Streamflow Gains and Losses in the Lower Boise River Basin, Idaho, 1996–97

By Charles Berenbrock

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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 (ft^3/s)	0.0283	cubic meter per second
cubic foot per second per mile [(ft^3/s)/mi]	0.0176	cubic meter per second per kilometer
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.1894	meter per kilometer
mile (mi)	1.609	kilometer

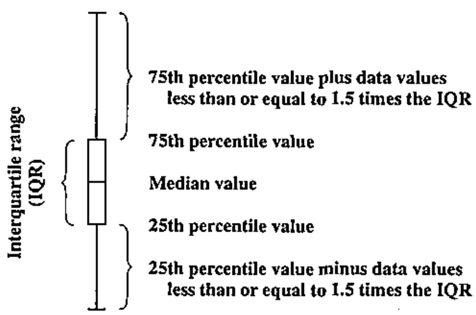
Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (° C) as follows:

$$°C = 5/9\ (°F - 32)$$

Sea level: In this report, sea level refers to the National Geodetic Vertical Datum of 1929 (NGVD 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.

EXPLANATION OF BOXPLOT
Figure 5

● Individual seepage run
3 Number of seepage runs



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Abstract

Information on streamflow gains and losses in the lower Boise River Basin is needed by the Idaho Department of Water Resources to determine recharge to and discharge from the ground-water system. A method was developed to select canal and creek reaches such that a minimum of two reaches were measured in each of 12 different areas that share a set of common environmental characteristics. After a large number of environmental characteristics were evaluated, soil type, land use, and canal density were selected to define the 12 areas.

Seepage runs were made on 39 irrigation canal and creek reaches in the lower Boise River Basin in June-July and September 1996. During the June-July seepage runs, irrigation canals gained and lost water, whereas in September, most reaches lost. No substantial differences were noted in the median and spread of flow gains and losses within the 12 areas; therefore, no direct relation could be defined between seepage and environmental areas.

Seepage runs were made on three reaches of the lower Boise River in November 1996 to identify flow gains and losses after the irrigation season. The two upstream reaches had net gains, whereas the most downstream reach, near the confluence with the Snake River, had a net loss. The total gain to the river from the three reaches was 90.71 cubic feet per second.

Because of potential flooding in March 1997, water was diverted from the Boise River into the New York Canal to reduce flows in the river. This allowed a seepage run on the canal when there were no irrigation diversions or return flows. Subsequently, two seepage runs were made in March when flows near Diversion Dam were about 440 and 860 cubic feet per second. Both gains and losses were measured along the canal, but losses were dominant. Total loss from the canal during the first seepage run was -54 cubic feet per second; during the second, -143 cubic feet per second. Sixteen wells near the canal were measured weekly from the last week in February through mid-June. Generally, water levels decreased from February to mid-April and then increased through June. Paired wells near the canal indicated downward movement of water, probably recharge from canal losses.

Study results indicate that additional seepage runs are needed on irrigation canals and creeks, the Boise River, and the New York Canal. Piezometers installed at different depths are needed to better define vertical ground-water movement and gradients. Additional work is needed to determine how seepage in canals and streams relates to environmental characteristics.

INTRODUCTION

Over the past decade, the lower Boise River Basin has experienced significant population growth that causes concerns about water resources in the basin. Urbanization is changing land use from traditionally flood-irrigated agriculture to residential, commercial, and/or light industrial use. Historically, irrigation activities have had a major effect on the hydrologic system in the lower Boise River Basin. In 1977, about 290,000 acres were irrigated with water from the Boise River and its tributaries. Water is diverted from the Boise River into canals at more than 45 points between Lucky Peak Reservoir and the river's confluence with the

Snake River. The irrigated area is served by an intricate network of more than 720 mi of main canals, 1,300 mi of lateral canals, and 650 mi of drains. Water in these thousands of miles of canals can leak into the ground-water system and, combined with leakage from flood-irrigated areas, have caused ground-water levels to rise. Consequently, the water table is much closer to land surface than before irrigation began. The Idaho Water Resources Research Institute (Christian Petrich, University of Idaho, written commun., 1997) believes that one of the largest ground-water recharge components is leakage from flood irrigation and unlined irrigation canals. Shallow wells supply many domestic water needs in the lower Boise River Basin.

Ensuring the long-term future of a reliable water supply while protecting established water rights is a topic of both concern and contention among planners, water managers, and other interested segments of the population. This concern has spurred a greater interest in finding ways to better manage the resource. In February 1996, the Idaho Legislature allocated $300,000 to the Idaho Department of Water Resources, lead agency, to begin the Treasure Valley Hydrologic Project (TVHP). This project will provide information to answer complex management questions and produce tools necessary to manage water resources in the lower Boise River Basin. Other TVHP contributors and technical assistance providers are United Water Idaho, Inc., Bureau of Reclamation, Idaho Water Resources Research Institute, University of Idaho, Boise State University, and the U.S. Geological Survey.

The U.S. Geological Survey, in cooperation with the Idaho Department of Water Resources, began a study to evaluate gains to and losses from the ground-water system along (1) irrigation canals and creeks, (2) lower Boise River, and (3) the New York Canal.

Seepage runs, the measurement of all surface-water inflows and outflows along a stream reach, provide data needed to examine interactions between a river or canal and the ground-water system. Seepage measurements in 1971 (Thomas and Dion, 1974) indicated that the Boise River gained about 200 ft^3/s between Lucky Peak Dam and the Snake River. Water purveyors have indicated that conveyance losses from canals are significant. An understanding of the spatial and temporal relations of gains and losses is needed to determine seasonal recharge to and discharge from the ground-water system.

Purpose and Scope

The purpose of this report is to document the results of seepage runs along irrigation canals and creeks, the lower Boise River, and the New York Canal. The report includes a discussion of the method used to select reaches of canals and creeks on the basis of environmental characteristics. Results are reported for seepage measurements on 39 canal and creek reaches in 12 areas that share common environmental characteristics. Results also are reported for seepage measurements on three reaches of the Boise River and for the New York Canal at two different flows. Water-level measurements in 16 wells adjacent to the New York Canal also are reported.

Description of the Study Area

The lower Boise River Basin is in the west-central part of the western Snake River Plain (fig. 1). The basin is bounded on the east and north by the foothills and Boise Mountains and on the south by the upland interfluve between the Boise and Snake Rivers. Physiography of the basin is dominated by a series of terraces created by the present and ancestral Boise River, a broad upland, and basalt flows that cap various surfaces. Relief throughout the basin is minimal compared to the surrounding foothills and mountains. Altitude increases from about 2,200 ft above sea level at the confluence of the Boise and Snake Rivers to about 3,000 ft at Lucky Peak Dam. Regional slope of the valley is about 13 ft/mi. The principal hydrographic feature is the lower reach of the Boise River, which flows westward about 60 mi from the Boise Mountains to the Snake River.

Climate in the basin is temperate to semiarid. Annual precipitation is from about 9 to 14 in. (Molnau, 1995); most falls during the winter. Winter temperatures are often above freezing; therefore, snowfall is light and accumulation minimal. Mean annual air temperature is 51.5°F. January has the lowest mean monthly temperature, 28.9°F; July the highest, 75.0°F. Typi-

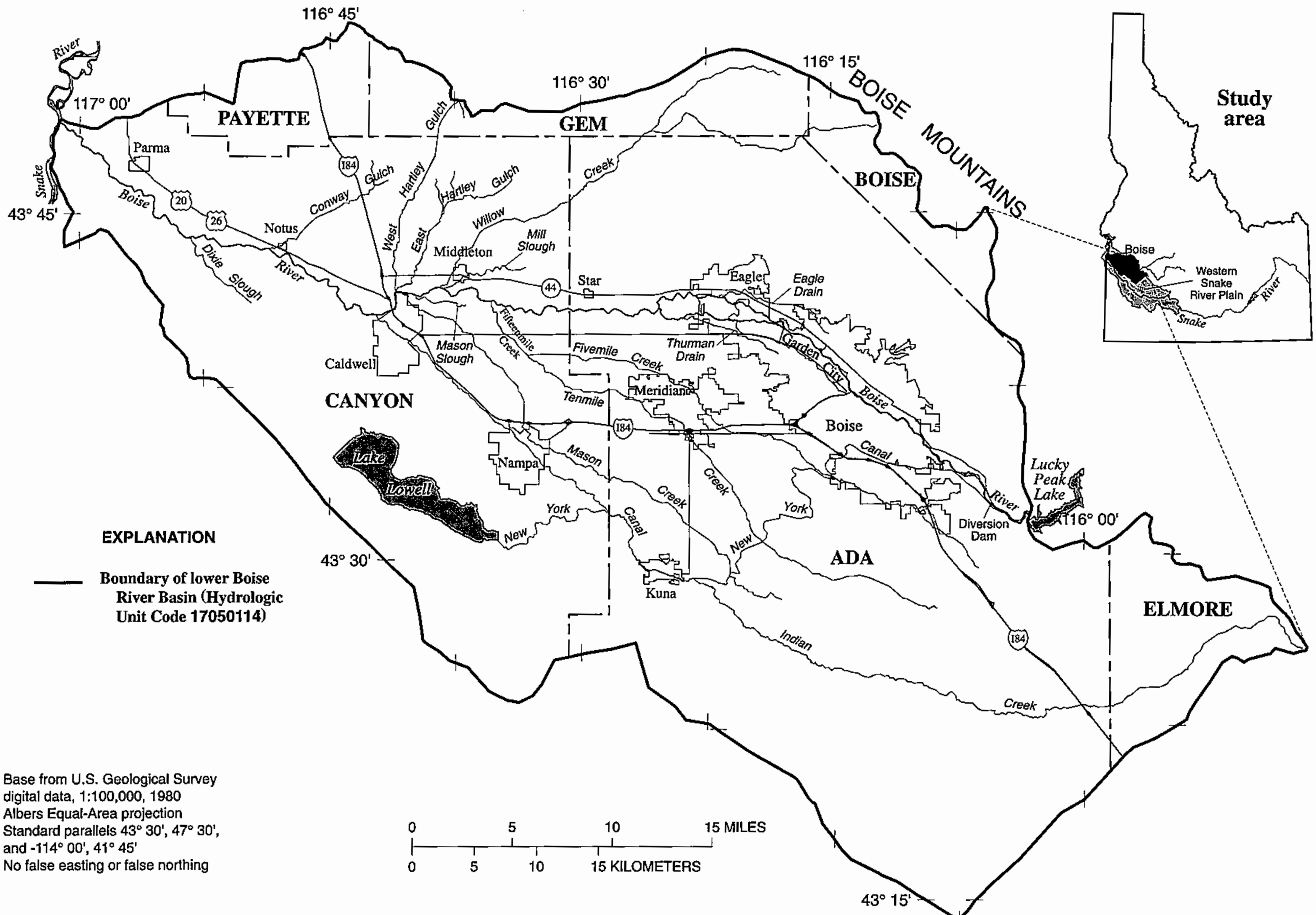


Figure 1. Location of the lower Boise River Basin, Idaho.

cally, the last freezing temperature in spring is May 9 and the first freezing temperature in fall is October 5 (Abramovich and others, 1998). This results in a mean freeze-free growing season of 149 days. Similarly, the first water usually is in canals in April, the last in September; resulting in irrigation water being in canals for about 180 days.

The current (1999) population of the lower Boise River Basin is about 300,000, about 40 percent of Idaho's total population. Included are the cities of Boise, Meridian, Eagle, Nampa, and Caldwell, and numerous smaller rural communities interspersed within large acreages of agricultural land. Demographic data for the area indicate a rapidly growing urban population and an ongoing and gradual shift from an agrarian to an urban-based economy (Dion, 1972; Parliman, 1998).

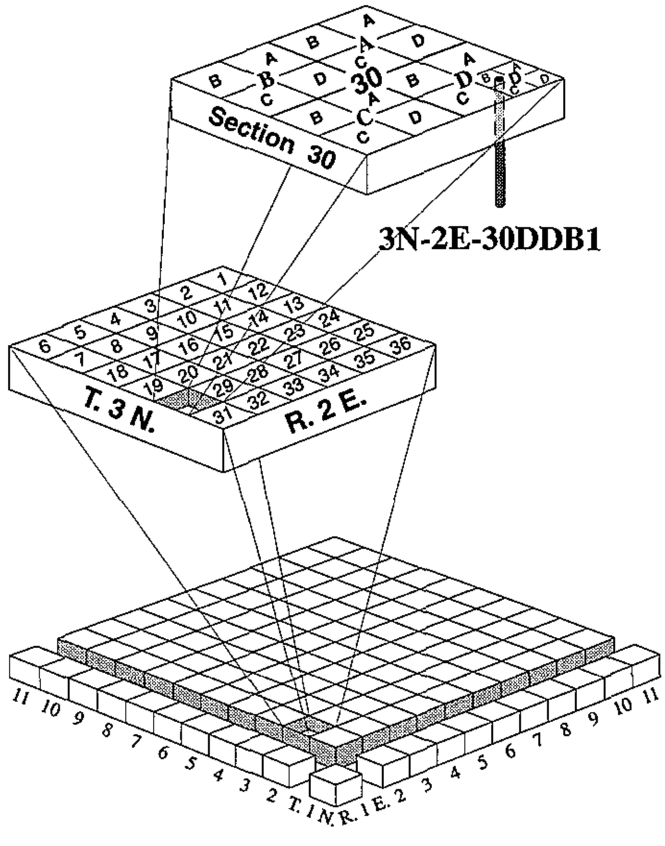
Urbanization of rural areas creates an increased demand for municipal, commercial, industrial, and domestic water supplies. The vast majority of municipal, commercial, and industrial water in the lower Boise River Basin is supplied by ground water, typically from confined water greater than 100 ft below land surface. A small but growing percentage of irrigation water also comes from ground water. An unconfined ground-water system, typically less than 100 ft below land surface, is present in unconsolidated alluvial deposits and terrace gravels (Parliman, 1998). This unconfined system supplies many domestic water needs.

Irrigation is the major use of surface water in the basin. Surface water is supplied by the lower Boise River and its tributaries. Flow in the lower Boise River is controlled primarily by upstream releases from Lucky Peak Lake (fig. 1). Instream flow is supplemented by gains from the ground-water system and return flows from canals. Dion (1972, p. 14) indicated that the New York Canal delivers more than 60 percent of all surface water used for irrigation in the area. Water is delivered through an intricate network of canals and laterals and is generally applied to fields by flooding. Conveyance losses are significant and are primarily leakage from unlined canals. Minor amounts of water also are lost from canals as evaporation and transpiration by riparian vegetation. In 1996, United Water Idaho, Inc., acquired the rights to use 3.5 ft^3/s of water from the Boise River for municipal supplies.

Leakage from unlined irrigation canals and flood irrigation is probably the largest component of recharge and, as a result, local ground-water mounds have formed below some of the major canals (Tungate and Berenbrock, 1995). The Idaho Water Resources Research Institute (Christian Petrich, University of Idaho, written commun., 1997) believes that overapplication of irrigation water has contributed to the rise of ground-water levels. Excess lawn watering, seepage of septic tank effluent, seepage from storm drains, and seepage of effluent from municipal sewer systems may also contribute to recharge. Drains transfer excess water out of areas where ground-water levels are near land surface. Ground water discharges as seepage to the Boise River and its major tributaries, evapotranspiration, seepage to drains and canals, and pumpage.

Well-Numbering System

The well-numbering system used by the U.S. Geological Survey in Idaho indicates the location of wells within the official rectangular subdivision of public lands, with reference to the Boise base line and Meridian. The first two segments of the number designate the township (north or south) and range (east or



west). The third segment gives the section number; four letters, which indicate the $^1/_4$ section (160-acre tract), $^1/_4$-$^1/_4$ section (40-acre tract), $^1/_4$-$^1/_4$-$^1/_4$ section (10-acre tract), and when needed, $^1/_4$-$^1/_4$-$^1/_4$-$^1/_4$ section (2 $^1/_2$-acre tract); and serial number of the well within the tract.

Quarter sections are designated by the letters A, B, C, and D in counterclockwise order from the northeast quarter of each section. Forty-acre, 10-acre, and 2$^1/_2$-acre tracts within each quarter section are lettered in the same manner. Well 3N-2E-30DDB1, for example, is in the NW$^1/_4$SE $^1/_4$SE$^1/_4$ sec. 30, T. 3 N., R. 2 E., and was the first well inventoried in the tract.

Acknowledgments

Appreciation is extended to Joe Spinazola, Bureau of Reclamation, who located the canal and creek reaches and arranged for them to be measured. Appreciation also is extended to the Idaho Department of Water Resources and Christian Petrich, Idaho Water Resources Research Institute, University of Idaho, for arranging for measurement of New York Canal sites and 16 wells. Thanks are also extended to Tony Morse, Idaho Department of Water Resources, for providing 1994 land-use data in paper and digital form.

SEEPAGE RUNS

Most streamflow measurements were made using a current meter under standard U.S. Geological Survey procedures (Rantz and others, 1982). Discharge measurements by current meters are rated according to criteria listed in Rantz and others (1982). A few criteria are: (1) spacing of measurement sections is such that each subsection will have approximately equal discharge with no more than 5 percent of the total flow within any individual subsection, and there are adequate sections in and around bridge piers, drains, and culverts; (2) equipment is in good condition and performs well in tests prior to measurements; (3) measurement section lies within a straight reach, streamlines are parallel to each other, flow is relatively uniform and free of eddies and excessive turbulence, and streambed is relatively uniform and free of boulders and aquatic growth; and (4) the water surface is not changing rapidly during the measurement. Every discharge measurement is rated as "Excellent" (±2 percent of actual), "Good" (±5 percent of actual), "Fair" (±8 percent of actual), or "Poor" (± >8 percent of actual), depending upon the quality of the measurement as previously listed. The discharge measurement multiplied by the rating in percent results in a possible discharge measurement error. For example, measured discharge of the Boise River at Glenwood Bridge near Boise (site 83) on November 12, 1996, was rated as "Good." Multiplying 246 ft^3/s (discharge measurement) by 5 percent (rating), results in a possible discharge measurement error of about ±12 ft^3/s. Therefore, the actual discharge is somewhere between 234 ft^3/s (246 ft^3/s - 12 ft^3/s) and 258 ft^3/s (246 ft^3/s + 12 ft^3/s).

Where a current meter could not be used because of low flow, discharge was estimated by determining the time it took to fill a bottle of known volume. The following sections explain the approach used for seepage runs on irrigation canals and creeks, the Boise River, and the New York Canal.

Approach and Methods

In 1996–97, seepage runs were made on irrigation canals and creeks, the Boise River, and the New York Canal in the lower Boise River Basin. A seepage run is the measurement of all surface water inflow and outflow along a given length, or reach, of a canal, creek, or river. Subtraction of outflow from inflow results in the net quantity of water exchanged between surface and ground water in a reach. If outflow exceeds inflow, the reach gains from ground water; conversely, if inflow exceeds outflow, the reach loses to ground water.

IRRIGATION CANALS AND CREEKS

The irrigation canal network in the lower Boise River Basin is extensive and complex; therefore, it was not possible to measure seepage in every canal and creek during this study and total seepage could not be quantified. The approach used was to define relations between seepage gains and losses along measured reaches and areas of similar environmental characteristics to extend seepage run results to unmeasured canals

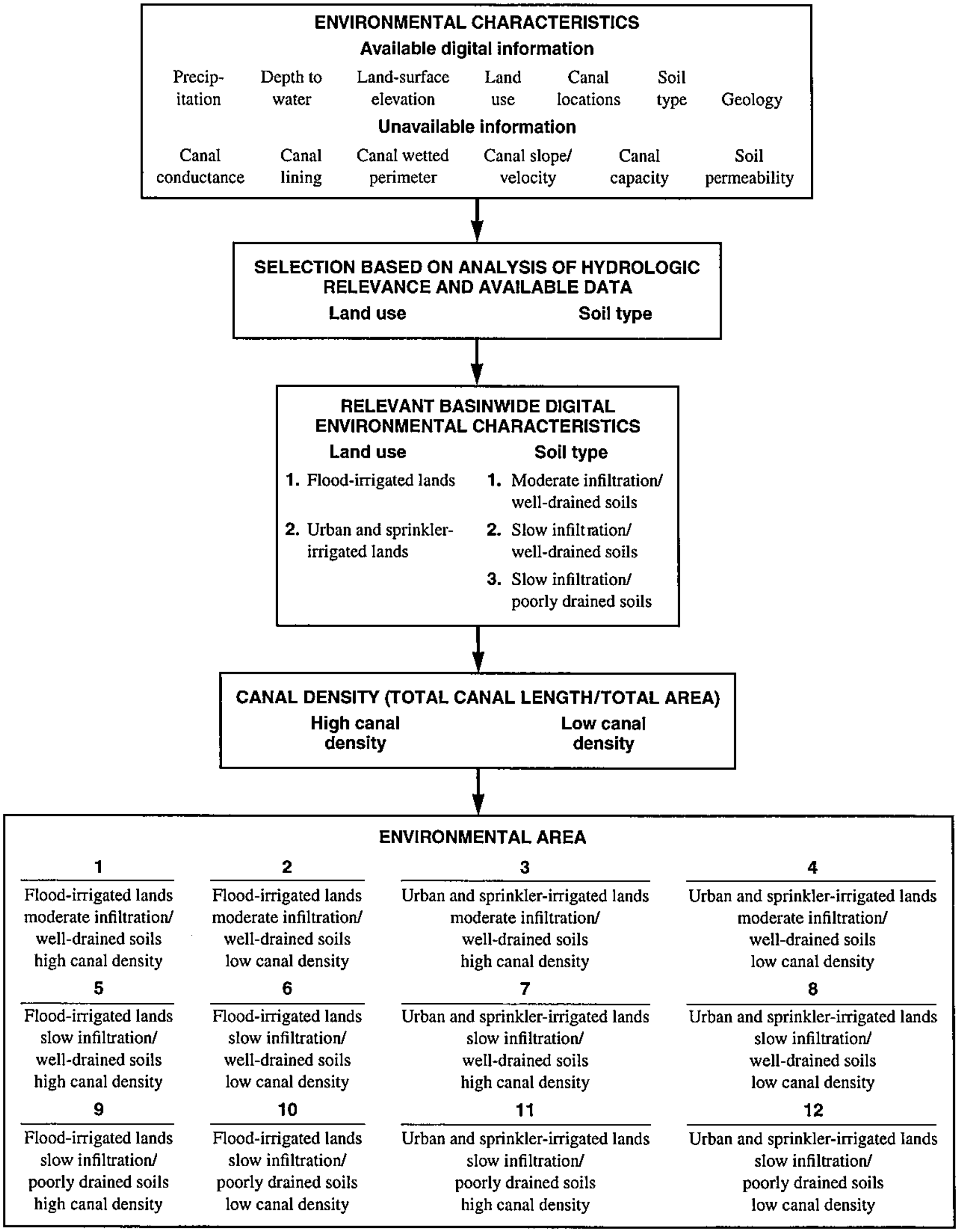


Figure 2. Chart showing the process used to define environmental areas in the lower Boise River Basin, Idaho. (Environmental areas shown in figure 3)

and creeks. This approach was used on 39 canal and creek reaches. A minimum of two reaches were measured in each of 12 different areas that share a set of common environmental characteristics (environmental area). Although a large number of environmental characteristics were considered, land use, soil type, and canal density were selected to define the 12 environmental areas presented in figure 2. The other environmental characteristics listed in figure 2 were not used because data for them were not available in a basinwide digital data layer, or because the resolution of an available digital data layer was inadequate.

Land-use data from IDWR (Idaho Department of Water Resources, written commun., 1997) were used to delineate flood-irrigated agricultural lands and urban plus sprinkler-irrigated agricultural lands. Higher ground-water levels were expected in agricultural areas that were flood irrigated with surface water than in urban and sprinkler-irrigated agricultural areas. Differences in ground-water levels in the two land-use areas were expected to result in different gain/loss relations between canals and creeks and the ground-water system.

Soils data were obtained from the State Soil Geographic Data Base (STATSGO), developed by the U.S. Natural Resource Conservation Service (U.S. Department of Agriculture, 1991). STATSGO soils data were aggregated from many large-scale soil survey maps (1:12,000 to 1:62,500) into one large data base that approximated a map scale of 1:250,000 (U.S. Department of Agriculture, 1991, p. 12). Rupert (1997, 1998) showed statistically that atrazine-enriched recharge water was correlated strongly with soil infiltration, and nitrogen-enriched recharge water was correlated strongly with soil drainage in the eastern Snake River Plain. His analysis considered clay content, drainage, hardpan occurrence, hydrologic groups, percentage of organic matter, soil permeability, infiltration, and the Unified Soil Classification rating. Therefore, the lower Boise River Basin was divided into three soil-type categories on the basis of soil infiltration and drainage characteristics. The three categories were (1) moderate infiltration on well-drained soils, (2) slow infiltration on well-drained soils, and (3) slow infiltration on poorly drained soils.

The two land-use areas were intersected with the three soil-type areas to produce six distinct soil-type/land-use areas. Canal density in each area was calculated by dividing total canal length by the size of the area. The median value of canal density also was calculated for each of the six areas. An area was considered to have high canal density if the canal density value was greater than the median for that soil-type/land-use area; conversely, if the canal density value was less than the median, the area was considered to have low canal density. This process was used to subdivide each soil-type/land-use area into areas of high and low canal density, resulting in a total of 12 environmental areas (fig. 2). A map was produced to show the extent of the different environmental areas (fig. 3).

Seepage was measured along 39 canal and creek reaches in the lower Boise River Basin. A minimum of two seepage runs were made in each of the 12 environmental areas. The remaining 15 seepage runs were in areas that comprised the highest percentages of land area to obtain more gain/loss values for statistical calculations. Topographic maps (scale 1:24,000) were overlain onto the environmental area map (fig. 3), and several candidate canal reaches were prioritized for measurement in each of the selected areas by considering canal length in relation to diversions and returns, the availability of bridges for measurement convenience, canal bank cuts and fills, and sinuosity. The candidate reaches were visited in the field in order of priority until suitable measurement locations were identified. The first set of seepage runs was made in June-July 1996, about 8 weeks after irrigation started; the second in September 1996, about 6 weeks before irrigation ended. There was no precipitation for 10 days prior to any of the measurements.

BOISE RIVER

Seepage was measured along three reaches of the Boise River in November 1996 to quantify flow gains and losses after the irrigation season. The reaches were selected on the basis of the ability to measure inflow and outflow along them. Boise River measurements were made at the same locations that Thomas and Dion (1974) measured in 1971. Results of this study were not compared with those of Thomas and Dion (1974) because they did not measure all inflow or outflow along the reaches.

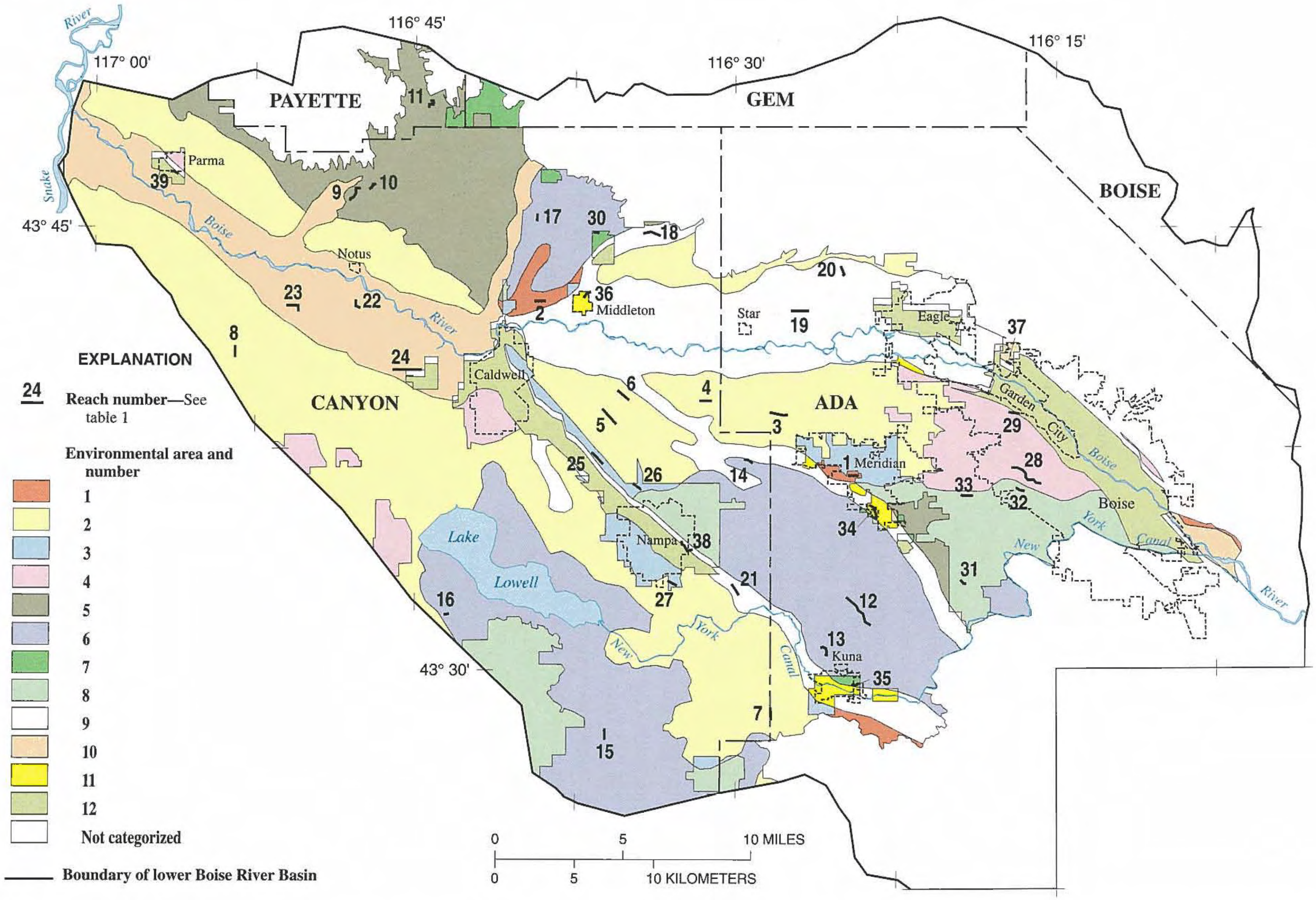


Figure 3. Location of seepage runs on canals and creeks, and distribution of environmental areas in the lower Boise River Basin, Idaho. (Areas defined in figure 2)

NEW YORK CANAL

High streamflow in the lower Boise River Basin in the spring of 1997 created a rare opportunity to quantify gains and losses in the New York Canal prior to the start of the irrigation season, which is usually about mid-April. After the start of irrigation, many more discharge measurements would be needed because of diversions and return flows. Starting on March 3, 1997, water was diverted into the New York Canal to reduce flow in the Boise River. Initially, a seepage run was to be made when flow in the New York Canal downstream from Diversion Dam had been about 860 ft^3/s for several weeks (fig. 4) and gains and losses along the canal were stable. However, flow in the canal was reduced to about 440 ft^3/s (fig. 4) after the second week of operation to prevent overfilling of Lake Lowell (fig. 1), and a seepage run was made at that flow. A second seepage run was made 4 weeks after the start of diversion when flow in the New York Canal downstream from Diversion Dam was about 860 ft^3/s (fig. 4). For each seepage run, measurements were made at the same 19 canal bridge crossings between Diversion Dam and Lake Lowell.

GROUND-WATER LEVELS

Water levels were measured in 16 wells within 1/8 mi of the New York Canal to monitor changes that might be related to canal water. The wells were measured at least once a week starting several weeks before water was diverted into the canal. Paired wells—two wells adjacent to one another and perforated at different depths—were used to determine vertical hydraulic gradients near the canals and temporal changes in gradients.

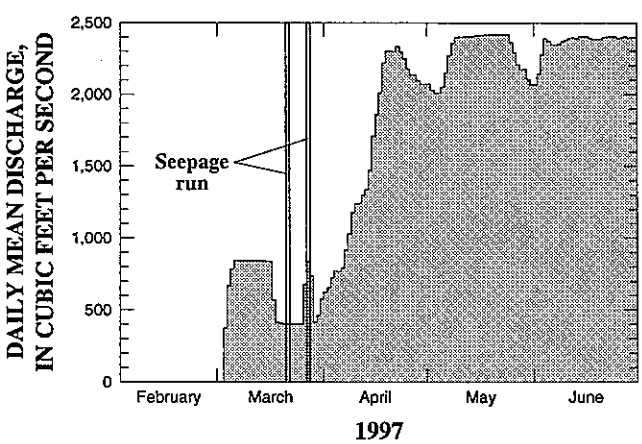


Figure 4. Daily mean discharge of the New York Canal downstream from Diversion Dam streamflow gaging station (13203000), February through June 1997.

RESULTS OF SEEPAGE RUNS

Results of the seepage runs made in 1996–97 on the irrigation canals and creeks, Boise River, and the New York Canal are given in the following sections.

Irrigation Canals and Creeks

Discharge measurements were made to define flow gains and losses along 39 irrigation canal and creek reaches in June-July and September 1996. Multiple measurements were made in each of the 12 environmental areas shown in figure 3. Results are listed in table 1. During the June-July seepage runs, canals and creeks both gained from and lost to ground water (fig. 5A). The median values of seepage in environmental areas 2, 5, 6, 9, and 10 were positive, indicating that canals and creeks gained from ground water. The median values in areas 3, 8, and 12 were negative, indicating that canals and creeks lost to ground water. The first set of seepage runs was made about 8 weeks after irrigation started. Gains from ground water were unexpected at that time because the water table is usually lowest near the start of irrigation and rises throughout the summer and early fall. Results of seepage runs indicate that ground water may have responded to recharge from canal leakage and/or irrigation more quickly than expected. No statistical inference could be calculated for areas 1, 4, 7, and 11 because of insufficient seepage data. Individual seepage values for these areas are shown in figure 5A. The largest median gain, 1.70 ft^3/s, was in area 5, an area of flood irrigation and well-drained soils. The spread (distance between the 25th quartile and the 75th quartile) in area 5 was more than twice that in other areas. The largest gain per mile (7.82 $ft^3/s/mi$) was also in area 5 along reach 9; the largest loss (-10.0 $ft^3/s/mi$) was in area 4 along reach 28. Figure 5A shows no substantial differences be-

Table 1. Flow gains and losses (-) along 39 irrigation canal and creek reaches in the lower Boise River Basin, Idaho, June-July and September 1996

[Environmental areas defined in figure 2; site locations shown in figure 3; No., number; mi, mile; ft^3/s, cubic feet per second; NA, not applicable]

						June-July 1996									
							Downstream				Upstream			Measured gain or loss (-) along subreaches	
Reach No.	Environ-mental area	Name	County	Township, Range, and Section	Reach length (mi)	Date	Latitude	Longitude	Dis-charge (ft^3/s)	In-flows (ft^3/s)	Latitude	Longitude	Dis-charge (ft^3/s)	(ft^3/s)	($ft^3/s/mi$)
1	1	Rutledge Lateral	Ada	3N-1W-12	0.42	7-2	43°36'34"	116°24'44"	7.25	NA	43°36'33"	116°24'14"	6.15	1.10	2.62
2	1	Unnamed ditch	Canyon	4N-3W-1 4N-3W-2	.45	6-27	43°42'30"	116°39'26"	7.85	0.05	43°42'30"	116°38'54"	8.71	-.91	-2.02
3	2	Five Mile Creek	Ada	4N-1W-33	.72	6-26	43°38'44"	116°28'24"	72.4	.21	43°38'38"	116°27'33"	73.9	-1.71	-2.38
4	2	Can-Ada/Elm Lane	Canyon	3N-2W-25	.49	7-8	43°39'08"	116°31'41"	17.2	NA	43°39'08"	116°31'06"	16.0	1.2	2.45
5	2	Nobel Drain	Canyon	4N-2W-32	.82	7-5	43°38'51"	116°36'17"	12.0	2.50	43°38'19"	116°35'37"	9.41	.1	.122
6	2	Maddens Spur Drain	Canyon	4N-2W-28	.59	7-11	43°39'29"	116°35'34"	4.47	.31	43°39'09"	116°35'01"	3.83	.33	.599
7	2	Van Duzer Lateral	Ada	2N-1W-28 2N-1W-33	.50	7-1	43°28'42"	116°28'24"	10.8	NA	43°28'16"	116°28'25"	9.87	.93	1.86
8	2	Drew Lateral	Canyon	4N-5W-13	.46	7-10	43°41'00"	116°53'30"	23.8	NA	43°40'36"	116°53'30"	24.2	-.4	-.87
9	5	Sand Hollow Creek	Canyon	5N-4W-15	.78	7-10	43°45'54"	116°48'10"	48.4	.94	43°46'18"	116°47'36"	41.4	6.1	-7.82
10	5	Notus Canal	Canyon	5N-4W-14	.48	7-10	43°46'24"	116°46'56"	16.3	NA	43°46'18"	116°47'13"	14.6	1.7	3.54
11	5	H-Line Canal	Canyon	6N-3W-30 6N-3W-31	.54	6-28	43°49'05"	116°44'27"	2.64	NA	43°49'22"	116°44'22"	2.9	-.26	-.48
12	6	Ridenbaugh Mason Creek Feeder	Ada	2N-1W-1 2N-1W-12	1.58	7-1	43°32'24"	116°24'49"	140	.72	43°31'27"	116°23'39"	132	7.0	4.4
13	6	Teed Lateral	Ada	2N-1W-14	.59	7-3	43°30'44"	116°26'01"	9.21	NA	43°30'28"	116°25'40"	9.79	-.58	-.98
14	6	Kennedy Lateral	Canyon	3N-1W-6B	.39	6-26	43°37'06"	116°29'36"	6.14	NA	43°36'58"	116°29'13"	5.04	1.10	2.82
15	6	Bennett Lateral	Canyon	2N-2W-32	.44	6-28	43°28'00"	116°36'11"	6.32	NA	43°27'37"	116°36'11"	7.03	-.71	-1.61
16	6	Dolbow Lateral	Canyon	2N-3W-3	.22	7-9	43°31'53"	116°43'22"	8.30	NA	43°31'53"	116°43'40"	7.59	.71	3.23
17	6	Unnamed canal	Canyon	5N-3W-23D	.31	6-27	43°45'13"	116°39'22"	2.50	NA	43°45'26"	116°39'15"	2.71	-.21	-.68
18	9	Willow Creek	Canyon	5N-2W-27	.74	7-12	43°44'47"	116°34'21"	3.85	1.03	43°44'40"	116°33'31"	4.66	-1.84	-2.49
19	9	Unnamed canal	Ada	4N-1W-9 4N-1W-10	.72	7-8	43°42'10"	116°27'29"	4.11	.2	43°42'10"	116°26'37"	1.56	2.35	3.26
20	9	Dry Creek	Ada	5N-1W-35D	.49	7-8	43°43'21"	116°25'00"	16.4	NA	43°43'41"	116°25'06"	15.8	.6	1.22
21	9	Unnamed ditch	Canyon	2N-1W-6 3N-1W-31	.52	7-11	43°32'53"	116°30'12"	2.71	.67	43°32'31"	116°29'50"	1.76	.28	.38
22	10	North Drain	Canyon	4N-4W-3 4N-4W-10	.45	6-27	43°42'33"	116°47'52"	22.7	NA	43°42'15"	116°47'35"	21.8	.9	2.0
23	10	Eureka Canal	Canyon	4N-4W-5 4N-4W-8	.71	7-11	43°42'21"	116°51'09"	27.2	NA	43°42'08"	116°50'33"	24.7	2.5	3.52
24	10	Unnamed canal	Canyon	4N-4W-24	1.14	6-27	43°40'12"	116°46'04"	3.94	1.47	43°40'12"	116°44'42"	2.85	-.38	-.33
25	3	West Lateral	Canyon	3N-2W-5 3N-2W-8	.65	6-28	43°37'20"	116°36'46"	13.5	NA	43°36'57"	116°36'13"	11.6	1.9	2.92
26	3	Middle Lateral	Canyon	3N-2W-16A	.40	7-12	43°36'17"	116°34'50"	47.8	NA	43°36'07"	116°34'25"	48.5	-.7	-1.75
27	3	Aaron Drain	Canyon	3N-2W-35C	.41	7-11	43°33'00"	116°33'10"	5.59	.64	43°32'49"	116°32'46"	5.15	-.20	-.49
28	4	Ridenbaugh Canal	Ada	3N-1E-12 3N-2E-7	1.51	7-12	43°36'48"	116°17'04"	404	.1	43°36'16"	116°15'41"	419	-15.1	-10
29	4	Settlers Canal	Ada	4N-1E-36	.46	6-26	43°38'42"	116°17'14"	149	0	43°38'39"	116°16'41"	147	2	4.35
30	7	Unnamed canal	Canyon	5N-2W-29B	.25	6-28	43°44'50"	116°36'41"	9.86	NA	43°44'47"	116°36'24"	9.17	.69	2.76
31	8	Cunningham Lateral	Ada	3N-1E-34	.31	6-27	43°32'59"	116°19'28"	9.58	NA	43°32'51"	116°19'11"	10.98	-1.40	-4.52
32	8	Farmers Lateral	Ada	3N-1E-13A	.38	6-28	43°36'06"	116°16'53"	37.9	NA	43°35'59"	116°16'28"	36.9	1.0	2.63
33	8	Wilson Fruit Canal	Ada	3N-1E-15A	.48	7-2	43°35'51"	116°19'27"	2.90	NA	43°35'51"	116°18'53"	3.14	-.24	-.5
34	11	Ten Mile Creek	Ada	3N-1W-13 3N-1E-18 3N-1E-19	.57	7-2	43°35'31"	116°23'44"	21.6	NA	43°35'10"	116°23'27"	22.0	-.4	-.7
35	7	Teed Lateral	Ada	2N-1W-24	.32	7-3	43°29'27"	116°24'34"	41.9	NA	43°29'33"	116°24'14"	39.7	2.2	6.9
36	11	Middleton Mill Ditch	Canyon	4N-2W-6	.40	7-10	43°42'38"	116°37'10"	37.5	NA	43°42'49"	116°36'47"	39.5	-2.0	-5.0
37	12	Valley Canal	Ada	4N-1E-24B	.25	6-25	43°40'25"	116°17'21"	18.0	NA	43°40'19"	116°17'05"	19.6	-1.6	-6.4
38	12	Indian Creek	Canyon	3N-2W-26	.7	7-11	43°34'21"	116°32'34"	26.2	NA	43°34'03"	116°31'59"	26.8	-.6	-.86
39	12	Unnamed canal	Canyon	5N-5W-9D	.35	7-10	43°46'53"	116°56'31"	20.8	NA	43°46'46"	116°56'10"	20.1	.7	2.0

Table 1. Flow gains and losses (-) along 39 irrigation canal and creek reaches in the lower Boise River Basin, Idaho, June-July and September 1996—Continued

Reach No.	Environ-mental area	Name	County	Township, Range, and Section	Reach length (mi)	September 1996 Date	Downstream Latitude	Downstream Longitude	Downstream Dis-charge (ft^3/s)	In-flows (ft^3/s)	Upstream Latitude	Upstream Longitude	Upstream Dis-charge (ft^3/s)	Measured gain or loss (-) along subreaches (ft^3/s)	Measured gain or loss (-) along subreaches ($ft^3/s/mi$)
1	1	Rutledge Lateral	Ada	3N-1W-12	0.42	9-6	43°36'34"	116°24'44"	4.34	NA	43°36'33"	116°24'14"	4.44	-0.10	-0.24
2	1	Unnamed ditch	Canyon	4N-3W-1 4N-3W-2	.45	9-12	43°42'30"	116°39'26"	10.2	0.01	43°42'30"	116°38'54"	10.6	-.4	-.89
3	2	Five Mile Creek	Ada	4N-1W-33	.72	9-4	43°38'44"	116°28'24"	96.2	0	43°38'38"	116°27'33"	94.6	1.6	2.22
4	2	Can-Ada/Elm Lane	Canyon	3N-2W-25	.49	9-11	43°39'08"	116°31'41"	16.8	NA	43°39'08"	116°31'06"	14.7	2.1	4.3
5	2	Nobel Drain	Canyon	4N-2W-32	.82	NA	43°38'51"	116°36'17"	NA	NA	43°38'19"	116°35'37"	NA	NA	NA
6	2	Maddens Spur Drain	Canyon	4N-2W-28	.59	NA	43°39'29"	116°35'34"	NA	NA	43°39'09"	116°35'01"	NA	NA	NA
7	2	Van Duzer Lateral	Ada	2N-1W-28 2N-1W-33	.50	9-5	43°28'42"	116°28'24"	11.6	NA	43°28'16"	116°28'25"	10.7	.9	1.8
8	2	Drew Lateral	Canyon	4N-5W-13	.46	9-6	43°41'00"	116°53'30"	14.2	NA	43°40'36"	116°53'30"	14.4	-.2	-.43
9	5	Sand Hollow Creek	Canyon	5N-4W-15	.78	9-12	43°45'54"	116°48'10"	50.9	.84	43°46'18"	116°47'36"	50.9	-.8	-1.03
10	5	Notus Canal	Canyon	5N-4W-14	.48	9-12	43°46'24"	116°46'56"	11.7	NA	43°46'18"	116°47'13"	12.4	-.7	-1.46
11	5	H-Line Canal	Canyon	6N-3W-30 6N-3W-31	.54	9-11	43°49'05"	116°44'27"	1.36	NA	43°49'22"	116°44'22"	1.21	.15	.28
12	6	Ridenbaugh Mason Creek Feeder	Ada	2N-1W-1 2N-1W-12	1.58	9-4	43°32'24"	116°24'49"	152	0	43°31'27"	116°23'39"	136	16	10.13
13	6	Teed Lateral	Ada	2N-1W-14	.59	9-6	43°30'44"	116°26'01"	7.24	NA	43°30'28"	116°25'40"	8.06	-.82	-1.39
14	6	Kennedy Lateral	Canyon	3N-1W-6B	.39	9-4	43°37'06"	116°29'36"	5.5	NA	43°36'58"	116°29'13"	5.59	-.09	-.23
15	6	Bennett Lateral	Canyon	2N-2W-32	.44	9-5	43°28'00"	116°36'11"	4.96	.09	43°27'37"	116°36'11"	3.62	1.25	2.84
16	6	Dolbow Lateral	Canyon	2N-3W-3	.22	9-6	43°31'53"	116°43'22"	.88	NA	43°31'53"	116°43'40"	.90	-.02	-.09
17	6	Unnamed canal	Canyon	5N-3W-23D	.31	9-5	43°45'13"	116°39'22"	2.55	NA	43°45'26"	116°39'15"	2.53	-.02	-.06
18	9	Willow Creek	Canyon	5N-2W-27	.74	9-6	43°44'47"	116°34'21"	33.5	1.80	43°44'40"	116°33'31"	29.2	2.5	3.4
19	9	Unnamed canal	Ada	4N-1W-9 4N-1W-10	.72	9-10	43°42'10"	116°27'29"	2.28	.99	43°42'10"	116°26'37"	.34	.95	1.32
20	9	Dry Creek	Ada	5N-1W-35D	.49	9-5	43°43'21"	116°25'00"	19.9	NA	43°43'41"	116°25'06"	18.9	1.0	2.0
21	9	Unnamed ditch	Canyon	2N-1W-6 3N-1W-31	.52	9-11	43°32'53"	116°30'12"	2.4	1.32	43°32'31"	116°29'50"	1.29	-.21	-.40
22	10	North Drain	Canyon	4N-4W-3 4N-4W-10	.45	NA	43°42'33"	116°47'52"	NA	NA	43°42'15"	116°47'35"	NA	NA	NA
23	10	Eureka Canal	Canyon	4N-4W-5 4N-4W-8	.71	9-5	43°42'21"	116°51'09"	26.5	NA	43°42'08"	116°50'33"	26.7	-.2	-.28
24	10	Unnamed canal	Canyon	4N-4W-24	1.14	9-10	43°40'12"	116°46'04"	3.74	0	43°40'12"	116°44'42"	4.34	-.60	-.53
25	3	West Lateral	Canyon	3N-2W-5 3N-2W-8	.65	9-11	43°37'20"	116°36'46"	9.85	NA	43°36'57"	116°36'13"	10.1	-.2	-.31
26	3	Middle Lateral	Canyon	3N-2W-16A	.40	9-6	43°36'17"	116°34'50"	26.9	NA	43°36'07"	116°34'25"	26.4	.5	1.25
27	3	Aaron Drain	Canyon	3N-2W-35C	.41	9-10	43°33'00"	116°33'10"	6.87	5.63	43°32'49"	116°32'46"	4.90	-3.66	-8.93
28	4	Ridenbaugh Canal	Ada	3N-1E-12 3N-2E-7	1.51	9-13	43°36'48"	116°17'04"	338	1.00	43°36'16"	116°15'41"	336	1	.66
29	4	Settlers Canal	Ada	4N-1E-36	.46	9-3	43°38'42"	116°17'14"	125	0	43°38'39"	116°16'41"	131	-6	-13
30	7	Unnamed canal	Canyon	5N-2W-29B	.25	9-10	43°44'50"	116°36'41"	4.08	NA	43°44'47"	116°36'24"	3.94	.14	.56
31	8	Cunningham Lateral	Ada	3N-1E-34	.31	9-6	43°32'59"	116°19'28"	5.96	NA	43°32'51"	116°19'11"	6.58	-.62	-2
32	8	Farmers Lateral	Ada	3N-1E-13A	.38	9-4	43°36'06"	116°16'53"	32	NA	43°35'59"	116°16'28"	32.5	-.5	-1.32
33	8	Wilson Fruit Canal	Ada	3N-1E-15A	.48	9-4	43°35'51"	116°19'27"	2.98	NA	43°35'51"	116°18'53"	2.64	.34	.71
34	11	Ten Mile Creek	Ada	3N-1W-13 3N-1E-18 3N-1E-19	.57	9-4	43°35'31"	116°23'44"	25.9	NA	43°35'10"	116°23'27"	26.6	-.7	-1.23
35	7	Teed Lateral	Ada	2N-1W-24	.32	9-6	43°29'27"	116°24'34"	33.7	NA	43°29'33"	116°24'14"	31.6	2.1	6.6
36	11	Middleton Mill Ditch	Canyon	4N-2W-6	.40	9-3	43°42'38"	116°37'10"	35.2	NA	43°42'49"	116°36'47"	38.6	-3.4	-8.5
37	12	Valley Canal	Ada	4N-1E-24B	.25	9-3	43°40'25"	116°17'21"	17.7	NA	43°40'19"	116°17'05"	18.8	-1.1	-4.4
38	12	Indian Creek	Canyon	3N-2W-26	.7	NA	43°34'21"	116°32'34"	NA	NA	43°34'03"	116°31'59"	NA	NA	NA
39	12	Unnamed canal	Canyon	5N-5W-9D	.35	9-5	43°46'53"	116°56'31"	21.1	NA	43°46'46"	116°56'10"	24.7	-3.6	-10.3

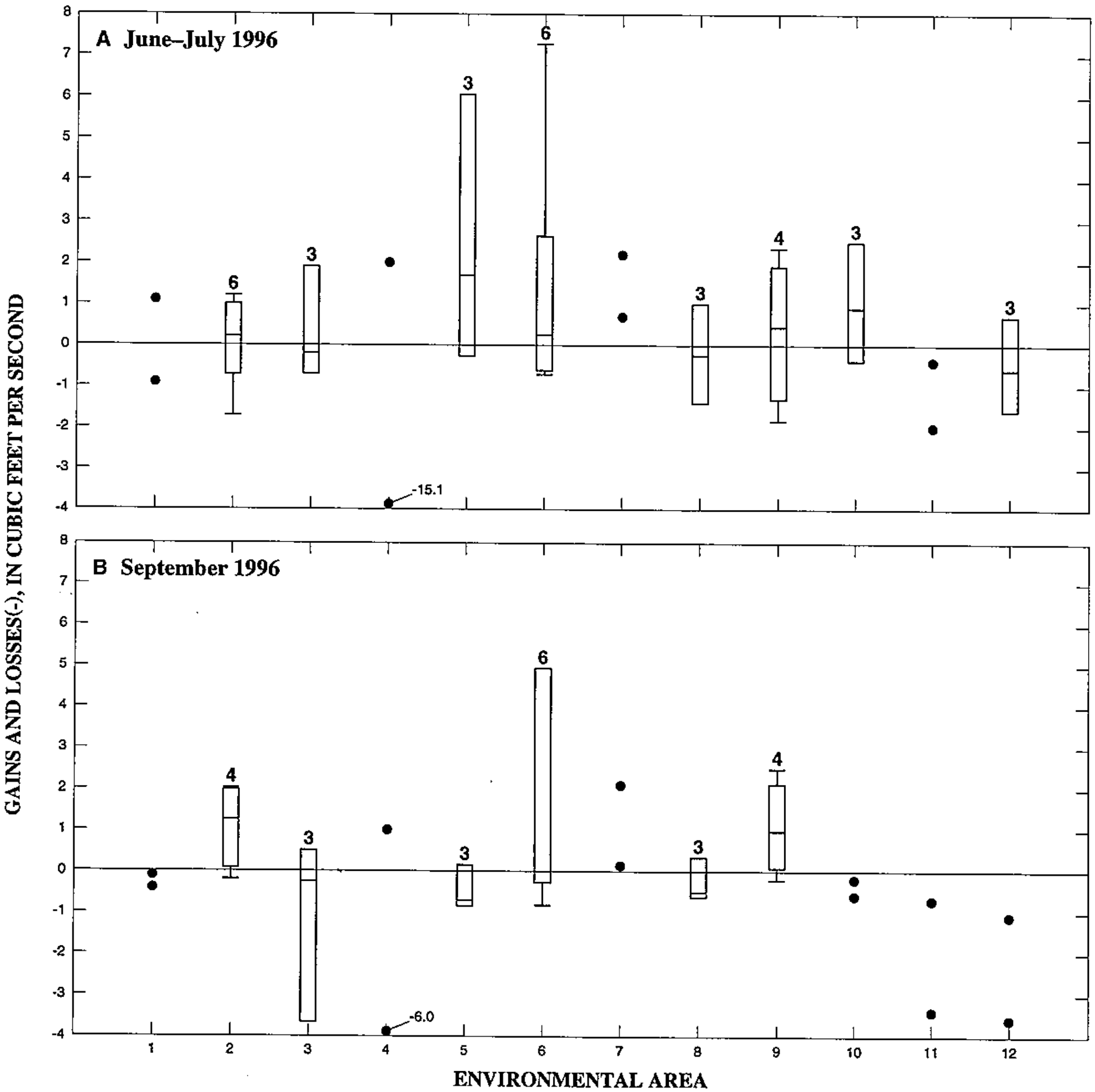


Figure 5. Gains and losses(-) along canals and creeks measured during (A) June–July 1996 and (B) September 1996 seepage runs in defined environmental areas in the lower Boise River Basin, Idaho. (Environmental areas defined in figure 2 and shown in figure 3)

tween median seepage values in different environmental areas; thus, no correlation could be made between measured June-July seepage rates and environmental areas.

The relative accuracy of measured gain or loss along a reach was based on the lowest rating at either the upstream or downstream measurement site. Measured gains or losses along 16 of 39 reaches were rated as "Good," 19 as "Fair," and 4 as "Poor." Measured gains or losses were greater than the discharge measurement error along 21 of 39 reaches (1, 2, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 23, 24, 31, 35, 36, and 37), indicating that estimated seepage is probably representative of actual conditions. Conversely, measured gains and losses along the remaining 18 reaches were less than the measurement error, indicating that estimated seepage may not be representative of actual gain/loss conditions.

During the September seepage runs, 20 of 35 canal and creek reaches lost to ground water. Eleven of 19 reaches that gained in June-July lost in September; 8 reaches that lost in June-July gained in September. Four reaches (5, 6, 22, 38) could not be measured in September because of changes in hydrologic conditions. For example, pumpage along reach 5 could not be measured, and upstream discharge on reach 38 could not be measured because it was not wadeable and a boat could not be operated in the canal.

Median values for all environmental areas remained positive or negative as in June-July except for area 5, which changed from positive to negative. In area 5, canals and creeks that gained from ground water in June-July lost in September. The largest gain (10.1 $ft^3/s/mi$) was in area 6, reach 12; the largest loss (-13.0 $ft^3/s/mi$) was in area 4, reach 29. Figure 5B shows no substantial differences between median seepage values in different environmental areas; thus, as for June-July, no correlation could be made between measured September seepage rates and environmental areas.

September discharge measurements along 12 canal and creek reaches were rated as "Good," 18 as "Fair," and 5 as "Poor." Measured gains or losses were greater than the discharge measurement error along 17 of 35 reaches (4, 10, 11, 12, 13, 15, 19, 20, 21, 24, 27, 31, 33, 35, 36, 37, and 39), indicating that estimated seepage is probably representative of actual conditions. Measured gains or losses along many of these reaches also were greater than the measurement error in June-July.

Boise River

In November 1996, seepage runs were made on three reaches of the Boise River (fig. 6). Numerous inflows and outflows were measured along each reach to estimate Boise River gains and losses.

Reach 1 gained throughout its length except from Lucky Peak Dam (site 1) to Barber Dam (site 2) where no gain or loss was measured (fig. 7 and table 2). Results of the seepage run in this reach are consistent with the configuration of the water table in October 1970 (Dion, 1972) and in August 1992 (Tungate and Berenbrock, 1995). The largest gain, 16.69 $ft^3/s/mi$, was in downtown Boise between sites 10 and 12; net gain was 51.98 ft^3/s (fig. 8 and table 2).

The largest gain along reach 2, 19.31 $ft^3/s/mi$, was in the Notus area between sites 60 and 64; the largest loss, -2.69 $ft^3/s/mi$, was between Star and Middleton (sites 23 and 30) (fig. 7). Reach 2 is the longest of the three reaches (about 22 mi) and had a net gain of 61.24 ft^3/s (fig. 8 and table 2). Results of the seepage run in this reach are consistent with the configuration of the water table in October 1970 (Dion, 1972) and August 1992 (Tungate and Berenbrock, 1995).

Along reach 3, the Boise River gained water between sites 65 and 68 and lost from site 68 to the confluence of the Boise and Snake Rivers (table 2). This was unexpected, because the configuration of the water table delineated by Thomas and Dion (1974, fig. 5), Newton (1991, fig. 3), and Parliman (1998) indicated that the lower part of the Boise River is a gaining stream. Reach 3 (fig. 6) had a net loss of -22.51 ft^3/s (fig. 8 and table 2).

The three reaches total about 47 mi, or 75 percent, of the Boise River from Lucky Peak Dam to its confluence with the Snake River. The largest unmeasured reach was from Garden City (site 83) to near Star (site 20), which includes an area near Eagle where an island divides the Boise River into north and south channels. The Boise River is generally a gaining

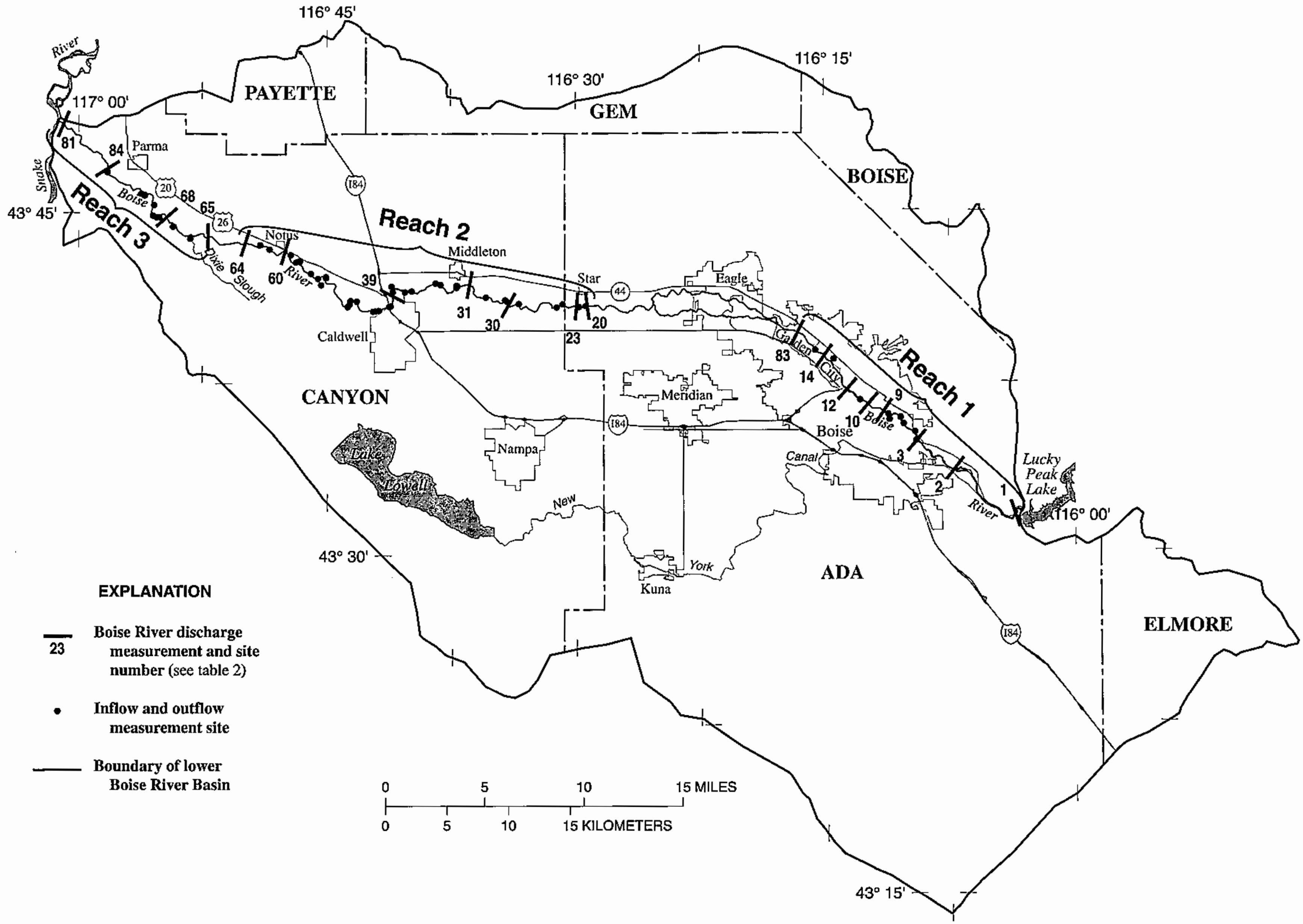


Figure 6. Location of seepage runs on the Boise River in the lower Boise River Basin, Idaho, November 1996.

Table 2. Flow gains and losses (-) along three reaches of the Boise River in the lower Boise River Basin, Idaho, November 1996

[Site locations shown in figure 6; No., number; mi, miles; ft³/s, cubic feet per second, ft³/s/mi, cubic feet per second per mile; —, no station No.]

Site No.	Site name	Station ID	County	Distance (mi)	Measurement date	Latitude	Longitude	Discharge (ft³/s)	Inflow to or outflow (-) from subreaches (ft³/s)	Measured gain or loss (-) along subreaches (ft³/s)	Measured gain or loss (-) along subreaches (ft³/s/mi)
	Reach 1										
1	Boise River near Boise	13202000	Ada	0	12	43°31'41"	116°03'36"	229			
2	Boise River below Barber Dam near Boise	13203700	Ada	4.35	12	43°33'37"	116°07'14"	229		0	0
3	Boise River at Loggers Creek	13204100	Ada	6.5	12	43°34'55"	116°09'31"	243		14.00	6.51
9	Boise River at Broadway Bridge at Boise	13204510	Ada	8.85	12	43°36'12"	116°11'30"	217	-35.12	9.12	3.88
10	Boise River at Ann Morrison Park	13205500	Ada	9.45	12	43°36'31"	116°12'26"	221		4.00	6.67
12	Boise River at Fairview Avenue	13205605	Ada	10.45	12	43°37'11"	116°13'42"	238	.31	16.69	16.69
14	Boise River at East 47th Street	13205645	Ada	12.45	12	43°38'37"	116°15'07"	242	-.17	4.17	2.09
83	Boise River at Glenwood Bridge near Boise	13206000	Ada	14.25	12	43°39'39"	116°16'41"	246		4.00	2.22
									Net gain or loss (-) =	**51.98**	
	Reach 2										
20	Boise River upstream from Canyon Canal, Star	13210000	Ada	0	15	43°40'53"	116°29'21"	340			
23	Boise River 0.3 mile downstream from Star Bridge	—	Ada	.5	15	43°40'53"	116°30'00"	294	-51.24	5.24	10.48
30	Boise River near Middleton	13210050	Canyon	4.55	12	43°40'54"	116°34'06"	342	58.91	-10.91	-2.69
31	Boise River at Middleton Bridge	13210820	Canyon	7.15	12	43°41'48"	116°36'27"	409	51.99	15.01	5.77
39	Boise River at Old Highway 20–26, Caldwell	13211000	Canyon	12.05	13	43°41'19"	116°41'07"	610	186.65	14.35	2.93
60	Boise River at Notus Road Bridge, Notus	13212500	Canyon	19.8	13	43°43'20"	116°47'32"	854	249.90	-5.90	-.76
64	Boise River downstream from Notus	—	Canyon	22.05	14	43°43'41"	116°49'58"	921	23.55	43.45	19.31
									Net gain or loss (-) =	**61.24**	
	Reach 3										
65	Boise River upstream from Dixie Slough	—	Canyon	0	14	43°43'56"	116°52'12"	916			
68	Boise River at Highway 95 near Parma	—	Canyon	2.6	15	43°44'49"	116°54'41"	1,010	85.91	8.09	3.11
84	Boise River at Parma	13213000	Canyon	7.3	14	43°48'52"	117°00'57"	987	2.60	-25.60	-3.85
81	Boise River at mouth near Parma	13213030	Canyon	10.7	14	43°46'56"	116°58'17"	982		-5.00	-1.47
									Net gain or loss (-) =	**-22.51**	
									Total gain or loss (-) =	**90.71**	

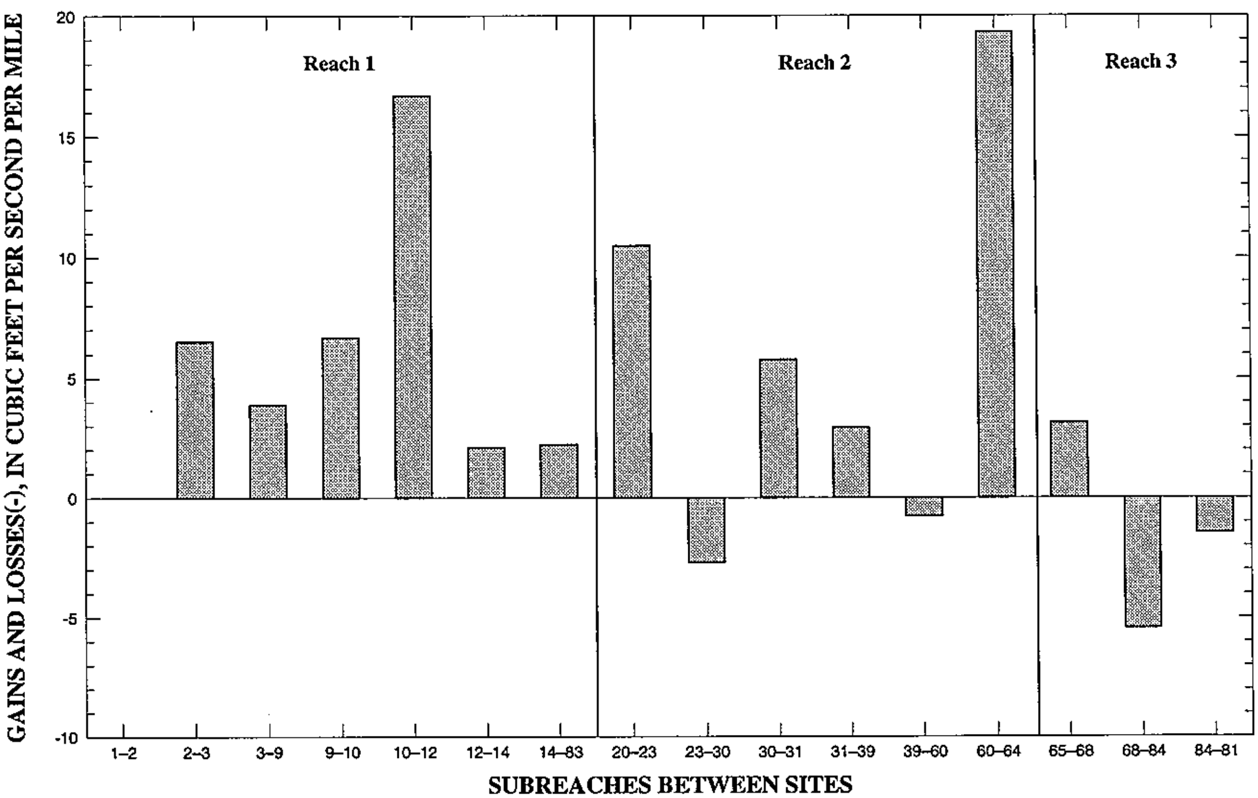


Figure 7. Gains and losses(-) along subreaches of the Boise River in the lower Boise River Basin, Idaho, November 1996. (See figure 6 for subreach locations)

stream. The largest gains were in reach 2 and the largest losses were in reach 3. Total gain from all three reaches was 90.71 ft^3/s (table 2).

All Boise River discharge measurements were rated as "Good." The subreaches between sites 2 and 3 and sites 10 and 12 were the only subreaches where measured gain or loss exceeded the discharge measurement error. Because measurement error is greater than the measured gain or loss, the gain and/or loss may not be representative of actual conditions. However, the net gains in reaches 1 and 2 were greater than measurement error. Twenty-two of 60 discharge measurements made on inflows and outflows were rated as "Good"; discharge ranged from about 1 ft^3/s to 225 ft^3/s. Twenty-four measurements were rated as "Fair"; all but one were less than 10 ft^3/s. The remaining 14 measurements were rated as "Poor"; all but one were less than 1 ft^3/s.

New York Canal

Two seepage runs were made on the New York Canal in March 1997 (table 3). The locations of sites measured and gains and losses are shown in figure 9 and table 3.

During the March 20–21 seepage run (table 3), gains and losses from site 1 to site 4 were small because the canal is lined with concrete. From site 4 to site 7, the canal is partially lined and gains and losses were larger. The largest loss (-26.5 $ft^3/s/mi$) was between sites 4 and 5; the largest gain (31.8 $ft^3/s/mi$) was between sites 5 and 6 (fig. 10 and table 3). Overall, the canal lost water to the ground-water system. Cumulative losses generally increased downstream as shown in figure 11. Total loss from the canal during the March 20–21 run was -54 ft^3/s (table 3).

Fourteen of 18 discharge measurements made during March 20–21 were rated as "Good." Measured gains or losses in 7 of 17 reaches were greater than the

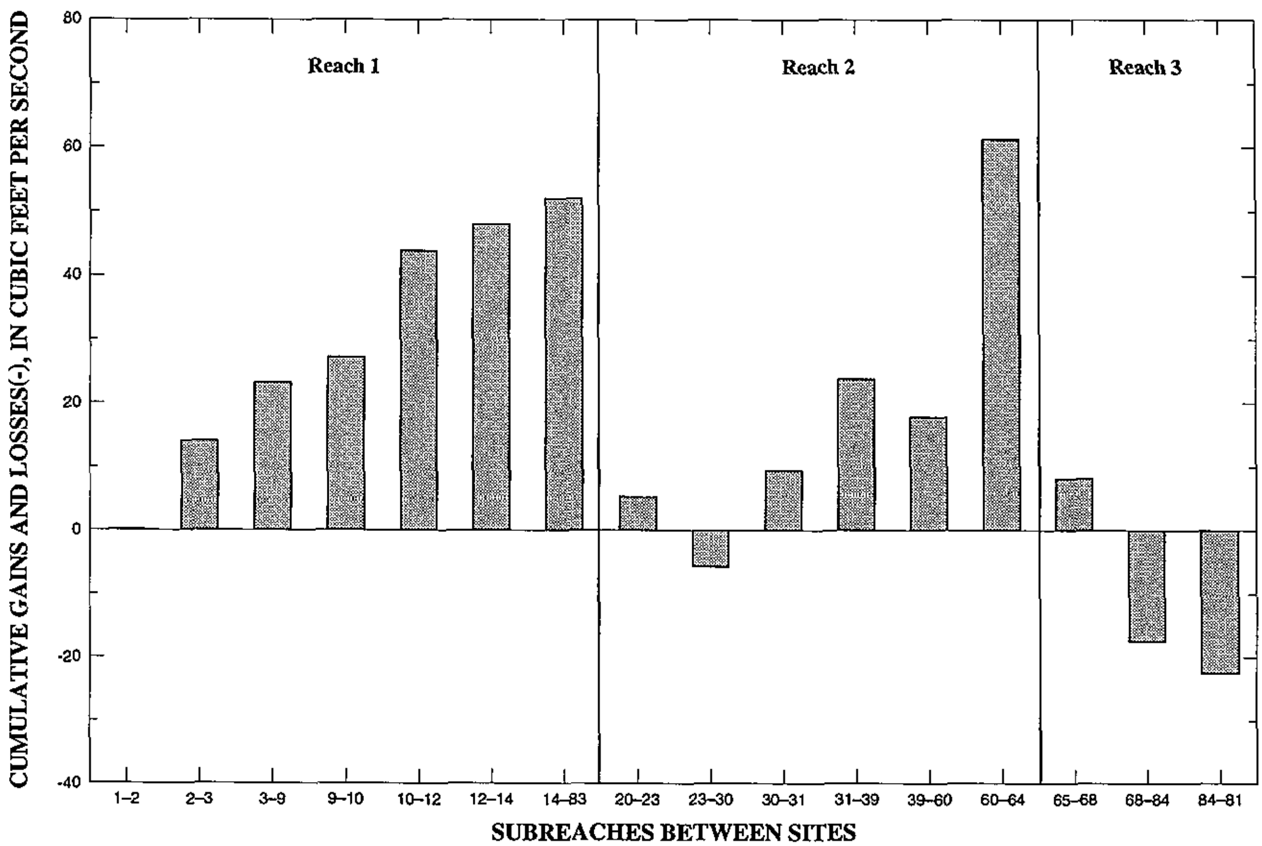


Figure 8. Cumulative gains and losses(-) along subreaches of the Boise River in the lower Boise River Basin, Idaho, November 1996. (See figure 6 for subreach locations)

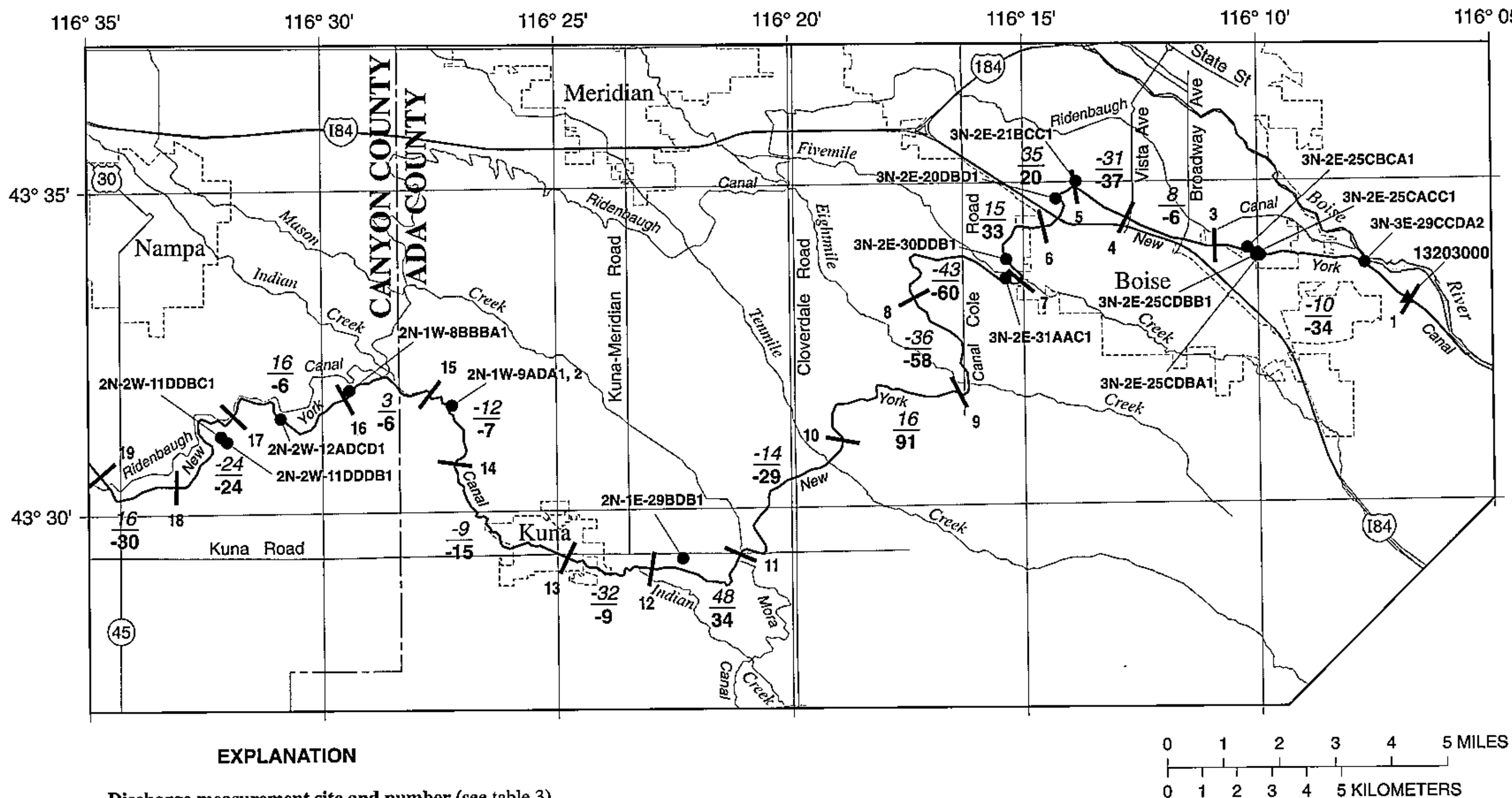
discharge measurement error. Measured gains or losses in 10 reaches were less than the measurement error and, therefore, may not be representative of actual gain/loss conditions. The measured loss between sites 1 and 19 was twice as much as the measurement error, indicating that, overall, the New York Canal lost water.

During the March 27–28 seepage run, discharge at site 1 was 862 ft^3/s, nearly twice that in March 20–21 (table 3). Again, the gains and losses in reaches from sites 1 to 4 and from sites 13 to 17 were small relative to those in other canal reaches (figs. 9 and 10). As before, the largest loss (-31.6 $ft^3/s/mi$) was between sites 4 and 5; the largest gain (27.8 $ft^3/s/mi$) was between sites 9 and 10 (fig. 10 and table 3). Overall, the canal lost water to the ground-water system. Cumulative losses generally increased downstream as shown in figure 11. Total loss from the canal during the March 27–28 run was - 143 ft^3/s (table 3), nearly 2.5 times the loss during March 20–21.

Eleven of 18 discharge measurements made during March 27–28 were rated as "Good"; measured discharges in only 3 reaches were greater than the discharge measurement error. Because discharges in the remaining reaches were less than the measurement error, measured values may not be representative of actual gains and losses. However, the measured loss between sites 1 and 19 was about four times greater than the measurement error, indicating that, overall, the canal loses water.

CHANGES IN GROUND-WATER LEVELS

Water levels in 16 wells along the New York Canal (fig. 9) were measured at least weekly from the last week in February through mid-June 1997. Depth to water was measured with a steel tape to an accuracy of 0.01 ft. Hydrographs for each well are shown in figure 12. From February to June, water levels in-



EXPLANATION

13 — Discharge measurement site and number (see table 3)

-14 — Gain or loss(-) in cubic feet per second—March 20–21, 1997

-29 — Gain or loss(-) in cubic feet per second—March 27–28, 1997

● 3N-3E-29CCDA2 — Well and number

▲ 13203000 — Gaging station and number

Figure 9. Location of measurement sites and gains and losses(-) along the New York Canal in the lower Boise River Basin, Idaho, March 1997.

Table 3. Flow gains and losses (-) along the New York Canal in the lower Boise River Basin, Idaho, March 1997

[Site locations shown in figure 9; No., number; mi, miles; ft^3/s, cubic feet per second, $ft^3/s/mi$, cubic feet per second per mile]

Site No.	Distance from Lake Lowell (mi)	Bridge site name	County	Latitude	Longitude	Mea-sure-ment date	Dis-charge (ft^3/s)	Measured gain or loss (-) along subreaches (ft^3/s)	Measured gain or loss (-) along subreaches ($ft^3/s/mi$)	Mea-sure-ment date	Dis-charge (ft^3/s)	Measured gain or loss (-) along subreaches (ft^3/s)	Measured gain or loss (-) along subreaches ($ft^3/s/mi$)
1	39.5	13203000 New York Canal downstream from Diversion Dam near Boise	Ada	43°33'08"	116°06'44"	20	439			27	862		
3	35.7	Gekeler Road	Ada	43°34'01"	116°10'55"	20	429	-10	-2.6	27	828	-34	-8.9
4	34.0	Vista Avenue	Ada	43°34'27"	116°12'48"	20	437	8	4.8	27	822	-6	-3.6
5	32.9	Roosevelt Street	Ada	43°34'58"	116°13'58"	20	406	-31	-26.5	27	785	-37	-31.6
6	31.8	Orchard Street	Ada	43°34'21"	116°14'35"	21	441	35	31.8	28	805	20	18.2
7	30.1	Gowen Road	Ada	43°33'29"	116°15'03"	21	456	15	9.1	28	838	33	19.9
8	27.0	Desert Street	Ada	43°33'15"	116°17'20"	21	413	-43	-13.7	28	778	-60	-19.2
9	24.6	Cole Road	Ada	43°31'47"	116°16'25"	21	377	-36	-15.5	28	720	-58	-24.9
10	21.4	Hubbard Road	Ada	43°31'03"	116°18'55"	21	393	16	4.9	28	811	91	27.8
11	17.9	Kuna Road	Ada	43°29'18"	116°21'08"	20	379	-14	-4.1	28	782	-29	-8.4
12	15.8	Strobel Road	Ada	43°29'05"	116°23'00"	20	427	48	22.8	28	816	34	16.1
13	14.0	Swan Falls Road	Ada	43°29'15"	116°24'47"	20	395	-32	-17.6	28	807	-9	-5.0
14	10.7	Black Cat Road	Ada	43°30'46"	116°27'11"	20	386	-9	-2.7	28	792	-15	-4.5
15	8.8	Ridgewood Road	Ada	43°31'51"	116°27'42"	21	374	-12	-6.5	28	785	-7	-3.8
16	6.9	Robinson Road	Ada	43°31'48"	116°29'32"	21	377	3	1.5	28	779	-6	-3.1
17	4.0	South Side Boulevard	Canyon	43°31'32"	116°31'56"	20	393	16	5.6	28	773	-6	-2.1
18	1.6	Power Line Road	Canyon	43°30'28"	116°33'07"	20	369	-24	-10.1	28	749	-24	-10.1
19	0.0	Lake Shore Drive	Canyon	43°30'37"	116°34'45"	20	385	16	9.8	28	719	-30	-18.4
				Total gain or loss (-) =				**-54**				**-143**	

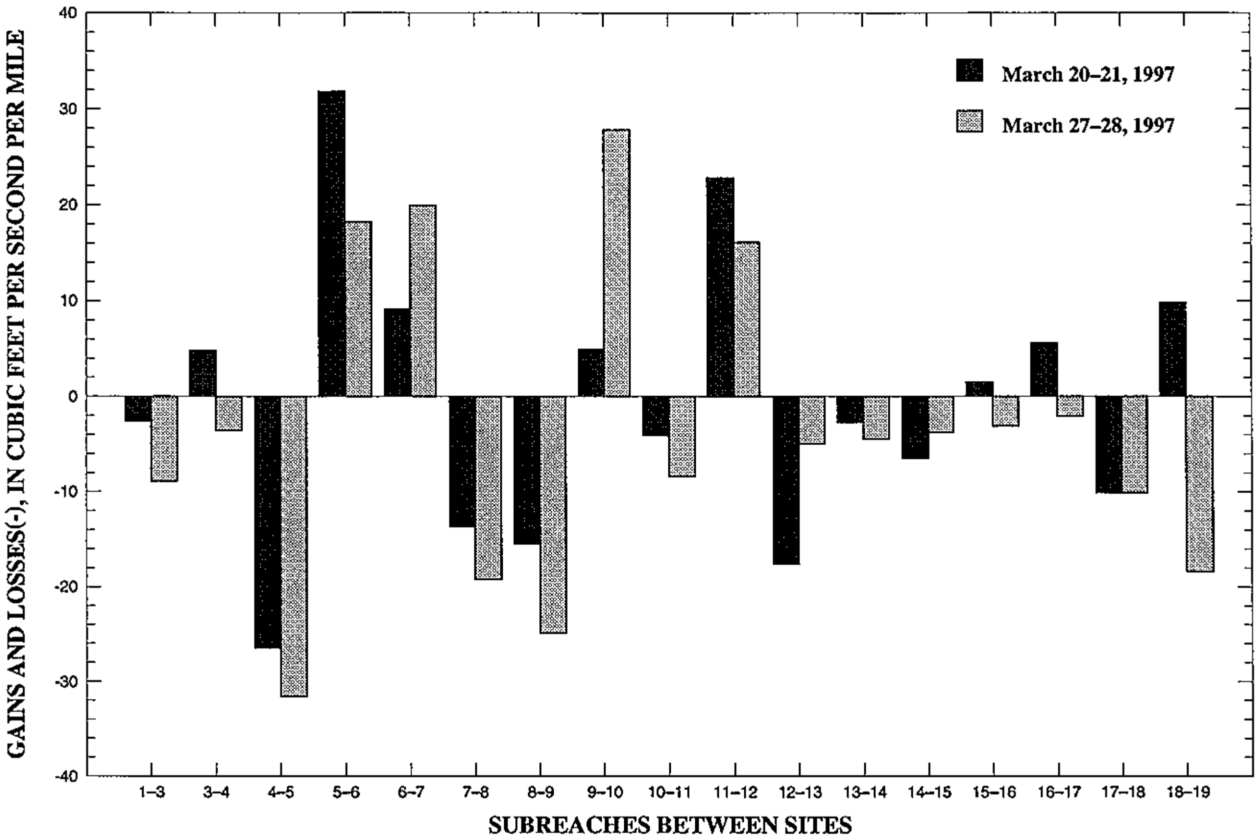


Figure 10. Gains and losses(-) along subreaches of the New York Canal in the lower Boise River Basin, Idaho, March 1997. (See figure 9 for subreach locations)

creased in 11 wells, declined in 3, and remained the same in 1. The 1-week decline of about 4 ft in well 3N-3E-29CCDA2 was probably the result of domestic pumpage.

Wells 3N-2E-25CACC1, -25CBCA1, -25CDBA1, and -25CDBB1 are within 1/8 mi of one another in west Boise (fig. 9) and are similar in depth. Water levels in wells 3N-2E-25CDBB1 and -25CDBA1, south of the New York Canal, increased slightly (about 1 ft) or remained the same from February to June; water levels in wells 3N-2E-25CACC1 and -25CBCA1, north of the canal, increased about 2 ft during that time (fig. 12). The water level in well 3N-2E-25CACC1 increased until mid-May, whereas the water level in well -25CBCA1 declined until mid-April and then increased through June. Similar responses were noted in wells near Kuna.

Wells 3N-2E-20DBD1 and -21BCC1 are in an area where the largest canal gains and losses were measured. The water level in well 3N-2E-20DBD1 increased about 27 ft during one week in mid-March. The net water-level increase in well 3N-2E-21BCC1 from February to June was less than 0.5 ft, although the water level increased about 2 ft from mid-April to June. Water levels in wells 3N-2E-30DDB1 and -31AAC1 near discharge measurement site 7 declined about 3 ft and 1 ft, respectively. The declines in these wells are probably the result of domestic pumpage. Also, the driller's log for well 3N-2E-31AAC1 indicates several clay layers that confine the underlying water-bearing zones and impede the movement of canal water to the well.

Water levels in wells 2N-2W-12ADCD1, 2N-1W-8BBBA1, -9ADA1, and -9ADA2 (fig. 12) declined until mid-April and then increased about 4 ft, 7 ft, 9 ft, and about 5 ft, respectively, through June. In paired wells 2N-1W-9ADA1 and -9ADA2, the water level in well -9ADA1 was about 5 ft higher than the

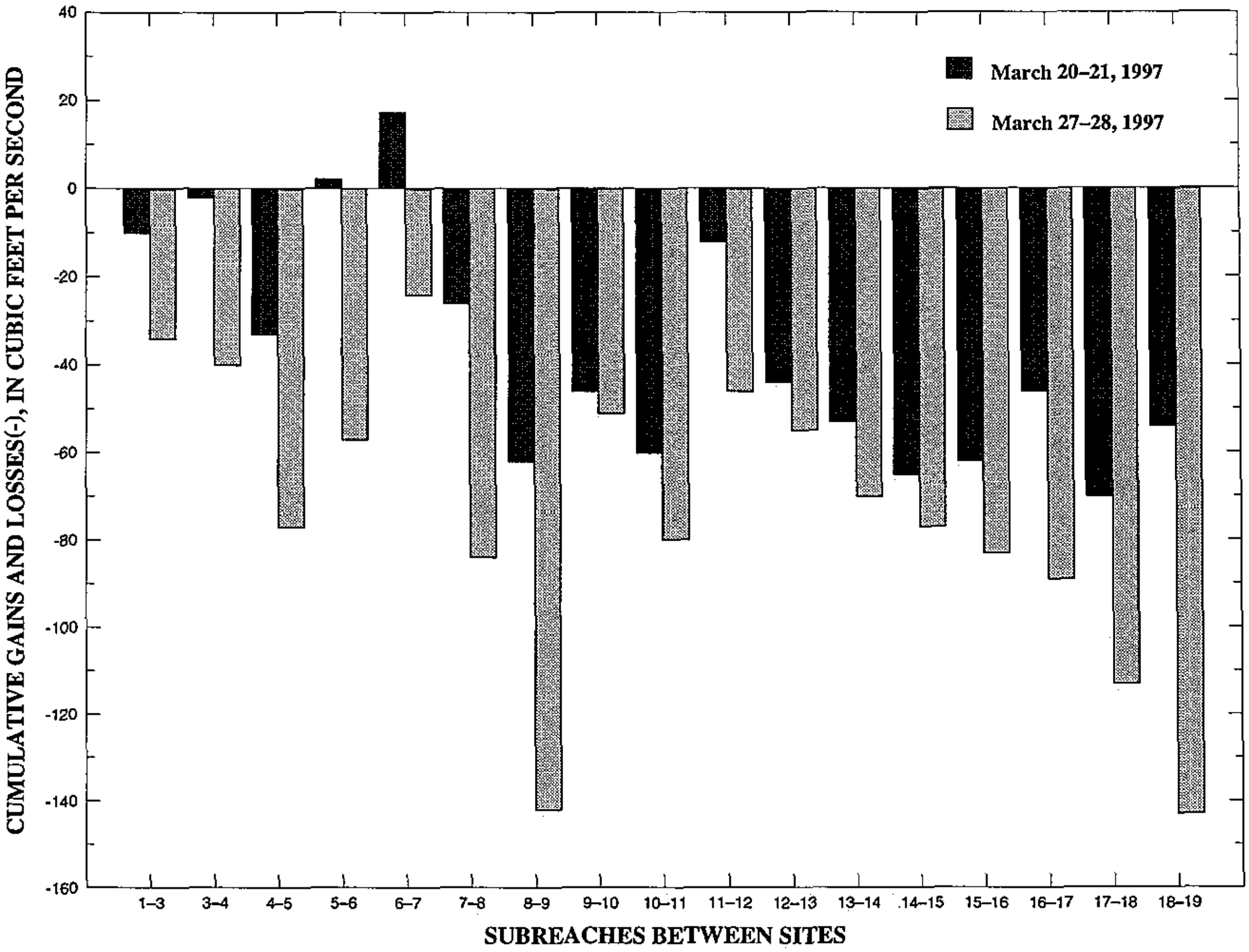


Figure 11. Cumulative gains and losses(-) along subreaches of the New York Canal in the lower Boise River Basin, Idaho, March 1997. (See figure 9 for subreach locations)

water level in well -9ADA2 from February to mid-April. By the end of June, the water level in well -9ADA1 was about 8 ft higher. Higher water levels in the shallow well indicate a downward movement of water in this area, probably the result of recharge from canal losses.

Wells 2N-2W-12ADCD1 and 2N-1W-8BBBA1 are in an area where canal gains and losses are small. Water levels in these wells (fig. 12) declined from February to mid-April; about 2 ft in well -8BBBA1 and 1 ft in well -12ADCD1. From mid-April through June, water levels in those wells increased about 8 ft and 4 ft, respectively. Wells 2N-2W-11DDBC1 and -11DDDB1 are adjacent to one another, and water levels in each increased about 5 ft from early March to June. Well 2N-2W-11DDBC1 is open only in the last 6 ft, whereas well -11DDDB1 is open throughout most of its depth. From late February through June, water levels in well 2N-2W-11DDBC1 were about 13 ft higher than in well -11DDDB1, which has a composite head.

SUGGESTIONS FOR FUTURE INVESTIGATIONS

The measurement of seepage in canals and creeks, the Boise River, and the New York Canal is a step in the process of understanding ground-water/surface-water relations in the lower Boise River Basin. Although much was learned during this study, additional, more detailed seepage data are needed. Nests of piezometers open to different depths are needed along canals and

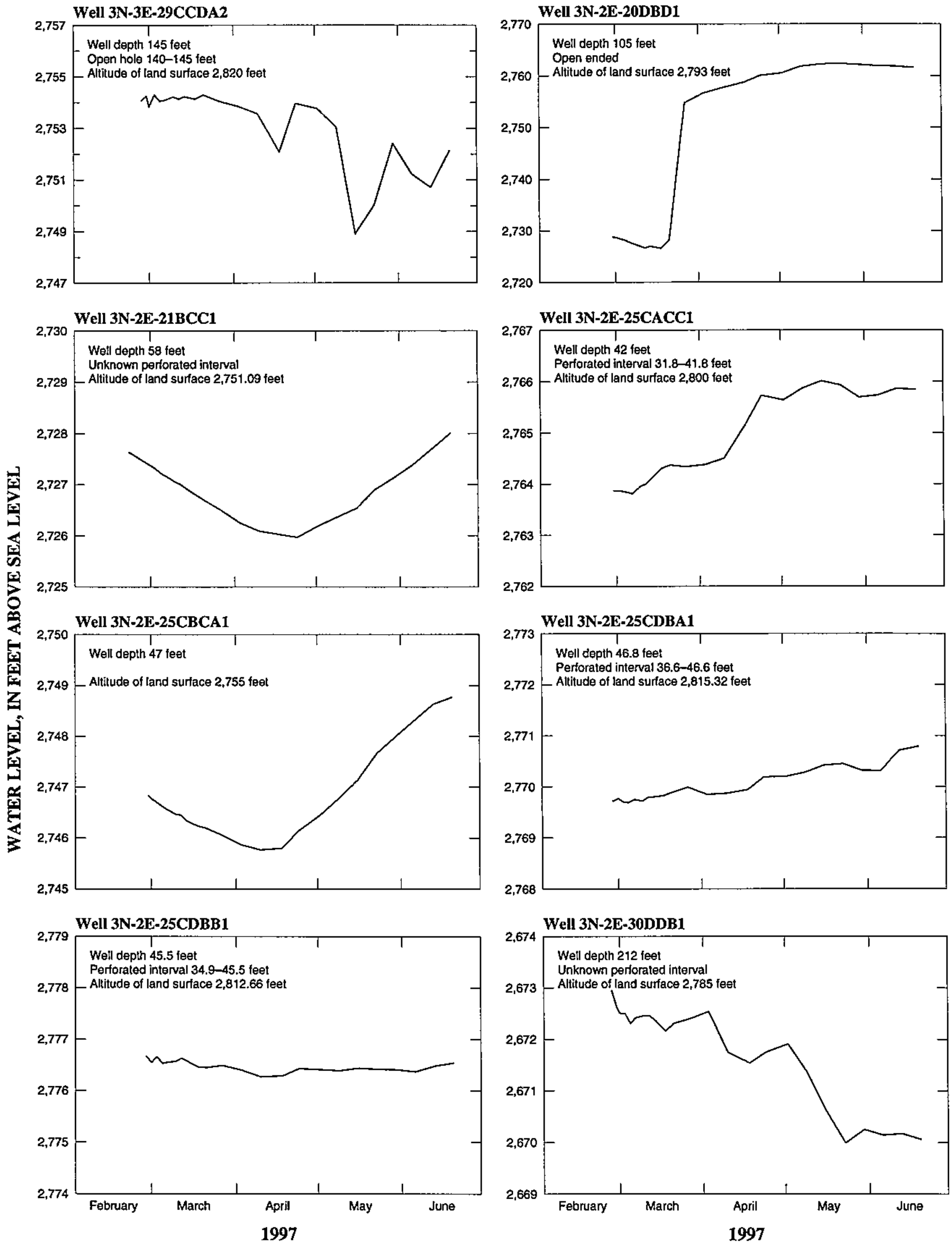


Figure 12. Water levels in selected wells along the New York Canal in the lower Boise River Basin, Idaho, February through June 1997. (See figure 9 for well locations)

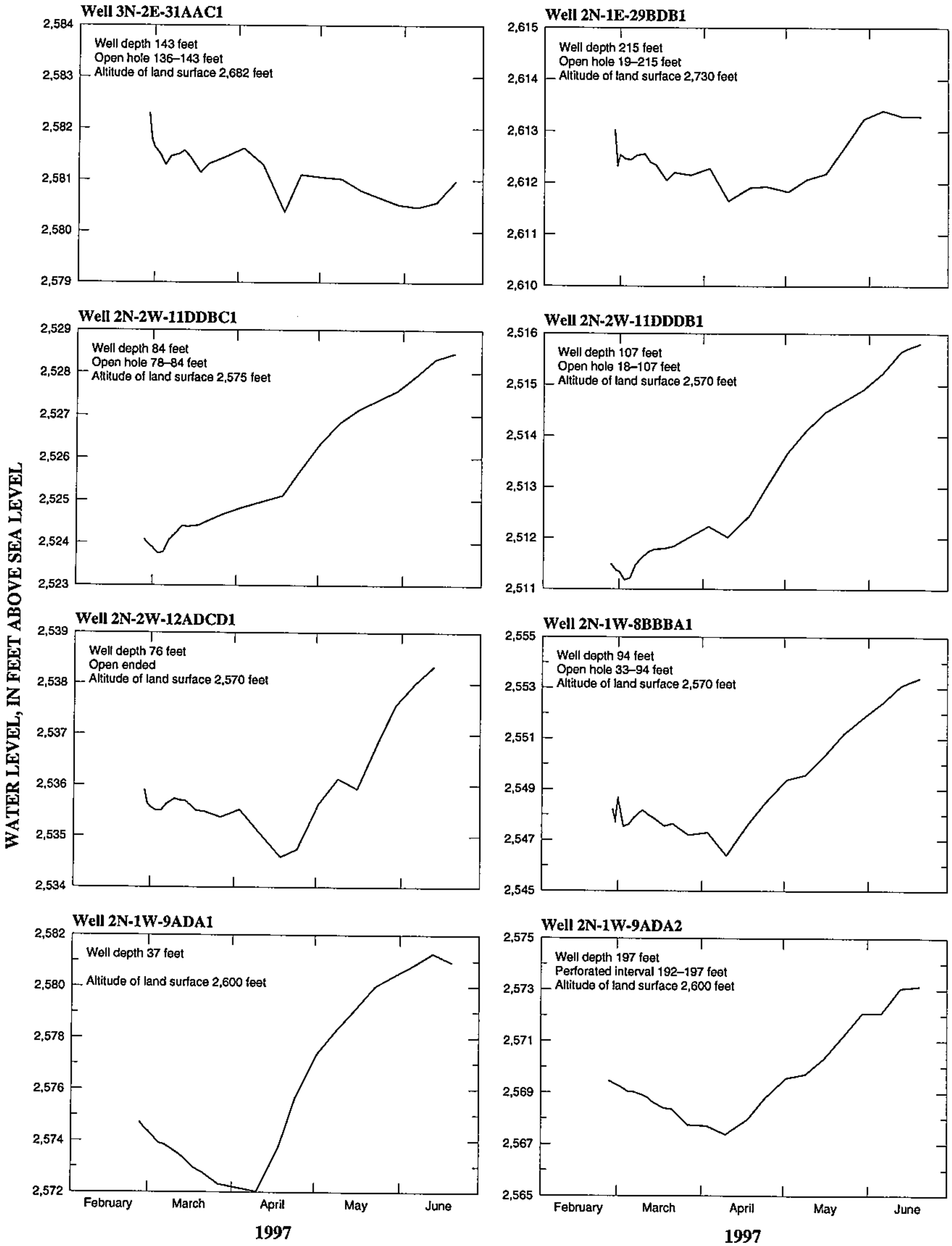


Figure 12. Water levels in selected wells along the New York Canal in the lower Boise River Basin, Idaho, February through June 1997—Continued.

streams to define vertical ground-water movement and gradients.

No correlation could be made between measured seepage and defined environmental areas. Additional work is needed to relate measured gains and losses in canals and streams to environmental characteristics. Additional data layers describing environmental characteristics (depth to water, principal recharge and discharge areas, and physical attributes of canals and streams) could be developed to enhance interpretation. The new layers could be synthesized with existing layers to create more specific environmental areas that better relate to seepage gains and losses.

SUMMARY

In February 1996, the Idaho Department of Water Resources began the Treasure Valley Hydrologic Project. The project was needed to provide information to answer complex water-management questions and produce tools necessary to protect water resources in the lower Boise River Basin in southwestern Idaho. Expected products from this effort included additional data and information on recharge to the ground-water system from canals, streams, and the Boise River. To help provide this information, the U.S. Geological Survey, in cooperation with the Idaho Department of Water Resources, began a study to evaluate gains to and losses from ground water at (1) irrigation canals and creeks, (2) the lower Boise River, and (3) the New York Canal.

To evaluate gains and losses in the complex irrigation network in the basin, a method was developed to select representative canal and creek reaches for study in areas with common environmental characteristics. The purpose of this approach was to determine whether seepage conditions along selected reaches could be related to a set of environmental characteristics that define the area containing the given reach. If a relation was determined, it might be assumed that the results of seepage runs along selected canal and creek reaches could be extended to unmeasured canals and creeks to estimate gains and losses.

During June-July 1996 seepage runs, canal and creek reaches in most environmental areas gained and lost water; 21 reaches gained and 18 reaches lost. The median seepage values in five environmental areas were positive, indicating that canals and creeks gained water. Three areas had negative median seepage values, indicating that canals and creeks lost water. No statistical inference could be calculated for four areas because of insufficient seepage data. The largest median gain, 1.70 ft^3/s, was in area 5; as was the largest gain per mile, 7.82 $ft^3/s/mi$. The largest loss per mile, -10.0 $ft^3/s/mi$, was in area 4. No correlation could be made between seepage and environmental area.

Seepage runs in June-July and September 1996 indicated that surface-water/ground-water relations are not static. Twenty of 35 canal and creek reaches lost water. Eleven of 19 canals and creeks that gained water in June-July lost water in September, and 8 reaches that lost water in June-July gained water in September. Median seepage values in all environmental areas were positive or negative in June-July and September except for areas 5 and 10. In areas 5 and 10, median seepage values changed from positive to negative, indicating that the reaches changed from gaining in June-July to losing in September. The largest median gain (1.25 ft^3/s) was in environmental areas 5 and 10. Measured seepage varied from a gain of 10.1 $ft^3/s/mi$ to a loss of -13.0 $ft^3/s/mi$. No correlation could be made between September seepage gains and losses and environmental areas.

In November 1996, seepage runs were made on three reaches of the Boise River that totaled 47 mi. The 12.25-mi reach from Lucky Peak Dam to the Glenwood Bridge gained 51.98 ft^3/s. The largest gain, 16.69 $ft^3/s/mi$, was in a 1-mi subreach through downtown Boise; the net gain for the reach was 51.98 ft^3/s. The 22.05-mi reach from Star to Notus had a net gain of 61.24 ft^3/s. The lower 2.25 mi of this reach had the largest measured gain of the three reaches, 19.31 $ft^3/s/mi$. The 10.7-mi reach from Dixie Slough to the confluence of the Boise and Snake Rivers had a net loss of -22.51 ft^3/s. Total gain to the river from all three reaches was 90.71 ft^3/s.

Two seepage runs were made on the New York Canal in March 1997 at flows of about 440 ft^3/s and 860 ft^3/s, as measured at the New York Canal downstream from Diversion Dam near Boise gaging station (13203000). The New York Canal gained and lost water during both runs. The largest measured gain was

31.8 $ft^3/s/mi$; the largest loss was -31.6 $ft^3/s/mi$. Total loss during the March 20–21 seepage run was -54 ft^3/s; during the March 27–28 run, the loss was -143 ft^3/s, about 2.5 times greater.

Water levels in 16 wells along the New York Canal were measured weekly from the last week in February through mid-June 1997. Generally, water levels in these wells decreased from late February to mid-April and then increased through mid-June. Water levels in a set of paired wells between Kuna and Nampa indicated a downward movement of ground water.

Study results indicated that additional data are needed to better understand the complex ground-water/surface-water relations in the lower Boise River Basin. Additional seepage runs are needed on irrigation canals and creeks, the Boise River, and the New York Canal. A more detailed study of Boise River gains and losses, especially upstream from the city of Boise, is needed. Nests of piezometers open to different depths are needed to define vertical ground-water movement and gradients. Additional work is needed to interpret the results of seepage runs and refine the method to relate seepage gains and losses to environmental characteristics.

REFERENCES CITED

Abramovich, R., Molnau, M., and Craine, K., 1998, Climates of Idaho: University of Idaho Cooperative Extension System, College of Agriculture, 216 p.

Dion, N.P., 1972, Some effects of land use changes on the shallow ground-water system in the Boise-Nampa area, Idaho: Idaho Department of Water Administration, Water Information Bulletin 26, 46 p.

Molnau, M., 1995, Mean annual precipitation, 1961–1990, Idaho: Moscow, University of Idaho, Agricultural Engineering Department, State Climate Program, scale 1:1,000,000.

Newton, G.D., 1991, Geohydrology of the regional aquifer system, western Snake River Plain, southeastern Idaho: U.S. Geological Survey Professional Paper 1408–G, 52 p.

Parliman, D.J., 1998, Ground-water quality in northern Ada County, lower Boise River Basin, Idaho, 1985–96: U.S. Geological Survey Fact Sheet FS–054–98, 6 p.

Rantz, S.E., and others, 1982, Measurement and computation of streamflow; volume 2, Computation of discharge: U.S. Geological Survey Water-Supply Paper 2175, p. 285–631.

Rupert, M.G., 1997, Nitrate (NO_2+NO_3–N) in ground water of the upper Snake River Basin, Idaho and western Wyoming, 1991–95: U.S. Geological Survey Water-Resources Investigations Report 97–4174, 47 p.

——— 1998, Probability of detecting atrazine/desethyl-atrazine and elevated concentrations of nitrate (NO_2+NO_3–N) in ground water in the Idaho part of the upper Snake River Basin: U.S. Geological Survey Water-Resources Investigations Report 98–4203, 32 p.

Thomas, C.A., and Dion, N.P., 1974, Characteristics of streamflow and ground-water conditions in the Boise River valley, Idaho: U.S. Geological Survey Water-Resources Investigations 38–74, 56 p.

Tungate, A.M., and Berenbrock, Charles, 1995, Configuration of the water table, 1970 and 1992, and water-table change between 1970 and 1992 in the Boise area, Idaho: U.S. Geological Survey Water-Resources Investigations Report 94–4116, 1 sheet.

U.S. Department of Agriculture, 1991, State soil geographic data base (STATSGO): U.S. Department of Agriculture, Soil Conservation Service, Miscellaneous Publication Number 1492, 88 p.