EXPANSION OF TREASURE VALLEY HYDROLOGIC PROJECT GROUNDWATER MODEL

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INTRODUCTION

Expansion of the Treasure Valley Hydrologic Project (TVHP) groundwater model was initiated during the Treasure Valley Comprehensive Aquifer Management Planning (CAMP) process. Western Water Consulting, Inc. (Cosgrove, 2010) was retained by the Idaho Department of Water Resources to evaluate ground water models in the Treasure Valley, Idaho area. Cosgrove (2010) evaluated seven models and concluded that the TVHP model was the most rigorously developed and best calibrated model. Cosgrove (2010) recommended that the TVHP model be modified to be more useful to CAMP. Recommendations included expanding the northern model boundary to the Payette River, expanding the model boundaries to include areas of projected development, and calibrating as a transient model.

The U.S. Bureau of Reclamation is calibrating a transient, enhanced version of the TVHP model in support of the research project, *Climate Change: Evaluating Water Management Responses to Global Climate Change Using Coupled Hydrologic and Economic Models*. The transient, enhanced version is being calibrated using the water budget developed by Schmidt, et al. (2008) for the Lower Boise Valley. The water budget does not extend to the areas recommended for inclusion in the expanded model boundary by Cosgrove (2010).

The U.S. Bureau of Reclamation has offered to incorporate the recommended expansion of the model boundary into the transient, enhanced version of the TVHP model. The expanded model boundary, discretization, and water budget data for the expansion areas were compiled by the Idaho Department of Water Resources. This report describes the model discretization, input data, and calibration targets developed for the expansion areas.

EXPANDED MODEL BOUNDARY AND DISCRETIZATION

The model boundary from the Treasure Valley Hydrologic Project (Petrich, 2004) was extended to include the East Ada and North Ada County study areas. 454 active cells of one square mile were added to the model. The model grid was extended by 12 cells on the north and by 4 cells on the east, resulting in a grid with 61 rows and 65 columns. Treasure Valley Hydrologic Project (TVHP) model grid row numbers 1 through 49 were reassigned to row numbers 13 through 61. The total number of active cells increased from 1,362 in the TVHP model to 1,816 in the expanded model (Figure 1).

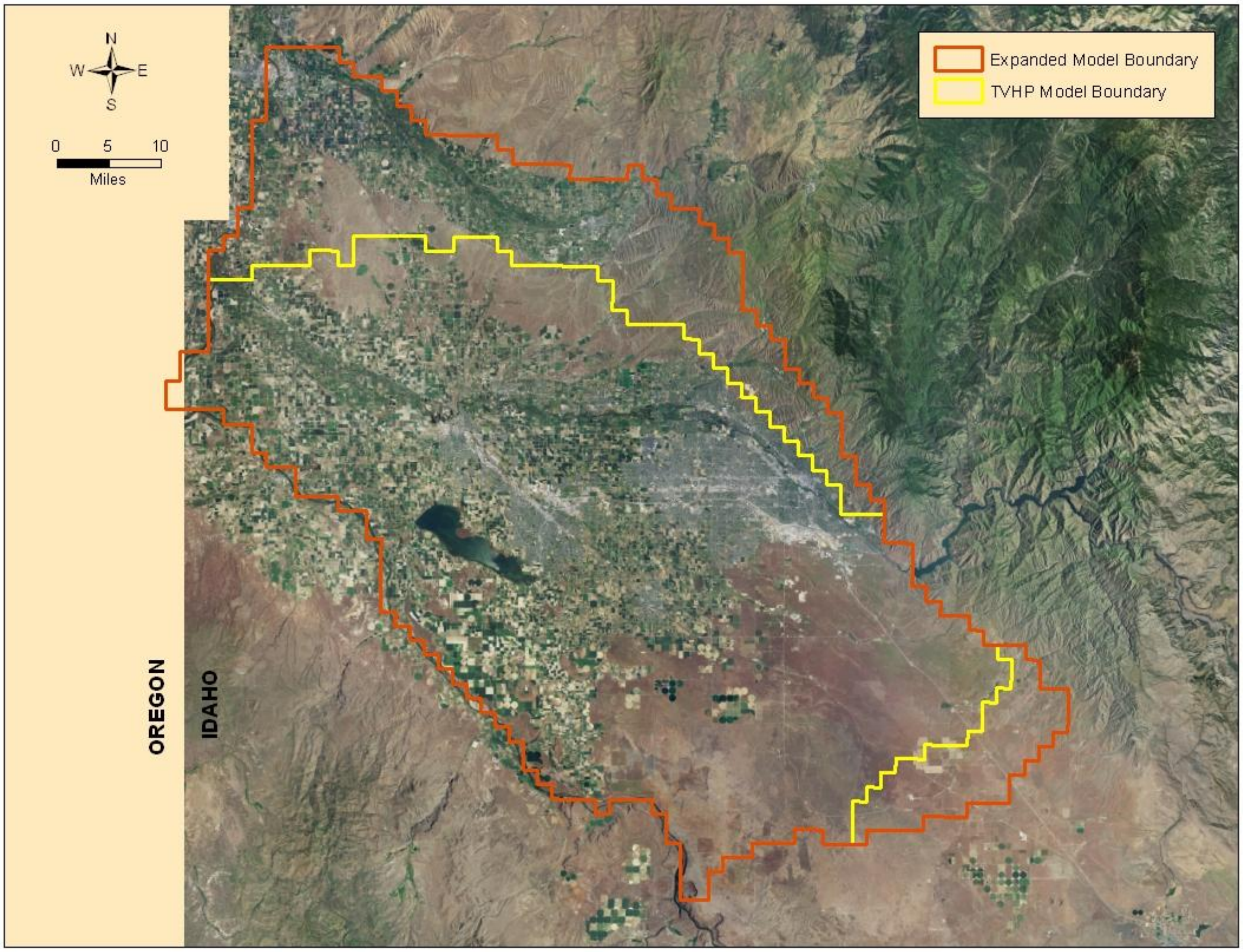

Figure 1. Expanded model boundary.

EAST ADA AREA

In the East Ada area, the model was extended approximately 5 miles to the southeast. 79 active cells of one square mile were added to the model on the southeast. The boundary was extended to a granitic bedrock contact (Bond et al, 1978) on the northeast, which is assumed to be a no flow boundary. On the southeast, the boundary was located between the Cinder Cone Butte Critical Groundwater Management Area and the location of wells with stable or rising water levels. The southeast boundary generally corresponds with the Treasure Valley CAMP planning boundary (Figure 2). Based on available data, this boundary appears to be parallel to the direction of groundwater flow and areas within the model boundary do not appear to be impacted by groundwater pumping within the Cinder Cone Butte CGMA. A no flow boundary is proposed to represent the southeast boundary of the East Ada area.

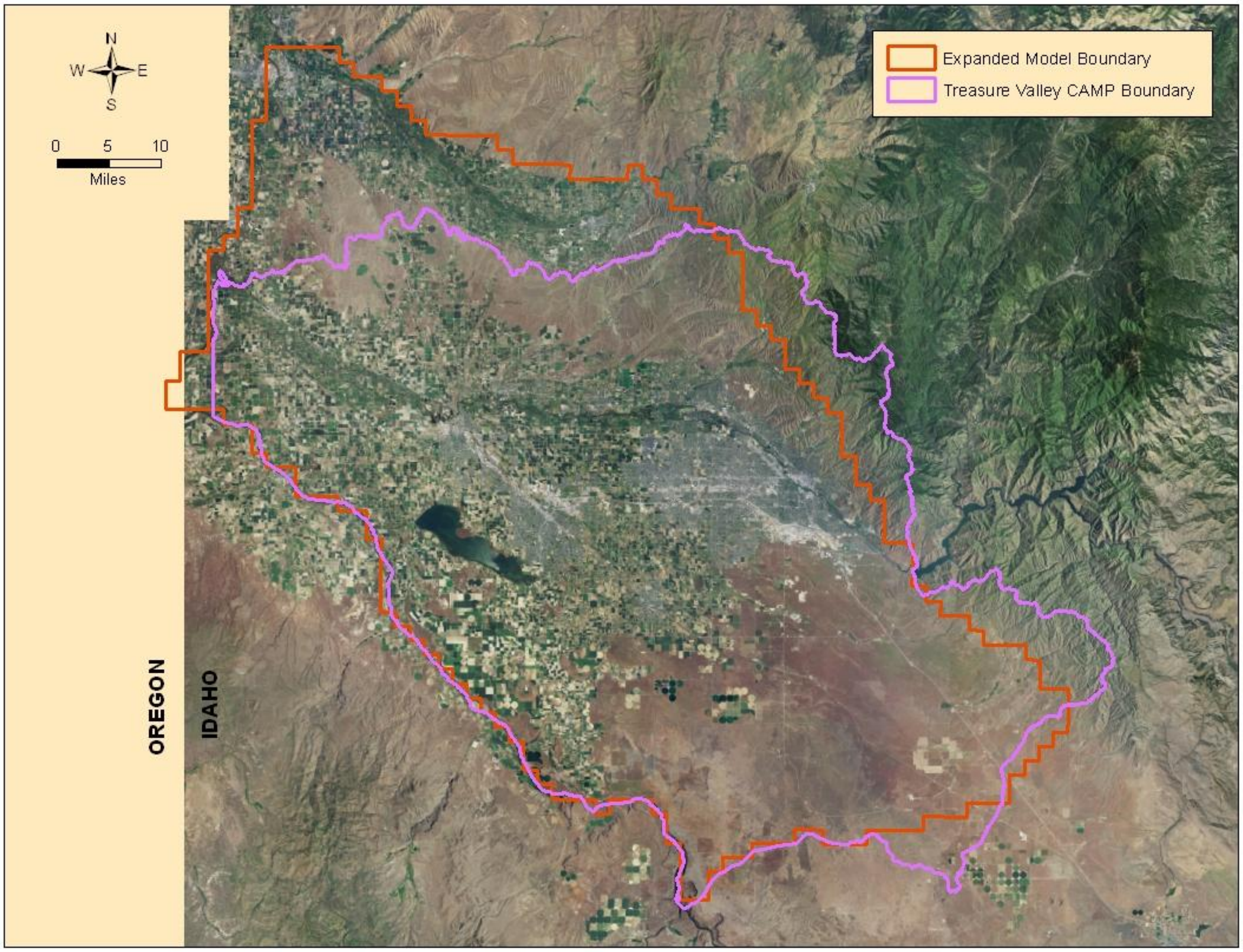

Figure 2. Treasure Valley CAMP boundary.

NORTH ADA AREA

In the North Ada area, the model was extended beyond the Treasure Valley CAMP boundary to the Lower Payette River Valley (Figure 2). The purpose of this expansion is to provide a tool for assisting in evaluation of potential groundwater flow from the Treasure Valley to the Lower Payette Valley. The Lower Payette River gains a significant amount of water from irrigation return flows and groundwater discharge between Emmett and Payette, with much of the gain occurring in the Letha to Payette reach. The model expansion and associated water budget will attempt to quantify the amount of these reach gains originating from sources in the Payette River basin and the amount of potential underflow and groundwater discharge originating in the Treasure Valley. 375 active cells of one square mile were added to the model on the north.

The model boundary was extended to the Payette River and Emmett Bench on the north and to contacts with granitic bedrock or basalt (Bond et al, 1978) on the northeast between Emmett and the Boise

Foothills. The northeast boundary from Emmett to the Boise Foothills is assumed to be a no flow boundary. The boundary has been extended to include areas of the Boise Foothills that were previously represented as a specified flux boundary in the TVHP model. Petrich (2004) reported that underflow from the Boise Foothills was estimated at 8,000 AF/yr from precipitation, evapotranspiration, and stream discharge, but during model calibration underflow was reduced significantly to 1,000 ft^3/day/cell. Underflow was represented in the TVHP model using the well package.

The northern boundary of the expanded model area between Emmett and Payette is represented as a specified flux to account for tributary underflow from the Big and Little Willow basins north of the Emmett Bench.

The expanded model area is bounded by the Snake River on the west. The Snake River was represented by a constant head boundary in the TVHP model (Petrich, 2004). The Snake River will be modeled as a general head boundary in the BOR/IWRRI model. The Snake River within the expanded model area will also be modeled as a general head boundary.

MODEL LAYERS

In the TVHP model, the top of Layer 1 is equivalent to ground surface at the center of the model cell (Petrich, 2004). For new active cells, the DEM elevation at the center of the model cell was assigned to the top of Layer 1. Note that TVHP top of layer 1 elevations for inactive cells in the TVHP model did not match DEM elevations and were overwritten. Land surface elevations of model cells are shown in Figure 3.

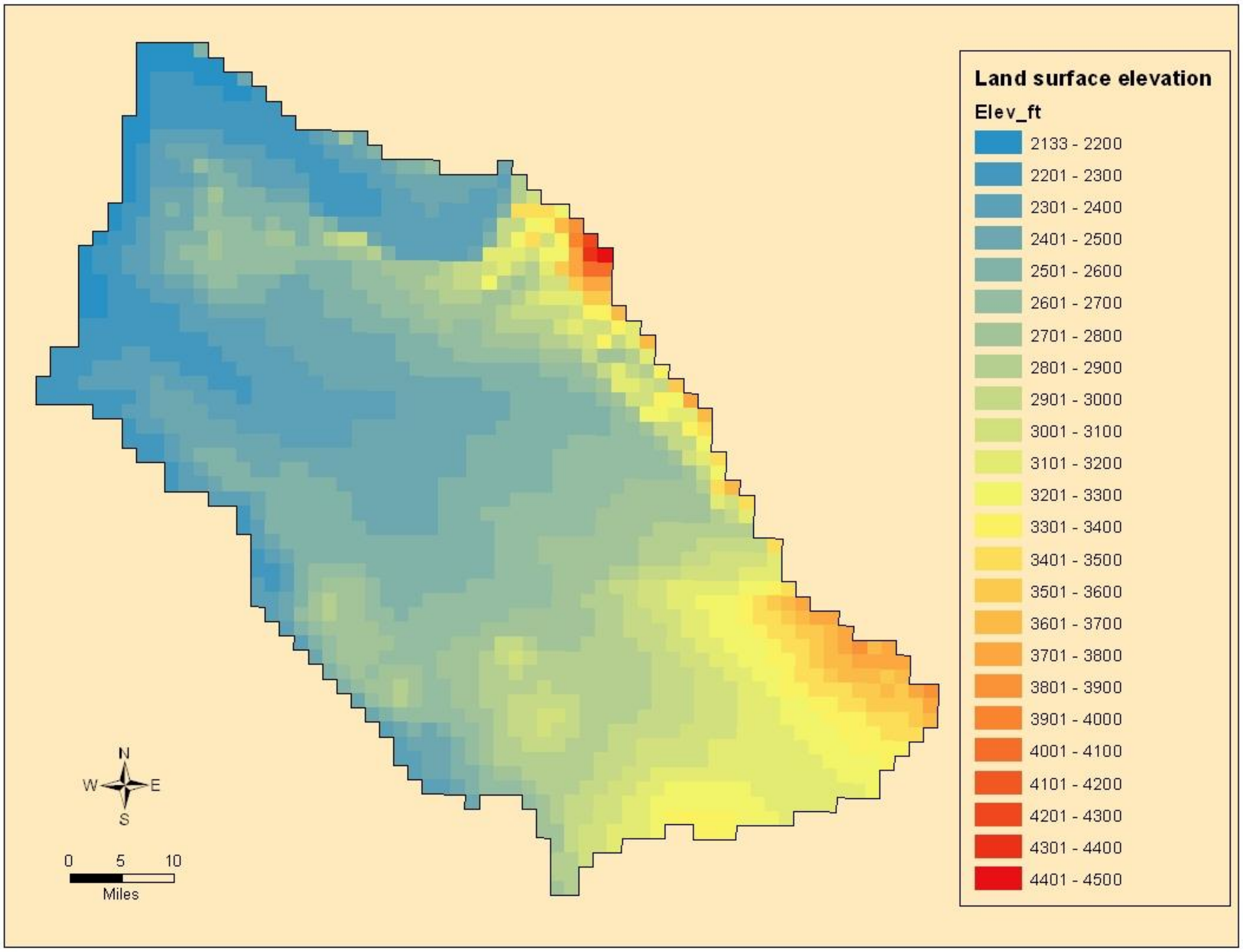

Figure 3. Land surface elevation.

Elevations of the bottom of Layer 1 (Figure 4) were assigned to new active cells as follows:

- The bottom of Layer 1 at the Payette River was assigned to an elevation 50 feet below the river stage elevation.
- The bottom of Layer 1 at the southern edge of the Emmett Valley was also assigned to an elevation approximately 50 feet below the Payette River stage elevation.
- The bottom of Layer 1 at cells 18_32 and 18_35 was assigned to an elevation of 2310 feet.
- Cells on or near the boundary of the TVHP model were assigned the bottom of Layer 1 elevations used in TVHP.
- Elevations for new active cells between the TVHP boundary and the Payette River were determined by kriging between the values listed above. Bottom of Layer 1 elevations for 16 active cells in the northeast corner of the TVHP model were overwritten with kriged values. These cells did not have observation or pumping wells in the TVHP model and the elevations

assigned for TVHP were too high to accommodate new observation well data located in this area.

- Elevations within foothills areas on the east and southeast sides of the model were assigned based on TVHP elevations with the layer bottom sloping upward toward the model boundary.

Layers 2, 3, and 4 were assigned a constant thickness consistent with the TVHP model layer thicknesses (Petrich, 2004). Layer 2 is 200 feet thick. Layers 3 and 4 are each 400 feet thick.

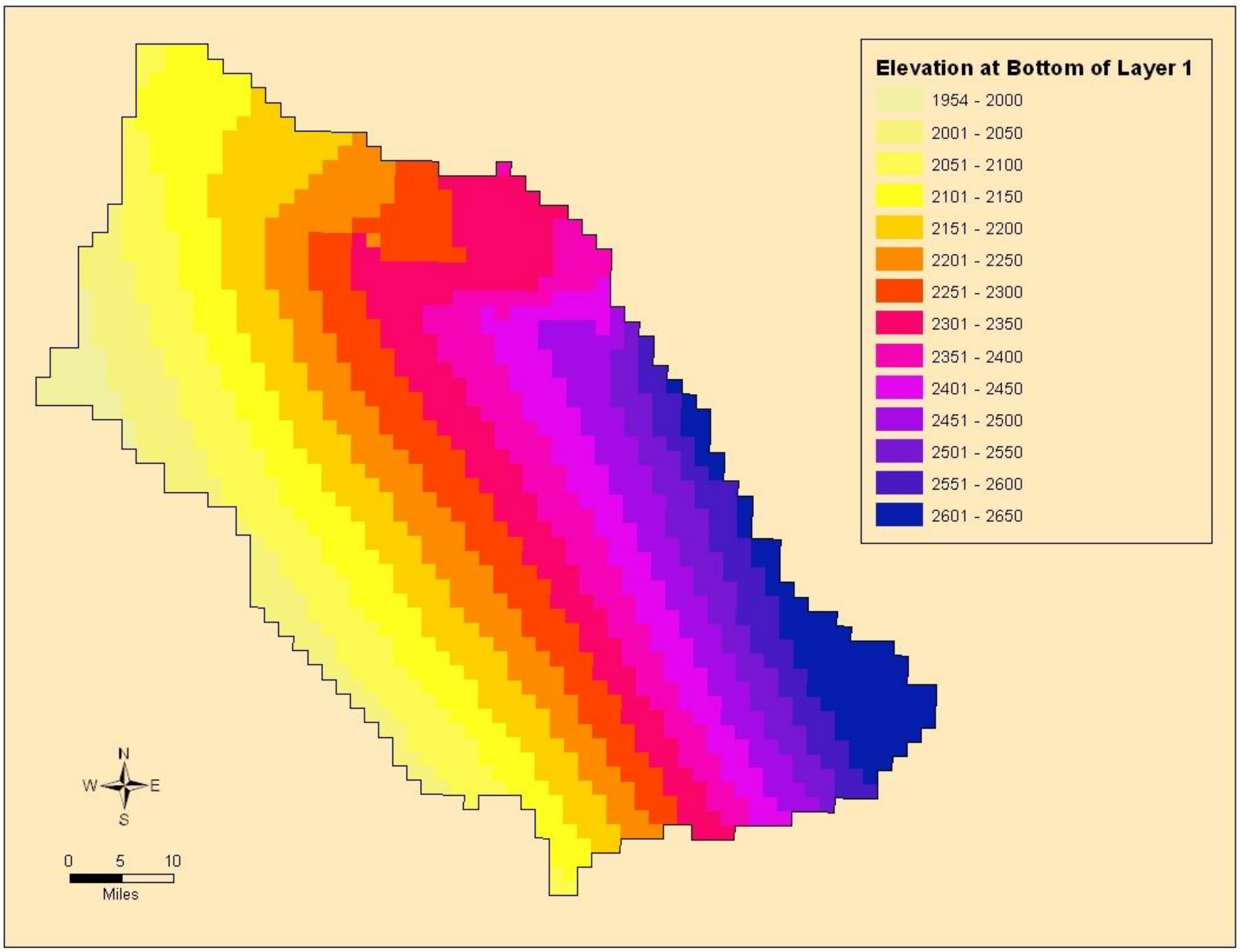

Figure 4. Elevation at bottom of Layer 1.

MODEL INPUT DATA

RIVER PACKAGE

The Payette River is represented by 28 river cells (Figure **5**), which allow recharge from and discharge to the river. For most cells, the average river stage elevation was based on topographic contours and digital elevation model data. At Emmett, Letha, and Payette, river stage height was based on the gage datum reported by the USGS plus the gage height reported for the average monthly discharge recorded between 1967 and 1997. Data available for the Letha gage were limited to 1978-1986 and 1994-1997. Note that gage heights were based on rating tables downloaded from the USGS on October 1, 2010, which may differ somewhat from rating curves used during the 1967 to 1997 period. Gage height data available from Hydromet were reviewed, but were only available for a limited number of years within the 1967 to 1997 period. River stage elevation data are summarized in Table 1.

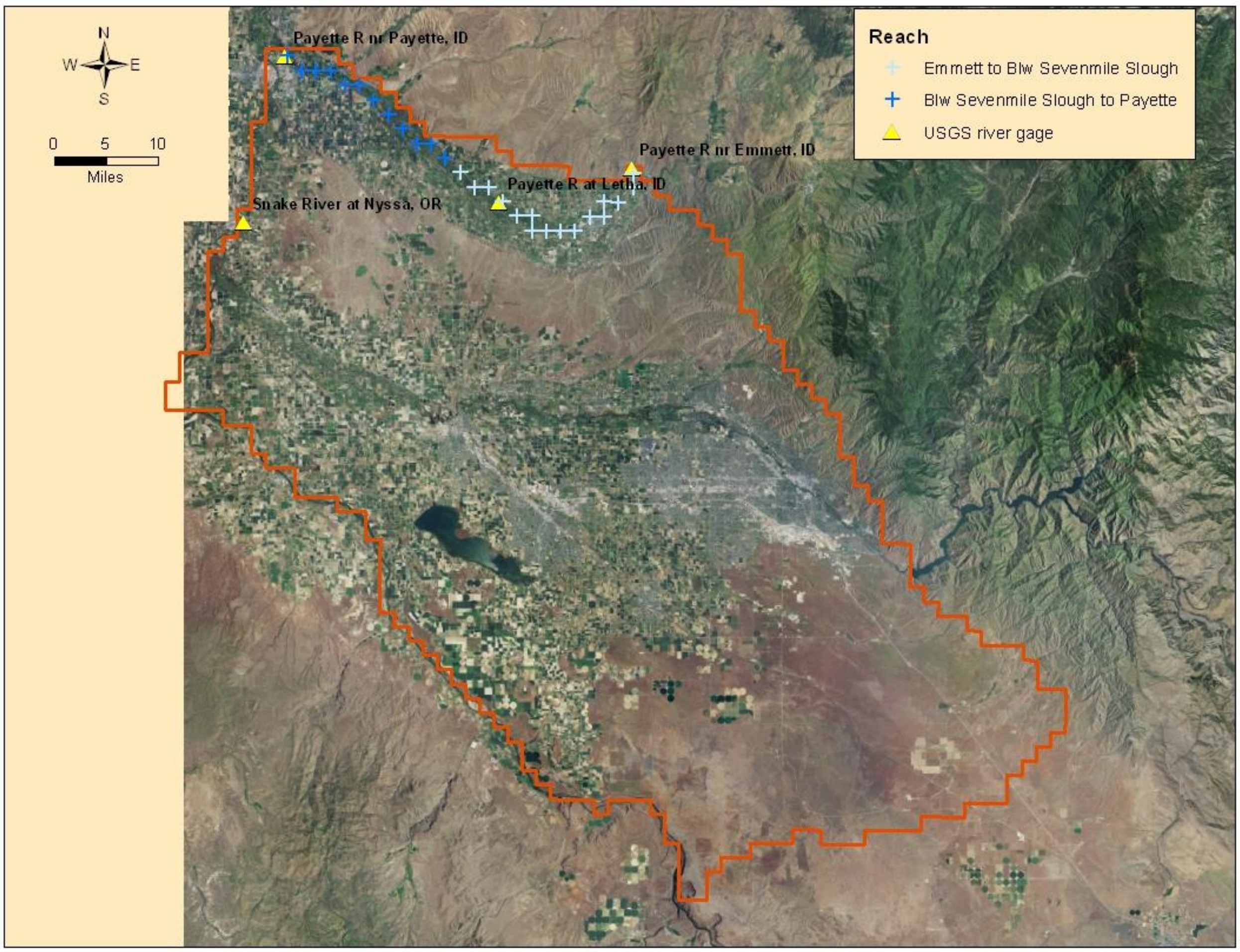

Figure 5. Model cells representing Payette River.

USGS Gaging Station	Average Stage Elevation (ft)	Minimum Monthly Average Elevation (ft)	Maximum Monthly Average Elevation (ft)	Average Seasonal Water Level Fluctuation (ft)
Payette nr Emmett	2404.2	2402.9	2406.6	3.7
Payette at Letha	2290.9	2289.3	2292.7	3.3
Payette nr Payette	2144.3	2143.3	2145.9	2.6
Snake at Nyssa	2168.7	2167.6	2168.7	2.4

Table 1. Summary of river stage elevations at USGS gaging stations.

Between Emmett and Letha, monthly river stage elevations were assumed to fluctuate similarly to river stage at the Emmett gage. Between Letha and Payette, monthly river stage elevations were based on fluctuations at the Letha gage.

The river was assumed to have a depth of 10 feet below the average stage elevation, which is identical to the average depth assumed for the Boise River in the TVHP model. All river cells were assigned an initial streambed conductance value of 200,000 ft^2/day, which was the initial conductance value used for the Boise River in the TVHP model (Petrich, 2004).

GENERAL HEAD BOUNDARY

The Snake River will be represented as a general head boundary. The expanded model domain includes 16 model cells along the Snake River (Figure 6). The average river stage elevation in each cell was based on topographic contours and digital elevation model data. Monthly fluctuation in Snake River stage height was based on gage data reported by the USGS for the gage at Nyssa between 1974 and 1997. Note that gage heights were based on a rating table downloaded from the USGS on January 4, 2011, which may differ somewhat from rating curves used during the 1974 to 1997 period. River stage elevation data are summarized in Table 1. The general head boundary cells in the new model domain were assigned the same initial hydraulic conductance value as upstream Snake River cells.

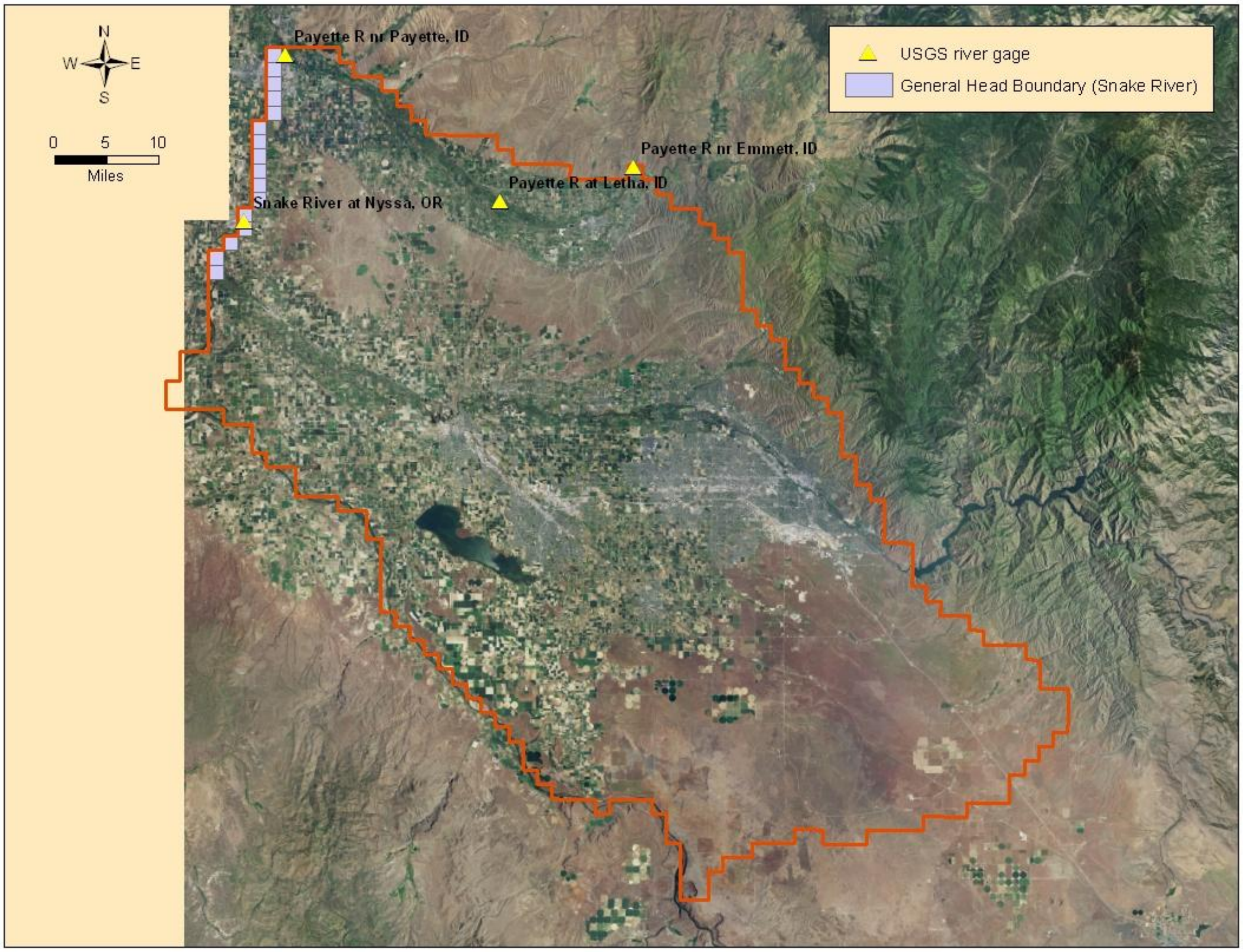

Figure 6. Snake River general head boundary cells in model expansion area.

DRAIN PACKAGE

Drains in the Lower Payette Valley and Emmett Valley are represented by 80 drain cells (Figure 7). Drains were assigned where observed water levels are within 10 feet of ground surface and in other cells within the Emmett Valley and Lower Payette Valley where agricultural drains are present. The drain cells allow discharge from the aquifer if head exceeds the drain elevation, but have no effect if the aquifer head falls below the drain elevation. Drain bottoms were assigned the same elevation as the ground surface elevation of the model cell, to be consistent with the TVHP model. All drain cells were assigned an initial drain conductance value of 50,000 ft^2/day, which was the initial conductance value used for drains in the TVHP model (Petrich, 2004).

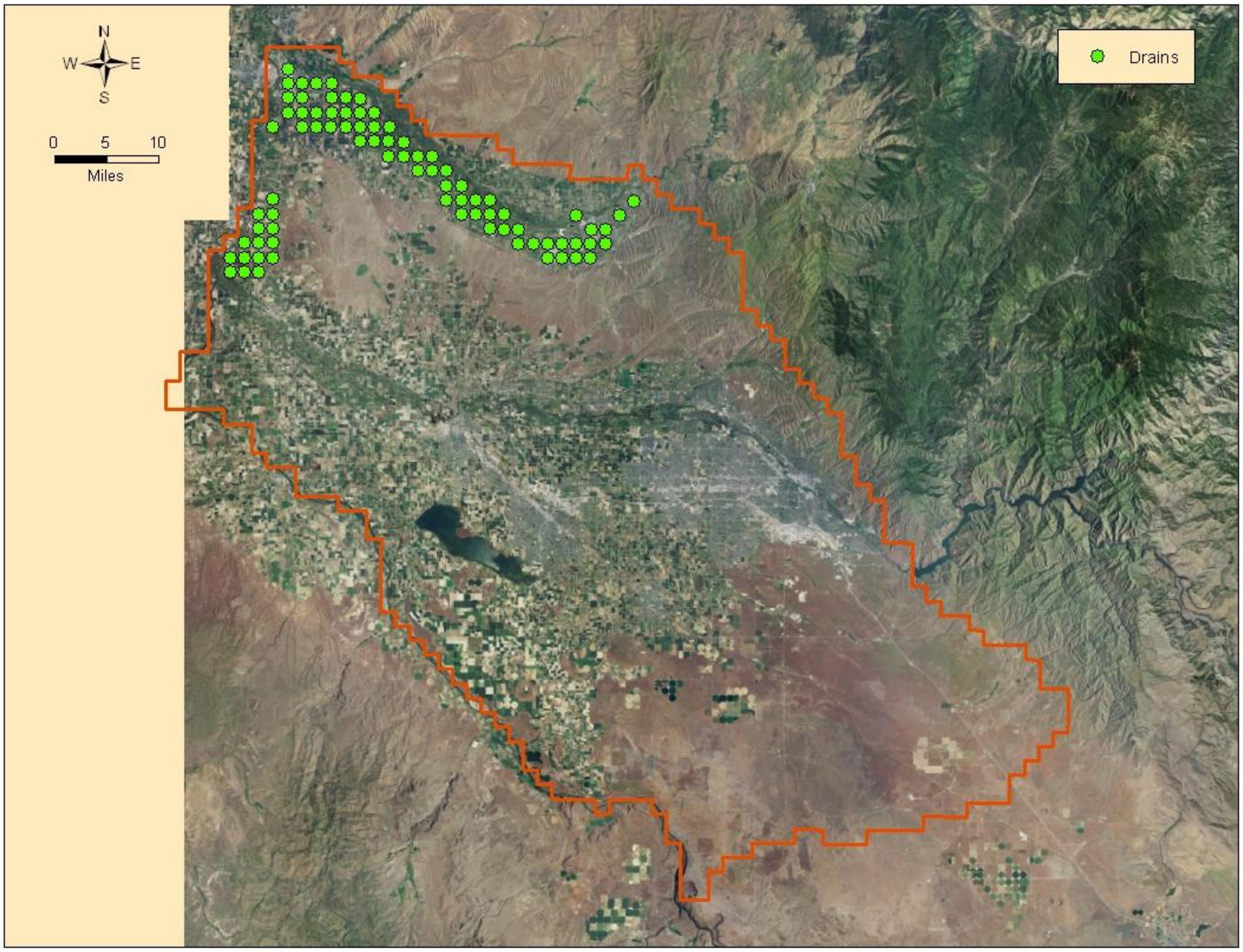

Figure 7. Drains in model expansion area.

RECHARGE PACKAGE

Net Recharge on Irrigated Agricultural Lands

Net groundwater recharge/discharge on irrigated agricultural lands was calculated by Schmidt, et al. (2008) as

NetRec/DisAg = OnFrmInfl + CanSeep – GWPmpAg – GwDrnRet,

where **OnFrmInfil = TotalFrmDel + PrecipAg – SurfIrrET – SurfDrnRet.**

On-farm infiltration on primary groundwater irrigated lands was assumed to be zero (BOR, 2008). "**GWPmpAg**" represents the consumptive use fraction of groundwater pumping and is calculated as ET minus precipitation during the irrigation season and assigned a value of zero during the winter months.

Irrigated Lands and Irrigation Entities

Irrigated land areas for the North Ada County area were determined using the Boise Valley 1994 land cover classification used by Schmidt, et al. (2008) and the Payette Valley 1997 land cover classification. An additional 100,282 acres of irrigated lands are included within the model boundary by adding the North Ada County and Payette Valley areas. Irrigation water is provided by 14 irrigation companies/districts and by private water rights. Irrigated acreage was assigned to an irrigation entity by splitting the irrigated lands polygons along irrigation company boundaries using the topology tool, then assigning each polygon to an irrigation district by intersecting the polygon centroids with irrigation company polygons. Where irrigation companies overlap, the irrigated land polygon was assigned to only one irrigation company to avoid duplication of irrigated acreage and preserve the total irrigated lands acreage. Estimated irrigated acreage for each irrigation entity is listed in Table 2.

The 100,282 acres of irrigated lands includes lands irrigated by surface water and/or groundwater. Lands located within irrigation company/district service areas were assumed to be irrigated primarily with surface water. Primary groundwater irrigation was assumed to occur where groundwater rights intersect with irrigated lands located outside irrigation company/district service areas. An estimated 3,069 acres are assumed to be irrigated with groundwater and 97,213 with surface water. Supplemental groundwater use within canal company service areas was assumed to be minimal and was neglected. The estimated 4,014 acres served by the Farmers Cooperative Ditch Company are irrigated with water from the Boise River and/or drains tributary to the Boise River. Net recharge values from adjacent lands included in the BOR(2008) study were applied to these lands.

Irrigated agricultural land in the East Ada County model expansion area was limited to approximately 378 acres between 1967 and 1997. Irrigated lands in the East Ada area were delineated using water right places of use and aerial photography. The distribution of irrigated agricultural lands within the model expansion areas is shown in Figure 8.

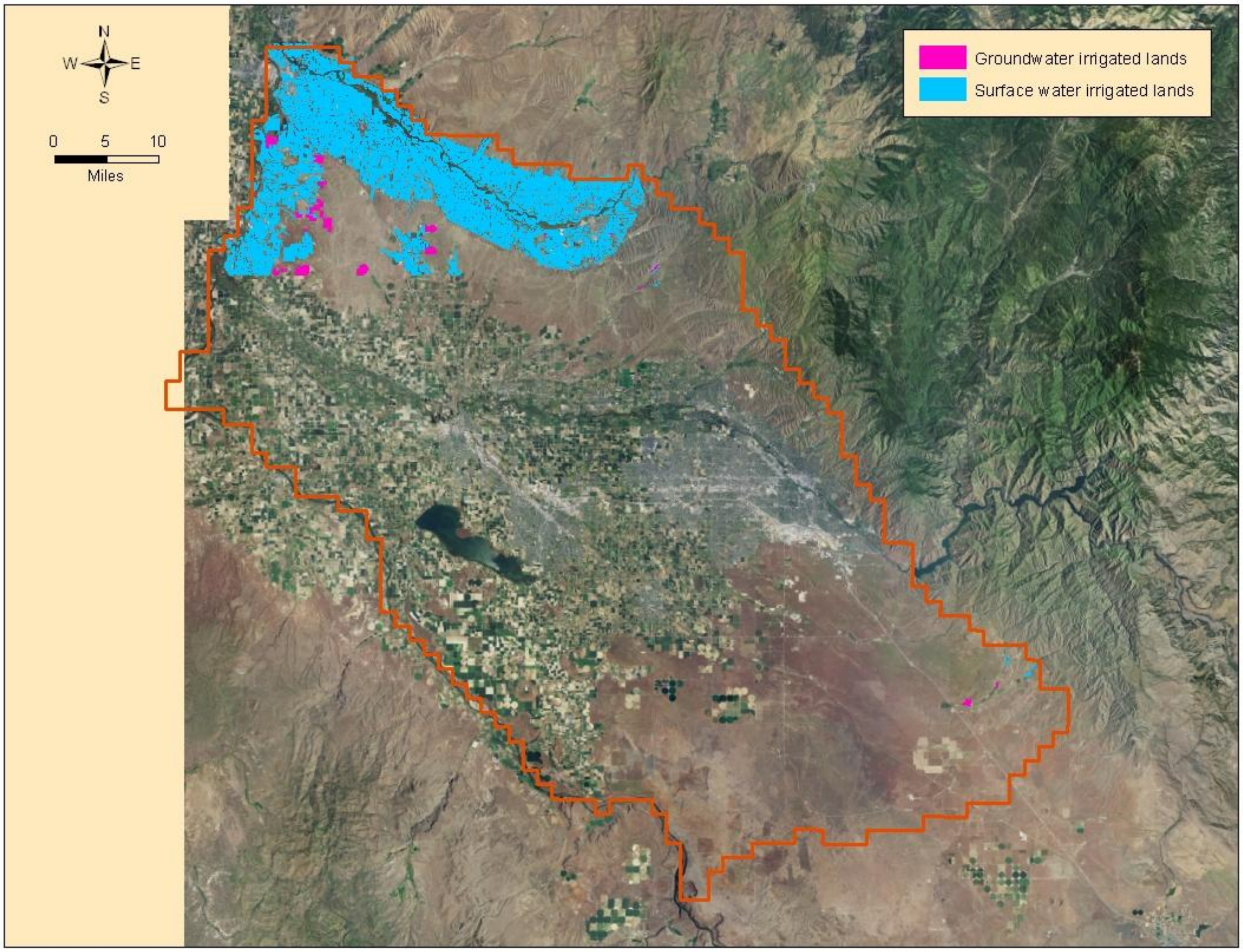

Figure 8. Irrigated agricultural lands (1994-1997) in model expansion area.

Irrigation Entity	Irrigated Acres
Black Canyon Irrigation District	22,508
Emmett Irrigation District	18,944
Farmers Cooperative Irrigation Co Ltd	12,660
Noble Ditch Co	10,438
Last Chance Ditch Co	5,922
Farmers Cooperative Ditch Co	4,035
Letha Irrigation & Water Co Inc	3,994
Lower Payette Ditch Co	3,593
Reed Ditch Co	2,387
Enterprise Ditch Co	2,246
Stewart Ditch Co	1,110
Bilbrey Ditch Co Ltd	734
Nesbitt Mc Farland Cooperative Ditch Co	284
Private Surface Water Irrigation	8,809
Private Ground Water Irrigation	3,069
Total	100,282

Table 2. Irrigated acreage in North Ada County and Payette Valley model expansion area.

Surface Water Diversions

Surface water diverted from the Payette River between Horseshoe Bend and Payette is used to irrigate land in the Emmett Valley, Emmett Bench, and Lower Payette Valley. This surface water irrigation contributes to net groundwater recharge and Payette River reach gains between Emmett and Payette. Monthly diversion data were obtained from the Snake River Planning Model. Data were available from 1967 through 1997 for the Emmett Irrigation District Northside and the Emmett Irrigation District/Black Canyon Irrigation District Southside diversions. Data were available from 1977 and 1993 through 1997 for 26 diversions, and from 1993 through 1997 for 8 diversions. For reference, the averages of the 1977 and 1993 through 1997 records for the Northside and Southside diversions were 1.3% and 5.1% lower than the 1967 through 1997 averages, respectively. The Northside and Southside diversions comprise approximately 319,700 AF (44%) of the estimated 721,300 AF average annual river diversions for lands within the model extension area (excluding water delivered through the Southside diversion to the Boise Valley water budget area, discussed below).

Black Canyon Irrigation District also diverts water to areas located within the TVHP model boundary and Schmidt, et al. (2008) water budget area. About 20 miles below Black Canyon Dam, a pumping plant lifts water from the main canal into a lateral system serving 26,014 acres (http://www.usbr.gov/projects/Powerplant.jsp?fac_Name=Black Canyon Powerplant). Approximately 3,126 acres served by the Black Canyon pumping plant are included in the model extension. The other 22,888 acres were included in the 42,000 acres of Black Canyon Irrigation District lands in the Boise Valley water budget (BOR, 2008). Urban (2004) reported diversions of 188,000 AF at the Black Canyon Irrigation District pumping plant. Assuming that 88% (22,888 of 26,014 acres) of the lands served by the pumping plant were included in the Boise Valley water budget (BOR, 2008), the estimated diversion from the Payette River for lands previously included in the Boise Valley water budget is 165,409 acre feet.

The Lower Payette Ditch Company and the Washoe Canal divert water above the Payette gaging station that is delivered to lands that drain to the Payette and Snake Rivers downstream of the Payette gaging station. These lands are not included in the model extension area.

Canal Losses

Canal losses include canal seepage and canal losses to evaporation. In the distributed parameter water budget for the Boise Valley (BOR, 2008) average annual canal seepage was estimated to be 492,284 AF (27.56% of river diversions). Canal seepage was estimated using data obtained from the Boise Project Board of Control and several irrigation districts. Farm deliveries average 4.3 AF per acre in the Boise Valley water budget area. Farm deliveries in the Sand Hollow drainage area in the northern part of the water budget study area were higher, averaging 6.7 AF per acre. Average annual canal seepage estimated for the TVHP water budget for the Boise Valley was 636,600 AF (36.56% of river diversions). An average farm delivery value of 4.3 AF per acre was used in the calculation of canal seepage (Urban, 2004). Average annual canal loss to evaporation in the Boise Valley was estimated to be 3,331 and 3,600 AF (0.186% and 0.207% of river diversions) in the BOR and TVHP water budgets, respectively.

For the Payette Valley, canal loss to evaporation was estimated by applying the ET values for open water (Table 5) to half the area of polygons classified as "major canal" in the 1997 Payette Valley land classification. ET was only applied to half the area of each polygon, because the polygons include access roads. The water surface area is assumed to comprise approximately half of the area. Average annual canal loss to evaporation for the Payette Valley was estimated to be 1,733 AF (0.237% of river diversions), which is similar to ratios estimated for the Boise Valley (BOR, 2008).

For the model extension area, canal seepage within each irrigation entity was estimated as follows.

Canal Seepage = Total Diversions – Canal Evaporation – Farm Delivery

Based on diversion and irrigated lands data, Payette Valley irrigation entities divert an average of 7.7 AF per acre. Farm delivery was assumed to be 5.4 AF per acre, which results in an average conveyance loss of 30%. Annual canal seepage averages 2.32 AF per acre, with values ranging from 0.28 to 4.64 AF per acre for most individual irrigation entities. One small irrigation entity has an estimated annual canal seepage of 16.31 AF per acre. Better estimates of canal seepage may be possible if additional data regarding farm delivery and irrigated acreage can be obtained from irrigation entities. However, since canal seepage is currently evenly distributed with the irrigated lands, better partitioning between canal seepage and on-farm infiltration components is not expected to significantly change net aquifer recharge/discharge within model cells.

Annual estimated canal seepage was distributed to monthly stress periods as a percentage of monthly diversions.

Farm deliveries and canal losses for the Farmers Cooperative Ditch Company, which diverts water from the Boise River were assumed to be equal to values from FDIN_IAL.dbf and CLOS_IAL.dbf (BOR, 2008) for the Farmers Cooperative Ditch Company for gravity irrigation near the Parma Experiment Station weather station, with drainage to the Snake River.

Surface Water Drain Returns

The Idaho Department of Environmental Quality (Ingham, 1999) identified a total of 34 irrigation drain returns between Black Canyon Dam and the Lower Payette River at Highway 95. Ingham (1999) compiled measured and estimated drain inflows to the Payette River for August 1996.

Limited flow measurement data for 16 of the 34 drains are available from the Idaho State Department of Agriculture and the Idaho Department of Environmental Quality, which have studied the effects of irrigation water returns on water quality in the Lower Payette River. Data available include the following:

1. Measurement of six of the 15 S-Drains between June 1992 and September 1993 (Ingham, 1996).
2. Measurement of five of the 15 S-Drains between April 2000 and March 2002 (Campbell, 2002). Three of these drains were also measured in the 1992-1993 study (Ingham, 1996). These measurements are outside of the model calibration time period, but give an indication of the relative magnitude of discharge from additional drains which were not measured in the 1992-1993 study.
3. Measurement of eight drains between the City of Emmett and the Gem-Payette county line between April 1996 and March 1998 (Campbell, personal communication, September 2010). Six of these drains are located on the north side of the Payette River.
4. Measurement of seven drains between the City of Emmett and the Gem-Payette county line between April 2008 and October 2008 (Campbell, 2009). These measurements are outside of the model calibration time period and all seven drains were included in the 1996-1998 study. Also, this study does not include winter time measurements and thus is not useful for estimating the groundwater contribution to drain discharge. Measurements from this study were not used in estimating drain returns for the recharge calculation.

Drains were aggregated and assigned to irrigation entities as follows:

1. North side drains between Black Canyon Dam and the county line (including Pioneer, Big-4, Mesa, Beacon, Silverleaf, and Sand Hollow) drain the Emmett Irrigation District northside service area.
2. South side drains between Black Canyon Dam and the county line (including Tunnel No. 7 and County Line) generally drain the service areas of the Bilbrey Ditch Co., Enterprise Ditch Co., Letha Irrigation and Water Co., Reed Ditch Co., Stewart Ditch Co., and the Emmett Irrigation District southside service area.
3. The fifteen S-Drains generally drain service areas of the Noble Ditch Co., Farmers Cooperative Irrigation Co., and approximately 9,586 acres of the Black Canyon Irrigation District.
4. Surface water returns from the Farmers Cooperative Ditch Co and approximately 9,345 acres of the Black Canyon Irrigation District drain to the Snake River. Drain return data from SWDR_IAL.dbf (BOR, 2008) were used for these entities.
5. Surface water returns from approximately 3,126 acres of the Black Canyon Irrigation District drain to Sand Hollow Creek tributary to the Boise River. Drain return data from SWDR_IAL.dbf (BOR, 2008) were initially used for this entity, but these data indicate that drain return are large (2.86 acre feet per acre per year), resulting in negative on-farm infiltration. Groundwater levels are not near the surface in this area, so negative on-farm infiltration is not expected. Drain return data from item four (1.91 acre feet per acre per year) were assumed to be a better representation for surface drain returns from this area. Use of these data result in positive on-farm infiltration of 0.64 acre feet per acre per year.
6. Privately irrigated polygons and polygons within the Last Chance Ditch Co. and Nesbitt McFarland Ditch Co. were assigned drain return ratios similar to the nearest of the first four groups listed above.

Drain measurements from November through March were assumed to represent groundwater discharge to drains. Surface water contribution to drain flow was assumed to be negligible during these months. Groundwater discharge to drains from April through October was estimated by linear interpolation between the March and November drain flow measurements. The surface water component of drain flow between March and November was estimated by subtracting the interpolated groundwater discharge estimates from the total measured drain flow.

Precipitation

Daily precipitation data from eight National Weather Service (NWS) recording stations were used to develop the Schmidt, et al. (2008) water budget for the Treasure Valley. Four additional NWS recording stations were added to obtain additional precipitation data for the expanded model domain. These weather stations included Payette, Emmett 2E, Boise 7N and Mountain Home. Thiessen polygons were constructed using the 11 NWS recording stations. The average monthly precipitation at each station for the period between 1967 and 1997 was assumed to be uniformly distributed over the surrounding

Thiessen polygon (BOR, 2008). New irrigated lands are located within polygons represented by the Payette, Emmett 2E, Parma Experiment Station, and Caldwell weather stations. New dry lands are located within polygons represented by the Payette, Emmett, Parma Experiment Station, Boise 7N, Boise WSFO AP, Swan Falls, and Mountain Home weather stations.

Monthly precipitation data were downloaded from the NOAA National Climate Data Center. Data were available from 1967 to 1997 for the Payette, Emmett 2E and Mountain Home stations. Data were available from 1973 to 1997 for the Boise 7N station. Data for the Parma Experiment Station, Boise WSFO AP, Swan Falls, and Caldwell were obtained from Schmidt, et al. (2008) files.

Evapotranspiration

Schmidt, et al. (2008) estimated evapotranspiration (ET) on irrigated lands using application of the Blaney-Criddle method with historical crop and weather data. Crop distribution data were obtained from the Boise Project and the USDA National Agricultural Statistics Service (NASS). Crop coefficients obtained using the Blaney-Criddle method were adjusted to match coefficients derived from Boise Valley Agrimet data.

Crop distribution data for Gem and Payette Counties were obtained from the NASS Census of Agriculture for 1987, 1992, and 1997. An average estimated crop distribution for irrigated cropland and pasture was calculated from the NASS values (Table 3). Because the 1994 and 1997 land use files classify irrigated orchards separately from irrigated cropland and pasture, the distribution of orchards was obtained directly from the land use files. The average crop distribution was also calculated separately for Gem and Payette Counties (Table 4). The county line is very close to the Thiessen polygon boundaries. The Gem County crop distribution was used to calculate average ET for crop and pasture land located within the Caldwell and Emmett weather station polygons. The Payette County crop distribution was used to calculate average ET for crop and pasture land located within the Parma Experiment Station and Payette weather station polygons. ET values for orchards were applied to lands classified as “*irrigated perennial/orchards*” or “*irrigated orchards, vineyards, and nurseries*”.

ET values (“Actual ET”) for the model expansion area were obtained from ET Idaho http://www.kimberly.uidaho.edu/ETIdaho/ which uses the Penman-Monteith method. Monthly ET values were downloaded for the Payette, Emmett 2E, Parma Experiment Station and Caldwell weather stations from 1967 to 1997. Average monthly ET values were calculated for each crop type. Where ET Idaho provides data for two classifications within a crop type alfalfa with frequent cutting vs. less frequent cutting, pasture with high and low management, orchards with and without ground cover, sweet corn with early and late planting, potatoes with early and late harvest), an average ET value was used.

Crop Type	1987	1992	1997	Average
Irrigated Orchards (ac)	7,717	4,776	3,446	5,313
Irrigated Crop and Pasture Land (ac)	77,227	89,123	83,664	83,338
Irrigated Land (ac)	84,944	93,899	87,110	88,651
Fraction of irrigated crop and pasture land by crop type (excluding orchards)				
Grass pasture	24.8%	32.0%	28.9%	28.6%
Alfalfa	24.0%	21.5%	21.9%	22.5%
Winter Grain irrigated	5.3%	5.4%	13.0%	7.9%
Spring Grain irrigated	9.4%	7.4%	3.4%	6.8%
Grass Hay	6.6%	6.0%	7.7%	6.7%
Field Corn	6.8%	5.8%	5.1%	5.9%
Sugar Beets	5.8%	6.0%	3.8%	5.2%
Silage Corn	5.3%	4.7%	4.8%	4.9%
Sweet Corn	3.6%	4.0%	3.6%	3.7%
Alfalfa seed	3.5%	3.3%	2.7%	3.2%
Onions	1.7%	1.4%	1.6%	1.6%
Dry Beans fresh	2.2%	1.1%	0.9%	1.4%
Potatoes	0.8%	1.4%	2.0%	1.4%
Garden Vegetables	0.1%	0.1%	0.6%	0.2%
	100.0%	100.0%	100.0%	100.0%

Table 3. Estimated crop distribution for the Lower Payette Valley.

Crop Type	Payette County	Gem County
Grass pasture	24.2%	34.8%
Alfalfa	21.6%	23.8%
Sugar Beets	8.8%	0.0%
Winter Grain irrigated	8.4%	7.1%
Spring Grain irrigated	7.5%	5.7%
Sweet Corn	6.1%	0.3%
Silage Corn	4.2%	6.1%
Grass Hay	4.0%	10.6%
Field Corn	4.0%	8.5%
Alfalfa seed	3.8%	2.2%
Onions	2.6%	0.0%
Potatoes	2.3%	0.0%
Dry Beans fresh	2.0%	0.6%
Garden Vegetables	0.3%	0.2%
Total	100.0%	100.0%

Table 4. Distribution of irrigated crop and pasture land (excluding orchards) by county.

On Farm Infiltration

On farm infiltration was calculated from the previously described estimates of total farm delivery, precipitation on surface water irrigated lands, ET on surface water irrigated lands, and surface water returns to drains.

OnFrmInfil = TotalFrmDel + PrecipAg – SurfIrrET – SurfDrnRet.

Estimates of annual on-farm infiltration range from 0.36 AF per acre to 2.29 AF per acre for most irrigation entities. Estimates of annual on farm infiltration within the Farmers Cooperative Ditch Company are much higher, ranging from 5.50 to 5.91 AF per acre. These values result from application of Schmidt, et al. (2008) farm delivery data, which indicate that farm delivery by the Farmers Cooperative Ditch Company is very high at 13.88 AF per year.

Net Recharge on Irrigated Agricultural Lands

Net groundwater recharge/discharge on irrigated agricultural lands was calculated from the previously described estimates of on farm infiltration, canal seepage, consumptive use of groundwater for agricultural irrigation, and groundwater returns to drains.

NetRec/DisAg = OnFrmInfl + CanSeep – GWAgCU – GwDrnRet

The irrigated agricultural lands budget in the North Ada County and Lower Payette Valley areas is represented by two shapefiles. "NARD_Surf_Irrlands.shp" provides monthly average values for the components of on farm infiltration and net recharge/discharge for surface water irrigated lands. Annual net recharge/discharge on surface water irrigated lands within the model expansion area is estimated to be 221,921 acre feet.

"NARD_Ground_irrlands.shp" provides monthly average values for consumptive use on groundwater irrigation agricultural lands. Annual net recharge/discharge on groundwater irrigated lands within the North Ada County and Lower Payette Valley areas is estimated to be -7,185 acre feet. Total net annual recharge/discharge on irrigated agricultural lands within the North Ada County and Lower Payette Valley areas is estimated to be 214,736 acre feet.

The irrigated lands budget in the East Ada County area is represented by one shapefile, "EAda_Irrlands_NARD.shp", which includes both surface water and groundwater irrigated parcels. Irrigated acreage in 1997 was estimated from water right records. The total irrigated area represented is approximately 378 acres. Net recharge on surface water irrigated lands was estimated assuming alfalfa watered at 80% efficiency. Net discharge on groundwater irrigated lands was also estimated using the crop irrigation requirement for alfalfa. Average annual net recharge/discharge is estimated to be -338 AF/year on irrigated agricultural lands in the East Ada County area.

Net Recharge on Dry Lands and Water Bodies

Dry land areas and water bodies for the North Ada County and Lower Payette Valley areas were determined using the 1997 Payette Valley land cover classification. Dry land areas include areas classified as abandoned and idle agricultural land, other agricultural land (non-irrigated), rangeland, barren land, and transportation corridors. Water bodies include areas classified as open water and wetland/riparian. Some of the model domain is located in areas that are "not defined" in either the 1997 Payette Valley or 1994 Boise Valley land cover classification. These areas were considered to be rangeland for the purposes of assigning ET values. Areas outside of the land classification coverage were also generally assumed to be rangeland. A few parcels in the East Ada County area were digitized to represent Indian Creek Reservoir and irrigated agricultural, commercial, and residential land uses.

Net groundwater recharge and discharge was calculated as the difference between precipitation and ET. Precipitation was assigned using the same Thiessen polygons discussed previously under irrigated lands. ET was assigned using values from the Boise Valley water budget (BOR, 2008). During November through March, ET is assumed to be 0.007 feet per month for all categories of dry lands and water bodies. During April through October, monthly ET is assigned the values listed in Table 5.

Land Classification	ET (AF/month per acre) April through October	ET (AF/month per acre) November through March
Rangeland	0.113	0.007
Barren land	0.157	0.007
Idle, abandoned, and other agricultural land	0.101	0.007
Transportation corridors	0.196	0.007
Wetland	0.480	0.007
Water bodies	0.433	0.007

Table 5. Average monthly ET on dry lands (BOR, 2008).

Net Recharge on Residential, Commercial, and Public Recreation Lands

Schmidt, et al. (2008) calculated net recharge on residential, commercial, and public recreation lands for three categories of land use:

1. Net recharge in municipal areas = Infiltration - groundwater pumping
2. Net recharge in rural areas with surface water irrigation = Infiltration
3. Net recharge in rural areas without surface water irrigation = Infiltration - ET

Groundwater pumping for the cities of Emmett, New Plymouth, and Fruitland is represented in the well package as described in a later section of this report. Infiltration is assumed to be 0.25 AFA/ac. The monthly distribution was obtained from the spreadsheet file “final ResComPub GIS link.xls” (BOR, 2008). Monthly ET (outdoor consumptive use) values for each land class were also obtained from this file.

In the North Ada County and Lower Payette Valley model expansion area, most areas are located within irrigation districts and may have access to surface water for irrigation. Private surface water rights also cover some areas not included in irrigation districts. Net recharge outside of municipal areas was estimated assuming that commercial/industrial, dairy, feedlot, and residential farmstead polygons do not utilize surface water for outdoor use. Residential rural, residential new subdivision, public recreation lands, recreation areas, and agricultural land in transition are assumed to utilize surface water for outdoor use.

In the East Ada County area, all residential, commercial, and public recreation lands are assumed to use groundwater for outdoor consumptive use. Residential, commercial, and public recreation lands in the model expansion area are shown in Figure 9.

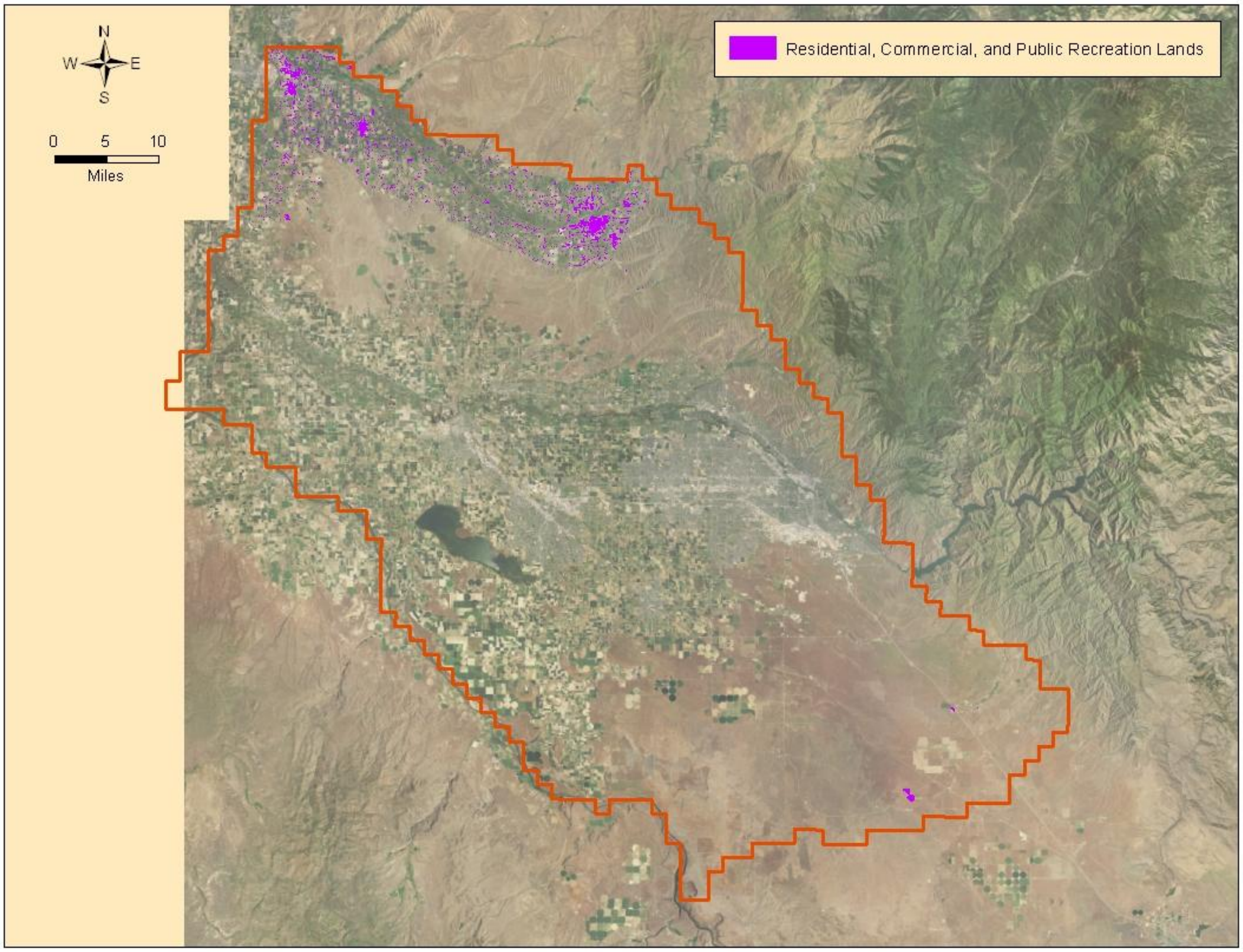

Figure 9. Residential, commercial, and public recreation lands (1997) in model expansion area.

WELL PACKAGE

The well package is used to represent municipal groundwater pumping and specified flux boundaries. Net groundwater pumping for agricultural use is included in the recharge package in the net recharge/discharge on irrigated agricultural lands following Schmidt, et al. (2008).

Municipal Pumping

Groundwater pumping in three cities (Emmett, New Plymouth, and Fruitland) is included in the well package (Figure 10). These cities have wastewater treatment plants which discharge to the Payette and/or Snake River. Groundwater pumping within these water systems is assumed to be consumptive with respect to the aquifer. Groundwater pumping for indoor use in rural domestic and small community water systems is assumed to be non-consumptive and is not included in the water budget.

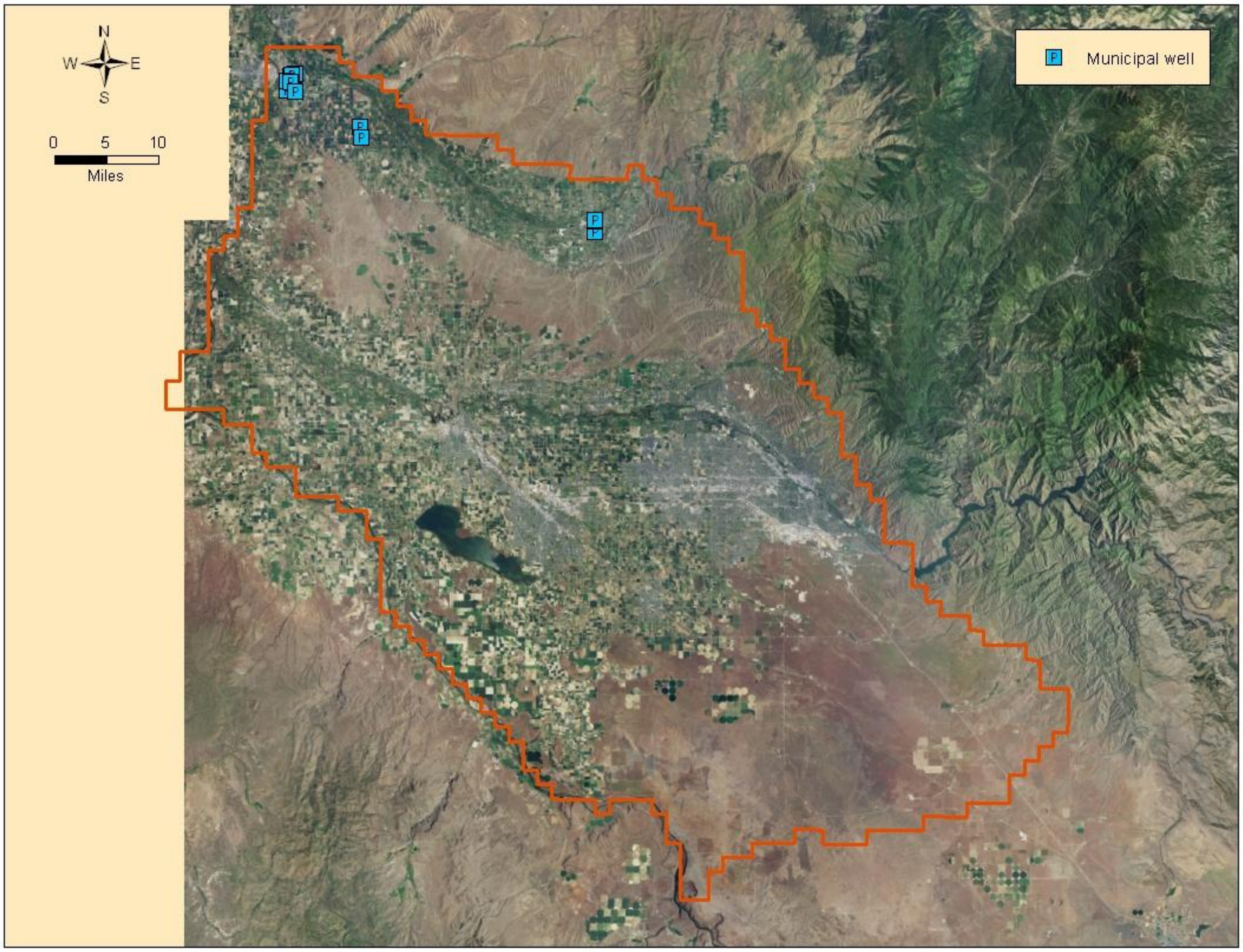

Figure 10. Municipal wells in model expansion area.

Groundwater pumping for the municipal systems was estimated from annual water usage data for the City of Fruitland during 2003 (Pharmer Engineering, LLC, 2007). Average day water use was estimated to be 235 gpcd from reported annual water use data and estimated population. Average day water use for the City of Fruitland, City of Emmett, and City of New Plymouth was estimated by multiplying the estimated 1997 population of each City by 235 gpcd. The estimated annual water use for the City of New Plymouth in 1997 is consistent with projections made in a 1997 water system facility plan (Holladay Engineering Company, 1997). Monthly water use for each City was estimated using the average monthly fraction of pumping reported for Boise Valley municipal wells in the file NARD_RCP.dbf (BOR, 2008). Withdrawals were apportioned to City wells drilled prior to 1997, based on capacity information from available water system reports.

Tributary Underflow from Willow Creek, Bissel Creek, and Haw Creek Basins

Tributary underflow from the drainage basins of Haw Creek, Bissel Creek, Little Willow Creek, and Big Willow Creek is represented as a specified flux applied to 18 model cells along the northern boundary (Figure 11). A total annual flux was estimated for these areas and was distributed evenly over the 12 monthly stress periods and the 18 model cells.

Annual groundwater underflow was estimated as precipitation less ET and recorded surface water discharge from these basins. The basins include approximately 244,889 acres, which includes approximately 7,674 acres of irrigated agricultural land and approximately 1,467 acres of water bodies. Irrigated acreage was estimated from the Payette Valley 1997 land classification and from water right place of use. Water bodies were digitized from 2004 NAIP aerial photography. The remaining land is assumed to be rangeland for the purpose of estimating ET.

Thiessen polygons were used to assign land to one of four weather stations (Payette, Emmett 2E, Weiser 2 SE, or Ola) for precipitation. ET values from Table 5 were assigned to rangeland and water bodies. An average annual ET value of 3.066 feet per acre was assigned to irrigated agricultural lands in the tributary basins.

Recorded stream discharge data are limited to measurements made by ISDA and IDEQ at Bissel Creek between April 1996 and March 1998, and at Big Willow Creek between June and November in 1992 and 1993. Stream discharge is underestimated in this calculation, resulting in overestimated groundwater underflow from these basins. However, tributary stream discharge is also underestimated in the calculation of Payette River reach gains, resulting in an equivalent overestimation of the groundwater contribution to Payette River reach gains.

Water budget components included in the tributary underflow estimate are summarized in Table 6. The estimated average annual tributary underflow is 59,389 AF/yr. A specified flux of 275 AF per monthly stress period was added to the recharge in 18 cells along the northern boundary of the model.

Figure 11. Tributary underflow in model expansion area.

Water Budget Component	Area (acres)	Volume (AF/yr)
Precipitation	244,889	323,182
Rangeland ET	235,747	-194,727
Irrigated Agriculture ET	7,674	-23,473
Water Bodies ET	1,467	-4,498
Recorded Stream Discharge		-41,095
Estimated Tributary Underflow		59,389

Table 6. Tributary underflow estimate for Big Willow, Little Willow, Bissel, and Haw Creek drainage areas.

CALIBRATION TARGETS

Water Level Observations

The BOR transient Treasure Valley groundwater model will use monthly water level observations as calibration targets. The BOR calibration targets are the average of available water level measurements made during a given month of the year over the period from 1967 to 1997. Figure 12 shows the location of wells with water level observations in the model expansion areas. In the North Ada area, there are 66 wells with usable measurements available from the period 1967 to 1997. In the East Ada area, there are 2 wells with usable measurements available from the period 1967 to 1997. Measurements were obtained from the IDWR Well Log database. Pumping water levels and water levels reported by drillers were removed from the data set. Average monthly water levels are provided in the attribute table for shapefile WellsMonthlyObs_67_97.shp.

Water level observations are also available for additional wells in the North Ada and East Ada areas from measurement programs implemented in 2008 and 2009. These measurements are not from the same time period used to develop the BOR Treasure Valley water budget, but are located in areas which are still largely undeveloped. These measurements are the best available approximation of water levels in these areas during the model period. Average monthly water levels are provided in the attribute tables for shapefiles MonthlyObsNAda_08_10.shp and MonthlyObsEAda_99_10.shp. These files include 7 wells in the North Ada area and 5 wells in the East Ada area. Three additional wells in the East Ada area are not assigned to a model layer, because they appear to obtain water from a perched aquifer. These three wells are included in the shapefile MonthlyObsEAda_99_10.shp, but are designated with Layer = 0.

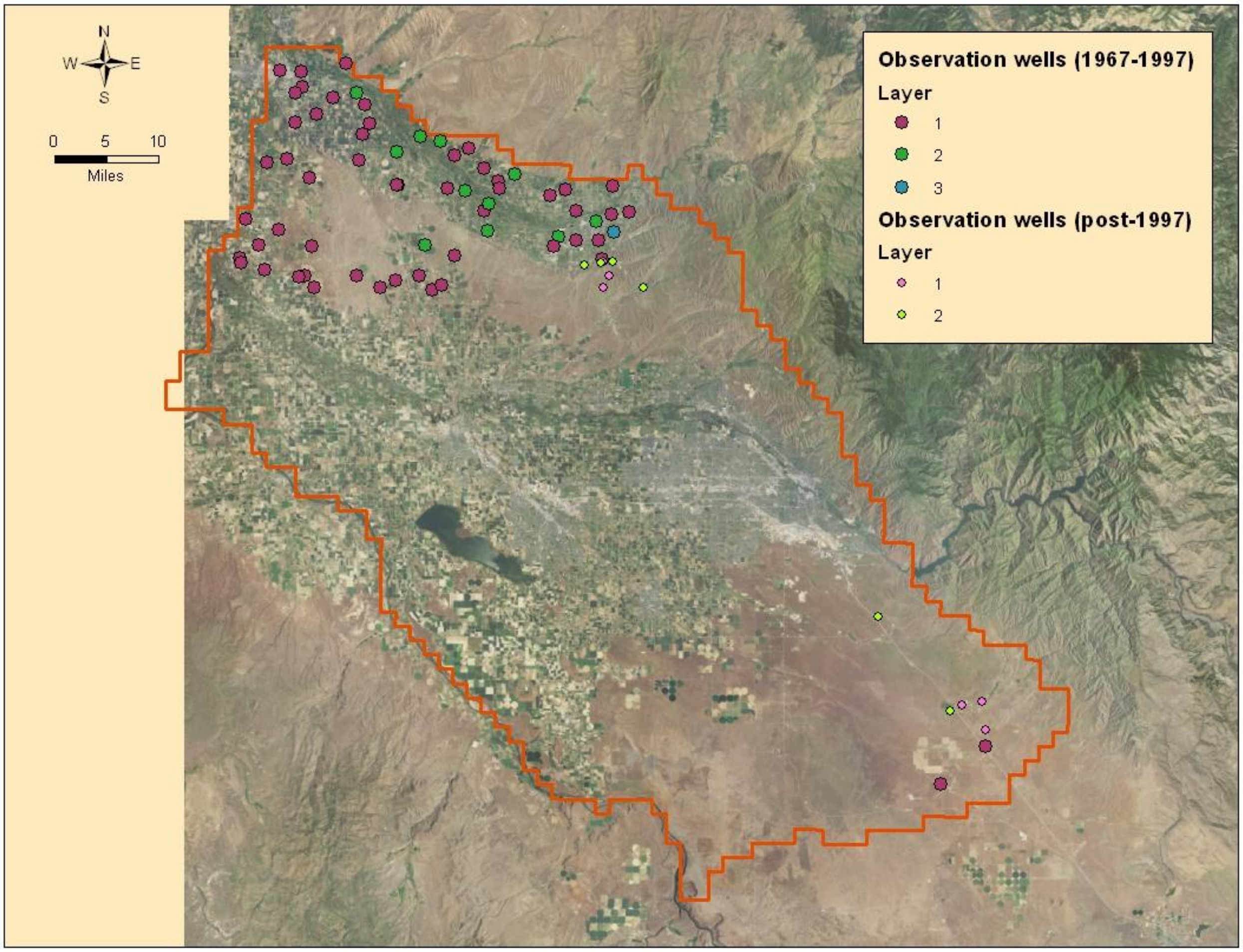

Figure 12. Wells with water level observations in model expansion area.

Ground Water Drain Returns

Drain return measurement data are described in the Surface Water Drain Returns section of this report. Estimation of the groundwater component of drain returns was also discussed previously. Because many drain cells include one or more unmeasured drains, groundwater drain return observations can be applied to only five drains, comprising a total of 17 drain cells (Figure 13). These drains include Tunnel No. 7 (3 cells), County Line (3 cells), S-5 (3 cells), S-13 (4 cells), and S-14 (4 cells). Average monthly groundwater discharge in cubic feet per day is provided in the file DrainReturns.xlsx, along with a list of grid cells included in each drain.

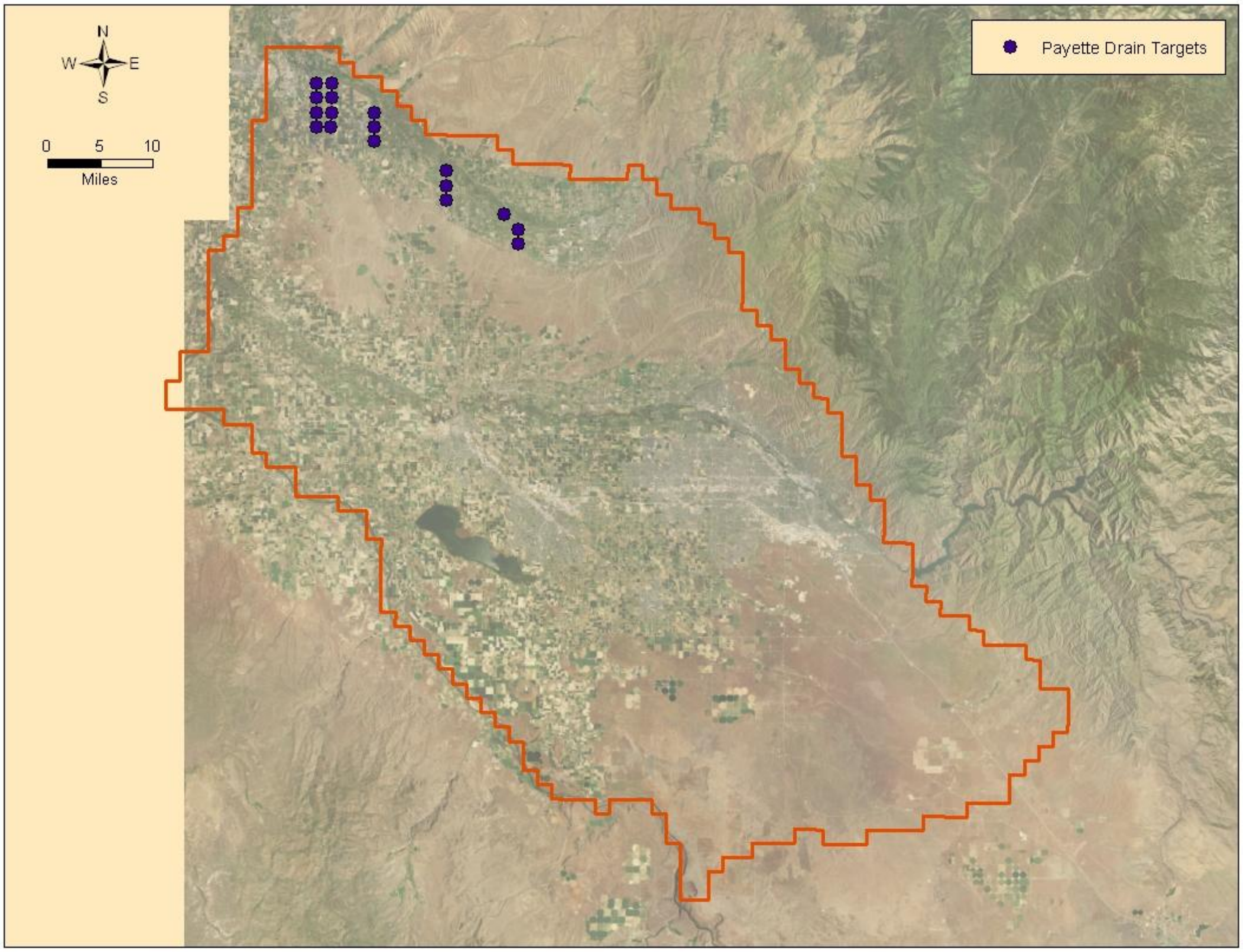

Figure 13. Drain targets in model expansion area.

River Reach Gains

River reach gains were calculated for the Emmett to Below Sevenmile Slough reach and the Below Sevenmile Slough to Payette reach (Figure 5). Reach gains were calculated from available data as

ReachGain = OutflowGage – InflowGage – Tributaries – Returns + Diversions

At Below Sevenmile Slough, the river gage reading is the sum of the Payette River at Letha gage and the End of Sevenmile Slough gage. Returns include measured and estimated agricultural drains, and estimated wastewater treatment plant returns. Limited data were available for tributary streams. Gains in both reaches are expected to be overestimated because of the lack of data for streamflows in Haw Creek and Little Willow Creek, and lack of data for winter flows in Big Willow Creek. This error is offset by an equivalent overestimation of tributary underflow from these basins.

Reach gains are provided in the file PayetteReachGains.xlsx, along with a list of grid cells included in each reach. Because the groundwater component of drain returns within the Emmett Irrigation District northside area appears to occur in close proximity to the river and primarily in model cells assigned to the Payette River, an adjusted reach gain data series is provided for the Emmett to Below Sevenmile Slough reach. The northside groundwater drain returns were added to the reach gains to obtain the second data series. This data series may be more appropriate for model calibration than the reach gain series.

SUMMARY AND RECOMMENDATIONS

Further investigation of the following items may be undertaken to attempt to refine the water budget.

- Diversion records obtained from the SRPM are available from 1967 through 1997 for the Emmett Irrigation District and Black Canyon Irrigation District diversions above Black Canyon Dam. Records for diversions between Black Canyon Dam and Payette are limited to 5 to 6 years (1993-1997 or 1977 and 1993-1997). Canal companies have not been queried regarding possible additional records of diversions between 1967 and 1992.
- Where irrigation companies overlap, the irrigated land polygon was assigned to only one irrigation company to avoid duplication of irrigated acreage. This may over or underestimate the number of acres assigned to a given irrigation entity, but preserves the total number of irrigated acreage. If available, irrigation company records might help refine the number of irrigated acres served by each entity.
- Supplemental groundwater use within canal company service areas was assumed to be minimal and was neglected in development of the irrigated lands water budget. Further review of supplemental groundwater rights and/or irrigation company delivery records (if available) could be considered.
- Farm delivery records were not obtained from canal companies for this analysis. Farm delivery was assumed to be 5.4 AF per acre for all Payette Valley irrigated lands. If available, canal company records may provide better representation of canal seepage and farm delivery. However, since canal seepage is currently evenly distributed with the irrigated lands, better partitioning between canal seepage and on-farm infiltration components is not expected to significantly change net aquifer recharge/discharge within model cells.
- Drain return data were limited to one to two years of data collected for water quality studies. Canal companies may have additional records of return flows.
- Areas classified as “not defined” in the Boise and Payette land use files were assumed to be rangeland. Areas located outside the boundaries of the land use files were also generally assumed to be rangeland. A few parcels in the East Ada County area were digitized to represent Indian Creek Reservoir and irrigated agricultural, commercial, and residential land uses.

- Lack of complete data for some tributary streams on the north side of the Payette River likely results in overestimation of tributary underflow and groundwater reach gains to the river. Estimates of streamflow could be made and deducted from these values. The errors are offsetting with respect to the water budget, but may affect head calibration on the north side of the river.
- Some additional portion of the groundwater component of drain returns may need to be added to the river reach gains for calibration to account for groundwater returns to drains that occur in close proximity to the river.

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