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SEEPAGE STUDY OF THE BEAR RIVER INCLUDING CUTLER RESERVOIR IN CACHE VALLEY, UTAH AND IDAHO

By L.R. Herbert and B.K. Thomas

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in cooperation with the
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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
cubic foot per second	0.02832	cubic meter per second
cubic foot per second per mile	0.0176	cubic meter per second per kilometer
foot	0.3048	meter
mile	1.609	kilometer

Water temperature is given in degrees Celsius (^{o}C), which can be converted to degrees Fahrenheit (^{o}F) by the following equation:

$$^{o}F = 1.8\ (^{o}C) + 32$$

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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U.S. GEOLOGICAL SURVEY

ABSTRACT

A study was made during 1990 on selected reaches of the Bear River including Cutler Reservoir in Cache Valley, Utah and Idaho, to determine gains or losses of flow from seepage in those reaches. The study showed a net gain of 23.5 cubic feet per second in the Riverdale, Idaho, to Smithfield, Utah, section of the Bear River. The upstream reach of this section of the river had a gain of 13.7 cubic feet per second, the middle reach had a gain of 2.1 cubic feet per second, and the downstream reach had a gain of 7.7 cubic feet per second. The Cutler Reservoir section of the Bear River (Smithfield to Wheelon, Utah) had a net gain of 79.0 cubic feet per second.

INTRODUCTION

This report gives the results of a seepage study on selected reaches of the Bear River including Cutler Reservoir in Cache Valley, Utah and Idaho. The study (eleventh in a series) is part of the statewide water-resources program conducted by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights.

Information on seepage gains or losses is needed by water managers for reallocating irrigation water. Detailed investigation of a river system can aid in determining the gaining and losing sections of the system.

The study included 48.53 miles of the Bear River from Riverdale, Idaho, to Smithfield, Utah (fig. 1), and 18.44 linear miles of the Bear River including Cutler Reservoir from Smithfield to Wheelon, Utah (fig. 2).

METHODS OF INVESTIGATION

A reconnaissance was made of the river and reservoir in the summer of 1990. Sections of the river selected for the study were examined for (1) the location of controls, turnouts, or other diversion structures, and the availability of bridges; (2) the general condition of the river; and (3) areas of natural and irrigation-return flow to the river.

Using the information from the reconnaissance, the selected sections of the river were divided into reaches, and measuring sites were selected within each reach. Water-stage recorders were operated at selected sites, mainly at the upstream and downstream end of each reach.

Three sets of seepage runs were made from October 22-24, 1990, at seven sites along the Riverdale, Idaho, to Smithfield, Utah, section of the Bear River. Three sets of seepage runs were made on November 1, 7, and 8, 1990, at two sites along the Cutler Reservoir (Smithfield to Wheelon, Utah) section of the Bear River. A seepage run for the purpose of this report includes

from about 2 to 8 discharge measurements on the river, from about 8 to 20 discharge measurements at turnouts and return-flow points on the river and reservoir, and estimates in places where measurements are not possible. Reservoir elevations were supplied by ECO System Research Institute[1] from a water-stage recorder about 0.5 mile west of Benson, Utah. Sites where a discharge measurement (or estimate) was made at least once are shown in figures 1 and 2.

Discharge measurements were made with a current meter, using standard methods of the U.S. Geological Survey (Buchanan and Somers, 1969). Each person making discharge measurements was assigned a reach in which the required number of measurements could be completed in a day. In each reach, discharge measurements were made at all selected measuring sites, including the upstream and downstream end of the reach, all turnouts, and all return-flow points. For each main-channel discharge measurement, the date and time of each measurement, discharge, specific conductance, and temperature of the water are listed in tables 1 and 2. For turnouts and return-flow points, the date and discharge also are listed in tables 1 and 2.

The numbers used for the turnouts and return-flow points in figures 1 and 2 (for example, T1 or R2) were assigned in a downstream order to those turnouts and return-flow points that had discharge during at least one set of measurements. Continuous water-stage records were obtained for each reach and are shown in figures 3 to 5.

PROCEDURE USED IN COMPUTING SEEPAGE GAINS AND LOSSES

Average seepage gains (no average losses were noted) determined from discharge measurements for Bear River reaches and Cutler Reservoir are given in table 3. The procedure used to obtain these results is described in the following pages.

A computation was made of the discharge that would be expected at each main river measuring site, assuming no gain or loss from seepage. Beginning with the discharge at the upstream end of each reach and proceeding downstream, all turnout discharges were subtracted and all return-flow discharges were added.

The computed value was subtracted from the measured value to determine the seepage gain or loss from the upstream measuring site to the downstream measuring site. The gain or loss was plotted as a function of distance downstream from the start of the reach. This was done for each set of measurements at each main river measuring site. The data obtained from the water-stage recorders showed that adjustments for fluctuations in flow were not necessary for the Riverdale, Idaho, to Smithfield, Utah, section of the Bear River.

The daily mean discharges from the upstream and downstream measuring sites were used for the Cutler Reservoir (Smithfield to Wheelon, Utah) section of the river. Data obtained from the water-stage recorder on Cutler Reservoir (fig. 5) were used to make adjustments in storage. The storage adjustment in acre-feet was converted to daily mean discharge and used to adjust the daily mean discharge of the downstream measuring site. The discharge measurements made on the turnouts and return-flow points were assumed to be equivalent to the daily mean discharges.

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[1] Any use of trade, product, or firm names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

In some instances, depending on the rate of gain or loss, or the scatter of plotted points, the river was segmented into shorter reaches. Data for each of the newly defined reaches were then plotted (figs. 6-7) with the gain or loss at each main river measuring site plotted as a function of distance from the upstream measuring site of the reach. A dashed line was fitted through the plotted points for each reach, and the quantity and rate of gain or loss were estimated from this line and are listed in table 3.

Within a given reach, the seepage gain or loss varied in each set of discharge measurements and among the several sets of discharge measurements. This variation is shown by the scatter of the plotted points in figures 6 and 7. The scatter is attributed to one or more of the following: (1) Poor measuring conditions, (2) changes in the rate of seepage loss from the river, (3) changes in the rate of seepage return to the river from ground water and unconsumed irrigation water, (4) the inability to adjust completely for fluctuation in the amount of flow within a given reach, and (5) the possibility that a water user changed the volume of flow in his turnouts or return-flow points during the time of discharge measurements.

EVALUATION OF THE RIVER SYSTEM

Bear River

Three sets of seepage runs were made at seven sites on the Bear River from near Riverdale, Idaho, to about Smithfield, Utah (fig. 1). This section of the river was divided into three reaches. Measurements indicated seepage gains for all three reaches of the river. The river had a net gain of 23.5 cubic feet per second, with a gain of 13.7 cubic feet per second in the upstream reach, a gain of 2.1 cubic feet per second in the middle reach, and a gain of 7.7 cubic feet per second in the downstream reach. Following is a brief description of each reach studied and the calculated changes in discharges (fig. 6 and table 3).

Reach BR1-BR3.—Site BR1 is a temporary gage in a discontinued U.S. Geological Survey gaging station where a water-stage recorder was operated to monitor changes in stages of the river, 5 miles north of Preston, Idaho, and near Riverdale, Idaho. Site BR3 is at a road bridge about 1.5 miles west of Preston, Idaho. The plot of discharge measurements for this reach had some scatter and showed a net gain of 13.7 cubic feet per second or about 1.3 cubic feet per second per mile.

Reach BR3-BR6.—Site BR6 is near the intersection of the river and State Route 170 near Trenton, Utah. The plot of discharge measurements for this reach had considerable scatter and showed a net gain of 2.1 cubic feet per second or about 0.1 cubic foot per second per mile.

Reach BR6-BR7.—Site BR7 is a U.S. Geological Survey station about 2.6 miles west of Smithfield, Utah. The plot of discharge measurements for this reach had some scatter and showed a net gain of 7.7 cubic feet per second, or about 0.5 cubic foot per second per mile.

Bear River Including Cutler Reservoir

Three sets of seepage runs were made at two sites on the Bear River including Cutler Reservoir from Smithfield to Wheelon, Utah, in November 1990 (fig. 2). These sets of seepage runs were made when Cutler Reservoir storage was at a minimum. Using daily mean discharges, this reach had an estimated gain of 79 cubic feet per second (table 3). The following is a brief description of the reach studied and the calculated changes in discharge (fig. 7 and table 3).

Reach CR1-CR2.—Site CR1 is a U.S. Geological Survey gaging station about 2.6 miles west of Smithfield, Utah. Site CR2 is the Utah Power and Light gaging station downstream from Cutler Reservoir near Wheelon, Utah. The discharge for reach CR1-CR2 is calculated from gaging station daily mean discharges instead of instantaneous discharge measurements because of numerous discharge changes resulting from water releases through the dam. The plot of average gain derived from daily mean discharges for this reach (fig. 7) had considerably less scatter than a plot derived from instantaneous measurements. The reach had an estimated net gain of 79 cubic feet per second or 4.3 cubic feet per second per mile.

SUMMARY

The net gain from seepage of the Bear River in the Riverdale, Idaho, to Smithfield, Utah, section was 23.5 cubic feet per second. The upstream reach had the largest gain of 13.7 cubic feet per second. The section of the Bear River including Cutler Reservoir (Smithfield to Wheelon, Utah) had an estimated net gain of 79.0 cubic feet per second.

REFERENCE CITED

Buchanan, T.J., and Somers, W.P., 1969, Discharge measurements at gaging stations: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A8, 66 p.

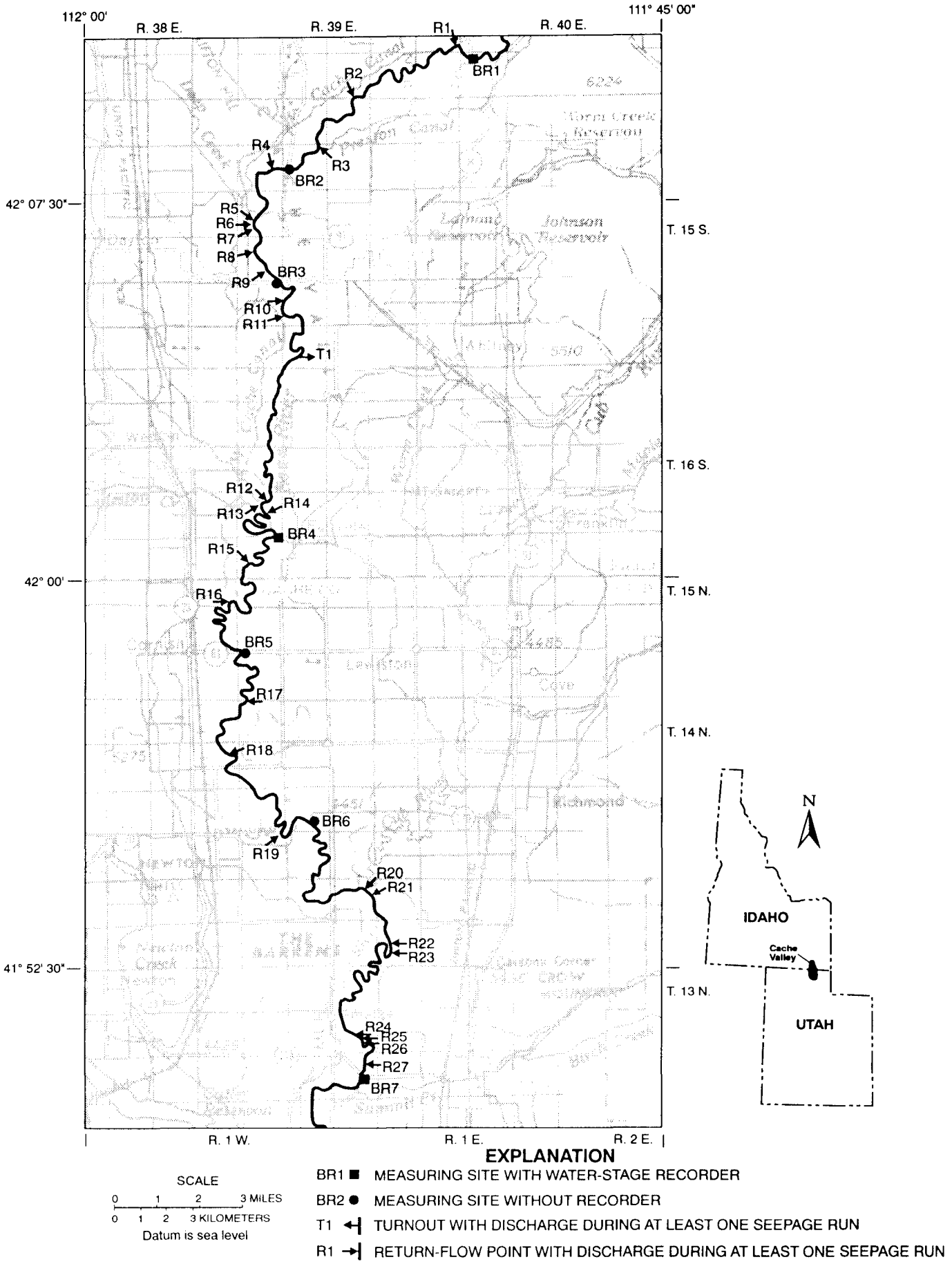


Figure 1.--Measuring sites on the Bear River.

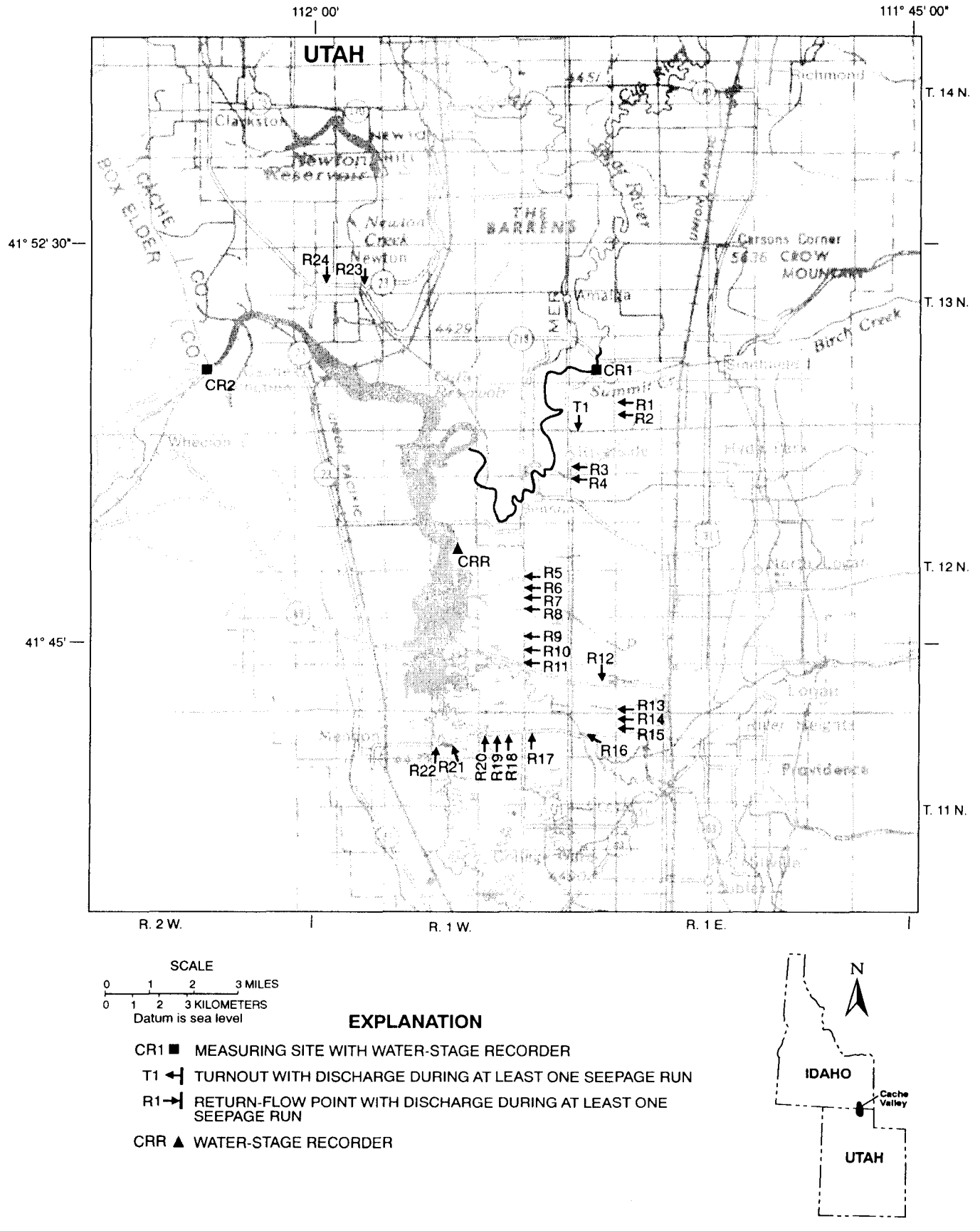


Figure 2.--Measuring sites on the Bear River including Cutler Reservoir.

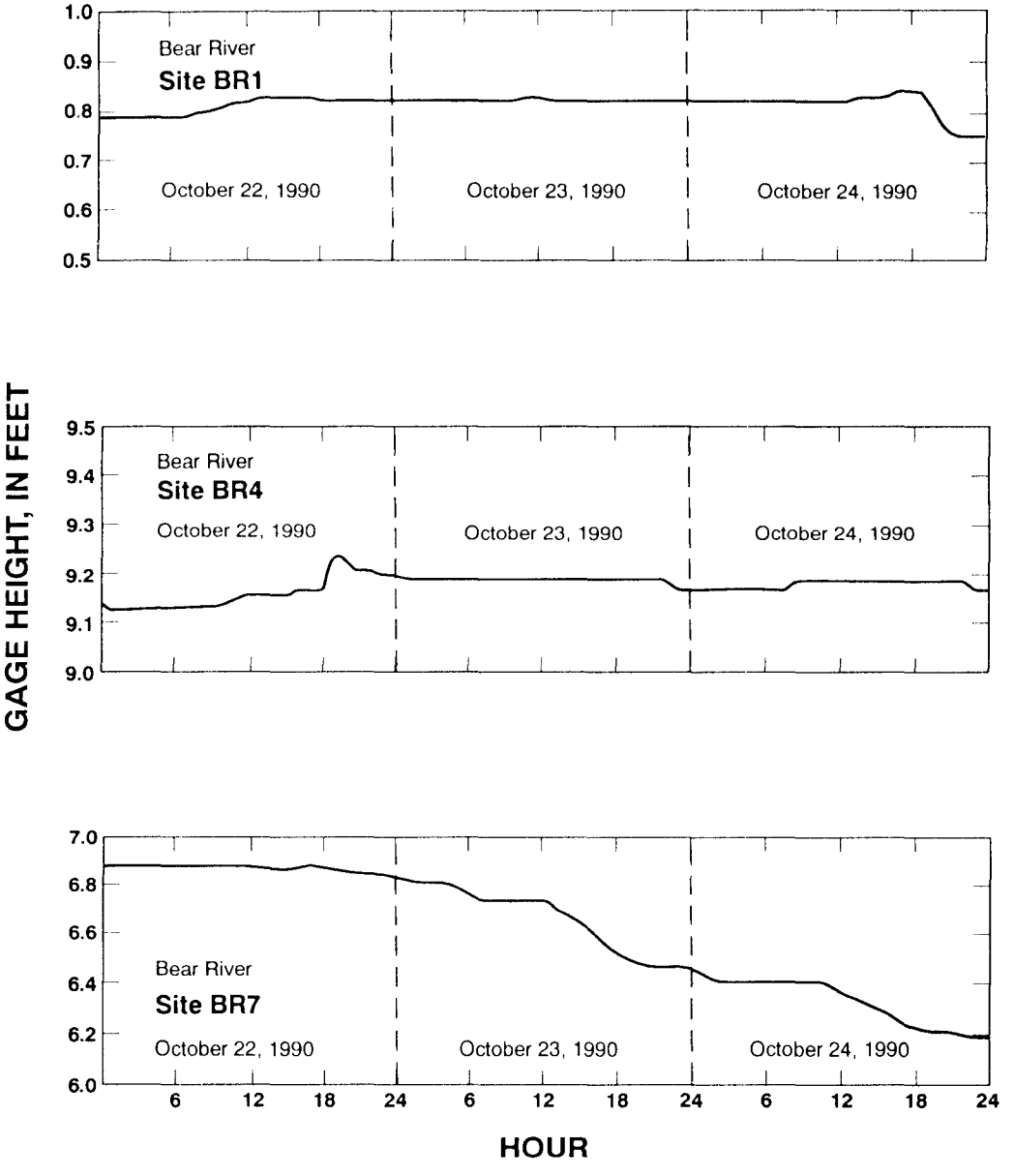


Figure 3.--Gage heights at water-stage recorder sites during discharge measurements on the Bear River, 1990.

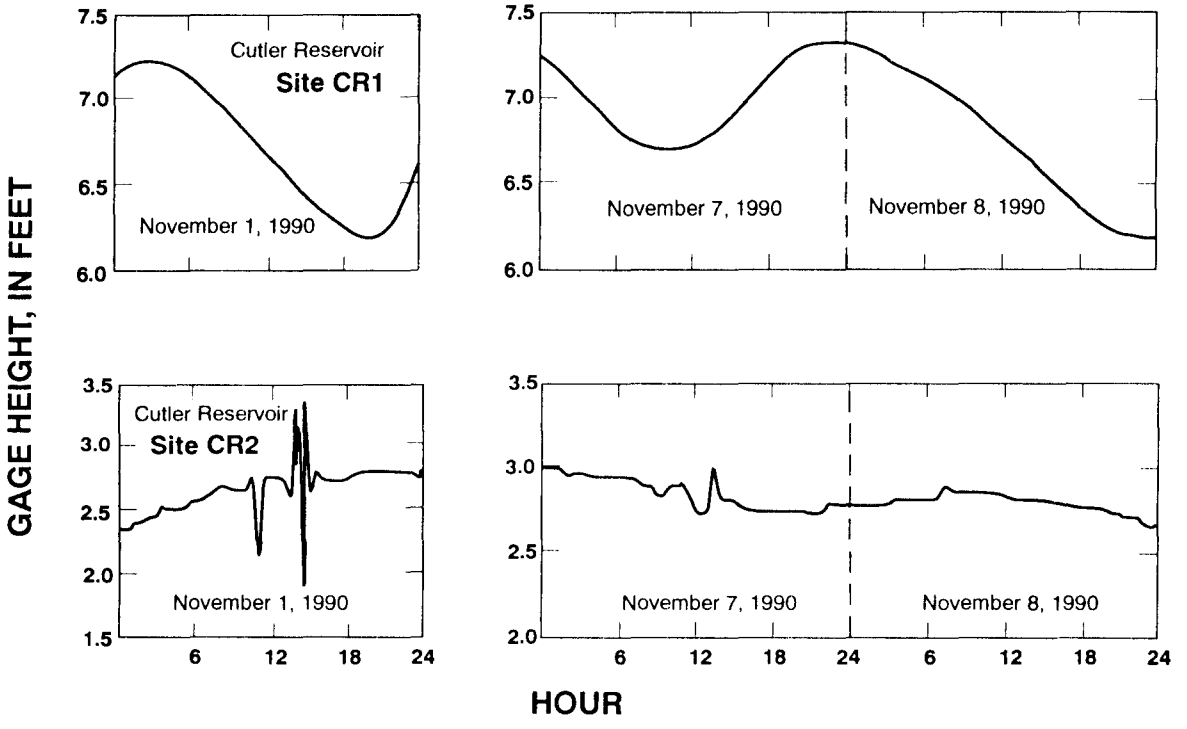
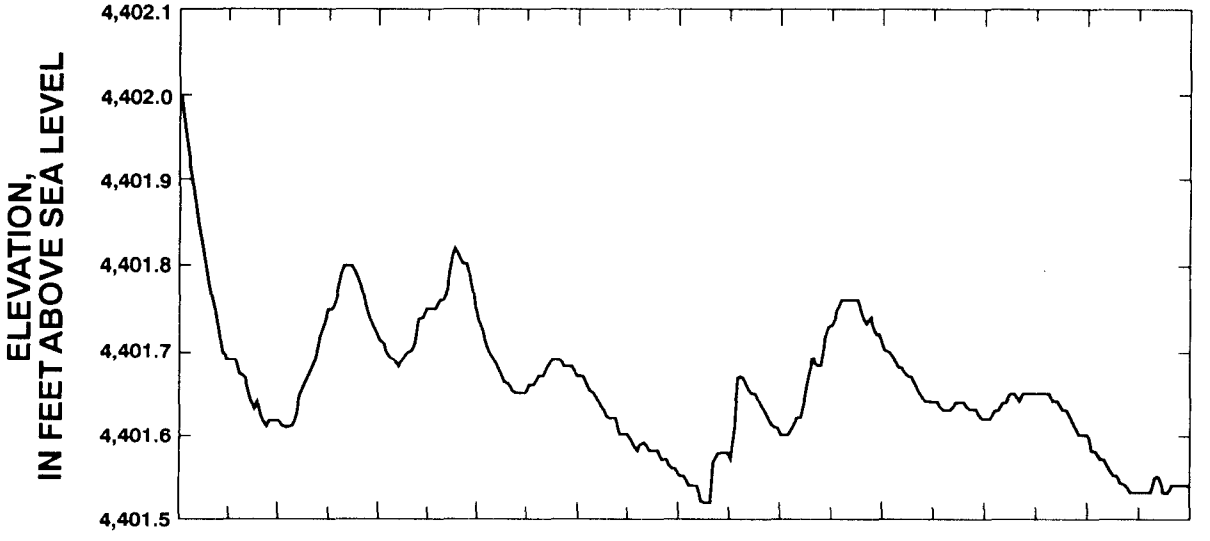


Figure 4.--Gage heights at water-stage recorder sites during discharge measurements on the Bear River including Cutler Reservoir, 1990.



Elevation (feet)	Contents (acre-feet)
4,401.5	2,320
4,401.6	2,460
4,401.7	2,630
4,401.8	2,800
4,401.9	3,020
4,402.0	3,240

Figure 5.--Elevation of Cutler Reservoir at site CRR, October 31 to November 9, 1990, and contents at selected elevations.

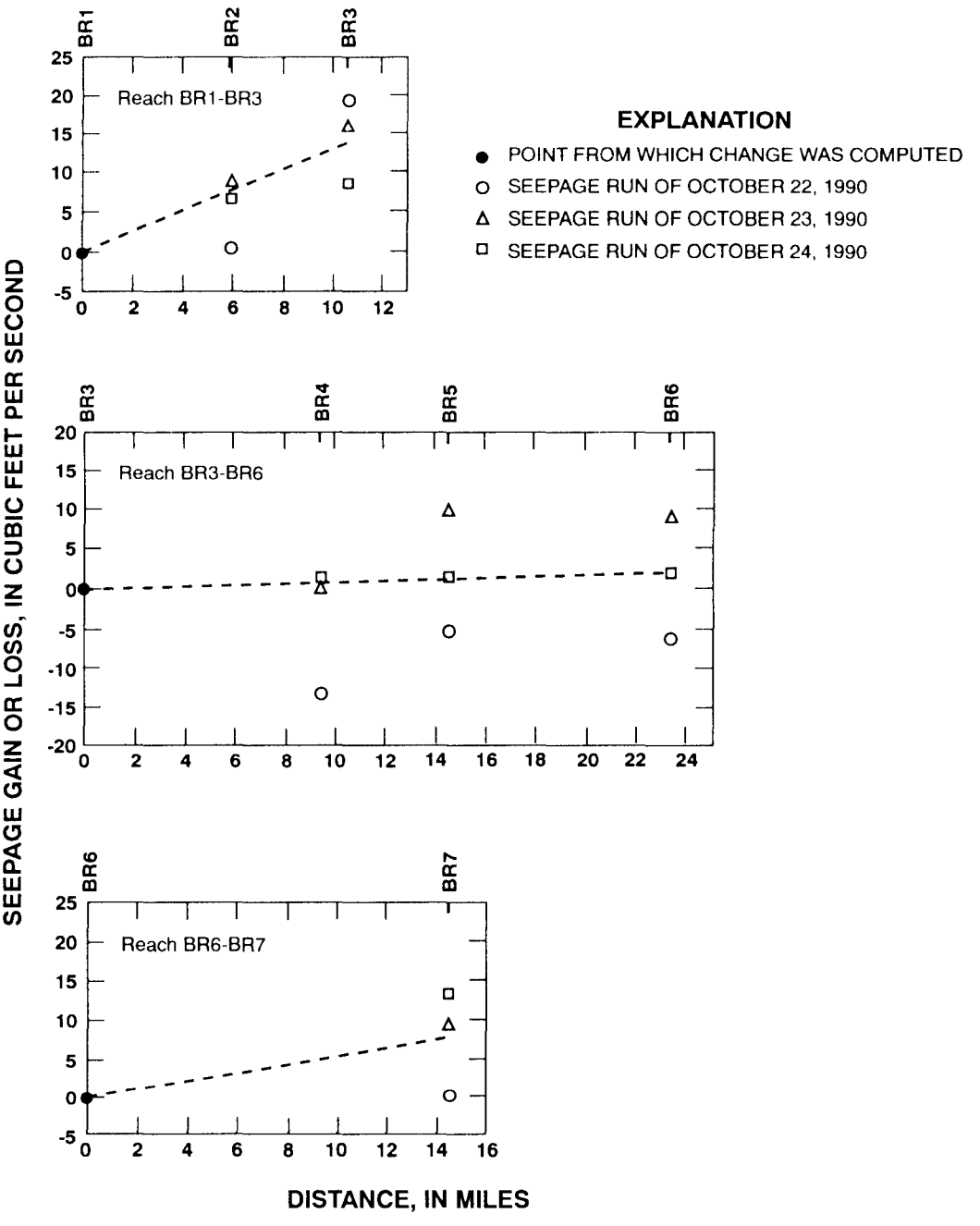
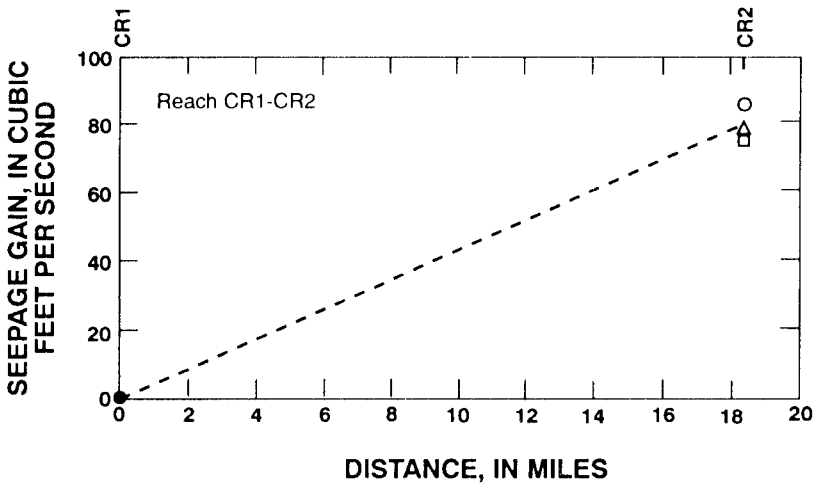


Figure 6.--Estimated average seepage gain or loss for reaches of the Bear River,1990.



EXPLANATION

- ● POINT FROM WHICH CHANGE WAS COMPUTED
- ○ SEEPAGE RUN OF OCTOBER 22, 1990
- △ SEEPAGE RUN OF OCTOBER 23, 1990
- □ SEEPAGE RUN OF OCTOBER 24, 1990

Figure 7.--Estimated average seepage gain for reaches of the Bear River including Cutler Reservoir, 1990.

Table 1.—*Measurements made on the Bear River*

Site: BR, river; R, return-flow point; T, turnout.

Discharge: e, estimated.

Site number (fig. 1)	Time (24-hour)	Discharge (cubic feet per second)	Specific conductance (microsiemens per centimeter, at 25 degrees Celsius)	Water temperature (degrees Celsius)
		Measurements made on October 22, 1990		
BR1	1145	118.0	870	8.0
R1		0.4		
R2		0.3		
R3		0.6		
BR2	1300	119.7	840	8.0
R4		2.4		
R5		7.1		
R8		0.2		
R9		2.9		
BR3	1400	151.1	1,410	9.0
R10		0.1		
R11		0.3e		
T1		0.1e		
R12		1.1e		
R13		3.7e		
R14		0.4e		
BR4	1515	142.3	1,420	8.5
BR4	1150	144.1	1,480	7.5
R15		0.2e		
R16		0.1e		
BR5	1250	151.5	1,440	8.0
R17		0.2e		
R18		0.2e		
R19		1.7e		
BR6	1405	152.8	1,490	7.5

Table 1.—*Measurements made on the Bear River*—Continued

Site number (fig. 1)	Time (24-hour)	Discharge (cubic feet per second)	Specific conductance (microsiemens per centimeter, at 25 degrees Celsius)	Water temperature (degrees Celsius)
		Measurements made on October 22, 1990—Continued		
R20		21.0		
R21		0.4e		
R22		0.1e		
R23		4.7		
R24		0.1e		
R25		5.0		
R26		0.8e		
R27		0.5e		
BR7	1525	185.4	1,360	8.0
		Measurements made on October 23, 1990		
BR1	0940	115.4	860	7.5
R2		0.4		
R3		0.2e		
BR2	1055	124.8	860	8.0
R4		2.4		
R5		6.6		
R6		0.2		
R7		0.1		
R9		3.2		
BR3	1155	144.4	1,410	9.0
R11		0.3		
T1		0.1e		
R12		1.2e		
R13		3.6		
R14		0.4		
BR4	1310	151.3	1,390	9.5
BR4	0850	148.5	1,350	6.5
R15		0.2e		
R16		0.1		
BR5	0945	160.2	1,380	6.5

Table 1.—*Measurements made on the Bear River*—Continued

Site number (fig. 1)	Time (24-hour)	Discharge (cubic feet per second)	Specific conductance (microsiemens per centimeter, at 25 degrees Celsius)	Water temperature (degrees Celsius)
		Measurements made on October 23, 1990—Continued		
R17		0.2e		
R18		0.3e		
R19		1.8		
BR6	1045	161.6	1,480	6.5
R20		22.2		
R21		0.6		
R22		0.1e		
R23		2.2		
R24		0.1e		
R25		4.8		
R26		1.1		
R27		0.5e		
BR7	1210	202.7	1,330	6.5
		Measurements made on October 24, 1990		
BR1	0910	118.7	880	8.5
R2		0.2		
R3		0.9		
BR2	1000	126.3	860	9.0
R4		2.4		
R5		6.2		
R6		0.2		
R7		0.1		
R9		3.1		
BR3	1100	140.2	1,380	9.5
R11		0.3		
T1		0.1		
R12		1.1		
R13		3.9		
R14		0.4		

Table 1.—*Measurements made on the Bear River*—Continued

Site number (fig. 1)	Time (24-hour)	Discharge (cubic feet per second)	Specific conductance (microsiemens per centimeter, at 25 degrees Celsius)	Water temperature (degrees Celsius)
		Measurements made on October 24, 1990—Continued		
BR4	1205	146.8	1,390	10.0
BR4	0845	147.2	1,440	8.5
R15		0.2		
R16		0.1		
BR5	0935	147.6	1,430	8.0
R17		0.1e		
R18		0.2e		
R19		1.6		
BR6	1030	149.9	1,460	8.0
R20		20.3		
R21		0.4		
R22		0.1e		
R23		0.2		
R24		0.1e		
R25		4.2		
R26		0.8		
R27		0.5e		
BR7	1155	190.0	1,320	8.5

Table 2.—*Measurements made on the Bear River including Cutler Reservoir*

Site: CR, reservoir; R, return-flow point; T, turnout.

Discharge: e, estimated.

Site number (fig. 1)	Time (24-hour)	Discharge (cubic feet per second)	Specific conductance (microsiemens per centimeter, at 25 degrees Celsius)	Water temperature (degrees Celsius)
		Measurements made on November 1, 1990		
CR1	1255	293.0	1,060	8.5
Daily Mean (CR1)		358		
R1		1.4		
R2		0.6		
R3		4.8		
R5		4.8		
R6		0.1e		
R7		0.1e		
R8		21.1		
R9		0.1e		
R11		10.0		
R13		2.6		
R14		0.1e		
R15		0.1e		
R16		130.5		
R17		0.1e		
R18		6.0		
R19		22.1		
R20		0.1e		
R21		24.7		
R22		0.1e		
R23		0.3		
R24		0.3		
CR2	1025	705.6	835	8.5
Daily Mean (CR2)		648		

Table 2.—*Measurements made on the Bear River including Cutler Reservoir*—Continued

Site number (fig. 1)	Time (24-hour)	Discharge (cubic feet per second)	Specific conductance (microsiemens per centimeter, at 25 degrees Celsius)	Water temperature (degrees Celsius)
		Measurements made on November 7, 1990		
CR1	1420	471.7	990	4.5
Daily Mean (CR1)		474		
R1		0.2		
R2		0.6		
T1		0.4		
R3		5.4		
R5		4.6		
R8		16.7		
R10		0.1e		
R11		7.4		
R12		0.1e		
R13		2.8		
R14		0.2e		
R15		0.2e		
R16		129.3		
R18		3.6		
R19		26.8		
R21		25.3		
R22		0.2e		
R23		0.3		
R24		0.2		
CR2	1125	725.7	1,080	3.5
Daily Mean (CR2)		786		

Table 2.—*Measurements made on the Bear River including Cutler Reservoir*—Continued

Site number (fig. 1)	Time (24-hour)	Discharge (cubic feet per second)	Specific conductance (microsiemens per centimeter, at 25 degrees Celsius)	Water temperature (degrees Celsius)
		Measurements made on November 8, 1990		
CR1	1300	341.0	1,050	4.5
Daily Mean (CR1)		393		
R1		0.2e		
R2		0.3e		
T1		0.3		
R4		5.2		
R5		5.1		
R8		21.4		
R11		8.5		
R12		0.1e		
R13		3.2		
R14		0.2e		
R15		0.2e		
R16		133.7		
R18		3.3		
R19		26.0		
R21		25.6		
R22		0.2e		
R23		0.3		
R24		0.2		
CR2	1040	813.7	940	4.0
Daily Mean (CR2)		780		

Table 3.—*Estimated average seepage gains determined from discharge measurements for Bear River reaches and Cutler Reservoir*

Reach	Length (miles)	Graphic averages (from figures 6 and 7)	
		Cubic feet per second	Cubic feet per second per mile
Bear River (Riverdale, Idaho, to Smithfield, Utah)			
BR1-BR3	10.62	13.7	1.3
BR3-BR6	23.42	2.1	0.1
BR6-BR7	14.49	7.7	0.5
TOTAL	48.53	23.5	
Cutler Reservoir (Smithfield to Wheelon, Utah)			
CR1-CR2	18.44	79.0	4.3