Representation of Irrigated Lands and Source of Irrigation Water, Eastern Snake Plain Aquifer Model Version 2, As Built

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July 2010

Idaho Water Resources Research Institute Technical Report 201002
ESPAM2 Design Document DDM V2-04 “Irrigated Lands As Built”

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DESIGN DOCUMENT OVERVIEW

During calibration of the Eastern Snake Plain Aquifer Model Version 1.1 (ESPAM1.1), a series of Design Documents were produced to document data sources, conceptual model decisions and calculation methods. These documents served two important purposes; they provided a vehicle to communicate decisions and solicit input from members of the Eastern Snake Hydrologic Modeling Committee (ESHMC) and other interested parties, and they provided far greater detail of particular aspects of the modeling process than would have been possible in a single final report. Many of the Design Documents were presented first in a draft form, then in revised form following input and discussion, and finally in an "as-built" form describing the actual implementation.

This report is a Design Document for the calibration of the Eastern Snake Plain Aquifer Model Version 2 (ESPAM2). Its goals are similar to the goals of Design Documents for ESPAM1.1: To provide full transparency of modeling data, decisions and calibration; and to seek input from representatives of various stakeholders so that the resulting product can be the best possible technical representation of the physical system (given constraints of time, funding and personnel). It is anticipated that for some topics, a single Design Document will serve these purposes prior to issuance of a final report. For other topics, a draft document will be followed by one or more revisions and a final "as-built" Design Document. Superceded Design Documents will be maintained in a "superceded" file folder on the project Website, and successive versions will be maintained in a "current" folder. This will provide additional documentation of project history and the development of ideas.

During development of the ESPAM2 water-budget data, many design decisions were communicated with memorandums, to quickly provide transparency and an opportunity for stakeholder comments, without the delay of a formal Design Document process. Consequently, many ESPAM2 Design Documents will actually be first published as as-built documents.

INTRODUCTION

The largest component of recharge to the Eastern Snake Plain Aquifer is recharge incidental to surface-water irrigation. The largest component of discharge under direct human control is pumping of groundwater for irrigation. The location and extent of irrigated lands are input data for the calculation of both water-budget components. The acreage of irrigated lands in each model cell directly affects the volume of evapotranspiration and the volume of precipitation on irrigated lands.

Combined with the data on irrigation water source, the acreage of irrigated lands also directly affects the spatial distribution of applied surface water. In the On-Farm algorithm, the spatial distribution of applied surface water enters into a calculation of depth. If the depth triggers an indication of deficit irrigation, the On-Farm algorithm will change the water budget to achieve a conceptual minimum depth of percolation. Hence, in ESPAM2 the representation of water source[1] on irrigated lands can actually change the water budget.

This Design Document outlines the treatment of irrigated lands and source of irrigation water for ESPAM2. It is an "as built" document describing the water budget delivered to calibrators in June 2010, and supercedes the draft Design Document on source of irrigation water (Contor and Pelot, 2008). If additional modifications are made during calibration, this document will be amended.

REVIEW OF ESPAM1.1 APPROACH

Irrigation Status. ESPAM1.1 Design Document DDW-015 (Contor 2004a) describes the single GIS data set that was used to represent irrigated lands for the entire calibration. This approach was taken to minimize the impact of differences in methodology and underlying data among the candidate irrigated lands data sets. Reductions for non-irrigated inclusions were based on hand-drawn polygons from Idaho Department of Water Resources (IDWR) from Adjudication processing.

Water Source. The source of irrigation water was derived from water-rights data, as described in ESPAM1.1 Design Document DDW-017 (Contor 2004b). Every parcel in the plain was assigned to "groundwater," "surface water" or "mixed source." It was understood that mixed-source parcels have legal authorization to use either groundwater or surface water, but are not necessarily physically supplied with both at all times.

For modeling purposes, all mixed-source parcels in a given entity were given the same groundwater fraction. Fractions were estimated based on an assumption that irrigated acreage and supplemental irrigation would have equilibrated to allow adequate supplies on surface-water only parcels in the entity. Remaining supplies in each diversion were then used to estimate a fraction of supply from groundwater on mixed-source lands.

[1] Water application method has a very minor impact on the water budget; it impacts only the ET adjustment factors, which are similar across application methods.

Design Document DDW-017 also discusses how imprecision in water source or source fraction on mixed source parcels resulted in imprecision in spatial distribution of recharge, but did not affect the water budget.

The final irrigated lands data for ESPAM1.1 included information both about irrigation status and water source.

ESPAM2 Data

One anticipated change in ESPAM2 was a refinement and revision of the water-source map, based upon additional progress in the Snake River Basin Adjudication. As discussed below, this change was *not* implemented in ESPAM2. However, discussion does include several changes that were undertaken:

1. Five irrigated lands data sets were employed, covering various time periods within the calibration period.
2. A new irrigated lands data set for 2002 was prepared by IDWR and incorporated in ESPAM2.
3. New calculations and sampling were employed to estimate reductions for non-irrigated inclusions.
4. Groundwater fraction on mixed-source lands was represented as spatially variable within entities, based upon proximity to water-right locations of irrigation wells.
5. For some entities, ad-hoc adjustments were made to groundwater fractions, in an attempt to produce more accurate outcomes from the On-Farm algorithm of the MKMOD recharge software.

<u>Irrigated Lands Data.</u>

Table 1 lists the underlying data that were used to generate irrigated-lands data sets:

Table 1
Underlying Data for Irrigated Lands
for Calibration of ESPAM2

Nominal Year	Original Data	Processing Algorithm	Author/ Agency	Applied to years
1980	LANDSAT	Vickers	Morse et al/ IDWR, USGS	1980-1982
1986	LANDSAT	Digital classification	Kramber/ IDWR[2]	1983-1988

[2] Kramber produced a raster image, from which IWRRI derived polygons. See discussion later in document.

Nominal Year	Original Data	Processing Algorithm	Author/ Agency	Applied to years
1992	Aerial photography & field verification	Manual photo interpretation and digitizing.	McAndrews et al/ US BOR, IDWR	1989-1995
2000	LANDSAT	Digital classification	Kramber/ IDWR[3]	1996-2000
2002	LANDSAT, USDA Common Land Unit polygons	Vegetative index determines irrigation status, CLU polygons determine geometry. Extensive manual refinement	Poulson, Wilkins, Kramber/ IDWR	2001-2003
2006	LANDSAT, USDA Common Land Unit polygons, USDA NAIP imagery	Vegetative index determines irrigation status, CLU polygons determine geometry. Extensive manual refinement	Morse, Wilkins, Kramber/ IDWR	2004-2008

Several modifications were made to these data prior to use in ESPAM2. These include:

1. Removal of dry farms, wetlands, cities and industrial areas.
2. Interpolation of data gap in 1980 data set.
3. Extraction of polygons from raster data (1986 and 2000 data).
4. Removal of semi-irrigated polygons (2002 and 2006 data).
5. Intersection with entity boundaries and water-source polygons.

Removal of non-irrigated land use/land cover areas. The 1986 and 2000 data sets were developed with time and budget constraints that precluded careful delineation of dry farms, wetlands, cities and industrial areas. For consistency, all data sets were masked with a common shapefile for these non-irrigated land

[3] IWRRI derived polygons from IDWR-supplied raster image.

use/land cover types derived from NRCS data described in the ESPAM1.1 Design Document (Contor, 2004a).

Interpolation of data gap. The 1980 data contain a strip of land indicated as non-irrigated that appears to be aligned with LANDSAT image boundaries. This affects some irrigated lands in Jefferson County. It was manually adjusted based on aerial photography and the 1992 data. Figure 1 shows the original 1980 data set (dark lined pattern) overlaid on the circa 1987 Adjudication image.

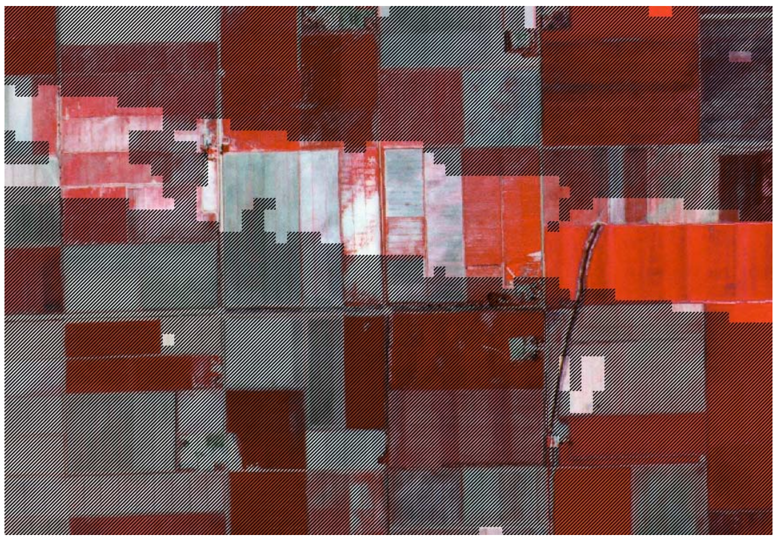

Figure 1. Sample of original 1980 irrigated lands data in western Jefferson County.

Extraction of polygons. For further processing with entity and source data, GIS polygons were required. The 1986 and 2000 irrigated lands data sets were developed from digital classification of LANDSAT satellite data. The result was a GIS raster of pixels scored "irrigated" or "non-irrigated." The threshold required to generally identify irrigated parcels resulted in some extraneous pixels indicated as irrigated in non-irrigated areas. Figure 2 shows the circa-1987 Adjudication image of irrigated parcels adjacent to a non-irrigated tract. Figure 3 shows the raw irrigated pixels from the IDWR raster.

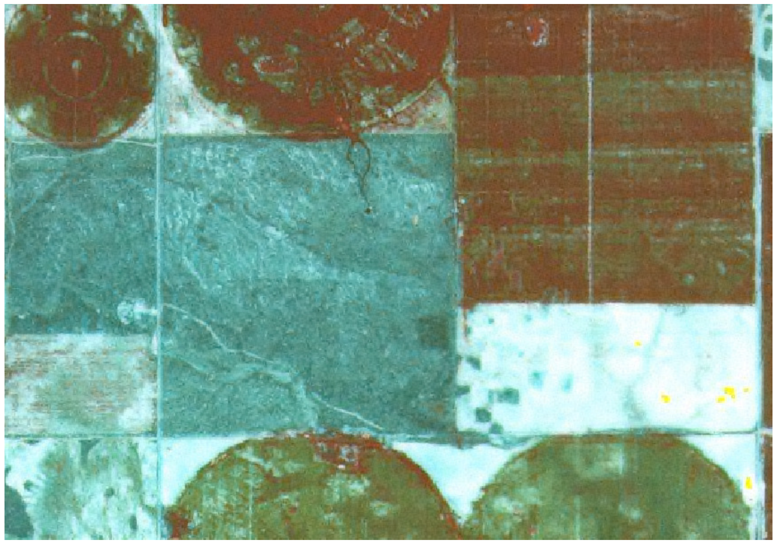

Figure 2. Adjudication image circa 1987.

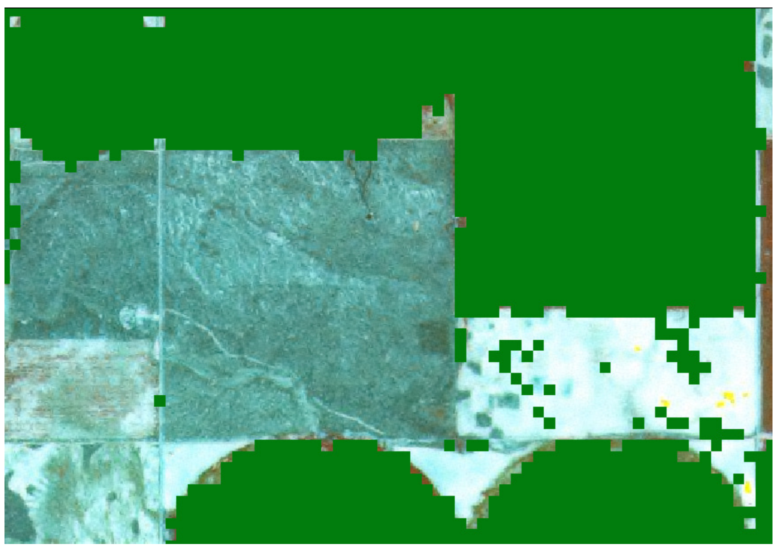

Figure 3. Irrigated pixels (green) from 1986 vegetative index analysis overlaid on Adjudication image, showing extraneous pixels in non-irrigated areas.

This presented two obstacles for calibration. The first was the existence of extraneous irrigated pixels distant from actual irrigated lands. This would work a spatial distortion in the representation of recharge or pumping from irrigation. The second was that converting these pixels to polygons (as needed for further processing) would result in a very large number of GIS polygons and vertices, which presents significant processing difficulties. Both issues were addressed by calculating a neigborhood "majority" statistic in ArcView3.x. This resulted in a smoothing of the raster, as shown in Figure 4.[4]

[4] Figure 4 and Figure 5 were regenerated from the same base data, but on a different computer and with a different GIS license than the original analysis. While the polygons in Figure 5 show minor differences from the polygons actually used, the concepts are correctly illustrated.

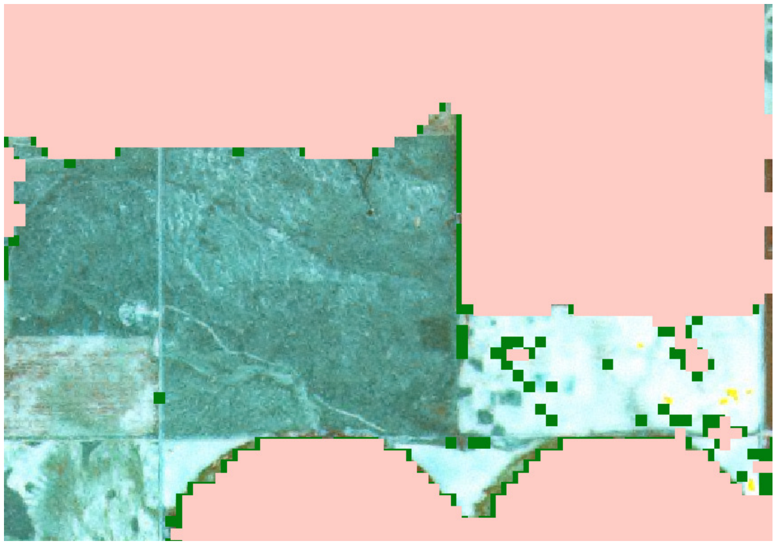

Figure 4. Nearest-neigbor analysis, 3-cell circular majority. The green pixels are the original resolution and the pink pixels are the smoothed resolution.

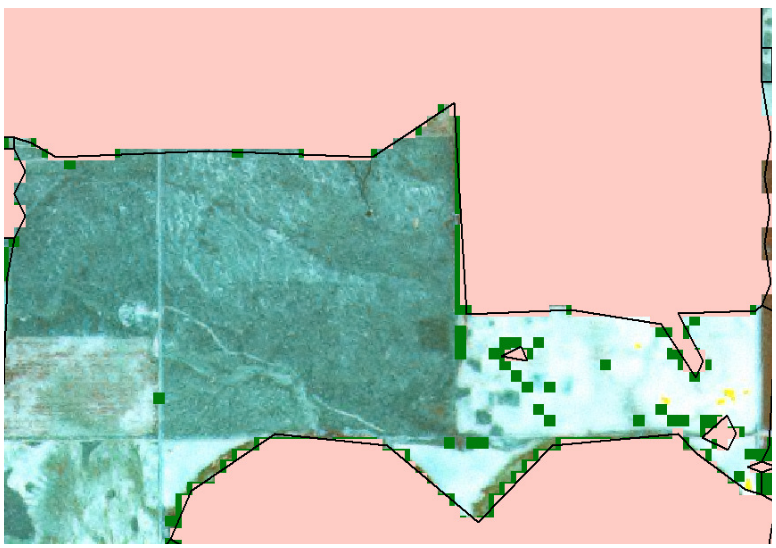

Figure 5. GIS polygon (black line) derived from smoothed raster (pink).

The generation of polygons was performed in ArcGIS3.x, which "points off" the corners of polygons.[5] This results in some geometric distortion and cosmetic flaws. However, due to the operation of the reduction for non-irrigated inclusions and the way data are used in the water budget, there is no negative impact on water budget calculations.

Removal of semi-irrigated polygons. The 2002 and 2006 data included a "semi-irrigated" classification that the other data sets did not have. A non-

[5] ArcGIS9.x can be set to produce a "squared-off" polygon that may be more appropriate for other purposes, and more aesthetically pleasing for all purposes.

statistical sample of parcels was compared across data sets, where aerial photography suggested there had been no change on the ground. It appeared that "semi-irrigated" in the 2002/2006 data most often corresponded to "non-irrigated" in other data sets. Consequently, only the "irrigated" polygons from the 2002 and 2006 data sets will be used for ESPAM2.

Intersection with entity boundaries and water-source polygons. Data set "base_entity_source_20100610.shp"[6] contains the geometry of the surface-water entities, groundwater polygons and water-source polygons, and model grid cells. It currently resides at http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/model_files/Version_2.0_Development/Current_Data/ESPAM2_Irrigated_Lands_20100629/Data_for_processing_irrigated_lands/.

Processing of Data. In ESPAM1.1, GIS data were converted to polygon feature classes in a personal geodatabase and were processed by a GIS Recharge Tool. The tool intersected the irrigated lands with the model grid and output a *.iar table that listed the raw GIS square footage of irrigated lands in each model cell, for each irrigation entity. Significant difficulty was encountered with "complex geometry" and other GIS processing errors.

For ESPAM2, IWRRI was never able to generate five complete polygon feature classes that simultaneously would process error free in the GIS tool. Consequently, the model grid was included in the "base entity source data" described above, so that the attribute tables contained the model grid data. Acreage was calculated directly in GIS. The attribute tables were exported as text files and processed with small Visual Basic utilities and hand calculations to produce the *.iar table. IDWR is currently developing a professionally-built utility that will produce the *.iar table, for continued use during the life cycle of ESPAM2.

Description of final irrigated lands data. The irrigated lands data exist as a single ESRI shapefile for each of the years 1980, 1986, 1992, 2000, and 2006. It is anticipated that year-2002 data will soon be completed and included in ESPAM2 model calibration. Table 2 describes the GIS fields that are essential for further processing of irrigated lands. Figures 6 through 11 illustrate each of the data sets at a single location on the plain. These figures illustrate differences in precision and resolution, as well as changes in actual underlying irrigation.

[6] An ESRI shapefile is a collection of files with the same filename and different extensions. In this Design Document, only the *.shp file is referenced but implicitly all the files are indicated.

Table 2
Essential Data Fields in GIS Irrigated-lands Shapefiles

Field	**Contents**	**Essential for GIS Recharge Tool**	**Essential for manual processing**
Entity	The name of the surface-water or groundwater irrigation entity	X	X
Water Source	Source of Irrigation Water	X	(see footnote)[7]
Source Fraction	The fraction of supply from the named entity, for this irrigated parcel	X	
Net Acres	The GIS acreage of this polygon times the source fraction		X
Row ID	The row identifier of the model cell		X
Column ID	The column identifier of the model cell		X

[7] The manual processing relied upon knowledge of water source, but since this is implicit in other fields, the manual processing did not require the "source" data field.

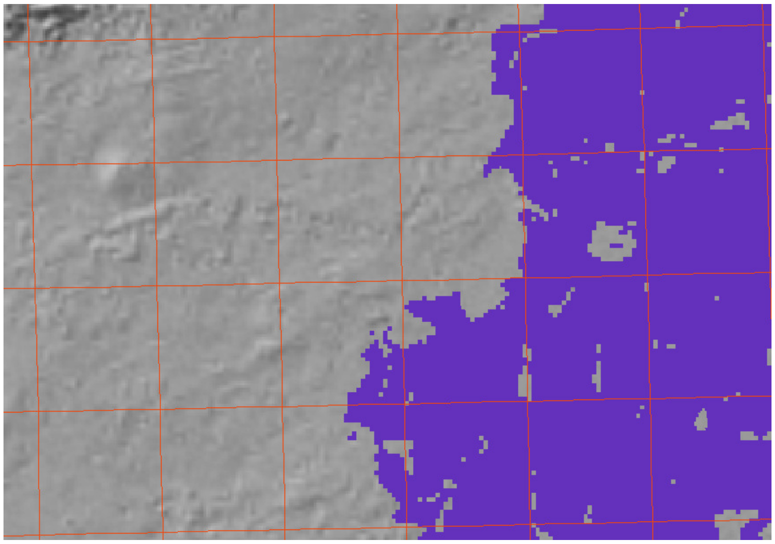

Figure 6. 1980 irrigated lands data. The red rectangles are public land survey sections (nominally one mile square).

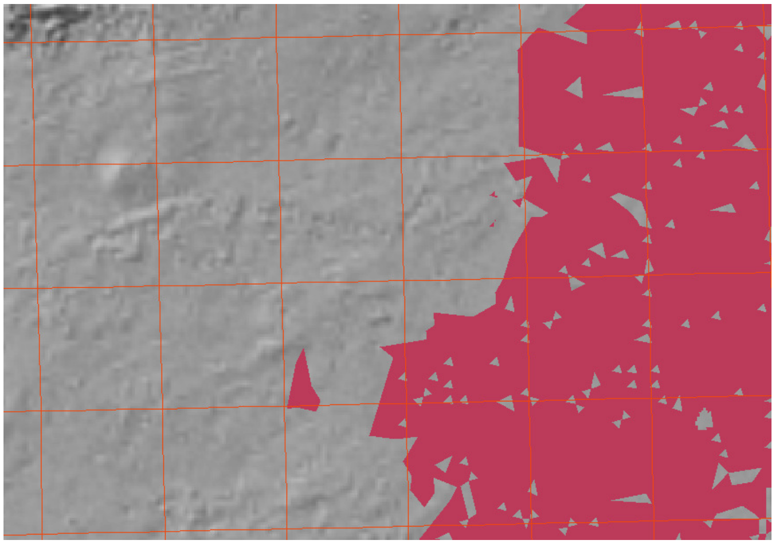

Figure 7. 1986 irrigated lands data.

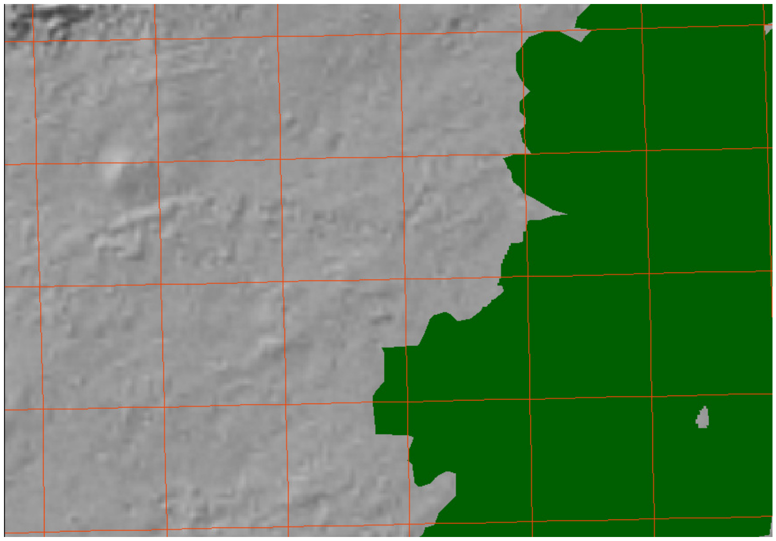

Figure 8. 1992 irrigated lands data.

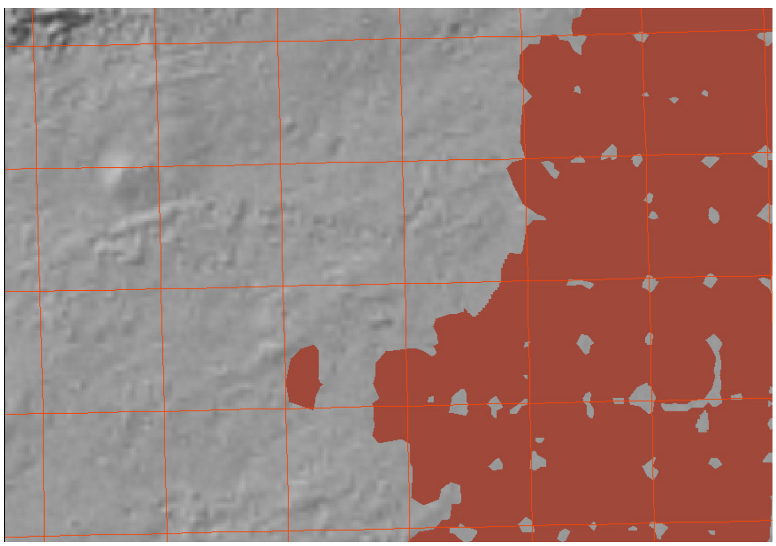

Figure 9. 2000 irrigated lands data.

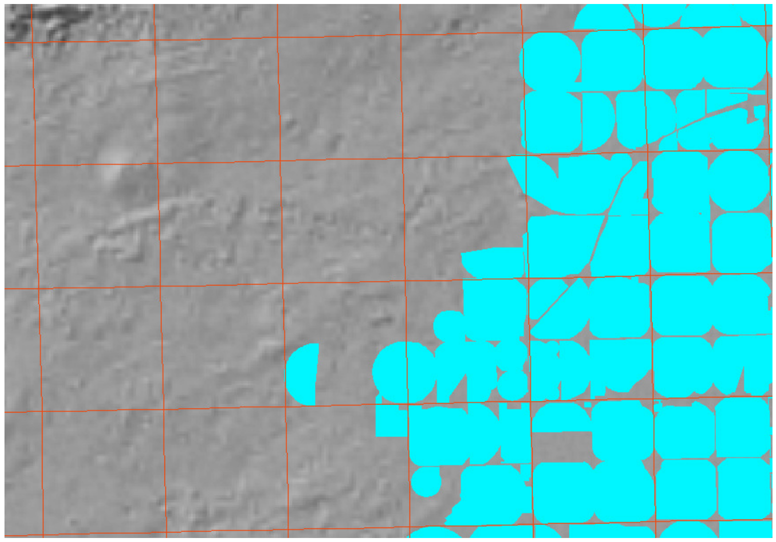

Figure 10. 2002 irrigated lands data.

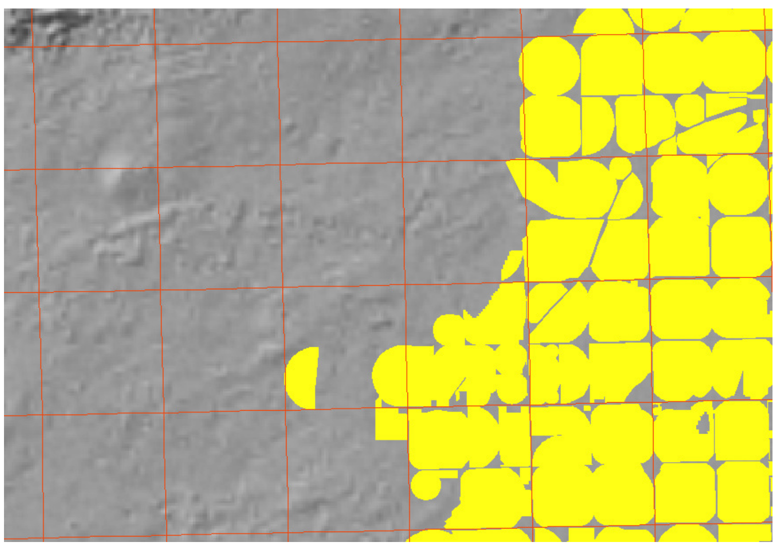

Figure 11. 2006 irrigated lands data.

Reduction for Non-irrigated Inclusions.

The areas of GIS irrigated lands polygons control the calculated volume of evapotranspiration and precipitation in each model cell. They also control the calculated depth of irrigation application, which can trigger a reduction in evapotranspiration if the On-Farm algorithm deems that excessive deficit irrigation has occurred. Therefore, it is important to represent the correct acreage. Due to resolution limitations of underlying data, most of the data sets systematically over-estimate the irrigated acreage, because small non-irrigated inclusions like field roads, corrals, equipment yards and haystack yards are undetected and therefore represented as irrigated. In ESPAM1.1 and ESPAM2, reduction factors for non-irrigated inclusions are employed to adjust for this fact, as shown in Equation (1). Factors were calculated using a comparison between data-set acreage and polygons drawn by hand (heads-up digitizing in GIS) from detailed aerial photography.

$$\text{Acres used in model} = (\text{GIS acres}) \times (1 - \text{reduction factor}) \qquad (1)$$

In ESPAM1.1, the reduction factors were based on hand-drawn polygons from IDWR Adjudication data. One concern was that these were not uniformly distributed across the study area, and included few groundwater irrigated lands. In the process of contemplating other approaches to non-irrigated inclusions, IWRRI became convinced that appropriate reduction factors could be used to overcome the differences between source data and processing methodology that were a concern in ESPAM1.1.

For ESPAM2, representative aerial imagery was identified for each candidate data set, and hand-drawn polygons (on-screen heads-up digitizing upon aerial imagery) were constructed on a statistical sampling of 100 model cells containing irrigation (Contor, 2009a). The memo discusses precautions that were taken to reduce imprecision resulting from differences in quality and resolution of underlying imagery, and to deal with temporal mismatch between data sets and images. Table 3 (modified from Contor, 2009a) shows the image data that were obtained. Note that years of image data do not always line up precisely with years of irrigated-lands data.

Table 3
Images Available for "True Acreage" Samples
for ESPAM2

Year	Data Source	Color	Resolution[8]	Coverage
1980	U2 aerial transparencies	near infrared false color	~ 30 meter[9]	partial
1983	U2 aerial transparencies	"	"	"
1987[10]	IDWR Adjudication	"	~10 meter[11]	nearly complete
1992[12]	DOQQ aerial photos	black and white	"	partial
2000,	SPOT	black and	~ 15 meter[14]	complete

[8] In some cases, the pixel size is actually smaller than the actual spatial resolution of data.
[9] Original images are 1:120,000 scale CIR airphotos but IWRRI obtained scans at only 70 dpi.
[10] Nominally 1987 but image dates appear to range from 1986 through 1992. These are administrative-basin mosaic images so the image date of any particular parcel is uncertain.
[11] Pixel size is actually 3.4 meter but underlying image resolution appears to be closer to 10 meter; that is, no objects smaller than about ten meters (i.e. automobiles, individual livestock) may be clearly identified in the images.
[12] Some images are 1993 and 1998.

Year	Data Source	Color	Resolution[8]	Coverage
2002[13]		white		
2004	NAIP	true color	1 meter	nearly complete
2006	NAIP	true color	2 meter	complete

Samples of hand-drawn and data-set polygons for one of the sample locations are shown in Figure 12 through Figure 16. In every case, the data set was presumed to be correct as to irrigated/non-irrigated status; the hand-drawn polygons were relied upon only to define geometry and irrigated area. For some locations or dates, an image from the exact year of the data set was not available. For instance, in Figure 15, it appears that the parcels boxed in blue had a change in parcel geometry between the data-set date and image date. In such cases of ambiguity, both the hand-drawn and data-set representation of the individual irrigated parcel were removed from the analysis.

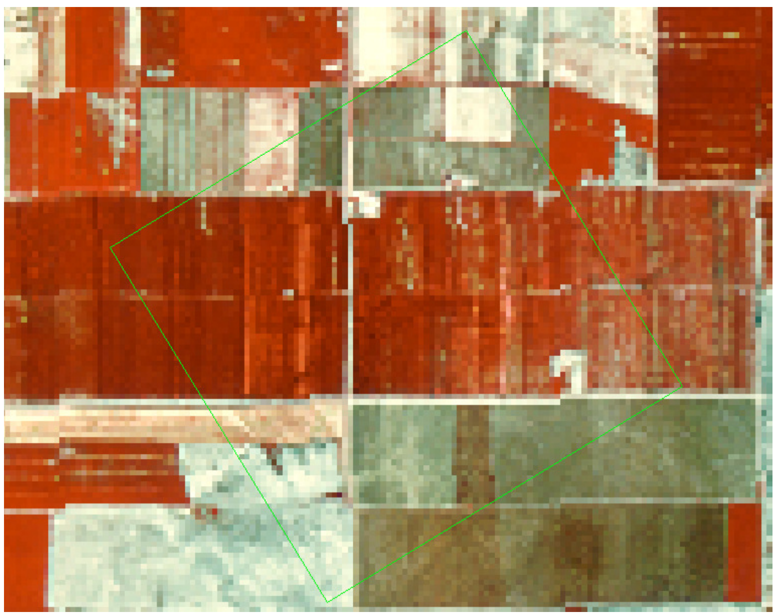

Figure 12. Sample location (green rectangle) on 1980 U2 aerial image.

[13] Some images in the 2000 data set are 2001; some in the 2002 data set are 2003.
[14] Pixel size is significantly smaller but underlying image resolution appears to be about 15 meter.

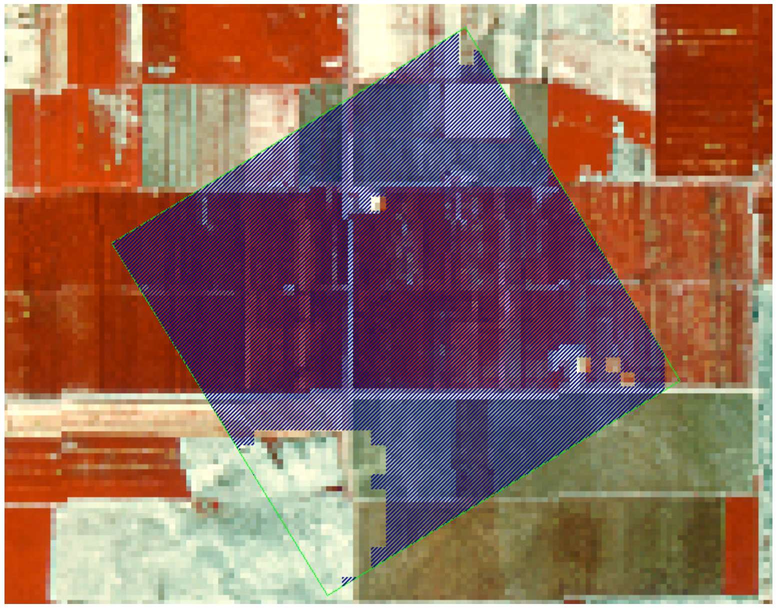

Figure 13. Irrigated lands from 1980 data set (blue cross-hatch).

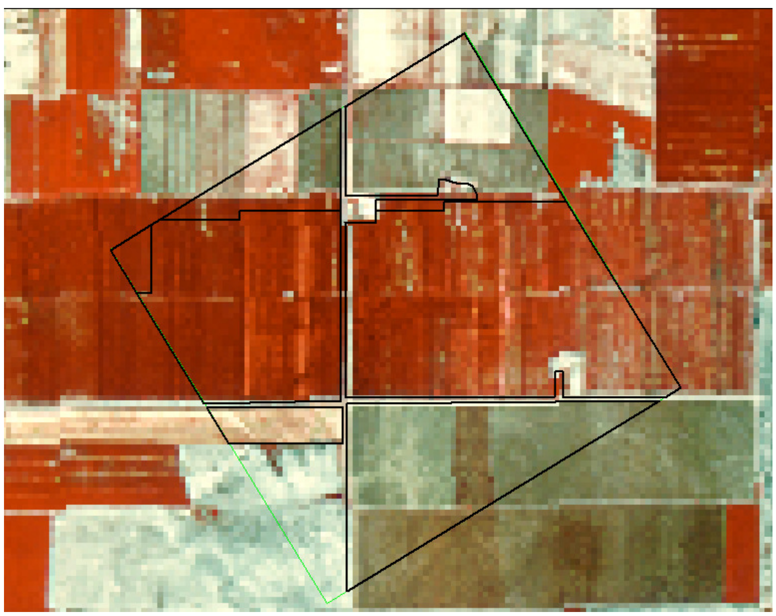

Figure 14. Hand-drawn polygons on 1980 U2 aerial photograph. Note that the technician had to adjust for slight imprecision in photo georeferencing, keeping parcel boundaries consistent with underlying irrigated lands data sets.

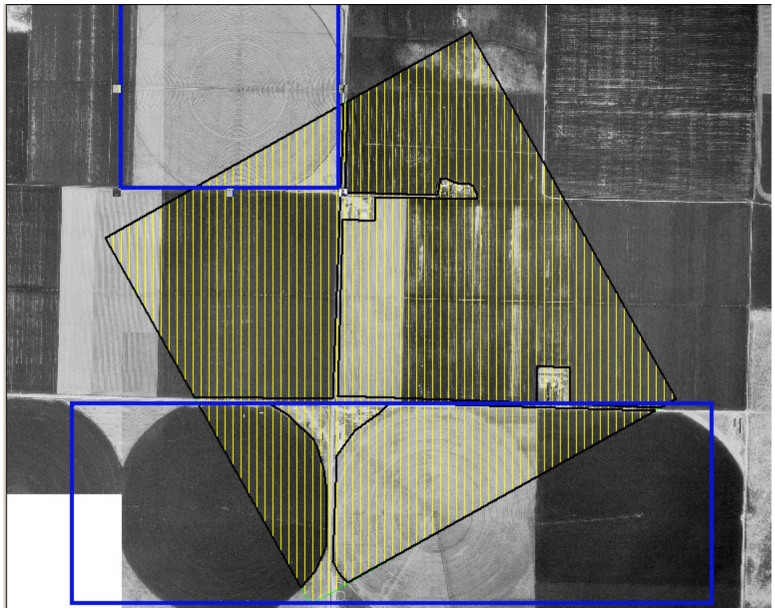

Figure 15. 1992 hand-drawn polygons (black) and 1992 irrigated-lands data (yellow) on 1998 DOQQ aerial photograph. In this case, there is a six-year gap between the time of the data set and the image. The boxed areas on the south and the northwest appear to have undergone a change in geometry between the time of the data set and the time of the image.

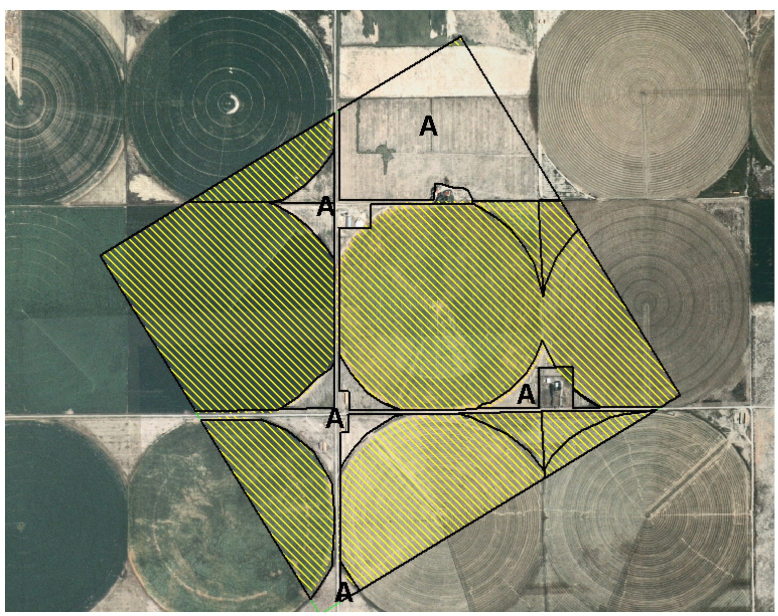

Figure 16. 2006 hand-drawn polygons (black) with 2006 data-set irrigated lands (yellow) and 2006 NAIP aerial photograph. Notice parcels at locations labeled "A." The technician defined separate geometry for these parcels, but did not attempt to determine irrigation status. Later in comparison with the irrigated-lands data set, these parcels were removed from the analysis.

Table 4 lists the resulting reductions for non-irrigated inclusions used in ESPAM2. While the calculation methods would accommodate separate reduction factors for sprinkler and gravity irrigated lands, lack of ability to unambiguously identify application method on individual sample parcels resulted in a single reduction factor being used for all parcels in each data set.

Table 4
Reduction factors for non-irrigated inclusions for ESPAM2 Calibration

Data set	Reduction factor
1980	0.07
1986	0.01
1992	0.06
2000	0.05
2002	zero[15]
2006	zero[16]

<u>Source of Irrigation Water</u>

In the Eastern Snake River Plain, parcels can be irrigated by surface water, groundwater, or from both sources. Approximately 300,000 acres of the 2,000,000 acres of irrigated land in the study area have both surface-water and groundwater rights and are called "mixed-source" lands in ESPAM1.1 and ESPAM2 water-budget development documents.

` As explained in the ESPAM1.1 Design Document (Contor, 2004b), in ESPAM1.1 location of water source and the fraction of supply on mixed-source lands did not change the water budget, but only affected spatial distribution of recharge. In ESPAM2, the On-Farm algorithm can actually change the water budget, depending on the acreage mapped to surface-water supplies and the fraction of supply assigned to surface-water irrigation on mixed-source lands. Hence, in ESPAM2 it is vital to appropriately represent both the source of irrigation water on a given parcel, and the fraction of supply from surface water on mixed-source parcels.

<u>Source of water.</u> In ESPAM1.1, the source of irrigation water was determined from a query of water rights by quarter-quarter section (nominally 40 acres), performed by Michael Ciscell of IDWR, and described in the ESPAM1.1 Design Document. This process could not be repeated for ESPAM2 because one of the intervening events in the Snake River Basin Adjudication was the water-right representation of the irrigated place of use for organized canal companies and irrigation districts as the entire service area. Figure 17 illustrates

[15] While the value was statistically non-zero (0.011 +/- 0.008) it is not practically different from zero. IWRRI and Kramber agree that with this high-fidelity CLU data set perhaps what is being measured is not non-irrigated inclusions within the CLU polygons but simply the limitations of hand-drawn polygons. IWRRI proposes that all future CLU-derived data sets be given an RED factor of zero.
[16] The calculated value was neither statistically nor practically different from zero.

the implications for ESPAM2 source of irrigation water. Because of this condition, the ESPAM1.1 delineation of water source was retained for ESPAM2.

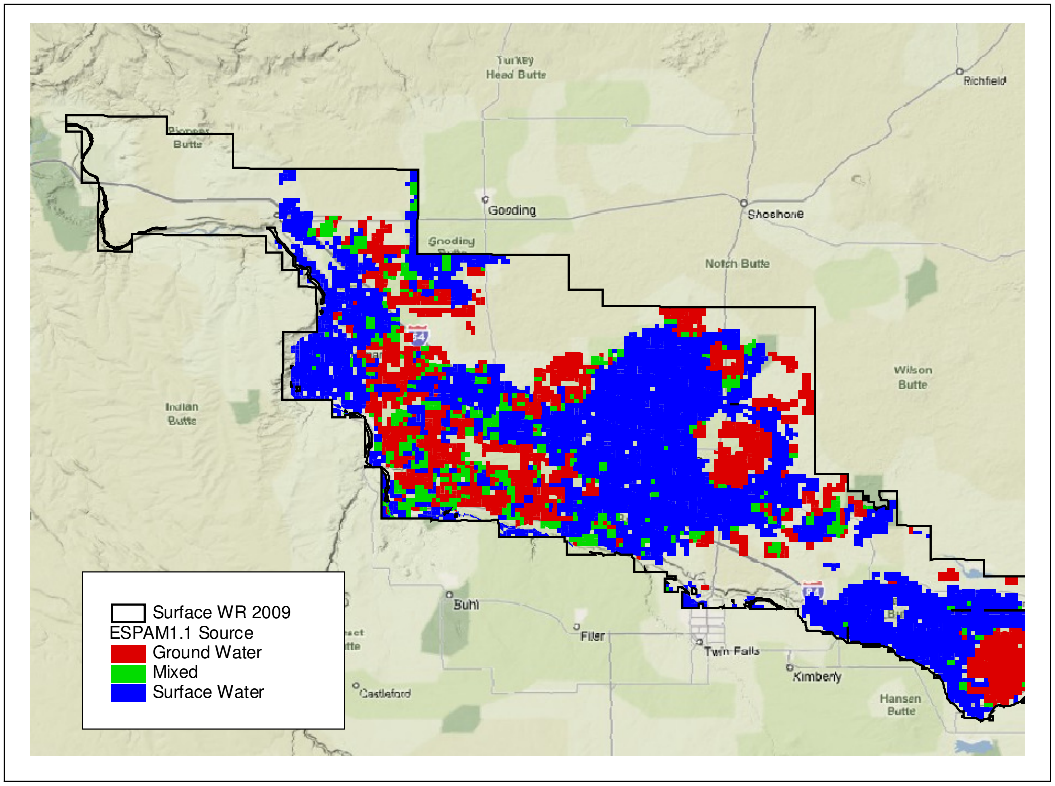

Figure 17. The colored polygons show the ESPAM1.1 source of irrigation water. The black outline shows the current water-right place of use for a single water right for one of the canal companies in this region. Application of the ESPAM1.1 methodology to the new water right data would result in all the groundwater only lands (red colored) being represented as mixed source.

<u>Mixed-source Fraction.</u> In ESPAM1.1, the source fraction on mixed-source fractions was based upon an assumption that supplies were generally adequate for surface water only parcels in a given irrigation entity. The rationale was that economic pressures would have already forced reduction of acres and/or development of supplemental groundwater supplies; sustained farming with inadequate water supplies would be economically infeasible. For each irrigation entity, a portion of diversions was set aside for surface-water only lands, and the remaining was applied to mixed source lands. Based upon estimated requirements, a fraction of supply from surface water was calculated and the remainder was deemed to have been supplied by groundwater. The fraction was applied uniformly to all mixed-source lands in the entity. The Design Document (Contor, 2004b) provides additional detail.

During the development of ESPAM2, ESHMC members expressed a desire for finer spatial discretization of mixed-source fraction, in the hopes that this may better facilitate matching aquifer head targets in calibration and therefore perhaps result in a more accurate distribution of aquifer parameters. In addition, IWRRI work for the Idaho Water Resource Board (Contor et al, 2008) indicated that in reality, most nominally mixed-source parcels with Snake River water rights were actually physically supplied by only surface water or only groundwater, despite the existence of both surface- and groundwater rights.[17]

In response to these concerns and additional data, the source fraction on mixed-source parcels for ESPAM2 was initially defined based on proximity to the water-right location of groundwater irrigation points of diversions. While not formally tested, the obvious anecdotal information from Contor et al was that mixed-source parcels near wells were likely to be physically irrigated from groundwater and mixed-source parcels distant from wells were likely to by physically irrigated from surface water. The ESPAM2 Draft Design Document (Contor and Pelot, 2008) describes this process in detail.

In the fall of 2009, IDWR adopted the On-Farm algorithm into the irrigation recharge calculations. Because of the operation of the On-Farm algorithm, a source fraction showing too much surface water could actually change the water budget, by triggering a deficit-irrigation response that overwrote evapotranspiration data with an algorithm-determined reduction. However, the hazard of showing too much groundwater was simply a spatial distortion in the location of recharge and a distortion of the apparent consumptive-use fraction of applied irrigation water in the On-Farm summary output. In some entities, the actual source fraction changes seasonally (more surface water in the spring, more groundwater in the fall) or from year to year (more surface water in years with high supplies, less in years with low supplies). The current representation of irrigated lands data does not accommodate this rapid changing of source fractions.

In two rounds of ad-hoc adjustments, with review opportunities for the ESHMC, IWRRI attempted to refine the source fraction to avoid biasing the water budget by incorrectly triggering adjustments within the On-Farm algorithm (Contor 2010a, 2010b). This resulted in a manual adjustment of source fraction on mixed-source lands in some entities. Because the hazard of representing too much reliance on groundwater was only a spatial distribution issue, while the hazard of representing too much reliance on surface water was a distortion of the water budget, the manual adjustments were biased to accommodate the years of lowest supply. Therefore, the adjusted values will often NOT be good estimates of the actual source fraction. They WILL be appropriate for modeling with the On-Farm algorithm. For those entities, the On-Farm output on consumptive-use fraction of applied irrigation water will also be distorted for years of high surface-water supplies.

[17] Informal observation suggests that in the Big Lost and Little Lost and perhaps other non-Snake areas, mixed-source lands are far more likely to physically be provided with both surface-water and groundwater infrastructure, and likely are truly irrigated using both sources.

To avoid blunders in data processing, the adjusted fractions were applied uniformly to those entities that were adjusted, and the spatial refinement based upon point of diversion locations was abandoned. Table 5 lists the entities whose source fractions were adjusted, and Figure 18 through Figure 21 show the resulting spatial distribution of groundwater fraction, for the 2006 irrigated lands data set.

Table 5
Entities With Ad-hoc Adjustments to Source Fraction on Mixed-source Lands

Number	Common Name
IESW005	BigLost
IESW008	BlaineCo
IESW011	ButteMrk
IESW014	Blcfoot
IESW018	Falls
IESW019	FortHall
IESW022	Idaho
IESW025	Litlwood
IESW027	Milner
IESW028	Minidoka
IESW035	Progress
IESW037	Reno
IESW040	Rexburg
IESW051	Dubois
IESW052	Small
IESW059	Good_Rch

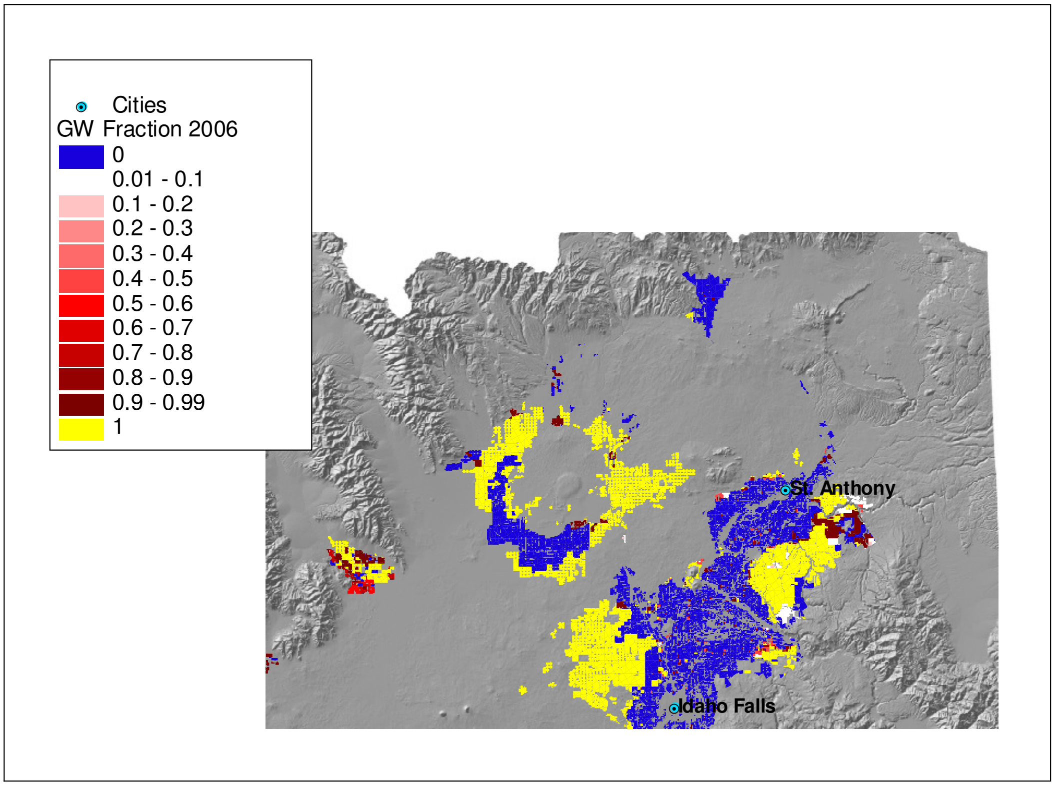

Figure 18. Adjusted modeling groundwater fraction, 2006 irrigated lands, northeast.

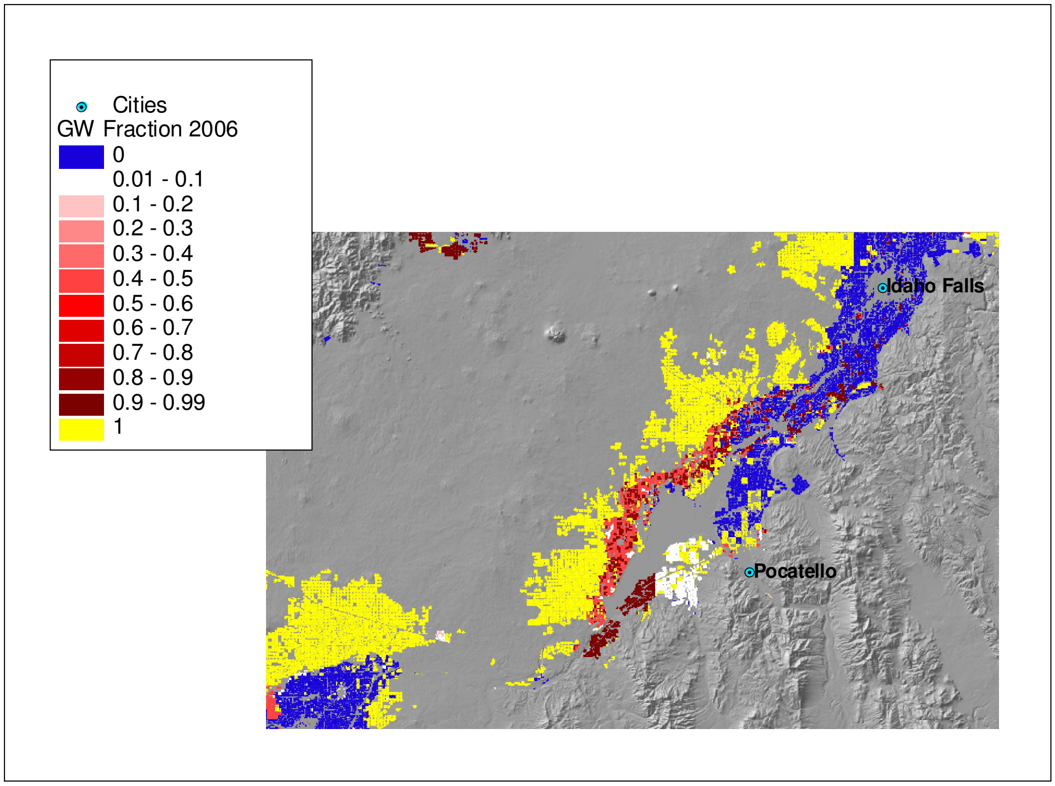

Figure 19. Groundwater fraction for modeling purposes, southeast.

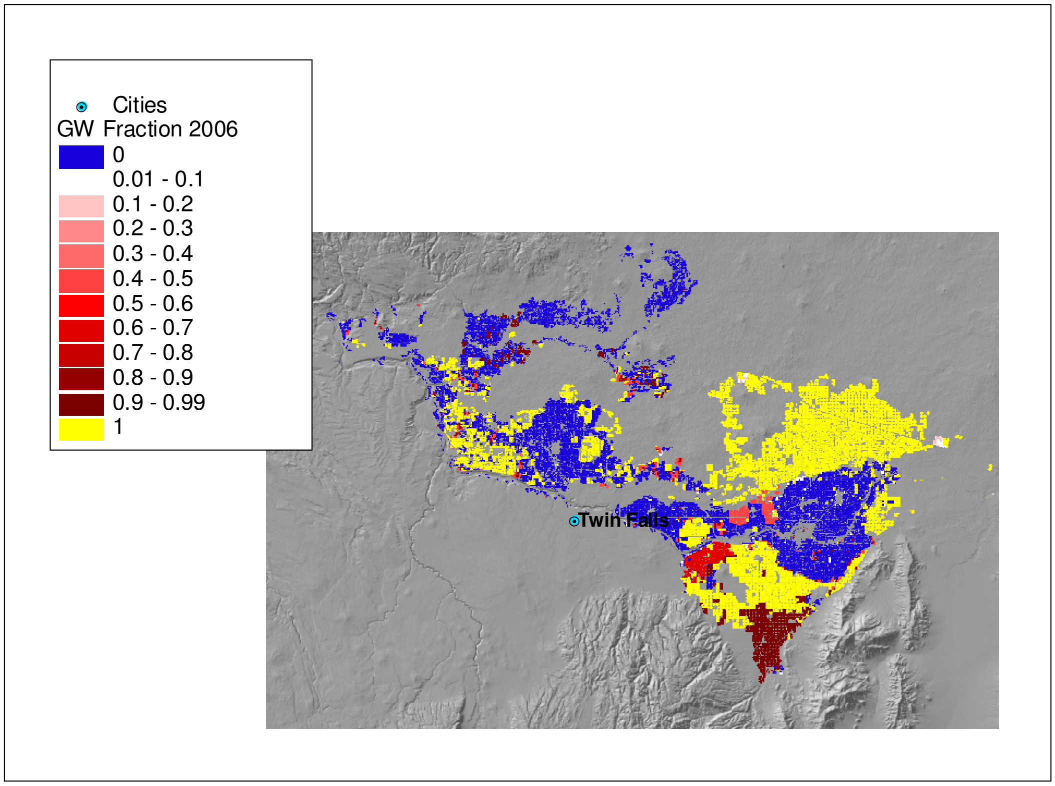

Figure 20. Groundwater fraction for modeling purposes, southwest.

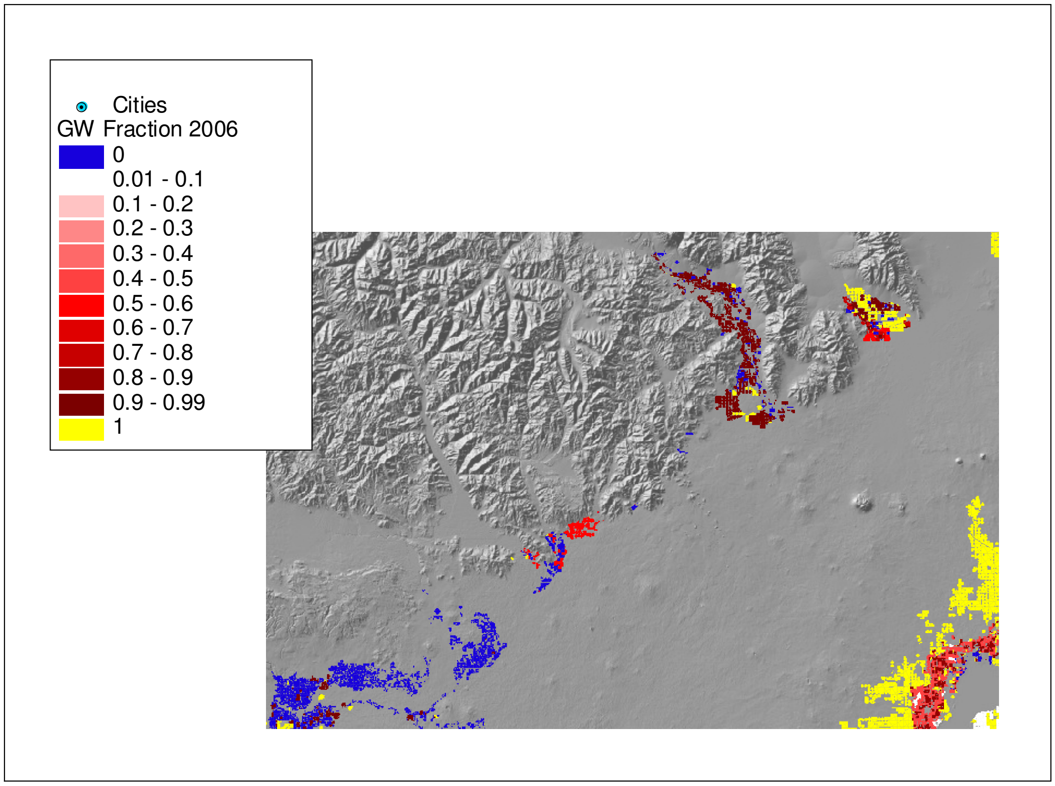

Figure 21. Groundwater fraction for modeling purposes, north central.

DESIGN DECISION

For calibration of ESPAM2, Irrigated lands will be represented for 1980, 1986, 1992, 2000, 2002 and 2006.

Source of irrigation water is based upon water-rights data obtained and processed for ESPAM1.1 Source fraction on mixed-source lands is based upon proximity to points of diversion for groundwater irrigation rights, except for irrigation entities where source fraction was manually adjusted to avoid potential biases in the On-Farm algorithm.

Data tables for input to the MKMOD software are currently assembled manually, though IDWR is building processing tools that are expected to be available for use by the time a calibrated version of ESPAM2 is released.

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