Water Right, Water Measurement, and Groundwater Modeling Evaluation of Rangen 2014 Delivery Call

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1.0 INTRODUCTION

1.1 Objectives

The objective of this report is to evaluate water measurements at the Curren Tunnel and to evaluate impacts of potential curtailment of junior groundwater use of the Eastern Snake Plain Aquifer (ESPA) as they relate to the delivery call placed by Rangen on June 27, 2014. That delivery call requests the curtailment of all groundwater rights within the common groundwater area within the domain of the Enhanced Snake Plain Aquifer Model (ESPAM) that are junior to July 1, 1957. The primary study area of focus of this report is shown on Figure 1.

1.2 Report Organization

This report is organized into 4 sections, beginning with this Introduction. Section 2 provides a description of the Rangen facility and Curren Tunnel water measurements. Section 3 describes analysis of the effects of curtailment of junior groundwater rights using ESPAM2.1 based on the Rangen 2014 delivery call. Section 4 presents a brief summary and conclusions.

1.3 Information Relied Upon

1. Interview with Tim Luke and Michelle Richman, and documents provided therewith, November 5, 2014
2. Sullivan (2015) Shortage Analysis
3. ESPAM2.1 Final Documentation and Model Files
4. ESPAM Curtailment Simulation Steps (Jennifer Sukow IDWR)
5. ESPAM Recharge Toolbox and associated GIS files
6. Final Rangen Order, January 29, 2014
7. IDWR Staff Memo for Rangen Delivery Call (36-02551 and 36-07694), February 27th, 2013
8. Kaehrle and Thibodeaux, 1992, *Testing of Submersible Pressure Transducers Installed in Crest-Stage Gage Pipes.*
9. Kirby, 1992*, Analysis of Errors in Stage Measurements by Pressure Transducers.*
10. USGS, 2004, Use of Submersible Pressure Transducers in Water-Resources Investigations

2.0 RANGEN WATER RIGHTS AND WATER MEASUREMENTS

2.1 Rangen Water Rights

Water rights with Martin-Curren Tunnel ("Curren Tunnel") as the source are listed in Table 1. The earliest rights date to 1884 and are for irrigation and domestic use. Several rights are held by Rangen Inc. for fish propagation and other uses. The Director's January 29th, 2014, *Final Order Regarding Rangen's Inc's Petition for Delivery Call; Curtailing Ground Water Rights Junior to July 13, 1962* ("Curtailment Order") found material injury to Rangen's 1962 priority right due to declines in Tunnel flows. Rangen's present delivery call seeks administration of groundwater rights junior to its July 1, 1957, priority right for 1.46 cfs (water right 36-15501).

The irrigation rights of Candy, Morris and Musser are also sourced at the Curren Tunnel. These diversions historically provided water via pipelines to irrigate parcels south of Billingsley Creek. The water rights for these diversions are senior to the Rangen rights, dating to as early as 1884. Water diverted under these rights reduce the water supply available to Rangen from the Tunnel.

In 2003, anticipating that groundwater users might in the future be required to mitigate declines in Tunnel and spring flows, North Snake Groundwater District (NSGWD) voluntarily constructed a pipeline (the "Sandy Pipeline") from ponds in Section 5 of T8S, R14E (the "Sandy Ponds") to the Curren Ditch. The pipeline was constructed to provide an alternative supply of irrigation water to Candy, Morris and Musser, thereby reducing or eliminating irrigation diversions at the Tunnel and increasing the Tunnel supply available to Rangen. This pipeline is in operation and is believed to have nearly eliminated irrigation diversions from the Tunnel.

2.2 Discharge Records

Flow measurement within the Rangen facility has relied primarily on recording the depth of water flowing over the check dams at the ends of raceways, and depth of water flowing over the "lodge dam" in Billingsley Creek. Flows through the raceways, when combined with discharge over the lodge dam and diversions for irrigation, was historically considered to be the total discharge of the Tunnel and springs at the head of Billingsley Creek. However, information presented by Sullivan in the May, 2013, hearing (see FF 50 of January 29, 2014, Order) indicate that some additional flows enter Billingsley Creek above the USGS measuring point just west of Road S1175E.Measurement of discharge specifically from the Curren Tunnel began in 1993 when the Idaho Department of Water Resources (IDWR) installed a sonic measuring device inside the tunnel.

2.3 Flow Measurement at the Curren Tunnel

Flow emanates from the Curren Tunnel in two ways, either by flowing out of a large diameter corrugated steel pipe that lines the outermost 50 feet of the Tunnel ("steel pipe") or by flowing through a 6" diameter white PVC pipe (aka "white pipe") that lies on the invert of the corrugated steel pipe. This pipe configuration is shown on Figures 2 -4. Total discharge from the Tunnel is assumed to be the sum of the flows in the two pipes.

Flow in the steel pipe has been measured by the IDWR since 1993. It is presently measured using a pressure transducer that records the depth of water above the transducer. In the past, other devices have been used to record flow depth. Figure 5 shows the measured flow in the Curren Tunnel derived from these IDWR activities, as presented by Michelle Richman in a November 5, 2014, interview with experts from various parties in this delivery call proceeding. The record has been augmented in certain periods when the IDWR measuring devices were malfunctioning or improperly situated.

The aim of all the measurement devices placed by the IDWR has been to obtain a record of flow depth or “stage” in the corrugated steel pipe that can be input to a stage-discharge relationship to calculate an estimate of flow. As with conventional stream gaging practice, the stage-discharge relationship is developed through concurrent field measurements of flow and stage reduced to a statistical relationship between the two. The reliability of this flow measurement procedure is discussed in more detail below.

Flow in the white pipe enters the Rangen hatch house and part of it is measured there by Rangen staff. Measurements are made weekly and reported to IDWR on an annual basis. This measurement procedure is discussed in more detail below, but it appears that the procedure may not capture all flows in the white pipe.

2.4 Critique of Measurement Methods in the Steel Pipe

The accuracy of flow measurement in the corrugated steel pipe is compromised by two basic conditions. First, flow in the pipe is highly turbulent, owing to the velocity of the flow and the corrugations of the pipe itself. Second, the presence of the white pipe at the invert (bottom) of the steel pipe presents an obstacle to flow and causes depth variations to occur independent of changes in flow rate. Both these conditions are discussed in more detail below.

2.4.1 Velocity Field Effects

Pressure transducers are normally used in situations where there is little or no flow velocity, such as stilling wells or observation wells. They are sometimes used directly in rivers where velocities are small and depths are large. An important reason for requiring low velocity conditions is that depth and velocity of flowing water are not independent characteristics. Established hydraulic principles state that, all other things being equal, an increase in flow velocity is accompanied by a decrease in flow depth. If velocity varies, flow depth will vary and the pressure recorded by the transducer will vary. The transducer records this pressure change as a change in depth, and thus flow, even if the flow rate has not changed. The slope and corrugations of the steel liner in the Tunnel insure that flows along the bottom of the liner are rapid and highly turbulent.

Kaehrle and Thibodeaux (1992) found that pressure measurements from transducers placed in velocity fields show pressure reductions of 30-50% of velocity head ($V^2/2g$ … the square of velocity divided by two times the acceleration of gravity). The pressure transducer does not account for changes in velocity head and simply interprets a pressure reduction as a decrease in depth of flow. When applied to the rating curve, this decreased depth is converted to a flow decrease, which may not have actually occurred. The USGS (2004) recommends methods for shielding transducers to mitigate some of this effect when transducers have to be placed in an active flow field.

Kirby (1992) found that, because of the increasing steepness of typical rating curves as stage (depth) approaches zero, a given % error in stage can translate to a 1.5 – 3x error in estimated discharge. In other words, if the stage measurement error is 10% the discharge error could be 15% to 30%. Discharge estimates are highly sensitive to accurate stage measurement at low flows.

The behavior cited by Kirby is evident in Figure 6, which shows the rating curve presently used by the IDWR to obtain estimates of discharge in the steel pipe. This figure was distributed by Michelle Richman during a March 5, 2014, interview regarding Curren Tunnel measurements. The rating curve approaches a near vertical line as the stage approaches zero. A very small difference in stage in this region can result in a significantly larger change in estimated discharge. Figure 7, also distributed by Ms. Richman, shows the error between transducer estimates and field-measurements of discharge used for development of the rating curve. As the stage approaches zero, the difference between the field measurement and the transducer estimate can be as high as 60%.

2.4.2 Effects of White Pipe

As described earlier, the white pipe rests at the invert of the steel pipe inside the Curren Tunnel. This configuration is shown in Figure 3. Flow in the steel pipe occurs around the outside of the white pipe. According to Michelle Richman (interview of November 5, 2014), flow in the steel pipe sometimes covers the white pipe completely, but at lower flow rates does not. Ms. Richman also explained that the white pipe sometimes floats in the flow of the steel pipe. This likely occurs when flows in the white pipe are smaller and the white pipe becomes buoyant. Flotation of the white pipe is problematic for measurement of flow in the steel pipe, because this buoyancy would cause changes in depth measured by the pressure transducer when there is no change in discharge.

Ms. Richman stated that the white pipe presents an obstacle to flow measurement (presumably field measurement) in the steel pipe. These measurements are those upon which the rating curve for the Tunnel are based. Tim Luke, who also participated in the November 5 interview, stated that he thought that because of these conditions in the rating section in the Tunnel (steel pipe) would be considered “fair to poor”.

From the foregoing we would conclude that the measurements of flow in the Curren Tunnel are not sufficiently accurate and reliable, particularly under low flow conditions, to support this delivery call.

2.4.3 Critique of Measurement Methods in White Pipe

The measurement procedure for flow in the white pipe is described in a December 15, 2003, memo from Cindy Yenter to Karl Dreher (Yenter, 2003). Briefly, Ms. Yenter makes the following statements in this memo:

- There is no measuring device on the pipe
- The pipe diverts an unspecified amount of water to the hatch house and to domestic and irrigation use
- Flows to the hatch house are estimated by Rangen staff based on the number of incubation and rearing tanks in operation
- Domestic and irrigation uses are not measured but are estimated as a constant 20 gallons per minute (0.044 cfs) year around
- This constant rate assumption is too low in summer when irrigation is occurring

Ms. Yenter also describes two tests, carried out by the IDWR in 2001 and 2002, to measure flow in the white pipe using a polysonic metering device. The results of these two tests showed 9% and 18% differences, respectively, from the pipe flow data reported by Rangen. At present, the measurement procedure for the white pipe appears to remain as described in the 2003 Yenter memo.

A rough estimate of the flow rate required to irrigate the 7 acres of grounds served from the white pipe would be 7 miners' inches (one inch per acre), or 0.14 cfs. This amount is considerably greater than the 20 gallons per minute (0.044 cfs) Ms. Yenter states is assumed by Rangen in its measurement procedure, meaning that the procedure underestimates the flow in the white pipe.

Based on the foregoing, it is our opinion that the flow records for the white pipe cannot be relied upon to estimate flows from the Curren Tunnel. While measurement error can't be rigorously quantified because of the lack of reliable measurement devices, it appears that error of at least 18% is likely under the present measurement regime. The error could be significantly greater.

Given the uncertainty and potential for error in flow measurement (particularly at low flows) in the Curren Tunnel and in the white pipe, we would recommend installation of improved measurement devices in both if administration is to be based on those flow measurements. Installation of a flume or weir accurate at low flows is recommended for the steel lined section of the Tunnel. A flow meter should be installed in the white pipe upstream of the bifurcation between the hatch house and the domestic/irrigation service line. This flow meter should be equipped with a data logger capable of matching the recording frequency of the measurement in the Tunnel itself.

3.0 SIMULATION OF CURTAILMENT OF JUNIOR GROUNDWATER RIGHTS UNDER RANGEN 2014 DELIVERY CALL

3.1 Background

Rangen filed its first delivery call in September of 2003. In 2004 the IDWR ordered curtailment of groundwater rights in Water District 130 with priority dates junior to July 13, 1962. However, shortly thereafter the IDWR released ESPAM—a computer model designed to predict the impacts of groundwater pumping on flows in the Snake River. Based on predictions of ESPAM, the IDWR withdrew its curtailment order, concluding the Rangen delivery call was a "futile call."

Rangen filed a second delivery call on December 13, 2011, asserting that an update of ESPAM from version 1 to version 2 warranted a new call. This proceeding was stayed for a time until ESPAM version 2 was complete.

As discussed previously, on January 29, 2014, the Director found injury to the 1962 priority right held by Rangen due, in part, to pumping by junior groundwater users. He determined that this injury was limited to flows emanating from the Curren Tunnel and that curtailment of junior groundwater uses within a Great Rift trimline would result in an increase in flow at the Tunnel of 9.1 cfs.

The "trimline" defines a zone of exclusion outside of which the benefits of curtailing a well are deemed to be too small or uncertain relative to the amount of water use curtailed, as determined by the groundwater model. The trimline concept was originally adopted by former Director Karl Dreher in his 2005 Orders stemming from the delivery calls of Blue Lakes Trout, Clear Springs Foods, the Surface Water Coalition, Rangen, Inc., and others. Director Dreher adopted a 10% trimline, meaning that at least 10% of the curtailed use had to appear as benefit, and stated in hearing testimony that he viewed this as a minimum level of model uncertainty, noting that model uncertainty had not been quantified. He went on to say that:

"…I made the determination it was not appropriate to curtail such junior priority ground water use if, in fact, we didn't know whether curtailment would result in a meaningful amount of water reaching the calling senior right." (Transcript at 1167: 480)

The Director's ruling for Rangen was appealed to the District Court, which issued its *Memorandum Decision and Order on Petitions for Judicial Review* on October 24, 2014. Among other things, the District Court remanded back to the Director the issue of the trimline used in the Director's injury determination. This issue has not yet been taken up in new proceedings, leaving the trimline definition unresolved.

Rangen filed its third delivery call on June 27, 2014, asserting shortage to its July 1, 1957 priority water right. This is the subject of this proceeding.

3.2 Annual Shortage Basis for 1957 Priority Date Curtailment for Rangen Delivery Call

An important consideration in the Rangen 2014 delivery call is the amount and duration of annual shortage to the water right that is the basis for the 7/1/1957 priority date delivery call. Sullivan (2015) has calculated the shortage to the Rangen 1957 water right to occur in only 3 months of the year May, June, and July by 0.21, 0.22, and 0.66 cfs respectively, for a total annual shortage of 68.4 acre-feet (af). The Sullivan (2015) analysis is presented for convenience as Appendix A of this report. By contrast, moving the curtailment date from 7/13/1962 to 7/1/1957 would eliminate beneficial use of 290,000 af within the CGWA of the model domain. This represents a shortage to foregone beneficial use ratio of 2 hundredths of a percent (0.02%). Figure 8 is an illustration of the additional foregone beneficial use from curtailment compared to annual shortage basis for the 1957 water right delivery call.

Table 2 shows the tabulated values for forgone beneficial use compared to Curren Tunnel benefits under the series of trimline assumptions discussed in section 3.3 below. The disparity between forgone beneficial use and potential benefit to Rangen increases as the trimline % decreases (a smaller trimline % encompasses a larger acreage). Curtailment of junior groundwater rights within a 5 percent trimline or smaller will all produce a benefit to additional forgone use ratio of less than one percent. Curtailment of junior groundwater rights within the 10% trimline of CGWA of the model domain eliminates an additional 340 acres and 1,030 af of foregone beneficial use. The percent benefit to forgone use with the 10 percent trimline is about 6-7 percent.

3.3 ESPAM2.1 Curtailment Simulation Runs and Methodology

Section 3 covers the discussion of a series of curtailment simulations to predict the increase in discharge to the springs and river reaches represented in ESPAM2.1. Two versions of ESPAM2.1 were utilized in the analysis:

1) ESPAM2.1 "SuperSteadyState"

   - This is a superposition version of the steady state model. Superposition can be considered a change model where to evaluate the impact of a given change in model stress instead of differencing two model runs (the original run less the results from the model run with the change) a single model run is set-up such that only the influence of interest is changed and any flux observed in model output is attributable only to that change. The steady state model version is a run with only 1 stress period, so only a single set of input of long-term average annual values are used and the model runs to equilibrium, which is essentially infinite time, where there is no longer a change in storage such that flows into the model (ie recharge) and flows out of the model (ie stream/spring discharge) are equivalent.

2) ESPAM2.1 “SuperTransient10yr_monthly”

- This is another superposition version of the model and follows the same principals as described above for the steady state superposition model. However this is a transient model simulation with 120 stress periods, where each stress period is one month (12/yr) and the model runs for 10 years.

For the curtailment simulation runs with the superposition models the MODFLOW .wel file (or .net) is where the stress change from foregone pumping from curtailment is applied. For each curtailment date used in a model simulation a .wel file needs to be created; a different .wel file is needed for the steady state compared transient models due to the difference in stress periods. To build this file for each model run IDWR’s GIS recharge toolbox and MKMOD preprocessor were utilized. The GIS toolbox is used to create the .IAR file for input into MKMOD. The IAR file essentially tells MKMOD the groundwater irrigation by entity associated with the curtailment date that is used to build the .wel file. MKMOD then translates the change in irrigation so that it can be applied to each model cell associated with the foregone groundwater pumping and output as a .wel file for MODFLOW.

For each curtailment simulation two GIS files need to be modified to create the correct .IAR files with the recharge tools. These files are the Point of Diversion (POD) shapefile and the irrigated lands raster. The POD shapefile describes the point of diversion and associated priority date for each water right represented, this is used to link the irrigated lands to the priority date for the curtailment. For all of the model runs made for this report the 2014 POD file was used. The irrigated lands raster is a coverage of irrigated lands and their associated source fraction between groundwater and surface water. For all of the model runs described in this report the 2008 Irrigated Lands Raster was used. The modification that needs to be made to the POD and irrigated lands raster for the curtailment runs before the GIS recharge tools is applied is that they need to be clipped to the zone of inclusion for curtailment (ie CGWA, 10% trimline, etc.). Figure 9 shows the trimline areas analysed in the curtailment simulations.

The curtailment simulations run for the analysis in this report are as follows:

1) Curtailment to 7/1/1957 priority within the CGWA with ESPAM2.1”SuperSteadyState”

2) Curtailment to 7/1/1957 priority within the CGWA with ESPAM2.1” SuperTransient10yr_monthly”

3) Curtailment to 7/1/1957 priority within the CGWA and within the Steady State 10% response to Rangen cell trimline with ESPAM2.1”SuperSteadyState”

4) Curtailment to 7/1/1957 priority within the CGWA and within the Steady State 10% response to Rangen cell trimline with ESPAM2.1” SuperTransient10yr_monthly”

5) Curtailment to 7/1/1957 priority within the CGWA and within the Steady State 5% response to Rangen cell trimline with ESPAM2.1”SuperSteadyState”

6) Curtailment to 7/1/1957 priority within the CGWA and within the Steady State 5% response to Rangen cell trimline with ESPAM2.1” SuperTransient10yr_monthly”

7) Curtailment to 7/1/1957 priority within the CGWA and within the Steady State 2.4% response to Rangen cell trimline with ESPAM2.1"SuperSteadyState"

8) Curtailment to 7/1/1957 priority within the CGWA and within the Steady State 2.4% response to Rangen cell trimline with ESPAM2.1" SuperTransient10yr_monthly"

9) Curtailment to 7/13/1962 priority within the CGWA with the ESPAM2.1"SuperSteadyState"

3.4 Effects of a 1957 Priority Date Curtailment for Rangen Delivery Call

To evaluate the implication of curtailment across the ESPA as defined by the parameters of a 7/1/1957 priority water delivery call at Rangen, a series of curtailment simulations using various "trimline" assumptions were run with ESPAM2.1, as described in section 3.3. In contrast to section 3.2, the analysis presented in this section compares the total foregone beneficial use to the total simulated benefit at the Curren Tunnel (63% of the Rangen Cell flux) and not just the additional curtailment impacts to the additional shortage identified in the present call for the 1957 water right.

Figure 10 shows a series of pie charts with the forgone beneficial use in acre-feet (af) compared to the Curren Tunnel benefit (amount of beneficial use increase to water right 36-15501) under the different trimline areas used in the ESPAM2.1 7/1/1957 curtailment runs described in section 3.3 above. Curtailment of junior groundwater rights within the 10% trimline of CGWA of the model domain would immediately eliminate 1,103 af of beneficial use and at steady state (literally at an infinite time) ESPAM2.1 predicts an increase in Curren Tunnel discharge of 99 af, this benefit is about 8% of the foregone beneficial use.

The disparity between forgone beneficial use and potential benefit to Rangen only increases as the trimline % decreases. When considering curtailment within the CGWA within the model domain there is almost 1.4 million acre-feet (Maf) of beneficial use forgone under the 1957 priority curtailment for a Curren Tunnel benefit of about 10 thousand acre-feet (Kaf). This scenarios shows that of the almost 1.4 Maf of beneficial use forgone from curtailment, only 0.7% will be able to be put to beneficial use at Rangen under water right 36-15501. Table 3 shows the tabulated values for forgone beneficial use compared to Curren Tunnel benefits under the series of trimline assumptions.

To this point only steady state benefits at the Curren Tunnel have been discussed. The series of ESPAM2.1 curtailment runs under the various trimline assumptions were run both using the steady state superposition ESPAM2.1 model as well as the 10 yr monthly transient superposition ESPAM2.1 model. When time is factored in, the near-term benefit at the Curren Tunnel from curtailment becomes an even smaller percentage of the foregone beneficial use. Table 4 shows the ESPAM2.1 volume of foregone beneficial use from a 7/1/1957 curtailment within the CGWA of the model domain compared to the simulated increase in volume of discharge at the Curren Tunnel at 1 year, 2 years, 5 years and 10 years after curtailment. This analysis shows that even 10 years after full curtailment only 0.51% of the foregone beneficial use from curtailment will be available to put to beneficial use at Rangen. Table 5 shows the time to reach 90% of the steady state simulated increase in discharge at the Rangen cell under the series of trimline assumptions.

Foregone groundwater use that is not simulated to accrue to Rangen would accrue to other connected river reaches, springs and baseflows, including those on which there are no water rights or diversions, those on which there are no delivery calls, those on which approved mitigation plans are already in place, and those on which diversions occur under water rights junior to those of the curtailed rights. Table 6 shows the gains to each river reach and spring complex from the 7/1/1957 priority curtailment simulation within the CGWA of the model domain using the ESPAM2.1 superposition steady state model. For each reach or spring complex, the table also summarizes the current administrative status of each, that is, whether there is an active call from that reach or spring and if so, whether an approved mitigation plan is already in place for it.

As can be seen from Table 6, roughly half the increase in discharge from simulated curtailment would accrue to springs and reaches with approved mitigation plans, and roughly half would accrue to springs and reaches where there is no active delivery call in place. Of the latter, it can reasonably be expected that some springs will be undeveloped with no diversions (e.g., Lower White Springs), that some would have diversions under water rights junior to Rangen's 1957 priority, and that some would have current diversions that fully satisfy their water rights. Additionally, a portion of the increased discharge would occur as underflow that goes from the aquifer directly to the Snake River without any use. Of the total 1915 cfs simulated increase in gains to the Snake River stemming from curtailment across the ESPA, only 1% will actually accrue to Rangen and only 0.7% will accrue to the Curren Tunnel.

From a practical water management standpoint the curtailment is highly wasteful, and won't deliver a significant amount of benefit to Rangen, especially compared to the forgone beneficial use.

4.0 SUMMARY AND CONCLUSIONS

In section 2 of this report we reviewed measurements of flows in the Curren Tunnel and in the white pipe lying on the floor of the Tunnel. We concluded that measurements of flow in the Tunnel are subject to significant error and uncertainty because of: 1) the obstruction caused by the presence of the white pipe within the Tunnel, 2) the velocity field effects on the transducer used to measure flow depth in the Tunnel, 3) the incomplete and unverified measurement of flow in the white pipe by Rangen. The first two sources of error are exacerbated by low flow conditions, such as those underlying the present delivery call.

It is our opinion that, under present conditions, these flow measurements do not provide a sufficiently accurate and certain basis for administration of water rights as requested by Rangen, Inc., in their delivery call under water right 36-15501.

In Section 3 of this report we evaluated the effects of the curtailment sought by Rangen, Inc., in this delivery call. This evaluation was done using ESPAM2.1 and related data sets and processing tools. That evaluation found that by changing the curtailment date from July 13,1962, to July 1,1957, an additional 290,455 acre-feet of beneficial use would be immediately foregone to permit an additional 68.4 acre-feet of beneficial use to Rangen under water right 36-15501. The benefit to Rangen would be 0.02% of the foregone beneficial use.

It is our opinion that the elimination of such a large amount of beneficial use to provide such a small amount of beneficial use is a waste of the water resource present in the Eastern Snake Plain Aquifer.

Also in Section 3 we evaluated the overall effects of the curtailment sought by Rangen, Inc., using different trimline assumptions and with a transient model version that permits assessment of the timing of effects. That evaluation found that curtailment of groundwater uses junior to July 1, 1957, under any trimline smaller than 5% (a smaller trimline encompasses a larger acreage) will produce flow increases at the Curren Tunnel that are less than 1% of the foregone beneficial use. In the case of curtailment across the full area of common groundwater, the only 0.7 % of the nearly 1.4 million acre-feet of foregone beneficial use will accrue to Rangen. When timing of effects is considered, ten years after complete curtailment of 1.4 million acre-feet of beneficial use only 0.5% of that foregone use will have accrued to Rangen.

It is our opinion that curtailment of junior groundwater rights junior to July 1, 1957, will not produce benefits at Rangen in a timely way and that the amount of benefit ultimately received by Rangen will be such a small part of the foregone beneficial use as to constitute a waste of the water resource.

TABLES

Table 1: Water Rights at the Head of Billingsley Creek

User Name	Water Right #	Priority Date	Amount (cfs)	Source*	Use
Candy	36-134A	10/9/1884	0.49	Martin-Curren Tunnel	Domestic, Irrigation
Rangen, Inc.	36-134B	10/9/1884	0.09	Martin-Curren Tunnel	Irrigation and domestic use
Morris	36-134D	10/9/1884	1.58	Martin-Curren Tunnel	Irrigation, Stockwater
Morris	36-134E	10/9/1884	0.82	Martin-Curren Tunnel	Irrigation, Stockwater
Musser	36-102	4/1/1892	4.1	Martin-Curren Tunnel	Domestic, Irrigation, Stockwater
Rangen, Inc.	35-135A	4/1/1908	0.05	Martin-Curren Tunnel	Irrigation and domestic use
Candy	36-135B	4/1/1908	0.51	Martin-Curren Tunnel	Irrigation
Morris	36-135D	4/1/1908	1.58	Martin-Curren Tunnel	Irrigation, Stockwater
Morris	36-135E	4/1/1908	0.82	Martin-Curren Tunnel	Irrigation, Stockwater
Morris	36-10141A	12/1/1908	0.82	Martin-Curren Tunnel	Irrigation, Stockwater
Morris	36-10141B	12/1/1908	0.43	Martin-Curren Tunnel	Irrigation, Stockwater
Rangen, Inc.	36-15501	7/1/1957	1.46	Martin-Curren Tunnel	Fish propogation use at the hatchery and research facility on Billingsley Creek
Rangen, Inc.	36-2551	7/13/1962	48.54	Martin-Curren Tunnel	Fish propogation use at the hatchery and research facility on Billingsley Creek (includes 0.1 fs for domestic use)
Rangen, Inc.	36-7694**	4/12/1977	26	Martin-Curren Tunnel	Fish propogation use at the hatchery and research facility on Billingsley Creek

*SRBA Partial Decree

**According to a memorandum from Cindy Yenter to Karl Dreher dated December 15, 2003, Rangen's submitted historical flow numbers show that flows have not been available to support water right number 36-7694 since October 1972, which predates the priority year of the right by nearly 5 years. Additionally, during the water right development period flows did not exceed 50 cfs, which is the total of water rights 36-15501 and 36-2551.

Table 2: ESPAM2.1 volume of additional foregone beneficial use from 7/13/1962 to 7/1/1957 priority date curtailment compared to 1957 benefit at the Curren Tunnel

Boundary	Additional Acres Curtailed	Foregone Beneficial Use (af)	Curren Tunnel Benefit (af)	% Benefit to Foregone Beneficial Use
CGWA	126,367	293,849	68.4	0.02%
5% Trimline	2,163	6,926	68.4	0.99%
10% Trimline	343	1,030	68.4	6.64%

1957 Run with SuperSS ESPAM2.1 and 2014 POD. 1962 data from IDWR Staff Memo for Rangen Delivery Call (WR 36-02551 & 36-07694)

Table 3: ESPAM2.1 volume of foregone beneficial use from 7/1/1957 curtailment compared to predicted increase in volume of Curren Tunnel discharge

Boundary	Acres Curtailed	Foregone Beneficial Use (af)	Curren Tunnel Benefit (af)	% Benefit to Foregone Beneficial Use
CGWA	605,570	1,386,788	10,167	0.7%
2.4% Trimline	55,590	158,012	4,429	2.8%
5% Trimline	14,509	42,883	1,951	4.5%
10% Trimline	367	1,103	99	8.9%

Run with SuperSS ESPAM2.1 and 2014 POD.

Table 4: ESPAM2.1 volume of foregone beneficial use from 7/1/1957 curtailment compared to predicted increase in volume of Curren Tunnel discharge

CGWA priority 7/1/1957	Foregone Beneficial Use (af)	Curren Tunnel Benefit (af)	% Benefit to Foregone Beneficial Use
Year 1	1,386,788	3,581	0.26%
Year 2	1,386,788	3,924	0.28%
Year 5	1,386,788	5,808	0.42%
Year 10	1,386,788	7,056	0.51%

Run with SuperTransient10yr_monthly ESPAM2.1 and 2014 POD.

Table 5: ESPAM2.1 time to reach 90% steady state simulated increase in discharge at the Rangen cell

Boundary	Acres Curtailed	Foregone Beneficial Use (af)	Curren Tunnel Benefit (cfs)	% Benefit to Foregone Beneficial Use	Years to Reach 90% of Steady State Increase
CGWA	605,570	1,386,788	14.0	0.7%	>10
2.4% Trimline	55,590	158,012	6.12	2.8%	3
5% Trimline	14,509	42,883	2.69	4.5%	2
10% Trimline	367	1,103	0.14	8.9%	1

Run with SuperTransient10yr_monthly ESPAM2.1 and 2014 POD.

Table 6: Simulated ESPAM2.1 Gains to River Reaches and Springs from 7/1/1957 Priority Curtailment within the CGWA

River Reach		ESPAM2.1 Gain (cfs)	Adminstrative Status
Ashton to Rexburg		128.26	No call
Heise to Shelley		203.14	No call
Shelley to Near Blackfoot		259.41	No call
Near Blackfoot to Neely		813.01	Mitigation plan
Springs	**Class**	**ESPAM2.1 Gain (cfs)**	**Adminstrative Status**
BANCROFT	C	0.76	No call
LSF to KH Spg Rch (10 unnamed springs)	C	3.37	No call
MALAD	B	54.03	No call (IPC*)
WHITE (cell 37,14)	C	0.19	No call
BIRCH	C	0.08	No call
BIGSP	C	8.46	No call
THREESP	B	16.04	Mitigation plan
TUCKERSP	C	1.30	No call
RANGEN	B	22.29	Active call
NFHATCH	B	14.28	No call
KSPGS	B	57.68	No call (IPC*)
SANDSPGS	B	24.00	No call
BOX	A	81.26	Mitigation plan
BANBURYSP	C	5.81	No call
Bul to LSF Spg Rch (8 unnamed springs)	C	2.53	No call
BRIGGS	A	2.18	No call
CLEARLK	B	47.54	Mitigation plan
NIAGARA	B	39.91	Mitigation plan
CRYSTAL	B	60.42	Mitigation plan
ELLISON	C	0.21	No call
WARM CRK SP (cell 61,23)	C	0.28	No call
BLUELK	B	24.27	Mitigation plan
DEVILSC	A	9.78	No call
DEVILWB	A	7.31	No call (IPC*)
Kim to Bul Spg Rch (10 unnamed springs)	C	2.43	No call
Totals		**ESPAM2.1 Gain (cfs)**	**% of total**
Undivertable baseflow (GHBs)		23.99	1%
Mitigation plans		1082.45	57%
No call		785.48	41%
Rangen		22.29	1%
Curren Tunnel		14.04	0.7%
Total Changes All Connected Reaches		**1914.22**	**100%**

F I G U R E S

Figure 1: Rangen 2014 Delivery Call and Eastern Snake Plain Aquifer Location Map

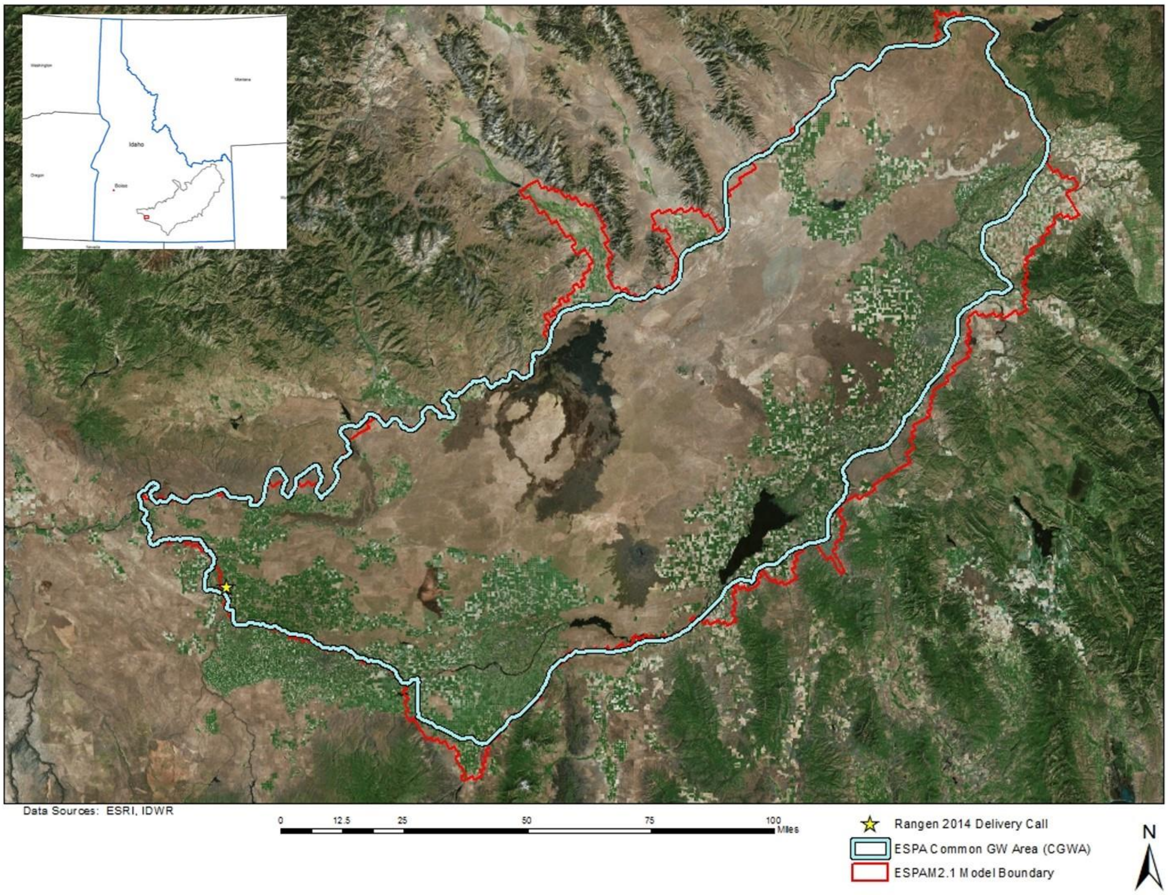


Figure 2: Rangen Facility Location Map

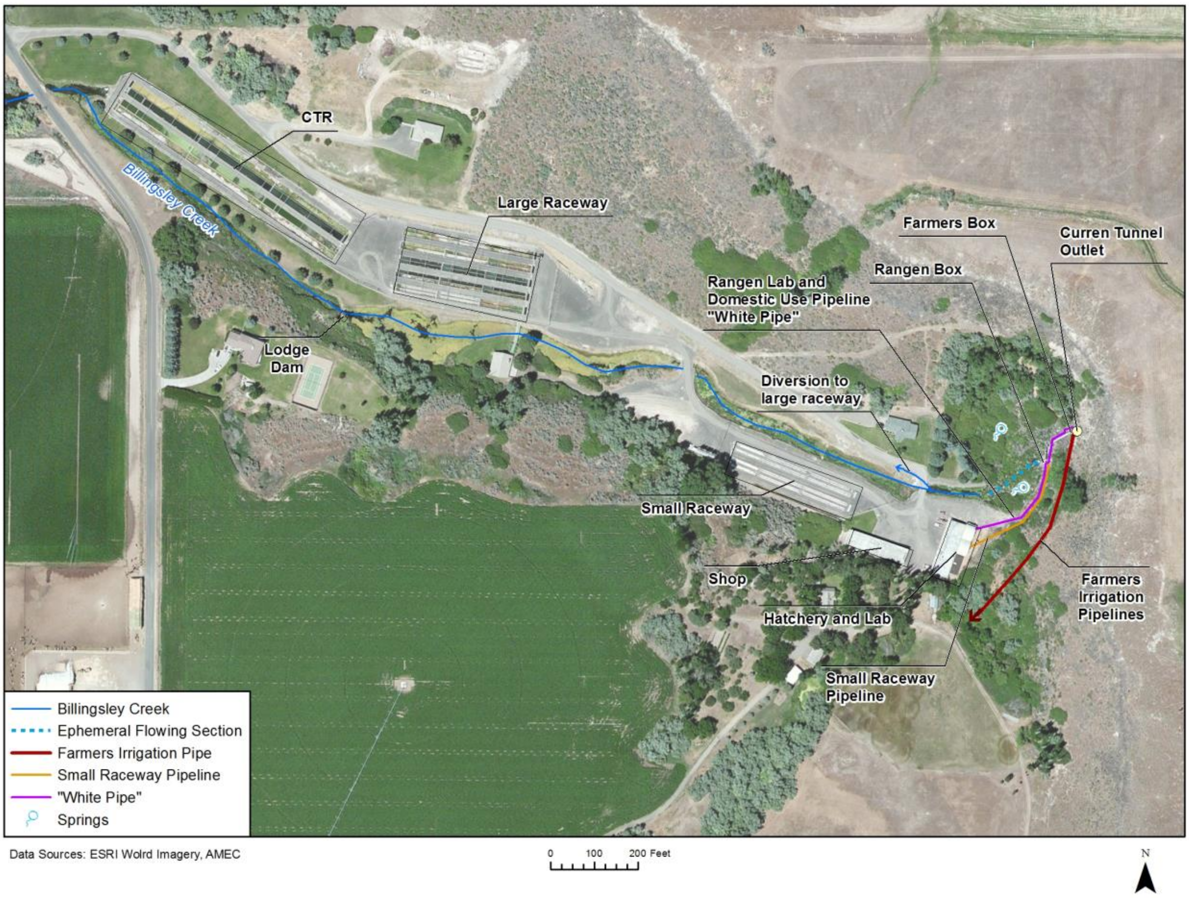


Figure 3: Configuration of White Pipe and Steel Liner in Curren Tunnel

Schematic of White Pipe and Steel Liner in Curren Tunnel

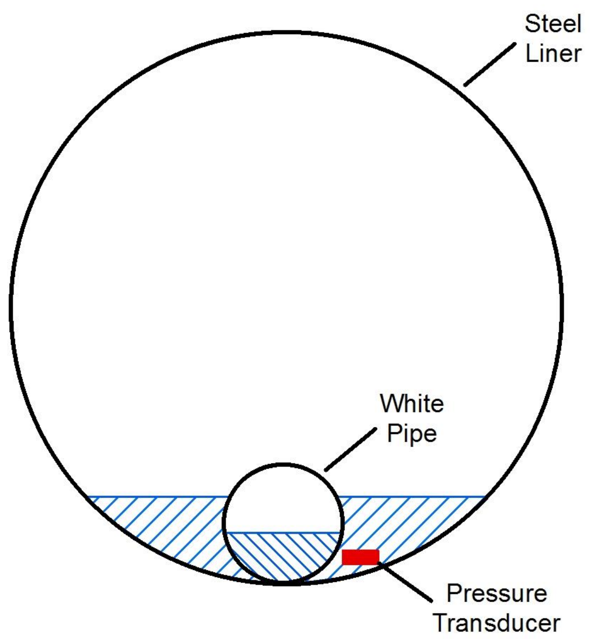


Figure 4: Curren Tunnel

Entrance to Curren Tunnel

Curren Tunnel to the Farmers Box

Figure 5: Curren Tunnel Flow Measurements

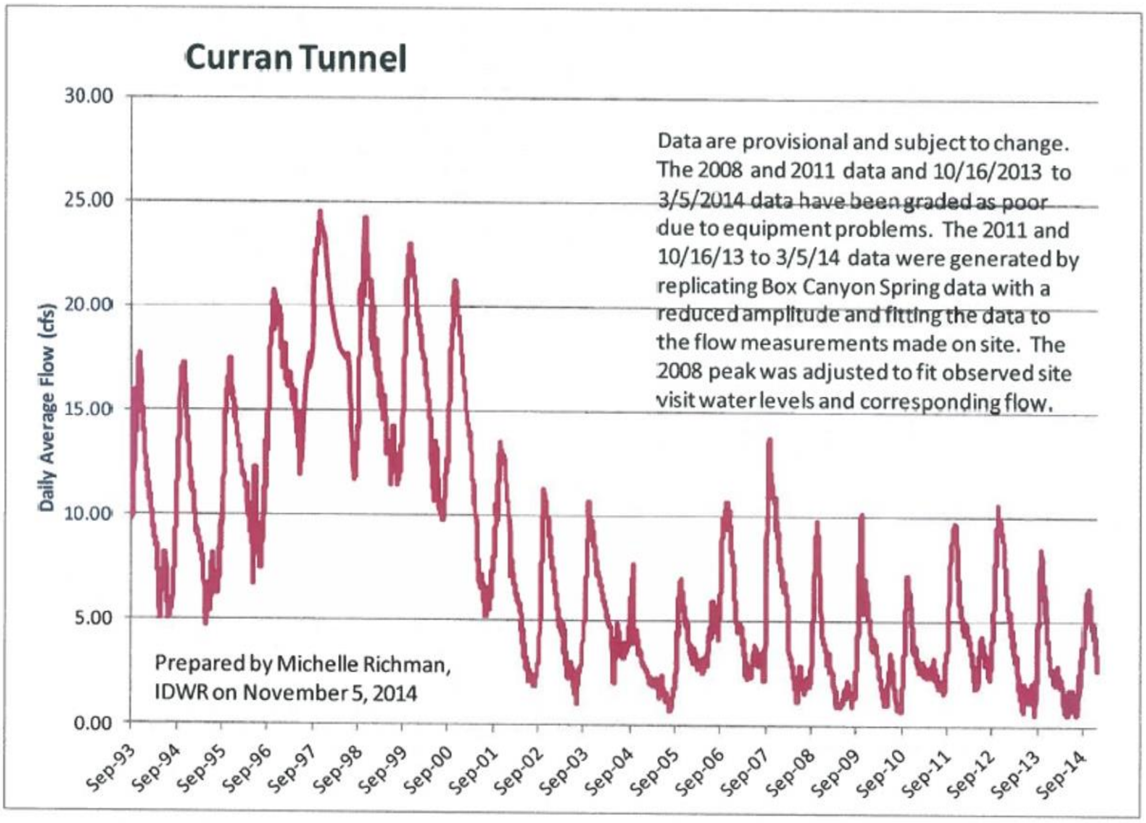


Figure 6: IDWR rating curve

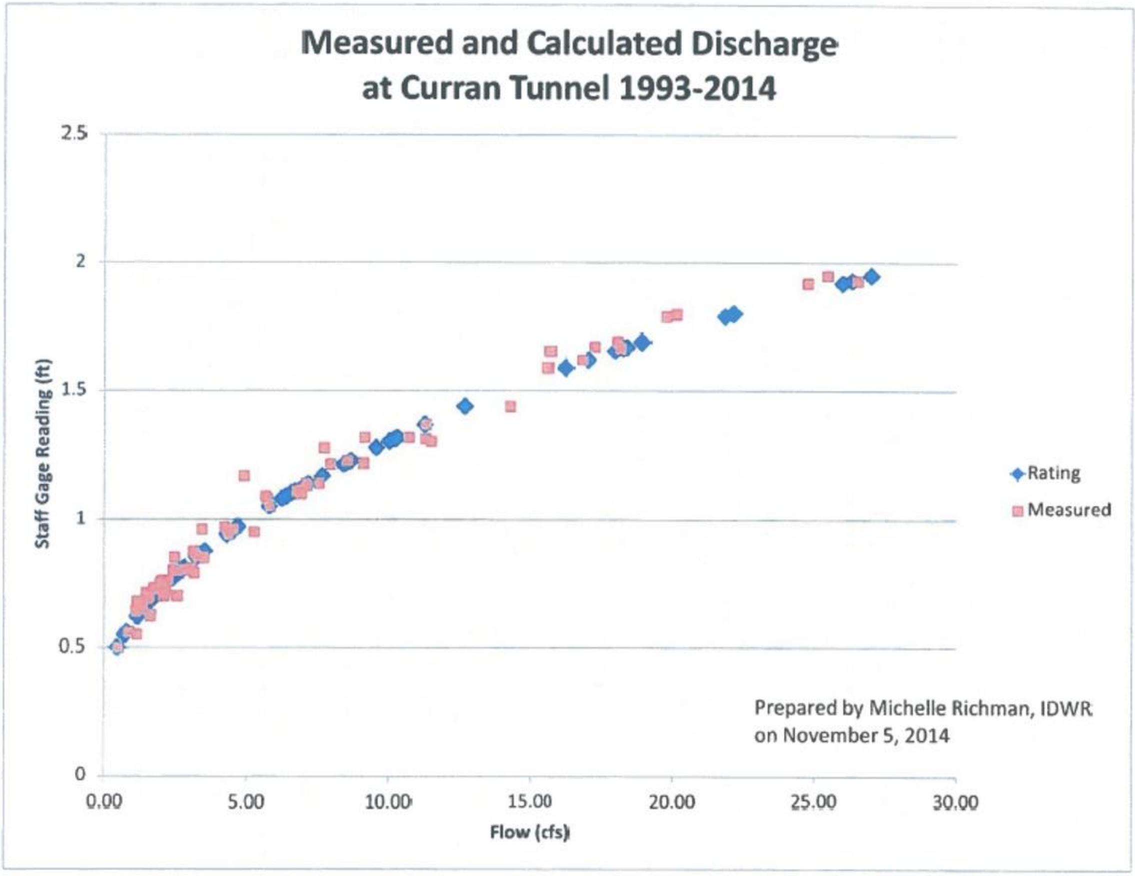


Figure 7: Discharge Measurement Error

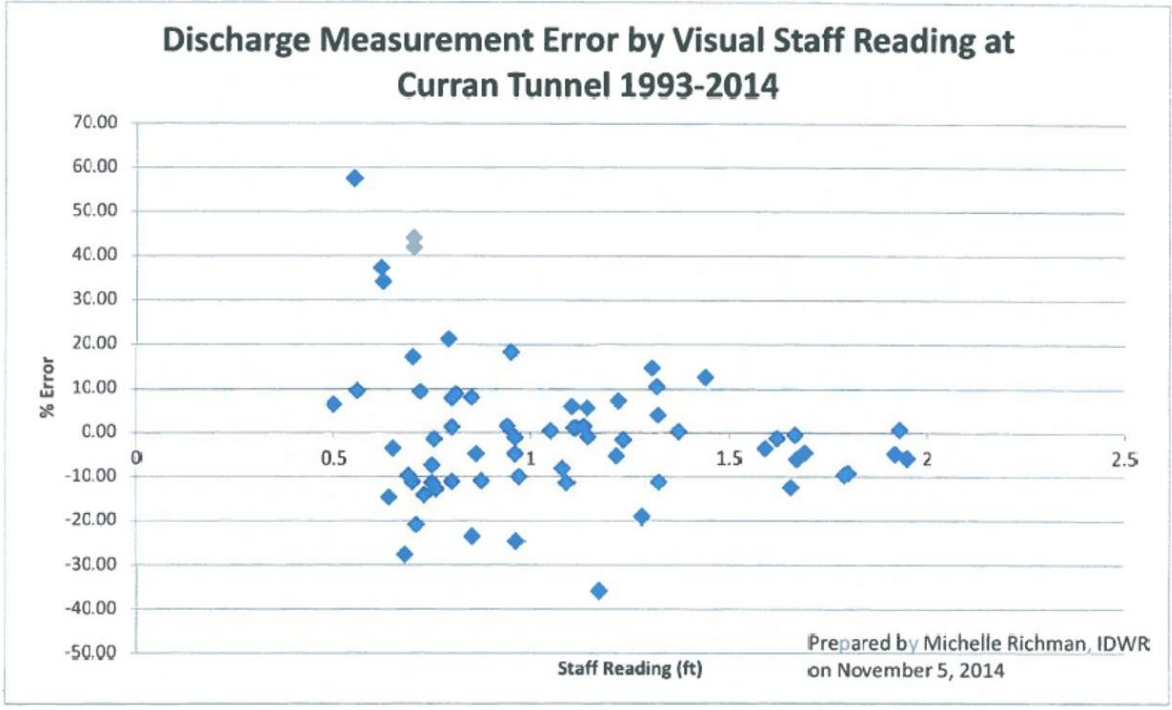


Figure 8: ESPAM2.1 Additional Volume of Foregone Beneficial Use from 7/13/1962 to 7/1/1957 Curtailment Compared to Curren Tunnel 1957 Water Right Annual Shortage

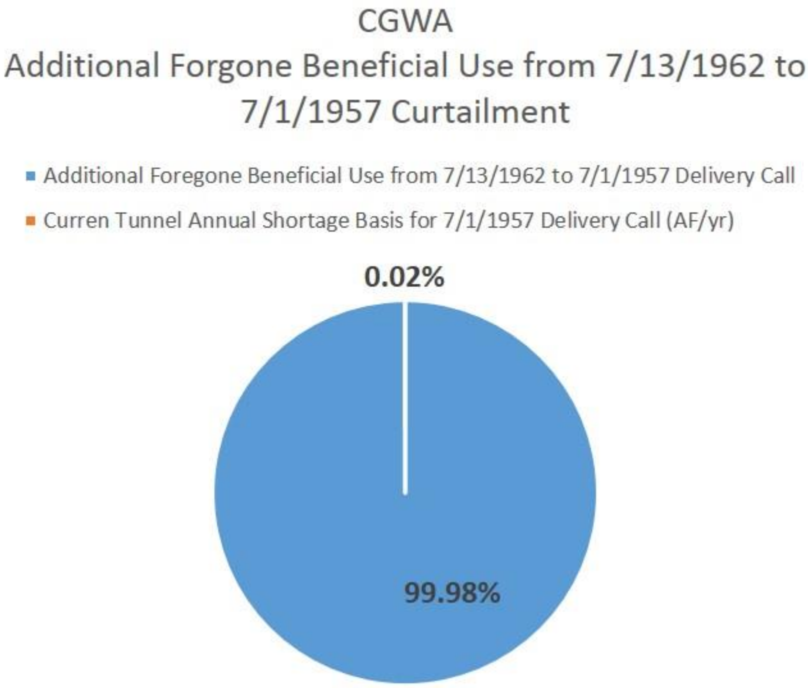


Figure 9: Rangen Cell % Steady State Response Function Trimlines

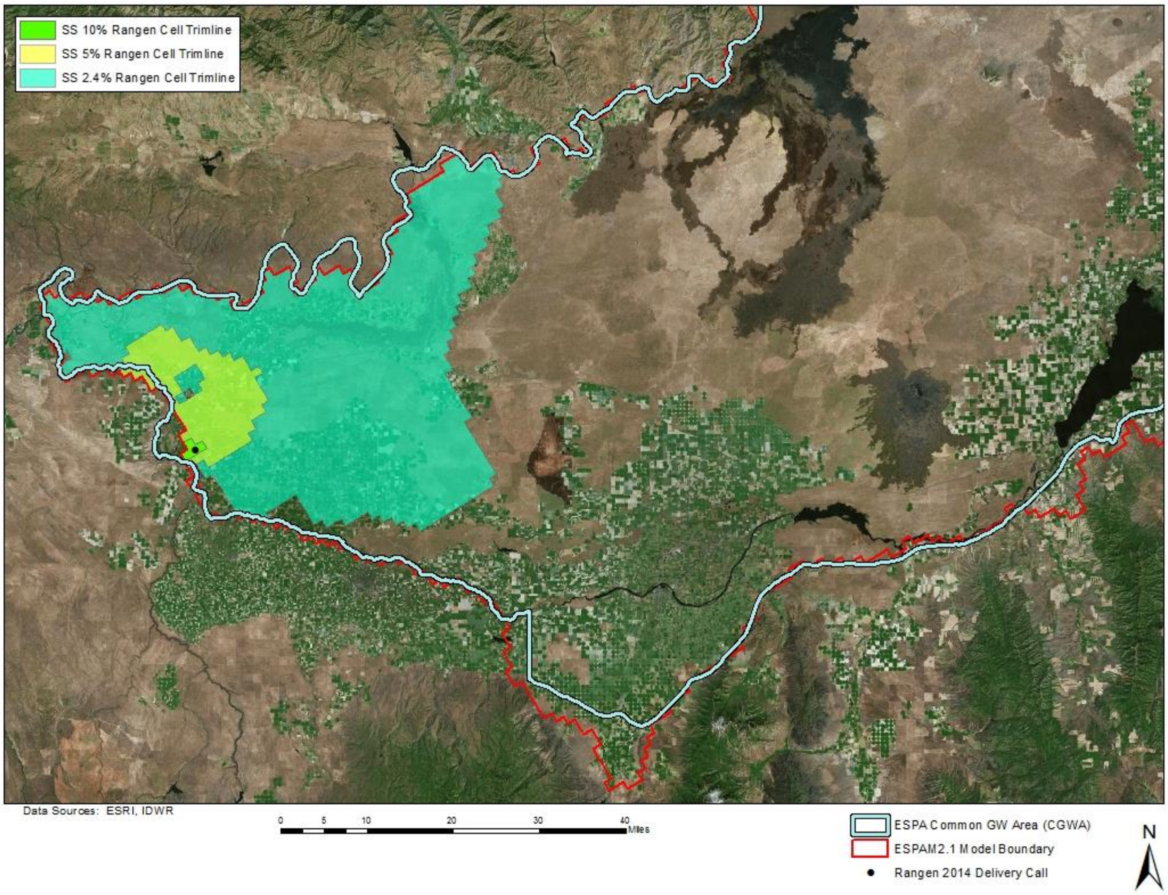
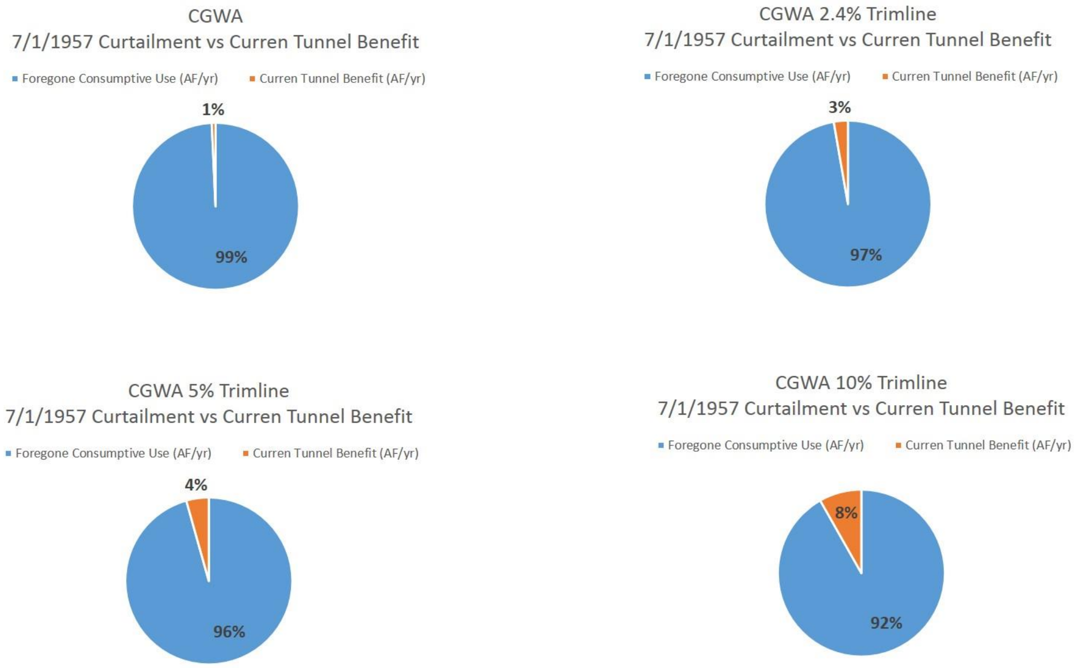


Figure 10: ESPAM2.1 Volume of Foregone Beneficial Use from 7/1/1957 Curtailment Compared to Predicted Increase in Volume of Curren Tunnel Discharge



Appendix A. SULLIVAN (2015) SHORTAGE ANALYSIS

Table 4-1

Summary of Available Curren Tunnel Flows and Allocation of Flows to Senior Water Rights
Morris Exchange Credit Calculations, and Water Available to Rangen's 1957 Priority Water Right
(CFS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Available Flows			Morris Exchange Credit		Rangen's 1957 Water Right					
Month	Avg Monthly Total Curren Tunnel Flow 2014	Total Senior Water Rights Diverted from Curren Tunnel	Total Curren Tunnel Water Available 2014	Decreed Morris Irrigation Water Rights	Morris Exchange Credit Available 2014	Rangen 36-15501 (7/1/1957)	Morris Exchange Credit to Rangen's 1957 Water Right	Other Curren Tunnel Flow to Rangen's 1957 Water Right	Total Flow to Rangen's 1957 Water Right	Shortage (-) to 1957 Water Right	Morris Exchange Credit Available to Rangen's 1962 Water Right
Jan	2.89	0.16	2.73	-	-	1.46	-	1.46	1.46	-	-
Feb	2.39	0.17	2.22	3.03	2.22	1.46	1.46	-	1.46	-	0.76
Mar	2.22	0.18	2.04	6.05	2.04	1.46	1.46	-	1.46	-	0.58
Apr	1.70	0.18	1.52	6.05	1.52	1.46	1.46	-	1.46	-	0.06
May	1.42	0.18	1.24	6.05	1.24	1.46	1.24	-	1.24	(0.22)	-
Jun	1.39	0.18	1.21	6.05	1.21	1.46	1.21	-	1.21	(0.25)	-
Jul	0.94	0.18	0.76	6.05	0.76	1.46	0.76	-	0.76	(0.70)	-
Aug	2.36	0.18	2.18	6.05	2.18	1.46	1.46	-	1.46	-	0.72
Sep	4.56	0.18	4.38	6.05	4.38	1.46	1.46	-	1.46	-	2.92
Oct	6.39	0.18	6.21	6.05	6.05	1.46	1.46	-	1.46	-	4.59
Nov	5.38	0.18	5.20	6.05	5.20	1.46	1.46	-	1.46	-	3.74
Dec	4.21	0.16	4.05	-	-	1.46	-	1.46	1.46	-	-
Ann Avg	2.99	0.18	2.81	4.79	2.23	1.46	1.12	0.24	1.36	(0.10)	1.11

Notes:

(1) Total Curren Tunnel flows (IDWR measurements plus 6-inch White Pipe) reported in 2014.

(2) Sum of the portions of the senior water rights that are reportedly still diverted at the Curren Tunnel including Candy 36-134A (0.04 cfs), Rangen 36-134B (0.09 cfs during the irrigation season 2/15 - 11/30 and 0.07 cfs during the non-irrigation season), and Rangen 36-135A (0.05 cfs).

(3) = (1) - (2).

(4) Sum of the irrigation portion of the Morris water rights which include 36-134D (1.58 cfs), 36-134E (0.82 cfs), 36-135D (1.58 cfs), 36-135E (0.82 cfs), 36-10141A (0.82 cfs), and 36-10141B (0.43 cfs) decreed for a period of use of 2/15 - 11/30.

(5) Minimum of Morris decreed water rights (4) and available Curren Tunnel flow (3).

(6) Rangen's decreed 1957 priority water right for fish propagation.

(7) Minimum of Morris Exchange Credit available (5) and Rangen's 1957 priority water right (6).

(8) Minimum of available Curren Tunnel flow (3) and Rangen's 1957 priority water right (6) less Morris Exchange Credit to Rangen's 1957 priority water right (7).

(9) = (7) + (8).

(10) = (9) - (6).

(11) = (5) - (7).