Memorandum

To: Rangen Inc.

From: Dennis McGrane, Jim Brannon, and Dave Colvin– Leonard Rice Engineers, Inc.

Date: December 9, 2011

Project: 1179MSB01

Subject: ESPAM Model V. 2.0 Curtailment Analysis

The Eastern Snake Hydrologic Modeling Committee (ESHMC) has been overseeing the development of the Eastern Snake Plain Aquifer ground water model (ESPAM). During the ESHMC's December, 2011 meeting, we expect they will announce that they have completed calibrating Version 2.0 of the ESPAM model.

At Rangen's request, Leonard Rice Engineers (LRE) used the current model (Model Version 2.0-E110712A) to:

- Determine whether junior well pumping has impacted Rangen spring flows and water rights;
- Quantify the cumulative impacts to Rangen spring flow over time;
- Quantify the recovery of the Rangen Spring if junior wells are administered (shut down); and
- Evaluate whether the model predicted recovery is reasonable.

Background

Rangen has five water rights on Billingsley Creek dated October 9, 1884 (0.09 cfs), April 1, 1908 (0.05 cfs), July 1, 1957 (1.46 cfs), July 13, 1962 (48.54 cfs), and April 12, 1977 (26.0 cfs). Spring flows at the Rangen spring are well documented and have been declining since 1966. LRE has inspected the Rangen facility and the spring flow measurement devices. LRE believes that Rangen has collected accurate flow measurements, that the water use is reasonable and not wasteful, and that Rangen has the physical capacity to put all of its water rights to use.

Figure 1 shows how weekly flow measurements averaged on an annual basis have declined from an average of approximately 51 cfs in 1966 to an average of approximately 14 cfs in 2011 (average through October), a total average decline since 1966 of approximately 37 cfs.

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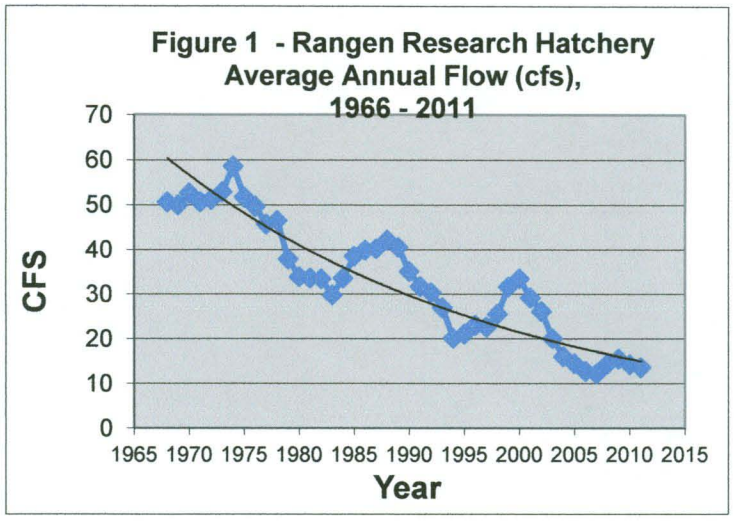

The decline is caused by several factors including junior well pumping which lowers the water table thereby reducing spring flow.

ESPAM Model Version 2.0

The ESPAM model was originally created by the Idaho Water Resources Research Institute (IWRRI). In the past, the Idaho Department of Water Resources (IDWR) used a superposition version of the ESPAM model (Versions 1 and 1.1) to evaluate delivery calls. IDWR also utilized a "trim line methodology" with ESPAM model Version 1.1 despite a White Paper written by six members of the ESHMC stating the method is not technically valid or justified (2). We agree that the "trim line methodology" is not a technically valid approach to evaluate delivery calls and believe other technically sound methods should be utilized.

Recognizing serious limitations of ESPAM model Version 1.1, IDWR (with assistance from ESHMC and IWRRI) recently completed significant improvements to the ESPAM model. ESPAM model Version 2.0 is significantly improved from model Version 1.1 because, among other things, it is actually calibrated to observed and documented Rangen spring flows. LRE utilized the ESPAM Version 2.0 model with a more appropriate "difference" modeling approach to evaluate the effects of a Rangen call. "Difference" models are commonly used, and widely accepted among hydrologists and water administrators, to evaluate the impacts of well pumping on water rights. The differencing technique involves calculating the difference between ESPAM Version 2.0 model output under noncurtailed and curtailed scenarios using the same steady state noncurtailed input heads. Since the model is now calibrated to the Rangen spring, the difference in transient runs accurately predict the Rangen spring response to the curtailment scenario. The trim line methodology does not.

2011 Curtailment Scenario

In the ESPAM v2.0 model simulated ground water pumping from the Eastern Snake Plain Aquifer is driven by the amount of designated "Ground Water Acres" determined by IDWR. There is not a

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direct connection between the amount of pumping determined by the model and the water rights Point of Diversion (POD) database that compiles actual well data. To tie ground water acres in the model to ground water rights in the POD database, we determined the percentage of junior water rights (post July 13, 1962) compared to total ground water rights from the POD database within each model cell and then multiplied that percentage by the total number of ground water acres assigned to each cell in the model. By doing this, we effectively reduced the ground water acres (and therefore pumping) by the percentage of ground water rights that are junior to Rangen. We then ran the model preprocessor to recalculate model input files for the curtailment scenario and reran the transient mode using steady state input heads from the noncurtailment run.

Results

Figure 2 shows observed and documented Rangen spring flows, modeled outflow at the cell containing the Rangen spring, and modeled outflow at the Rangen spring cell during the curtailment run. The Rangen spring is the only spring in its' model cell. The data for Figure 2 are also included as a table in Appendix A.

Figure 2 - Rangen Spring Flows Under ESPAM v2 Curtailment Scenarios

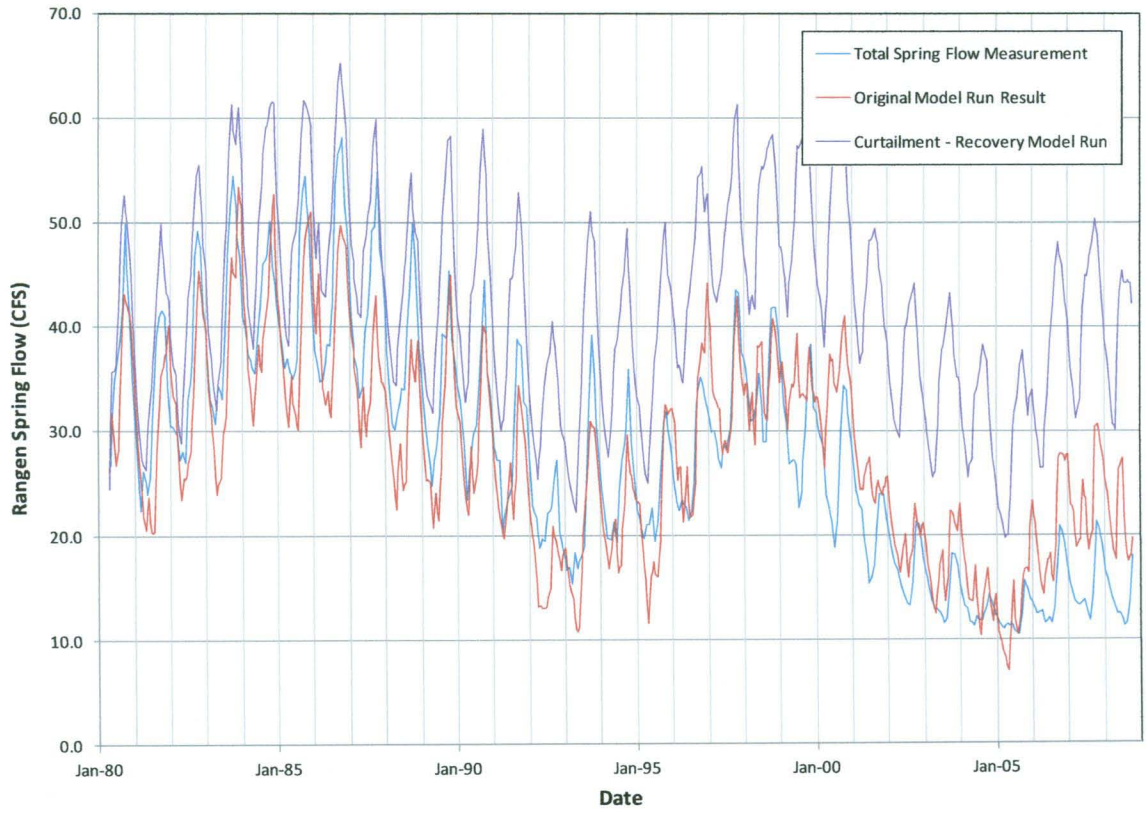
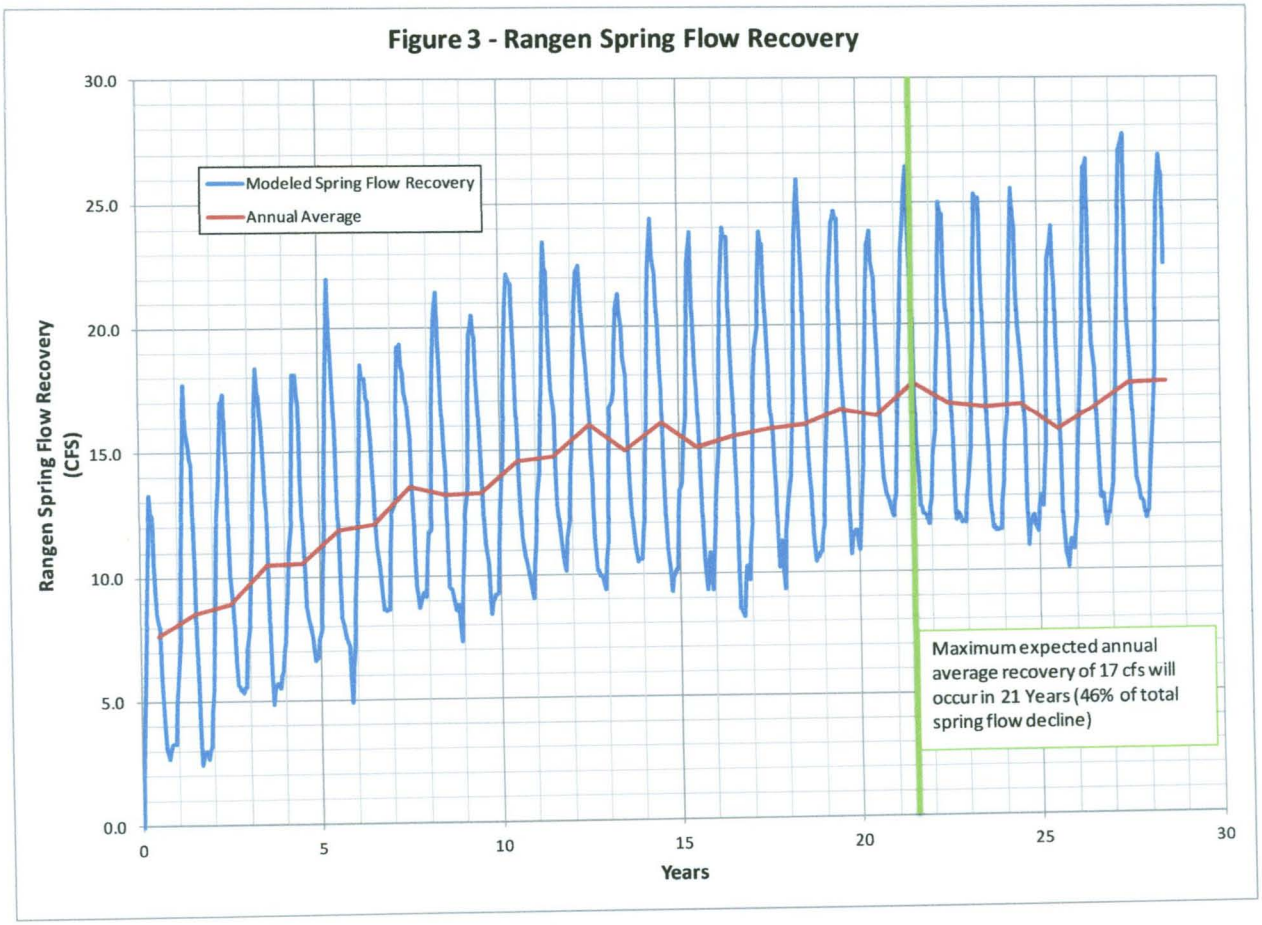


Figure 2 shows that:

- Observed and documented Rangen spring flows fluctuate seasonally;
- Modeled spring flows closely match those observed at the Rangen spring so the model is therefore "well calibrated" to the Rangen spring; and
- Modeled Rangen spring flows during the curtailment scenario plot above the noncurtailed scenario due to the quick recovery response of the spring.

Figure 3 shows the difference between the noncurtailed and curtailed runs shown in Figure 2 assuming that junior-priority ground water rights are curtailed.



The Rangen spring is expected to recover an average of 8 cfs during the first year which is more than 50 percent of Rangen's average current flow. A recovery of 17 cfs is expected within 21 years. This is 46 percent (17 cfs/37 cfs) of the approximate total decline since 1966, which is significant.

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Conclusions

We conclude:

- The ESPAM Model (Version 2.0) has undergone significant improvements since version 1.1. We believe the ESPAM Version 2.0 model is currently the best available science and any administrative modeling scenarios to evaluate impacts caused by junior-priority ground water pumping should be implemented using ESPAM Version 2.0 with a "difference" modeling approach.

- Using the "difference" modeling approach, we determined that junior-priority (post July 13, 1962) ground water pumping has caused the Rangen spring to decline approximately 17 cfs, which constitutes material injury to Rangen's water rights.

- If the IDWR curtailed junior-priority ground water pumping, the Rangen spring would likely recover approximately 17 cfs within 21 years.

- The predicted model response is likely accurate since the ESPAM Version 2.0 model is "well calibrated" to regional observations and to the historical Rangen spring observations.

Recommendations

We recommend that Rangen request that the Idaho Department of Water Resources curtail all junior-priority ground water pumping in the area encompassed by ESPAM Version 2.0 model.

References:

1) IDWR Second Amended Order in response to the "Rangen Call" dated May 19, 2005

2) The Eastern Snake Hydrologic Modeling Committee (ESHMC), May 6, 2009. "White Paper - Technical Evaluation of Trim Line and Method Used to Evaluate Impacts to Spring in ESPAM Model." Prepared by the following members of the ESHMC: John Koreny, HDR, Inc., Willem Schreuder, Principia Mathematica, Charles Brockway, Sr., Brockway Engineering, Inc., John Bowling, Dave Blew, Idaho Power Co., Jim Brannon, Leonard Rice Engineers, Inc., and Jennifer Johnson, Bureau of Reclamation. Available on Request.

APPENDIX A

Rangen Spring Flow Measurements and

ESPAM V. 2.0 Curtailment Model Results

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Rangen Spring Flow Measurements and ESPAM V. 2.0 Curtailment Model Results

Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
5/1/1980		26.1	24.4
5/16/1980	26.7	29.1	31.1
6/1/1980		31.7	35.7
6/16/1980	34.9	28.4	35.7
7/1/1980		26.8	36.4
7/16/1980	36.7	27.5	39.3
8/1/1980		28.1	41.4
8/16/1980	38.5	33.5	46.1
9/1/1980		37.2	49.7
9/16/1980	41.8	40.7	51.2
10/1/1980		43.2	52.6
10/16/1980	49.9	42.5	51.0
11/1/1980		42.1	50.1
11/16/1980	41.1	41.2	47.3
12/1/1980		40.1	45.1
12/16/1980	34.9	37.9	41.8
1/1/1981		36.0	39.1
1/16/1981	31.1	33.2	36.2
2/1/1981		31.2	33.8
2/16/1981	26.7	28.8	31.8
3/1/1981		26.9	30.1
3/16/1981	22.4	25.4	28.6
4/1/1981		24.0	27.3
4/16/1981	26.2	21.9	26.8
5/1/1981		20.5	26.4
5/16/1981	24	22.5	29.2
6/1/1981		23.8	31.1
6/16/1981	25.5	21.4	32.6
7/1/1981		20.4	33.9
7/16/1981	31.5	20.3	36.3
8/1/1981		20.4	38.2
8/16/1981	37.3	24.8	40.8
9/1/1981		28.0	43.2
9/16/1981	41	32.3	47.1
10/1/1981		35.3	49.8
10/16/1981	41.6	35.9	47.8
11/1/1981		36.2	46.6
11/16/1981	41	37.2	44.8
12/1/1981		37.5	43.3
12/16/1981	34.1	39.2	43.1
1/1/1982		40.1	42.5
1/16/1982	30.6	36.0	38.9
2/1/1982		33.4	36.4
2/16/1982	30.1	33.1	35.9

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Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
3/1/1982		32.7	35.4
3/16/1982	29.7	29.6	32.7
4/1/1982		27.5	30.7
4/16/1982	27.2	25.0	29.6
5/1/1982		23.4	28.8
5/16/1982	28.1	24.4	32.2
6/1/1982		25.6	34.8
6/16/1982	27	25.4	37.5
7/1/1982		25.8	39.7
7/16/1982	33	27.0	42.7
8/1/1982		28.0	45.0
8/16/1982	37.1	31.0	48.1
9/1/1982		33.2	50.5
9/16/1982	46.8	37.3	52.6
10/1/1982		40.1	54.5
10/16/1982	49.2	43.4	55.0
11/1/1982		45.4	55.5
11/16/1982	47.6	43.8	52.6
12/1/1982		42.8	50.7
12/16/1982	41.9	41.2	47.8
1/1/1983		39.7	45.4
1/16/1983	37	36.5	42.1
2/1/1983		34.0	39.5
2/16/1983	33.1	32.7	38.2
3/1/1983		31.6	37.0
3/16/1983	32.3	29.7	35.2
4/1/1983		28.3	33.9
4/16/1983	30.7	25.7	32.9
5/1/1983		24.0	32.0
5/16/1983	34.3	24.9	34.7
6/1/1983		25.6	36.6
6/16/1983	33	27.8	40.8
7/1/1983		29.8	44.3
7/16/1983	39.1	30.4	47.3
8/1/1983		31.4	49.8
8/16/1983	47.1	36.3	53.8
9/1/1983		39.7	56.9
9/16/1983	51.5	43.8	59.3
10/1/1983		46.7	61.3
10/16/1983	54.4	45.3	58.7
11/1/1983		44.7	57.4
11/16/1983	48.6	50.2	59.8
12/1/1983		53.3	61.1
12/16/1983	46.7	52.2	58.2

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Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
1/1/1984		51.4	56.3
1/16/1984	41	46.0	51.5
2/1/1984		42.3	48.0
2/16/1984	40.1	40.7	46.3
3/1/1984		39.3	44.8
3/16/1984	37.4	36.0	42.0
4/1/1984		33.6	39.8
4/16/1984	36.1	31.8	38.8
5/1/1984		30.6	37.9
5/16/1984	35.5	33.1	41.5
6/1/1984		34.9	44.2
6/16/1984	39	36.7	47.7
7/1/1984		38.4	50.4
7/16/1984	41.9	36.2	52.0
8/1/1984		35.6	53.7
8/16/1984	46.1	38.8	56.7
9/1/1984		40.9	59.0
9/16/1984	46.9	42.0	59.3
10/1/1984		43.0	60.0
10/16/1984	50.1	46.9	61.0
11/1/1984		49.1	61.5
11/16/1984	45.8	51.4	61.5
12/1/1984		52.7	61.5
12/16/1984	44.1	47.4	55.9
1/1/1985		43.9	52.0
1/16/1985	40.2	41.0	48.9
2/1/1985		38.6	46.2
2/16/1985	38.3	37.4	44.4
3/1/1985		36.1	42.7
3/16/1985	36.1	34.0	40.8
4/1/1985		32.5	39.2
4/16/1985	37	31.3	38.7
5/1/1985		30.3	38.2
5/16/1985	35.7	33.1	43.4
6/1/1985		35.3	47.1
6/16/1985	35	32.7	48.1
7/1/1985		31.5	49.1
7/16/1985	36.9	30.5	50.7
8/1/1985		30.2	52.2
8/16/1985	49.3	35.5	55.3
9/1/1985		39.2	58.1
9/16/1985	52.9	43.5	60.1
10/1/1985		46.4	61.6
10/16/1985	54.5	48.4	61.3

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Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
11/1/1985		49.5	61.1
11/16/1985	49.1	50.5	60.1
12/1/1985		51.0	59.3
12/16/1985	42.5	46.7	54.8
1/1/1986		43.7	51.5
1/16/1986	37.8	41.3	48.8
2/1/1986		39.3	46.5
2/16/1986	36.5	42.9	48.7
3/1/1986		45.1	50.0
3/16/1986	34.8	39.7	46.1
4/1/1986		36.4	43.6
4/16/1986	34.9	34.0	43.3
5/1/1986		32.5	42.9
5/16/1986	38.3	33.2	45.2
6/1/1986		33.8	46.9
6/16/1986	38.2	32.0	48.4
7/1/1986		31.4	49.8
7/16/1986	42.2	34.7	52.6
8/1/1986		37.0	54.9
8/16/1986	53.6	40.9	58.1
9/1/1986		43.8	60.9
9/16/1986	56.6	47.2	63.3
10/1/1986		49.7	65.2
10/16/1986	58.1	49.0	63.3
11/1/1986		48.6	62.1
11/16/1986	51.5	48.3	60.3
12/1/1986		47.8	59.0
12/16/1986	48.9	44.8	55.2
1/1/1987		42.5	52.3
1/16/1987	43.3	40.9	50.0
2/1/1987		39.3	47.9
2/16/1987	38.2	37.5	46.2
3/1/1987		36.0	44.6
3/16/1987	36.1	34.2	42.8
4/1/1987		32.7	41.3
4/16/1987	33.2	30.1	41.2
5/1/1987		28.4	40.9
5/16/1987	34.1	31.9	44.7
6/1/1987		34.2	47.3
6/16/1987	39.5	31.1	48.0
7/1/1987		29.5	48.8
7/16/1987	41.2	31.5	50.6
8/1/1987		32.8	52.1
8/16/1987	49.2	36.7	55.1

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Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
9/1/1987		39.3	57.5
9/16/1987	49.6	41.3	58.7
10/1/1987		43.0	59.8
10/16/1987	54.8	39.5	55.6
11/1/1987		37.1	52.7
11/16/1987	47.4	36.1	49.8
12/1/1987		34.8	47.3
12/16/1987	45.3	34.6	45.3
1/1/1988		33.8	43.4
1/16/1988	37.6	32.4	41.6
2/1/1988		31.3	40.0
2/16/1988	33.9	29.4	38.6
3/1/1988		28.0	37.3
3/16/1988	30.8	26.7	35.9
4/1/1988		25.6	34.7
4/16/1988	30.1	23.8	34.6
5/1/1988		22.6	34.3
5/16/1988	31.7	26.3	38.0
6/1/1988		28.8	40.7
6/16/1988	34.1	25.8	42.1
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9/1/1988		32.7	51.2
9/16/1988	43.7	36.3	53.2
10/1/1988		38.8	54.7
10/16/1988	50	36.4	51.3
11/1/1988		34.8	49.0
11/16/1988	43.1	37.3	48.7
12/1/1988		38.7	48.2
12/16/1988	37.9	35.1	44.5
1/1/1989		32.6	41.7
1/16/1989	34.4	30.5	39.3
2/1/1989		28.7	37.3
2/16/1989	31.3	26.8	35.6
3/1/1989		25.3	34.1
3/16/1989	28.7	25.5	33.3
4/1/1989		25.2	32.5
4/16/1989	24.7	22.5	32.2
5/1/1989		20.9	31.7
5/16/1989	27.2	22.7	35.1
6/1/1989		24.1	37.6
6/16/1989	29	22.2	39.6

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Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
7/1/1989		21.5	41.2
7/16/1989	31.5	24.5	44.5
8/1/1989		26.3	46.8
8/16/1989	39.3	30.9	50.7
9/1/1989		34.5	54.1
9/16/1989	38.9	38.3	56.2
10/1/1989		41.0	57.9
10/16/1989	45.4	43.3	58.0
11/1/1989		44.9	58.2
11/16/1989	38.7	40.8	52.9
12/1/1989		38.1	49.3
12/16/1989	36.7	35.0	45.8
1/1/1990		32.4	42.9
1/16/1990	34.3	31.8	41.1
2/1/1990		30.8	39.2
2/16/1990	31.7	28.4	37.3
3/1/1990		26.6	35.6
3/16/1990	28.8	24.9	34.1
4/1/1990		23.5	32.8
4/16/1990	23.4	22.5	33.9
5/1/1990		22.0	34.6
5/16/1990	26.3	25.8	39.5
6/1/1990		28.6	43.1
6/16/1990	28.9	25.7	43.5
7/1/1990		24.1	44.0
7/16/1990	30.5	25.9	47.0
8/1/1990		27.0	49.2
8/16/1990	34.4	30.8	52.6
9/1/1990		33.6	55.4
9/16/1990	39.2	37.5	57.3
10/1/1990		40.2	58.9
10/16/1990	44.4	39.7	56.3
11/1/1990		39.3	54.7
11/16/1990	35.6	35.6	49.4
12/1/1990		32.9	45.5
12/16/1990	32.1	31.1	42.7
1/1/1991		29.5	40.2
1/16/1991	28.6	27.2	37.7
2/1/1991		25.3	35.5
2/16/1991	27.2	24.0	34.0
3/1/1991		22.8	32.5
3/16/1991	27.3	21.9	31.2
4/1/1991		21.0	30.0
4/16/1991	20.3	20.3	30.8

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Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
5/1/1991		19.8	31.0
5/16/1991	22.9	22.3	35.3
6/1/1991		24.3	38.4
6/16/1991	23.9	25.5	41.8
7/1/1991		27.0	44.6
7/16/1991	24.8	23.5	44.6
8/1/1991		21.6	45.0
8/16/1991	31.5	24.0	46.5
9/1/1991		25.5	47.7
9/16/1991	38.8	30.9	50.8
10/1/1991		34.3	52.9
10/16/1991	38.1	32.3	49.7
11/1/1991		31.2	47.9
11/16/1991	32.8	30.1	44.3
12/1/1991		28.8	41.6
12/16/1991	32.3	26.1	38.4
1/1/1992		24.1	35.8
1/16/1992	27.4	22.6	33.7
2/1/1992		21.1	31.9
2/16/1992	22.9	20.0	30.4
3/1/1992		18.9	29.1
3/16/1992	21.8	15.5	27.0
4/1/1992		13.2	25.4
4/16/1992	18.9	13.3	27.4
5/1/1992		13.3	28.5
5/16/1992	19.7	13.1	30.9
6/1/1992		13.1	32.7
6/16/1992	19.5	13.1	34.2
7/1/1992		13.2	35.4
7/16/1992	22.1	14.2	36.5
8/1/1992		14.9	37.4
8/16/1992	22.8	18.7	39.0
9/1/1992		21.0	40.6
9/16/1992	25.3	20.1	39.0
10/1/1992		19.7	38.0
10/16/1992	27.3	18.9	36.2
11/1/1992		18.2	34.8
11/16/1992	20.4	17.6	32.5
12/1/1992		16.8	30.5
12/16/1992	18.9	18.2	29.8
1/1/1993		18.8	29.0
1/16/1993	16.8	17.4	27.6
2/1/1993		16.4	26.3
2/16/1993	17	15.5	25.4

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Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
3/1/1993		14.8	24.6
3/16/1993	15.4	14.4	23.9
4/1/1993		14.0	23.4
4/16/1993	18.5	12.2	22.7
5/1/1993		11.1	22.2
5/16/1993	16.9	10.8	25.5
6/1/1993		11.2	27.9
6/16/1993	18.2	16.4	33.4
7/1/1993		20.1	37.4
7/16/1993	19	21.6	41.0
8/1/1993		23.3	44.0
8/16/1993	26	25.0	46.0
9/1/1993		26.8	48.1
9/16/1993	33.1	29.1	49.5
10/1/1993		31.0	51.0
10/16/1993	39.2	30.5	49.2
11/1/1993		30.3	48.3
11/16/1993	31.2	28.6	44.2
12/1/1993		26.9	41.1
12/16/1993	27.5	25.3	38.3
1/1/1994		23.7	36.0
1/16/1994	24.3	22.2	33.9
2/1/1994		20.7	31.9
2/16/1994	22.3	19.9	30.7
3/1/1994		19.0	29.5
3/16/1994	19.8	17.9	28.5
4/1/1994		16.9	27.5
4/16/1994	19.6	18.7	30.4
5/1/1994		20.1	32.4
5/16/1994	21.4	20.7	35.6
6/1/1994		21.5	37.9
6/16/1994	19.4	18.3	38.3
7/1/1994		16.5	38.9
7/16/1994	24.4	17.0	40.4
8/1/1994		17.1	41.5
8/16/1994	27.3	20.7	43.5
9/1/1994		23.1	45.2
9/16/1994	30.1	26.9	47.6
10/1/1994		29.6	49.5
10/16/1994	35.9	27.4	45.8
11/1/1994		26.0	43.5
11/16/1994	28.8	25.6	40.6
12/1/1994		24.6	38.0
12/16/1994	25.8	24.1	36.1

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Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
1/1/1995		23.5	34.4
1/16/1995	22.5	23.3	33.3
2/1/1995		23.1	32.3
2/16/1995	20.7	20.6	30.4
3/1/1995		18.9	28.9
3/16/1995	19.7	17.2	27.3
4/1/1995		15.8	26.0
4/16/1995	21.1	13.2	25.5
5/1/1995		11.6	25.0
5/16/1995	21.1	14.0	27.5
6/1/1995		16.0	29.7
6/16/1995	22.7	16.6	31.9
7/1/1995		17.5	34.0
7/16/1995	19.5	16.4	36.6
8/1/1995		16.1	38.8
8/16/1995	22.7	17.9	41.1
9/1/1995		19.4	43.2
9/16/1995	27.3	24.2	45.2
10/1/1995		27.3	47.0
10/16/1995	30.9	30.4	48.8
11/1/1995		32.5	50.0
11/16/1995	31.9	32.1	47.1
12/1/1995		31.5	45.0
12/16/1995	28.5	32.1	43.8
1/1/1996		32.1	42.7
1/16/1996	25.4	31.4	41.3
2/1/1996		30.8	40.2
2/16/1996	23.3	27.5	37.8
3/1/1996		25.3	36.1
3/16/1996	22.4	26.4	36.3
4/1/1996		26.6	35.9
4/16/1996	23.4	23.2	35.0
5/1/1996		21.4	34.6
5/16/1996	22.8	24.4	38.6
6/1/1996		26.6	41.6
6/16/1996	21.5	23.2	42.3
7/1/1996		21.7	43.3
7/16/1996	22.2	21.9	44.7
8/1/1996		22.0	46.0
8/16/1996	25.1	23.6	47.1
9/1/1996		24.9	48.5
9/16/1996	32.6	31.2	51.9
10/1/1996		35.2	54.3
10/16/1996	35.2	37.0	54.8

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Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
11/1/1996		38.4	55.3
11/16/1996	34.2	37.9	52.8
12/1/1996		37.5	51.0
12/16/1996	32.6	41.8	52.2
1/1/1997		44.2	52.7
1/16/1997	31.6	41.6	50.1
2/1/1997		40.1	48.2
2/16/1997	29.9	36.3	45.8
3/1/1997		33.8	44.1
3/16/1997	30	33.4	43.3
4/1/1997		32.6	42.4
4/16/1997	27.4	32.2	43.3
5/1/1997		32.1	43.9
5/16/1997	26.5	29.1	44.8
6/1/1997		27.8	45.8
6/16/1997	28.7	28.5	47.5
7/1/1997		29.1	49.0
7/16/1997	28.2	28.2	50.5
8/1/1997		27.9	51.7
8/16/1997	30.1	29.8	53.2
9/1/1997		31.3	54.6
9/16/1997	37.6	36.0	57.6
10/1/1997		39.2	59.8
10/16/1997	43.6	41.3	60.6
11/1/1997		42.9	61.3
11/16/1997	43.3	39.3	56.0
12/1/1997		36.8	52.4
12/16/1997	37.5	35.1	49.4
1/1/1998		33.4	46.9
1/16/1998	36.1	34.4	45.9
2/1/1998		34.6	44.8
2/16/1998	33.6	31.8	42.8
3/1/1998		30.0	41.2
3/16/1998	30.9	32.5	42.5
4/1/1998		33.7	43.0
4/16/1998	31.1	30.5	42.2
5/1/1998		28.8	41.7
5/16/1998	32.6	34.2	47.6
6/1/1998		38.1	51.9
6/16/1998	35.5	38.0	53.6
7/1/1998		38.6	55.4
7/16/1998	28.9	34.1	55.2
8/1/1998		31.8	55.5
8/16/1998	28.9	31.2	56.2

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Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
9/1/1998		31.1	57.0
9/16/1998	36	34.1	57.3
10/1/1998		35.9	57.8
10/16/1998	41.7	39.0	58.2
11/1/1998		40.8	58.4
11/16/1998	41.9	39.4	55.2
12/1/1998		38.2	52.8
12/16/1998	39.5	36.4	50.1
1/1/1999		34.6	47.8
1/16/1999	36.5	36.1	47.6
2/1/1999		36.6	47.0
2/16/1999	32.6	35.1	45.7
3/1/1999		34.1	44.7
3/16/1999	30.8	31.8	42.5
4/1/1999		30.1	40.9
4/16/1999	26.9	32.7	44.2
5/1/1999		34.4	46.3
5/16/1999	27.3	34.3	48.3
6/1/1999		34.8	50.1
6/16/1999	26.9	37.3	54.3
7/1/1999		39.3	57.4
7/16/1999	22.6	35.2	57.0
8/1/1999		33.2	57.3
8/16/1999	24.1	33.4	57.7
9/1/1999		33.6	58.2
9/16/1999	30.3	33.2	57.5
10/1/1999		33.0	57.3
10/16/1999	36.5	36.3	56.9
11/1/1999		38.0	56.8
11/16/1999	38.3	35.7	53.4
12/1/1999		34.0	50.7
12/16/1999	32.2	33.6	48.6
1/1/2000		32.8	46.6
1/16/2000	31.7	33.3	45.3
2/1/2000		33.2	43.9
2/16/2000	29.3	31.2	42.6
3/1/2000		29.9	41.4
3/16/2000	28.5	27.9	39.6
4/1/2000		26.4	38.1
4/16/2000	23.9	30.3	41.4
5/1/2000		32.2	43.1
5/16/2000	22.8	35.0	48.0
6/1/2000		37.4	51.6
6/16/2000	21.3	36.8	53.8

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Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
7/1/2000		36.9	55.8
7/16/2000	18.8	34.6	56.1
8/1/2000		33.7	56.9
8/16/2000	24	34.7	58.1
9/1/2000		35.7	59.5
9/16/2000	30.1	37.6	60.2
10/1/2000		39.3	61.1
10/16/2000	34.3	40.4	60.3
11/1/2000		41.1	59.9
11/16/2000	34	38.4	55.4
12/1/2000		36.3	52.1
12/16/2000	29.5	34.7	49.3
1/1/2001		33.2	46.9
1/16/2001	27	31.1	44.6
2/1/2001		29.4	42.5
2/16/2001	24.2	28.1	41.0
3/1/2001		26.8	39.5
3/16/2001	23.1	25.5	37.9
4/1/2001		24.3	36.5
4/16/2001	22.5	24.4	37.2
5/1/2001		24.4	37.5
5/16/2001	19.4	25.7	41.4
6/1/2001		26.8	44.0
6/16/2001	15.4	27.0	46.4
7/1/2001		27.5	48.3
7/16/2001	16	25.1	48.3
8/1/2001		23.8	48.6
8/16/2001	17.1	23.3	49.0
9/1/2001		23.0	49.5
9/16/2001	20.7	24.6	48.6
10/1/2001		25.3	48.0
10/16/2001	24	24.6	45.7
11/1/2001		23.8	43.9
11/16/2001	24	24.6	41.7
12/1/2001		24.7	40.0
12/16/2001	21.8	25.5	39.3
1/1/2002		25.7	38.4
1/16/2002	20.1	23.7	36.3
2/1/2002		22.3	34.6
2/16/2002	18.4	21.1	33.4
3/1/2002		20.2	32.4
3/16/2002	17.3	19.0	31.1
4/1/2002		18.1	30.0
4/16/2002	16.1	17.2	29.8

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Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
5/1/2002		16.5	29.4
5/16/2002	15	17.7	32.3
6/1/2002		18.8	34.4
6/16/2002	14.3	19.4	37.5
7/1/2002		20.2	39.7
7/16/2002	13.6	17.3	40.2
8/1/2002		15.9	40.9
8/16/2002	13.31	17.6	42.1
9/1/2002		18.7	43.2
9/16/2002	17.64	21.3	43.6
10/1/2002		23.1	44.1
10/16/2002	21.38	21.9	41.6
11/1/2002		20.9	39.7
11/16/2002	21.06	20.6	37.3
12/1/2002		19.8	35.3
12/16/2002	18.9	20.9	34.3
1/1/2003		21.2	33.2
1/16/2003	16.5	18.9	31.3
2/1/2003		17.4	29.7
2/16/2003	15.1	16.6	28.7
3/1/2003		15.9	27.8
3/16/2003	13.9	14.6	26.6
4/1/2003		13.6	25.6
4/16/2003	12.9	13.0	26.0
5/1/2003		12.6	26.1
5/16/2003	12.9	14.3	28.6
6/1/2003		15.6	30.4
6/16/2003	12.7	17.2	34.8
7/1/2003		18.6	37.8
7/16/2003	11.6	15.2	38.1
8/1/2003		13.7	39.0
8/16/2003	12	15.0	40.0
9/1/2003		16.0	41.1
9/16/2003	14.9	19.9	42.3
10/1/2003		22.4	43.3
10/16/2003	18.3	22.3	41.3
11/1/2003		21.9	39.9
11/16/2003	18.18	21.3	37.3
12/1/2003		20.4	35.2
12/16/2003	16.06	22.1	35.1
1/1/2004		23.0	34.7
1/16/2004	14.57	20.5	32.2
2/1/2004		18.8	30.4
2/16/2004	13.29	17.8	29.4

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Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
3/1/2004		17.0	28.6
3/16/2004	13.08	15.3	26.9
4/1/2004		13.9	25.6
4/16/2004	11.73	13.9	26.7
5/1/2004		13.7	27.3
5/16/2004	11.41	15.6	30.9
6/1/2004		17.1	33.4
6/16/2004	12.22	14.1	33.8
7/1/2004		12.6	34.4
7/16/2004	11.82	11.2	35.2
8/1/2004		10.4	35.9
8/16/2004	11.83	12.9	37.2
9/1/2004		14.4	38.3
9/16/2004	13.05	16.0	37.3
10/1/2004		16.9	36.7
10/16/2004	14.38	15.0	33.7
11/1/2004		13.6	31.5
11/16/2004	13.7	12.7	29.3
12/1/2004		11.7	27.4
12/16/2004	12.8	13.7	26.4
1/1/2005		14.4	25.4
1/16/2005	12.1	12.1	23.9
2/1/2005		10.8	22.7
2/16/2005	11.4	9.8	21.9
3/1/2005		9.0	21.2
3/16/2005	11.1	8.6	20.4
4/1/2005		8.2	19.7
4/16/2005	11.5	7.5	20.0
5/1/2005		7.1	20.1
5/16/2005	11.4	9.5	22.2
6/1/2005		11.1	23.6
6/16/2005	11.5	13.6	27.6
7/1/2005		15.7	30.6
7/16/2005	10.8	12.0	31.8
8/1/2005		10.5	33.2
8/16/2005	10.6	11.4	34.7
9/1/2005		12.3	36.3
9/16/2005	12.36	14.6	36.9
10/1/2005		16.2	37.7
10/16/2005	15.67	16.7	36.1
11/1/2005		16.8	35.0
11/16/2005	14.99	16.9	33.0
12/1/2005		16.5	31.4
12/16/2005	14.05	20.8	33.1

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Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
1/1/2006		23.3	33.9
1/16/2006	13.2	21.9	32.3
2/1/2006		21.2	31.3
2/16/2006	12.55	19.2	30.1
3/1/2006		17.9	29.1
3/16/2006	12.63	16.6	27.6
4/1/2006		15.6	26.4
4/16/2006	12.77	14.9	26.5
5/1/2006		14.4	26.5
5/16/2006	11.61	16.0	30.3
6/1/2006		17.6	33.4
6/16/2006	12.17	17.7	36.2
7/1/2006		18.4	38.6
7/16/2006	11.68	16.2	40.2
8/1/2006		15.6	42.0
8/16/2006	13.09	17.5	43.9
9/1/2006		19.1	45.8
9/16/2006	17.05	24.1	46.9
10/1/2006		27.4	48.1
10/16/2006	20.99	27.8	46.9
11/1/2006		27.8	45.9
11/16/2006	19.53	27.6	44.1
12/1/2006		27.1	42.5
12/16/2006	17.59	27.7	41.7
1/1/2007		27.7	40.6
1/16/2007	15.67	25.0	38.1
2/1/2007		23.0	36.0
2/16/2007	14.58	22.7	35.0
3/1/2007		22.2	33.9
3/16/2007	13.75	20.3	32.5
4/1/2007		18.9	31.2
4/16/2007	13.35	19.5	32.5
5/1/2007		19.6	33.1
5/16/2007	13.64	23.0	38.3
6/1/2007		25.3	41.9
6/16/2007	13.84	23.7	43.3
7/1/2007		23.5	45.0
7/16/2007	12.75	20.1	44.9
8/1/2007		18.6	45.7
8/16/2007	11.83	19.5	46.8
9/1/2007		20.4	48.1
9/16/2007	16.64	26.5	49.3
10/1/2007		30.3	50.4
10/16/2007	21.28	30.5	49.5

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Rangen Spring Flow Measurements and ESPAM V. 2.0 Curtailment Model Results

Date	Total Spring Flow Measurement (CFS)*	Original Model Run Result (CFS)	Curtailment - Recovery Model Run (CFS)
11/1/2007		30.7	48.8
11/16/2007	20.49	29.9	46.7
12/1/2007		28.7	44.7
12/16/2007	19.02	28.0	42.7
1/1/2008		27.1	40.8
1/16/2008	16.6	25.5	38.7
2/1/2008		24.0	36.8
2/16/2008	15.15	22.4	35.2
3/1/2008		21.2	33.8
3/16/2008	14.09	19.9	32.2
4/1/2008		18.6	30.7
4/16/2008	13.36	18.2	30.5
5/1/2008		17.7	30.1
5/16/2008	12.54	22.8	36.7
6/1/2008		26.3	41.1
6/16/2008	12.59	26.6	43.4
7/1/2008		27.3	45.4
7/16/2008	11.35	22.2	44.4
8/1/2008		19.5	44.3
8/16/2008	11.65	18.2	44.1
9/1/2008		17.6	44.5
9/16/2008	13.66	18.0	44.2
10/1/2008		18.1	44.2
10/16/2008	18.11	19.8	42.2

Note:
*The historical monthly values were calculated using historical measurements at key locations in the Rangen Spring complex. However, some minor components of the total historical spring flow were estimated based on incomplete available data or empirical information when available. The methods and data used to make these estimates were documented and reviewed by the ESHMC and IDWR and approved.