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FIXED POINT PUMPING AND OFFSITE GROUND WATER PUMPING

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Eastern Snake Plain Aquifer Model Enhancement Project
Scenario Document Number DDW-026

Eastern Snake Plain Aquifer Model Enhancement Project
Water Budget Design Document Number DDW-   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.

INTRODUCTION

The GIS and FORTRAN recharge tools contemplate three classes of point impacts to the aquifer: Fixed point pumping, offsite ground-water pumping, and scenario point pumping or recharge. This design document describes the data that will be used for fixed point pumping and offsite ground water pumping. Scenario point data will be not used in calibration of the model. The intent of the scenario point capability is to allow users to test hypotheses by applying “what-if” recharge or discharge of water at desired locations without needing to adjust the files that represent actual recharge data.

USE OF DATA

Fixed point pumping (or recharge) represents an impact that occurs at a single point and does not enter into any other recharge calculation. Negative values are applied directly as an extraction from the model cell that contains the point, and positive values are applied as a direct injection.

Irrigation Wells. In the Eastern Snake Plain Aquifer Model Enhancement project, certain irrigation wells are treated as fixed-point pumping because the pumped water is delivered to a natural water body and is included in the water-master reported diversion volume of water diverted for irrigation from the water body. One group includes wells known as “exchange wells,” which pump water into the Teton River or the Snake River. Their volumes are included as diversions within the diversion data files from the IDWR planning model (see design document DDW-012, Estimating Snake River Surface Water Diversions). The other group of fixed-point wells includes the wells that deliver water into Mud Lake or Camas Creek in Jefferson County, for diversion to irrigation entity IESW029. Their volumes are included within the diversion volumes reported by Water District 31 (see design document DDW-025, Estimating Non-Snake Surface Water Diversions). Industrial or municipal uses could potentially be treated as fixed-point extractions, but in the Eastern Snake Plain Aquifer Model Enhancement Project these are represented by average extraction rates per area, as outlined in DDW-003, Recharge on Non-irrigated Lands.

Offsite ground water pumping refers to irrigation pumping that is conveyed to a distant location for application to irrigated lands. It must be accounted as a withdrawal from the model cell that contains the well, and must be accounted as applied irrigation water to the model cells that contain the irrigated lands. While physically this is the same process that is represented by fixed-point pumping for the exchange wells and Mud Lake wells described above, the accounting difference is that offsite-pumping volumes have not been included in a water-master reported diversion volume. They must be added to diversions within the recharge calculations. In this modeling effort, wells in Jefferson County that supply water to irrigation entity IESW044 are represented as offsite ground water pumping. While irrigation entities IESW001 (A & B Irrigation District) and IESW018 (Falls Irrigation District) also pump ground water into canals for conveyance to places of use, their wells are distributed approximately uniformly across the irrigated service area, similar to other ground-water irrigated areas within the study area. There is not a need to spatially separate the extraction and recharge associated with irrigation.

Data Corrections. During model calibration, the need for two corrections became apparent. As described in Design Document DDW-003, Recharge on Non-irrigated Lands, a correction was required for model cells that contained both wetlands and irrigated lands. The recharge tools apply the cell-average non-irrigated recharge rate to the non-irrigated lands within each model cell. When part of the cell is irrigated and part is wetlands, the cell-average rate is biased by the non-irrigated-recharge rate associated with the soil type on the irrigated lands. This bias is corrected by applying an offsetting volume to a wetlands class of fixed points in those cells containing both irrigation and non-excluded wetlands.

The second correction is explained in Design Document DDW-003, Percolation, Runoff, and Deficit Irrigation. Because most irrigated areas with limited surface-water supplies have supplemental wells, the recharge tools automatically impute ground-water pumping whenever surface-water supplies are inadequate to meet consumptive use demand. For some stress periods this is an inappropriate calculation for irrigation entity IESW007 (in the Richfield area), since deficit irrigation occurs without the opportunity for supplemental ground-water pumping. This is corrected by applying an offsetting volume to a deficit-irrigation class of fixed points, in those cells where deficit irrigation occurs without supplemental ground water.

SPATIAL LOCATIONS

Irrigation Wells. The spatial location of the "exchange wells" class of fixed points was obtained from GPS data or public land survey legal descriptions supplied by Water District 01 (Madsen 2000, Olenichak 2003). The location of one point (identified with a blue triangle in Figure 1) was adjusted slightly to include it within the modeled area since it is near to potential observation wells and its pumping may affect observed heads (the model is unable to represent activity not in an active cell).

The GIS points for the Mud Lake fixed points and the offsite ground-water pumping wells were placed to represent groups of physical wells within small local areas. The actual locations of the physical wells were obtained from IDWR GPS data (1999) and aerial photography. Figure 2 shows the fixed points selected, relative to the model grid, observation wells, and physical pumping wells. Figure 3 shows the offsite ground-water pumping wells. The appendix lists the points included.

Correction Points. Figure 4 illustrates all the fixed points, including the wetlands and deficit-irrigation correction points.

VOLUME DATA

Wetlands correction point volumes were determined by calculating the correct non-irrigated recharge in individual cells with both wetlands and irrigation, and comparing the volumes to the volumes calculated by the recharge tool. These volumes are reported in Appendix B.

Deficit irrigation correction volumes were determined by identifying cells without groundwater where net irrigation from surface-water irrigation was zero or negative. Using a spreadsheet, a correction volume was calculated to offset the indicated negative recharge. Appendix B lists these volumes, by point.

Pumping volumes for the "exchange wells" fixed points are obtained from Water District 01 annual reports (2003). These data are complete for the entire calibration period. The annual reports include monthly pumpage volume for each well that is active in a given year. The gross pumping volume for the all "Mud Lake" fixed points is obtained from Water District 31 data, as described in DDW-025. To apportion the Mud Lake volume to individual points, the number of wells per point was adjusted to better reflect informal field observations of relative production of individual well groups. The fraction of the total volume assigned to each point was proportioned to the adjusted number of wells, as shown in Table 1. An error in apportionment represents imprecision in the spatial distribution of discharge, but not an error in the water budget. Appendix B lists the fixed-point volumes.

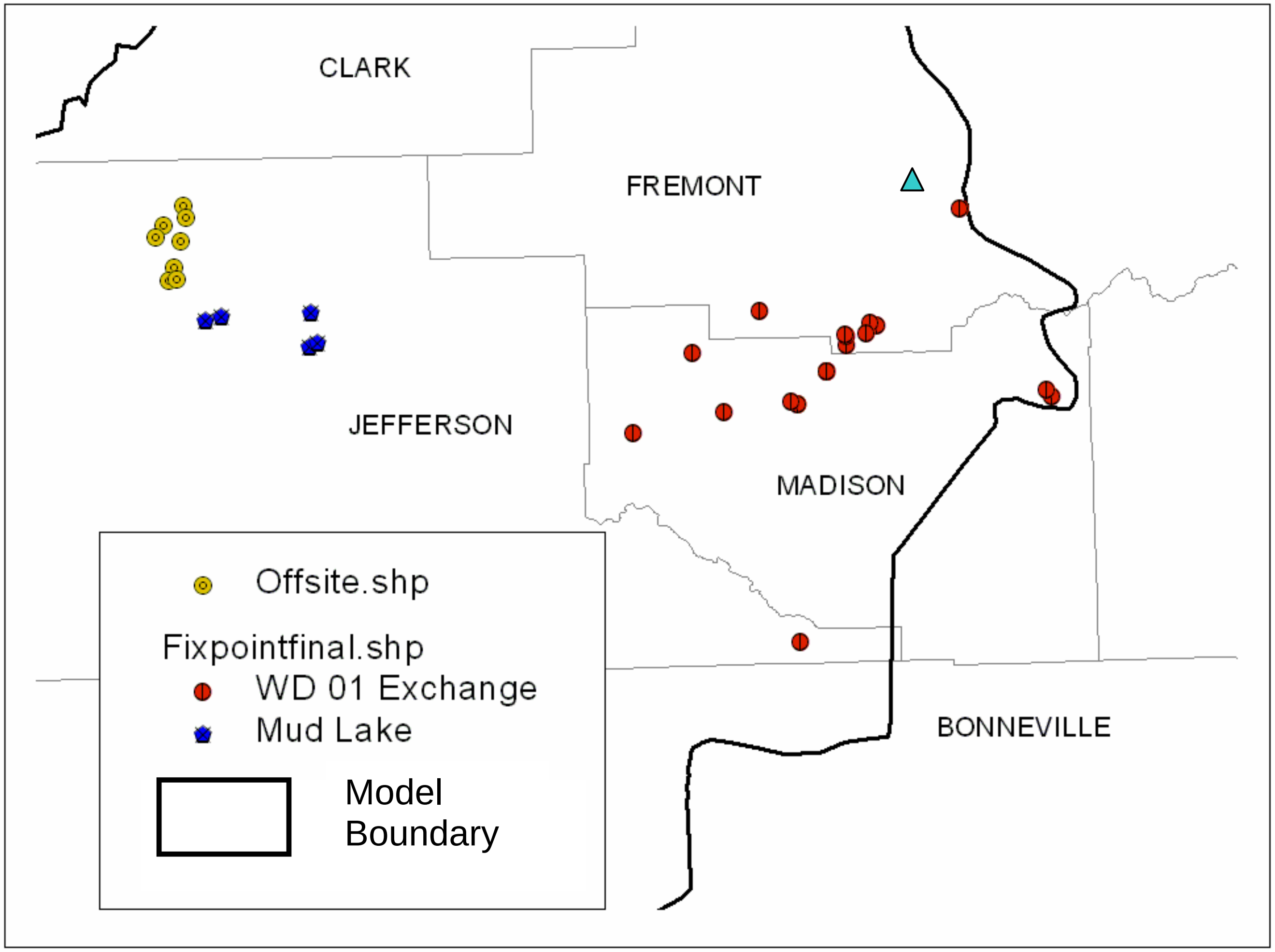

Figure 1. Fixed Points and Offsite Pumping Points for Exchange Wells

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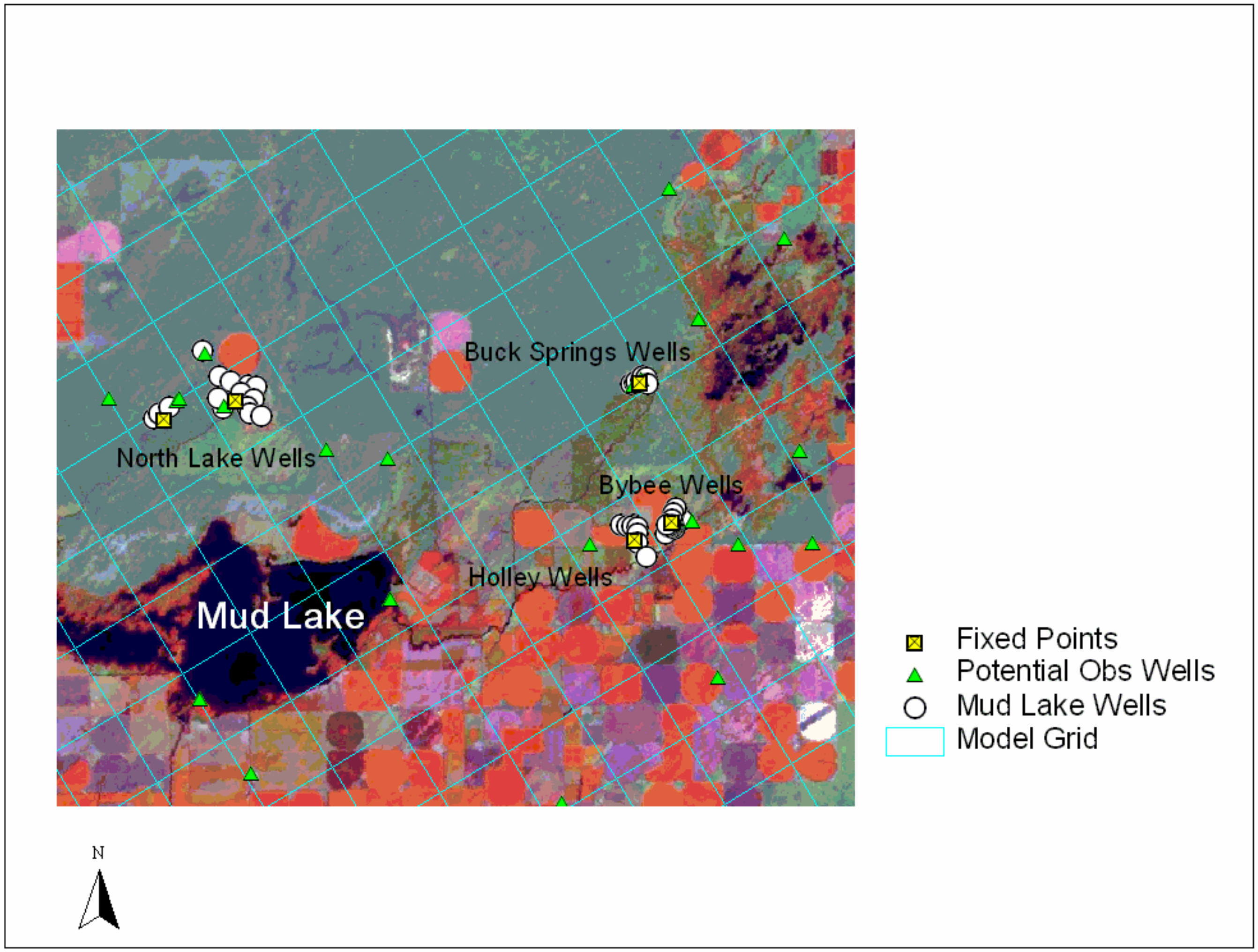

Figure 2. Mud Lake Fixed Points

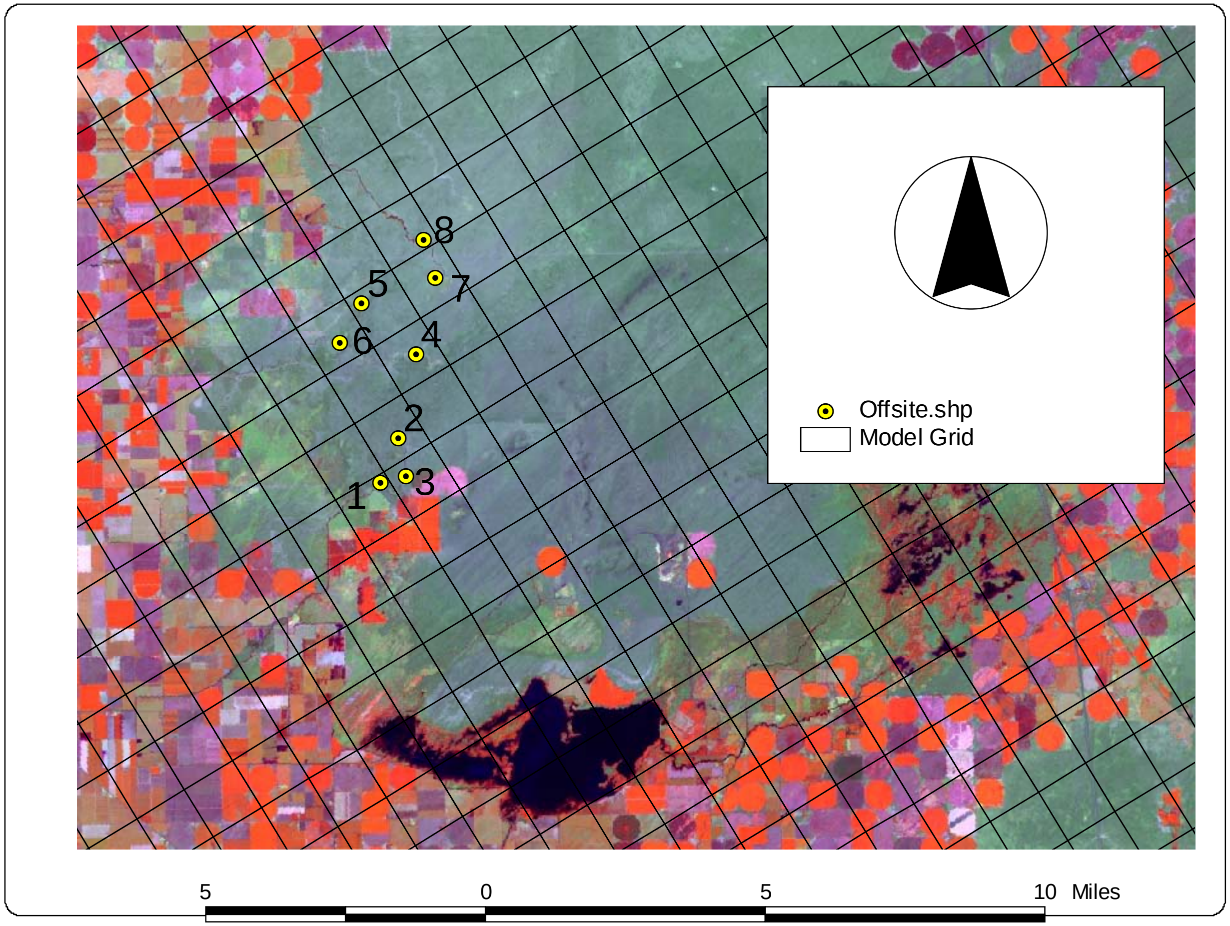

Figure 3. Offsite Ground Water Pumping Points

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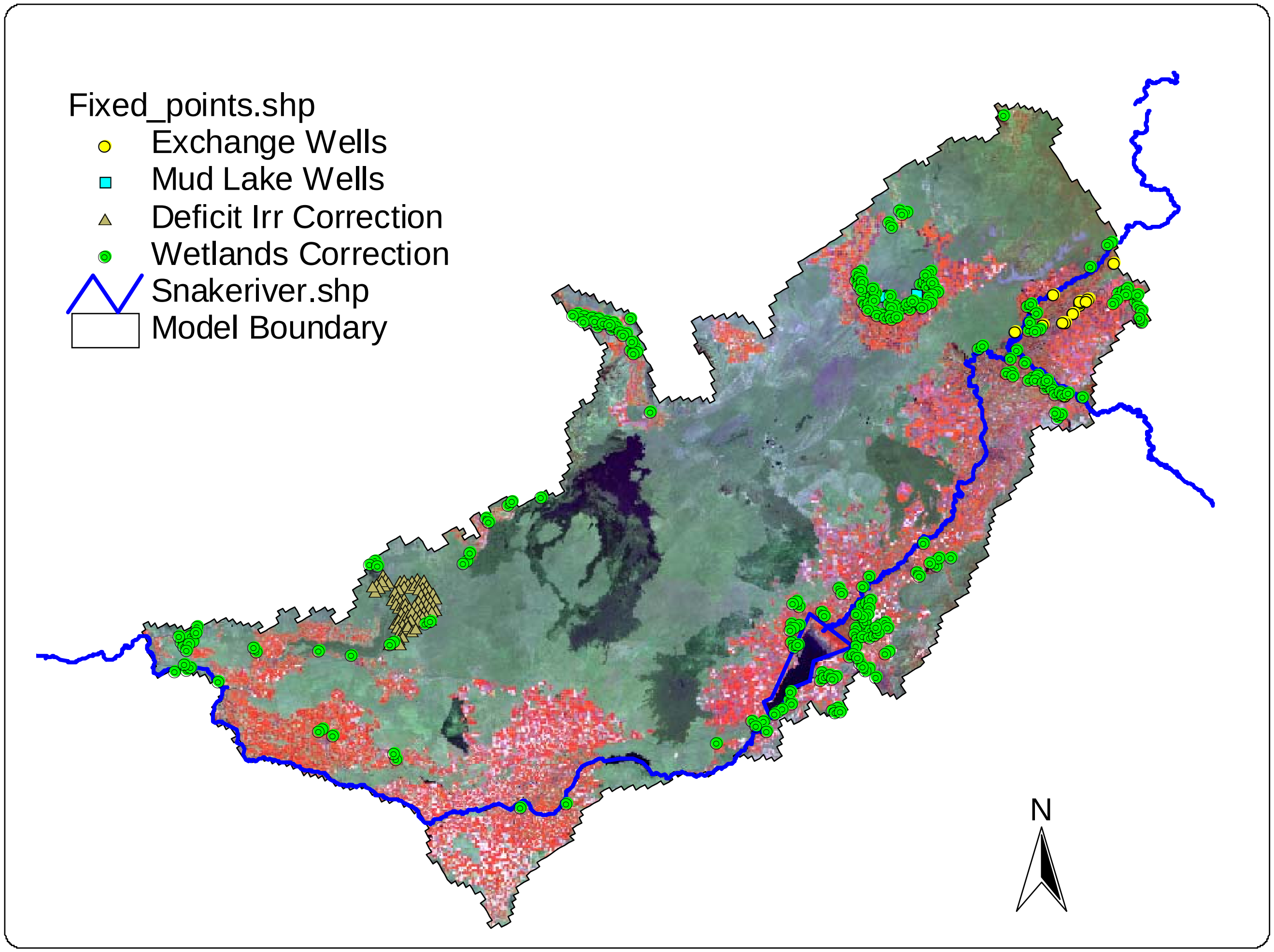

Figure 4. Fixed Points by Class

Table 1
Number of Wells and
Pumping Volume Assigned to
Mud Lake Fixed Points

Fixed Point	No. Wells	Adjusted No. Wells	Percent of Total Volume[1]
Buck Springs	7	7	18%
Bybee	13	14	35%
Holley	6	8	21%
North Lake, East	12	7	18%
North Lake, West	3	3	8%

Offsite Pumping Wells. In the FORTRAN recharge tool, the pumped volume from the offsite ground water pumping wells is removed from the cells in which the wells are located, and added to diversions for IESW044. The entire pumped volume is included in the irrigated-lands recharge calculation as a contribution towards recharge. Volume-for-volume, any over-estimate in pumping becomes an over-estimate in irrigated-lands recharge, and any under-estimate in pumping becomes an under-estimate in recharge. The errors balance, so that the only consequence of an error in estimating pumping volume is an error in spatial distribution of discharge and recharge. This area is distant from the Snake River so these potential errors have a low probability of impacting predictions near the river.

A first estimate of four acre feet per acre per year comes from the author's experience in the North Water Measurement District for water years 1997 through 1999. This is checked against an assumption of 2.0 to 2.5 feet of evapotranspiration (ET), with 0.5 feet of precipitation. If field irrigation efficiency is 60% and conveyance efficiency is 85%, the combined efficiency is 51%. Expected pumpage is (ET - Precip)/Combined efficiency or 2.9 to 3.9 feet.

As a further check, the acreage of irrigated polygons within IESW044 from the 2000 crop classification (see DDW-015) was calculated by crop class using GIS. Year 2000 Agrimet ET (US Bureau of Reclamation 2003) was applied by crop to the acreage. Adjusting the volume to account for the difference between 1997/1998 ET (94% of average, see below) and 2000 ET (101% of average) and subtracting actual 2000 precipitation gives 1.91 to 2.06 ft of ET to be supplied by irrigation. Four feet of diversion implies a combined efficiency of 36% to 44%. An additional check was provided by preliminary SEBAL ET estimates based on remote sensing (Allen 2003). These estimates (adjusted as above to reflect the

[1] Adjusted slightly to overcome rounding errors. Reported values sum to 100%.

difference between 1997/1998 and 2000 ET levels) imply a combined efficiency of 73% to 78% with four feet of pumpage. Because these checks bracket the original estimate, the original estimate is retained. It must remember that any error results in imprecision in spatial distribution and not a water budget error.

The lands in IESW044 are aggregated from three irrigation companies; Jefferson Irrigation, Monteview, and Producers canal companies. Three of the offsite points are associated with the Jefferson lands, three with the Monteview lands, and three with the Producers lands. Based on the original shapefiles (see DDW-008, Aggregating Surface-water Irrigation Entities), the 2000 irrigated lands map was clipped to show irrigated lands in each of the three companies. The acreage of these lands was multiplied by four feet to determine a gross pumpage volume for each company, then divided by the number of points to obtain an annual volume per point. The annual volume was distributed among the months according to a crop-weighted average monthly ET from US Bureau of Reclamation (2003) Agrimet data for 2000.

To scale pumpage to reflect year-to-year differences in ET, an index was constructed for each year 1980 through 2000 using revised ET values (Allen 2002) for Hamer, Idaho (the nearest weather station with a full record). For each year, the index was that year's sum of ETr divided by the average ETr sum for all the years. The index for year 2000 was applied to the Monteview[2] Agrimet (US Bureau of Reclamation 2003) ET for year 2000 to calculate an equivalent Agrimet base ET, then that equivalent base and the 2001 Agrimet ET were used to calculate an index for year 2001. The results are summarized in Table 2:

Table 2.
Evapotranspiration Index
Offsite Ground Water Pumping Points

Year	**Index**	**Year**	**Index**
1980	0.94	1991	1.03
1981	0.98	1992	1.11
1982	0.97	1993	0.94
1983	0.96	1994	1.09
1984	0.94	1995	0.94
1985	1.01	1996	0.97
1986	1.03	1997	0.94
1987	1.07	1998	0.93
1988	1.10	1999	0.96
1989	1.03	2000	1.01

[2] Agrimet does not maintain a station at Hamer. Agrimet Monteview data are available back to 1997.

Year	Index	Year	Index
1990	1.07	2001	1.11

To calculate pumpage volume for offsite ground water pumping, the base monthly values were multiplied by the index values from Table 2 for each year. The data CD contains the data files showing monthly volumes for each fixed point and each offsite ground water pumping point. Appendix C lists the offsite pumping volumes used in the calibration data set.

DESIGN DECISION

Fixed point pumping sites represent injections or withdrawals to the aquifer which do not affect the GIS or FORTRAN recharge calculation. This could include uses that are wholly consumptive, injected water that does not impact the water budget, or water pumped and delivered to irrigated lands where the pumped volumes are already included in water-master records of diversions to irrigation. In this project, exchange wells on the Teton and Snake Rivers, whose volumes are included in diversions from the Snake or Teton, are represented as fixed point withdrawals. Wells that pump water into Camas Creek or Mud Lake for use in Irrigation Entity IESW029 are also represented as fixed points. Their volumes are also included in water-master reported diversions to irrigation.

Offsite ground water pumping sites represent wells that extract water from the aquifer to be delivered to distant places of use, without being included in water-master reported diversion volumes. The offsite ground water calculation represents only a spatial redistribution of net recharge; every unit extracted at an offsite point increases recharge at the irrigated place of use by exactly one unit. In this project, the wells supplying Irrigation Entity IESW044 are represented by offsite pumping locations. Volumes for these wells are estimated based on evapotranspiration calculations and experience with North Water Measurement District data. Volumes are distributed among points by approximate area served, among months according to the temporal distribution of Agrimet (US Bureau of Reclamation 2003) ET, and year-to-year according to an ET-based index.

One class of correction points adjusts for bias in the calculation of non-irrigated recharge in model cells that include both irrigated lands and wetlands. Another class of correction points adjusts for deficit irrigation during dry periods, on lands with limited surface-water supplies and no supplemental ground water.

REFERENCES

Allen, R.G. 2002. Revised Evapotranspiration Estimates for Idaho. Electronic files.

Allen, R.G. 2003. Preliminary SEBAL Evapotranspiration Data. Electronic files.

Idaho Department of Water Resources. 1999. GIS point file, GPS locations of Mud Lake-area wells.

Madsen, R. 2000. GIS point file, GPS location of Water District 01 measurement and diversion locations.

Olenichak, T. 2003. Water District 01. Personal communication.

US Bureau of Reclamation, 2003. Agrimet ET internet-access data. http://mac1.pn.usbr.gov/agrimet

Water District 01. 2003. Annual Reports 1980 - 2001.