NON-SNAKE RIVER DIVERSIONS AND PERCHED RIVER SEEPAGE

University of Idaho

Idaho Water Resources
Research Institute

by Nathan Erickson,
Daren Nelson
and Bryce Contor
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Eastern Snake Plain Aquifer Model Enhancement Project
Water Budget Design Document Number DDW-024 Draft As-Built

DESIGN DOCUMENT OVERVIEW

Design documents are a series of technical papers addressing specific design topics on the eastern Snake River Plain Aquifer Model upgrade. Each design document will contain the following information: topic of the design document, how that topic fits into the whole project, which design alternatives were considered and which design alternative is proposed. In draft form, design documents are used to present proposed designs to reviewers. Reviewers are encouraged to submit suggested alternatives and comments to the design document. Reviewers include all members of the Eastern Snake Hydrologic Modeling (ESHM) Committee as well as selected experts outside of the committee. The design document author will consider all suggestions from reviewers, update the draft design document, and submit the design document to the SRPAM Model Upgrade Program Manager. The Program Manager will make a final decision regarding the technical design of the described component. The author will modify the design document and publish the document in its final form in .pdf format on the SRPAM Model Upgrade web site.

The goal of a draft design document is to allow all of the technical groups which are interested in the design of the SRPAM Model Upgrade to voice opinions on the upgrade design. The final design document serves the purpose of documenting the final design decision. Once the final design document has been published for a specific topic, that topic will no longer be open for reviewer comment. Many of the topics addressed in design documents are subjective in nature. It is acknowledged that some design decisions will be controversial. The goal of the Program Manager and the modeling team is to deliver a well-documented, defensible model which is as technically representative of the physical system as possible, given the practical constraints of time, funding and manpower. Through the mechanism of design documents, complicated design decisions will be finalized and documented. Final model documentation will include all of the design documents, edited to ensure that the “as-built” condition is appropriately represented. This document is the as-built document for diversions and perched river seepage for rivers other than the Snake River.

INTRODUCTION

This design document describes diversion and return data and perched-river seepage for streams and rivers other than the Snake River. It is acknowledged that some reaches of some streams may be hydraulically connected with the aquifer. Because data were limited and because the purpose of this model was to represent regional interaction between the Snake River and the aquifer, all non-Snake streams and rivers are represented using head-independent perched seepage. This simplification applied the correct flux for model calibration, but in use of the model, ground-water/surface-water interactions for these water bodies will not be simulated.

Diversion and return data and estimates for these streams and for the Snake River are incorporated in the diversion spreadsheet, which generates input files for the GIS Recharge Tool. Perched river seepage is represented in a GIS line data set and a data table, which are also inputs to the GIS Recharge Tool.

Diversions from the Snake River are represented by data from Idaho Department of Water Resources, as reported in Design Document DDW-012 (Gilliland 2002). Interaction between the Snake River and the aquifer are discussed in Design Documents DDM-007 (Wylie, in review), DDM-010 (Wylie, in review) and DDM-017 (Johnson, in review).

METHODS AND DATA SOURCES

Data came from various sources, including electronic files from Idaho Department of Water Resources (2001), paper and microfiche watermaster records (IDWR 2002), and other sources. Individual data are described stream-by-stream below. Because data were prepared before stress period definitions were defined, monthly data were gathered or annual data were interpolated to monthly values. When stress periods were defined, monthly values were summarized to appropriate stress period lengths.

In the case of watermaster reports, data were generally available as annual summaries. Monthly fractions were determined by hand calculation from a sample of microfiche or paper copies of daily watermaster records, and applied to annual data.

For some streams, different data were used for early periods and late periods. Individual stream descriptions below discuss methods to interpolate missing periods, and methods to estimate diversions and perched seepage where data were not available. Figure 1 illustrates the individual features for which perched seepage were calculated. Most of these features are streams for which diversions and returns were calculated. The same data were often used for both diversion and seepage calculations. Each of these features are described in geographic order, starting from the northeast:

<u>Camas Creek and Lone Tree.</u> Camas Creek provides irrigation water to lands in the Kilgore area and near Mud Lake. It is part of the supply for the Camas National Wildlife Refuge and is tributary to Mud Lake. A constructed flood-control diversion at Lone Tree spreads water on basalt lands in wet years.

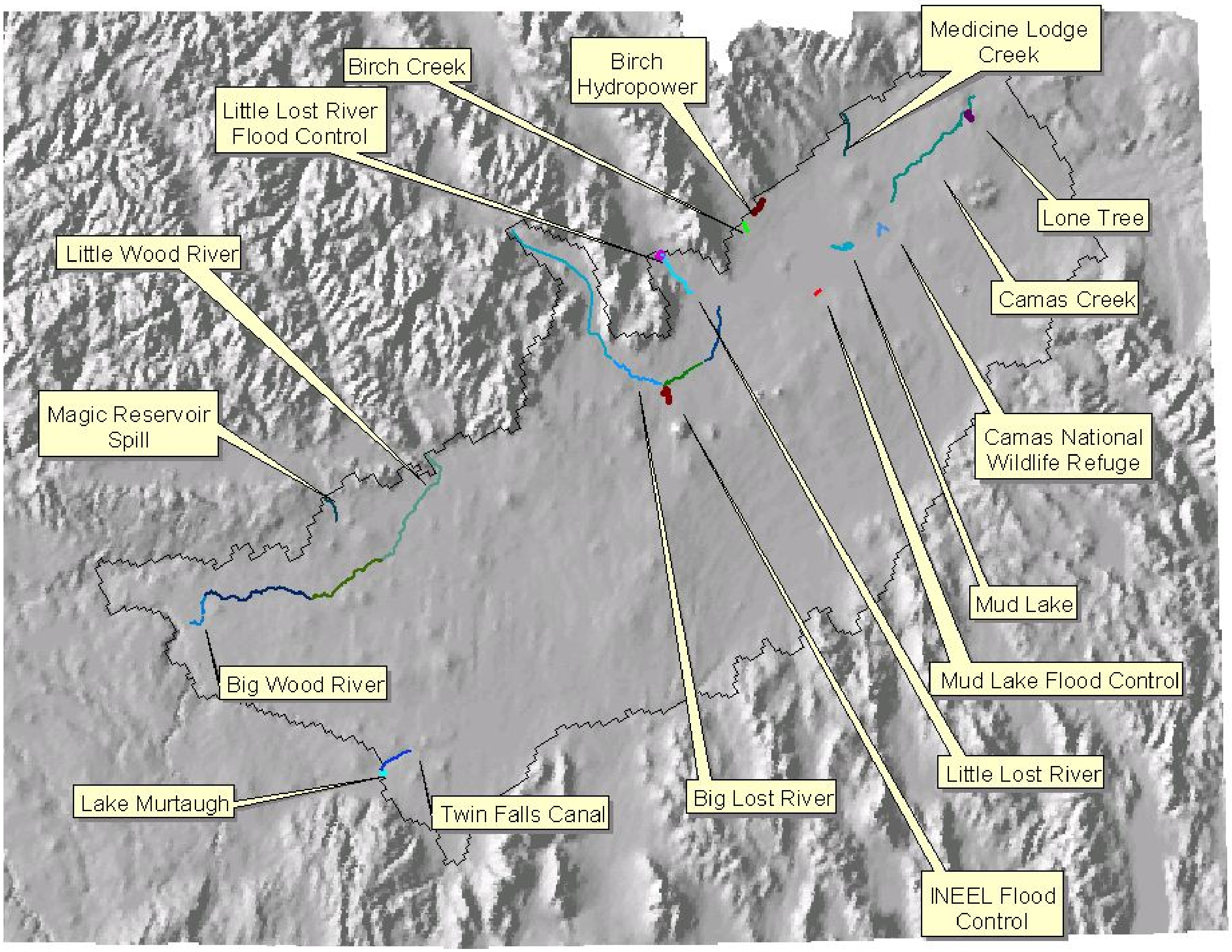
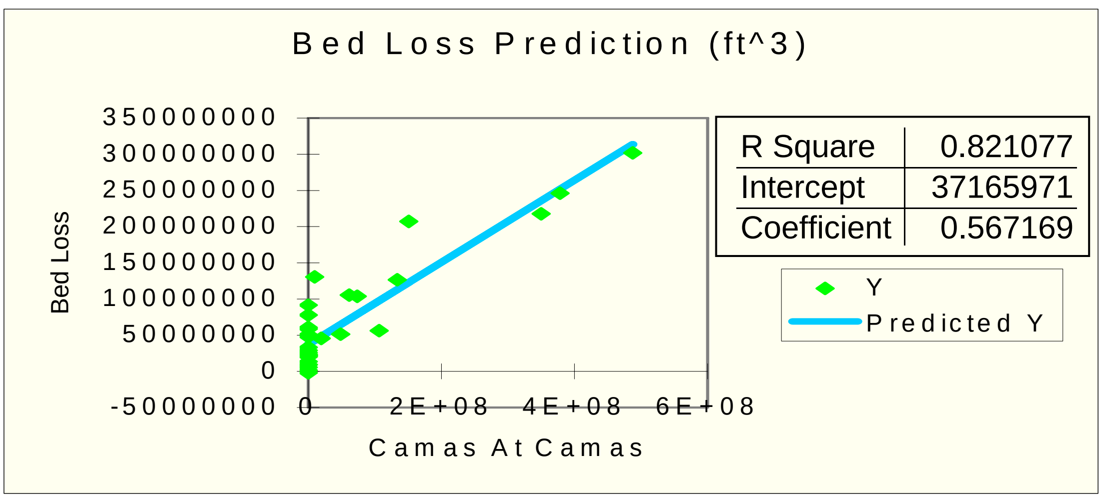


Figure 1. Location of streams and features for which non-Snake diversions and perched river seepage were represented.

Diversion data for entities IESW029 (water delivered via Mud Lake) and IESW051 (Camas Creek water delivered upstream of Mud Lake) came from watermaster annual reports. No returns were applied to these entities. See the Camas National Wildlife Refuge and Mud Lake discussion below for more information about entity IESW029.

Flood-control diversion volumes (USGS 2002) were applied as a line source at the Lone Tree spreading location. Camas Creek perched-river seepage (bed loss) was based on the difference in flow between two gauging stations at Camas Creek. The upper gauging station is Camas Creek at Red Road near Kilgore and the lower is Camas Creek near Camas. Corrections were made for diversions at Lone Tree and irrigation diversions between the two gauges (Shenton 2002).

Actual irrigation diversions and Lone Tree flood control diversion data were available for all years, as well as Camas at Camas gauge data. However, the Red Road gauge data series was incomplete (the north end of the losing reach). Several relationships were examined as candidates for prediction of missing values: Camas at Red Road vs. Camas at Camas, Camas at Red Road vs. gauging records on various near by drainages, Camas at Red Road vs. precipitation at Dubois, Camas at Red Road vs. diversions, bed loss vs. diversions, and bed loss vs. Camas at Camas. Based on the predictive ability indicated by the r-squared values and visual inspection of scatter plots, the relationship illustrated in Figure 2 was selected.



R Square	0.821077
Intercept	37165971
Coefficient	0.567169

Figure 2, Bed loss prediction of Camas at Camas

The final perched seepage values used in model calibration were based gauge data for all periods where data were available, and the predicted seepage where Red Road gauge data were not available.

Medicine Lodge Creek. The diversion records for Medicine Lodge creek are recorded as a total for the district, but only part of this total is within the study area. GIS analysis showed that 45% of District 32-c irrigated lands are within the study area. Annual diversions were multiplied by 45% and then distributed among summer months using average monthly fractions calculated by hand from several individual years. These diversions were applied to irrigation entity IESW052. GIS analysis showed that the USGS gauging station "Medicine Lodge near Small Idaho" was below the diversions for out-of-study-area irrigation and above the diversions for inside-study-area irrigation.

Medicine Lodge Creek sinks into the plain south of the irrigated lands. Bed loss was calculated by subtracting the inside-study-area diversions from the gauged flow at Medicine Lodge near Small Idaho. The gauging station for Medicine Lodge began to function during the summer of 1985; records before this time were not kept. For years after 1985, the "Big Lost River Below Mackay Reservoir" gauging station was compared with Medicine Lodge creek gauge records using linear regression. This produced a reasonable prediction equation, which was applied to years before 1985 (Figure 3). For all years before 1985 the predicted Medicine Lodge gauge record was used with actual diversions in calculating bed loss. Actual data were used to calculate bed loss for all years after 1985.

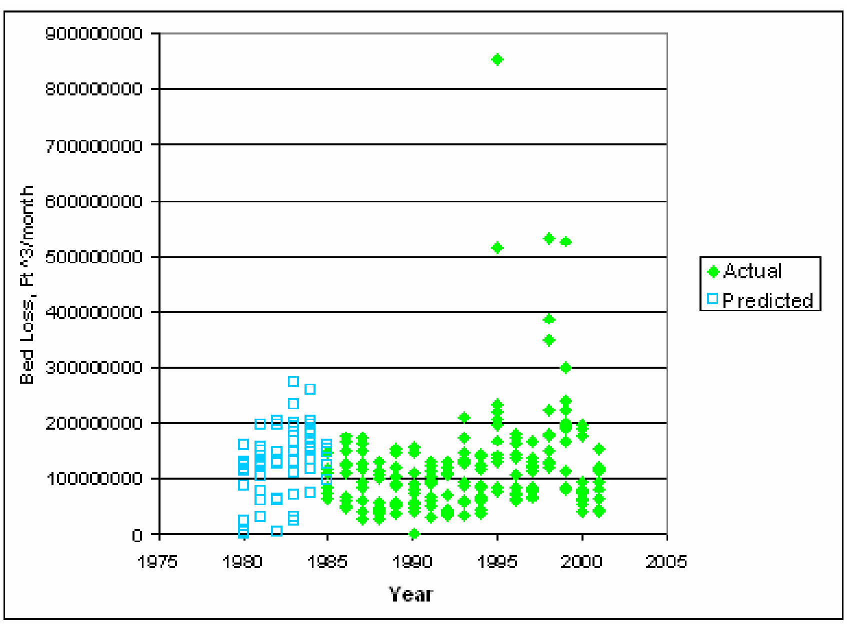


Figure 3. Calculated bed loss based on actual and predicted Medicine Lodge Gauge data.

No return flows were represented for entity IESW052.

Birch Creek and Birch Creek Hydropower Plant. The bed loss and diversion calculations for Birch creek are divided into two different time periods. Before 1987, water was delivered to Reno Ranch through a ditch with an estimated 50% bed loss. After 1987, water was diverted into a lined canal and pipeline and delivered to the Birch creek hydroelectric plant before being used by the Reno Ranch (Sorenson Engineering 2002).

Prior to 1987, Birch Creek was measured at the USGS gauge station "Birch Creek at 8-mile Canyon Road Near Reno Idaho". Water measured by this gauge station was then diverted into the old Reno Ranch ditch during summer months. Excess water (and all water the during winter months) was allowed to continue downstream and flow out onto the desert (Figure 4).

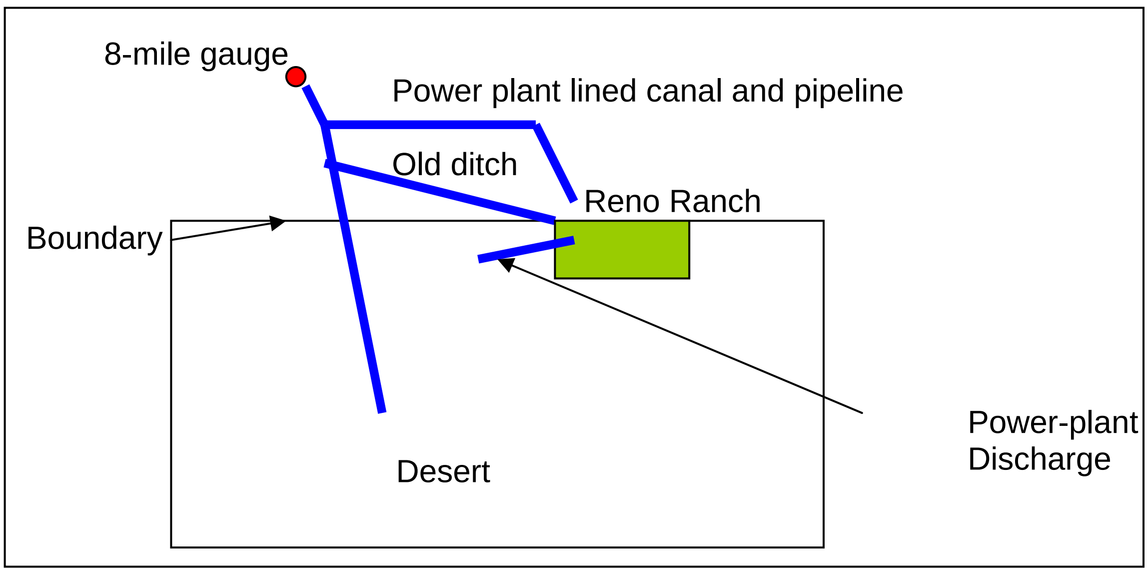


Figure 4, Conceptual map of Birch Creek water use.

For months when the Eight-mile gauge station was not active, gauge records were predicted using regression based on Birch creek diversions (Figure 5). Prior to 1987, half the reported diversions were applied as diversions to irrigation entity IESW037. The eight-mile gauge record, less diversions applied to IESW037, was applied as perched river seepage (bed loss) in the natural channel of Birch Creek within the study area. This actually applied the 50% ditch loss from the old ditch to the natural channel of Birch Creek, but since the old ditch is outside the model study area, seepage from the ditch actually enters the model domain as sub-surface flow in the model cells near the creek channel.

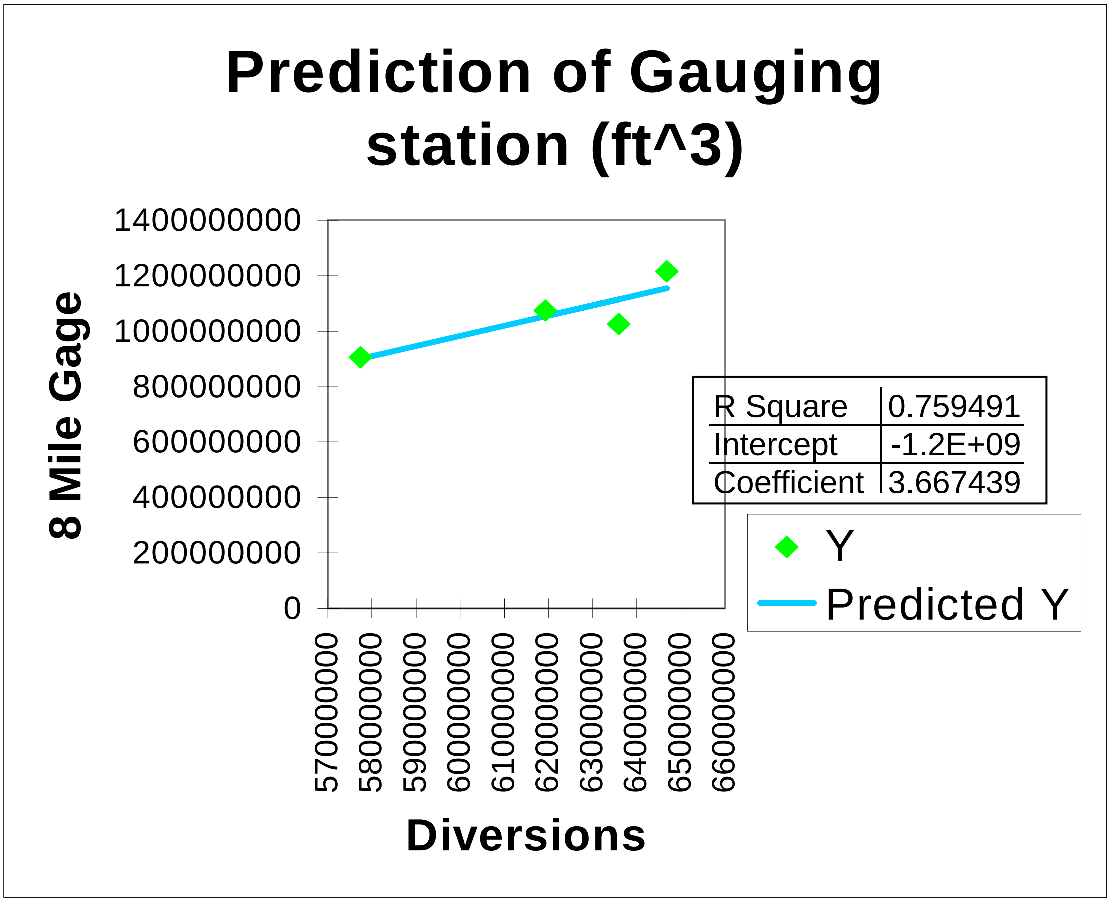


Figure 5, Prediction of Birch Creek flow at 8-mile canyon road near Reno Idaho.

During the summer of 1987 the Birch creek hydroelectric plant began to operate and the Eight-mile gauge was discontinued. The entire flow of Birch Creek is delivered to the plant is through a lined canal and pipe system. Outflow from the plant is applied to irrigation of the Reno Ranch or delivered to a channel where it sinks. Discharge records were obtained from the Birch Creek hydroelectric plant for use in calculating bed loss (Sorenson Engineering 2002). For 1987 and later years, the full water-master-reported diversion volume is applied to irrigation entity IESW037 and any hydropower plant discharge in excess of diversions is applied to the Birch Hydropower line feature in the perched seepage GIS data set. At the time the hydropower plant was developed, some upstream irrigation was retired to provide more flow through the plant. Both irrigation diversions to IESW037 and perched seepage in the Birch Creek area increased after 1987.

No return flows are represented for IESW037.

Camas National Wildlife Refuge and Mud Lake. These water bodies receive water from Camas Creek, but also have water delivered to them from wells. Both lose water to evapotranspiration (ET). Both can lose water to the aquifer via seepage or receive water from the aquifer via springs. In addition, irrigation water is pumped from Mud Lake. To represent the net impact to the aquifer from these water bodies, a combination of recharge components are applied in the GIS and FORTRAN recharge tools:

1. ET. For both water bodies, the net effect of precipitation and ET is represented by including the area as “wetland or water” in the non-irrigated recharge calculation, as described in Design Document DDW-003 (Contor 2002).

2. Perched river seepage, wildlife refuge. For the wildlife refuge, surface-water delivery volumes are recorded by the watermaster. These volumes are applied in the perched river seepage calculation (as aquifer recharge) to a GIS line feature along the axis of the wetland.

3. Net effect of refuge. In the model cells representing the refuge, the non-irrigated recharge calculation applies a discharge to the water budget calculation. The perched river seepage calculation applies a recharge whenever Camas Creek water is delivered to the refuge by the watermaster. The net stress applied to the aquifer is correct, whether there is aquifer extraction by wells, spring discharge into the refuge, ET by phreatophytes, or net recharge from applied Camas Creek water.

4. Diversions and returns from Mud Lake. All water delivered from the lake for irrigation is recorded by the watermaster. This is applied as a diversion to irrigation entity IESW029. No returns are represented.

5. Pumping of wells into the lake. Because the wells are located some distance from the lake, the pumping of wells is represented as offsite pumping as described in Design Document DDW-____ (Contor, in review). This shows the pumping as an aquifer discharge at the well location. When this water is delivered from the lake, it is included in the delivery volume reported by the watermaster and included in diversions applied to IESW029 in the model.

6. Camas Creek inflows to Mud Lake. In some years, particularly during the winter, Camas Creek supplies water to Mud Lake. In the perched river seepage data set, Camas Creek inflows are applied as perched river seepage (recharge to the aquifer) to a GIS line feature that occupies the same model cells as the lake. Summertime values are obtained from watermaster records (Shenton, 2002). Wintertime inflows are not recorded directly, but are computed from a mass-balance calculation of

October and May lake contents, winter-time pumping to the lake, and estimates of winter-time ET and precipitation, using watermaster-supplied data.

7. Net recharge to the aquifer associated with the lake. The water-budget simplifications described sum to the net recharge (positive values) or net discharge (negative values) associated with Mud Lake.

Mud Lake Flood Control. In high water years, water is pumped from Mud Lake to the desert south of the farm lands. Data are obtained from watermaster records. No irrigation diversions are associated with this perched river seepage site.

Little Lost River and Little Lost River Flood Control. Two irrigation entities are supplied by the Little Lost River. Entity IESW008 represents lands served by the Blaine County Canal Company and Entity IESW051 represents lands served by older, privately held water rights. Two entities were established because of differences in diversion depth and sprinkler percentage. Diversion data for both entities were obtained from annual watermaster reports. No returns were represented for either entity.

Because the Little Lost River sinks a short distance beyond the irrigated lands, perched river seepage is calculated as the difference between flow at the Little Lost River gauge (very near the model boundary) and diversion volume.

When annual diversion volumes were interpolated to monthly values based on percentages from 2001 daily records, many negative bed loss values were generated.[1] To correct this condition, annual diversion volumes were distributed temporally according to summer gauging station temporal patterns. This gave a more reasonable distribution without causing negative bed loss values.

The gauging station at Little Lost near Howe ceased functioning in 1991. A number of prediction options were explored to estimate gauging records for the last years of the simulation. Figure 6 illustrates the option finally chosen, linear regression based on precipitation at the Howe gauge. Note the low r^2 statistic and scatter in the data, suggesting that even this prediction is not very precise.

[1] If the stream were hydraulically connected to the aquifer this could indicate periods when the stream was gaining, but within the model boundary the Little Lost River is physically perched above the aquifer by many tens of feet.

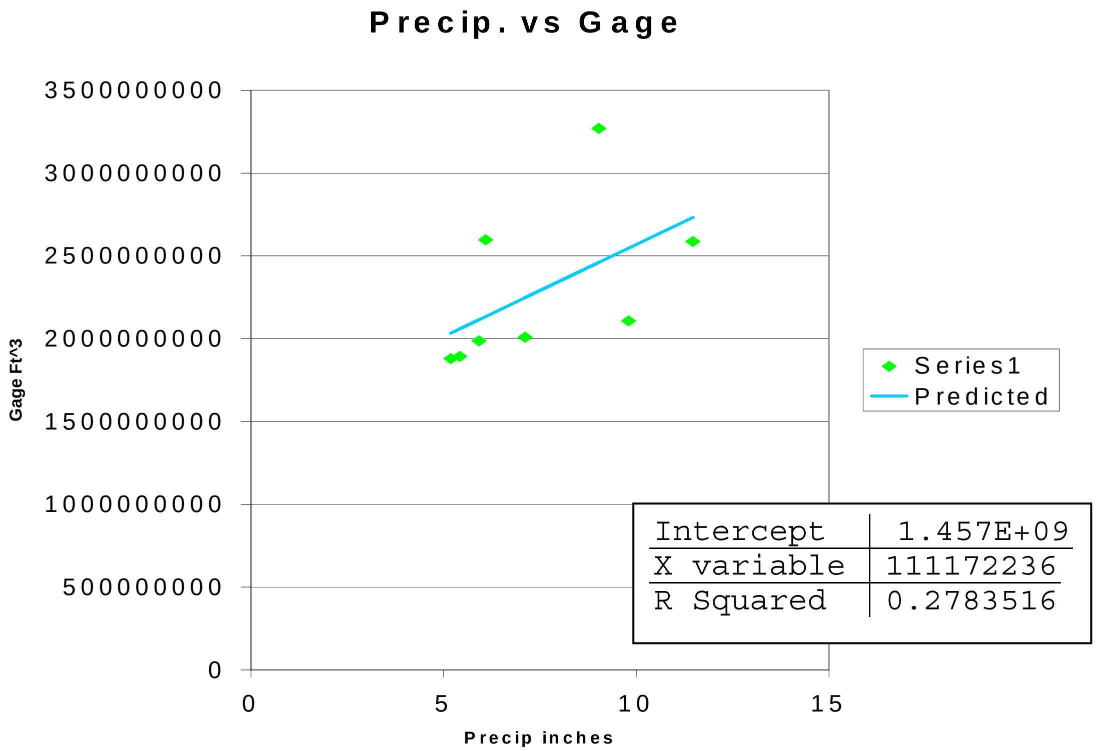


Figure 6, Prediction of Little Lost River gauge station discharge.

(Yes I know I have to fix this figure)

Using the predicted yearly gauge station record for years after 1991, yearly diversions were subtracted to give a total bed loss for each year. Annual values were interpolated to monthly results using percentages from the pre-1991 data. To smooth the time series, months were grouped together and averaged. The groups were April-Oct, Nov-Feb, and March.

In 1985 a flood-control spreading area was developed up-river of Little Lost River diversions. During winter months water is diverted to the spreading area to prevent icing and local flooding. Another line source was developed to show this location as a point of recharge during winter months. Prior to 1985, wintertime bed loss is applied to the channel of the Little Lost River below the gauge. For 1985 and later years it is applied to the spreading area. Summer-time bed loss is always applied to the river channel.

Big Lost River. Watermaster delivery records from the Big Lost River include only surface-water diversions for early years in the calibration period, but include both surface-water and ground-water diversions in later years. Annual summaries do not provide adequate breakdown of water source, and not all of the daily watermaster record books were available.

The entire irrigated area of the Big Lost Valley that is included within the model area is bounded between two gauges on the Big Lost River. The river flows through irrigated lands throughout this area, and there is a fairly dense network of diversion canals and laterals throughout the irrigated area. The gauge data were complete for the entire calibration period. Therefore, the recharge associated with surface water irrigation, canal leakage and perched river seepage was all lumped into the surface-water irrigation calculation. For summer months, the entire difference between the upstream gauge (Mackay Dam) and the downstream gauge (Near Arco) was applied as a diversion to entity IESW005. In the winter months, the entire difference was applied as bed loss (perched river seepage) to the line feature representing the riverbed, illustrated in Figure 1. This resulted in some wintertime negative values, which could be consistent with the processes of periodically gaining reaches and of lagged return flows. These are both physical possibilities and pose no modeling obstacles (Wylie 2001), so the negative values were retained in the data. Three gauges below Arco and records of diversions to a flood-control spreading ground at the INEEL were used to spatially distribute any water discharging past the Near Arco gauge to the spreading ground and lower reaches of the river.

<u>Big Wood River and Little Wood River.</u> These rivers supply irrigation entity IESW025 (Carey), IESW054 (Richfield) and IESW007 (Big Wood and Milner-Gooding). Snake River water is also applied to IESW007. IDWR electronic data were used for these entities (2001).

No records are available for IESW025 diversions, so the estimated constant flow from IDWR electronic data (2001) was applied. No returns were applied to this entity.

Electronic data for IESW054 included records of diversions and returns, which were applied directly to this irrigation entity. Data for IESW007 also included diversions and returns, but these were adjusted to avoid double counting of water. Diversion data reported for this entity included Snake River diversions delivered via the Milner-Gooding canal and diversions from the Big Wood River. However, some water from the Milner-Gooding is spilled into the Big Wood and included in recorded diversions from the Big Wood. To correct this double-counting, Milner-Gooding deliveries to the Big Wood were added to the return flow data set, offsetting their double inclusion in Snake River diversions and Big Wood diversions. Return flow data for IESW007 also included all data files that represent actual physical return flows.

Most of the Big Wood River was represented with no perched seepage because the bed loss calculated from gauge data oscillated about zero, with very small magnitude relative to stream discharge. Upstream and downstream gauge data (adjusting for diversions and returns) were used to calculate bed loss in the

Little Wood River, the lower reach of the Big Wood River, and the reach of the Big Wood identified in Figure 1 as the “Magic Reservoir Spill,” just below the reservoir.

Twin Falls Canal and Lake Murtaugh. Because nearly all of the Twin Falls Canal Company lands lie outside the study area, the diversions applied to irrigation entity IESW041 were discounted substantially. However, the leaky portion of the canal within the study area and a part of Lake Murtaugh within the study area contribute recharge to the aquifer based on total diversions. Because of the large volume of recharge relative to the small fraction of diversions applied to the model, these leaky features were not treated with the leaky canal function of the GIS and FORTRAN recharge tools. Instead, recharge for these locations was calculated in a spreadsheet using the full diversion volume, and applied in recharge calculations as perched river seepage to the locations illustrated in Figure 1. Leakage calculations relied upon data from Twin Falls Canal Company (circa 1955).

DESIGN DECISION

The perched river seepage capability of the GIS and FORTRAN recharge tools was used to represent head-independent seepage from streams other than the Snake River. Because the Snake River was the focus of the modeling effort and because of data limitations, this included representation of some reaches that physically may be interconnected. The flux imposed on the aquifer during model calibration was correctly represented, but in model use, the hydraulic connections will not be represented.

Additionally, the perched river seepage function was used to represent some human-made structures and surface-water/aquifer/wetlands interactions in the Mud Lake area.

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