LAND USE

University of Idaho

Idaho Water Resources
Research Institute

by Bryce A. Contor
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Eastern Snake Plain Aquifer Model Enhancement Project Scenario
Document DDW-015Final 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 (ESPAM) Enhancement Project. 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 ESPAM 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 ESPAM 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 ESPAM Enhancement 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 is the final as-built report for determination of land use and land cover.

INTRODUCTION

Recharge calculations depend on the type of land use or land cover. Recharge on irrigated lands was calculated according to the net application of irrigation water from surface sources, the mix of crops, the application method, and the adjusted evapotranspiration rate according to the nearest weather station. Design Documents DDW-001, DDW-002, and DDW-005 through DDW-017 discuss various aspects of this calculation. Recharge on non-irrigated lands was calculated according to procedures presented in Design Document DDW-

003. Knowledge of land use or cover was required to determine which calculation method to use, and to apply the appropriate parameters in calculating recharge.

There are large differences in recharge rate, depending on the land use. Wetlands that are interconnected with the aquifer may result in a recharge of negative two feet per year or more (Goodell 1988), while other non-irrigated lands may have positive recharge of a few tenths of a foot (Garabedian 1992). Irrigated lands may have positive recharge rates of up to several feet. These large differences in recharge rate make it important to correctly identify the land use within the study area. This paper describes land use maps used in previous studies, the options available for the Eastern Snake Plain Model Enhancement Project, and the methods chosen.

PAST PRACTICE

Garabedian (1992) used a map of irrigated lands based on 1980 LANDSAT data for the calibration period of April 1980 through March 1981. For long-term model simulations, other maps (source not identified) were used to represent earlier time periods, with approximately a twenty-year period represented by each land cover map. IDWR (1997, 2) used the same 1980 LANDSAT classification for its calibration period, and used other data sets from LANDSAT images, aerial photographs, and field inspections for other time periods in simulations. IDWR also used some water right data to supplement these data sources. Each map appeared to represent about a ten-year time period.

SOURCES OF DATA

Sources of data considered for the model enhancement project include:

1. 1980 LANDSAT data (GIS coverage RASA80LC, IDWR 1980)
2. Water right data
3. Adjudication claims data (GIS coverage QQ-SCR-DATE, IDWR 2001)
4. Field determination of early-1980’s application method (GIS coverage IWM 82, US Natural Resource Conservation Service 1987)
5. GIS coverage SRBAS91LU (IDWR 1994)
6. GIS coverage SNAKLC92 (IDWR 1997, 1)
7. GIS coverage ID_NLCD92 (US Geological Survey and US EPA circa 1992)
8. GIS coverage ESPAC2000 (IDWR 2002).

Shapefile RASA80LC is a classification of LANDSAT data performed by the Idaho Image Analysis Facility of IDWR (IDWR 1982). This used the "thematic mapper" LANDSAT sensor and Vicker's classification algorithms, which are not directly comparable with later LANDSAT data and methods (Morse 2001). The Adjudication Claims shapefile is based upon a query for irrigation claims by quarter-quarter, within the study area. IWM 82 is digitized from paper maps completed in the field by Natural Resource Conservation personnel. SRBAS91LU and ID_NLCD92 are classifications of LANDSAT satellite images. SNAKLC92 is based on 1987 aerial photography and extensive field work. The coverage ESPAC2000 is a LANDSAT classification performed by IDWR specifically for this project, using classification of multiple images, with a two-week to one-month image frequency.

These data sources are used to identify irrigated lands, wetlands, cities, and other minor land use types. Non-irrigated range lands are further classified by soil type as described in Design Document DDW-003.

To select appropriate data sources for each purpose and time period, data were tested to determine:

1. How much change in land use has occurred between 1980 and 2001?
2. How much difference in *indicated* land use appears to be due to differences in methods and data sources?
3. Which data sources should be used to represent land use for the ESPAM Enhancement project?
4. How should differences between data sets be migrated temporally throughout the model calibration period (1980 through 2001)?

This paper describes the tests applied and results obtained.

POTENTIAL LIMITATIONS

Water rights and adjudication claims describe authorization to irrigate, rather than actual practice. Data from the IDWR water-rights database is limited by the fact that not all water rights are represented within the database. Until 1963 (for ground water) or 1971 (for surface water), a water right could be perfected in Idaho without using the permit and licensing procedure. Unless a dispute over such a water right has resulted in a court decree, no record will exist in the water-rights database. Further, many informal "accomplished transfers" that occurred from the 1950s through 1970s were not recorded on the department records. These are two of the reasons for the commencement of the Snake River Basin Adjudication, which required owners of all water rights to file claims to reflect their water rights. These claims data are limited by their very nature as "claims," potentially overstating actual water rights and use. IDWR's investigation of these claims within the study area was not completed within the time required by the model enhancement project.

A more serious limitation of both water rights and claims data, however, is the existence of overlapping water rights. A single 40-acre tract may have three water rights of 20 acres each. Without manually looking at the remarks and conditions of each right, it is impossible to determine whether these rights are adjacent or concurrent. The actual irrigation on this tract could range from somewhat less than 20 acres to nearly 40.

The RASA80LC, SRBAS91LU, ID_NLCD92 and ESPAC2000 classifications are based on interpretation of satellite images, with varying degrees of ground-truthing. The distinctions between dryland and irrigated agriculture, between irrigation and natural wetlands, and between irrigated agriculture and suburban residential areas, are not always clear cut (Morse 2001). Because of time and resource constraints, the ESPAC2000 LANDSAT classification was performed without attempting to distinguish suburban residential or wetland areas from irrigated agriculture, with the intent to use other data sources to make these delineations. Wetlands were a separate category considered in the 1980 RASA classification (IDWR 1982), but many areas classified as wetland in other data sets are identified as irrigated agriculture in the RASA classification.

The SNAKLC92 data set is based upon 1987 aerial photography with considerable field truthing and water-rights data cross-checking. Because the field work spanned the five intervening years between 1987 and 1992, the actual date represented by this data set is unclear. While this data set includes categories for wetlands, range land, and dry farms, inspection shows that some non-irrigated lands are simply omitted from the data set, rather than being assigned to these particular classes.

The IWM 82 data set is a compilation of paper maps classified in the field by Natural Resource Conservation Service (NRCS) personnel and digitized by IDWR. There are three limitations to this data set: 1) Spatial resolution is coarse. For instance, a large tract may be represented as irrigated, even if there are non-irrigated inclusions within the tract. 2) Coverage is not complete. No irrigation is indicated south of American Falls reservoir. It also appears that some lands were omitted due to access problems for the ground crews performing the inventory. 3) The exact date represented is unclear. The GIS metadata file indicates that the fieldwork was performed in 1980 and 1981, but some of the field work may have been done as late as 1985 (Swensen 2002). IDWR digitized the maps in approximately 1987.

An over-riding limitation on all of the data sets is the difference in methods and data sources between the classifications. While data sets exist representing the beginning, middle, and ending of the calibration period, there is no method or data source common to all time frames. This raises the question of whether period-to-period differences reflect actual changes in land use or differences in methods used.

TESTS AND COMPARISONS

Because of the issues of overlapping water rights, the water rights and adjudication claim data were rejected for determining actual irrigated acreage. Other tests and comparisons were performed on the other data, to assess the effects of differences in methods and changes over time and to select data sources for each time period. Because of computer memory limitations and the large number of polygons involved in the GIS data sets, these comparisons were performed on a sample illustrated in Figure 1 instead of on the whole study area. The test areas were selected to include recently-developed lands and wetlands, two areas of concern.

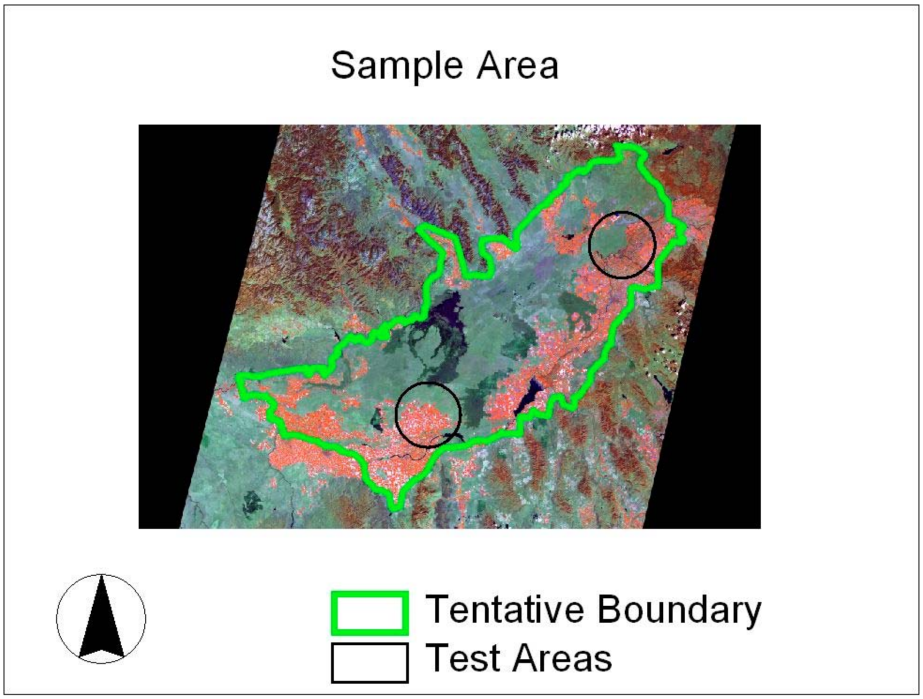

Figure 1, Test Areas

Comparisons

Two important questions considered were the total amount of irrigation occurring and the spatial location of irrigation. Both questions must be answered in considering differences between methods that represent a single moment in time, and in considering changes over time. The first question (gross amount of irrigation) was addressed by simply comparing indicated irrigated acreage between the data sources. This considers only the number of acres of irrigation; a later test considers whether offsetting subtractions and additions may have occurred. Figure 2 illustrates the results of the gross acreage test. The first two bars represent the beginning of the calibration period, the next three represent approximately the mid point, and the last bar represents the ending of the period. It is significant to note that the differences between data sets within a give time frame are larger than overall differences across the period. Since the largest differences appear within a single time frame, differences in methods and data sources are important.

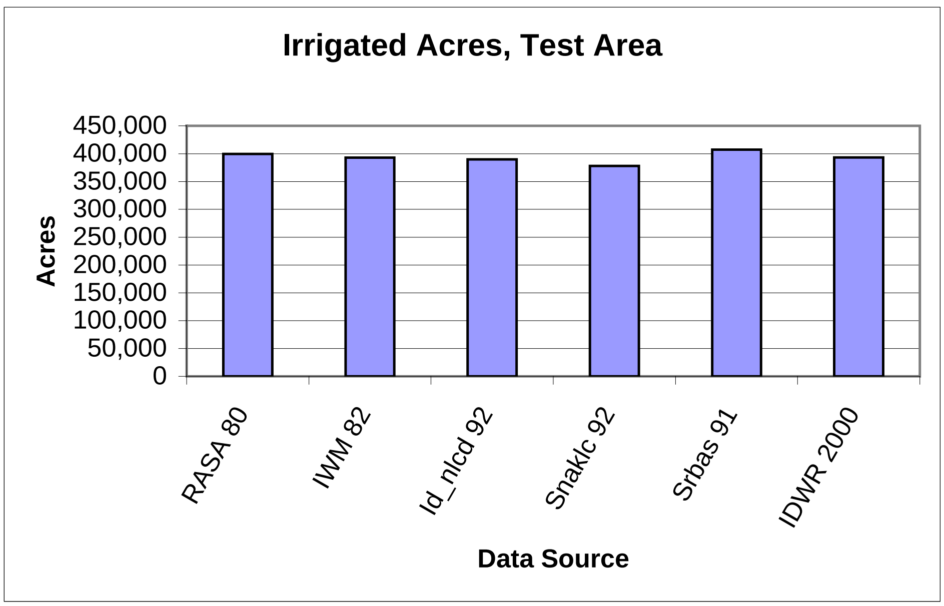

Figure 2, Irrigated Acreage by Data Source

The change in spatial distribution of irrigation over time was assessed by visually comparing the irrigated area indicated by the RASA80LC, SNAKLC92, and ESPAC2000 data sets within a statistical sample of 165 Public Land Survey sections that intersect irrigated lands. Twenty-eight sections (17%) show an increase in irrigation, offset by twelve sections (8%) showing a decrease. Visual inspection of GIS maps that alternately overlay earlier and later irrigation data sets show that a small amount of regional change in spatial distribution is indicated. There was some indicated shift of irrigation away from areas west of Idaho Falls, Idaho between 1980 and 1992, and some indicated shift of irrigation towards the Hamer, Idaho area over the same period. These indications match known areas of Conservation Reserve Program (CRP) enrollment and late-1980s development.

The differences in spatial distribution between different methods representing a single moment in time were assessed by visually comparing GIS overlays of the three early-1990s data sets, and by comparing the two early-1980s sets. In neither case did any regional difference of spatial distribution appear.

Detailed Comparison of Differences in Methods

To understand the differences between methods, GIS shapes were constructed that represent the differences between data sets of the same time period. Each GIS shape shows lands indicated as irrigated by one method but not another, within a given time period. These were intersected with a random selection of public land survey sections within the test area. Because the “sections” data set included some government lots along the river, the sample was slightly biased towards areas that may include wetlands. Since wetlands are a particular area of concern, this bias was accepted.

These sections were examined individually. For the 1980/82 time frame, seventeen sections were looked at, and fifteen for the 1991/92 time frame. In each section, an assessment was made regarding which data set best represented actual irrigated lands, and an attempt was made to identify the cause of the discrepancy. The assessment was based on the year-2000 LANDSAT image, all the available classifications, 1987 and 1976 aerial photographs that covered part of the northern test circle, and the investigator’s familiarity with some of the areas. Figure 3 illustrates the result of the early-period comparison, and Figure 4 represents the mid-period comparison.

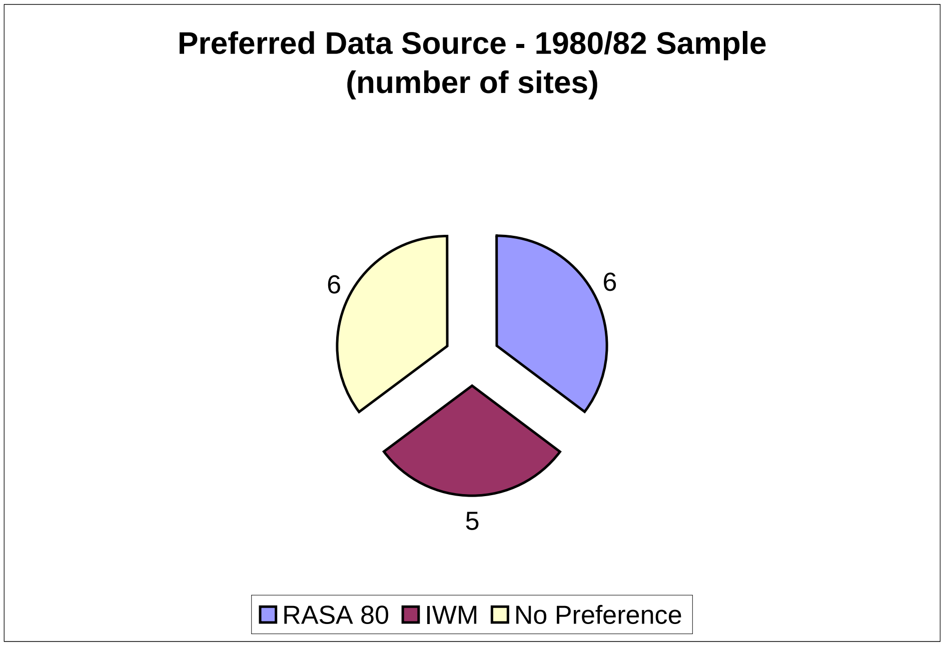

Figure 3, Preferred Data Source 1980/82

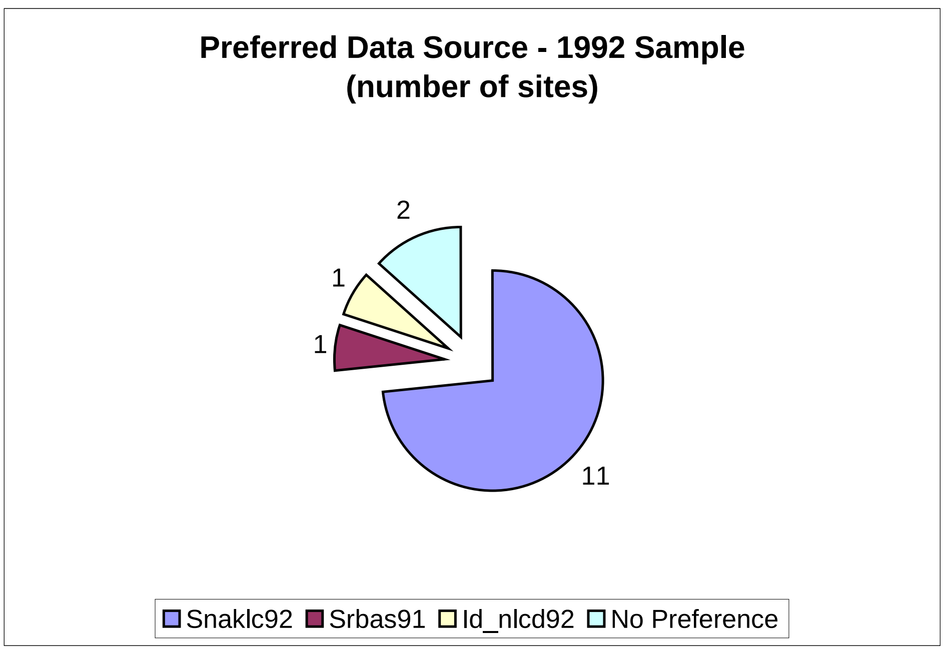

Figure 4, Preferred Data Source 1992

Edge Effects and Inclusions

Not every square foot of every irrigated field actually receives irrigation water. IDWR (1997) discounted the RASA80LC irrigated acres by five percent for ground-water irrigation, or fifteen percent for surface-water irrigation, to account for roads, ditch banks, stack yards, etc. Cosgrove et al (1997) found that in the Twin Falls, Idaho area (an area predominantly gravity irrigated), actual irrigated acreage determined by planimeter measurements of aerial photographs averaged 87.5 percent of nominal public land survey acreage.

In the public land survey sections examined for the previously-described test, it appeared that the RASA80LC data were more likely to correctly indicate non-irrigated borders and inclusions within an irrigated tract than were the IWM 1992 data. In the 1991/1992 comparison, the SNAKLC92 and ID_NLCD92 data were more likely to correctly represent these inclusions than were the SRBAS91LU data. It appeared that some of the edges and inclusions represented as not irrigated by ID_NLCD92 actually were irrigated. The ESPAC2000 data set appeared to be comparable to the RASA80LC and SNAKLC92 data.

Because the previously-used discounts are substantial, and because of significant occurrence of edge effect differences in the test samples, this aspect of land use is the subject of further investigation. Actual irrigated place of use from IDWR adjudication data (Norquest 2002) and digitized irrigated polygons from each of the data sources were compared for a statistical sampling of public land survey sections. The reduction finally used for model calibration was 0.12. Surprisingly, the results for sprinkler and gravity lands were not statistically different, so this factor was applied to both sprinkler-irrigated lands and gravity-irrigated lands. As explained below, final calibration used only the SNAKLC92 data set, so its factors were applied to the entire calibration period.

Wetlands

Wetlands have very different net recharge characteristics from irrigated lands, and the test showed that wetlands were treated differently by different data sources. Several wetland areas were compared visually within the full study area. In general, it was found that the RASA80LC data set will include lands as “pasture,” “alfalfa,” or “other irrigated” that are identified as wetlands in other data sets, and that are known to be wetlands or appear so from the image. The IWM 82 data set generally will not include these as irrigated. In fact, the only sites where the IWM data set was preferred to the RASA data set were wetland sites. SNAKLC92 and SRBAS91LU tend not to represent wetlands as irrigated, while ID_NLCD92 showed some wetlands as irrigated. The ESPAC2000 data set, as expected, included as “wetlands or other irrigated” many lands that are believed to be wetlands.

The classification of the 2000 LANDSAT image was not intended to identify wetlands and residential areas that might otherwise be classified as irrigated. Since these uses represent small acreages, and their delineation represents large costs, the SRBAS91LU minor land-use classes were applied to the ESPAC2000 data set. These were applied to the SNAKLC92 data because it tended to omit non-irrigated lands, and to the RASA80LC data because it tended to represent as irrigated, lands that are actually wetlands.

New Development

Three areas were examined for representation of new development, the Hamer, Idaho area, the Medicine Lodge, Idaho area, and the Minidoka, Idaho area. This examination tests whether new irrigation has occurred and whether the new irrigation represents an increase in irrigated acres or just a change in location of irrigation. In general, the amount of development appearing since 1980 is modest. The RASA80LC and IWM 82 data set tended to agree, as did the three 1991/1992 data sets. Where there was disagreement, IWM 82 showed more irrigation than RASA80LC, and the 1992 data sets showed more than the 1991. This matches the expected chronology of development. The general development pattern shown in the 1976, 1987, and 2000 images in the north test area agreed with the progression in the data sets. Figure 5 illustrates the area of greatest development over the calibration period. The 1980 irrigated lands are illustrated in pale green. The darker gray lands were added by 1992, and the black striped lands were added by 2000. Many of the later additions represent water-right transfers.

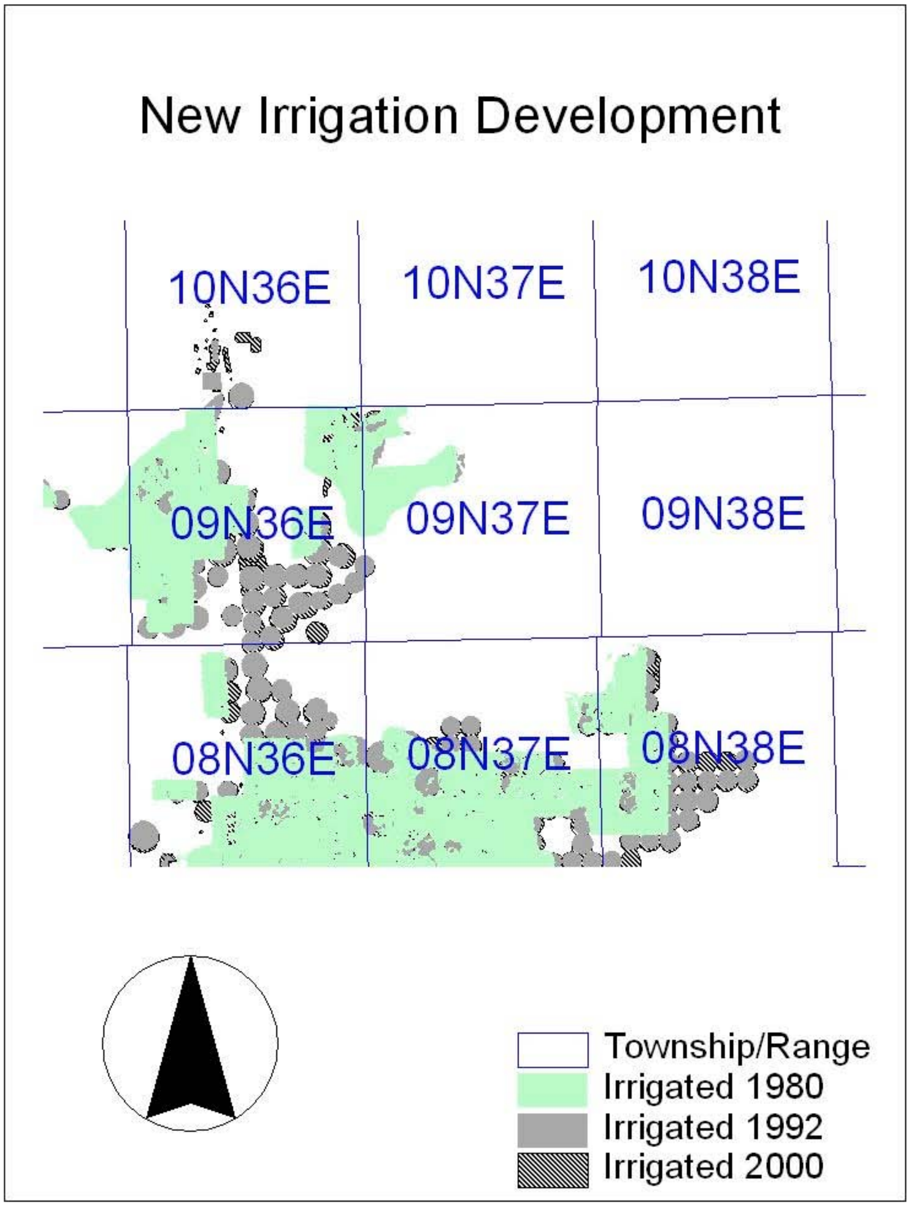

Figure 5, Illustration of New Development

Dry Farms

Dry farm areas in the Rexburg Bench and west of Idaho Falls, Idaho, were examined. The RASA80LC and IWM 82 data sets generally agreed, as did the SNAKLC92 and ID_NLCD92 data. These were consistent with the images and the investigator's knowledge. Some lands shown as irrigated by SRBAS 91 were shown as dry farm by other sources. In virtually every case, the ESPAC2000 classification agreed with the investigator's interpretation of images. Dry farms constitute a very small number of acres relative to the irrigated lands. All lands represented as dryfarm in the SRBAS91LU data were considered dryfarm in the non-irrigated recharge calculations discussed in Design Document DDW-003. The dryfarm recharge rates were applied in all stress periods where the irrigated lands data did not cover the same parcel.

Cities

The 2000 LANDSAT image for Idaho Falls, Idaho was compared with all the data sources. All the data sources except the ESPAC2000 classification generally agreed and appeared to be correct. It is striking that despite the perception of growth of Idaho Falls over the last 20 years, there was far more agreement than disagreement, underscoring that relative to irrigated agriculture, city areas are a small component of land use in this study area. As discussed, the ESPAC2000 classification was not intended to delineate cities. Cities were handled in the same way as wetlands, by using the SRBAS91LU data identify those areas for the 2000 land use map.

SELECTION OF CALIBRATION DATA

<u>Preliminary Selection.</u> Based on the above comparisons, the RASA80LC, SNAKLC92, and ESPAC2000 (with modifications described above) were the preferred data sets. These appeared to represent their time periods most satisfactorily, and were generally consistent with one another. Differences were expected to indicate actual changes. It was originally intended to use all three of these data sets for model calibration.

<u>Temporal Migration.</u> The water rights or adjudication claims data bases were considered as possible sources of data for refinement of the dates of development, and for the temporal migration between data sets. However, much new development is accomplished by transferring older water rights from other lands. Permit-based water right priority is based on the date of application. With normal development allowances and extensions, the actual commencement of irrigation can be several years after the priority date. An informal check of several fields shown as irrigated in 2000 but not in 1980 showed priority dates ranging from 1951 to the mid 1980s. Because the differences in land use are small, and because data are not available to readily construct interim land cover data sets, it was originally proposed that each data set be used to represent a block of years, with a stepped transition to the next data set.

<u>As-built Change.</u> During model calibration, comparison of the water budget with the aquifer water levels and spring discharges indicated that the slight trend of

decreasing irrigated acreage over time was inconsistent with trends in measured modeling targets. Inspection suggested that the differences in spatial distribution between the three land-cover data sets were minor, and where they did occur was distant from river or spring reaches of concern. Final model calibration used the SNAKLC92 data set for the entire calibration period.

DESIGN DECISION

Irrigated land use was described by selecting only irrigated polygons from GIS shapefile SNAKLC92. Recharge on these lands was calculated as described in other Design Documents. The recharge calculation included a reduction factor of 0.12 for non-irrigated inclusions. All other lands followed the non-irrigated lands procedures described in Design Document DDW-003, using spatial locations for dry farms, wetlands and cities from the SRBAS91LC data set.

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