Representation of Recharge from Canal Leakage for Calibration of Eastern Snake Plain Aquifer Model Version 2, As Built, Revision 1

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ESPAM2 Design Document DDW-V2-01-Rev1 As Built "Canal Recharge"

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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. Superseded Design Documents will be maintained in a “superseded” file folder on the project Website, and successive versions will be maintained in a “current” folder.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.

This is Revision 1 of the October 2009 As-built document (Contor, 2009). Revision was necessary due to adjustments made to accommodate the On-Farm algorithm of recharge-calculation software MKMOD adopted by IDWR.

INTRODUCTION

As described in ESPAM1.1 Design Document DDW-020 (Contor, 2004), water that seeps from the bed of ditches and canals is direct recharge to the aquifer and is unavailable for delivery to farm fields[1] (and therefore unavailable for crop evapotranspiration, return flows to the surface-water source, or in-field incidental recharge). In the ESPAM1.1 representation, as well as the previous ESPAM2 representation, recharge from canal seepage affected the spatial distribution of modeled recharge, but did not affect the mass balance of recharge or the aquifer water budget.

With the adoption of the On-Farm algorithm, canal seepage is subtracted from gross diversions before the field-headgate delivery volume is calculated. Depending on the calculated adequacy of field-headgate deliveries, the On-Farm algorithm can change the water budget. With this realization, IWRRI proposed and the ESHMC concurred that a second look at canal seepage was necessary. This Design Document reports on the canal-seepage estimates that resulted from this attempt at refinement. Further data and discussion are posted by Idaho Department of Water Resources (IDWR, 2010a, 2010b).

REVIEW OF ESPAM1.1 APPROACH

In ESPAM1.1, for the most of the study area, recharge from canal seepage was implicitly included in the general calculation of incidental recharge from irrigation. Recharge from canal seepage was explicitly represented for a few canals using the Leaky Canal functionality of the GIS and FORTRAN components of the Recharge Tool. In those canals, seepage was represented as a percentage of diversions. The tools have the capability of applying a unique seepage fraction to each stress period, though data adequate for applying time-varying fractions were only available for one canal.

The ESPAM1.1 Recharge Tool included the capability for automated calibration of recharge from canal seepage, though this was not used in calibration of ESPAM1.1. In the Recharge Tool, each stress period's calculation of recharge from canal leakage for an individual model cell is as follows:

$$R_c = (1/Cells) * (Divs) * (Frac) * (Mult) \qquad (1)$$

Where
- R_c = recharge from canal seepage for the individual cell
- Cells = number of model cells intercepted by the canal
- Divs = diversion volume for the entity served, for the stress period
- Frac = seepage fraction for the stress period

[1] Seeped water is unavailable for delivery to farm fields from the canal, in the context of calculating net impact of irrigation for aquifer water budget purposes. After entering the aquifer, the water could be re-diverted from wells, or enter springs and river reaches, and again applied to beneficial use.

Mult = multiplier for automated calibration (default 1.0)[2]

Important details include:

1. An individual entity may have more than one canal, with its unique seepage fraction and multiplier.
2. In the case of multiple canals in a single entity, calculation of each canal's seepage is independent of the others.
3. A unique seepage fraction may be applied to each stress period.
4. A single multiplier applies to all stress periods in a given simulation.
5. Water devoted to canal seepage is subtracted from the net diversions available for evapotranspiration and incidental recharge.
6. While each leaky canal has its unique multiplier, one or more multipliers may be tied (using the parameter-estimation software) in order to control the number of parameters.

Representation of canal seepage changed only the spatial location of recharge and not the water budget. This is because water would have been applied as incidental recharge in the irrigated-lands calculations had it not been applied to canal leakage.

In ESPAM1.1, only a few major canals were represented. The rationale for this decision was that the spatial distribution of canals and laterals is dense relative to the model grid, and that the implicit representation of seepage uniformly distributed across irrigated lands was a good representation of reality for most irrigation entities.

REVIEW OF INITIAL ESPAM2 APPROACH

The October 2009 Design Document (Contor, 2009) outlines discussion topics and theoretical considerations of canal seepage. The result was a non-linear expression of canal-seepage as a function of diversions, described in Equation 2. In Figure 1, the equation is illustrated with some of the data discussed in the October document.

Monthly seepage fraction =

$$0.30 - 0.10 * (\ln (\text{Mo Div Index})) \qquad (2)$$

Where: Mo Div Index = (Monthly Diversions)/(Maximum Diversions[3])

[2] The ESPAM1.1 READINP utility included an error trap to prevent the automated parameter routine from causing effective canal seepage fraction to exceed 1. For ESPAM2, READINP has been replaced by MKMOD.

[3] Maximum diversions is the largest monthly diversion observed during the period of record.

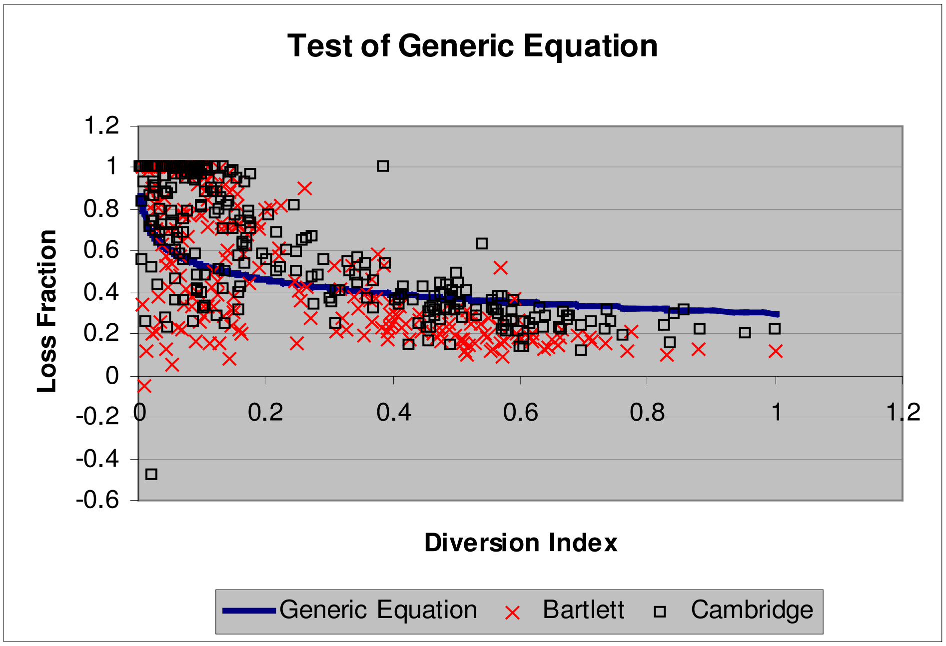

Figure 1. Illustration of October 2009 equation with canal data from Nebraska.

The initial ESPAM2 approach adopted the ESPAM1.1 recharge calculation algorithm, under which canal seepage changed the spatial distribution of recharge but not the water budget. However, leaky canals were represented for nearly all surface-water irrigation entities. The ESHMC rationale in making this representation was that better representation of the spatial distribution of recharge may improve matching aquifer head targets and thereby perhaps improve estimation of aquifer properties, especially storage coefficient.

REVISION TO CANAL SEEPAGE TO ACCOMMODATE ON-FARM ALGORITHM

IDWR has replaced the READINP recharge-calculation utility with software MKMOD, constructed by Principia Mathematica and Spronk Water Engineers. It is anticipated that IDWR and/or one of the developers will describe the software and recharge-calculation algorithms and assumptions in a separate Design Document.

The primary motivation for adoption of MKMOD was the inclusion of an On-Farm algorithm, which reduces effective evapotranspiration and increases percolation and/or runoff in cases where calculations indicate that deficit irrigation has occurred. Since this determination is made after canal seepage is subtracted from diversions, canal seepage can materially affect the water budget and not only the spatial distribution of recharge. Similarly, the On-Farm algorithm causes representation of water source and source fraction on mixed-source lands to potentially affect the water budget. These too had previously only affected spatial distribution of recharge.

In late 2009 or early 2010, IWRRI proposed that this potential to change the water budget justified a second look at these estimates and recharge components. The process and outcome is described in detail in a memo posted on the IDWR website (Contor, 2010). In order to limit the opportunities for blunders and reduce complexity, IWRRI abandoned the non-linear calculation of canal-seepage fraction. Canal seepage fractions were set to honor the water budget implied by measured return flow data (the On-Farm algorithm does not use return flow data, but independently calculates returns) and data or anecdotal information about canal seepage, to the extent possible.

DESIGN DECISION

The following design decision is proposed:

1. Canal leakage will be represented as a fraction of gross diversions, with the fraction constant across stress periods. The fractions are listed in Table 1.
2. Leaky canals will be represented by the linear features illustrated in Figure 2 through Figure 14.
3. Note that some entities will have more than one canal. The fractions in Table 1 will be apportioned to the canals in the entity.
4. Data tables produced for input to MKMOD will identify the model grid cells intersected by each GIS line feature illustrated in the figures, and the seepage fractions listed in Table 1, apportioned to individual canals if needed.
5. The Murtaugh-to-Pickets reach of the Twin Falls South Side Canal will be represented as a line source in the Perched River Seepage data set, as was done in ESPAM1.1.

Table 1
Canal Seepage Fractions for ESPAM2
Calibration Water Budget

Entity	Common Name	Seepage Fraction	Entity	Common Name	Seepage Fraction
IESW000	Null	(none)	IESW030	NewSwedn	0.21
IESW001	A&B	0.15	IESW032	Nrthside	0.31
IESW002	AbSpring	0.62	IESW034	Peoples	0.42
IESW005	BigLost	0.23	IESW035	Progress	0.31
IESW008	BlaineCo	0.30	IESW036	Liberty	0.30
IESW009	Burgess	0.38	IESW037	Reno	0.22
IESW010	Burley	0.38	IESW038	Rexburg	0.42

Entity	Common Name	Seepage Fraction	Entity	Common Name	Seepage Fraction
IESW011	ButtMrk	0.15	IESW039	Chester	0.30
IESW012	Canyon	0.08	IESW040	Oakley	0.34
IESW014	Blckfoot	0.15	IESW044	Monteview	0.20
IESW015	Dewey	0.30	IESW051	Dubois	(none)
IESW016	Egin	0.60	IESW052	Small	(none)
IESW018	Falls	0.10	IESW053	Howe	0.30
IESW019	FortHall	0.50	IESW055	Labelle	0.31
IESW020	Harrison	0.38	IESW056	Sugrcity	0.60
IESW022	Idaho	0.30	IESW057	Blk_Chub	0.37
IESW025	LitlWood	0.40	IESW058	AmFalls2	0.77
IESW027	Milner	0.40	IESW059	Good_Rch	0.42
IESW028	Minidoka	0.35			
IESW029	MudLake	0.05			

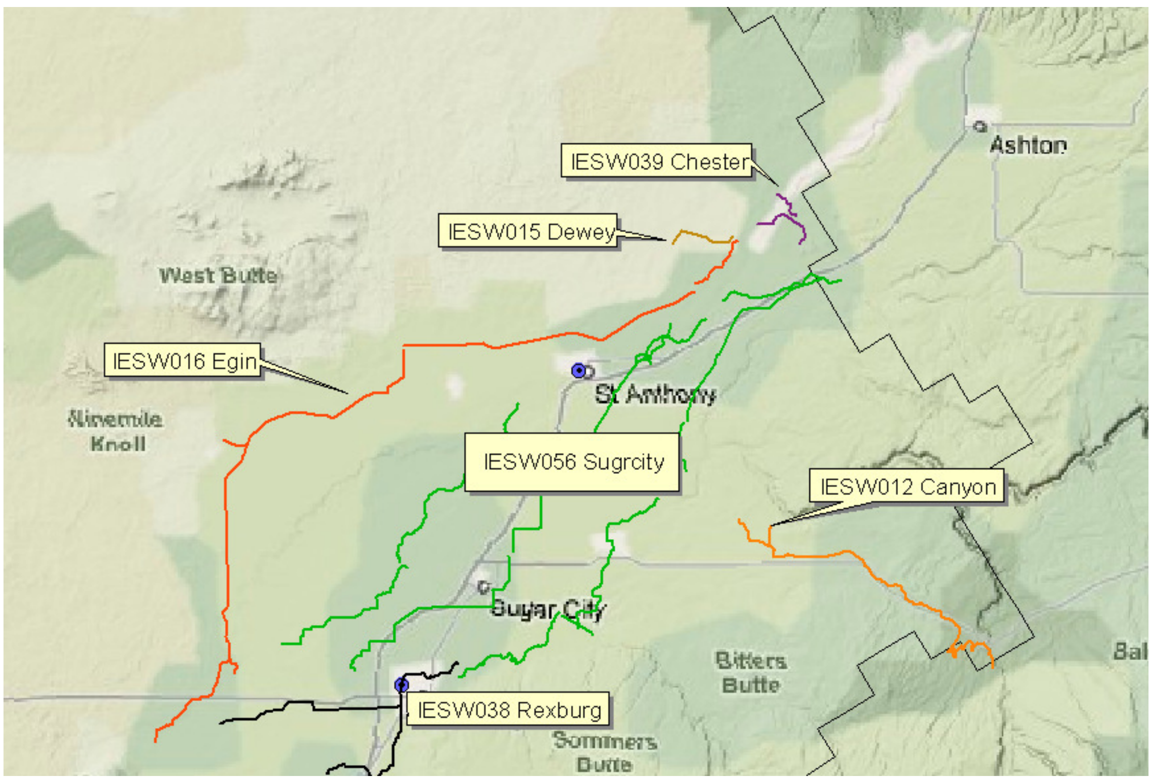

Figure 2. Canals in the St. Anthony/Rexburg area.

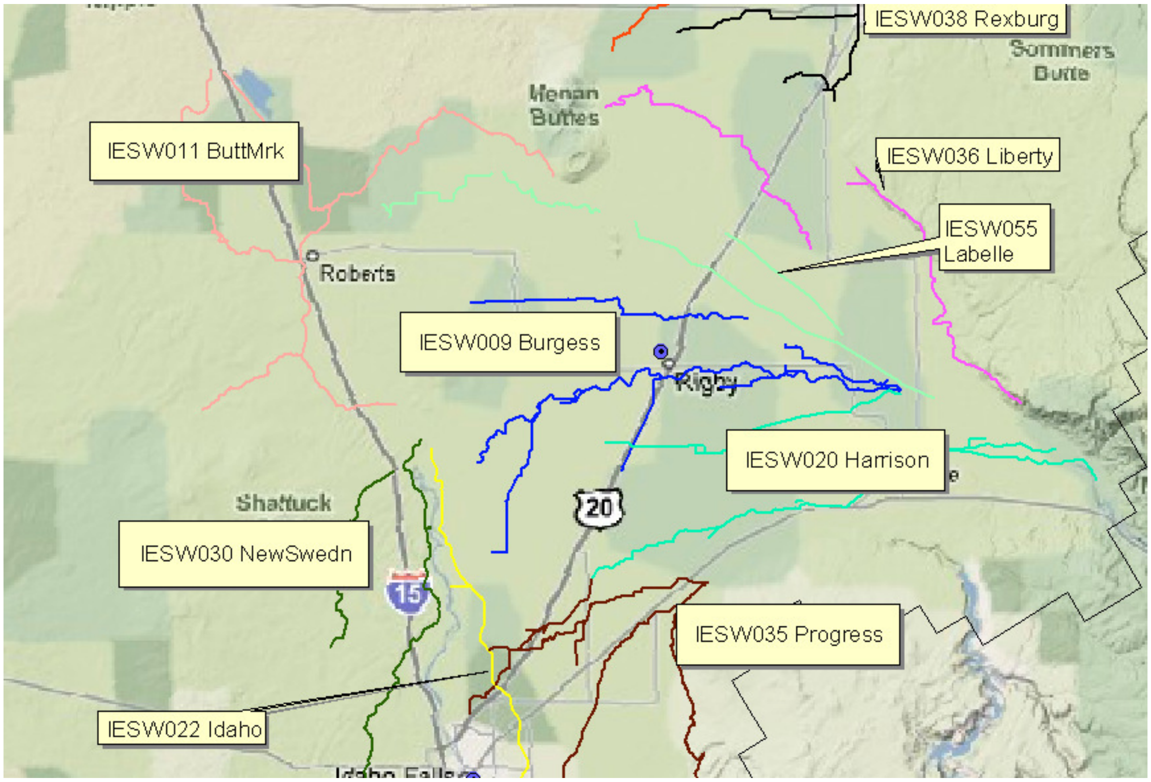

Figure 3. Canals in the Rigby/Ririe/Ucon area.

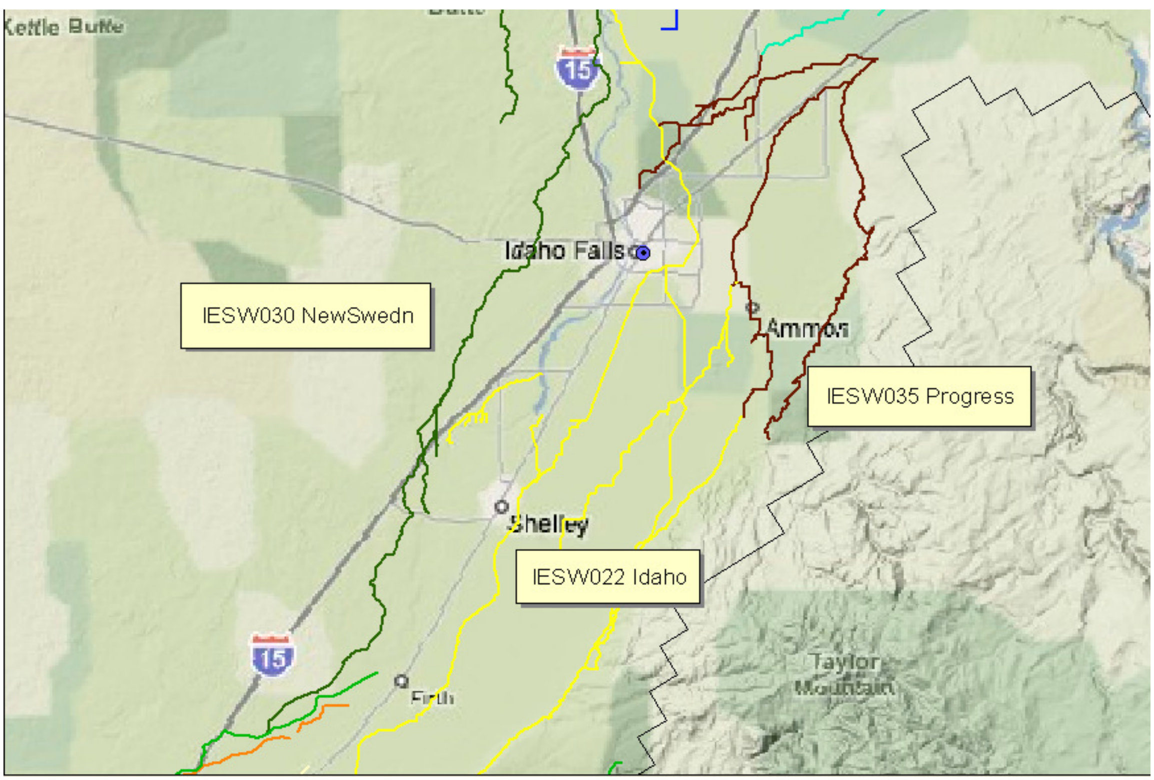

Figure 4. Canals in the Idaho Falls/Shelley area.

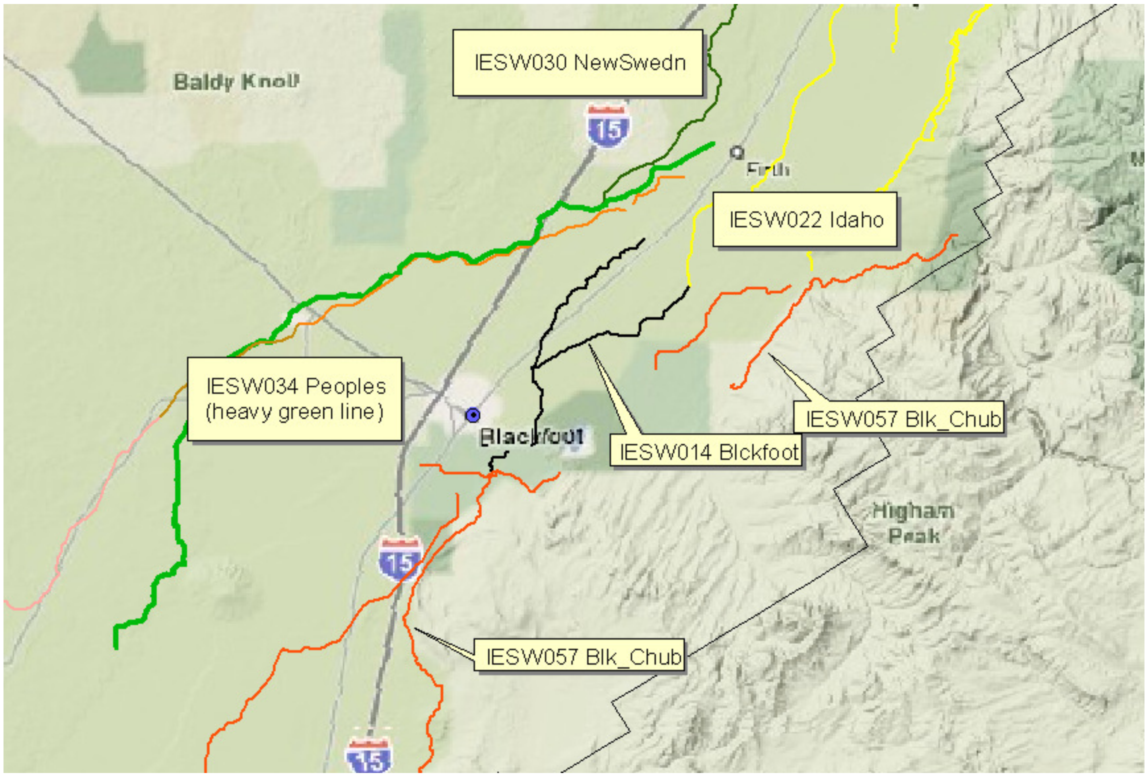

Figure 5. Canals in the Blackfoot area (see Figure 6 for Aberdeen-Springfield canal reaches).

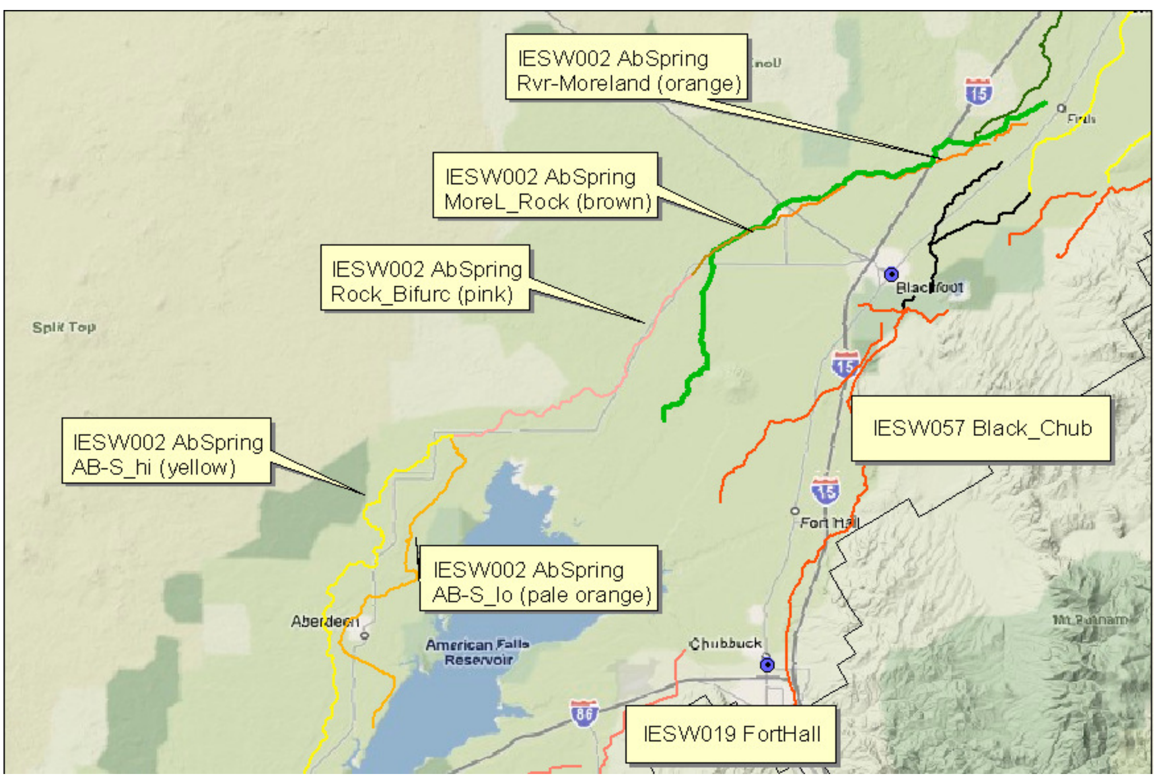

Figure 6. Canals in the Aberdeen/Fort Hall/Blackfoot area.

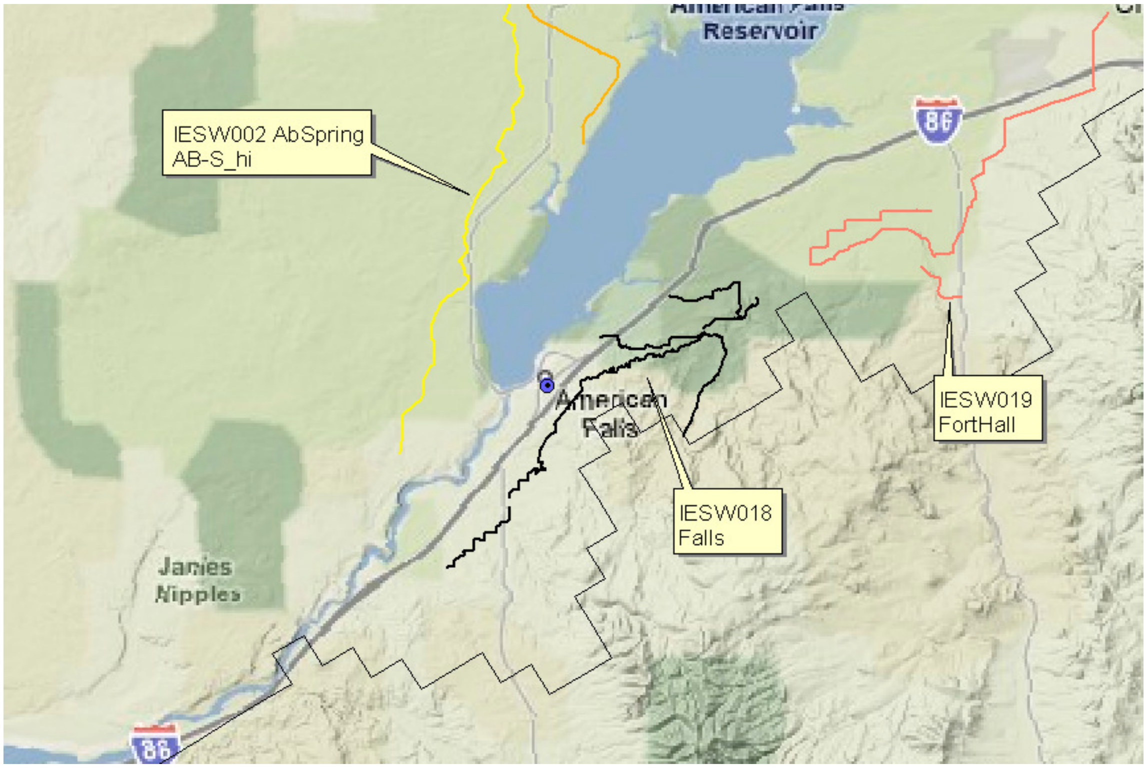

Figure 7. Canals in the American Falls area.

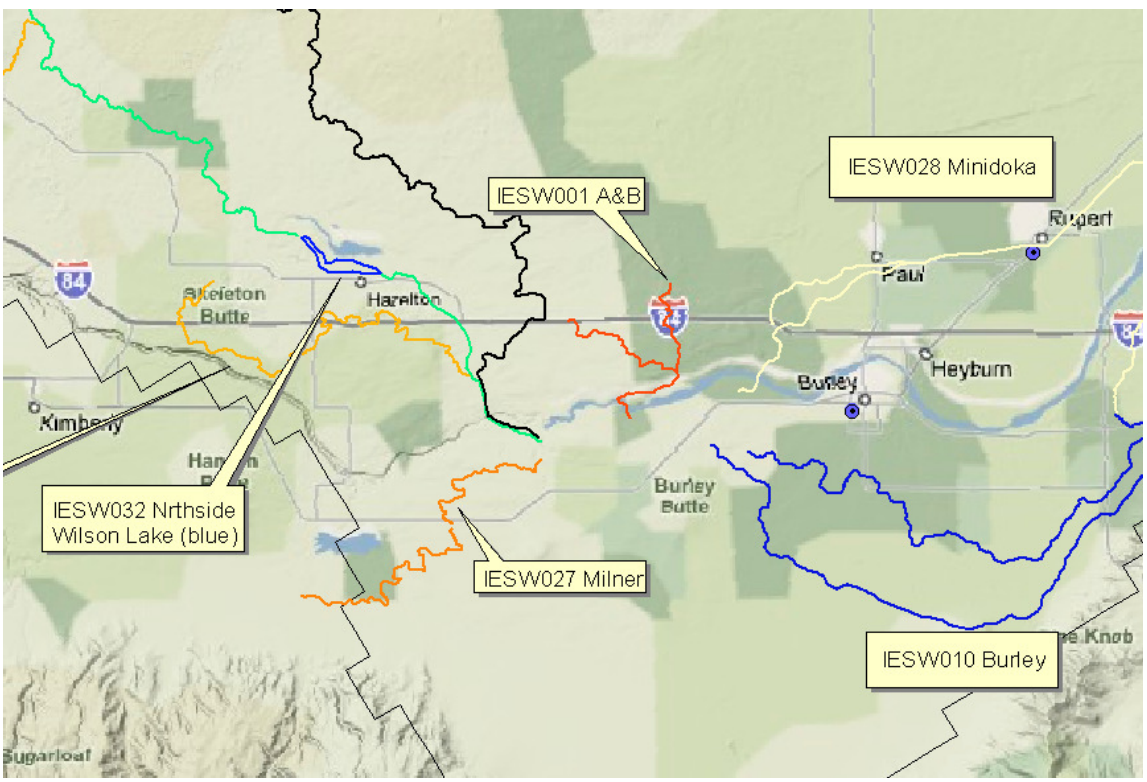

Figure 8. Canals in the Burley/Rupert area.

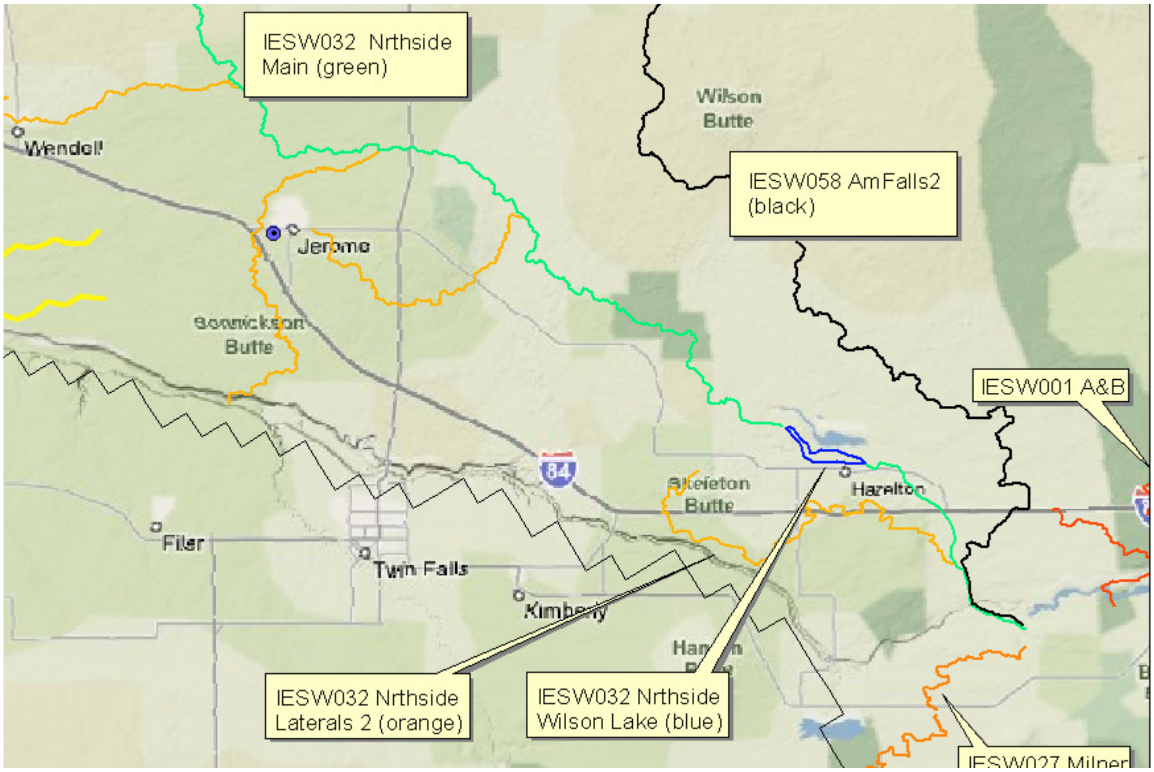

Figure 9. Canals in Northside/Milner area.

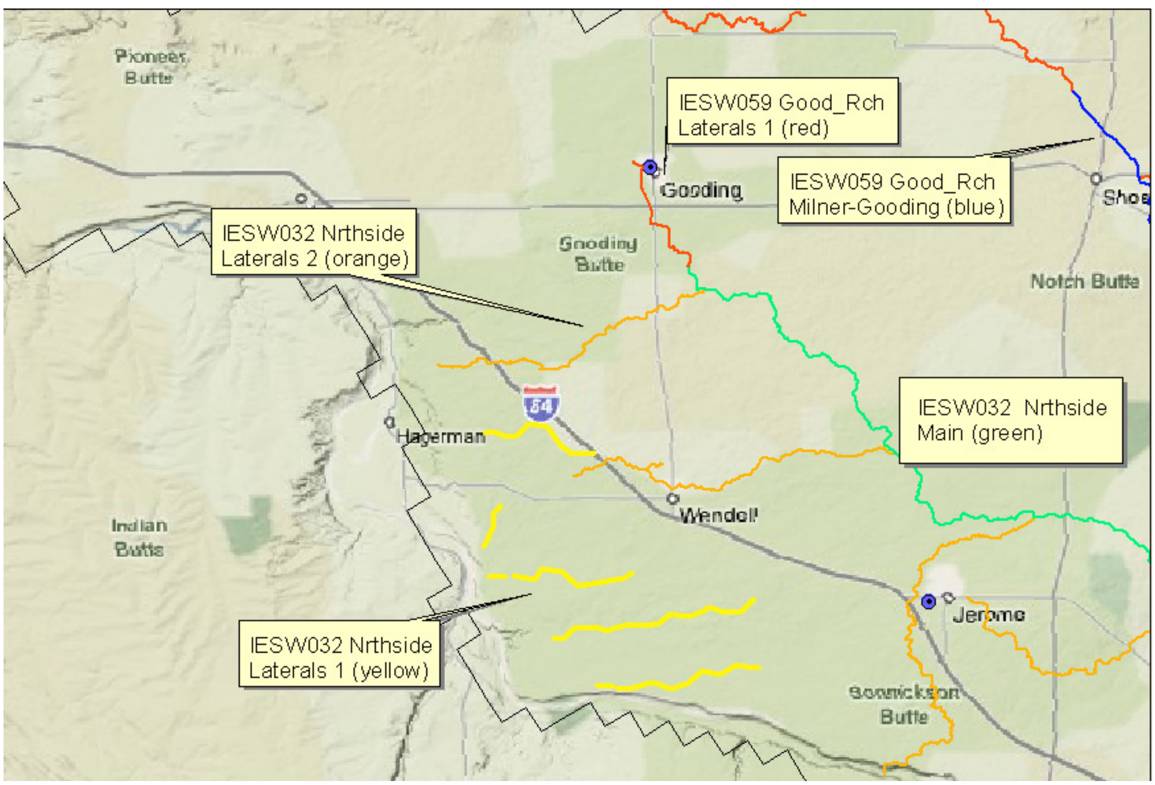

Figure 10. Canals in the Northside area.

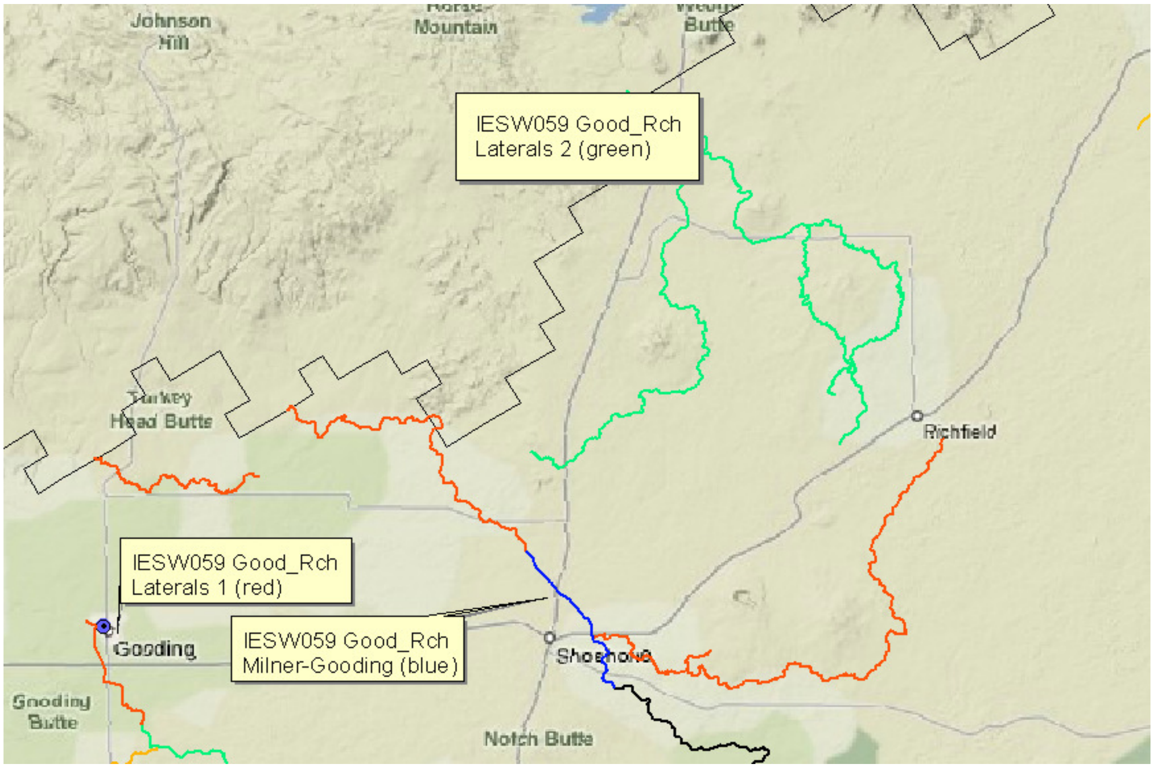

Figure 11. Canals in the Gooding-Richfield area.

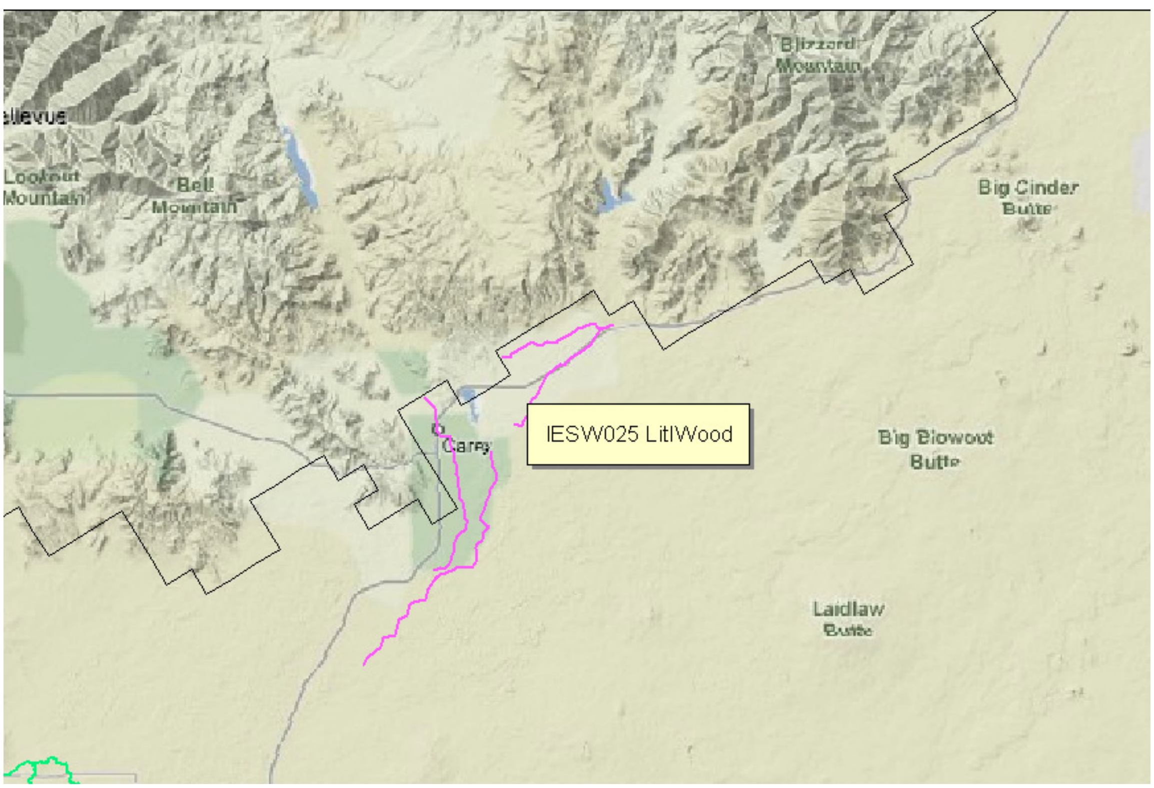

Figure 12. Canals in the Carey area.

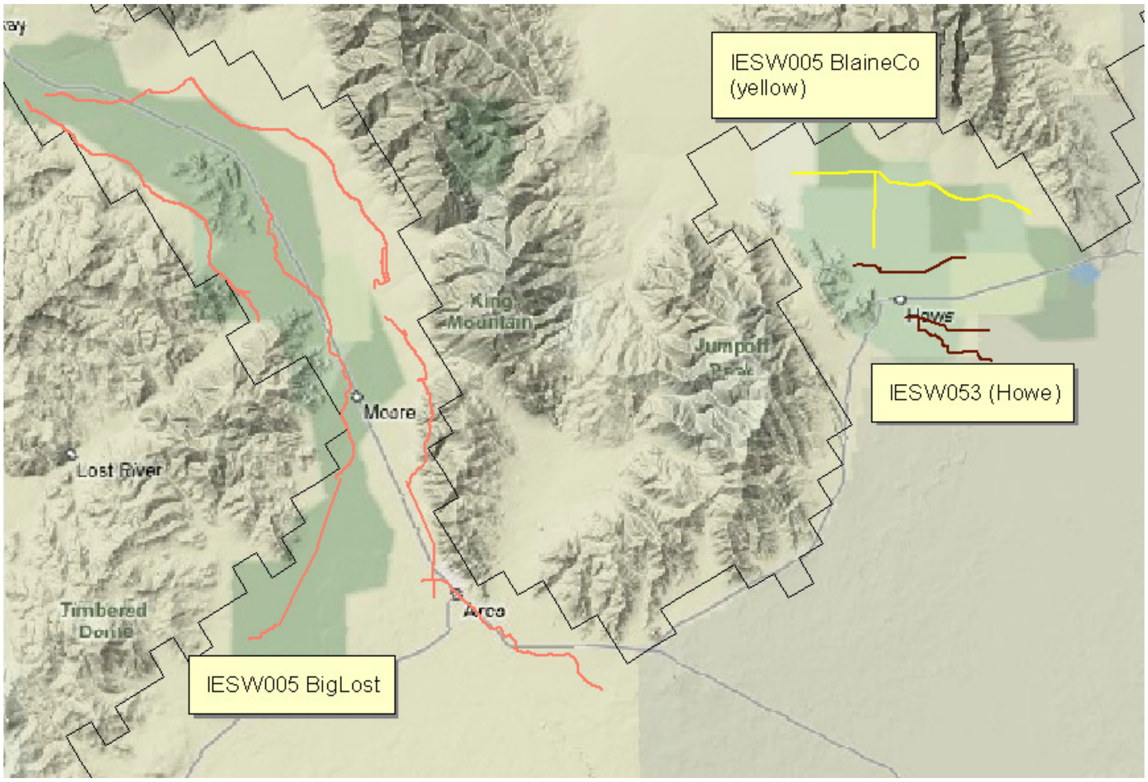

Figure 13. Canals in the Big Lost/Little Lost area.

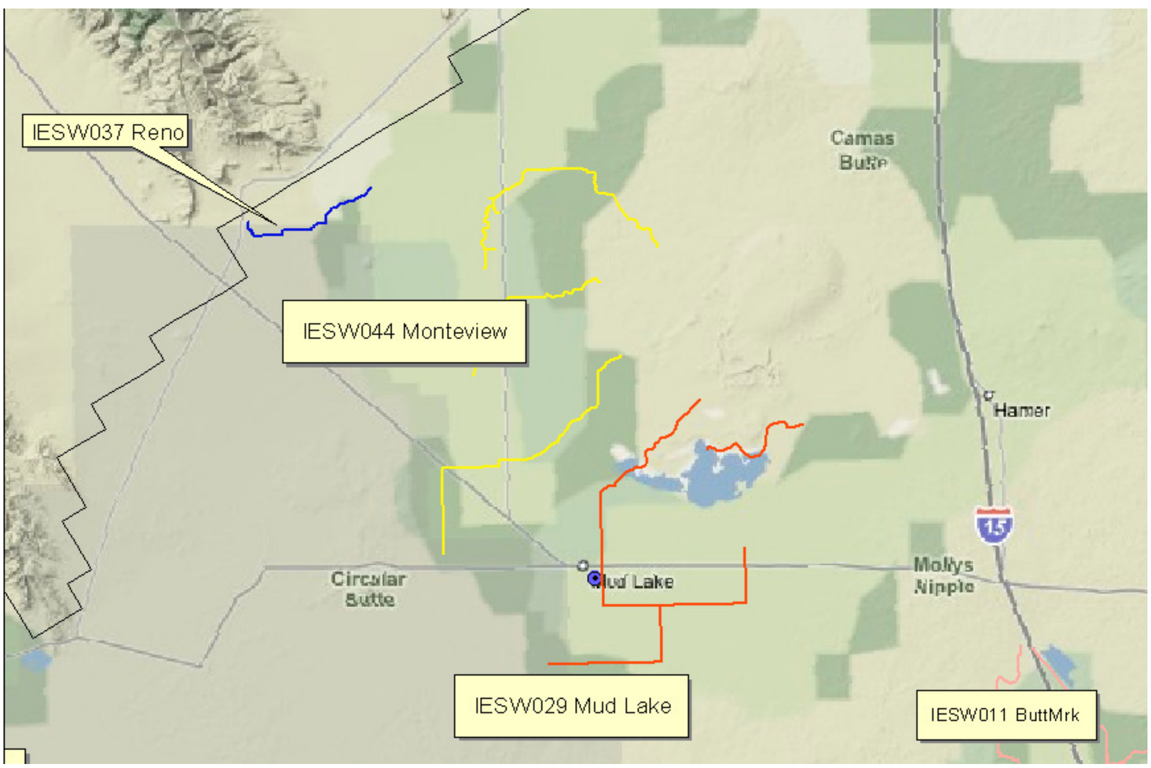

Figure 14. Canals in the Monteview/Mud Lake area.

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