifers. Simulated leakage from the upper unconfined aquifer was applied as recharge to the lower confined aquifer. The model area encompassed the Bellevue fan area south of Bellevue and a uniform, square grid was specified with 23 rows, 29 columns, and a cell size of 0.5 mi. The model used 1-week

timesteps and was calibrated with data collected from May 1975 to July 1976. A number of scenarios were run with varying model periods.

In response to single and multi-year drought conditions between 1977 and 1992 that resulted in decreased streamflow and a fish kill in Silver Creek, Wetzstein and others (1999) of the Idaho Water Resources Institute created a groundwater-flow model of the Bellevue fan area south of Hailey using the MODFLOW model code of McDonald and Harbaugh (1988). As described in the previous section, the model was completed in two phases: Brockway and Kahlown (1994) compiled data for the model and Wetzstein and others (1999) described the model. The model contains three layers and 355 active cells (in the uppermost layer) in 34 columns and 35 rows in a uniform, square grid of 0.5-mi cells. The model calibration period was April 1993 to April 1994; each of the 24 time steps was 15.2 days. A number of scenarios were then run with varying model periods.

Loinaz (2012) constructed a MIKE SHE-MIKE 11 "catchment scale integrated hydrological model" of the Wood River Valley below Hailey "coupled to a stream temperature model of the Silver Creek Basin." The hydrological model was calibrated to the 2003-09 period and the temperature model was calibrated to the 2007-09 period. Management scenarios were simulated for changes in land use, water use, river morphology (sedimentation), stream-bank and vegetation; a final scenario examined the effects of returning the Silver Creek watershed to natural conditions.

Consulting firms have developed a number of proprietary groundwater-flow models of parts of the Wood River Valley for the evaluation of localized hydrologic conditions. These models have been applied to such uses as water-right transfers and development applications.

Surface water

Note: Prior to 1986 the USGS used Big Wood River basin for the drainage above the confluence with the Snake River, Malad River basin has been used since then. As discussed here, Malad River basin is used.

The first published streamflow measurements of Silver Creek and the Big Wood River were made in the summer of 1889 and are found in Powell (1891). Chapman (1921) compiled 1921 canal deliveries for the Big and Little Wood River basins above their confluence but the report includes additional information including descriptions of the hydrology and streamflow measurements from about 30 stations in the area.

Stearns and others (1938) assessed the groundwater resources of the Snake River Plain and its tributaries; this report includes a discussion of Silver Creek and the Big Wood River including measured and estimated flows near Picabo and below Magic Dam. Jones (1952) catalogued streamgage data, reservoirs, and surface-water diversions for the entire Malad River basin including Camas Creek and the Big and Little Wood River drainages.

Smith (1959) described the groundwater system of the Wood River Valley but noted that groundwater and surface water in the Wood River Valley "cannot be considered successfully as separate entities." Smith (1960) evaluated hydrogeologic conditions at streamgages in the Malad River basin in order to evaluate the possibility of underflow and its effect on basin yield calculations.

Castelin and Winner (1975) measured streamflow at 12 sites in the Wood River Valley six times between September 1972 and February 1974. Moreland (1977) described groundwater/surface-water interaction in the Silver Creek area. In order to quantify this interaction he made discharge measurements at 88 sites three times in 1975. While unable to quantify groundwater/surface-water interaction in the Big Wood River because of the complexity

introduced by diversions, Moreland demonstrated a relation between discharge in Silver Creek and water levels in shallow wells.

Brockway and Grover (1978) measured streamflow at 22 sites (streams, diversions, and returns) during the 1975 and 1976 irrigation seasons at intervals ranging from twice weekly to every two weeks. They also made a detailed analysis of canal seepage at nine sites for application to their groundwater-flow model. Luttrell and Brockway (1984) measured flow at 13 sites on the Big Wood River and tributaries in September 1983 and March 1984 to estimate streamflow gain/loss on the Big Wood River.

Frenzel (1989) conducted a seepage study in August 1986 with measurements at 22 sites including the Big Wood River, various tributaries, and canal diversions. His report includes a qualitative comparison of water levels in four wells near the Big Wood River and canals to discharge in the Big Wood River.

Brockway and Kahlown (1994) installed stage recorders or staff gages at 15 sites on the Bellevue fan; the stage was read on a weekly basis between May 1993 and April 1994. An additional three sites on the District 45 canal were instrumented and read on a weekly basis during the 1993 irrigation season.

Skinner and others (2005) analyzed historic trends in streamflow at three streamgages: The Big Wood River at Hailey (13139500), Big Wood River near Bellevue (13141000), and Silver Creek at Sportsman Access (13150430). They also made 13 streamflow measurements in October 2006 for the determination of streamflow gains and losses. The report contains a table of streamgages within a 25-mi radius of the Wood River Valley and the period of record for each.

Personnel of the Nature Conservancy's Silver Creek Preserve have collected streamflow and water temperature data for Silver Creek and its tributaries. Much of this data is available from the Save Silver Creek website at *http://www.savesilvercreek.org*

References Cited

Bartolino, J.R., 2009, Ground-water budget for the Wood River Valley aquifer system, South-Central Idaho: U.S. Geological Survey Scientific Investigations Report 2009-5016, 36 p. Accessed October 17, 2013 at *http://pubs.usgs.gov/sir/2009/5016/*

Bartolino, J.R., and Adkins, C.B., 2012, Hydrogeologic framework of the Wood River Valley aquifer system, south-central Idaho: U.S. Geological Survey Scientific Investigations Report 2012–5053, 46 p., 1 plate in pocket. Accessed October 17, 2013 at *http://pubs.usgs.gov/sir/2012/5053/*

Berenbrock, C.E., Bassick, M.D., Rogers, T.L., and Garcia, S.P. 1995, Depth to water, 1991, in the Rathdrum Prairie, Idaho; Spokane River valley, Washington; Moscow-Lewiston-Grangeville area, Idaho; and selected intermontane valleys, east-central Idaho: U.S. Geological Survey Water-Resources Investigation Report 94-4087, scales 1:250,000, 1:317,000, 1:500,000, 3 maps on 2 sheets. Accessed November 1, 2013, at *http://pubs.er.usgs.gov/publication/wri944087*

Briar, D.W., Lawlor, S.M., Stone, M.A., Parliman, D.J., Schaefer, J.L., and Kendy, Eloise, 1996, Ground-water levels in intermontane basins of the northern Rocky Mountains, Montana and Idaho: Hydrologic Atlas 738-B, scale 1:750,000, 1 sheet. Accessed November 1, 2013, at *http://pubs.er.usgs.gov/publication/ha738B*

Brockway, C.E., and Grover, K.P., 1978, Evaluation of urbanization and changes in land use on the water resources of mountain valleys: Moscow, University of Idaho Water Resources Research Institute, 104 p. plus appendix. Accessed October 17, 2013 at *http://contentdm.lib.uidaho.edu/u?/idahowater,515*

Brockway, C.E., and Kahlown, M.A., 1994, Hydrologic Evaluation of the Big Wood River and Silver Creek Watersheds Phase I: Kimberly, University of Idaho Water Resources Research Institute, Kimberly Research Center, 53 p. plus 5 appendices. Accessed November 15, 2013, at *http://contentdm.lib.uidaho.edu/u?/idahowater,406*

Castelin, P.M., and Chapman, S.L., 1972, Water resources of the Big Wood River–Silver Creek area, Blaine County, Idaho: Boise, Idaho Department of Water Administration, Water Information Bulletin 28, 44 p. Accessed October 17, 2013 at *http://www.idwr.idaho.gov/WaterInformation/Publications/default.htm*

Castelin, P.M., and Winner, J.E., 1975, Effects of urbanization on the water resources of the Sun Valley-Ketchum area, Blaine County, Idaho: Boise, Idaho Department of Water Resources, Water Information Bulletin 40, 86 p. Accessed October 17, 2012 at *http://www.idwr.idaho.gov/WaterInformation/Publications/default.htm*

Chapman, S.H., 1921, Water distribution and hydrometric work, Districts 7 and 11, Big and Little Wood Rivers: Shoshone, Annual Report Watermaster Districts 7 and 11, 21 p., 67 charts.

De Sonneville, J.L.J., 1972, Development of a mathematical groundwater model: Moscow, University of Idaho, Ph.D. dissertation, 227 p. Accessed October 22, 2013 at *http://contentdm.lib.uidaho.edu/u?/idahowater,104*

Frenzel, S.A., 1989, Water resources of the upper Big Wood River basin, Idaho: U.S. Geological Survey Water-Resources Investigation Report 89-4018, 47 p. Accessed October 17, 2013 at *http://pubs.er.usgs.gov/pubs/wri/wri894018*.

Jones, R.P., 1952, Evaluation of streamflow records in the Big Wood River basin, Blaine County, Idaho: U.S. Geological Survey Circular 192, 59 p., 1 plate in pocket, accessed October 17, 2013 at *http://pubs.er.usgs.gov/usgspubs/cir/cir192*.)

Loinaz, M.C., undated (2012), Integrated hydrologic model of the Wood River Valley and stream temperature model of the Silver Creek basin—model development, calibration and scenarios report: report submitted to the Nature Conservancy, 39 p.

Luttrell, S.P., and Brockway, C.E., 1984, Impacts of individual on-site sewage disposal facilities on mountain valleys – Phase II – Water-quality considerations: Moscow, Idaho Water and Energy Resources Research Institute, University of Idaho, Research Technical Completion Report WRIP/371403, 74 p. Accessed October 17, 2013 at *http://contentdm.lib.uidaho.edu/u?/idahowater,428*

Maupin, M.A., 1991, Depth to water in the western Snake River Plain and surrounding tributary valleys, southwestern Idaho and eastern Oregon, calculated using water levels from 1980 to 1988: U.S. Geological Survey Water-Resources Investigation Report 91-4020, scales 1:1,000,000 and 1:750,000, 2 maps on 1 sheet. Accessed November 1, 2012 at *http://pubs.er.usgs.gov/usgspubs/wri/wri914020*

Maupin, M.A., 1992, Depth to water in the eastern Snake River Plain and surrounding tributary valleys, southwestern Idaho and eastern Oregon, calculated using water levels from 1980 to 1988: U.S. Geological Survey Water-Resources Investigation Report 90-4193, scales 1:1,000,000 and 1:750,000, 2 maps on 1 sheet.

Moreland, J.A., 1977, Ground water-surface water relations in the Silver Creek area, Blaine County, Idaho: Boise, Idaho Department of Water Resources, Water Information Bulletin 44, 42 p., 5 plates in pocket. Accessed November 1, 2013 at *http://www.idwr.idaho.gov/WaterInformation/Publications/default.htm* Also published as U.S. Geological Survey Open-File report 77-456, 66 p., plates in pocket. Accessed November 1, 2012 at *http://pubs.er.usgs.gov/pubs/ofr/ofr77456*

Newton, G.D., 1978, Application of a simulation model to the Snake River Plain aquifer: Moscow, University of Idaho, M.S. thesis, 82 p.

Powell, J.W., 1891, Eleventh Annual report of the Director of the United States Geological Survey, Part 2: 1889-1890: U.S. Geological Survey Annual Report 11, 390 p. Accessed November 12, 2013 at *http://pubs.er.usgs.gov/publication/ar11_2*

Schmidt, D.L., 1962, Quaternary geology of the Bellevue area in Blaine and Camas Counties, Idaho: U.S. Geological Survey Open File Report 62-120, 127 p. Accessed November 17, 2013 at *http://pubs.er.usgs.gov/pubs/ofr/ofr62120*

Skinner, K.D., 2013, Post-fire debris-flow hazard assessment of the area burned by the 2013 Beaver Creek Fire near Hailey, central Idaho: U.S. Geological Survey Open-File Report 2013-1273, 12 p., 9 pls. Accessed November 17, 2013 at *http://pubs.usgs.gov/of/2013/1273/*

Skinner, K.D., Bartolino, J.R., and Tranmer, A.W., 2007, Water-resource trends and comparisons between partial development and October 2006 hydrologic conditions, Wood River Valley, south-central Idaho: U.S. Geological Survey Scientific Investigations Report

2007-5258, 31 p., 4 plates, 1 appendix. Accessed October 17, 2013 at *http://pubs.er.usgs.gov/usgspubs/sir/sir20075258*

Smith, R.O., 1959, Ground-water resources of the middle Big Wood River-Silver Creek area, Blaine County, Idaho: U.S. Geological Survey Water-Supply Paper 1478, 61 p., 2 pls. Accessed October 17, 2013 at *http://pubs.er.usgs.gov/usgspubs/wsp/wsp1478*

Smith, R.O., 1960, Geohydrologic evaluation of streamflow records in the Big Wood River basin, Idaho: U.S. Geological Survey Water-Supply Paper 1479, 64 p., 4 pls. Accessed October 17, 2012 at *http://pubs.er.usgs.gov/pubs/wsp/wsp1479*

Stearns, H.T., Crandall, Lynn, and Steward, W.G., 1936, Records of wells on the Snake River Plain, in southeastern Idaho: U.S. Geological Survey Water-Supply Paper 775, 134 p. Accessed October 17, 2013 at *http://pubs.er.usgs.gov/publication/wsp775*

Weppner, K.N., Phillips, W.M., Turner , J., O'Connell, D., Protti, B., and Bernstein, K.M., 2013a, NEHRP site class map for the Wood River Valley, Blaine County, Idaho: Moscow, Idaho Geological Survey Digital Database 8, available at URL: *http://www.idahogeology.org/Products/reverselook.asp?switch=title&value=NEHRP_Site_Class_and_Liquefaction_Susceptibility_Maps_for_the_Wood_River_Valley,_Idaho*

Weppner, K.N., Phillips, W.M., Turner , J., O'Connell, D., Protti, B., and Bernstein, K.M., 2013b, Liquefaction susceptibility map for the Wood River Valley, Blaine County, Idaho: Moscow, Idaho Geological Survey Digital Database 8, available at URL: *http://www.idahogeology.org/Products/reverselook.asp?switch=title&value=NEHRP_Site_Class_and_Liquefaction_Susceptibility_Maps_for_the_Wood_River_Valley,_Idaho*

Wetzstein, A.B., Robinson , C.W., and Brockway, C.E., 2000 , Hydrologic evaluation of the Big Wood River and Silver Creek watersheds, phase II: Kimberly, University of Idaho Water Resources Research Institute, Kimberly Research Center, 136 p. Accessed November 17, 2013 at *http://contentdm.lib.uidaho.edu/u?/idahowater,412*