MEMO

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Date: February 27, 2013

To: Gary Spackman, Hearing Officer

From: Jennifer Sukow

cc: Rick Raymondi, Sean Vincent, Allan Wylie, Neal Farmer, Tim Luke, Cindy Yenter

Subject: Staff memorandum in response to expert reports submitted for Rangen Delivery Call (In the Matter of Distribution for Water to Water Right Nos. 36-02551 and 36-07694)

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Executive Summary

This report was prepared in response to expert reports submitted for the Rangen Delivery Call, which requests curtailment of groundwater users with water right priority dates junior to July 13, 1962 for distribution of water to water rights 36-2551 and 36-7694. A total of 18 expert reports and rebuttal reports were submitted to the Idaho Department of Water Resources (IDWR) on behalf of Rangen, Inc. (Rangen), the Idaho Ground Water Appropriators (IGWA), the City of Pocatello, and Freemont Madison Irrigation District (FMID). The main issues raised by the parties' experts appear to be[1]:

1. Whether Rangen is entitled to make a call based on discharge from the entire spring complex or only discharge from Martin-Curren Tunnel, which is the source listed on the partial decrees for Rangen's water rights.
2. Whether Martin-Curren Tunnel is a surface water source.
3. Whether Rangen is beneficially using available water with reasonable efficiency, or is using water inefficiently and wasting water.
4. Whether Rangen has suffered material injury because of reduced water availability.
5. Whether the economic impact of curtailment outweighs the economic benefit to Rangen and Rangen's right to water.
6. Whether Rangen's water measurement methods are acceptable.
7. Whether Rangen has made sufficient efforts to increase water availability to its facility.
8. Whether ESPAM2.1 is capable of providing a reasonable prediction of the effects of curtailment at the Rangen spring complex, or is only capable of providing predictions to a larger reach.
9. Whether some groundwater users should be excluded from curtailment based on the fraction of their curtailed use that will accrue to springs and river reaches other than Rangen.
10. Whether water that would accrue to springs and river reaches other than Rangen would be wasted.

Several of these issues are legal or policy issues that cannot be appropriately addressed by IDWR technical staff. This memorandum was prepared by IDWR staff with the intent of summarizing the parties' expert reports and providing IDWR staff opinions regarding Rangen's water measurement methods and the use of ESPAM2.1 as a tool to provide information on the hydrologic effects of curtailment of junior groundwater use. IDWR staff contributors to this memorandum included:

[1] This is a summary of the issues identified in the expert and rebuttal reports and is not intended to convey agreement or disagreement regarding the relevancy of these issues.

- Jennifer Sukow, P.E., P.G., primary author, ESPAM2.1 analyses
- Dr. Allan Wylie, P.G., Ph.D., report reviewer, ESPAM2.1 analyses
- Tim Luke, contributing author, water measurement methods
- Neal Farmer, report reviewer, geology
- Sean Vincent, P.G., report reviewer
- Rick Raymondi, report reviewer
- Cindy Yenter, report reviewer, water measurement methods

Between the 1960s and the present, discharge of the Rangen spring complex has decreased in response to changes in the ESPA water budget. These changes include increased groundwater pumping, decreased incidental recharge associated with surface water irrigation, and changes in natural recharge derived from precipitation. Between 1966 and 2011, the average annual discharge at the Rangen spring complex decreased from 51 cfs to 15 cfs. Because the Rangen spring complex is hydraulically connected to the ESPA, it is clear that groundwater pumping has contributed to the decrease in discharge, but decreases in incidental recharge and natural recharge derived from precipitation have also contributed. The portion of the decrease that is attributable to groundwater pumping is more difficult to determine. ESPAM2.1 is a numerical groundwater model that was developed for the purpose of determining the effects of groundwater pumping on discharge to spring and river reaches, such as the Rangen spring cell.

Numerical models are recognized by the U.S. Geological Survey as the most robust approach for predicting the effects of groundwater pumping on surface-water discharge (Barlow and Leake, 2012). A numerical model is able to account for spatial variation in hydrogeologic features and aquifer stresses, and the temporal variation of aquifer stresses. ESPAM2.1 accounts for these features within the constraints of a one-square-mile model grid and one-month stress periods, which is superior to any other predictive method developed for the ESPA to date. Geologic controls on hydrologic responses to aquifer stress are reflected in the discharge and aquifer head data used to calibrate the model. ESPAM2.1, like all groundwater models, is an imperfect approximation of a complex physical system, but it is the best available scientific tool for predicting the effects of groundwater pumping on discharge at the Rangen spring cell and other spring and river reaches. ESPAM2.1 is a regional groundwater model and is suitable to predict the effects of junior groundwater pumping on discharge at the Rangen spring cell because the spring discharge responds to regional aquifer stresses, and junior groundwater pumping is a dispersed, regional aquifer stress.

The parties' experts disagree on whether or not ESPAM2.1 is capable of providing a reasonable prediction of the response to groundwater pumping at the model cell containing the Rangen spring complex. In the opinion of Brockway et al. (2012), the model is capable of predicting the response at the Rangen spring cell. In the opinion of Contor (2012), the model is only capable of providing a reasonable prediction of the response at the Buhl to Lower Salmon Falls reach. Brendecke (2012) appears to offer two opinions. Dr. Brendecke argues that the model prediction of the response at the Rangen spring cell is too uncertain to be used. He also argues that if IDWR uses ESPAM2.1, the steady state response functions, which are the model-predicted responses at the Rangen spring cell to curtailment within individual model cells, should be used to delineate a 10% trimline.

IDWR staff recommend using ESPAM2.1 as a predictive tool to evaluate the effects of groundwater pumping and curtailment of groundwater pumping on discharge at the Rangen spring cell and to evaluate the portion of curtailed use that will accrue to the Rangen spring cell. ESPAM2.1 predicted responses to curtailment of junior groundwater pumping within various areas are summarized in Table 1. These areas were selected in response to areas or de minimis standards discussed in the parties' expert reports, and are not intended to convey an opinion regarding the use of a trimline and/or the area of common groundwater supply to limit the area of curtailment.

ESPAM2.1 may also be used to predict the effects on discharge in the Buhl to Lower Salmon Falls reach and the portion of curtailed use that will accrue to the reach, as suggested by Contor (2012a). If ESPAM2.1 is not used to predict to the spring cell, apportioning the change in reach gain to the Rangen spring cell would need to be accomplished using an alternative method. The parties' experts did not suggest methods for apportioning the change in reach gain to the Rangen spring complex. IDWR staff evaluated potential alternative methods for predicting effects at the Rangen spring cell, but note that the alternative methods consider fewer data and are less robust than the ESPAM2.1 numerical model.

ESPAM2.1 was developed in an open, collaborative environment, with guidance from the Eastern Snake Hydrologic Modeling Committee (ESHMC). During development of ESPAM2.1, the ESHMC provided a forum for discussing model design, providing parties to this water call (and other interested parties) the opportunity for technical review and input throughout the model development process. Decisions regarding the conceptual model, model grid size, drain elevations, locations of transmissivity pilot points, spring discharge and aquifer head targets, the location of general head boundaries, calibration bounds, and other model features were presented to the ESHMC with opportunity for committee members to provide comments and suggest alternative approaches.

Summary of IDWR staff conclusions

Use of ESPAM2.1 as a predictive tool

1. ESPAM2.1 is the best available scientific tool for answering the following questions that may be relevant to this water call.

    a. What is the effect of junior groundwater pumping within the ESPA on discharge at the Rangen spring cell?

    b. What portion of curtailed groundwater use will accrue to the Rangen spring cell?

    c. What portion of curtailed groundwater use will accrue to other spring cells and reaches of the Snake River?

    d. How long will it take for the effects of curtailment of junior groundwater pumping to reach the Rangen spring cell?

    e. What is the effect of junior groundwater pumping within the ESPA on discharge at the Buhl to Lower Salmon Falls reach?

2. ESPAM2.1 incorporates the spatial distribution of aquifer recharge and discharge and regional-scale hydrogeology within the constraints of a one-mile square grid size and transmissivity pilot point spacing, which is approximately two to four miles in the vicinity of the Buhl to Lower Salmon Falls reach. The grid and transmissivity pilot point spacing allow ESPAM2.1 to reflect variations in aquifer stress and hydrogeologic properties with greater resolution than other available predictive methods.

3. Junior groundwater pumping within the ESPA occurs over an approximately 11,000 square mile area. The effect of this pumping on springs and river reaches is a regional-scale question that cannot be addressed with a small-scale, local model.

4. ESPAM2.1 was calibrated to over 43,000 observed aquifer water levels, over 2,000 monthly river gain and loss estimates, and over 2,000 monthly spring discharge observations collected from 14 different spring complexes, including 283 monthly spring discharge observations at the Rangen spring cell. These calibration targets reflect the impact of geologic features on hydrologic responses. Because the ESPAM2.1 calibration process considered such a large number of data, ESPAM2.1 is superior to other available predictive methods that consider significantly fewer data.

5. ESPAM2.1 was calibrated to observed monthly discharge data from May 1985 through October 2008 at the Rangen spring cell. The observed discharge is the response to regional aquifer stresses within the ESPA. ESPAM2.1 provides reasonable predictions of the response to changes in regional aquifer stress within the range of stress encountered during the May 1980 through October 2008 simulation period. The Rangen spring complex is the only spring complex in the Rangen model cell.

6. ESPAM2.1 was developed in an open, collaborative environment, with guidance from the Eastern Snake Hydrologic Modeling Committee (ESHMC). During development of ESPAM2.1, the ESHMC provided a forum for discussing model design, providing parties to this water delivery call (and other interested parties) the opportunity for technical review and input throughout the model development process. Decisions regarding the conceptual model, model grid size, drain elevations, locations of transmissivity pilot points, spring discharge and aquifer head targets, the location of general head boundaries, calibration bounds, and other model features were presented to the ESHMC with opportunity for committee members to provide comments and suggest alternative approaches. At the completion of ESPAM2.1, the ESHMC recommended, "*The Eastern Snake Hydrologic Modeling Committee recommends that the Department begin using ESPAM version 2.1 rather than ESPAM version 1.1 for ground water modeling.*" Two members of the committee (Mr. Sullivan and Dr. Brendecke) qualified this recommendation with, "*although other tools or models may be more appropriate in certain circumstances*." Two other members of the committee (Mr. Warner and Mr. Contor) dissented from the recommendation.

7. The consumptive use of groundwater associated with irrigation water rights junior to July 13, 1962 within the ESPAM2.1 model boundary averages approximately 1.2 MAF/year. Curtailment of this use would increase net aquifer recharge to a volume within the range encountered during the model calibration period. For example, curtailment of this use during the years 2003-2007 (when average annual net ESPA recharge was approximately 4.4 MAF/year) would increase the net ESPA recharge to 5.6 MAF/year, which was the average annual net ESPA recharge during the years 1993-1997. Therefore, it is important that ESPAM2.1 was calibrated with equal consideration for each observed monthly value at the Rangen spring complex. It would not be appropriate to increase the weight of post-2000 observations during model calibration as suggested by Brendecke (2012, 2013) and Hinckley (2013).

8. Contor (2012a), Hinckley (2012, 2013), and Brendecke (2012, 2013) conclude that ESPAM2.1 does not include sufficient local-scale detail to be capable of providing a reasonable prediction of responses at the Rangen spring cell, but do not suggest alternative methods for estimating the response at the Rangen spring cell. If ESPAM2.1 is used to predict the response at the Buhl to Lower Salmon Falls spring reach, as suggested by Contor (2012a), then an alternative method for apportioning the reach response between the Rangen spring complex and other springs would need to be used. ESPAM2.1 incorporates the spatial distribution of recharge and groundwater pumping, a large number of water level and aquifer discharge observations, regional-scale hydrogeology, and the transient response of aquifer discharge to spatially and temporally distributed recharge and pumping. An alternative approach would likely neglect one or more of these factors and be inferior to using ESPAM2.1 to predict the response at the Rangen spring cell.

9. Steady state response functions for the Rangen spring cell consist of 11,236 model predictions of response at the Rangen spring cell to pumping in a single model cell. If ESPAM2.1 were not capable of providing a reasonable prediction of the effects of model-wide curtailment on discharge at the Rangen spring cell, it would also be incapable of reasonably predicting response functions for the Rangen spring cell and would not be able to provide a reasonable prediction of the location of the 10% trimline that Brendecke (2012) proposes.

10. Whether a trimline should be applied, and the basis for delineating a trimline, are policy and/or legal decisions. If a trimline is based on steady state response functions, as proposed by Brendecke (2012), the trimline delineates an area within which the portion of curtailed use that will accrue to the Rangen spring cell exceeds a given threshold percentage. Groundwater users outside of this area would be excluded from curtailment because the portion of their curtailed use that accrues to the Rangen spring cell is predicted to be less than the threshold percentage.

11. The ESPAM2.1 predicted response functions used to delineate the 10% trimline proposed by Dr. Brendecke are subject to the same types of model uncertainty as the ESPAM2.1 predicted response to model-wide curtailment. Use of the steady state response functions to delineate a trimline requires accepting that the ESPAM2.1 provides the best available prediction of response at the Rangen spring cell.

12. Delineation of a trimline based on steady state response functions is a direct application of ESPAM2.1-predicted responses, and is not an "*adjustment to model predictions*" as suggested by Brockway et al. (2012, 2013).

13. ESPAM2.1 is an improvement to ESPAM1.1, which was used as a tool to predict the effects of groundwater pumping, curtailment, and mitigation practices for administration of previous ESPA water calls.

ESPAM2.1 predictions

1. ESPAM2.1 predicted responses to junior groundwater curtailment within various areas are summarized in Table 1. These areas were selected in response to areas or de minimis standards discussed in the parties' expert reports, and are not intended to convey an opinion regarding the use of a trimline and/or the area of common groundwater supply to limit the area of curtailment.

2. ESPAM2.1 predicts that a model-wide curtailment of groundwater irrigation junior to July 13, 1962 would increase discharge at the Rangen spring cell by 17.9 cfs and reach gains in the Buhl to Lower Salmon Falls reach by 242 cfs at steady state. It would take approximately 13 years to reach 90% of the steady state response. The simulated curtailment would affect approximately 565,000 acres and would increase net aquifer recharge by approximately 1.2 MAF/year (1,705 cfs). The benefit predicted at the Rangen spring cell is only 1% of the curtailed use. The other 99% of the benefit would accrue to other springs and reaches of the Snake River. The predicted benefit to the Buhl to Lower Salmon Falls reach is 14% of the curtailed use. This curtailment simulation includes areas located outside of the current area of common groundwater supply.

3. Based on comparison of the historic response of the Rangen spring complex to changes in net recharge to the ESPA, the ESPAM2.1 predicted response of 17.9 cfs to a 1.2 MAF/year increase in net recharge appears to be reasonable. Rangen discharge data indicate that spring discharge decreased approximately 35 cfs between 1966 and 2007, in response to a decrease in average annual net recharge of approximately 1.7 MAF. Linear regression of Rangen spring complex discharge with a 5-year trailing average of net ESPA recharge indicates that spring discharge has historically changed by approximately 13 cfs per MAF change in the ESPA water budget (Figure 1), indicating that the response to a 1.2 MAF decrease in consumptive groundwater use should result in an increase on the order of 16 cfs in spring discharge. IDWR staff consider this predictive method inferior to ESPAM2.1, but it does provide a "reality check" that indicates the ESPAM2.1 prediction is not unreasonable given historic responses observed at the Rangen spring complex.

Area of curtailment	Predicted increase in discharge (cfs)			Portion of curtailed use accrued to reach (%)		
	Rangen spring cell	Buhl to Lower Salmon Falls reach[2]	Buhl to Lower Salmon Falls springs[3]	Rangen spring cell	Buhl to Lower Salmon Falls reach	Other reaches
Model domain	18	242	236	1%	14%	86%
Area of common groundwater supply (ACGW)	17	229	223	1%	15%	85%
10% trimline based on response at Buhl to Lower Salmon Falls reach (within ACGW)	15	198	193	3%	34%	66%
5% trimline based on response at Rangen cell	3.3	29	28	7%	59%	41%
10% trimline based on response at Rangen cell	0.01	0.08	0.08	13%	81%	19%

Table 1. Summary of ESPAM2.1 predicted responses to curtailment of groundwater irrigation junior to July 13, 1962.

[2] Includes increase in base flow modeled at general head boundaries.
[3] Excludes increase in base flow modeled at general head boundaries.

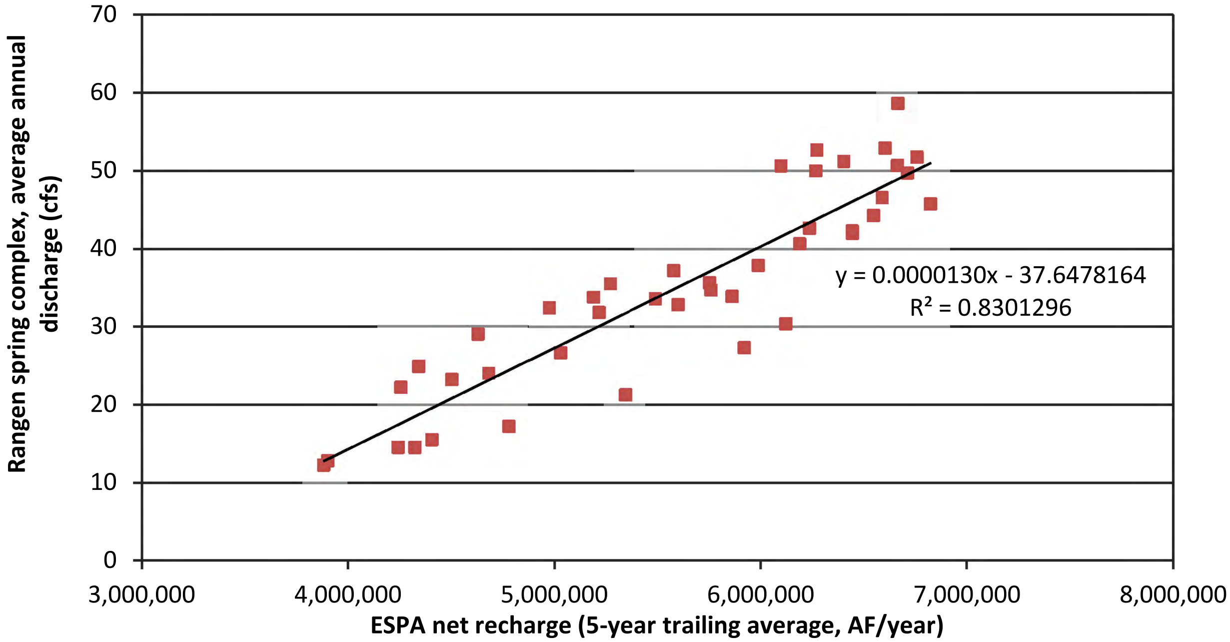


Figure 1. Comparison of average annual discharge at Rangen spring complex with net ESPA recharge.

4. ESPAM2.1 steady state response functions (Figure 2) indicate that discharge in the Rangen spring cell responds to stresses dispersed throughout the ESPA. Collectively, model-wide groundwater pumping has a significant effect on discharge at the Rangen spring cell, but more than 84% of the effects of groundwater pumping in any individual model cell propagate to other springs or reaches of the Snake River. The percentage of the effects of groundwater pumping that accrue to the Rangen spring cell generally decreases as distance from Rangen increases. Less than 1% of the effects of groundwater pumping east of the Great Rift[4] accrue to the Rangen spring cell.

5. If simulation of curtailment of groundwater irrigation is limited to the current area of common groundwater supply, ESPAM2.1 predicts that the benefit to the Rangen spring cell would be 16.9 cfs and the benefit to reach gains in the Buhl to Lower Salmon Falls reach would be 229 cfs. It would take approximately 11 years to reach 90% of the steady state response. The simulated curtailment would affect approximately 479,000 acres and would increase net recharge by approximately 1.1 MAF/year (1,509 cfs). The benefit predicted at the Rangen spring cell is only 1% of the curtailed use. The other 99% of the benefit would accrue to other springs and reaches of the Snake River.

[4] The Great Rift extends north to south across the plain from the Big Lost River Valley to just west of American Falls Reservoir. The transmissivity of the Great Rift is low relative to adjacent areas of the ESPA (IDWR, 2013).

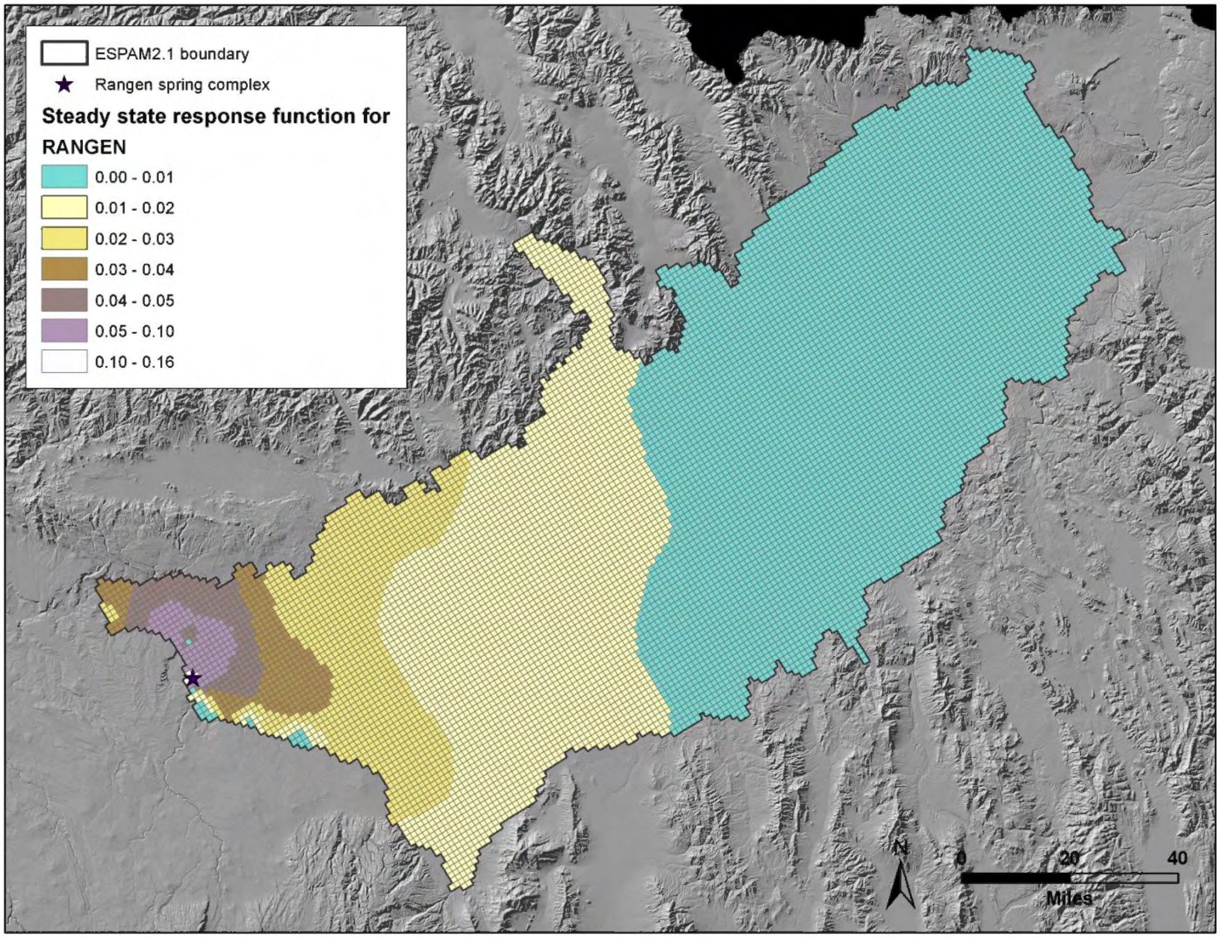


Figure 2. Steady state response functions indicating the portion of curtailed use that would accrue to the Rangen spring cell.

6. If simulation of curtailment of groundwater irrigation is limited to areas where at least 10% of the benefit is predicted to occur at the Rangen spring complex, ESPAM2.1 predicts that the benefit will be negligible (0.01 cfs).

7. If simulation of curtailment of groundwater irrigation is limited to areas where at least 5% of the benefit is predicted to occur at the Rangen spring complex, ESPAM2.1 predicts that the benefit would be 3.3 cfs. The simulated curtailment would affect approximately 12,300 acres and would increase net aquifer recharge by approximately 36,000 AF/year (49.6 cfs). Approximately 7% of the benefit would accrue to the Rangen cell, the other 93% would accrue to other springs and river reaches.

8. If simulation of curtailment of groundwater irrigation is limited to areas within the area of common groundwater supply where at least 10% of the benefit is predicted to occur at springs within the Buhl to Lower Salmon Falls reach, ESPAM2.1 predicts reach gains in the Buhl to Lower Salmon Falls reach would increase by 198 cfs and spring discharge at the Rangen cell would

increase by 14.7 cfs. The simulated curtailment would affect approximately 169,000 acres and would increase net aquifer recharge by approximately 419,000 AF/year (578 cfs). Approximately 34% of the curtailed use would benefit the Buhl to Lower Salmon Falls reach, and approximately 2.5% would benefit the Rangen cell.

9. ESPAM2.1 was calibrated to total discharge at the Rangen spring cell, and is not capable of predicting the effects of curtailment on Curren Tunnel discharge and other spring discharge separately. If there is a need to predict the effects of curtailment on tunnel discharge, IDWR staff recommend using the slope of the linear regression of tunnel discharge with total spring complex discharge. This method indicates that the response at the tunnel will be 70% of the total response (i.e., the predicted response at the tunnel would be 12.5 cfs for model-wide curtailment, 11.9 cfs for the area of common groundwater supply, 2.3 cfs for a 5% trimline, and negligible for a 10% trimline).

Model uncertainty

1. The ESPAM2.1 predicted responses to curtailment at the Rangen spring complex and the Buhl to Lower Salmon Falls spring reach are the best available predictions. Because of predictive uncertainty associated with using the model, the actual response may be lower or higher than the prediction. Predictive uncertainty was evaluated by Wylie (2012a). Model uncertainty was evaluated Contor (2012a, 2012b), and Brendecke (2012).

2. Wylie (2012a) evaluated the uncertainty of the ESPAM2.1 calibration with respect to predictive uncertainty at the Clear Lakes spring cell. None of the analyses involving Clear Lakes resulted in significant uncertainty.

3. The ESPAM2.1 calibration procedure allowed adjustment of several components of the water budget (including evapotranspiration, tributary underflow, recharge on non-irrigated lands, canal seepage, and non-Snake River seepage) within ranges of uncertainty determined by the ESHMC. The IDWR predictive uncertainty analysis (Wylie, 2012a) incorporated the impact of uncertainty associated with these components of the water budget on predictive uncertainty.

4. Contor (2012a) concluded that model uncertainty is at least 17%, based on uncertainty of the water budget input data. IDWR staff note that not all sources of uncertainty significantly impact every prediction. This is illustrated by the IDWR predictive uncertainty analysis (Wylie, 2012a), which incorporated the uncertainty associated with many of the components of the water budget and indicated that predictive uncertainty is low with respect to the response at the Clear Lakes spring cell. Further, a 17% increase or decrease (as suggested by Contor, 2012a) in the predicted response to curtailment at the Rangen spring complex would only be a change of 3 cfs (i.e. 17.9 cfs ± 17% would be a range of 14.9 to 20.9 cfs).

5. Brendecke (2012) evaluated conceptual model uncertainty by developing two alternative models that he asserts better represent local conditions in the vicinity of the Rangen spring cell. IDWR staff simulated a model-wide curtailment with these models and found that the models

predicted responses of 18.5 cfs and 18.0 cfs at the Rangen spring cell. These responses are less than 0.6 cfs different from the response of 17.9 cfs predicted by ESPAM2.1.

6. IDWR staff also used Dr. Brendecke's alternative conceptual model to simulate the response to curtailment within the four mile square area located within a 10% trimline defined using ESPAM2.1 predictions of responses at the Rangen spring cell. The response to this curtailment simulation was a negligible amount of water (0.01 cfs) using both alternative models and ESPAM2.1.

7. The evaluations of model uncertainty performed by Contor (2012a, 2012b) and Brendecke (2012) have not been subjected to peer review by the ESHMC, and IDWR staff disagree with some of the methods used and conclusions drawn by these parties.

8. The evaluations performed by IDWR and the parties' experts are partial evaluations of model uncertainty and do not fully explore or quantify all aspects of model uncertainty. These evaluations do not contradict IDWR's conclusion that ESPAM2.1 is capable of providing a reasonable prediction of the response to groundwater pumping at the Rangen spring cell. These evaluations also do not contradict IDWR's conclusion that ESPAM2.1 is the best available scientific tool to estimate the quantity of the response.

Consideration of alternative predictive methods

1. Contor (2012a), Hinckley (2012), and Brendecke (2012) conclude that ESPAM2.1 does not include sufficient local-scale detail to be capable of providing a reasonable prediction of responses at the Rangen spring complex, but do not propose alternative methods for predicting the effects of curtailment of junior groundwater pumping at Rangen. IDWR staff considered the following alternative predictive methods.

    a. Do not predict the effects of curtailment. This alternative provides the hearing officer with no information regarding the magnitude of effects of curtailment at Rangen or other springs and river reaches, no information for delineating an area of de minimis effects, and no information regarding potential mitigation requirements or the effects of proposed mitigation plans.

    b. Use ESPAM2.1 to predict the response at springs within the Buhl to Lower Salmon Falls reach and use an inferior method to estimate the portion of the reach gains that would benefit the Rangen spring complex.

        i. Use the Covington and Weaver ratio method previously used with ESPAM1.1 to apportion discharge to the Rangen spring complex. This method results in a predicted accrual of 2.9 cfs at the Rangen spring complex in response to model-wide curtailment, and 2.4 cfs in response to curtailment within a 10% trimline for the reach. This method is inferior to using the ESPAM2.1 prediction for the Rangen spring cell, because it considers fewer data than ESPAM2.1, neglects regional hydrogeologic conditions that are included in ESPAM2.1, neglects the spatial distribution of aquifer recharge and discharge, and neglects the sensitivity of higher elevation springs to changes in aquifer head.

ii. Use a linear regression of Rangen spring complex discharge with reach gain to predict change in Rangen spring discharge corresponding to the modeled change in reach gain. This method results in a predicted accrual of 6.8 cfs at the Rangen spring complex in response to model-wide curtailment and 5.5 cfs in response to curtailment within a 10% trimline for the reach. This method is inferior to using the ESPAM2.1 prediction for the Rangen spring cell, because it considers fewer data than ESPAM2.1, neglects regional hydrogeologic conditions that are included in ESPAM2.1, and neglects the spatial distribution of aquifer recharge and discharge.

c. Use ESPAM2.1 to predict the response at Well 989, which is the closest head target and water level change target to the Rangen spring cell, located approximately ½ mile northeast of the Rangen spring complex. Use a linear regression of observed Rangen spring complex discharge with observed water level elevation to evaluate the response at the Rangen spring complex to change in head at Well 989. This method predicts accrual of 16.5 cfs at the Rangen spring complex in response to model-wide curtailment. This method considers nearly all of the data used by ESPAM2.1, but the correlation between Well No. 989 and Rangen spring discharge does not consider the transient response time between the two locations.

d. Use a linear regression between observed Rangen discharge and the estimated annual net recharge to the ESPA to predict the response to curtailment. This method is inferior to ESPAM2.1 because it considers far fewer data than ESPAM2.1, neglects regional hydrogeologic conditions that are included in ESPAM2.1, and neglects the spatial distribution of aquifer recharge and discharge. This method predicts a response of 16.1 cfs to a model-wide curtailment of junior groundwater irrigation.

2. ESPAM2.1, like many other groundwater models, was developed as a tool to answer questions that could not be addressed adequately with other predictive methods. The groundwater model is able to incorporate more observed data than other predictive methods, and can calibrate hydrogeologic properties that cannot be measured to best fit the observed data. ESPAM2.1 is the best developed scientific tool for predicting the effects of junior groundwater pumping on the Buhl to Lower Salmon Falls spring reach and at the Rangen spring complex.

3. Numerical models are recognized by the U.S. Geological Survey as the best approach for predicting the effects of groundwater pumping on surface-water discharge. The U.S. Geological Survey states, "*Numerical models provide the most robust approach for determining the rates, locations, and timing of streamflow depletion by wells*." (Barlow and Leake, 2012). The use of a numerical model, like ESPAM2.1, is able to account for the irregular geometry of aquifer

boundaries, irregular geometry of rivers and spring locations, heterogeneous aquifer properties, and time-varying aquifer stresses applied at various locations within a basin. ESPAM2.1 accounts for these features within the constraints of a one-square-mile model grid, the transmissivity pilot point spacing, and one-month stress periods, which is superior to any other predictive method developed for the ESPA to date.

Adequacy of Rangen discharge measurements

1. Rangen submitted annual water measurement reports directly to IDWR from 1995 through 2009, and to Water District 36A from 2010 to 2012. IDWR has accepted these annual water measurement reports during this period of record understanding that Rangen estimates hatchery diversions or flows using fish raceway check boards as non-standard weir measuring devices.

2. Check board weirs are not considered standard measurement devices. IDWR's *Minimum Acceptable Standards for Open Channel and Closed Conduit Measuring Devices* specify that construction, installation and operation of open channel measuring devices, including contracted rectangular weirs and suppressed rectangular weirs, should follow published guidelines such as those published by the United States Bureau of Reclamation (USBR, 1997).

3. Although the raceway check boards are not considered standard measuring devices, IDWR accepts measurements using these structures at Rangen and many hatcheries in the area because IDWR's standards allow an accuracy of +/-10 percent for open channel measuring devices when compared to measurements using standard portable measuring devices. Rangen likely under-measures actual flows, but an error up to -10% is acceptable pursuant to IDWR's *Minimum Acceptable Standards for Open Channel and Closed Conduit Measuring Devices.*

4. The calibration target used for ESPAM2.1 was submitted to the ESHMC for review and comment in the fall of 2009. ESHMC members were provided the opportunity to review and comment on the proposed calibration target during development of ESPAM2.1.

5. Systematic under-measurement of discharge at the Rangen spring cell by 10% would be expected to result in slightly lower model predictions of discharge and response to curtailment at the Rangen spring cell. This would favor the groundwater users, not Rangen.

Summary of expert reports

This section summarizes and responds to the following expert reports submitted in the Matter of Distribution for Water to Water Right Nos. 36-02551 and 36-07964, hereafter referred to as the Rangen Delivery Call.

1. Brockway, C.E., D. Colvin, and J. Brannon, 2012. *Expert Report in the Matter of Rangen, Inc. – Availability of Spring Flow and Injury to Water Rights*, prepared for Rangen, Inc., December 20, 2012.
2. Smith, C. E., 2012. *Expert Report in the Matter of Distribution of Water to Rangen, Inc's Water Right Nos. 36-02551 and 36-07694*, prepared for Rangen, Inc.
3. Hinckley, B., 2012. *Rangen Groundwater Discharge and ESPAM2.1 Hydrogeologic Investigation*, prepared for Racine, Olson, Nye, Budge, and Bailey, Chartered, December 20, 2012.
4. Brendecke, C.M., 2012. *Hydrology, Water Right and Groundwater Modeling Evaluation of Rangen Delivery Call*, prepared for Racine, Olson, Nye, Budge, and Bailey, Chartered, December 21, 2012.
5. Rogers, T.L., 2012. *Expert Witness Report by Thomas L. Rogers, Fisheries Biologist/Fish Culturist,* prepared on behalf of the Idaho Ground Water Appropriators, Inc., December 21, 2012.
6. Church, J.S., 2012. *Expert Witness Report by John S. Church, Economist*, prepared on behalf of the Idaho Ground Water Appropriators, Inc., December 21, 2012.
7. Contor, B.A., 2012a. *Technical Report on ESPAM2.0 Modeling Issues*, prepared for Fremont Madison Irrigation District, October 1, 2012.
8. Contor, B.A., 2012b. *Supplement to Technical Report on ESPAM2.0 Modeling Issues*, prepared for Fremont Madison Irrigation District, December 13, 2012.
9. Sullivan, G.K., 2012. *Spronk Water Engineers, Inc. Expert Report in the Matter of Distribution for Water to Water Right Nos. 36-02551 and 36-07694 (Rangen, Inc.)*, prepared for the City of Pocatello, December 21, 2012.

Summary of expert reports submitted on behalf of Rangen, Inc. (Rangen)

Brockway et al. (2012) provide brief descriptions of eastern Snake Plain aquifer (ESPA) geology and hydrogeology, the historical response of the ESPA to changing water use, the history of the Rangen Hatchery, and the history of Rangen's delivery calls. The report addresses historical water availability at the Rangen Hatchery, water measurement procedures, and provides a brief discussion of alternatives Rangen has evaluated for increasing water supply. The report discusses the development of ESPAM2.1, evaluates IDWR tools developed for simulating curtailment of junior groundwater pumping with ESPAM2.1, and evaluates the algorithm used to represent spring discharge in ESPAM2.1. The report also discusses incidental benefits to other water users resulting from the requested curtailment.

Regarding adequacy of measurement, Brockway et al. (2012) state that Rangen applies a modified weir coefficient to calculate discharge from stage measured over 2-inch thick boards at the CTR raceways and Lodge Pond Dam. They state this is consistent with standard practice at aquaculture facilities.

Brockway et al. (2012) indicate that Rangen has evaluated six alternatives for increasing water supply to the hatchery. The first alternative, diverting water formerly used for agricultural irrigation, was implemented after construction of the Sandy Pipeline. The other alternatives considered included withdrawing water from vertical wells, constructing a horizontal well below the Curren Tunnel, diverting water from the Weatherby Springs/Hoagland Tunnel complex, reducing possible downward flow through existing wells upgradient of Curren Tunnel, treating and re-using hatchery tailwater. The report provides explanations for why these five alternatives are not considered feasible.

Brockway et al. (2012) present results of one modeling simulation performed using the ESPAM2.1. Input data were processed using tools and methodology developed by IDWR for simulating curtailment of groundwater irrigation. Curtailment of groundwater irrigation junior to July 13, 1962 was simulated using ESPAM2.1 in superposition mode. The simulation predicts 17.9 cfs will accrue to the Rangen spring complex at steady state, in response to curtailment of junior groundwater irrigation within the ESPAM2.1 model boundary.

Brockway et al. (2012) present correlations of the Rangen spring complex discharge with water levels measured in seven wells to demonstrate the relationship between aquifer head and spring discharge. They conclude that this analysis demonstrates that Rangen spring complex responds to regional aquifer head, and that this response supports use of ESPAM2.1 to predict responses to changes in aquifer head at the Rangen spring complex.

Brockway et al. (2012) provided sixteen statements of opinion on pages 26 and 27 of their report. Selected points are summarized in this paragraph. In their opinion, the exercise of Rangen's water rights has been impacted by junior groundwater rights, Rangen is appropriately measuring and using available spring flow, Rangen does not have feasible alternatives for increasing water flow through the hatchery via either alternative sources or reuse of hatchery tailwater, and curtailment to mitigate injury to a senior water right is not a waste of the water resource. In their opinion, ESPAM2.1 is the best available science and the IDWR tools and methodology developed for simulating curtailment are sufficient for calculating the impacts of curtailment on water levels and spring flows. Their simulation of curtailment of groundwater pumping junior to July 13, 1962 within the ESPAM2.1 model boundary resulted in a predicted steady state impact of 17.9 cfs at the Rangen spring complex. In their opinion, this prediction is the best available prediction and should not be modified or adjusted using estimates of model uncertainty.

Smith (2012) provided opinions on beneficial use of the water supply currently available to Rangen, and addressed Rangen's ability to put additional water to beneficial use. Mr. Smith visited the hatchery in July and October 2012, and stated that Rangen was using all of the available water to raise fish and conduct research. Mr. Smith stated that 20 of 20 small raceways, 21 of 30 large raceways, and 6 of 9 CTR raceways were unused because of insufficient water flow. Mr. Smith provides additional detail regarding Rangen's use of water to raise fish for research testing of fish feeds and for sale to Idaho Power Company. Mr. Smith states that Rangen currently orders eggs only three times per year because of low water flows, and that trout eggs must be ordered one to two years in advance. Mr. Smith states that fish production is constrained by fish loadings (lbs/gpm of water flow) and fish densities (lbs/ft^3 of space) and acknowledges that the allowable loading and density for rainbow trout currently raised for sale to Idaho Power Company are lower than required for fish sold to processors. Mr. Smith notes that Idaho Power Company pays a higher price per pound than local processors.

Mr. Smith states that water currently being used at the Rangen hatchery is of excellent quality, having optimum temperature for growth of rainbow trout (59-60° F), pH between 7.8 and 8.1, hardness of approximately 130 ppm as $CaCO_3$, and is saturated with dissolved oxygen. Mr. Smith concluded that Rangen is using all of the currently available water in a reasonable manner to raise fish, and that Rangen could raise more fish and/or conduct more research if more water was available.

Summary of expert reports submitted on behalf of Idaho Ground Water Appropriators, Inc. (IGWA)

Hinckley (2012) evaluates geology and hydrogeology in a study area encompassing Thousand Springs to Malad Gorge and the Wendell area and evaluates the ESPAM2.1 representation of this area. Mr. Hinckley concludes that ESPAM2.1 does not adequately represent the details and complexity of geologic and hydrogeologic conditions in his study area, and that there is "*considerable uncertainty in the use of the ESPAM2.1 to inform detailed hydrologic analyses of the groundwater discharges at Rangen*." Mr. Hinckley concludes that the Curren Tunnel is a horizontal flowing well that was not constructed to maximize sustainable, year-round production. Mr. Hinkley concludes that "*there are opportunities to develop substantially more robust access to quantities of groundwater to those historically measured at the Curren Tunnel*" by moving the point of diversion and constructing a vertical well above the rim in the area east of Rangen.

Brendecke (2012) discusses hydrology of the Eastern Snake Plain, water rights for the Rangen Hatchery, ESPAM development, simulation of curtailment of junior water rights, and model uncertainty. Dr. Brendecke provides 87 conclusions in Section 1.3 of his report; selected points are summarized in this paragraph. Dr. Brendecke concludes that the source for water rights 36-2551 and 36-7694 is the Martin-Curren Tunnel, which he argues meets the definition of a well, and implies that Rangen does not have a right to divert from the "*natural springs*" that have also historically supplied the hatchery. Dr. Brendecke concludes that water shortages should be evaluated with respect to historic flow in the Martin-Curren Tunnel, not historic diversions to the hatchery. Dr. Brendecke argues that ESPAM2.1 is not capable of separating the effects of groundwater pumping on flows from Martin-Curren Tunnel from other springs in the Rangen complex, and that ESPAM2.1 is not sufficiently detailed in its general formulation or its representation of hydrogeologic conditions at Rangen to be used reliably to predict effects of curtailment at Rangen. Dr. Brendecke presents two alternative calibrated models, which he asserts better reflect hydrogeologic conditions near Rangen. Dr. Brendecke claims that benefits predicted at Rangen using his alternative models are significantly less than predicted by ESPAM2.1, and argues these models illustrate the potential effects of conceptual model uncertainty on predicted responses at the Rangen spring complex. Although Dr. Brendecke argues that ESPAM2.1 is not sufficiently detailed to be used reliably to predict effects of curtailment at Rangen, Dr. Brendecke does not propose other tools, models, or methodology for predicting these effects. Dr. Brendecke concludes that "*application of ESPAM2.1 should at a minimum restrict curtailment to junior rights for which ESPAM2.1 predicts at least 10% of the curtailed water will accrue to Rangen*", and that any curtailment of groundwater is a waste of the water resource because the majority of the foregone use would not accrue to Rangen.

Rogers (2012) discusses fish hatchery operation, operations at the Rangen Hatchery, and hypothetical fish-rearing scenarios. Mr. Rogers notes the Rangen hatches eggs in incubators and the fry are reared in troughs until they are large enough to be moved to the small raceways. As the fish grow and approach maximum density or flow indices in the small raceways, they are transferred to the large raceways. According to Mr. Rogers, Rangen currently rears triploid (sterile) rainbow trout under contract to Idaho Power Company (IPCO). The fish are released for sport fishing. Mr. Rogers states that Rangen also continues to perform research related to fish feed, fish flesh, color development and disease, and that Rangen sells some excess rainbow trout on the spot market. Mr. Rogers states that the IPCO contract requires adherence to strict water flow and fish density guidelines, which is consistent with a conservation hatchery program because of the desire to produce good quality fish with increased ability to survive in the natural environment. Mr. Rogers also states that the IPCO contract, which requires fish be ready for release in the months of May and June, prevents Rangen from timing the production cycle to coincide with seasonal fluctuations in water flow. Mr. Rogers concludes that Rangen could raise more fish if flow and density standards, and timing of the production cycle, were not dictated by Rangen's contract with IPCO.

Rogers (2012) concludes that even with the density restraints imposed by the IPCO contract, Rangen could raise more fish with its current water flows. Mr. Rogers bases his analysis on one lot of fish reared in 2011-2012. He states that constraints on production due to water quality generally occur during final rearing, when the fish are largest in size. He also states that estimates at the end of the rearing cycle in the large raceways noted a Density Index of 0.295 and a Flow Index of 0.74, which were below the maximum levels of 0.3 and 0.8 required by the IPCO contract. Mr. Rogers also provides analyses of how many additional fish could be reared if less restrictive Density and Flow Indices were used.

Rogers (2012) offers two suggestions for maximizing water supply to the hatchery. These suggestions include pumping water from Rangen's lower diversion up to the small raceways and developing wells in the ESPA above the canyon rim.

Church (2012) discusses the economics of rearing trout for food, Rangen's grant applications under the Eastern Snake Plain Aquifer Assistance Grants program, grant applications from other spring users, and the economic impacts of curtailment of groundwater irrigation. He asserts that Rangen should have implemented some of the measures outlined in these grant applications. Mr. Church concludes, "*Clearly Rangen has not expended even a minimum effort…to more efficiently use or to augment the waters available to its facility*," and, "*it would be absurd to curtail ground water use in order to fractionally* *increase water flows to Rangen, without first requiring Rangen to undertake efforts on its own to augment or more efficiently use its water supply by employing measures that are available and have been utilized at other aquaculture facilities*."

Summary of expert reports submitted on behalf of Freemont Madison Irrigation District (FMID)

Contor (2012a) was submitted on October 1, 2012 and is based on analyses performed using ESPAM2.0. Mr. Contor states that the determination and application of a de minimis threshold is a policy question, and that a de minimis policy could be defined in terms of a threshold fraction below which propagating effects are considered de minimis, or in terms of a threshold total volume per time, below which effects are considered de minimis. Either approach could be implemented using ESPAM.

Contor (2012a) simulated benefits to the Buhl to Lower Salmon Falls reach from curtailment of groundwater irrigation on the Egin Bench using ESPAM2.0. Using ESPAM2.0, Mr. Contor predicted the cumulative benefit to the Buhl to Lower Salmon Falls reach from curtailment on the Egin Bench junior to July 13, 1962 is 1.90 AF after 150 years, or 0.04% of the curtailed volume. Contor (2012b) concludes that the differences between ESPAM2.0 and ESPAM2.1 do not appear to substantially change the model results relied upon in Contor (2012a). Mr. Contor did not submit an analysis using ESPAM2.1.

Contor (2012b) recommends that ESPAM results be applied using Administrative Reaches that are comprised of entire Calibration Reaches and are no smaller than the distance between nearby transmissivity pilot points. He asserts this will greatly reduce uncertainty (p. 7). He also recommends that administrative decisions that hinge on the timing of arrival of effects be strongly informed by both the short-term temporal performance of the model during calibration and that great caution be exercised whenever administrative outcome is sensitive to timing differences shorter than approximately four months.

Contor (2012b) provides discussions of temporal and spatial uncertainty, the effect of uncertainty, and potential sources of uncertainty. He concludes that the uncertainty arising from the water budget is likely at least 17%, and that overall uncertainty exceeds this estimate. Mr. Contor concludes that uncertainty will always decrease as questions are asked on larger spatial scales and longer cumulative time scales.

Summary of expert reports submitted on behalf of the City of Pocatello

Sullivan (2012) discusses the Rangen Hatchery facilities, water rights for the hatchery and other diversions from the Curren Tunnel, historical flow records, Rangen fish production data, and the City of Pocatello's water rights and water use.

Mr. Sullivan concludes that the Rangen facility has a capacity of slightly greater than 50 cfs, which is the combined flow rate of Rangen's 1957 and 1962 priority water rights. Mr. Sullivan notes that the decreed source of water for the Rangen water rights is the Martin-Curren Tunnel and does not include the spring sources below the tunnel. He concludes that it is not clear that Rangen can demand curtailment to satisfy deliveries associated with the springs below the tunnel.

Sullivan (2012) evaluates fish production data and concludes that the number of fish raised at the Rangen Hatchery is limited by density and flow indices in Rangen's contracts with Idaho Power. Mr. Sullivan suggests that Rangen could increase flow to their upper, small raceways by pumping water from above their lower diversion structure.

Mr. Sullivan identifies City of Pocatello water rights junior to July 13, 1962 that are within the current area of common groundwater supply and analyzes the effect of curtailment of these water rights on Rangen spring complex discharge using ESPAM2.1 response functions. His analysis indicates that the steady state response to curtailment of approximately 3,200 AF/yr would be 13.7 AF/yr (0.019 cfs) at the Rangen spring cell.

IDWR staff comments regarding expert reports

IDWR staff comments regarding expert reports submitted on behalf of Rangen

On page 5, Brockway et al. (2012) state, "*USGS records for Curren Tunnel indicate 50 cfs in 1902 and 96 cfs in 1917*", citing Nace et al. (1958) as a reference. IDWR staff disagrees with this statement. Published records referenced by Nace suggest that these are measurements of the flow in Billingsley Creek and may include discharge from other springs tributary to Billingsley Creek downstream from Curren Spring. Published records do not suggest these records represent the discharge from Curren Tunnel as stated by Brockway et al. (2012).

Nace et al. (1958) provided a compilation of historic spring measurements published by the USGS and the State of Idaho. In April 1902, J.D. Stannard measured and estimated seepage at 119 locations along the Snake River for the Idaho State Engineer. These measurements were first published by Ross (1902) and were referenced by Nace et al. (1958). In April 1902, Mr. Stannard measured 54.4 cfs in Billingsley Creek at a location described as "*4 miles below Salmon Falls*". Nace et al. (1958) states that the location of the measured section is not accurately determinable. In IDWR's opinion, it cannot be conclusively determined from the published information whether this measurement represents the discharge of only the Rangen spring complex, or includes contributions from other springs to Billingsley Creek. Because the Rangen spring complex is located approximately 2.5 miles east-northeast of Upper Salmon Falls and the mouth of Billingsley Creek is about 4.5 miles south of Upper Salmon Falls, it seems more likely that Stannard's measurement includes discharge from the Rangen spring complex and other springs tributary to Billingsley Creek.

The location of the 1917 measurement cited by Brockway et al. (2012) is also uncertain. Nace et al. (1958) cite USGS (1921), Meinzer (1927), and Stearns et al. (1938) as references for a 91.8 cfs measurement in September 1917. These three sources describe a measurement of Kearns Springs located in Section 36, Township 7 South, Range 13 East by the Twin Falls North Side Land and Water

Company. Nace et al. (1958) state that Kearns was probably a misunderstanding of a vocal reference to Curran Spring and believe this measurement likely applies to Curran Spring. However, IDWR staff note the location described by USGS (1921), Meinzer (1927), and Stearns et al. (1938) is consistent with Billingsley Creek near the Vader Grade road, and the measurement may or may not include discharge from Spring Creek Spring.

On page 14, Brockway et al. (2012) state, "*ESPAM2.1 utilizes the MODFLOW Drain Package to represent 90 spring discharges from the aquifer*…" IDWR staff note that although ESPAM2.1 has 90 drains, many of the spring discharge targets used in model calibration are represented by two, three, or four drains located in one or two model cells. ESPAM2.1 represents spring discharge at 50 spring complexes or groups of springs. Fourteen of these had transient calibration targets (Group A & B springs), and 36 had a single, average calibration target. Individual drains do not explicitly represent a particular discharge point within a given spring complex.

On pages 21-23, Brockway et al. (2012) present results from a steady state ESPAM2.1 simulation of curtailment of groundwater irrigation within the model boundary junior to July 13, 1962. Their analysis predicts a benefit of 17.9 cfs at the Rangen spring complex. Their report states that curtailment results in "*a decrease in ESPA depletion of 1,456,405 acre feet per year*," but their model files indicate that the modeled stress was actually 1.24 MAF/year. This may be the result of misinterpreting the MKMOD output table values for "*total pumping*", which includes water that seeps back into the ESPA and is not equal to the net stress. The net stress is equal to the crop irrigation requirement, which is listed in the MKMOD output table as "*CIR*".

IDWR staff performed a steady state model simulation of the same curtailment to verify the results presented by Brockway et al. (2012). The IDWR analysis was performed using methodology described in Sukow (2012a, 2012b). IDWR's analysis predicts that curtailment within the model boundary will result in a 1.24 MAF/year reduction in depletions to the ESPA, while curtailing irrigation on approximately 565,000 acres. At steady state, this will result in a corresponding increase in gains to the Snake River and springs of 1,705 cfs, with 416 cfs predicted to accrue to springs and reach gains below Milner, 242 cfs predicted to accrue to the Buhl to Lower Salmon Falls reach, and 17.9 cfs predicted to accrue at the Rangen spring complex. IDWR's results are consistent with those presented in Dr. Brockway's Table 2, except for the totals presented at the bottom of his table, which are not consistent with his model files. Results of IDWR's analysis are provided in Attachment A.

It should be noted that the curtailment analysis performed by Brockway et al. (2012) includes curtailment in areas currently outside the area of common groundwater supply as defined by IDAPA 37.03.11.050. If the curtailment simulation is limited to the current area of common groundwater supply, curtailment is reduced to approximately 479,000 acres and the reduction in depletions to the ESPA is 1.09 MAF/year. At steady state, this will result in a corresponding increase in gains to the Snake River and springs of 1,509 cfs, with 392 cfs predicted to accrue to springs and reach gains below Milner, 229 cfs predicted to accrue to the Buhl to Lower Salmon Falls reach, and 16.9 cfs predicted to accrue at Rangen Spring. Results of IDWR's analysis are provided in Attachment A.

On pages 25-26 and in Appendix C, Brockway et al. (2012) discuss the development of relationships between groundwater levels and discharge at the Rangen spring complex as an alternative method. Dr. Brockway states that regression analyses indicate that over 88% of the variability in Rangen spring discharge can be explained by the water level variability in a predictor well. IDWR staff note that this approach generally appears to be valid, but that use of ESPAM2.1 or another method would still be required to predict the change in water level in the predictor well in response to curtailment.

IDWR staff agree with Brockway et al. (2012) that ESPAM2.1 is the best available science for predicting the response at Rangen Spring to curtailment of groundwater irrigation on the Eastern Snake Plain. IDWR staff also agree that measures of specific components of model uncertainty (uncertainty in model input data, uncertainty in measured observations used as calibration targets, uncertainty in calibrated aquifer parameters) are not equivalent to the uncertainty of a specific model prediction. Predictive uncertainty, as shown in Wylie (2012a), varies with the locations of stresses and responses and cannot be assigned a single numeric value. Regardless of the numeric value of uncertainty, the ESPAM2.1 prediction is currently the best available and most unbiased prediction.

IDWR staff comments regarding expert reports submitted on behalf of IGWA

On page 22 and Figure 12, Mr. Hinckley discusses a schematic MODFLOW model comparison developed by AMEC that is intended to illustrate the potential increase in discharge resulting from construction of Curren Tunnel. IDWR staff note that this model assumes there are no outlets for spring discharge other than the tunnel and thus does not illustrate the potential increase in total discharge to the Rangen spring complex. The lack of an alternative outlet for groundwater in the AMEC model is acknowledged by Mr. Hinckley on page 22.

On page 22, Hinckley (2012) states, "*The outlet elevation of Curren Tunnel has been variously reported as 3138 ft. (Covington and Weaver, 1990), 3145 ft. (Farmer, 2009) and 3150 ft. (IDWR, 2011).*" IDWR staff disagree with part of this statement. Covington and Weaver (1990) mapped "*Rangen Spring*" emerging from Malad Basalt pillow lava facies at an elevation of 3,138 feet, but did not suggest that this elevation represented the tunnel.

On page 24, Hinckley (2012) states, "*Farmer (2009) also rejects a multiple-pathways-through-the-talus interpretation…*" IDWR staff note that Farmer (2009) stated, "*One theory posed is that the actual spring discharge elevation from in-situ geology may be higher than where the spring is visible on the slope due the concept of water flowing out of the in-situ layer (buried beneath the slope material) and then flowing downward through talus and overburden slopes vertically in the subsurface, then flowing laterally again to where it daylights or is visible on the hillside. In my opinion, this phenomenon doesn't occur at Rangen or other springs north of Rangen up to Malad Gorge to as great of a degree as other upriver springs such as Crystal or Clear Springs because of the presence of the GFF in this reach and less overburden and talus*." Mr. Farmer did not reject the possibility of discharge pathways through the talus. He stated that he believes it is not as significant at Rangen spring as at Crystal or Clear Springs. IDWR staff agree that Mr. Farmer identifies two discrete geologic contacts that may control a substantial portion of the discharge to the Rangen spring complex (see Figure 24 in Farmer, 2009), but IDWR staff note that this is a conceptual model that is intended to describe apparent major pathways for spring discharge, not all potential pathways for discharge.

On pages 26-27 and Figure 16, Hinckley (2012) criticizes the groundwater elevation contours published in Farmer and Blew (2012), and provides an alternative interpretation of groundwater elevation contours in an approximately 3.5 square mile area adjacent to the Rangen spring complex. The Farmer and Blew (2012) elevation contours were compiled based on water levels measured in 196 wells and 39 springs during November 2011. Mr. Hinckley contoured groundwater elevations in a smaller area based on 18 water level measurements. Mr. Hinckley removed three measurements from the Farmer and Blew dataset and added three measurements taken during different time periods. The measurements collected by Mr. Hinckley included a measurement from November 2007, from well T7S R14E 28DCB1. Measurements collected from the same well in October 2008 and February 2010 indicate water levels 9 to 12.5 feet lower than the November 2007 measurement selected by Mr. Hinckley. IDWR staff disagree with Mr. Hinckley's use of any measurements from well T7S R14E 28DCB1, because none of the measurements are representative of conditions during the November 2011 mass measurement.

Farmer and Blew (2012) contoured groundwater elevations with Surfer software using the Kriging option. This procedure has the advantage of being objective, and does not represent details that are not explicitly defined by the available data. Mr. Hinckley appears to have contoured groundwater elevations using Kriging, then manually adjusted some of the contours based on professional judgement and his interpretation of local conditions. This procedure has the advantage of incorporating geologic knowledge, but also has the disadvantage of incorporating bias based on interpretations that may not accurately reflect the complexity of local conditions. For example, Mr. Hinckley argues on page 26, "*the contouring* [of Farmer and Blew, 2012] *includes a closed contour approximately 1 mile northeast of Rangen. This represents a depression in the potentiometric surface, an unlikely occurrence in a prolific aquifer outside the active irrigation season*." IDWR staff note that the November 2011 synoptic measurement occurred shortly after the end of the irrigation season and that residual transient effects of irrigation well pumping and recharge from surface water irrigation activities may still have resulted in local water level variations, such as depressions or mounds in the potentiometric surface.

On page 27, Mr. Hinckley concludes based on his Figure 16, "*A groundwater divide to the south distinguishes the local Rangen system from the Thousand Springs area. A groundwater divide to the north distinguishes the local Rangen system from rim springs between Rangen and the Malad River*." IDWR staff are unclear what Mr. Hinckley means by "*distinguishes from*" or why Mr. Hinckley believes the existence of these local groundwater divides is significant. Groundwater divides are relevant in controlling contaminant transport, but do not result in hydraulic disconnection nor prevent responses to aquifer stress such as recharge or pumping. Well pumping results in drawdown that propagates radially in all directions (Figure 3). In a finite aquifer without unlimited recharge, drawdown will occur throughout the aquifer. The reduction in aquifer head will be largest near the well and may be very small in distant parts of the aquifer. A groundwater divide is not a hydraulic disconnection, unless caused by a continuous impermeable barrier. A stress applied on one side of a groundwater divide will affect aquifer heads on the other side of the divide and may affect the presence or location of a groundwater divide, which may change seasonally with changes in aquifer stresses. While Hinckley

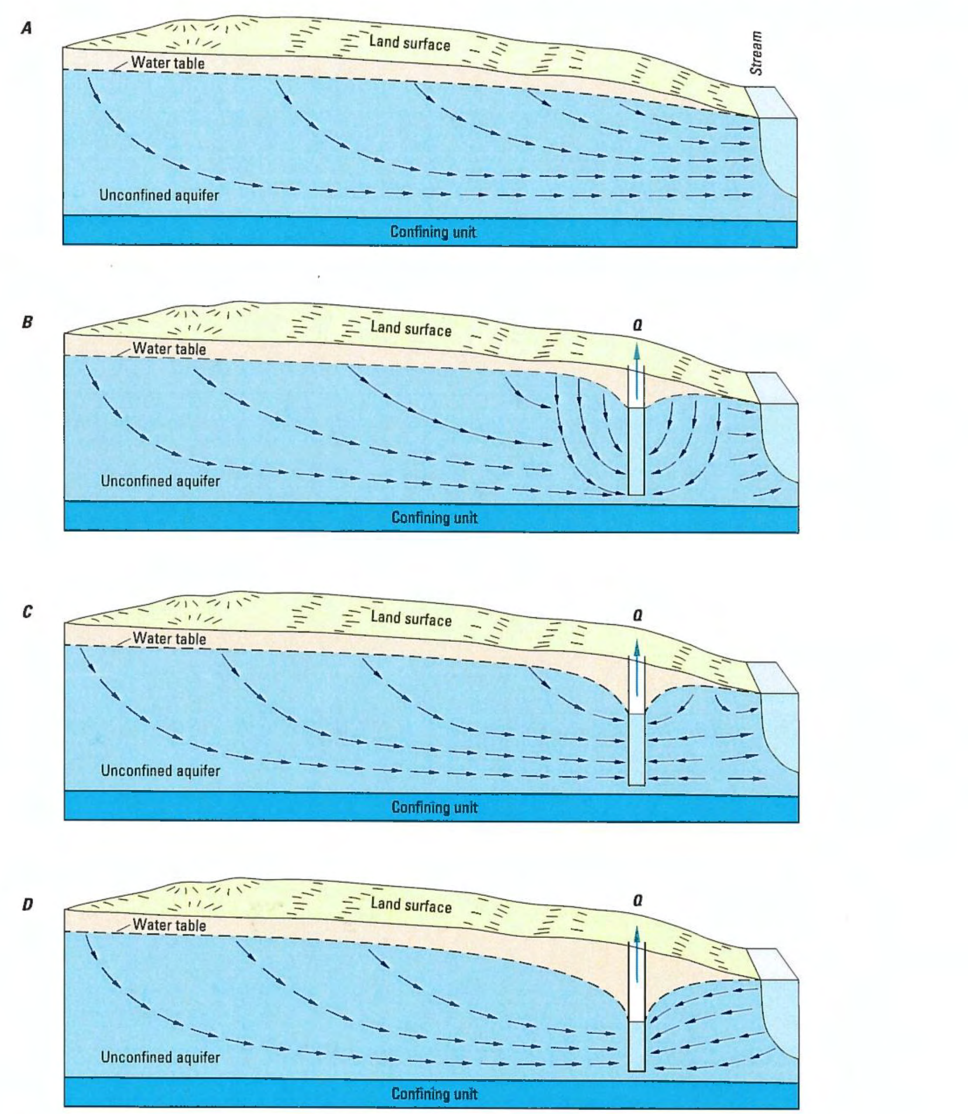
(2012) and Farmer and Blew (2012) provide different interpretations of head contours in this area, the presence or absence of these groundwater divides is not relevant to the hydraulic connectivity of the Rangen spring complex to the larger ESPA. As shown in Hinckley (2012) Figure 7, the area contoured in his Figure 16 extends less than two miles from the rim. The extent of the groundwater divides shown by Mr. Hinckley is small relative to the area contoured by Farmer and Blew (2012). Regardless of the precise details of preferred flow pathways and direction in the immediate vicinity of the rim, spring discharge responds to head in the aquifer, and head in the aquifer responds to stresses applied throughout the aquifer.

On page 27, Hinckley (2012) states, "*Groundwater gradients also determine the discharge rates of springs and drainage tunnels. Given an opportunity for discharge, discharge rate is a function of the gradient*." IDWR staff note that this is only partially true, the discharge rate is the product of the gradient and the conductance of the feature (spring or tunnel) at which the discharge occurs. A site with a low gradient may have high discharge if conductance is high, conversely a site with a high gradient may have low discharge if conductance is low. Because spring conductance is a lumped parameter that incorporates all of the head loss between the drain and the point where aquifer head is known or modeled, values for conductance vary over a large range. Conductance depends on the characteristics of the convergent flow pattern toward the drain, as well as on the characteristics of the drain and its immediate environment (Harbaugh, 2005; McDonald and Harbaugh, 1988). Conductance may be influenced by flow turbulence, the size of the drain feature, the size and interconnectivity of fractures or pore spaces, and other physical properties that are difficult or impossible to measure. Because of the number of factors that influence conductance, and the large natural variability in each of these factors, the large range in drain conductance modeled by ESPAM2.1 is realistic.

On page 27 and Figure 17, Hinckley (2012) presents the relationship between discharge of the Rangen spring complex and groundwater level measurements collected in a domestic well (07S 14E33 BBB1) located approximately one mile east-northeast of the Rangen spring complex. Water level measurements from this well were collected approximately bi-monthly by the USGS from 1985 to 2009, and by IDWR beginning in 2009. Mr. Hinckley asserts there is considerable uncertainty in the relationship between aquifer head and spring discharge. IDWR staff disagree, because Mr. Hinckley is not comparing spring discharge with aquifer head immediately adjacent to the spring complex his analysis ignores other factors, such as localized water level responses to nearby pumping wells or recharge sources, potential measurement error in both water level and spring discharge, and transient timing of responses to stress. Figure 4 shows a time-series graph of water level in well 07S 14E BBB1 and discharge at the Rangen spring complex. Figure 5 shows a graph of the relationship between measured water level and spring discharge. Note that much of the scatter discussed by Mr. Hinckley is associated with points in Figure 5 that appear to be outliers occurring when water levels above 3,166 feet were measured in mid-summer. These spikes in the water level measurements suggest that the well is responding to changes in nearby stresses. Changes in aquifer head immediately adjacent to the spring complex will be a function of the transient response time to these and other aquifer stresses.

On page 28 and Figure 18, Hinckley (2012) presents the relationship between discharge of the Curren Tunnel and groundwater level measurements collected in a monitoring well located approximately 600 feet east of the Rangen spring complex. The monitoring well was installed by the Idaho Water Resource Board (IWRB) in 2008, and daily water level measurements were collected by IDWR beginning in October 2009. In Figure 18, Mr. Hinkley compares daily measurements of water level and Curren Tunnel discharge. Mr. Hinkley asserts that this relationship indicates there is considerable uncertainty in the relationship between aquifer head and Curren Tunnel discharge, again ignoring potential measurement error and transient timing of spring responses to aquifer stresses. Further, linear regression of this relationship (Figure 6) indicates that 85% of the variability in the tunnel discharge during this 3-year period can be explained by a linear relationship with head in the monitoring well (Figure 5). Because the monitoring well was not installed until 2008, these data do not provide sufficient information to evaluate the response to water level changes that would be expected to occur if the aquifer water budget was changed by a model-wide curtailment of groundwater irrigation junior to 1962.

A more representative comparison of aquifer head and Rangen spring complex discharge would be comparison with IDWR Well No. 989, which is located approximately ½ mile northeast of the Rangen spring complex. This well is closer to the Rangen spring complex than well 07S 14E 33 BBB1 and has a longer record of water level measurements than the IWRB monitoring well. Well No. 989 has a record of 68 water level measurements collected between March 1998 and October 2008, representing a broader range of aquifer water budget conditions than the IWRB monitoring well. Well No. 989 was also used as a water level change calibration target in ESPAM2.1 (Figure 7). Comparison of measured water levels with spring discharge indicates that linear regression explains approximately 91% of the variability in the relationship between aquifer head at this location and discharge at the Rangen spring (Figure 8). These data indicate that there is a strong relationship between the change in discharge at the Rangen spring complex and change in aquifer head at the location of Well No. 989, with the discharge increasing by approximately 3.7 cfs per foot of increase in head.



12 **Streamflow Depletion by Wells—Understanding and Managing the Effects of Groundwater Pumping on Streamflow**

Figure 7. Effects of pumping from a hypothetical water-table aquifer that discharges to a stream. *A,* Under natural conditions, recharge at the water table is equal to discharge at the stream. *B,* Soon after pumping begins, all of the water pumped by the well is derived from water released from groundwater storage. *C,* As the cone of depression expands outward from the well, the well begins to capture groundwater that would otherwise have discharged to the stream. *D,* In some circumstances, the pumping rate of the well may be large enough to cause water to flow from the stream to the aquifer, a process called induced infiltration of streamflow. Streamflow depletion is equal to the sum of captured groundwater discharge and induced infiltration (modified from Heath, 1983; Alley and others, 1999). [*Q*, pumping rate at well]

Figure 3. Effects of well pumping on aquifer head and surface water discharge (from Barlow and Leake, 2012).

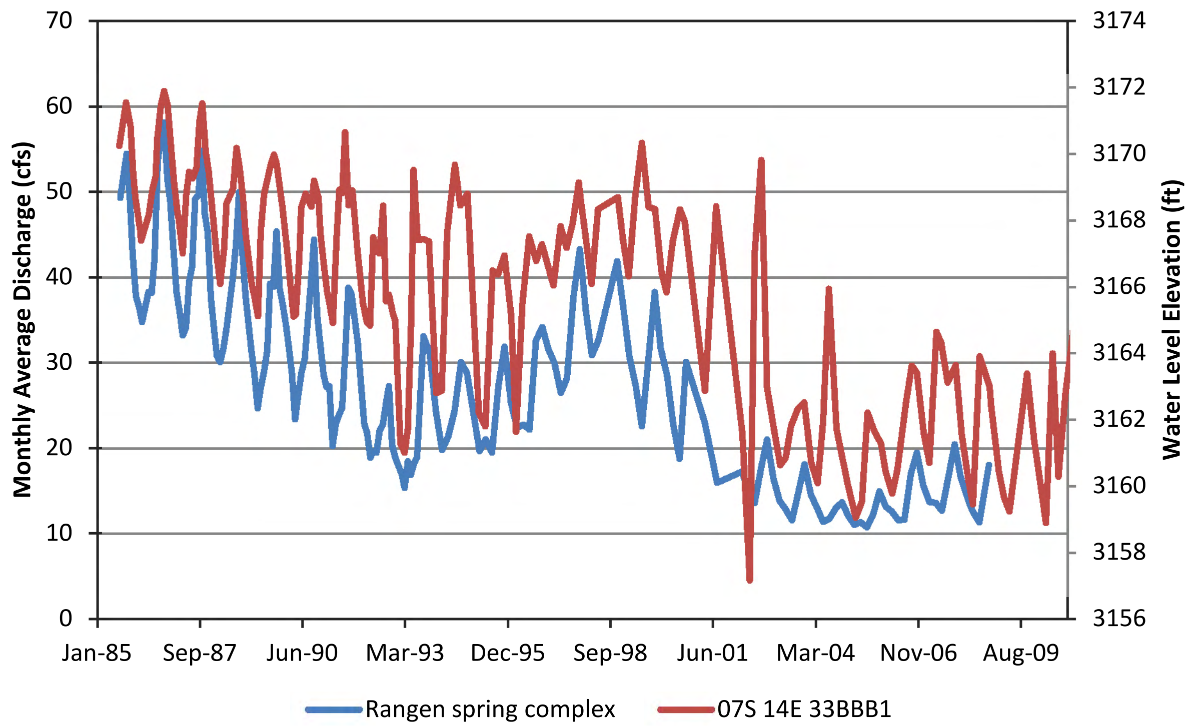


Figure 4. Measured water level in well 07S 14E 33 BBB1 and monthly average discharge at Rangen spring complex.

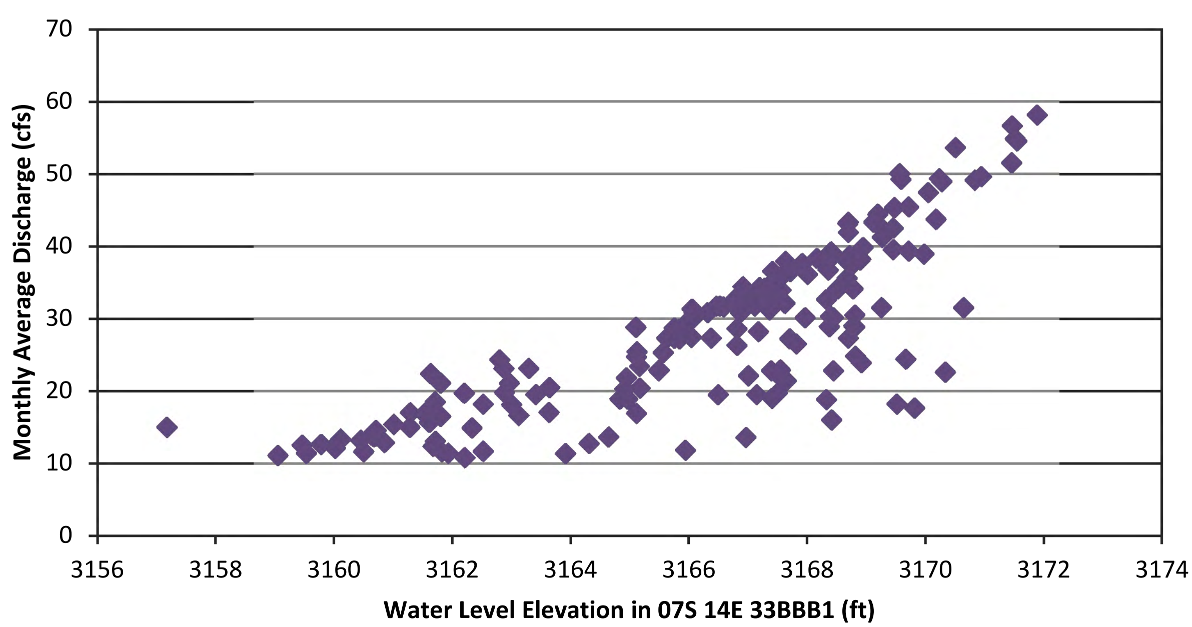


Figure 5. Relationship between measured water level in well 07S 14E 33 BBB1 and monthly average discharge at Rangen spring complex.

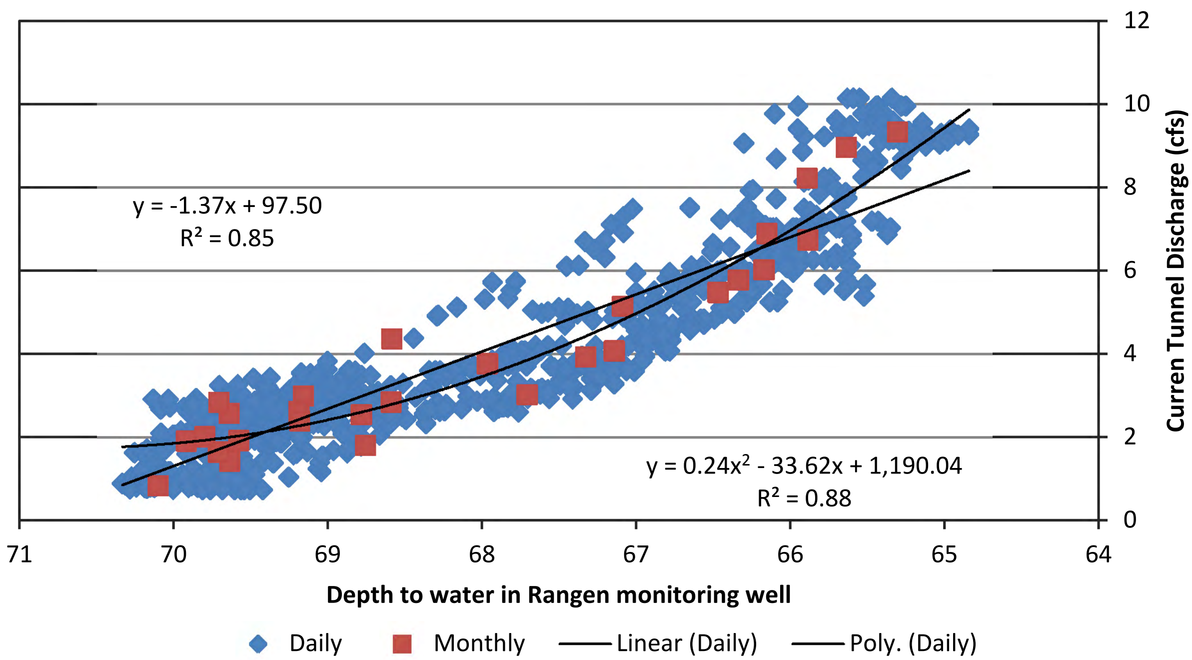


Figure 6. Relationship between Curren Tunnel discharge and water level in Rangen monitoring well, August 2008 to January 2012.

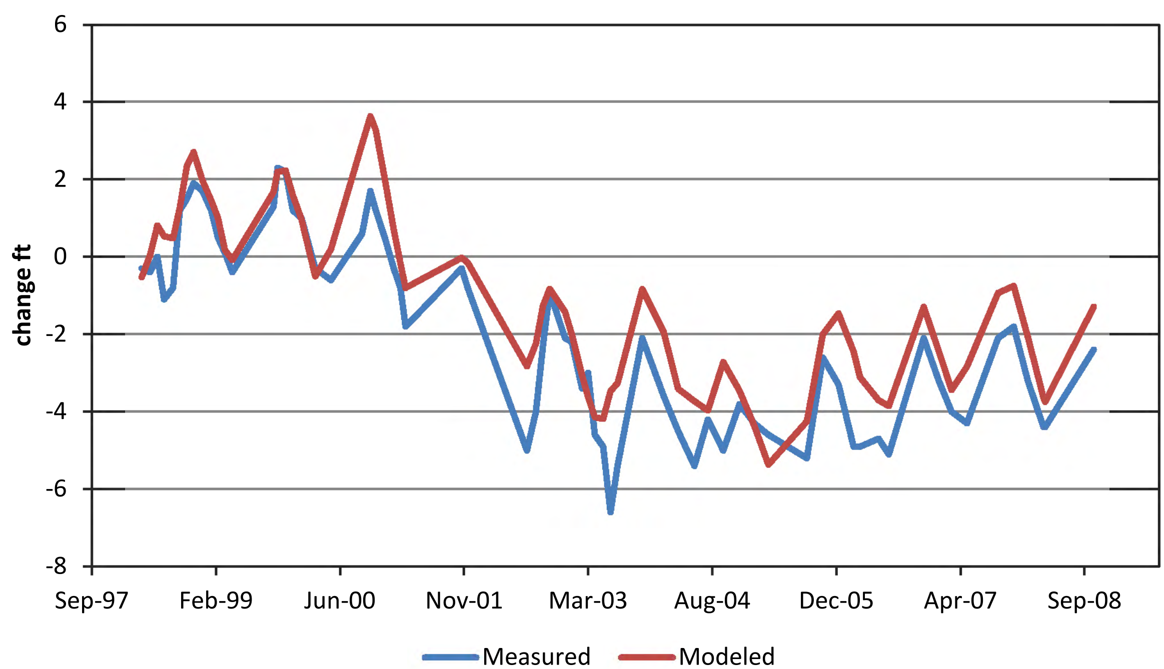


Figure 7. ESPAM2.1 calibration to water level change in IDWR Well No. 989.

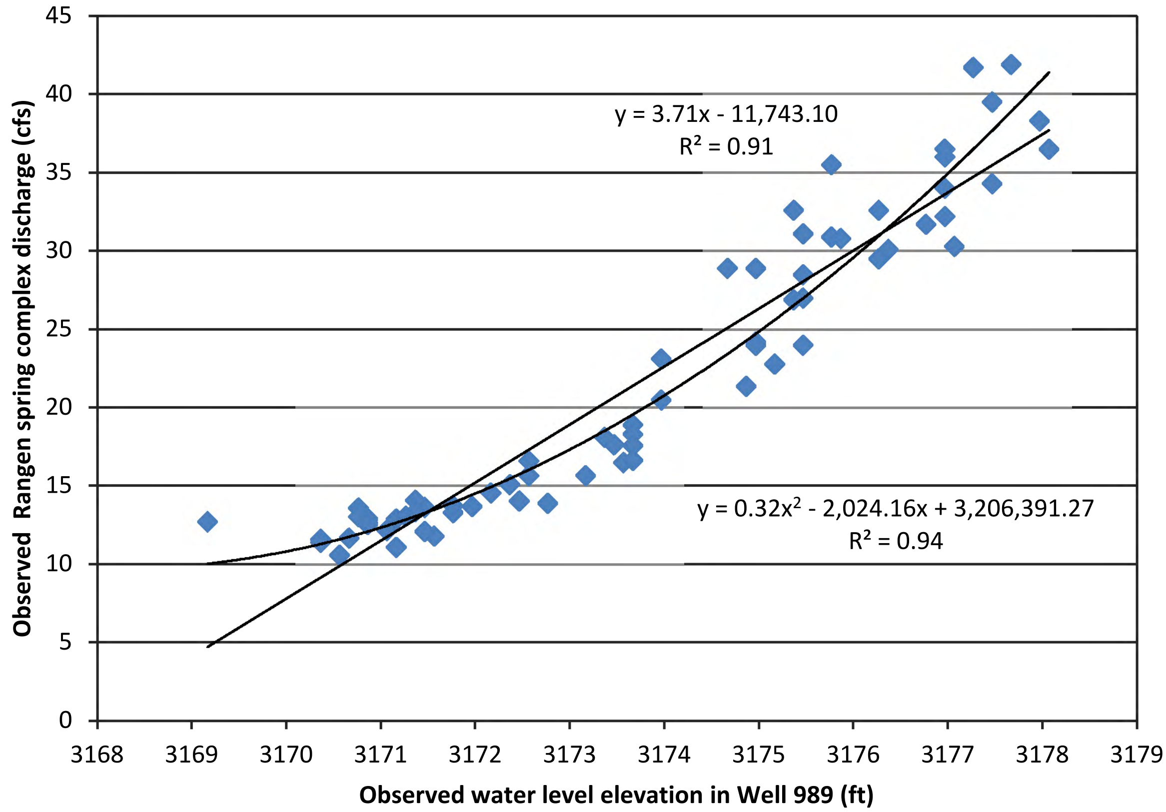


Figure 8. Relationship between Rangen spring complex discharge and aquifer head at IDWR Well No. 989.

On pages 30-45, Mr. Hinckley evaluates the ESPAM2.1 representation of the area between Thousand Springs and Malad. IDWR staff agree with some of Mr. Hinkley's points, but disagree with his conclusion that ESPAM2.1 cannot provide a reasonable prediction of the response at the Rangen spring cell to groundwater pumping in the ESPA. Because ESPAM2.1 is discretized into one-square-mile grid cells, it does not represent detailed topographic and geologic features that are smaller than one-mile in scale. However, ESPAM2.1 does represent regional topography and hydrogeologic features within the constraints of the one-square-mile model grid and the spacing of transmissivity pilot points, which is generally two to four miles in the vicinity of the Buhl to Lower Salmon Falls reach. This provides a better representation of the spatial and hydrogeologic relationships than is available in any other predictive model or method available for evaluating the effects of groundwater pumping within the ESPA on spring and river flows. On a local scale it is not possible to model the complexity of the aquifer with one-square-mile grid cells, however, on a regional scale, the response of head-dependent discharges to springs and rivers is dependent on aquifer head responses to recharge and well withdrawals. This allows responses to regional-scale stresses, such as groundwater pumping throughout the plain to be modeled with less uncertainty than responses to stresses applied in a small area located immediately adjacent to the spring or river.

IDWR staff agree with Mr. Hinckley that ESPAM2.1 is a linear approximation of a non-linear system, and does not reflect non-linear relationships between aquifer head and spring discharge. IDWR staff note that comparison of aquifer head and discharge (Figures 6 and 8) indicate that a linear regression does provide a reasonable approximation of the relationship, explaining 85 to 91% of the variability in these examples. Non-linear, polynomial regressions of these data only improve this correlation slightly, explaining only an additional 3% of the variability.

As stated by Mr. Hinckley, the model does not allow transmissivity to vary with time. Time-constant transmissivity models of unconfined systems are common in practice, because calibrating models with variable transmissivity is generally not feasible with automated parameter adjustment. Although IDWR staff agree that ESPAM2.1 is a linear approximation of a non-linear system and that this contributes to model uncertainty, IDWR staff do not agree with Mr. Hinckley's conclusion that ESPAM2.1 is not suitable for evaluating the response to aquifer stresses at the Rangen spring cell. ESPAM2.1 is the best available scientific tool for predicting responses to curtailment of groundwater pumping or other changes in regional aquifer stresses within the ESPA. The model was calibrated to spring and river responses to a range of aquifer stresses applied over a 23.5-year period, with net aquifer recharge ranging from 3.2 MAF/year to 6.3 MAF/year and measured discharge at the Rangen spring complex ranging from 11 to 58 cfs. The model calibration targets reflect geologic controls on hydrologic responses to a range of aquifer stresses. ESPAM2.1 provided reasonable approximations of measured discharge at the Rangen spring complex within this range of stresses and responses, and is expected to provide a reasonable approximation of the response to curtailment, which falls within the range of the calibration data set.

On pages 40-41, Hinckley argues, "*ESPAM2.1 is structurally incapable of modeling the relationships shown on Figures 17 and 18. Figure 28, for example, presents the data of Figure 18, expressed as deviations from an ideal linear model as required by ESPAM2.1. The average error in the predicted discharge is 20% of the average discharge, and deviations as large as 50% are not uncommon. Because Figure 28 uses well-measured, paired daily data (e.g. rather than monthly averages), and because the monitor well and discharge points are in near proximity, the relationship presented should be well controlled with respect to data-collection and location based errors.*" IDWR staff disagrees with these statements. The IWRB well referred to by Mr. Hinckley in Figure 28 is located approximately 600 feet from the Rangen spring complex. His comparison of paired daily data ignores transient timing of spring responses to changes in aquifer head, magnifies the impact of measurement error, and results in overestimation of deviations from a linear relationship. Because ESPAM2.1 calculates discharge at the Rangen spring complex to aquifer head at the Rangen spring complex, it is not appropriate to quantify deviations from linearity based on comparisons with aquifer head at a well any distance from the spring complex. As shown in Figure 6, a linear relationship explains approximately 85% of the variability between Curren Tunnel discharge and aquifer head at the IWRB well. Transient response time, measurement error, and physical non-linearity are factors in the other 15% of the variability. It is not appropriate for Mr. Hinckley to attribute all of the variability to physical non-linearity.

On page 42, Hinckley (2012) argues that the use of general head boundaries along the Hagerman rim effectively reverses the removal of the Hagerman Valley from the ESPAM2.1 model domain. IDWR staff disagree with this statement. The general head boundaries were added along the Hagerman rim to allow discharge from the ESPA to Billingsley Creek and/or the Snake River via one of several pathways that may include talus flow that does not daylight as spring discharge, discharge from the ESPA to Tertiary sediments to Billingsley Creek, or discharge from the ESPA to Tertiary basalts to the Snake River as conceptualized by Farmer, 2009 (Figure 9). The general head boundaries were added to provide an outlet for ESPA discharge that reaches Billingsley Creek or the Snake River without surfacing as springs. This does not reverse the removal of the Hagerman Valley from the ESPAM2.1 model domain, because there is no modeled aquifer recharge or discharge occurring in the Hagerman Valley, and elevations of the general head boundary were selected to be low enough that there was not any flux modeled from the Snake River into the ESPA in the reaches below Milner.

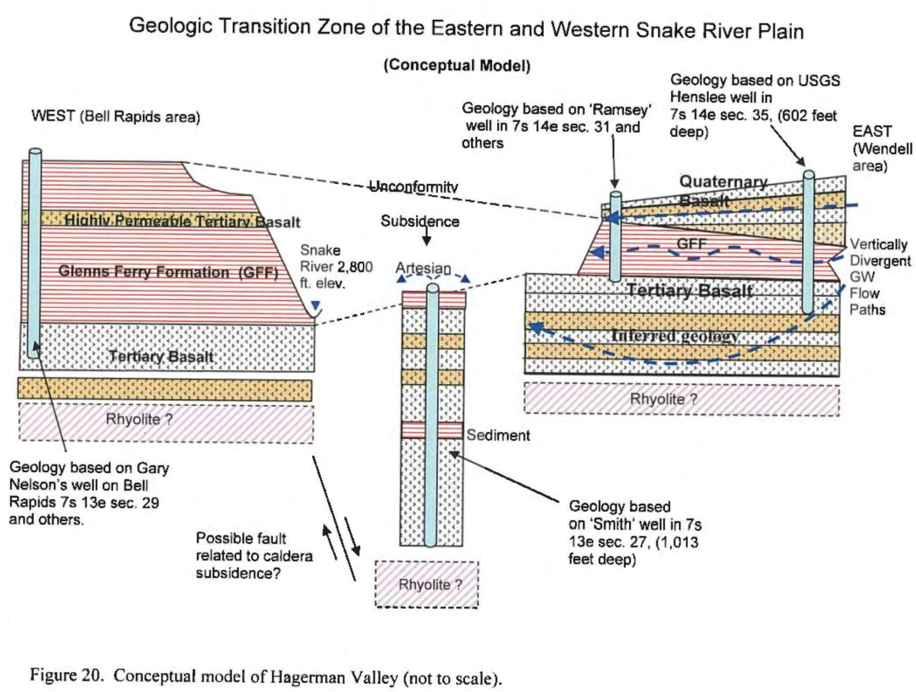


Figure 20. Conceptual model of Hagerman Valley (not to scale).

Figure 9. Farmer (2009) conceptualization of potential groundwater flow from ESPA to Tertiary sediments and basalts.

The locations of general head boundaries used to model base flow below Milner were discussed by the ESHMC, including Dr. Brendecke on December 12, 2011 and the committee agreed that a general head boundary "*would be assigned to cells with springs that butt against the river, and for cells along the edge of the Hagerman Valley*" (Raymondi, 2011). IDWR staff note that the analyses submitted by Leonard Rice Engineers, Inc. with Rangen's December 13, 2011 Petition for Delivery Call was performed using a preliminary calibration of ESPAM2 that pre-dated addition of the general head boundaries to the model. The results of their analysis (McGrane, et al., 2011) were similar to the results predicted by ESPAM2.1, suggesting that the addition of the general head boundaries along the Hagerman rim had little effect on model predictions of response at the Rangen spring complex.

On page 43, Hinckley (2012) claims that the ESPAM2.1 calibration targets for the general head boundary base flow were "*a constant, average value…despite the fact that the total gains through this reach have declined over the period, and include seasonal fluctuations of 700 cfs.*" This claim is false. In ESPAM2.1, each base flow reach was calibrated to an average value for the calibration period, not a constant value. During calibration, the average of model-calculated discharge from May 1985 through October 2008 was computed and compared to the target average value from Wylie (2012b). The model calibration is only constrained by the average value for the calibration period, and is still allowed to vary the base flow discharge with time to match fluctuations in the transient reach gain targets.

Brendecke (2012) concludes that observed flows of Billingsley Creek have not been high enough to provide any water to water right 36-7964 since October 1976, a date which precedes the water right's 4/12/1977 priority date. This is consistent with IDWR's previous review of this water right. Dreher (2005), stated "…*Rangen may be entitled to divert water under this right when such water is physically available. However, because water was not available to appropriate on the date of appropriation for right no. 36-07694, Rangen may not be entitled to have a delivery call recognized against junior priority rights*." From a practical standpoint this is not relevant, because the predicted benefit from curtailing all groundwater users junior to the 7/13/1962 priority date of water right 36-2551 is only 17.9 cfs, and curtailment is not expected to provide more water than Rangen is entitled to divert under water right 36-2551. Between 2002 and 2011, annual average spring discharge ranged from 12 to 16 cfs, and monthly average spring discharge ranged from 11 to 22 cfs (Sullivan, 2012, Table 2-2). Based on 2002 to 2011 conditions, the predicted total annual average spring discharge would be between 30 and 34 cfs with curtailment.

Brendecke (2012) concludes that the source for water right 36-2551 is the Martin-Curren Tunnel and that flows from the tunnel have never been high enough to deliver the maximum diversion rate authorized under water right 36-2551. IDWR staff agree that the SRBA partial decree for water right 36-2551 lists the source as Martin-Curren Tunnel and describes the 10-acre tract containing the tunnel. A cursory review of the water right file indicates that the water right was licensed with the source described as "*underground springs tributary to Billingsley Creek*" and the point of diversion is located in the 40-acre tract containing both Curren Tunnel and Rangen's diversion at the head of the creek. The water right file also contains two survey drawings showing the point of diversion from the creek and the 36-inch pipe to the large raceways. The licensed priority date was July 31, 1962. The files reviewed did not indicate why the source, point of diversion, and priority date were changed in the SRBA.

Brendecke (2012) concludes that the Martin-Curren Tunnel meets the physical definition of a well contained in Idaho Code 42-230(b), which states, *"'Well' is an artificial excavation or opening in the ground more than eighteen (18) feet in vertical depth below land surface by which ground water of any temperature is sought or obtained*." The partial decree lists the source for water right 36-2551 as "*Martin-Curren Tunnel*", not "*Ground Water*". Whether the tunnel is considered a well or a developed spring for administration of water right 36-2551 is a legal, not a technical, question.

Brendecke (2012) concludes that much of the change in spring discharge in the Milner to King Hill reach since 1960 can be attributed to reduction in incidental recharge from surface water irrigation. IDWR staff acknowledge that reduction in incidental recharge from surface water irrigation has contributed significantly to reductions in spring discharge. Spring flows respond to changes in various types of aquifer stress, including changes in incidental recharge from surface water irrigation, well pumping, and infiltration of precipitation. ESPAM2.1 was calibrated with all of these stresses, and then the calibrated model was used to calculate the response to a change in well pumping while other stresses were held constant. ESPAM2.1 provides a method for determining the portion of the water shortage at the Rangen hatchery that can be attributed to junior groundwater pumping, rather than holding junior groundwater users accountable for the entire decrease in spring discharge. Spring discharge records indicate that the annual average spring discharge was 51 cfs in 1966 and 14 cfs in 2008 (Sullivan, 2012, Table 2-2). The steady state impact of junior groundwater pumping predicted by ESPAM2.1 is less than half of the total decrease in spring discharge between 1966 and 2008. Note that spring discharge in 1966 would have already been reduced to some extent by junior groundwater pumping developed between 1962 (the priority date for water right 36-2551) and 1966.

Brendecke (2012) states that "*The 1992 moratorium on new irrigation wells suggests that decreases in discharge after the mid-1990s are not the result of groundwater pumping*." IDWR staff note that groundwater pumping junior to July 13, 1962 has resulted in depletions to spring discharge every year since 1962. While the rate of depletion due to groundwater pumping may not have increased significantly since 1992, the depletions continue to occur. These depletions are superimposed on decreases in spring discharge resulting from changes in surface water irrigation practices and natural recharge derived from precipitation. Even if the rate of depletion due to groundwater pumping has been approximately constant since 1992, groundwater pumping continues to contribute to removal of water from aquifer storage, declines in ESPA water levels, and decreases in spring discharge.

Brendecke (2012) mentions that former Director Dreher found that curtailment of water rights junior to July 13, 1962 would not result in a meaningful increase in the quantity of water discharge from springs in the Thousand Springs to Malad Gorge spring reach, which includes the Curran Spring from which Rangen diverts surface water. Dreher (2005) indicates that this conclusion was based on simulations using ESPAM1.1. During development of ESPAM2.1, IDWR discovered that values from Covington and Weaver (1990) that were used to estimate discharge for Thousand Springs and springs in the Thousand Springs to Malad spring reach for calibration of ESPAM1.1 were inaccurate. These values were corrected in the calibration targets used for ESPAM2.1. These corrections included a significant decrease in the spring discharge target at Thousand Springs and a significant increase in spring discharge targets in the Billingsley Creek area (Table 2). ESPAM2.1 calibration targets also provided the model with information regarding transient changes in spring discharge in the Billingsley Creek area. Because ESPAM2.1 incorporates these and other improvements to ESPAM1.1, ESPAM2.1 model predictions are an improvement to analyses performed using ESPAM1.1.

ESPAM1.1 Spring Reach	ESPAM1.1 Discharge Target (cfs)	ESPAM1.1 Proportion of Milner to King Hill Discharge	Sum of Average ESPAM2.1 Discharge Targets (cfs)	ESPAM2.1 Proportion of Milner to King Hill Discharge
Devil's Washbowl to Buhl	1,002	0.18	840	0.14
Buhl to Thousand Springs	1,584	0.28	1,431	0.24
Thousand Springs	1,749	0.31	811	0.13
Thousand Springs to Malad (Billingsley Creek)	77	0.01	223	0.04
Malad	1,117	0.20	1,070	0.18
Malad to Bancroft	91	0.02	103	0.02
Baseflow, Kimberly to King Hill (ESPAM2.0 only)	--	--	1,537	0.26
Sum	5,620	1.00	6,015	1.00

Table 2. Comparison of calibration targets for springs below Milner.

Brendecke (2012) mentions that approximately 24,000 linear feet of lateral off the W-Canal in the area west of Wendell have been lined or placed in pipe since the 1990s, reducing incidental recharge. IDWR staff note that ESPAM2.1 does model this reduction in incidental recharge, because the sum of incidental recharge and canal seepage in the North Side Canal Company service area is equal to recorded diversions less crop irrigation requirement and return flow. IDWR staff also acknowledge that, while the volume of recharge reflects the canal lining/piping projects, the spatial distribution of the recharge does not reflect this change. The pre-processing tools developed for use with ESPAM2.1 have the ability to reflect changes in canal seepage rates with time, and this improvement could likely be incorporated into future versions of ESPAM2 if proposed to the ESHMC for consideration.

On page 4-4 Brendecke (2012) states that in ESPAM2.1 "*canal seepage losses are still considered to be constant throughout the model study period*." IDWR staff would like to clarify that canal seepage rates in ESPAM2.1 were calculated as a constant percentage of diversions. Canal seepage losses vary with time, because diversions vary with time.

On page 4-6, Brendecke (2012) states that the number of adjustable parameters in ESPAM2.1 model calibration increases the likelihood that the model is not linear. Dr. Brendecke appears to misinterpret a quote from Doherty (2005). This quote refers to the linearity of the model calibration process, not the linearity of the calibrated MODFLOW model. IDWR addressed the non-linearity of the calibrated MODFLOW model in Sukow (2012c) with respect to the use of superposition to perform curtailment simulations.

On page 4-9, Brendecke (2012) states that water levels in the ESPA near Rangen vary seasonally by about 5 feet and that "*These changes are nearly 100% of the saturated thickness above the Tunnel and about 10% of the thickness above the lower springs, further indicating that the requirements for superposition are not met at Rangen*." Dr. Brendecke appears to be referring to the guidelines for using a time-constant representation of transmissivity, not requirements for superposition. As stated in the ESPAM2.1 model documentation (IDWR, 2013), "*The generally considerable saturated thickness of the ESPA supports a time-constant representation of transmissivity, because drawdown is generally expected to be less than 10% of total saturated thickness (Anderson and Woessner, 1992)*." Note that this guideline applies to water level change as a percentage of the total saturated thickness. The portion of the saturated thickness that is above the tunnel elevation is not relevant, because the tunnel is not located at the base of the aquifer. If the lower springs are assumed to be located at the base of the aquifer, the water levels changes would be about 10% of the total saturated thickness, as acknowledged by Dr. Brendecke. Therefore, the conditions described by Dr. Brendecke are at the limit of the standard cited in IDWR (2013), but do not exceed this standard.

Brendecke (2012) indicates that ESPAM2.1 is not capable of separating the effects of groundwater pumping on flows from the Martin-Curren Tunnel from the effects on other springs in the Rangen complex. IDWR staff agree with this statement. Even in other spring cells where ESPAM2.1 has two drains, the model is calibrated to target data that reflect the total flow of all springs in the cell. Apportioning the predicted response between the tunnel and other springs in the Rangen complex, could done by applying a post-model calculation to the model prediction. The methodology should consider the amplitude of observed changes in the tunnel discharge and discharge from other springs, not the average magnitude of the discharges. Observed data (Figure 10) indicate that Curren Tunnel discharge is more responsive than discharge from other springs in the complex to changes in aquifer head. Linear regression of Curren Tunnel discharge with total Rangen spring complex discharge (Figure 11) indicates that the change in discharge at Curren Tunnel will be approximately 70% of the change in total spring complex discharge.

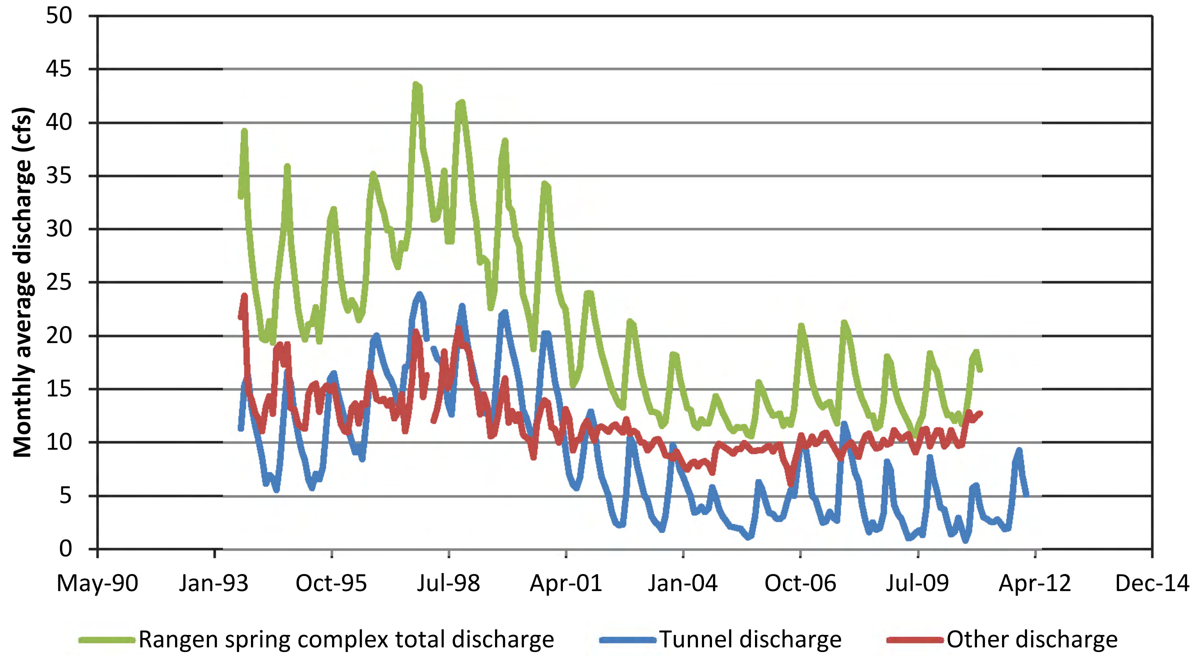


Figure 10. Observed monthly average discharge at Rangen spring complex and Curren Tunnel.

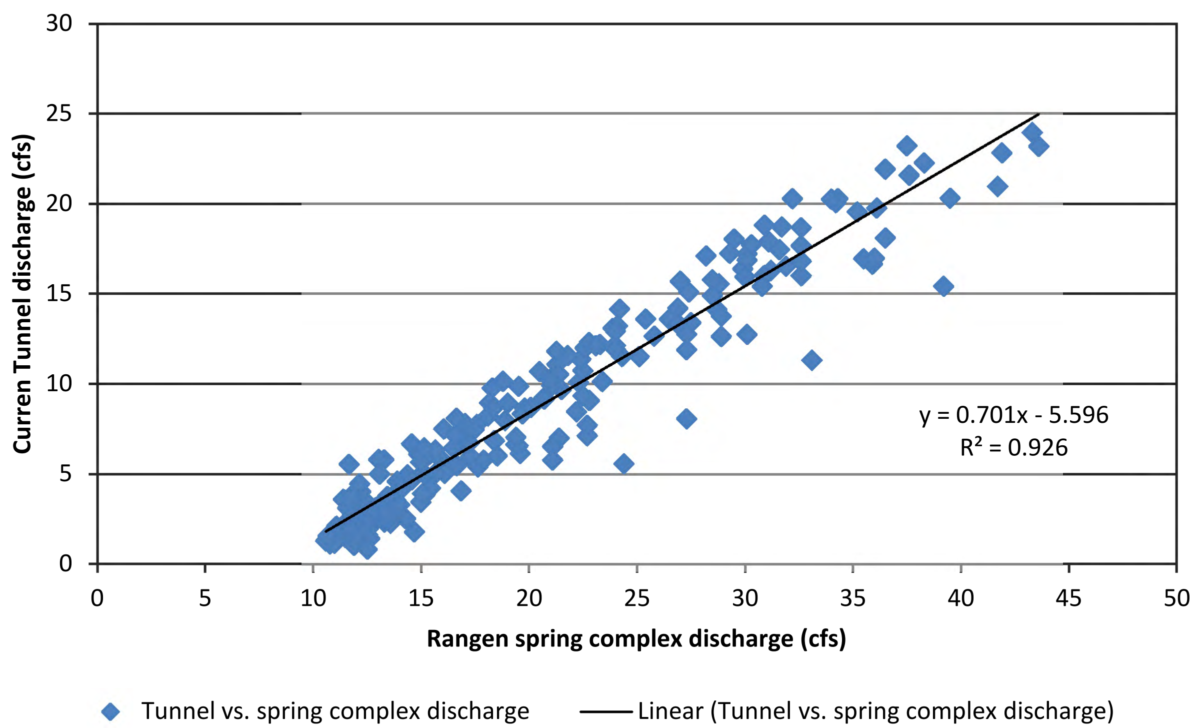


Figure 11. Relationship between Curren Tunnel discharge and total Rangen spring complex discharge, September 1993 to December 2010.

Brendecke (2012) and Hinckley (2012) suggest that ESPAM2.1 would better represent the Rangen spring complex if two drains with different elevations were assigned to the model cell. IDWR staff agree that adding a second drain to the model cell would provide PEST with an additional tool and would likely improve the match to the Rangen calibration target. This improvement has been suggested for ESPAM2.2 (for Rangen and several other spring cells), and could likely be incorporated into future versions of ESPAM if proposed to the ESHMC for consideration. Although IDWR staff agree that adding a second drain to the model cell would be appropriate, IDWR staff disagree that the drains could be used to calculate the response at Curren Tunnel separately from other springs in the Rangen complex. In ESPAM2.1, spring cells with two drains are calibrated to a single set of discharge data representing discharge occurring throughout the model cell. The use of two drain cells allows PEST to find an effective elevation (Equation 1) between the upper and lower drain elevation that allows the best linear approximation of the relationship between aquifer head and observed spring discharge. Because the elevation or range of elevations at which the spring discharge loses hydraulic connection with the aquifer are unknown, using two drain elevations provides PEST the opportunity to find the best estimate for the effective elevation (within the assigned range) based on available head and discharge data. Provided aquifer head remains above both drain elevations throughout the simulation period, total drain discharge in the model cell can be represented by Equation 2.

$$z_{eff} = (C_1 z_1 + C_2 z_2)/(C_1 + C_2) \qquad \text{(Equation 1)}$$

where:
z_{eff} = effective drain elevation (ft)
C_1 = conductance of upper drain (ft^2/day)
z_1 = elevation of upper drain (ft)
C_2 = conductance of lower drain (ft^2/day)
z_2 = elevation of lower drain (ft)

$$Q_d = C_1(z_1 - h_{aq}) + C_2(z_2 - h_{aq}) = (C_1 + C_2)(z_{eff} - h_{aq});\ \text{if } h_{aq} > z_1 \text{ and } h_{aq} > z_2 \qquad \text{(Equation 2)}$$

where:
Q_d = total drain discharge (ft^3/day) in model cell, negative values indicate flux out of the aquifer
h_{aq} = aquifer head at center of cell containing the drain (ft)

Hinckley (2012) and Brendecke (2012) argue that representing the Rangen spring discharge with a single drain at elevation 3,138 feet in ESPAM2.1 resulted in a drain conductance that is unrealistically high. Brendecke (2012) explored the effects of representing the Rangen spring discharge with two drains in his alternative models, AMEC Model 1 and AMEC Model 2. Dr. Brendecke's drain file for AMEC Model 1 show that his model has a drain conductance of 11,307 ft^2/day at an elevation of 3,100 feet and a drain conductance of 363,270 ft^2/day at an elevation of 3,152 feet. In this model, the Rangen spring discharge is represented by an effective conductance of 374,577 ft^2/day at an effective elevation of 3,150.4 feet. AMEC Model 2 has a drain conductance of 23,862 ft^2/day at an elevation of 3,100 feet and a drain conductance of 357,756 ft^2/day at an elevation of 3,148 feet. In this model, the Rangen spring discharge is represented by an effective conductance of 381,618 ft^2/day at an effective elevation of 3,145.0 feet. The effective response to a unit change in head in Dr. Brendecke's alternative models is only 9-11% lower than in ESPAM2.1, contradicting Mr. Hinckley and Dr. Brendecke's assumptions that the ESPAM2.1 drain conductance value is unreasonable.

Brendecke (2012) said that the predictive uncertainty analysis of ESPAM2.1 carried out by IDWR explores only a limited aspect of model uncertainty, and that conceptual model uncertainty is fundamental to overall model uncertainty. Dr. Brendecke presents two alternative conceptual models, AMEC Model 1 and AMEC Model 2, which he uses to explore conceptual model uncertainty. Dr. Brendecke asserts that these alternative models better represent local conditions in the vicinity of Rangen through the following modifications to ESPAM2.1:

1. A horizontal flow barrier was added to represent a geologic discontinuity between the Rangen spring complex and the Tucker spring complex.
2. The Rangen spring complex was represented by two drains. The lower drain was assigned an elevation of 3,100 feet in both alternative models. The upper drain was assigned an elevation of 3,152 in AMEC Model 1 and 3,148 feet in AMEC Model 2.
3. General Head Boundaries assigned to four cells along the Hagerman rim were removed.
4. In AMEC Model 2, the calibration weights for Rangen spring discharge observations after the year 2000 were increased to encourage the model to concentrate on matching those observations at the expense of earlier observations.
5. Water level data from an additional well were added to the calibration targets.

IDWR staff note that several of the conceptual model decisions implemented in ESPAM2.1, including the use of a single drain with an elevation based on Covington and Weaver (1990), the assignment of General Head Boundaries to model cells along the Hagerman Rim, and calibration weights were discussed with the ESHMC. Items 2 and 5 could likely be implemented in calibration of future versions of ESPAM if proposed to the ESHMC for consideration. Item 4 is an inappropriate change. Encouraging the model to match observations during a particular time period at the expense of other time periods results in a poorer representation of physical conditions. Items 1 and 3 are based on subjective geologic interpretations that would need to be presented to the ESHMC for review and discussion.

Dr. Brendecke evaluates the calibration quality of his alternative models by comparing the model and observed values for only three calibration targets, the Rangen spring complex discharge and aquifer head elevation in two wells. IDWR staff did not perform an extensive review of the alternative models, but did note that the contributions to the objective function shown in Dr. Brendecke's calibration files indicate both AMEC models had a poorer match to observed discharges at the nearby Three/Weatherby springs complex. These files and Dr. Brendecke's Figure 6.4b indicate that the improved match to the last eight years of observed Rangen complex discharge in AMEC Model 2 was achieved at the expense of the overall match to discharge observed during the other 20 years of the ESPAM2.1 simulation period. The contribution of residuals at the Rangen spring complex to the objective function is approximately 60% larger in AMEC Model 2 than in ESPAM2.1.

On pages 6-7 and 6-8, Dr. Brendecke explores the conceptual model uncertainty by performing analyses of curtailment of junior groundwater use within an area defined by a 10% trimline using AMEC Model 1 and AMEC Model 2. IDWR staff analyses indicate that Dr. Brendecke overstates the uncertainty illustrated by these alternative models for several reasons:

1. It appears that Dr. Brendecke did not use the correct 10% trimline in his analysis performed with ESPAM2.1. AMEC's model files show that pumping was applied in model cells 1041014 and 1043013, which both have steady state response functions of 9.53% with respect to the Rangen spring complex. IDWR analysis using ESPAM2.1 indicates that the response to curtailment within the 10% trimline, which only consists of four model cells (a four-square-mile area), is negligible (0.01 cfs) because the simulated curtailment volume is negligible.
2. It appears that Dr. Brendecke did not use the correct 10% trimline in his analysis performed with AMEC Model 1. AMEC's model files show that pumping was applied in model cell 1041014, which has a steady state response function of 9.74% in AMEC Model 1.
3. An analysis of model uncertainty should be performed by comparing responses to the same stress. Dr. Brendecke uses a different stress file in each of his three simulations, with total stress applied ranging from 0.1 to 2.0 cfs. This comparison does not illustrate uncertainty in the ESPAM2.1 MODFLOW model; it illustrates uncertainty in delineating the area subject to curtailment. In Dr. Brendecke's example, mistakes in delineating the 10% trimline appear to be the primary source of the uncertainty cited by Dr. Brendecke on pages 6-7 and 6-8.
4. IDWR compared model predictions made by AMEC's alternative models with ESPAM2.1 predictions applying consistent stress files. Table 3 shows the results of these comparisons, which indicate that the predictions made by AMEC's alternative models are very similar to predictions made by ESPAM2.1.

Curtailed area	**ESPAM2.1 prediction (cfs)**	**AMEC Model 1 prediction (cfs)**	**AMEC Model 2 prediction (cfs)**
Model extent	17.9	18.5	18.0
Four cells in ESPAM2.1 10% trimline for Rangen	0.01	0.01	0.01

Table 3. IDWR comparison of predicted responses at the Rangen spring cell to curtailment junior to July 13, 1962 using ESPAM2.1 and AMEC's alternative models.

The results shown in Table 3 indicate that the conceptual model changes implemented by Dr. Brendecke in AMEC Model 1 and AMEC Model 2 did not significantly affect the prediction of responses to curtailment within a given area. For the model extent, the responses predicted by AMEC's alternative models were slightly (0.6% to 3.5%) larger than those predicted by ESPAM2.1. For the area delineated by the four cells in the ESPAM2.1 10% trimline for the Rangen spring cell, the response is negligible using all three models.

Brendecke (2012) said that ESPAM2.1 mischaracterizes the physical relationship between water levels and flows at Rangen, resulting in over-sensitivity of the change in drain flow to a simulated change in water level due to curtailment. Dr. Brendecke asserts that changes in spring flows are over-predicted by nearly a factor of 4 (page 1-6 and 4-9). IDWR staff disagree with this conclusion. Dr. Brendecke compares the calibrated drain conductance in ESPAM2.1 with the relationship between the discharge of Curren Tunnel and water level in a monitoring well located about 600 feet east of the Rangen spring complex (Hinckley, 2012, Figure 18). This is not a valid comparison because the ESPAM2.1 drain conductance is calibrated to the total discharge of the Rangen spring complex, not the discharge from Curren Tunnel, and because the data available for the comparison in Hinckley (2012) only represent a limited time period between August 2008 and January 2012. These data do not represent the range of responses included in the calibration data set for ESPAM2.1, which extended from May 1985 to October 2008. Further, simulations performed with Dr. Brendecke's alternative models, which he asserts better characterize the physical relationship between water levels and flows at Rangen, provide similar predictions to ESPAM2.1 (Table 3).

Dr. Brendecke also concludes that the representation of the Rangen spring complex as a single drain with an elevation of 3,138 feet and ESPAM2.1's over-prediction of spring complex discharge in recent years result in over-prediction of responses to curtailment. Dr. Brendecke explored these issues in his alternative models AMEC Model 1 and AMEC Model 2. As shown previously in Table 3, analyses performed using these alternative models predict responses similar to ESPAM2.1. In simulations of curtailment of junior groundwater pumping over the model extent, Dr. Brendecke's alternative models predict slightly larger responses, even in AMEC Model 2, which concentrated on matching Rangen spring discharge observations after the year 2000. These results contradict Dr. Brendecke's conclusion.

Brendecke (2012) compares the area encompassed by a 5% trimline to the Rangen spring complex in ESPAM2.1 to ESPAM2.0, and concludes that the ESPAM2.1 5% trimline has expanded to include areas "*on the opposite side of the Malad Gorge from Rangen, which are hydrogeologically disconnected from Rangen Spring*." IDWR disagrees with Dr. Brendecke's assertion that this is "*evidence of unexpectedly large changes in ESPAM2.1*" for two reasons. First, the changes in the delineation of a 5% trimline are the result of response functions in cells changing from slightly less than 5% (4.822% to 4.997%) in ESPAM2.0 to slightly greater than 5% (5.0004% to 5.118%) in ESPAM2.1. Stresses applied in areas outside the 5% trimline will still result in a response at the Rangen spring complex; the response will be less than 5%, but will not be zero. Second, the area on the opposite side of the Malad Gorge is hydraulically connected to the Rangen spring complex via the ESPA aquifer to the east of Malad Gorge. This is acknowledged by Hinckley (2012), who notes that, "*If the aquifer is severed by the gorge…any impacts to groundwater levels on the north side can only be communicated to the south side via the continuously saturated portions of the primary aquifer further east, or through the lower aquifer*…" IDWR staff analyses also indicate that the predicted response at the Rangen spring complex to curtailment within the area delineated by the ESPAM2.1 5% trimline is 3.35 cfs, nearly identical to the prediction calculated using ESPAM2.0.

On page 4-11, Brendecke (2012) states that ESPAM2.1 is "*called upon to represent highly localized conditions such as those governing discharge from specific outlets of a specific spring complex*." IDWR staff would like to clarify that ESPAM2.1 does not represent specific spring outlets. In no case does it represent or predict discharge at a scale smaller than a one-square-mile model cell. In the case of the Rangen spring complex, which is the only spring complex in its model cell, ESPAM2.1 is calibrated to the total discharge of the spring complex. It is not calibrated to, and cannot predict discharge from specific outlets within the spring complex.

Brendecke (2012) concludes that ESPAM2.1 is a linear representation of a non-linear physical system. IDWR staff agree with this conclusion and acknowledge that ESPAM2.1, like all models, is an approximation of the physical system. Although there is uncertainty associated with using a model to approximate a physical system, it is the opinion of IDWR staff that ESPAM2.1 is the best available scientific tool for predicting the response at the Rangen spring complex to regional curtailment of groundwater. Based on IDWR's analyses, ESPAM2.1 predicts a response of 17.9 cfs to curtailment within the model boundary, 16.9 cfs to curtailment within the area of common groundwater supply, and 0.01 cfs to curtailment within the area delineated by a 10% response function. While there is uncertainty in these predictions, it is likely that the response to curtailment within the model boundary or the common groundwater area will be a measurable amount of water, and that the response to curtailment in an area delineated by a 10% response function will be a negligible amount of water.

Brendecke (2012) concludes that ESPAM2.1 predicts a benefit of 0.19 cfs will accrue to the Rangen spring complex if a 10% trimline is applied. IDWR analyses indicate that Dr. Brendecke did not use the correct area for the 10% trimline, and that the predicted benefit using ESPAM2.1 is 0.01 cfs if a 10% trimline is applied. Review of Dr. Brendecke's model files also indicates that he applied a stress equal to total pumping, rather than applying a stress equal to the crop irrigation requirement or net pumping. Total pumping includes some water that is pumped from wells, but is returned to the aquifer as recharge. IDWR staff recommend modeling a stress equal to the crop irrigation requirement to represent the long term effects of groundwater use. IDWR staff also note that delineation of a trimline based on response functions for the Rangen spring complex is a direct application of ESPAM2.1-predicted responses at the Rangen spring cell, which Dr. Brendecke argues are unreliable predictions. If, as argued by Dr. Brendecke, ESPAM2.1 "*cannot be relied upon to accurately predict changes in flow at Rangen*" because it is a regional model then it would be more appropriate to use predictions of steady state response functions for the Buhl to Lower Salmon Falls reach, as suggested by Contor (2012a).

On pages 1-2, Table 5.2 and Table 6.1, Brendecke (2012) asserts that less than 3% of the curtailed groundwater rights within a 10% trimline would accrue to the Rangen spring complex. IDWR staff disagree with this statement. By definition, a 10% trimline is the area within which 10% or greater of the effect of an applied stress will accrue to the Rangen spring complex. In Tables 5.2 and 6.1, Dr. Brendecke compares the change in flow at the Rangen complex to a typical maximum water right diversion rate of 0.02 cfs per irrigated acres. The maximum diversion rate is considerably greater than the actual curtailed groundwater use. Dr. Brendecke should have compared the change in flow at the Rangen complex to the curtailed groundwater use in the fourth column of Table 5.2 and fifth column of Table 6.1. The resulting increase as a percentage of the curtailed groundwater use for Dr. Brendecke's simulations is 10.5% for his ESPAM2.1 simulation, 10.8% for his Alternative Model #1 simulation, and 11.6% for his Alternative Model#2 simulation. IDWR's analysis performed using ESPAM2.1 with the correct 10% trimline indicates that the response at Rangen is 12.8% of the curtailed groundwater use.

On page 1-7, Dr. Brendecke quantifies the effects of curtailing all junior groundwater irrigation within the model domain as modeled by ESPAM2.0. Dr. Brendecke provides an incorrect value for the volume of curtailed consumptive use and did not update the results using ESPAM2.1. IDWR's analyses with ESPAM2.1 indicate that there are approximately 565,026 acres within the model domain irrigated with groundwater rights junior to July 13, 1962. The estimated consumptive use (net withdrawal from the aquifer) associated with this irrigation is 1.24 MAF per year. At steady state, ESPAM2.1 predicts curtailment will result in an increase of 17.9 cfs at the Rangen spring complex. The model predicts that it will take approximately 13 years for the response to reach 90% of the steady state increase.

On page 4-10, Brendecke (2012) states that the comparison of ESPAM2.1 with ESPAM1.1 performed by IDWR "*highlights the sensitivity of ESPAM2 results to conditions in particular years*." This is not a valid interpretation of the results. Changes in estimates of irrigated acreage between ESPAM1.1 and 2.1 are the result of improvements in GIS technology and methodology used to delineate irrigated lands, not sensitivity to conditions in particular years. Changes in estimates of crop irrigation requirements result largely from changing from 1971-2000 average precipitation used with ESPAM1.1 to a November 1998 to October 2008 average precipitation with ESPAM2.1. The 1971-2000 period used to estimate precipitation with ESPAM1.1 curtailment simulations resulted in estimates of precipitation higher than the long term average from 1934 through 2008. Average precipitation from the 1998-2008 period used with ESPAM2.1 curtailment simulations is closer to the long term average.

On page 4-13, Brendecke (2012) claims that the IDWR predictive uncertainty analysis "*assumed that pumping stress for entire Water Districts could be applied at the centroids of each District without loss of accuracy*." IDWR staff would like to clarify that IDWR did not make such an assumption. The predictive uncertainty analysis was not intended to model the impacts of Water Districts on spring discharge or reach gains. The centroids of Water Districts were used to select representative points for the analyses that were distributed throughout the model domain in areas where irrigated lands are present.

On page 4-14, Brendecke (2012) states "*While it is clearly an improvement over its predecessor, several important features are the same in ESPAM1.1 and ESPAM2.1. The two are still conceptually the same regional model. Differences between them are largely the result of differences in input data and in values of calibration parameters resulting from use of that input data. Both models represent the details of the Rangen spring complex and the surrounding geology in highly simplified form, omitting several key features that would make significant differences in predicted benefits of curtailment*." IDWR staff note the differences between these models' predictions of response to curtailment at springs tributary to Billingsley Creek are largely the result of the use of calibration targets in ESPAM1.1 that were not representative of discharge at springs tributary to Billingsley Creek and at Thousand Springs. The ESPAM2.1 calibration targets were a significant improvement over ESPAM1.1. ESPAM2.1 was also calibrated with more closely spaced transmissivity pilot points than ESPAM1.1, allowing more local-scale variation in transmissivity than ESPAM1.1. IDWR staff also note that Dr. Brendecke assumes that details not included in the ESPAM2.1 representation of the Rangen spring complex and surrounding geology "*would make significant differences in predicted benefits of curtailment*," but does not provide evidence supporting this statement. Dr. Brendecke's exploration of conceptual model uncertainty shows that the predicted benefits of curtailment at Rangen made by his alternative models are less than 3.5% different than the prediction made by ESPAM2.1.

On page 4-14, Brendecke (2012) states that curtailment of large amounts of junior groundwater pumping would results in water use conditions "*that are radically different from those extant in the model calibration period*." IDWR staff disagree with this statement. As shown in Figure 12, when the simulated curtailment volume is added to the 2002-2007 average annual net recharge, the net ESPA recharge is within the range of net recharge during the model calibration period and is closest to conditions that occurred in the late 1990s.

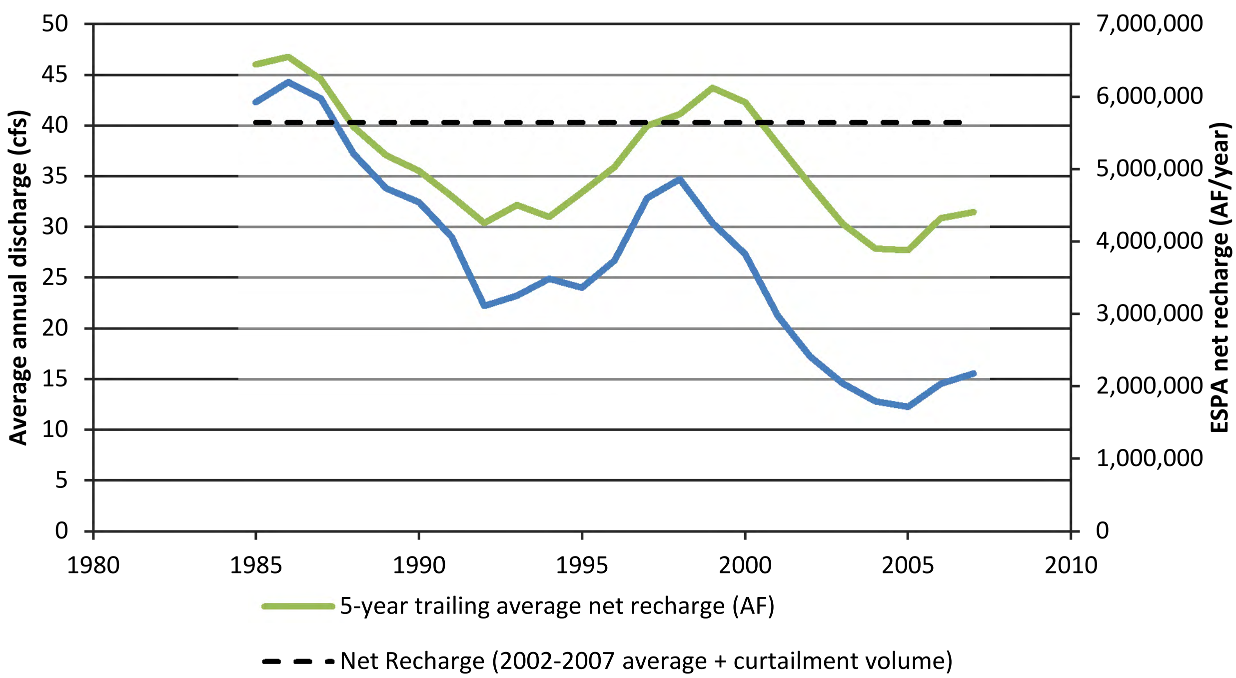


Figure 12. Comparison of net ESPA recharge during model calibration period and simulation of curtailment to July 13, 1962.

On page 5-1, Brendecke (2012) mentions that IDWR provided a superposition version of ESPAM2.1 and states that "*a superposition model can introduce significant error into the analysis of effects of stress changes*." IDWR staff note that the fully populated model files are also available to Dr. Brendecke and the public[5]. Dr. Brendecke could have simulated the curtailment using the fully populated version of the model to explore any potential difference in the prediction at the Rangen spring complex. IDWR staff explored the difference between predictions made using fully populated and superposition versions of ESPAM2.0 and found that there was not a significant difference in predicted responses to curtailment at the Rangen spring cell (Sukow, 2012c). Because the model structure and degree of model linearity did not change between ESPAM2.0 and ESPAM2.1, the conclusions of Sukow (2012c) apply to ESPAM2.1. IDWR staff did not perform the curtailment simulation for this water delivery call with the fully populated version, because IDWR staff are confident the predicted response would not be significantly different from the results of the superposition version.

On page 9, Church (2012) states, "*assuming a diversion rate of 0.02 cfs per acre, the curtailment of 479,200 groundwater irrigated acres would immediately eliminate beneficial use of 9,584 cfs. By this comparison, Rangen would receive less than two-tenths of 1% (0.0018) of the curtailed water*." IDWR staff disagree with Mr. Church's assumption that the curtailed use will be 0.02 cfs per acre, because this is the typical maximum authorized diversion rate. Mr. Church assumes that irrigators would be diverting the maximum diversion rate 24 hours per day, 7 days a week, 365 days per year and significantly overestimates their water use. The actual curtailed use would be significantly less. Attachment A shows IDWR's analysis of curtailment of 479,200 acres of junior groundwater irrigation within the current area of common groundwater supply. The volume of curtailed consumptive use would be approximately 1.09 MAF/year, an average rate of 1,509 cfs. ESPAM2.1 predicts that 16.9 cfs, which is approximately 1.1% of the curtailed use, would accrue to the Rangen spring cell.

IDWR staff comments regarding expert reports submitted on behalf of FMID

Contor (2012a, p. 5) states, "*The determination and application of a Deminimus* (sic) *effect is a policy question that will not be addressed in this report. The concept of uncertainty may be considered in making this policy determination, and uncertainty will be addressed. A Deminimus* (sic) *policy could be defined in terms of Capture Fraction, specifying a threshold fraction below which propagating effects are considered Deminimus* (sic)*. This is essentially the definition of a Trim Line which has been applied in administration of water calls using ESPAM1.1. The policy could also specify a threshold total volume or volume per time, below which effects are considered Deminimus* (sic)*. This is the concept that has been applied in use of ESPAM1.1 for water-right transfers. ESPAM2.0 can be operated to calculate either of these potential Deminimus* (sic) *thresholds*." IDWR staff agree that ESPAM2.1 can be used to calculate either of these types of de minimis thresholds, but do not recommend attempting to quantify model uncertainty to make a de minimis policy determination. As noted by Contor (2012a), model uncertainty is generally greater when smaller areas of the regional ESPA model are considered. Therefore, the uncertainty associated with predicting the response to curtailment within a small area defined by a trimline is likely to be greater than the uncertainty associated with predicting the response to curtailment throughout the ESPA. Further, uncertainty does not mean that it is uncertain whether or not there will be a response to curtailment, it means there is uncertainty in the magnitude of the

[5] http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/2012_ESHMC/11_9_2012/E121025A001_spresdsheets.zip/mudflow (last visited February 20, 2013.

response. As shown in the IDWR predictive uncertainty analysis (Wylie, 2012) and the alternative conceptual models developed by Brendecke (2012), ESPAM2.1 appears to do a good job of predicting whether or not curtailment will result in a measurable amount of water at a given spring or river reach.

On page 24, Contor (2012a) states "*The IDWR Predictive Uncertainty work indicates that the difference between two Calibrated ESPAM2.1-framework models can exceed 500% for some questions, though it is generally much smaller*." IDWR staff disagree with this statement. The IDWR Predictive Uncertainty work does not indicate predictive uncertainty exceeding 500%. Further, high percentage differences in predictive uncertainty are misleading in cases where the predicted response is small. For example, if ESPAM2.1 predicts a response of 0.02 cfs at a given location, and the alternative model calibration predicts a response of 0.04 cfs at the same location, the percentage difference would be 100%, but both models indicate that the response at that location is insignificant.

On page 24, Contor (2012a) state, "*For any particular questions, quantity uncertainty is probably at least in the range of the 17% result obtained from the water-budget analysis*." IDWR staff have not conducted a detailed review of Mr. Contor's analysis, but note that this range of uncertainty does not prevent the model from providing a useful prediction of whether or not curtailment will result in a measurable amount of water at a given spring or river reach. For example, if a range of $\pm$20% is applied to the ESPAM2.1 predicted responses to curtailment within the model domain, a response between 14.3 and 21.5 cfs would be expected at the Rangen spring cell and a response between 194 and 291 cfs would be expected at the Buhl to Lower Salmon Falls reach. Even with this range of uncertainity, the model tells us that a model-wide curtailment would result in a measurable amount of water at the Rangen spring complex and the Buhl to Lower Salmon Falls reach. The model also tells us that only a very small fraction (approximately 1%) of the benefit of a model-wide curtailment would accrue to the Rangen spring complex. The majority of the curtailed water use would benefit other springs and reaches of the Snake River.

On pages 5-6, Contor (2012a) presents results of simulating curtailment of groundwater use junior to July 13, 1962 within the Egin Bench area of the Freemont Madison Irrigation District. Mr. Contor used ESPAM2.0 to perform this analysis and did not update the analysis with ESPAM2.1. Mr. Contor estimated that curtailment of groundwater use within the Egin Bench would reduce pumping by 4,730 acre feet per year and that after 150 years, the cumulative benefit to the Buhl to Lower Salmon Falls reach would be 1.90 acre feet (0.04% of the curtailed use), in response to a single year of curtailment. It is not clear how Mr. Contor estimated the volume of curtailed use. Mr. Contor did not simulate continuous curtailment, thus this simulation does not represent conditions that would occur if these groundwater users were curtailed for multiple years in response to an ongoing spring delivery call. IDWR staff review indicates that steady state response functions in model cells containing points of diversion for FMID groundwater irrigation rights range from 0.004% to 0.05% with respect to the Rangen spring cell, and 0.05% to 0.78% with respect to the Buhl to Lower Salmon Falls springs. The average response function, weighted by irrigation diversion rate, is 0.04% with respect to the Rangen spring cell and 0.55% with respect to the Buhl to Lower Salmon Falls springs. This indicates that Mr. Contor's methods underestimate the fractional response to a continuous curtailment at the Buhl to Lower Salmon Falls reach by an order of magnitude. Although the steady state response predicted by

ESPAM2.1 at the Buhl to Lower Salmon Falls springs is not as small as indicated by Mr. Contor's analysis, it is still a small fraction of the curtailed use, with greater than 99% of the curtail use accruing to other reaches of the Snake River.

On pages 8 and 23, Contor (2012a) recommends that ESPAM2.1 not be used to predict responses at reaches smaller than the distances between nearby transmissivity pilot points. Figure 13 shows the ESPAM2.1 transmissivity pilot points in the vicinity of the Rangen spring cell and Buhl to Lower Salmon Falls reach. The Rangen spring cell is a one-square-mile model cell. The Buhl to Lower Salmon Falls reach is comprised of 24 model cells. The spacing between pilot points in the vicinity of the Buhl to Lower Salmon Falls reach is generally between two and four miles. If Mr. Contor's recommendation is applied, ESPAM2.1 would be used to predict the response at the Buhl to Lower Salmon Falls reach, because it is the smallest calibration reach that is greater than four miles in length.

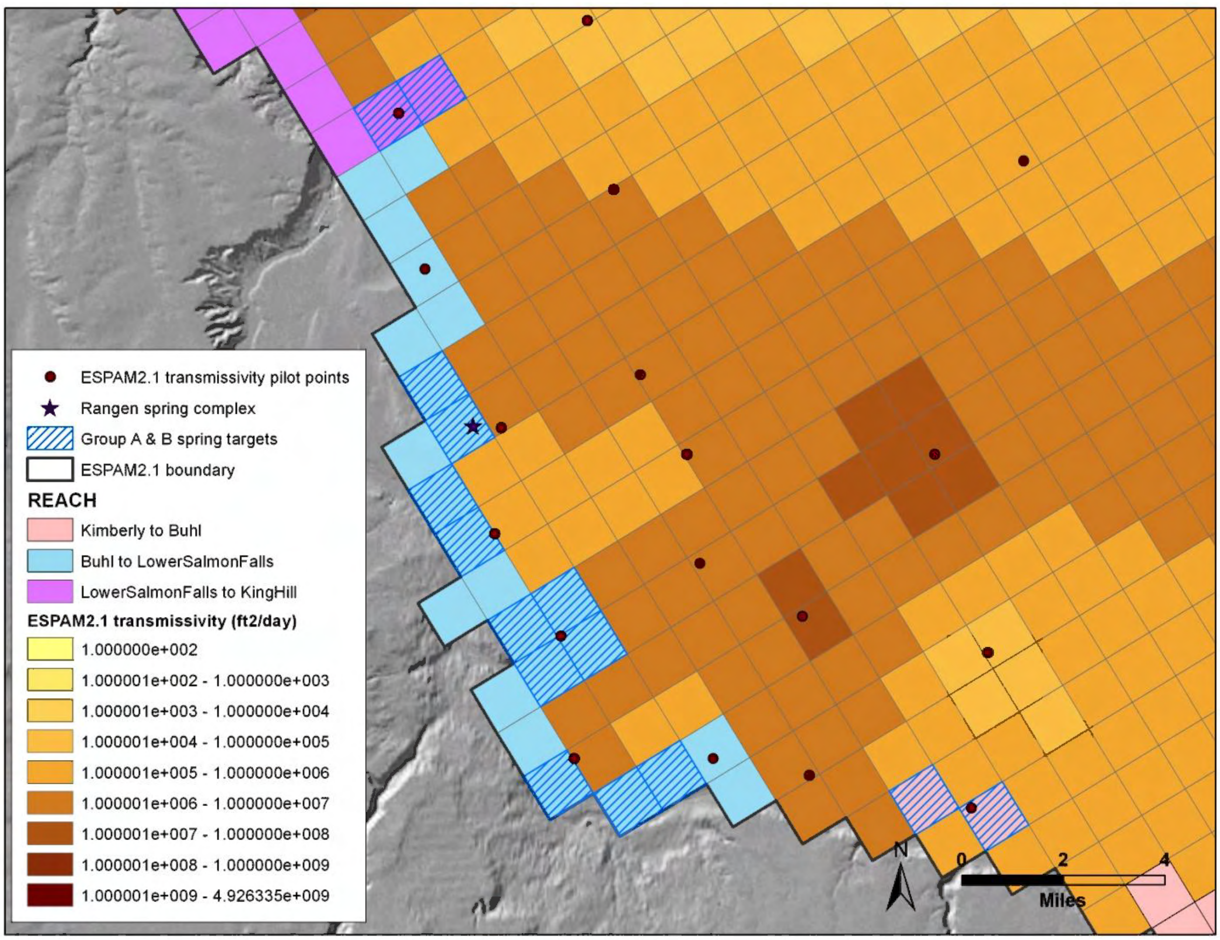


Figure 13. ESPAM2.1 transmissivity pilot points in the vicinity of the Buhl to Lower Salmon Falls reach.

Mr. Contor does not recommend a method for apportioning the ESPAM2.1-predicted response at the Buhl to Lower Salmon Falls reach to the Rangen spring cell, stating on page 6, "*However, no attempt has been made to apportion these benefits to individual diversions*." If Mr. Contor's recommendation is applied, a method for apportioning the reach benefit to spring cells would be needed to predict the response at the Rangen spring cell. In response to Mr. Contor's recommendation, IDWR staff performed analyses using ESPAM2.1 to predict the response at the Buhl to Lower Salmon Falls reach to curtailment of groundwater irrigation junior to July 13, 1962. IDWR analyses indicate that the response at the reach would be 242 cfs in response to curtailment within the entire model domain, 229 cfs in response to curtailment within the current area of common groundwater supply, and 198 cfs in response to curtailment within the area delineated by a 10% steady state response (Figure 14) and the area of common groundwater supply. Model results are provided in Attachment B.

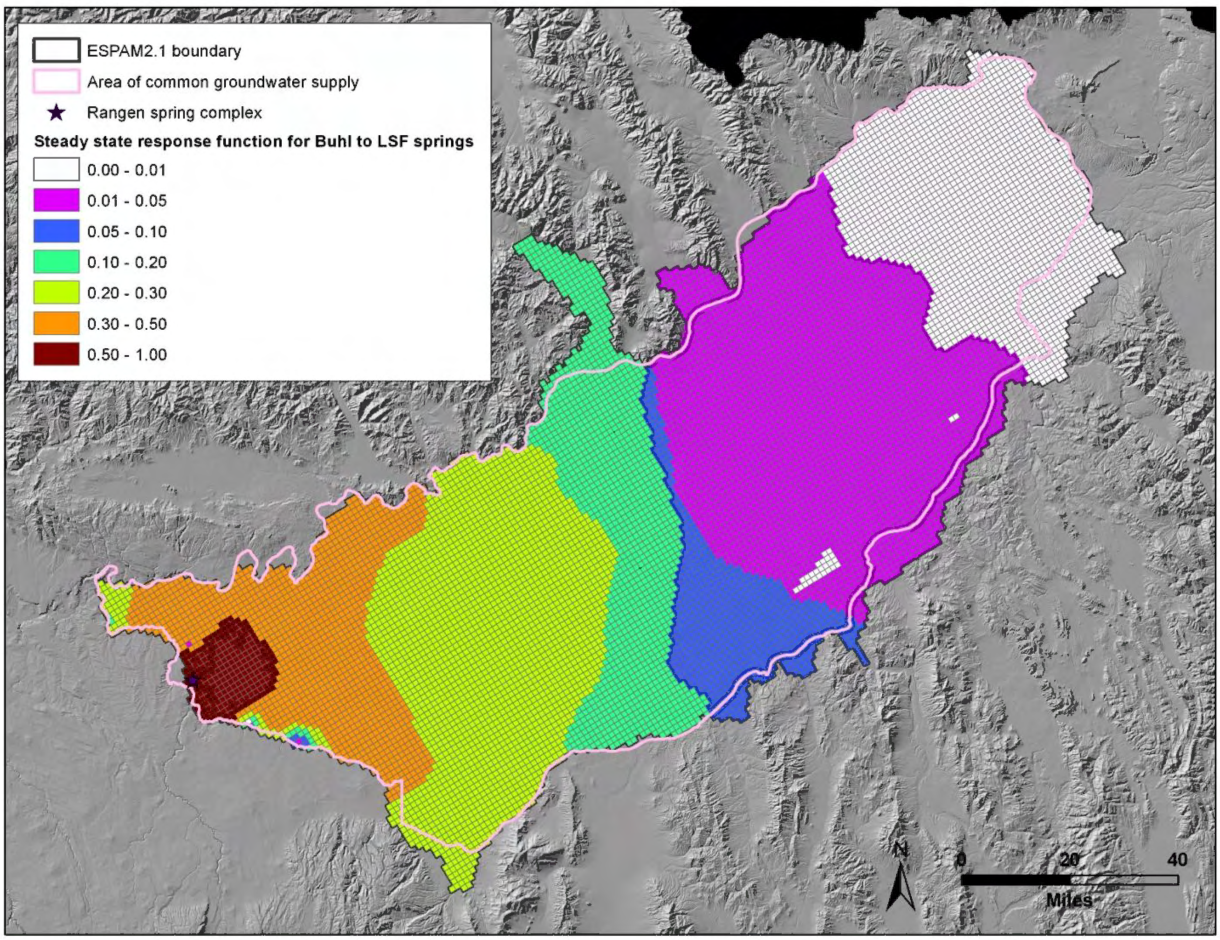


Figure 14. Steady state response functions indicating portion of curtailed use that would accrue to springs in the Buhl to Lower Salmon Falls reach.

IDWR staff considered two methods for apportioning the response at the reach to the Rangen spring cell. IDWR staff consider both of these methods to be inferior to using ESPAM2.1 directly to predict the response at the Rangen spring cell.

1. Use the Covington and Weaver ratio method previously used with ESPAM1.1 to apportion discharge to the Rangen spring complex. This method is identical to the method used with ESPAM1.1 except that the Covington and Weaver discharge values for Thousand Spring and the Three/Weatherby spring complex were updated[6]. Based on the Covington and Weaver discharge estimates of 35.5 cfs for the Rangen spring complex and 2,852 cfs for all spring in the reach, a ratio of 0.0124 was multiplied by the ESPAM2.1-predicted response at springs within the reach. This method results in a predicted accrual of 2.9 cfs at the Rangen spring complex in response to model-wide curtailment and 2.4 cfs in response to curtailment within a 10% trimline for the reach. This method is inferior to using the ESPAM2.1 prediction for the Rangen spring cell, because it considers fewer data than ESPAM2.1, neglects regional hydrogeologic conditions that are modeled in ESPAM2.1 at a scale smaller than the 24 cell reach, neglects the spatial distribution of aquifer recharge and discharge, and neglects the sensitivity of higher elevation springs to changes in aquifer head. Figure 15 illustrates how this method provides a poorer prediction of discharge at the Rangen spring complex than ESPAM2.1. Use of this method with ESPAM1.1 was necessary because the discharge data compiled for calibration of ESPAM2.1 were not available for use with ESPAM1.1. The additional data currently available allow development of better methods for predicting the response at the Rangen spring cell.

[6] See attribute field ESPAM2_cfs in http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/monitoring_data/Springs/Covington_Weaver_Spgs.zip/Covington_Weaver_Spgs.shp (last visited February 20, 2013).

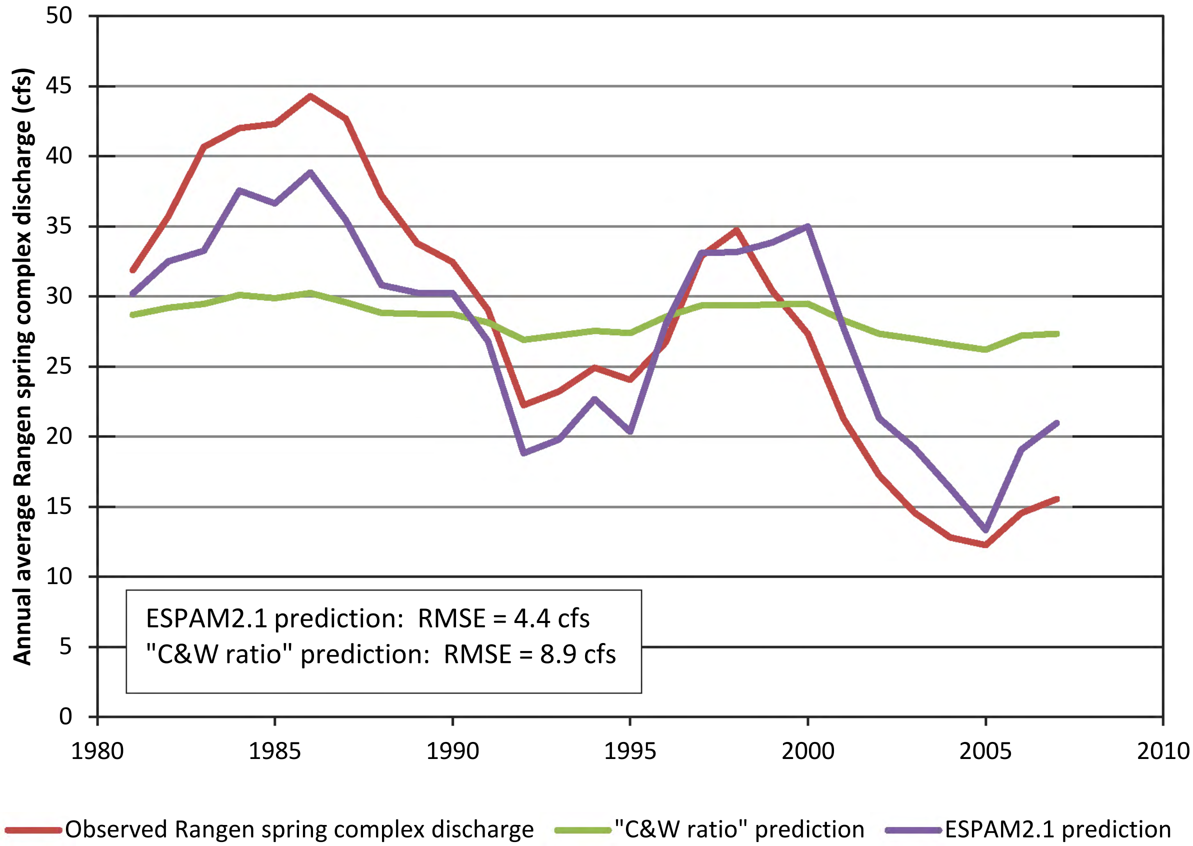


Figure 15. Comparison of Covington and Weaver ratio prediction method and ESPAM2.1 prediction of discharge at Rangen spring cell.

2. Use a linear regression of Rangen spring complex discharge with reach gain to predict change in Rangen spring discharge corresponding to the modeled change in reach gain (Figure 16). This method predicts a 0.028 cfs change in Rangen spring complex discharge per unit cfs change in reach gain, resulting in a predicted accrual of 6.8 cfs at the Rangen spring complex in response to model-wide curtailment and 5.5 cfs in response to curtailment within a 10% trimline for the reach. This method is inferior to using the ESPAM2.1 prediction for the Rangen spring cell, because it considers fewer data than ESPAM2.1, neglects regional hydrogeologic conditions that are modeled in ESPAM2.1 at a scale smaller than the 24 cell reach, and neglects the spatial distribution of aquifer recharge and discharge. This method is a slight improvement over the Covington and Weaver ratio method, because it incorporates some consideration of the sensitivity of higher elevation springs to changes in aquifer head. Figure 17 illustrates how this method provides a poorer prediction of discharge at the Rangen spring complex than ESPAM2.1, but a better prediction than the Covington and Weaver ratio method.

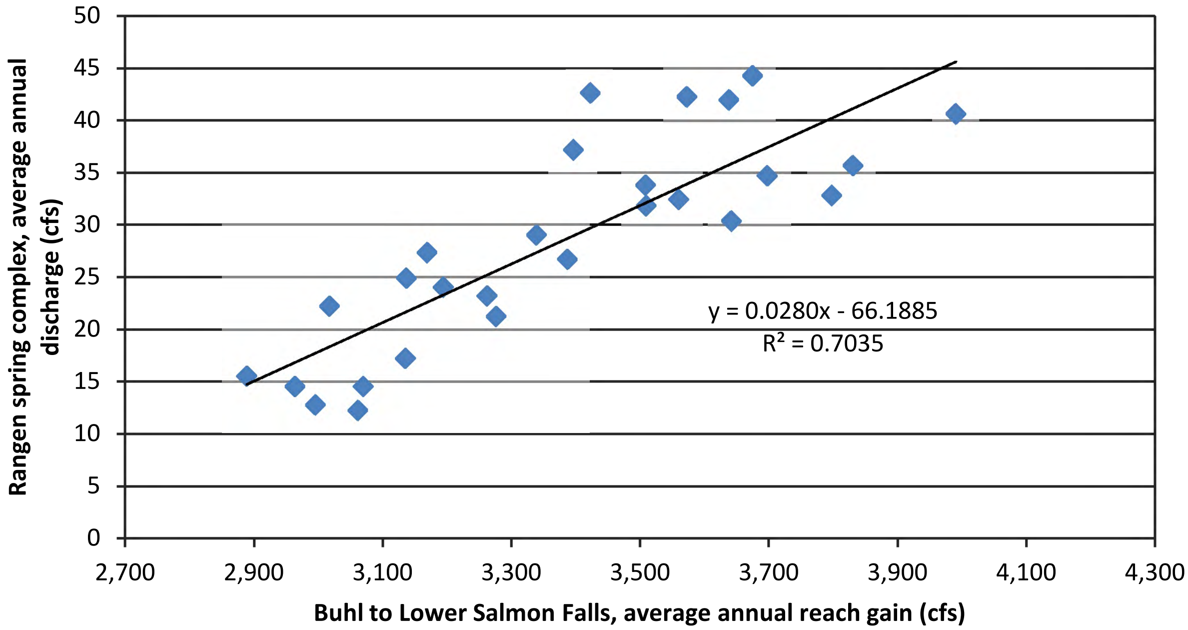


Figure 16. Linear regression of Rangen spring complex discharge with reach gain.

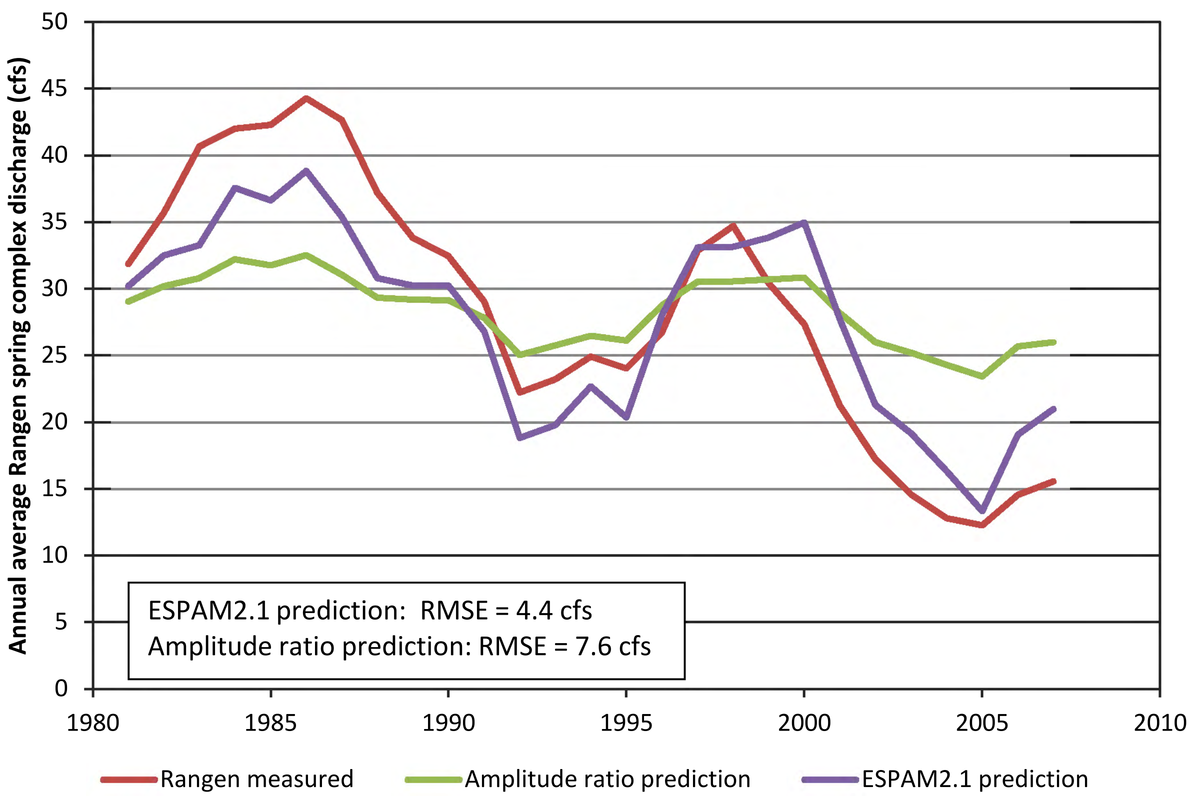


Figure 17. Comparison of amplitude ratio prediction method and ESPAM2.1 prediction of discharge at Rangen spring cell.

IDWR staff comments regarding expert reports submitted on behalf of the City of Pocatello

IDWR staff review indicates that ESPAM2.1 steady state response functions for model cells containing groundwater points of diversion for the City of Pocatello range from 0.37% to 0.47% with respect to the Rangen spring cell. Based on the response functions, IDWR staff agrees with Sullivan (2012) that curtailment of the City of Pocatello's groundwater use will result in a negligible increase in discharge at the Rangen spring complex. ESPAM2.1 predicts that more than 99.5% of the curtailed use would benefit other springs and reaches of the Snake River.

Sullivan (2012) provided a copy of the results of an IDWR analysis of the response at the Rangen spring cell to curtailment within various areas defined by steady state response functions. These analyses limited the area of curtailment to areas where the fraction of curtailed use accruing to the Rangen spring cell exceed values ranging from 0.2% to 10%. The results of the analyses performed by IDWR and submitted by Mr. Sullivan were calculated with ESPAM2.0 and were not updated using ESPAM2.1. IDWR staff updated these analyses with ESPAM2.1 in response to Mr. Sullivan's submittal. The results are provided in Table 4 and Figure 18. These results supersede the results presented by Mr. Sullivan in his Figure 8-4.

Area of curtailment[7]	Curtailed groundwater irrigation (ac)	ESPAM2.1 predicted response at Rangen spring cell (cfs)	Acres curtailed per cfs of benefit at Rangen spring cell (ac/cfs)
Model Boundary	565,026	17.89	31,591
Area Common Ground Water Supply (CGW)	479,203	16.94	28,296
CGW 0.2% trim line	257,673	16.15	15,956
CGW 1% trim line	160,389	14.55	11,022
CGW 1.5% trim line	154,270	14.32	10,774
CGW 1.7% trim line	108,543	11.84	9,167
CGW 2% trim line	67,093	9.31	7,210
CGW 3.5% trim line	26,694	5.71	4,678
CGW 5% trim line	12,346	3.35	3,689
CGW 10% trim line	24	0.01	1,868

Table 4. IDWR analysis of response to curtailment within various areas.

[7] Trim lines used to define the area of curtailment were delineated to include model cells where greater than a given percentage of the curtailed use will accrue to the Rangen spring cell. This method relies on ESPAM2.1 predictions of response at the Rangen spring cell. The area within the trim line was also clipped to exclude areas outside of the current area of common groundwater supply.

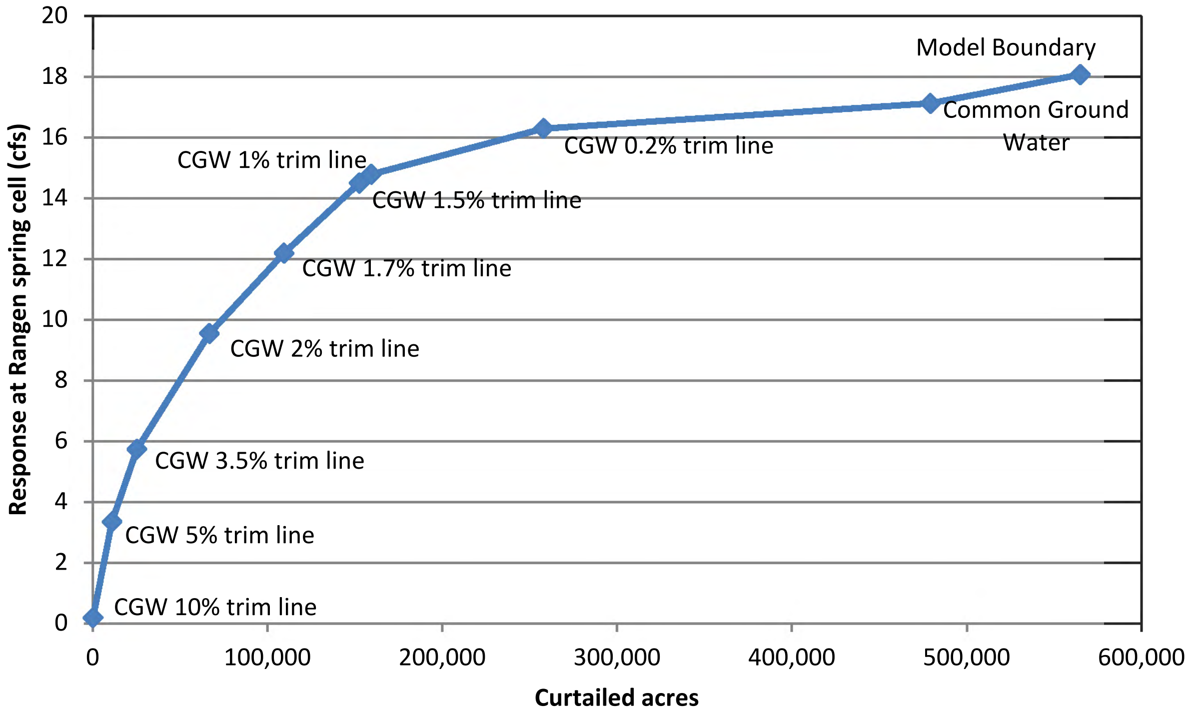


Figure 18. Comparison of predicted response and acres curtailed.

Summary of expert rebuttal reports

This section summarizes and responds to the following expert rebuttal reports submitted in the Rangen Delivery Call. No expert rebuttal reports were submitted on behalf of FMID.

1. Brockway, C.E., D. Colvin, and J. Brannon, 2013a. *Rebuttal Report in the Matter of Rangen, Inc. – Availability of Spring Flow and Injury to Water Rights*, prepared for Rangen, Inc., February 8, 2013.
2. Brockway, C.E., D. Colvin, and J. Brannon, 2013b. *Rebuttal Report by Bryce Contor in the Matter of Rangen, Inc. – Availability of Spring Flow and Injury to Water Rights*, prepared for Rangen, Inc., February 8, 2013.
3. Smith, C. E., 2013. *Rebuttal Expert Report in the Matter of Distribution of Water to Rangen, Inc's Water Right Nos. 36-02551 and 36-07694*, prepared for Rangen, Inc.
4. Green, G., 2013. *Rebuttal Report in the Matter of Distribution to Water Right Nos. 36-02551 and 36-07694*, prepared for Brody Law Offices, PLLC.
5. Brendecke, C.M., 2013. *Review of Expert Report in the Matter of Rangen, Inc. – Availability of Spring Flow and Injury to Water Rights by Charles E. Brockway, David Colvin, JimBrannon*, prepared for Racine, Olson, Nye, Budge, and Bailey, Chartered, February 8, 2013.

6. Hinckley, B., 2013. *Review of "Expert Report in the Matter of Rangen, Inc. – Availability of Spring Flow and Injury to Water Rights", December 20, 2012 by Charles E. Brockway, David Colvin, and Jim Brannon*, prepared for Racine, Olson, Nye, Budge, and Bailey, Chartered, February 8, 2013.
7. Rogers, T.L., 2013. *Rebuttal Report by Thomas L. Rogers,* prepared on behalf of the Idaho Ground Water Appropriators, Inc., February 8, 2013.
8. Sullivan, G.K., 2013. *Spronk Water Engineers, Inc. Expert Rebuttal Report in the Matter of Distribution of Water to Water Right Nos. 36-02551 and 36-07694 (Rangen, Inc.)*, prepared for the City of Pocatello, February 8, 2013.
9. Woodling, J.D., 2013. *Expert Rebuttal Report in the Matter of Distribution of Water to Water Right Nos. 36-02551 and 36-07694*, prepared on behalf of the City of Pocatello.

Summary of rebuttals on behalf of Rangen

Brockway et al. (2013a) respond to the expert reports submitted on behalf of IGWA by Brendecke (2012), Hinckley (2012), Rogers (2012) and the expert report submitted on behalf of the City of Pocatello by Sullivan (2012). Brockway et al. (2013a) "*assert that the water rights issued by IDWR for the Rangen facility and the administration of those define and treat the entire Range Spring as a single source*." Brockway et al. (2013a) reiterate their opinions that ESPAM2.1 is the best available scientific tool for evaluation of responses to changes is ESPA water use and that uncertainty analyses performed on ESPAM2.1 and other ESPA groundwater models do not support the use of the trimline proposed by Brendecke (2012).

Brockway et al. (2013a, p. 2) criticize the alternative conceptual models presented by Brendecke (2012), stating, "*Hypothetical interpretations of the Rangen Spring geology offered by IGWA consultants Hinckley and Brendecke are not justified and different conceptual models, as proposed by IGWA consultants, are incorrect*," and "*These expert reports can be characterized as a sudden reversal of a decade of open and collaborative ESPAM model development led by IDWR and with the cooperation and oversight of the members of the ESHMC, including Brendecke and Sullivan*." Brockway et al. (2013a, p. 17) also note that Dr. Brendecke's alternative models predict similar responses to curtailment at the Rangen spring complex and state, "*The similarities between the results from alternative models presented by Brendecke and results from ESPAM2.1 prove that ESPAM2.1 is a robust model. Even when inappropriate changes are made to the conceptualization of the model, it predicts virtually the same Rangen Spring response to full ESPA curtailment of junior ground water pumping*."

Brockway et al. (2013a) provide additional discussion of Rangen's water measurement methods and reiterates their opinion that historic flow measurements at the Rangen facility are accurate and adequate for the purposes for which they have been used, including calibration of ESPAM2.1. Brockway et al. (2013a) criticizes the Sullivan (2012, p. 6) analysis of Rangen's beneficial use and efficiency of water use, stating, "*This assumption reflects an un-familiarity with the operation of aquaculture facilities which require periodic harvesting and movement of stock within the facility which results in temporary non-use of specific raceways or rearing facilities*.

Brockway et al. (2013b) respond to the expert reports submitted on behalf of FMID by Contor (2012a, 2012b). Brockway et al. (2013b) criticize the Contor (2012a) analysis of model uncertainty, and disagree with Mr. Contor's conclusion that transmissivity uncertainty is approximately equal to water budget uncertainty. They also question how Mr. Contor calculated the 17% estimate of water budget uncertainty, and criticize statements made by Mr. Contor regarding the results of IDWR's uncertainty analysis.

Smith (2013) responds to expert reports submitted on behalf of IGWA by Church (2012) and Rogers (2012) and on behalf of the City of Pocatello by Sullivan (2012). Mr. Smith states that pumped water and reused water are less desirable than first use spring water because of dissolved oxygen concentrations, concentration of waste, and potential failure due to loss of power. Mr. Smith asserts that the hatcheries using pumped water and recycled water mentioned by Rogers (2012) are federal or state hatcheries that do not have to make a profit to operate. Mr. Smith asserts that pumped water is too unreliable for large commercial hatcheries and that recirculation hatcheries are subject to catastrophic losses of fish to pumping failures, nitrite toxicity and disease outbreaks such as infectious hematopoietic necrosis (IHN). Mr. Smith submitted a copy of an expert report submitted by John R. MacMillan on behalf of Clear Springs Foods in a previous proceeding and stated that he is in general agreement with Dr. MacMillan's report. Smith (2013) also discusses errors in calculations presented by Rogers (2012).

Smith (2013) reiterates his conclusions that the flow indices and density indices used by Rangen for the purpose of raising fish for Idaho Power Co. are reasonable, the Rangen hatchery is currently beneficially using all available water and not wasting water, and that the hatchery could use more water to raise fish if it was available.

Green (2013) responds to Church (2012) and states, "*My opinion of Mr. Church's analysis is that his analysis is incomplete and inaccurate*." Mr. Green states that Idaho farm raised trout is a multi-million dollar business and that Idaho trout production capacity is a substantial portion of the U.S. total trout production, and that the U.S. trout producing industry is not in decline. Mr. Green criticizes Mr. Church's assertion that Rangen should use their own money to make efforts to remedy a problem caused by junior groundwater pumping. Mr. Green concludes, "*Ronald Coase, a Nobel Prize winning economist, suggests the persons' imposing an externality, ground water farmers, on other property owners, Rangen, can and should compensate the damaged party, Rangen*."

Summary of rebuttals on behalf of IGWA

Hinckley (2013) responds to Brockway et al. (2012). Mr. Hinckley reiterates his opinion that ESPAM2.1 does not adequately represent aquifer geometry and hydrogeologic conditions in the area of the Rangen spring complex. Mr. Hinckley also reiterates his opinion that Rangen should obtain additional water by constructing a vertical well in the ESPA, or by developing another horizontal tunnel below Curren Tunnel.

Brendecke (2013) responds to Brockway et al. (2012) and reiterates his opinions that ESPAM2.1 is a regional model that cannot be relied upon to accurately predict effects at Rangen from curtailment of junior groundwater rights, that Rangen consistently underestimates available flows, that Rangen could pump additional water to its small raceways, and that Rangen should make improvements to Curren Tunnel or construct a vertical well. Dr. Brendecke states that the Brockway et al. (2012) simulation of curtailment throughout the model domain ignores the statutory definition of the area of common groundwater supply, and that "*delivery of less than 1% of the curtailed use to the calling water right constitutes a waste of water by any reasonable definition*."

Rogers (2013) responds to Smith (2012), Brockway et al. (2012), and Sullivan (2012) and reiterates his opinions that Rangen does not maximize fish production, is not using water efficiently, and is wasting water currently available to the hatchery. Mr. Rogers also reiterates his opinion that Rangen should consider pumping systems, reuse of water, and developing new wells to enhance flows.

Summary of rebuttals on behalf of the City of Pocatello

Sullivan (2013) responds to Brockway et al. (2012) and Smith (2012). Mr. Sullivan provides a detailed discussion regarding the accuracy of Rangen flow measurement procedures and concludes that "*significant under-measurement of the flows during the calibration period calls into question the model calibration to the Curren spring flows, and would likely require that the model be re-calibrated*." Mr. Sullivan points out that he and Chuck Brendecke qualified the ESHMC recommendation for ESPAM2.1 with "*although other tools or models may be more appropriate in certain circumstances*." Mr. Sullivan argues that Rangen has not shown material injury and states, "*No data or analyses were provided to support the opinion that Rangen would increase fish production with additional flow*," and, "*An overarching implication in the Brockway Report is that depletions predicted by the ESPAM2.1 model from junior ground water users equals injury. This is not how the prior versions of the ESPAM have been used in delivery calls. Only after it has been proven that a senior water user is suffering material impacts due to water shortages…has the Department used the ESPAM to assess the magnitude of the shortage…*"

IDWR staff comments regarding rebuttals on behalf of Rangen

On page 4, Brockway et al. (2013a) state "*The best estimate of the impact of junior groundwater pumping on Rangen spring is the unmodified output from ESPAM2.1. Utilization of a trimline of any percentage magnitude, justified by an unsubstantiated estimate of ground water model uncertainty, arbitrarily limits the true hydraulic impact of junior pumping and is not hydraulically or statistically supported. There has never been an uncertainty analysis performed on ESPAM2.1 or any ESPA ground water model to support the use of a trimline as currently configured*." IDWR staff agree that ESPAM2.1 provides the best prediction of the impact of junior groundwater pumping on spring discharge in the Rangen spring cell. This conclusion applies both to the ESPAM2.1-predicted response to model-wide curtailment and to the ESPAM2.1-predicted steady state response functions. These response functions provide the best prediction of the percentage of curtailed groundwater use that would accrue to the Rangen spring cell, and the percentage of curtailed use that would accrue to other springs and reaches of the Snake River. This information can be used to delineate a trimline, if the Director finds it is not appropriate to curtail groundwater users if less than a certain percentage of their curtailed use would accrue to the Rangen spring cell.

On page 14, Brockway et al. (2013a) provide results of curtailment simulations performed using the alternative models presented by Brendecke (2012). Their results are identical to those obtained by IDWR and presented previously in the section "IDWR staff comments regarding submittals on behalf of IGWA".

On page 15, Brockway et al. (2013a) provide a table of response functions for seven model cells in the Rangen area. Their results are identical to those obtained by IDWR and discussed previously in the section "IDWR staff comments regarding submittals on behalf of IGWA".

IDWR staff comments regarding rebuttals on behalf of IGWA

On page 1, Hinckley (2013) asserts that ESPAM2.1 represents the aquifer "*as a single, 4,000-ft. thick layer*". IDWR staff disagree with this comment. ESPAM2.1 represents the aquifer using time-constant transmissivity. Transmissivity, which is the product of hydraulic conductivity and saturated thickness, is adjusted during model calibration to obtain the best fit to observed data. Neither hydraulic conductivity nor saturated thickness is explicitly represented in the ESPAM2.1, and their individual contributions to transmissivity are not relevant in a time-constant transmissivity model.

On page 1, Hinckley (2013) asserts that "*characterization of aquifer geometry is important*" and that ESPAM2.1 "*models the aquifer as being laterally continuous in all directions from the Rangen discharge points*." IDWR staff disagree with Mr. Hinckley's assertions that ESPAM2.1 ignores aquifer geometry and represents the aquifer as laterally continuous in all directions. ESPAM2.1 models the aquifer geometry and the geometry of spring discharge locations along the Snake River and Hagerman rims within the constraints of a one-square-mile model grid. While the ESPAM2.1 representation does not allow delineation of details smaller than one mile, it does provide a better representation of aquifer geometry than other available models or predictive methods.

Hinckley (2013) discusses water levels in Well No. 797 on pages 5-6 and in Figure 2. He inappropriately compares the slope of a linear regression of data collected only in the 2000s with the linear slope of water levels modeled by ESPAM2.1. It is not appropriate to use data collected only in the 2000s to evaluate ESPAM2.1, which was calibrated to data collected between 1985 and 2008. The data collected in the 2000s represents a period of relatively low net ESPA recharge, and do not reflect the range of conditions that occurred between 1985 and 2008 or the volume of net ESPA recharge that would occur if groundwater pumping junior to 1962 was curtailed. As shown previously in Figure 12, curtailment of groundwater pumping junior to 1962 would result in net ESPA recharge similar to the late 1990s. Further, IDWR staff disagree with the use of Well No. 797 by both Brockway et al. (2012) and Hinckley (2013) for prediction of impacts at the Rangen spring complex. This well is located approximately 6.5 miles north of the Rangen spring complex and has a significantly different spatial relationship to junior irrigated lands in this area. Well No. 989 would be a more appropriate well to use for prediction of impacts at the Rangen spring complex, as discussed previously in the section "IDWR staff comments regarding submittals on behalf of IGWA."

Hinckley (2013) discusses water levels in Well No. 991 on page 6 and in Figures 3a and 3b. This well was not used to calibrate ESPAM2.1, because water levels and the well driller's report indicate that it is not completed in the ESPA. The maximum water level elevation in this well is approximately 3,007 feet, more than 80 feet lower than the elevation of Spring Creek Spring, which is the lowest elevation spring in the same model cell. This well is not included in the shapefile, Wells.shp[8], which shows the wells used as calibration targets. Water level measurements for this well are included in the spreadsheet ESPAM2_ESPAM21.xlsm[9], but all measurements are weighted zero, indicating that they were not used to calibrate the model.

On page 2-2, Brendecke (2013) compares historic measurements of 50 cfs in April 1902 and 96 cfs in September 1917 and suggests the difference between these measurements may be seasonal variation in discharge from the Rangen spring complex. As previously discussed in response to Brockway et al. (2012), IDWR staff review of these historic records indicates that these measurements were likely collected at two different locations along Billingsley Creek, and it is likely both measurements include more than just the discharge from the Rangen spring complex.

On page 4-1, Brendecke (2013) states, "*There is nothing in the Department's report on this comparison that attributes the increase in curtailed consumptive use to 'increased confidence in model inputs and calibration targets'. Most changes in model inputs were associated with extension of the model period and disaggregation to monthly stress periods. The curtailment difference is largely due to the use of different time periods to represent current conditions*." This statement does not reflect the conclusions presented by IDWR in Sukow (2012a), which stated that most of the increase in junior irrigated land area resulted from improvements in GIS methods used to delineate irrigation lands. Sukow (2012a) also stated that changes in estimates of crop irrigation requirements result largely from changing from 1971-2000 average precipitation used with ESPAM1.1 to a November 1998 to October 2008 average precipitation with ESPAM2.1. The 1971-2000 period used to estimate precipitation with ESPAM1.1 curtailment simulations resulted in estimates of precipitation higher than the long term average from 1934 through 2008. Average precipitation from the 1998-2008 period used with ESPAM2.1 curtailment simulations is closer to the long term average.

On page 4-2 and Table 4.1, Brendecke (2013) states that differences between ESPAM2.0 and ESPAM2.1 predictions of responses to curtailment differed by up to 30%. IDWR staff note that the prediction which changed by up to 30% was the prediction of the response at the Ellison spring cell, which is a Group C spring and had an insignificant response (0.115 cfs in ESPAM2.0 and 0.162 cfs in ESPAM2.1).

[8] Available at
http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/2012_ESHMC/11_9_2012/E121025A001_spresdsheets.zip in the gis folder (last visited February 20, 2013).

[9] Available at
http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/2012_ESHMC/11_9_2012/E121025A001_spresdsheets.zip (last visited February 20, 2013).

Model calibration with respect to Group C springs is not well constrained, because the Group C springs do not have transient calibration targets. The difference between the ESPAM2.0 and ESPAM2.1 predictions of response at the Rangen spring cell was only approximately 1%, suggesting that the Group B transient target for the Rangen spring cell adequately constrains model calibration with respect to the Rangen spring cell.

On page 4-3, Brendecke (2013) states, "*seasonal water level fluctuations and predicted water level changes (due to curtailment) are nearly 100% of the saturated thickness above the Tunnel and about 10% of the thickness above the lower springs at Rangen."* He states that the use of time-constant transmissivity in ESPAM2.1 was not justified. As stated in the ESPAM2.1 final report (IDWR, 2013), "*The generally considerable saturated thickness of the ESPA supports a time-constant representation of transmissivity, because drawdown is generally expected to be less than 10% of total saturated thickness (Anderson and Woessner, 1992)*." Note that this guideline applies to water level change as a percentage of the total saturated thickness, which Dr. Brendecke acknowledges is about 10%. The portion of the saturated thickness that is above the tunnel elevation is not relevant, because the tunnel is not located at the base of the aquifer. The conditions described by Dr. Brendecke are at the limit of the standard cited in IDWR (2013), but do not exceed this standard.

On page 4-3, Dr. Brendecke asserts, "*The curtailment scenario discussed by Rangen represents a 'new distribution of stress' as described by Reilly (1987)*." As shown previously in Figure 12, curtailment of groundwater use junior to 1962 would result in net ESPA recharge within the range that occurred during the model calibration period. Because the model is calibrated using net recharge, not the groundwater pumping portion of net recharge, the comparison made by Dr. Brendecke in Figure 4-1 is not relevant.

On page 4-6, Dr. Brendecke states, "*The consistent over-prediction of low flow values in recent years is problematic because this is the starting point for any changes due to curtailment*." Dr. Brendecke again overstates the importance of conditions during recent drought conditions. The best modeled representation of a system is obtained with calibration to a range of conditions. This was accomplished with ESPAM2.1 by calibration during a 23.5-year period that included both wet and dry years. Low flow values in recent years are not more important than flow values in the 1980s or 1990s. For predicting the response to curtailment, it is the difference between low flow values and historic values that is most important. Over-prediction of low flow values in recent years and under-prediction of flows in the 1980s likely results in slightly lower predictions of the response to curtailment. This is illustrated by Dr. Brendecke's alternative model (AMEC Model 2), which Brendecke (2012) states "*appears to resolve the overprediction problem noted for ESPAM2.1 in recent years*." AMEC Model 2 predicts a response of 18.0 cfs in response to curtailment within the model domain, which is slightly higher than the ESPAM2.1-predicted response of 17.9 cfs.

On page 4-7, Brendecke (2013) states, "*…the inability to quantify uncertainty does not disprove its existence or demonstrate that it should be ignored*." IDWR staff agree that model uncertainty exists and do not suggest that it should be ignored. However, there is no evidence to support Dr. Brendecke's assumption that model uncertainty is so high that ESPAM2.1 cannot reliably predict whether or not the response to curtailment at the Rangen spring complex would be a measurable amount of water.

Accepting the predictions made by ESPAM2.1 as the best available prediction is not ignoring model uncertainty. Actual responses may be higher or lower than the prediction, so adjusting a model prediction in one direction would favor one party over another. IDWR staff also note that delineation of a trimline using ESPAM2.1-predicted response functions is not a "*modification of the output*" as stated in the Brockway et al. (2012) quote that Brendecke (2013) is responding to on page 4-7. Delineation of a trimline using ESPAM2.1-predicted response functions is a direct application of unmodified ESPAM2.1 predictions of response at the Rangen spring complex. The steady state response functions are subject to the same types of uncertainty as the predicted response to model-wide curtailment. Use of the steady state response functions to delineate a trimline requires accepting that the ESPAM2.1 provides the best available prediction of response at the Rangen spring cell.

On page 4-7, Brendecke (2013) states regarding the 2009-2010 validation scenario, "*This is important since curtailment would begin with present, rather than historical, aquifer conditions*." IDWR staff disagree with this statement. Curtailment of groundwater use would increase the net ESPA recharge to historic conditions reflected during the calibration period in the 1990s (Figure 12). Present conditions are not more relevant than historic conditions.

On page 7-1, Brendecke (2013) states, "*Relatively modest changes to the model demonstrate quite different model results*." IDWR staff review of Dr. Brendecke's modified alternative models indicates that his models actually demonstrate quite similar results, as presented previously in the section "IDWR staff comments regarding expert reports on behalf of IGWA".

On page 7-3, Brendecke (2013) states, "*Good model calibration is a necessary but not sufficient condition for reliable model prediction. Reliable prediction also requires accurate model representation of hydrologic and hydrogeologic conditions in the area of the prediction. ESPAM2.1 does not contain this detailed representation*." In the opinion of IDWR staff, ESPAM2.1 is capable of providing a reasonable prediction of the response at the Rangen spring cell to regional stresses in the ESPA, such as curtailment of groundwater use. ESPAM2.1 does represent the aquifer geometry and regional hydrogeologic conditions within the constraints of a one-square-mile model grid and the transmissivity pilot point spacing, which is generally two to four miles in the vicinity of the Buhl to Lower Salmon Falls reach. ESPAM2.1 considers more hydrologic and hydrogeologic data than any other method available for predicting the response at the Rangen spring cell.

IDWR staff comments regarding rebuttals on behalf of the City of Pocatello

On pages 5-14, Sullivan (2013) discusses the accuracy of Rangen's flow measurements and rebuts statements made by Brockway et al. (2012). IDWR staff have reviewed Rangen's flow measurement methods during previous proceedings and have a number of comments in response to Sullivan (2013) and Brockway et al. (2012, 2013).

Rangen submitted annual water measurement reports directly to IDWR from 1995 through 2009, and to Water District 36A from 2010 to 2012. IDWR has accepted these annual water measurement reports during this period of record understanding that Rangen estimates hatchery diversions or flows using fish raceway check boards as non-standard weir measuring devices.

Based on the IDWR memorandum dated December 4, 2003 from Jennifer Berkey to Tim Luke (Berkey, 2003), reported measurement data submitted to IDWR by Rangen from 1995 through 2002 for the hatchery diversion (IDWR diversion number 410089) are the sum of the CTR raceway measurements and the measurement at the dam on Billingsley Creek (also known as the "Lodge dam"). IDWR understands that the Rangen measurement reports submitted to IDWR after 2002 are also based on the sum of the CTR raceways and the Lodge dam. The CTR raceway measurements include all water flowing through the hatchery, including the water diverted from Billingsley Creek and water diverted from the Curren Tunnel to the hatchery lab and upper raceways. Water diverted from the Curren Tunnel to the lab and upper raceways is re-diverted to the lower raceways (Large and CTR raceways). Water measured over the Lodge dam in the creek is water that bypasses the hatchery. The hatchery diversions and layout are described in the IDWR memo from Cindy Yenter to Director Karl Dreher, dated December 15, 2003 (Yenter, 2003).

Measurement of flow through the hatchery using 2-inch rectangular stop logs or check dam boards[10] (check boards) is not considered a standard methodology of measurement because the check board weirs are not considered standard measurement devices. IDWR's *Minimum Acceptable Standards for Open Channel and Closed Conduit Measuring Devices* specify that construction, installation and operation of open channel measuring devices, including contracted rectangular weirs and suppressed rectangular weirs, should follow published guidelines such as those published by the United States Bureau of Reclamation (USBR, 1997).

Although the raceway check boards are not considered standard measuring devices, IDWR accepts measurements using these structures at many hatcheries in the area given that IDWR's standards allow an accuracy of +/-10 percent for open channel measuring devices when compared to measurements using standard portable measuring devices. Many of the area hatcheries have long used raceway check board structures for measuring devices out of convenience and lack of any other installed standard type devices. Some hatchery operators have not installed standard measuring devices due to lack of suitable measurement locations and added costs associated with installing standard devices. IDWR has not calibrated or compared the Rangen raceway check board measurements against standard portable measuring device measurements due to the lack of suitable locations within the hatchery where flows can be measured with portable measuring equipment. However, IDWR staff has compared portable discharge measurements against check board structures at other hatchery and irrigation diversions in both the Hagerman area and other locations in Idaho. IDWR has found those check board measurements, when used with the standard suppressed rectangular weir equation[11] and acceptable

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[10] IDWR has observed that the check boards used at the Rangen Hatchery and other area hatcheries are standard 2" x 4" boards in which the actual thickness measures 1-1/2 inches, or 0.125 ft.

[11] The Francis equation for a standard suppressed rectangular weir is $Q = 3.33\ L\ H^{1.5}$ where Q = discharge, L = weir crest length, and H = head of water above the weir crest, and the value 3.33 is a constant coefficient (US BOR, 1997, p 7-19)

head measurements are typically within +/- 10 percent of standard portable flow meter measurements. In her memo dated December 15, 2003, Cindy Yenter, Water District 130 watermaster, states the following:

> *"My experience has been that measurements taken at flat-crested dam boards are generally less accurate than those taken at sharp crested weirs, and that flat crested dam measurements return indications of flow which are typically 5-10% lower than actual flow, when checked against other methods of measurement."*

The Yenter memo further states that the sum of the IDWR staff measurements of the CTR raceways and Lodge dam on November 25, 2003 was 10 percent higher than the measurements taken by the Rangen staff a day earlier[12]. The memo was the basis for of Finding of Fact No. 76 in the May 19, 2005 Second Amended Order issued by Director Dreher which states in part that "…*measurement of flows through hatchery raceways reported by Rangen may be systematically about 10 percent lower than actual flows*." The Yenter memo suggests that the difference may be due largely to methods in measuring the head above the weir crest between IDWR and hatchery staff. Yenter notes that the proper location for measurement of head is upstream from the weir crest. Sullivan (2013, p. 11-12) correctly states that the head measurement for a standard weir should be upstream of the weir crest a distance of at least four times the maximum head on the crest. Yenter (2003) states that if it is not possible to obtain a proper upstream head measurement, "*the proper technique for using a hand held staff gage directly on the crest is to turn the surface of the gauge into the flow slightly, to overcome the drawdown (over the crest) and simulate a true head reading*." This method of measuring head on a weir is described in more detail in Brockway (2013) on pages 4-5. The description provided by Brockway is consistent with the methodology used by IDWR staff. IDWR rarely finds that staff gages are installed in the proper location for either standard or non-standard weirs. The method described by Yenter and Brockway therefore is used extensively by IDWR staff when measuring head at weirs found in the field where no staff gage is installed or gages are not installed in the proper location.

The other source of discrepancy between the IDWR and Rangen staff measurements noted in Yenter (2003) is the use of different weir equations or rating tables. IDWR used the standard suppressed weir equation (Francis equation), $Q = 3.33\ L\ H^{1.5}$, where Rangen used a rating table based on a modified weir equation. The table used by Rangen is found in Appendix A of the Brockway report dated December 20, 2012. This same table was also found in IDWR's records (attached) and appears to have been faxed to the IDWR Southern Region office on December 18, 2003 by Rangen staff. The table includes a rating for the Large raceways, the CTR raceways and the Lodge dam. The Large and CTR raceway ratings employ a fixed length weir crest even though the crest lengths at individual raceways vary slightly in size.

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[12] IDWR staff measured a total of 18.97 cfs at the Rangen hatchery based on sum of the Large raceways + Lodge Dam, or a total of 18.69 cfs based on sum of CTR raceways and Lodge dam. The 2003 measurement report submitted to IDWR by Rangen reports a total of 17.51 cfs on November 24, 2003, which is a difference of either 1.46 or 1.18 cfs, or a difference of -7.7% and -6.31% respectively. IDWR measured 0.48 cfs at the Lodge dam on November 25, 2003.

When using the IDWR head measurements from November 25, 2003 with the Rangen discharge table, the flow at the Large raceways is 16.9 cfs and the flow at the CTR raceways is 16.2 cfs. The Yenter memo states that Rangen staff measured 16.6 cfs and 15.9 cfs at the Large and CTR raceways respectively on November 24, 2003, a difference of only 0.3 cfs between IDWR and Rangen when using the Rangen discharge table, or a difference of less than 2 percent at each set of raceways. The relatively minor differences between the IDWR and Rangen measurements when using the Rangen discharge tables indicates that the differences in flow measurements between IDWR and Rangen on November 25th and 24th, 2003, was due mostly to the use of different weir equations or rating tables, rather than differences in head measurements.

Page 9 of Brockway (2012) indicates that the Rangen rating table "appears to match most closely with a standard rectangular contracted weir formula with a coefficient of 3.09 rather than the typical 3.33 coefficient." IDWR staff note that use of this formula with the 3.09 coefficient yields values that are slightly different than the values in the Rangen table. Columns 5 and 6 of Tables 1-3 through 1-5 in the SWE rebuttal report show the coefficients derived from both the suppressed weir and contracted weir equations using the Rangen rating table. As seen in Tables 1-3 through 1-5 the coefficients used in the Rangen rating table range from 2.85 to 3.20.

Brockway (2012) states that the Rangen rating tables "*are likely to be more accurate*" than a standard rectangular weir discharge using USBR weir flow calculations, but the report does not provide an explanation for the improved accuracy. Brockway (2013) on page 5 states the following:

> *"Studies conducted on flow over check boards at the ends of raceways on aquaculture facilities indicate that the weir coefficient that should be used for flow over check boards, is near 3.09 as compared to the standard Francis formula, which assumes a sharp crested weir with a coefficient of 3.33 (USBR Water Measurement Manual, 1967). King and Brater, (Appendix A), 1967 compiled research on broad crested weir coefficients which shows a weir coefficient for use on a broad crested weir of approximately 2-inch width of 3.08. This would be applicable to flow over check boards with heads between 3 and 4.5 inches (0.25 to 0.38 ft.)"*

Sullivan (2013, p. 7) cites King and Brater, 1976, whereby the standard suppressed rectangular weir equation with a coefficient of 3.09 is used as the standard broad crested weir equation.

The statements from Dr. Brockway above with respect to use of a standard contracted weir equation with a 3.08 coefficient that is more appropriate for a broad crested weir raise the following concerns:

1) IDWR's review of the 1984, 1997 and 2001 editions of the USBR Water Measurement Manual confirm that a coefficient of 3.33 is used for standard sharp crested thin plate weirs. However, IDWR's review of the USBR manuals found no mention or reference to studies conducted on flow over check boards in aquaculture raceways and the recommended use of a coefficient of either 3.09 or 3.08 when using 2-inch thick check boards.

2) As shown in Table 1-1 of Sullivan (2013), which is taken from King and Brater, 1976, a broad crested weir coefficient of 3.08 corresponds to a crest breadth (or width) of 0.5 ft. and head of 0.6 ft., as well as a crest breadth of 1.0 ft. and head of 1.2 ft. The 2-inch thick check boards used at the Rangen facility represents a crest width of about 0.17 ft. As stated on page 7-2 of the USBR Water Measurement Manual, 1997, "true broad crested weir flow occurs when upstream head above the crest is between the limits of 1/20 and 1/2 the crest length in the direction of flow" (between 0.05 and .50). Additionally, Bos (1989) states that for use of broad crested weirs, the length of the weir crest in the direction of flow (L) should be related to the total energy head (H) over the weir crest as: $0.07 \leq H/L \leq 0.50$. A crest width of 2 inches (0.17 ft) and a head of 4.5 inches (0.38 ft.) referenced by Dr. Brockway results in the ratio H/L being equal to 2.24, thereby exceeding the recommended ratio provided in both Bos (1989) and the USBR (1997). Moreover, a description of a broad crested weir provided in Sullivan (2013, p. 9) notes that "*a weir will function as broad crested when the width (aka breadth) exceeds twice the measured head*." Using a 2-inch check board as a broad crested weir provides a crest width of only 1.5 inches, which is less than one-half the typical measured head of 4.5 inches cited by Dr. Brockway, not two times the measured head.

3) Bos (1989) states that where a broad crested weir with ratio of $H/L > 1.5$, "*the nappe may separate completely from the crest and the weir in fact acts as a sharp crested weir. If H/L becomes larger than 1.5 the flow pattern becomes unstable and is very sensitive to the 'sharpness' of the upstream weir edge*". Column 7 of Tables 1-3 through 1-5 in Sullivan (2013) show that H/L (or H/B) for the Large, CTR and Lodge weirs is 1.5 or greater starting at a head of 3 inches. Mr. Sullivan also notes in his rebuttal report on page 9 that "when the measured head exceeds 1 to 2 times the width of the crest, the nappe will ordinarily spring clear and the weir will hydraulically operate as sharp-crested (Chow, 1964, King, 1976)."

4) Although Rangen has apparently used a rating table that more closely approximates a broad crested weir equation and coefficient, IDWR staff note that every annual measurement report submitted by Rangen to IDWR from 1995 through 2009 states that standard suppressed rectangular weirs are used (see Section III A of the IDWR annual report forms). Section III C of the IDWR annual report forms asks that copies of measuring device rating tables be attached to the report unless previously supplied to IDWR. None of the annual reports submitted to IDWR by Rangen include copies of rating tables used by Rangen. IDWR records do not show that the rating table identified in Appendix A of the December, 2012 Brockway report was received by IDWR until December 18, 2003. IDWR had assumed that Rangen was using standard rectangular suppressed weir tables from 1995 through 2002.

Tables 1-3 through 1-5 in Sullivan (2013) show computed discharges at the Large raceways, CTR raceways and the Lodge dam for what Mr. Sullivan calls "'*Hybrid Weirs' based on their function as broad crested weirs at low heads and sharp crested weirs at higher flows*." Also included in column 1 of Tables 1-3 through 1-5 are the corresponding discharges from the Rangen rating tables. As seen on page 11 of Sullivan (2013), the range of differences between the Hybrid Weir discharges and the Rangen rating table discharges is +0.8% to 10.2% for the Large Raceways, +1.1% to 10.9% for the CTR Raceways, and -6.4% to 20.2% for the Lodge Dam. Other than the Lodge Dam, the range of differences is within +/- 10 percent except for several head measurements on the Large Raceways with heads between 0.28 and 0.31 ft., where the differences are between 10.2% and 10.9%.

Column 8 of Tables 1-3 through 1-5 in Sullivan (2013) show the discharge coefficients used in Mr. Sullivan's Hybrid Weir equation. It is noted that for heads greater than 0.25 ft (3 inches), the coefficient is 3.32, or essentially the same as the coefficient used in the standard rectangular contracted and suppressed weir equations. Mr. Sullivan uses lower Hybrid Weir coefficients which approximate coefficients used for broad crested weirs for heads at 0.25 ft and less. It is important to note that head measurements above weir crests should exceed 0.2 ft. for sharp crested weirs as per USBR published guidelines (USBR, 1997). Use of a broad crested weir equation with coefficients of about 3.08 or 3.09 may be more appropriate for heads that measure 0.2 ft or less. At such heads, the ratio H/L is less than 1.50.

Based on review of the expert reports, IDWR staff provides the following opinions:

1. IDWR concurs with the Brockway (2013, p. 5) that the difference in weir coefficients between the standard suppressed rectangular weir with C=3.33 and use of the contracted rectangular weir with C=3.09 results in a difference of about 8%. IDWR also agrees with the statement on p. 9 of Brockway (2012), that "*the standard rectangular weir discharge using USBR weir flow calculations were within 8% of the Rangen staff reported flows*." (Note: The Rangen staff reported flows were -8% as compared to the same measurements using the USBR rating table for a standard contracted rectangular weir).

2. IDWR concurs with the Brockway rebuttal (2013, p. 5) that "standard weir formulas assume a sharp crested weir is in place and not a 2-inch board." However, the typical measured head at the Rangen raceways exceeds one to two times the 2-inch width weir crest such that the nappe separates from the crest and the weir more closely approximates a sharp crested weir where C = 3.33, which is the coefficient used with standard rectangular and suppressed weir equations.

3. IDWR concurs with both the Brockway (2013) and Sullivan (2013) rebuttal reports that the raceway check boards do not constitute standard suppressed rectangular weirs because the check boards are not sharp crested. It should also be noted that "*suppressed weirs must have proper ventilation of the cavity underneath their nappes. This ventilation is commonly done by installing properly sized pipes in the walls to vent the cavity under the nappe. Standard equations and tables are valid only when sufficient ventilation is provided. The weir will deliver more water than indicated by the tables and equations when ventilation is inadequate.*" (USBR, 1997, p. 7-41).

4. IDWR concurs with the Brockway (2013, p. 5) that the differences in measurements between IDWR staff and Rangen staff are not due to differences in measurements of head at the weirs.

IDWR concludes that the differences are due mostly to the use of different rating tables and weir coefficients.

5. IDWR does not concur with Brockway (2013, p. 5) that finds concern with IDWR's comparison of IDWR staff measurements with Rangen staff measurements "*because IDWR staff utilized the discharge rating curve for a standard sharp crested weir when in fact the flow was over dam boards, which is best represented by a modified weir coefficient resulting in a discharge rating similar to that utilized by Rangen personnel*." IDWR disagrees with this statement because the discharge rating used by Rangen uses coefficients that more closely approximate the standard coefficient used with a broad crested weir. As stated in item 2 above, the typical flow conditions for the Rangen check boards do not approximate conditions for a broad crested weir. Rather, typical flow conditions more closely resemble those for a rectangular sharp crested weir. IDWR maintains that without the installation of a standard measuring device, it is more appropriate to use the USBR sharp crested weir formula with a coefficient of 3.33 for estimating flows over the Rangen raceway check boards.

6. IDWR concurs with Sullivan (2013, p. 8) that the Rangen check boards do not conform to specifications of sharp crested weirs, contracted rectangular weirs, suppressed rectangular weirs or broad crested weirs. IDWR further concurs with Mr. Sullivan that use of the standard weir equation to compute flow does not result in the most accurate measurement of raceway discharges and that "it is appropriate to calibrate the weirs based on flow measurements to establish empirical rating tables that describe the relationship between discharge and measured head." However, IDWR continues to recommend the use of the standard suppressed weir equation at raceway check board dams with a coefficient of 3.33 since neither weir calibrations nor standard measurement devices exist at the Rangen Hatchery. If Mr. Sullivan recommends use of the Hybrid weir equation and coefficients, then IDWR notes that there is no difference in discharges between the Hybrid and standard suppressed weir equations for heads greater than 0.25 ft. Similarly, there is very little difference in discharge between the Hybrid Weir and the Rangen discharge tables for heads less than 0.25 ft (differences are between +0.8 to -6.8 % for CTR and Large Raceways).

7. IDWR does not concur with Sullivan (2013, p. 13) that the extent of under-measurement at the Rangen hatchery may be as high as 30 to 40 percent or more. SWE has not explained how or why the error may be this large unless they are merely adding the largest percent errors found in column 11 of Tables 1-3 through 1-5 for the CTR and Large Raceways, and the Lodge Dam, or they are merely relying on the example cited by the USBR in which a 0.1 ft. error in head measurement for a head of 0.45 ft. over a 6 ft. long rectangular weir results in an under-measurement of 2 cfs or 35 percent (USBR, 1997, p. 5-9). As described in these comments, the difference in head measurements between IDWR and Rangen staff on November 24 and November 25, 2003 appear to be relatively minor, and IDWR measured heads in a manner that minimized error.

8. IDWR accepted the measurements submitted by Rangen that are based on head measurements over raceway check boards and use of the Rangen rating tables because such measurements should be within a +/- 10 percent range of accuracy. The measurements likely under-measure actual flows, but an error up to -10% is acceptable pursuant to IDWR's *Minimum Acceptable Standards for Open Channel and Closed Conduit Measuring Devices.*

On page 13, Sullivan (2013) argues, "*The actual amount of any under-measurement of flow can be determined by conducting discharge measurements in the raceways and in Billingsley Creek using a current meter at various discharges to establish a calibrated rating table for each structure*." In the opinion of IDWR staff, it is difficult to obtain good, accurate measurements of discharge at or near the Rangen facility for calibrating the check board measurements, because flow and/or cross-sectional conditions are less than ideal. The USGS periodically measures the discharge in Billingsley Creek just downstream of the Rangen hatchery, but subjectively rates most of the measurements "fair" or "poor" indicating that USGS water measurement experts also found that flow and/or cross-sectional conditions in Billingsley Creek are not ideal and contribute to measurement error.

On page 14, Sullivan (2013) argues that "*under-measurement of the flows during the calibration period calls into question the model calibration to the Curren Spring flows, and would likely require that the model be re-calibrated*." The calibration target used for ESPAM2.1 was submitted to the ESHMC for review and comment in the fall of 2009. ESHMC members, including Mr. Sullivan and Dr. Brendecke, had more than two years to review the proposed calibration target and did not object to its use in ESPAM2.1. IDWR staff note that systematic under-measurement of discharge at the Rangen spring complex would be expected to result in lower model predictions of discharge and response to curtailment at the Rangen spring cell. This would favor the groundwater users, not Rangen.

On page 16, Sullivan (2013) points out that the ESHMC recommendation, "*The Eastern Snake Hydrologic Modeling Committee recommends that the Department begin using ESPAM Version 2.1 rather than ESPAM Version 1.1 for groundwater modeling*," was qualified by Mr. Sullivan and Dr. Brendecke with, "*although other tools or models may be more appropriate in certain circumstances*." IDWR staff note that neither Mr. Sullivan nor Dr. Brendecke proposed other tools or models that would be more appropriate for making a prediction in this circumstance.

References

Barlow, P.M., and Leake, S.A., 2012. *Streamflow Depletion by Wells – Understanding and Managing the Effects of Groundwater Pumping on Streamflow*, U.S. Geological Survey Circular 1376.

Berkey, J., 2003. Review of Rangen Hatchery Data, Idaho Department of Water Resources, memorandum to Karl Dreher, December 11, 2003.

Bos, M.G., 1989. *Discharge Measurement Structures*, ILRI Publication 20, Third Revised Edition, Wageningen, The Netherlands.

Covington, H.R., and J.N. Weaver, 1990. *Geologic map and profile of the north wall of the Snake River Canyon*, U.S. Geological Survey Miscellaneous Investigation Series, Maps I-1947A through I-1947E.

Dreher, K.J., 2005. *Second Amended Order in the Matter of Distribution of Water Rights Nos. 36-15501, 36-02551, and 36-07694*, Idaho Department of Water Resources, May 15, 2005.

Farmer, C.N., 2009. *Review of Hydrogeologic Conditions Located at and Adjacent to the Spring at Rangen, Inc.*, Idaho Department of Water Resources Open File Report, March 4, 2009.

Harbaugh, A. W., 2005. MODFLOW-2005, *The U.S. Geological Survey Modular Ground-Water Model – the Ground-Water Flow Process*, U.S. Geological Survey Techniques and Methods 6-A16.

IDWR, 2013. *Enhanced Snake Plain Aquifer Model Version 1.1 Final Report*, Idaho Department of Water Resources with guidance from the Eastern Snake Hydrologic Modeling Committee, January 2013.

Kjelstrom, L.C., 1995. *Streamflow Gains and Losses in the Snake River and Ground-Water Budgets for the Snake River Plain, Idaho and Eastern Oregon*, U.S. Geological Survey Professional Paper 1408-C.

McDonald, M.G., and A. W. Harbaugh, A.W., 1988. *A Modular Three-dimensional Finite-difference Ground-water Flow Model*, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 6, Chapter A1, 586 p.

McGrane, D., J. Brannon, and D. Colvin, 2011. *ESPAM Model V2.0 Curtailment Analysis,* Leonard Rice Engineers, Inc., memorandum to Rangen, Inc., December 9, 2011, Exhibit 11 to December 13, 2011 Petition for Delivery Call.

Meinzer, O.E., 1927. *Large Springs in the United States*. U.S. Geological Survey Water-Supply Paper 557, p. 46.

Nace, R.L., I.S. McQueen, and A. Van't Hul, 1958. *Records of Springs in the Snake River Valley, Jerome and Gooding Counties, Idaho 1899-1947*, U.S. Geological Survey Water-Supply Paper 1463, p. 54-55.

Raymondi, R., 2011. *ESHMC Meeting Notes December 12th, 2011*, Idaho Department of Water Resources.

Reilly, T.E., O.L. Franke, and G.D. Bennett, 1987. *The Principle of Superposition and Its Application in Ground-Water Hydraulics*, U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 3, Chapter B6.

Ross, D.W., 1902. *Biennial Report of the State Engineer to the Governor of Idaho for the Years 1901-1902*, Statesman Print, Boise, Idaho, p. 158-162.

Stearns, H.T., L. Crandall, and W.G. Steward, 1938. *Geology and Ground-Water Resources of the Snake River Plain in Southern Idaho*, U.S. Geological Survey Water-Supply Paper 774, p. 165.

Sukow, J., 2012a. *Comparison of Eastern Snake Plain Aquifer Model Version 2.0 with Version 1.1 via the Curtailment Scenario*, Idaho Department of Water Resources, July 2012.

Sukow, J., 2012b. *Comparison of Enhanced Snake Plain Aquifer Model Version 2.1 with Version 1.1 via the Curtailment Scenario*, *Addendum to Comparison of Eastern Snake Plain Aquifer Model Version 2.0 with Version 1.1 via the Curtailment Scenario*, Idaho Department of Water Resources, November 2012.

Sukow, J. 2012c. *Comparison of Superposition Model with Fully Populated Model for Eastern Snake Plain Aquifer Model Version 2.0,* Idaho Department of Water Resources, July 2012.

USBR, 1997. *Water Measurement Manual*, *Third Edition*, U.S. Bureau of Reclamation.

USGS, 1921. *Surface Water Supply of the United States, 1921, Part XII. North Pacific Slope Drainage Basins, B. Snake River Basin*, U.S. Geological Survey Water-Supply Paper 533, p. 285-286.

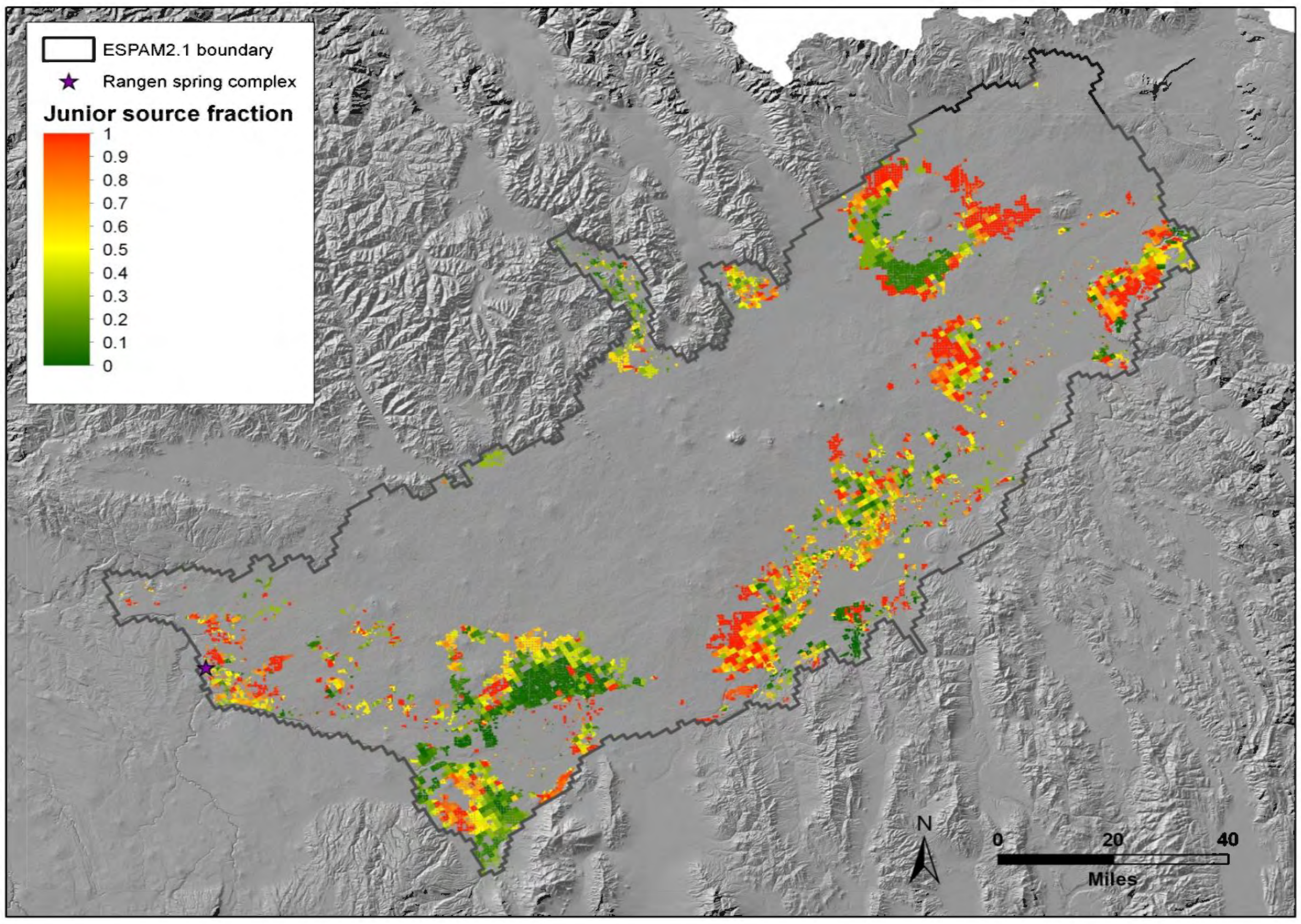
Wylie, A., 2012a. *Enhanced Snake Plain Aquifer Model Version 2.1 Uncertainty Analysis*, Idaho Department of Water Resources, December 2012.

Wylie, A., 2012b. *Magic Valley Underflow*, Idaho Department of Water Resources, memorandum to ESHMC, January 12, 2012.

Yenter, C., 2003. *Water Right Review and Sufficiency of Measuring Devices, Rangen Aquaculture, Idaho Department of Water Resources*, memorandum to Karl Dreher, December 15, 2003.

ATTACHMENT A. IDWR SIMULATIONS OF CURTAILMENT JUNIOR TO JULY 13, 1962

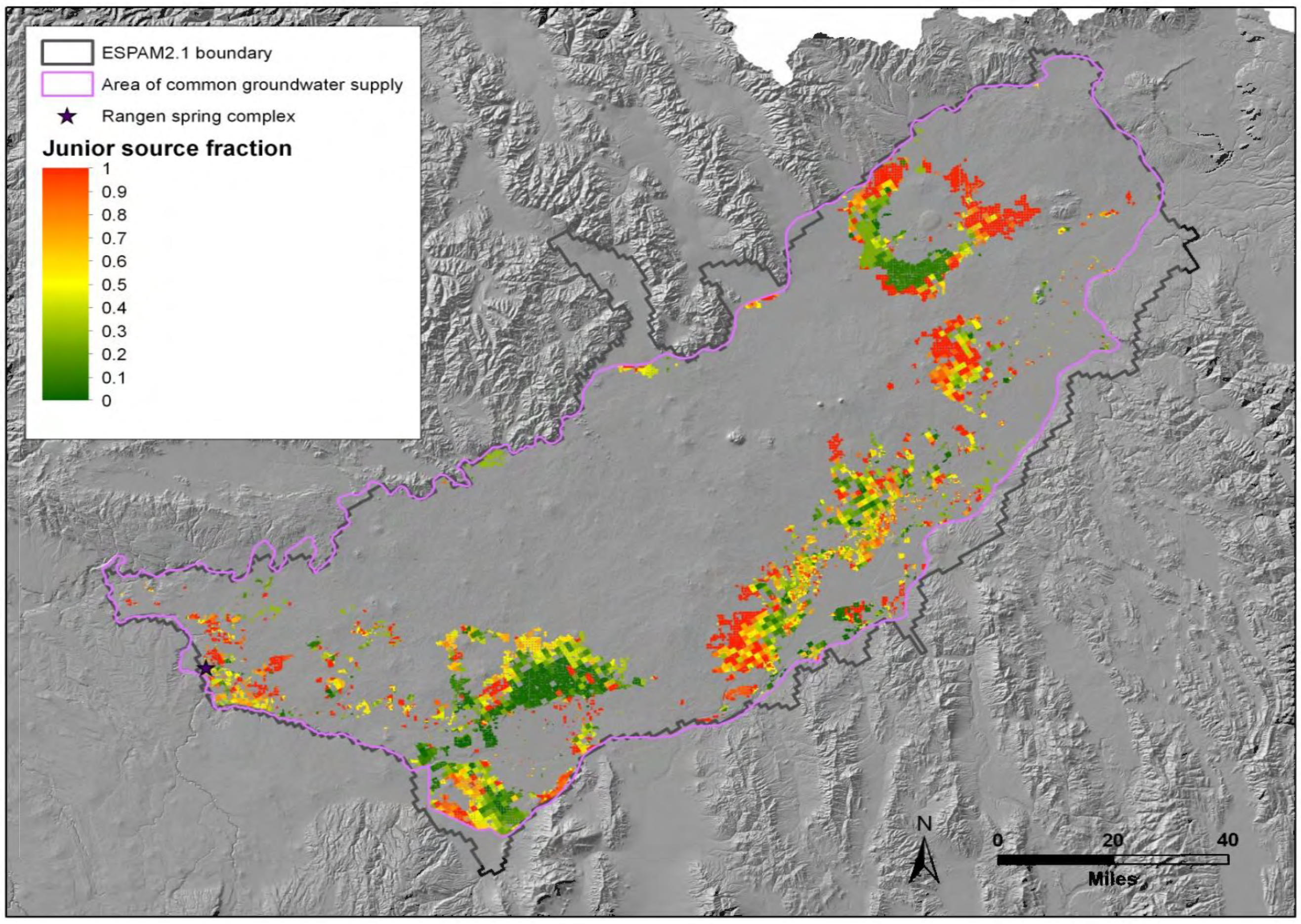
Simulated curtailment junior to July 13, 1962 within ESPAM2.1 model boundary



Simulated curtailment:		565,026	acres	
		1,235,157	AF/yr	crop irrigation requirement
		1,704.93	cfs	crop irrigation requirement
		2.19	AF/ac/yr	crop irrigation requirement

Predicted response:	**Reach**	**Response (cfs)**	**Response (AF/yr)**
	Ashton to Rexburg	157.79	114,312
	Heise to Shelley	206.50	149,598
	Shelley to Near Blackfoot	229.60	166,335
	Near Blackfoot to Minidoka	695.22	503,664
	Kimberly to Buhl	121.67	88,148
	Buhl to Lower Salmon Falls	242.40	175,610
	Lower Salmon Falls to King Hill	51.75	37,492
	Total	1,704.93	1,235,158
	Group A&B Spring Reaches		
	Devil's Washbowl	5.67	4,107
	Devil's Corral	7.39	5,354
	Blue Lakes	20.02	14,501
	Crystal	45.75	33,141
	Niagara	31.98	23,167
	Clear Lake	41.84	30,310
	Briggs	1.14	822
	Box Canyon	68.74	49,801
	Sand	18.33	13,281
	Thousand	50.06	36,269
	National Fish Hatchery	11.37	8,237
	Rangen	17.89	12,957
	Three	13.03	9,439
	Malad	43.95	31,839
Reach of interest:	Rangen	17.89	12,957
	Response/simulated stress	1.0%	
	Time to reach 90% steady state	13	years
Response at other reaches:		1,687.04	1,222,200
	Response/simulated stress	99.0%	

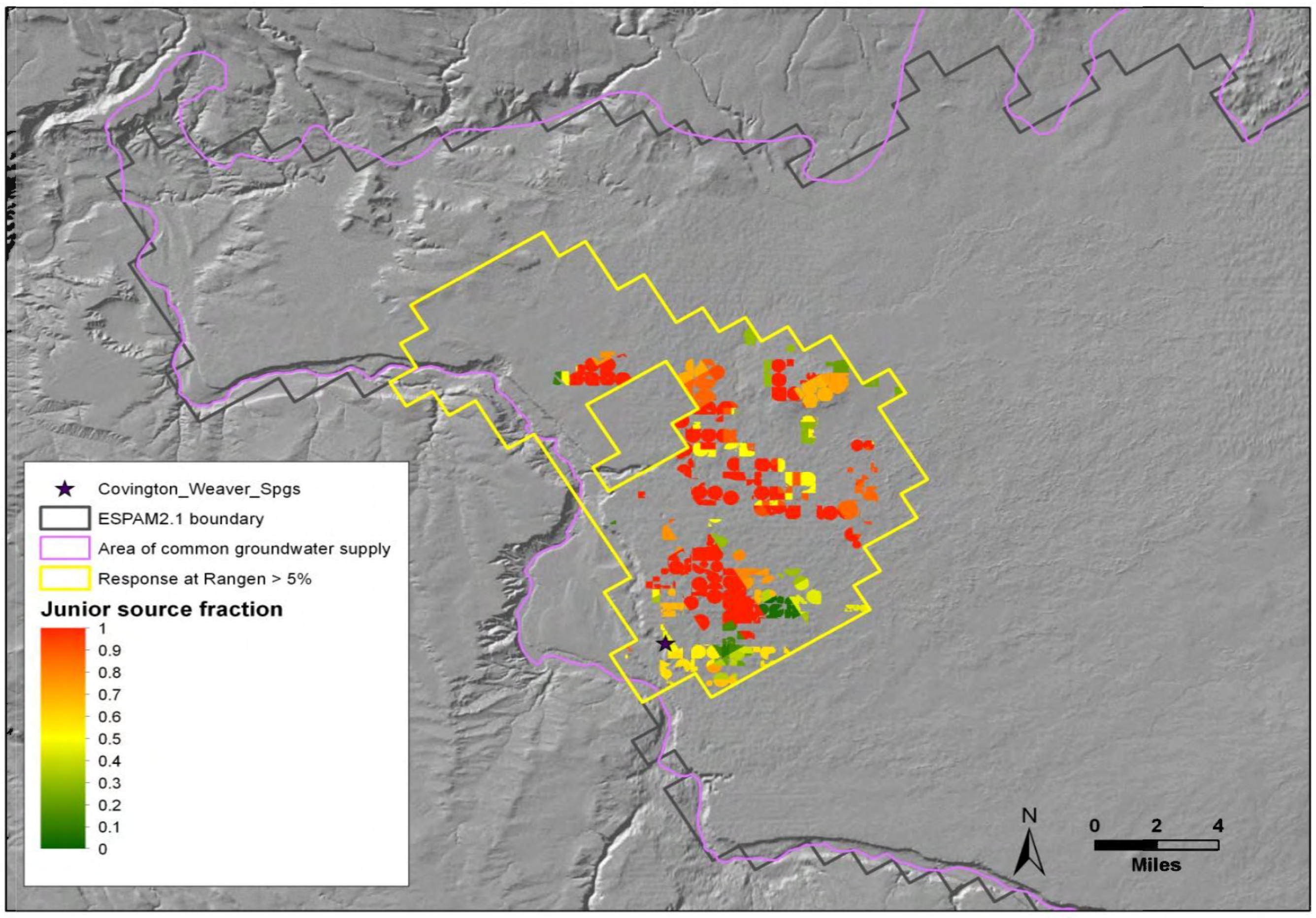
Simulated curtailment junior to July 13, 1962 within area of common groundwater supply



Simulated curtailment:	479,203	acres	
	1,092,938	AF/yr	crop irrigation requirement
	1,508.62	cfs	crop irrigation requirement
	2.28	AF/ac/yr	crop irrigation requirement

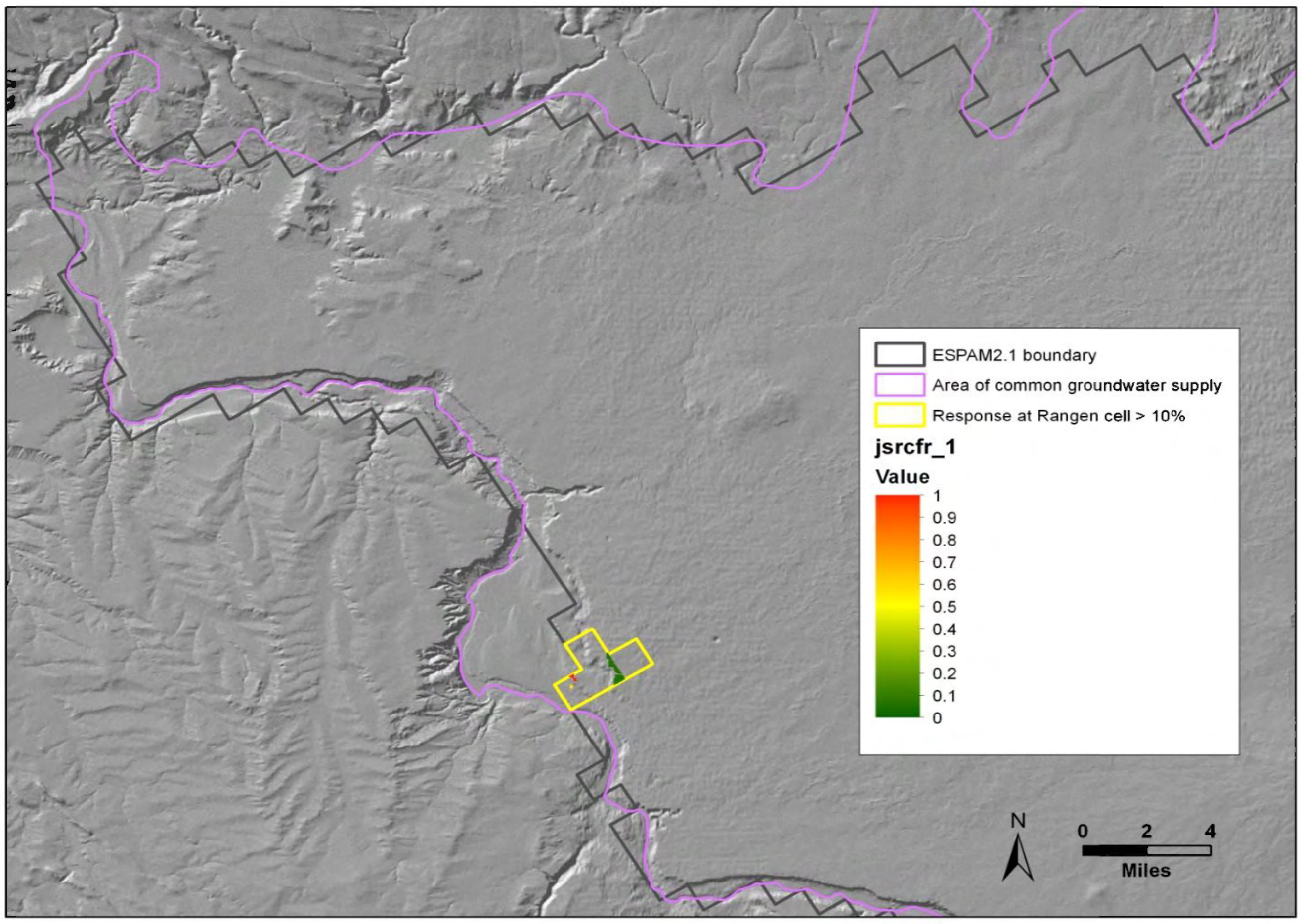
Predicted response:	**Reach**	**Response (cfs)**	**Response (AF/yr)**
	Ashton to Rexburg	111.43	80,730
	Heise to Shelley	160.20	116,056
	Shelley to Near Blackfoot	209.31	151,636
	Near Blackfoot to Minidoka	635.93	460,705
	Kimberly to Buhl	113.33	82,100
	Buhl to Lower Salmon Falls	228.90	165,829
	Lower Salmon Falls to King Hill	49.53	35,882
	Total	1,508.62	1,092,938
	Group A&B Spring Reaches		
	Devil's Washbowl	5.15	3,732
	Devil's Corral	6.72	4,869
	Blue Lakes	18.39	13,326
	Crystal	42.99	31,148
	Niagara	30.13	21,827
	Clear Lake	39.44	28,572
	Briggs	1.07	775
	Box Canyon	64.78	46,934
	Sand	17.29	12,523
	Thousand	47.35	34,304
	National Fish Hatchery	10.76	7,798
	Rangen	16.94	12,269
	Three	12.34	8,940
	Malad	42.00	30,431
Reach of interest:	Rangen	16.94	12,269
	Response/simulated stress	1.1%	
	Time to reach 90% steady state	11	years
Response at other reaches:		1,491.68	1,080,669
	Response/simulated stress	98.9%	

Simulated steady state curtailment junior to July 13, 1962 within area where response at Rangen cell is greater than 5%



Simulated curtailment:		12,346 acres		
		35,957 AF/yr	crop irrigation requirement	
		49.63 cfs	crop irrigation requirement	
		2.91 AF/ac/yr	crop irrigation requirement	
Predicted response:	**Reach**	**Response (cfs)**	**Response (AF/yr)**	
	Ashton to Rexburg	0.0599	43.38	
	Heise to Shelley	0.1754	127.07	
	Shelley to Near Blackfoot	0.5253	380.58	
	Near Blackfoot to Minidoka	1.7553	1,271.65	
	Kimberly to Buhl	5.0987	3,693.79	
	Buhl to Lower Salmon Falls	29.1239	21,099.16	
	Lower Salmon Falls to King Hill	12.8946	9,341.65	
	Total	49.6330	35,957.28	
	Group A&B Spring Reaches			
	Devil's Washbowl	0.0558	40.43	
	Devil's Corral	0.0758	54.94	
	Blue Lakes	0.3567	258.41	
	Crystal	2.2504	1,630.34	
	Niagara	2.1947	1,589.96	
	Clear Lake	3.1098	2,252.92	
	Briggs	0.0861	62.35	
	Box Canyon	5.6407	4,086.47	
	Sand	1.6911	1,225.13	
	Thousand	7.4121	5,369.78	
	National Fish Hatchery	2.0780	1,505.42	
	Rangen	3.3467	2,424.56	
	Three	2.4990	1,810.42	
	Malad	11.0826	8,028.93	
Reach of interest:	Rangen	3.35	2,424.6	
	Response/simulated stress	6.7%		
Response at other reaches:		46.29	33,532.7	
	Response/simulated stress	93.3%		

Simulated steady state curtailment junior to July 13, 1962 within area where response at Rangen cell is greater than 10%

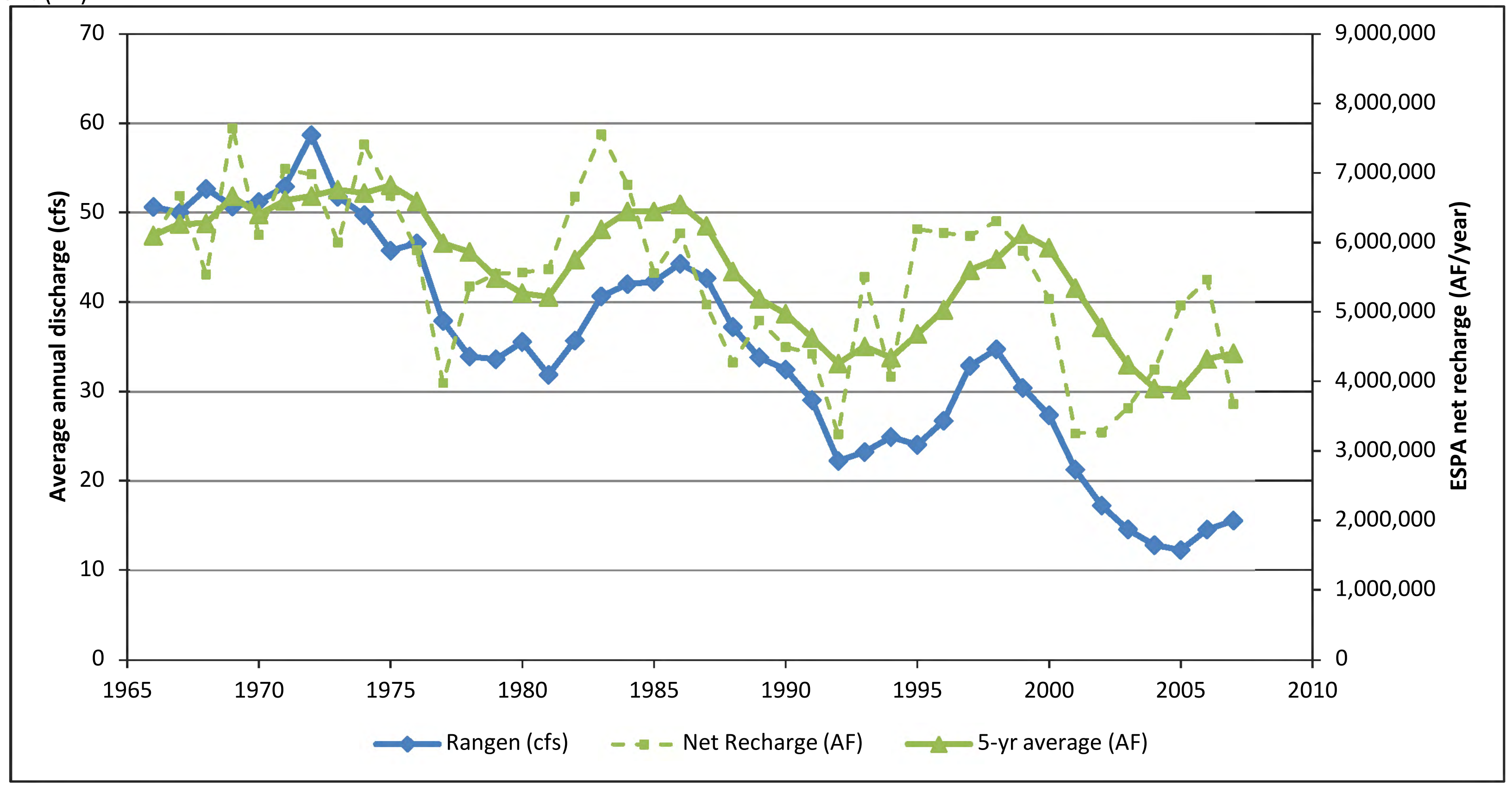


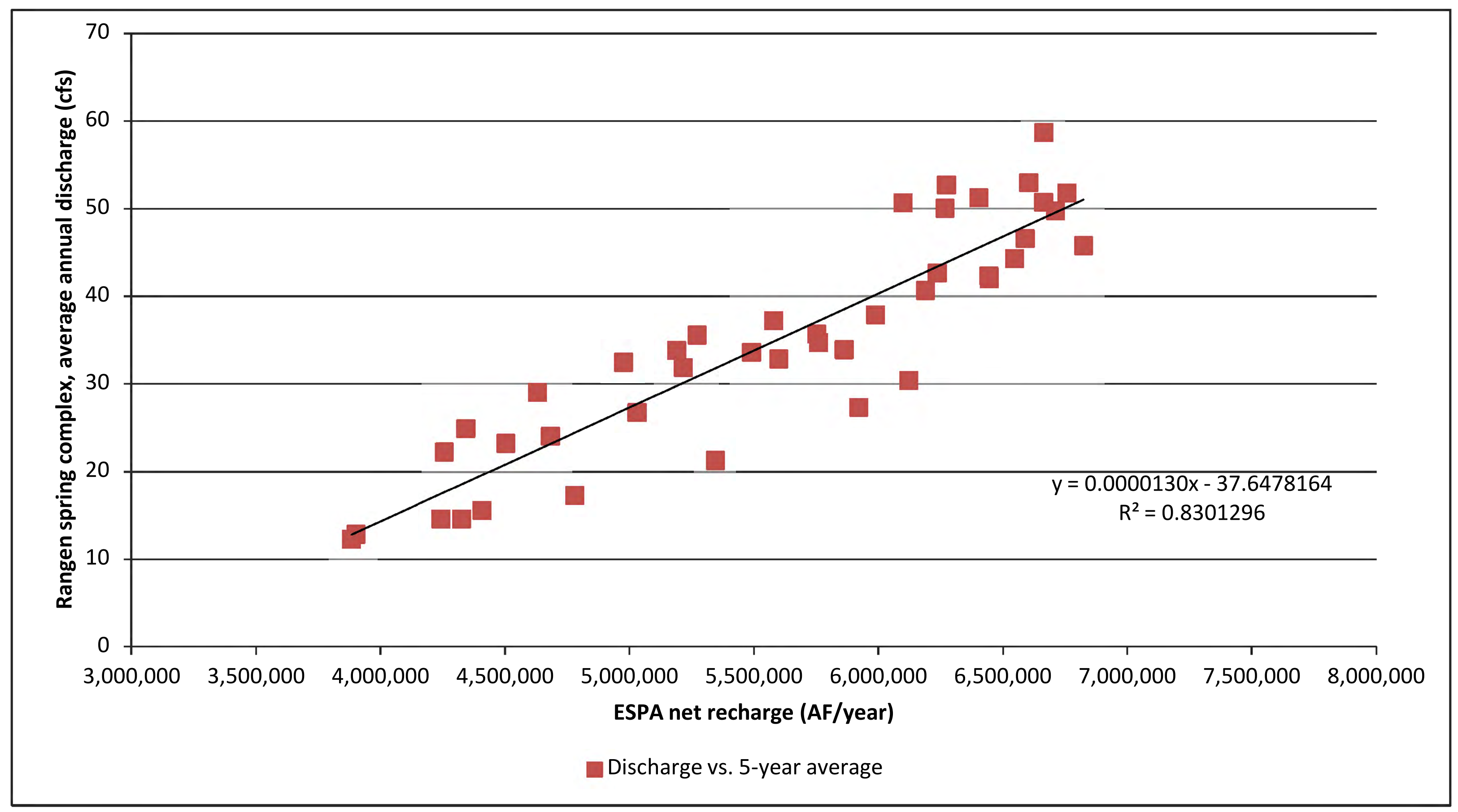
Simulated curtailment:		24 acres	
		73 AF/yr	crop irrigation requirement
		0.10 cfs	crop irrigation requirement
		3.03 AF/ac/yr	crop irrigation requirement

Predicted response:	**Reach**	**Response (cfs)**	**Response (AF/yr)**
	Ashton to Rexburg	0.0001	0.04
	Heise to Shelley	0.0002	0.12
	Shelley to Near Blackfoot	0.0005	0.37
	Near Blackfoot to Minidoka	0.0017	1.24
	Kimberly to Buhl	0.0055	4.00
	Buhl to Lower Salmon Falls	0.0814	58.95
	Lower Salmon Falls to King Hill	0.0111	8.02
	Total	0.1004	72.75
	Group A&B Spring Reaches		
	Devil's Washbowl	0.0001	0.04
	Devil's Corral	0.0001	0.05
	Blue Lakes	0.0004	0.26
	Crystal	0.0024	1.76
	Niagara	0.0024	1.76
	Clear Lake	0.0036	2.62
	Briggs	0.0001	0.07
	Box Canyon	0.0072	5.22
	Sand	0.0024	1.73
	Thousand	0.0291	21.07
	National Fish Hatchery	0.0129	9.33
	Rangen	0.0128	9.31
	Three	0.0050	3.63
	Malad	0.0097	7.03
Reach of interest:	Rangen	0.01	9.3
	Response/simulated stress	12.8%	
	Time to reach 90% steady state	5 months	
Response at other reaches:		0.09	63.4
	Response/simulated stress	87.2%	

ATTACHMENT B. ALTERNATIVE PREDICTIVE METHODS

Year	Rangen (cfs)	Net Recharge (AF)	5-year average net re	Net Recharge with Curtailment (AF)
1962		5,830,000		
1963		5,510,000		
1964		5,690,000		
1965		7,410,000		
1966	50.65	6,060,000	6,100,000	5,642,712
1967	50.01	6,670,000	6,268,000	5,642,712
1968	52.67	5,540,000	6,274,000	5,642,712
1969	50.70	7,640,000	6,664,000	5,642,712
1970	51.21	6,110,000	6,404,000	5,642,712
1971	52.93	7,060,000	6,604,000	5,642,712
1972	58.67	6,980,000	6,666,000	5,642,712
1973	51.77	6,000,000	6,758,000	5,642,712
1974	49.74	7,410,000	6,712,000	5,642,712
1975	45.76	6,670,000	6,824,000	5,642,712
1976	46.57	5,890,000	6,590,000	5,642,712
1977	37.89	3,980,000	5,990,000	5,642,712
1978	33.92	5,370,000	5,864,000	5,642,712
1979	33.62	5,550,000	5,492,000	5,642,712
1980	35.55	5,570,000	5,272,000	5,642,712
1981	31.87	5,616,920	5,217,384	5,642,712
1982	35.69	6,660,929	5,753,570	5,642,712
1983	40.65	7,555,369	6,190,644	5,642,712
1984	42.00	6,829,733	6,446,590	5,642,712
1985	42.29	5,562,063	6,445,003	5,642,712
1986	44.28	6,131,979	6,548,015	5,642,712
1987	42.66	5,108,736	6,237,576	5,642,712
1988	37.22	4,273,605	5,581,223	5,642,712
1989	33.82	4,876,753	5,190,627	5,642,712
1990	32.47	4,495,566	4,977,328	5,642,712
1991	29.04	4,398,489	4,630,630	5,642,712
1992	22.25	3,243,850	4,257,653	5,642,712
1993	23.23	5,506,157	4,504,163	5,642,712
1994	24.93	4,072,345	4,343,281	5,642,712
1995	24.05	6,194,348	4,683,038	5,642,712
1996	26.73	6,139,823	5,031,305	5,642,712
1997	32.87	6,095,010	5,601,537	5,642,712
1998	34.73	6,305,636	5,761,432	5,642,712
1999	30.42	5,883,367	6,123,637	5,642,712
2000	27.35	5,189,381	5,922,643	5,642,712
2001	21.27	3,256,481	5,345,975	5,642,712
2002	17.26	3,270,479	4,781,069	5,642,712
2003	14.59	3,620,557	4,244,053	5,642,712
2004	12.82	4,174,080	3,902,196	5,642,712
2005	12.29	5,096,649	3,883,649	5,642,712
2006	14.57	5,466,940	4,325,741	5,642,712
2007	15.57	3,679,551	4,407,555	5,642,712

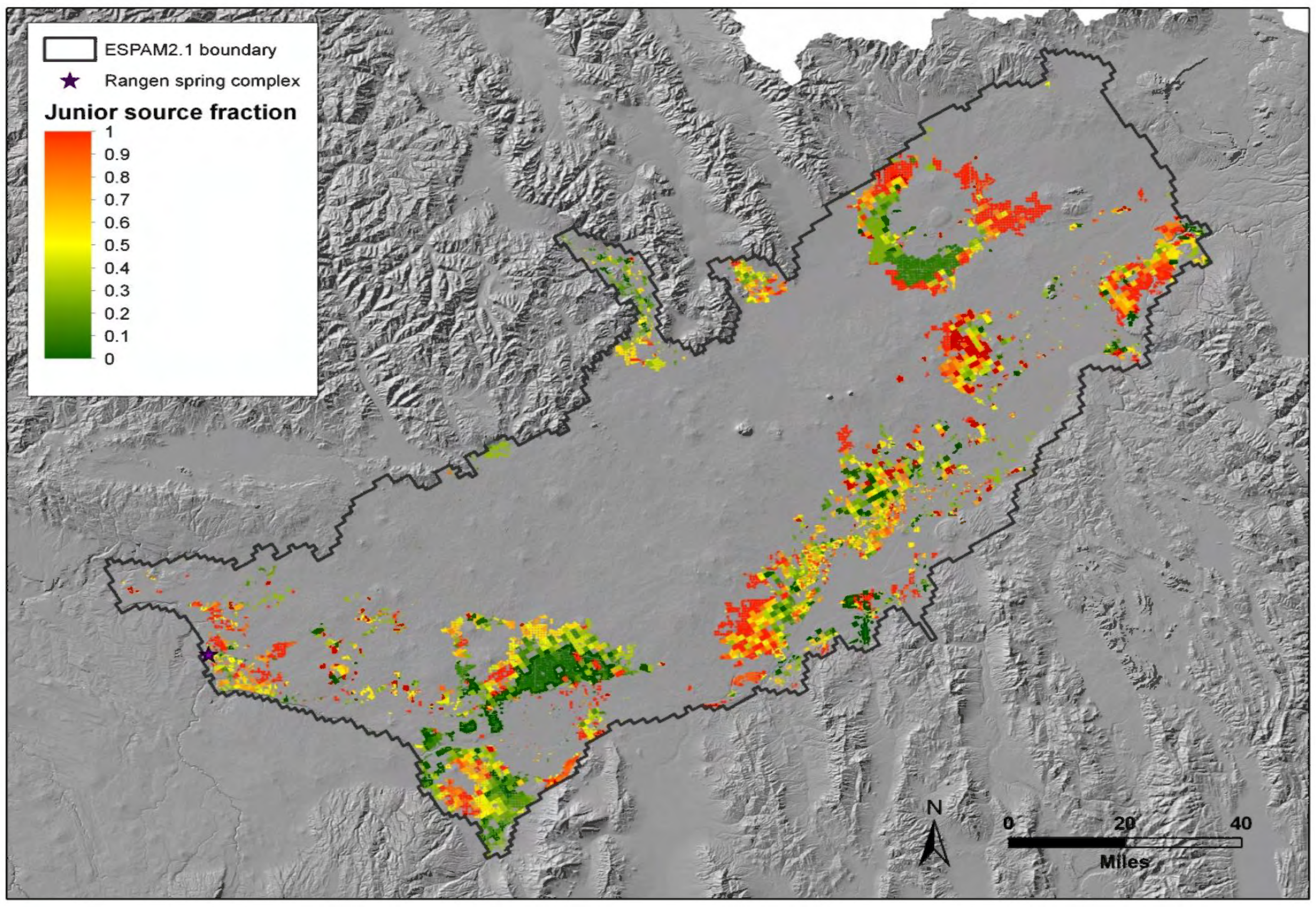




Curtailment volume	1,235,157	AF/yr
Change in discharge/change in recharge	0.0000130	cfs/AF
Predicted change in discharge	16.1	cfs

IDWR staff consider this prediction inferior to the ESPAM2.1-predicted response at the Rangen spring complex. This prediction method neglects the spatial distribution of all components of historic net recharge and of junior groundwater irrigated lands.

Simulated curtailment junior to July 13, 1962 within ESPAM2.1 model boundary



Simulated curtailment:	565,026	acres	
	1,235,157	AF/yr	crop irrigation requirement
	1,704.93	cfs	crop irrigation requirement
	2.19	AF/ac/yr	crop irrigation requirement

	Reach	**Response (cfs)**	**Response (AF/yr)**
Predicted response:	Ashton to Rexburg	157.79	114,312
	Heise to Shelley	206.50	149,598
	Shelley to Near Blackfoot	229.60	166,335
	Near Blackfoot to Minidoka	695.22	503,664
	Kimberly to Buhl	121.67	88,148
	Buhl to Lower Salmon Falls	242.40	175,610
	Lower Salmon Falls to King Hill	51.75	37,492
	Total	1,704.93	1,235,158
Reach of interest:	Buhl to Lower Salmon Falls	242.40	175,610
	Response/simulated stress	14.2%	
Response at other reaches:		1,462.53	1,059,548
	Response/simulated stress	85.8%	

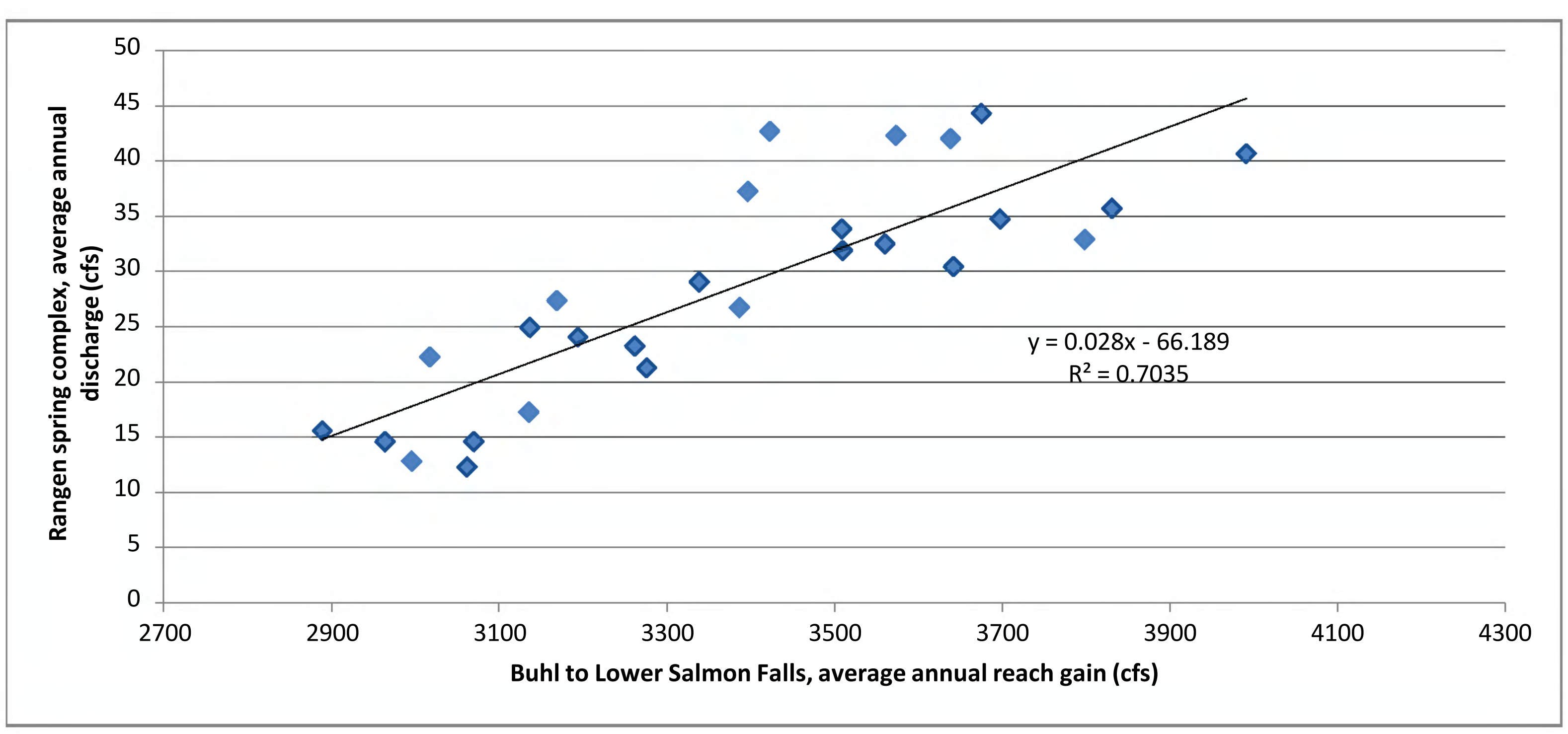
Apportionment of reach gains:

Observed Amplitude Ratio	2.80%	
Portion of reach response assigned to Rangen spring complex	6.8	cfs

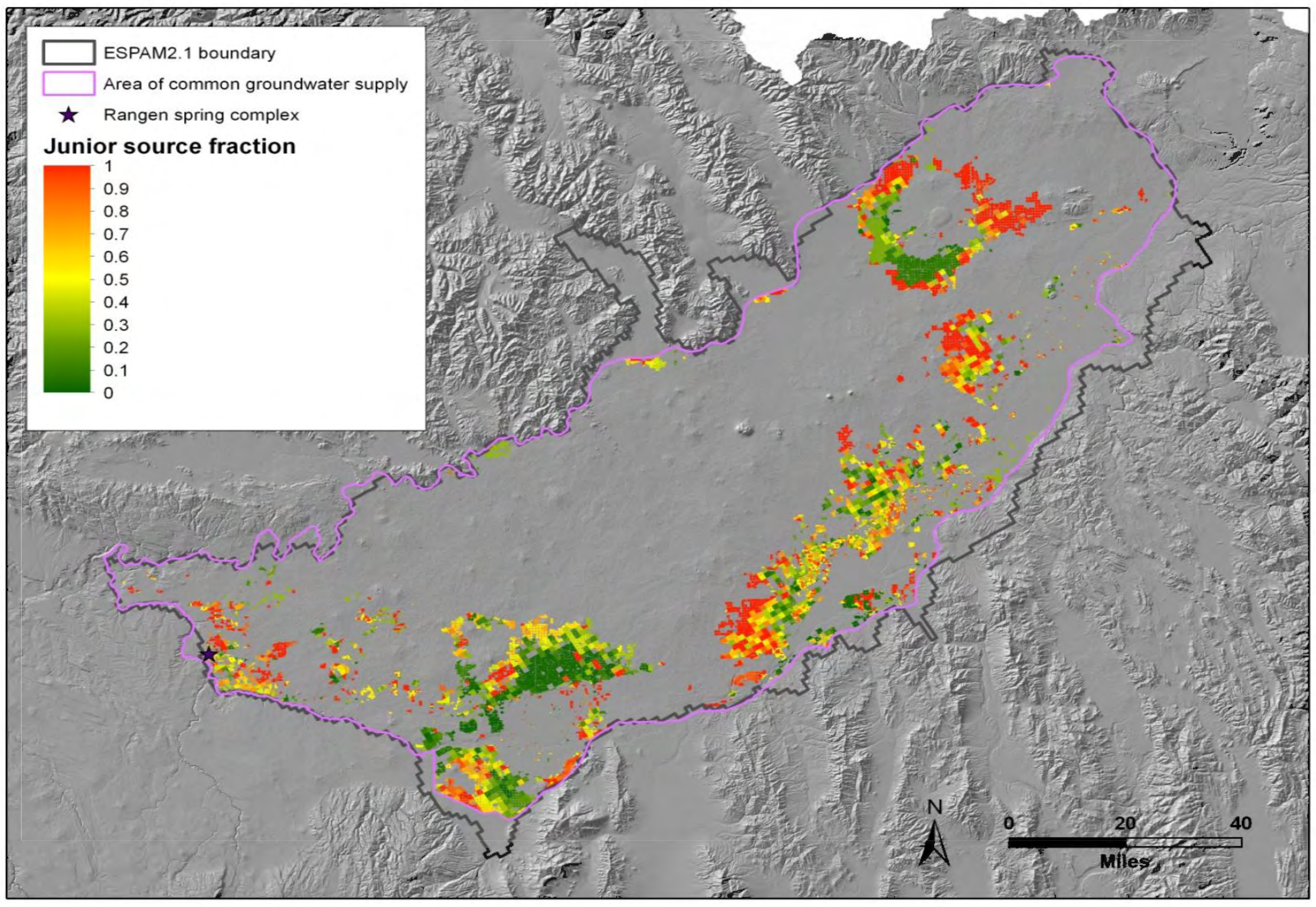
IDWR staff consider this prediction inferior to the model-predicted response at the Rangen spring complex.

This prediction method neglects spatial relationships between the springs within the reach and junior irrigation lands, and numerous other data used to calibrate ESPAM2.1.

ESPAM2.1 predicts a response of 17.9 cfs at the Rangen spring complex for this simulation.



Simulated curtailment junior to July 13, 1962 within area of common groundwater supply



Simulated curtailment:	479,203	acres	
	1,092,938	AF/yr	crop irrigation requirement
	1,508.62	cfs	crop irrigation requirement
	2.28	AF/ac/yr	crop irrigation requirement

Predicted response:	**Reach**	**Response (cfs)**	**Response (AF/yr)**
	Ashton to Rexburg	111.43	80,730
	Heise to Shelley	160.20	116,056
	Shelley to Near Blackfoot	209.31	151,636
	Near Blackfoot to Minidoka	635.93	460,705
	Kimberly to Buhl	113.33	82,100
	Buhl to Lower Salmon Falls	228.90	165,829
	Lower Salmon Falls to King Hill	49.53	35,882
	Total	1,508.62	1,092,938
Reach of interest:	Buhl to Lower Salmon Falls	228.90	165,829
	Response/simulated stress	15.2%	
Response at other reaches:		1,279.72	927,109
	Response/simulated stress	84.8%	

Apportionment of reach gains:

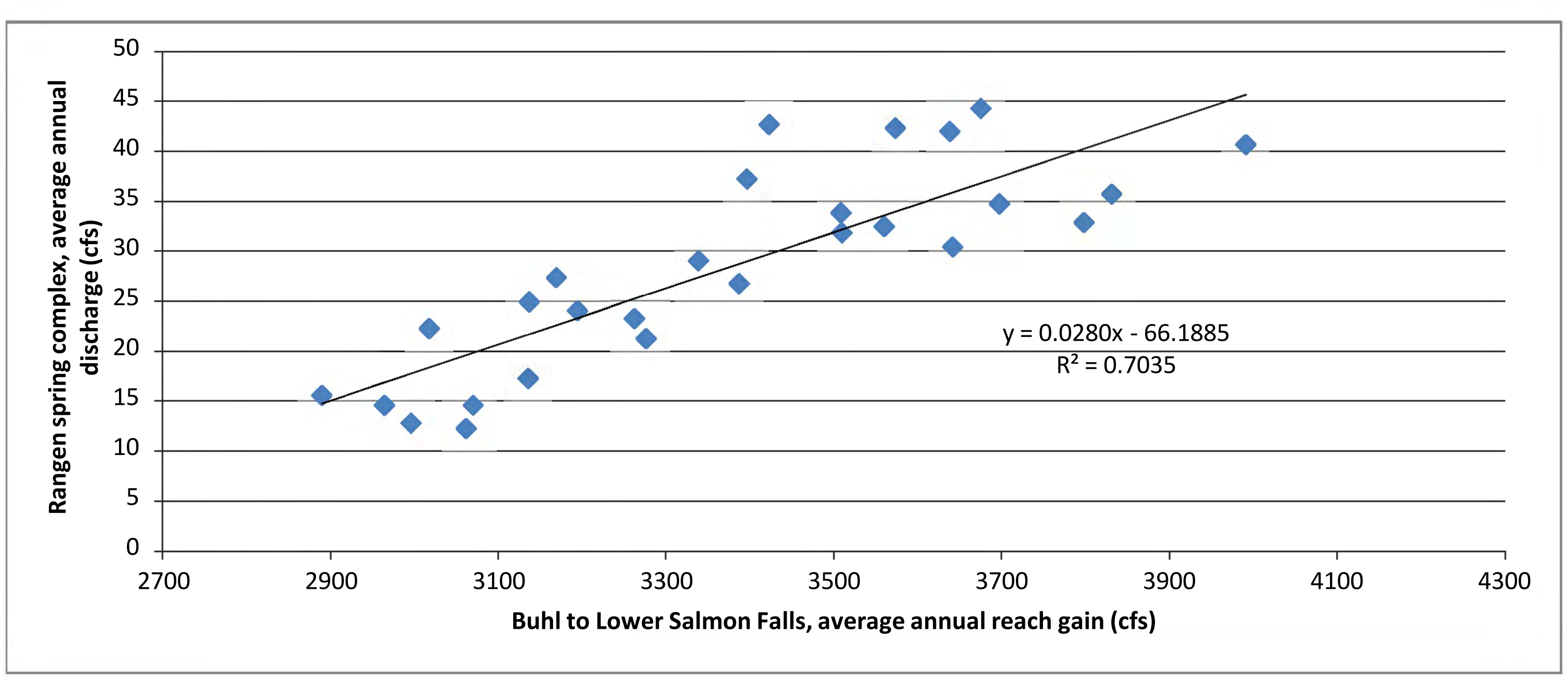
Observed Amplitude Ratio 2.8%

Portion of reach response assigned to Rangen spring complex 6.4 cfs

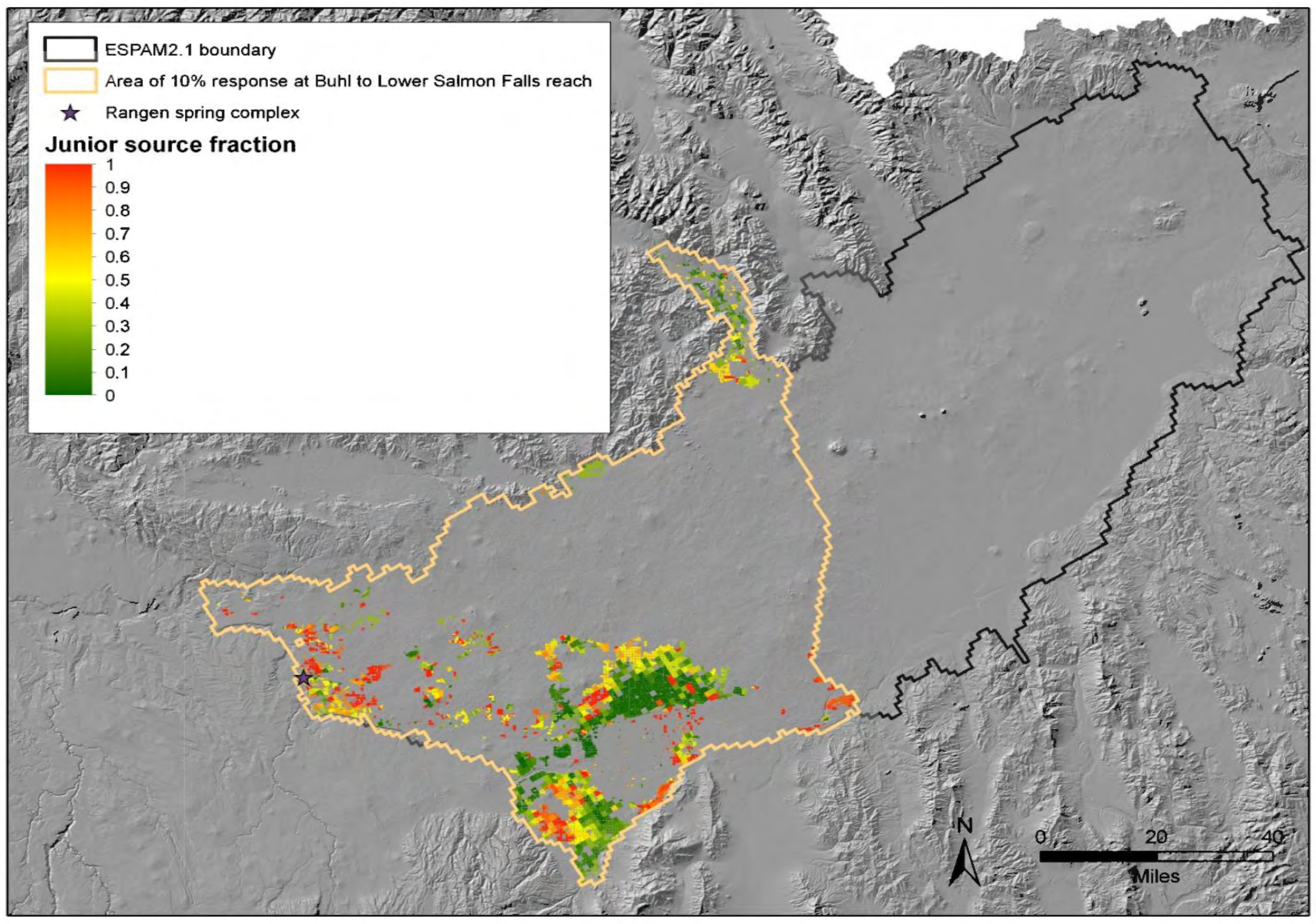
IDWR staff consider this prediction inferior to the model-predicted response at the Rangen spring complex.

This prediction method neglects spatial relationships between the springs within the reach and junior irrigation lands, and numerous other data used to calibrate ESPAM2.1.

ESPAM2.1 predicts a response of 16.9 cfs at the Rangen spring complex for this simulation.



Simulated curtailment junior to July 13, 1962 within area of 10% response at Buhl to Lower Salmon Falls Reach



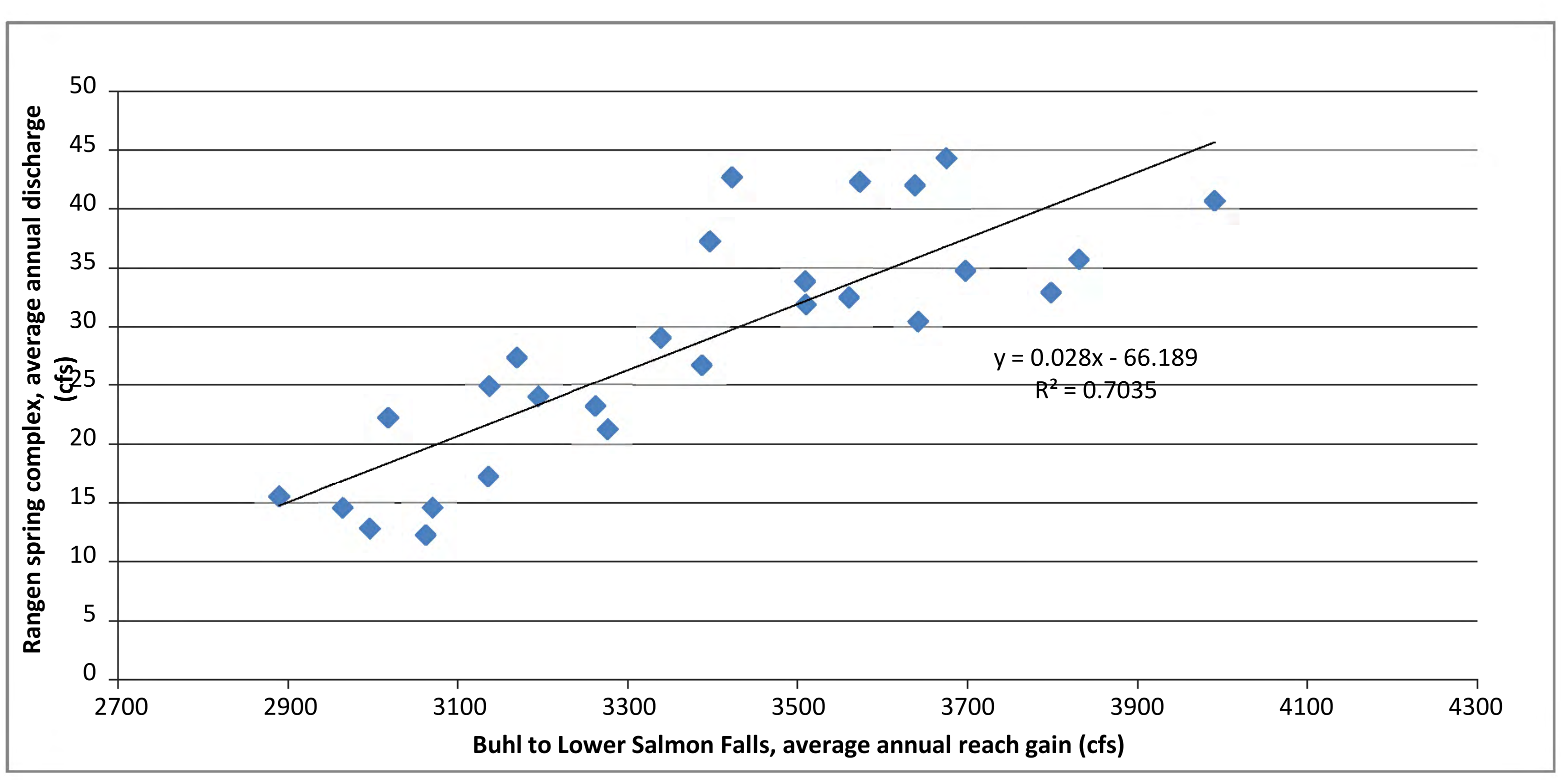
Simulated curtailment:		184,941 acres	
		454,737 AF/yr	crop irrigation requirement
		627.69 cfs	crop irrigation requirement
		2.46 AF/ac/yr	crop irrigation requirement

Predicted response:	**Reach**	**Response (cfs)**	**Response (AF/yr)**
	Ashton to Rexburg	6.33	4,588
	Heise to Shelley	18.52	13,419
	Shelley to Near Blackfoot	55.40	40,135
	Near Blackfoot to Minidoka	189.38	137,195
	Kimberly to Buhl	102.89	74,538
	Buhl to Lower Salmon Falls	209.08	151,472
	Lower Salmon Falls to King Hill	46.09	33,390
	Total	627.69	454,737
Reach of interest:	Buhl to Lower Salmon Falls	209.08	151,472
	Response/simulated stress	33.3%	
Response at other reaches:		418.61	303,265
	Response/simulated stress	66.7%	

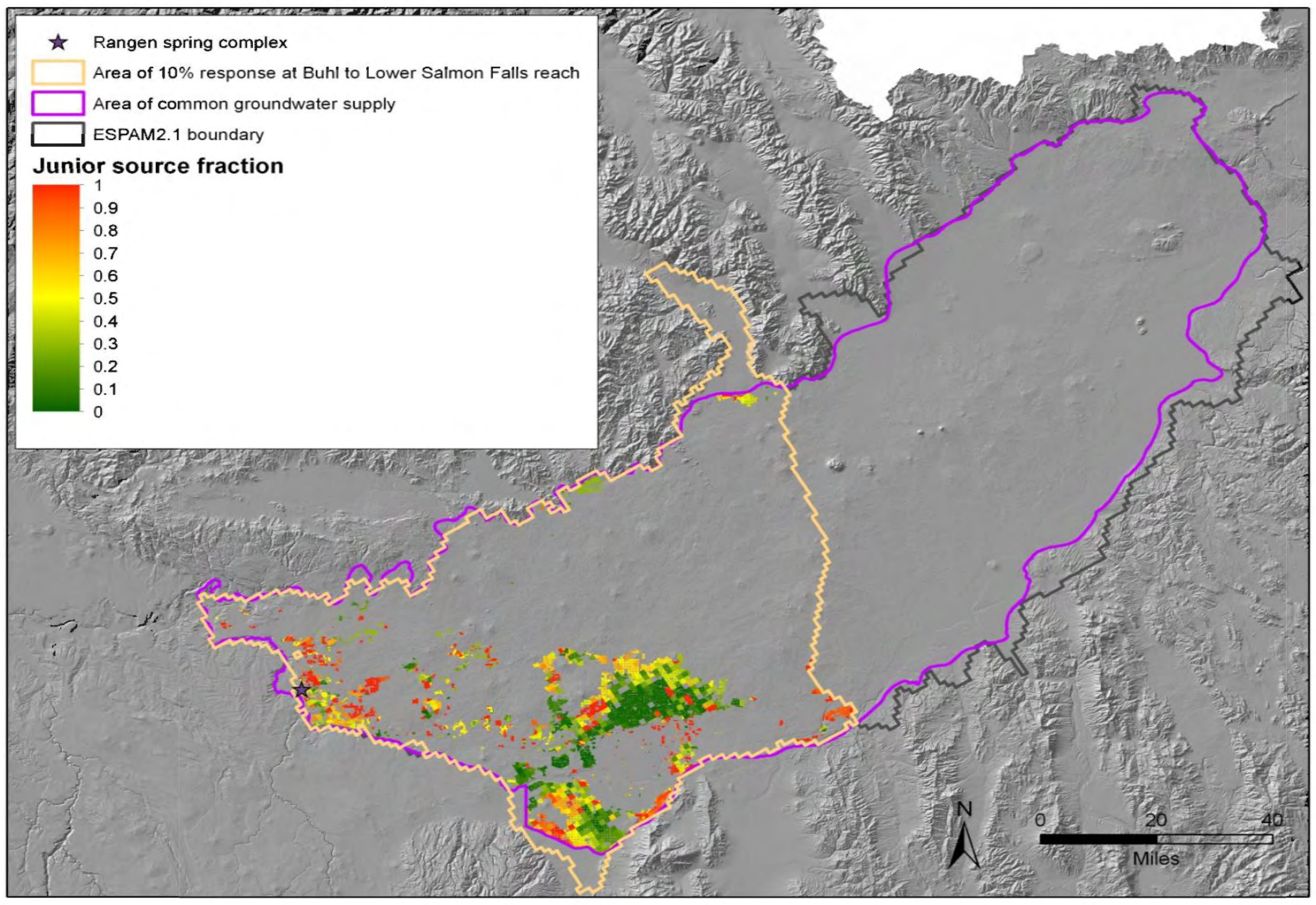
Apportionment of reach gains:

Observed Amplitude Ratio	2.8%	
Portion of reach response assigned to Rangen spring complex	5.9	cfs

IDWR staff consider this prediction inferior to the model-predicted response at the Rangen spring complex.
This prediction method neglects spatial relationships between the springs within the reach and junior irrigation lands, and numerous other data used to calibrate ESPAM2.1.
ESPAM2.1 predicts a response of 15.5 cfs at the Rangen spring complex for this simulation.



Simulated curtailment junior to July 13, 1962 within area of 10% response at Buhl to Lower Salmon Falls Reach and area of common groundwater supply



Simulated curtailment:		168,559 acres		
		418,575 AF/yr	crop irrigation requirement	
		577.77 cfs	crop irrigation requirement	
		2.48 AF/ac/yr	crop irrigation requirement	

Predicted response:	**Reach**	**Response (cfs)**	**Response (AF/yr)**
	Ashton to Rexburg	5.60	4,055
	Heise to Shelley	16.40	11,881
	Shelley to Near Blackfoot	49.12	35,587
	Near Blackfoot to Minidoka	168.68	122,201
	Kimberly to Buhl	95.80	69,406
	Buhl to Lower Salmon Falls	197.92	143,384
	Lower Salmon Falls to King Hill	44.26	32,062
	Total	577.77	418,575
Reach of interest:	Buhl to Lower Salmon Falls	197.92	143,384
	Response/simulated stress	34.3%	
Response at other reaches:		379.86	275,191
	Response/simulated stress	65.7%	

Apportionment of reach gains:

Observed Amplitude Ratio 2.8%

Portion of reach response assigned to Rangen spring complex 5.5 cfs

IDWR staff consider this prediction inferior to the model-predicted response at the Rangen spring complex.

This prediction method neglects spatial relationships between the springs within the reach and junior irrigation lands, and numerous other data used to calibrate ESPAM2.1.

ESPAM2.1 predicts a response of 14.7 cfs at the Rangen spring complex for this simulation.