STREAMFLOW LOSSES AND GROUND-WATER LEVEL CHANGES ALONG THE BIG LOST RIVER AT THE IDAHO NATIONAL ENGINEERING LABORATORY, IDAHO

by C.M Bennett

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 90-4067

Prepared in cooperation with the
U.S. DEPARTMENT OF ENERGY

Idaho Falls, Idaho
April 1990

U.S. DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, JR., Secretary
U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

For additional information
write to:

U.S. Geological Survey
INEL, MS 4148
P.O. Box 2230
Idaho Falls, ID 83403

Copies of this report can be
purchased from:

U.S. Geological Survey
Books and Open-File Reports Section
Box 25425, Federal Center
Denver, CO 80225

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

For readers who prefer to use metric (International System) units, conversion factors for terms used in this report are listed below.

Multiply inch-pound units	By	To obtain metric unit
acre	0.4047	hectare
acre-foot (acre-ft)	1,233	cubic meter
acre-foot per month (acre-ft/mo)	1,233	cubic meter per month
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
cubic foot per second (ft^3/s)	0.02817	cubic meter per second
cubic foot per second per mile (ft^3/s)/mi	0.01760	cubic meter per second per kilometer
foot (ft)	0.3048	meter
foot squared per day (ft^2/d)	0.09290	meter squared per day
inch (in.)	25.4	millimeter
inch per year (in/yr)	25.4	millimeter per year
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Metric units used in this report that do not have commonly-used inch-pound equivalents are mg/L (milligram per liter) and μS/cm (microsiemens per centimeter at 25 degrees Celsius).

For temperature, degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) by using the formula °F = (1.8)(°C)+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 both the United States and Canada, formerly called Sea Level Datum of 1929.

STREAMFLOW LOSSES AND GROUND-WATER LEVEL CHANGES ALONG THE BIG LOST RIVER AT THE IDAHO NATIONAL ENGINEERING LABORATORY, IDAHO

By

C.M. Bennett

ABSTRACT

The Big Lost River flows onto the eastern Snake River Plain near Arco, Idaho, and across the INEL (Idaho National Engineering Laboratory). Most streamflow infiltrates the bed of the Big Lost River channel, INEL spreading areas A, B, C, and D, and playas located at the terminus of the river, to recharge the Snake River Plain aquifer.

Average annual streamflow during 1965-87 for the Big Lost River upstream from the INEL diversion dam was 104,400 acre-feet; 52,000 acre-feet were diverted to the INEL spreading areas, 9,800 acre-feet infiltrated between the INEL diversion dam and Lincoln Boulevard, and 42,600 acre-feet infiltrated downstream from Lincoln Boulevard or flowed to playas. Streamflow losses to evapotranspiration were minor compared to infiltration losses.

Losses were measured in selected reaches of the 44 miles of river from Arco to playa 1 at discharges that ranged from 37 to 372 ft^3/s (cubic feet per second). Infiltration losses were from 1 to 2 $(ft^3/s)/mi$ (cubic feet per second per mile) at discharges less than 100 ft^3/s throughout most of the reach between measurement site 1 (near Arco) and measurement site 13 (upstream from the Big Lost River Sinks). Loss from the river in the reach between measurement site 6 (INEL diversion) and measurement site 7 ranged from 1 to 4 $(ft^3/s)/mi$. Loss in the reach between measurement site 13 and measurement site 14 ranged from 7 to 12 $(ft^3/s)/mi$. Discharge measurements made May 6-8, 1985, when streamflow near Arco was 372 ft^3/s, indicated that channel infiltration is largest at high stages. A maximum loss of 28 $(ft^3/s)/mi$ was measured in the area of the Big Lost River Sinks. Water

levels in the area immediately southwest of the Radioactive Waste Management Complex and the area between the Naval Reactors Facility and playas 1 and 2 were substantially affected by recharge from the Big Lost River.

INTRODUCTION

The Big Lost River is the principal stream in the 890-mi^2 area that encompasses the INEL (Idaho National Engineering Laboratory) in southeastern Idaho (fig. 1). The river drains about 1,500 mi^2 of Butte and Custer Counties, including the northeastern flanks of the Pioneer Mountains and the southwestern flanks of the Lost River Range. The Big Lost River flows onto the eastern Snake River Plain near Arco and is a major source of recharge to the Snake River Plain aquifer, part of which underlies the INEL.

The Snake River Plain aquifer, a ground-water reservoir that may contain more than 1 billion acre-ft of water (Barraclough and others, 1981), consists of a hydraulically connected sequence of basaltic lava flows interbedded with sedimentary deposits. Ground water is transmitted through fractures, cavities, and volcanic clinker zones between individual lava flows, and through interstitial voids in sedimentary deposits. Transmissivity of the aquifer generally ranges from 134,000 to 13,400,000 ft^2/d (Robertson and others, 1974, p. 12).

The INEL is used for testing various types of nuclear reactors and reactor fuel cells; the processing, consolidation, and temporary storage of nuclear wastes; and various environmental research projects. As a consequence of these operations, tritium, strontium-90, iodine-129, nitrate, sodium, and chloride have been disposed to or have migrated downward to the Snake River Plain aquifer.

Water infiltrating from the Big Lost River dilutes the concentrations of various radioactive and non-radioactive constituents and influences their areal distribution and rates of migration. For detailed discussions on the occurrence of the waste constituents, refer to reports by Mann and others (1989) and Pittman and others (1988). Information about streamflow-

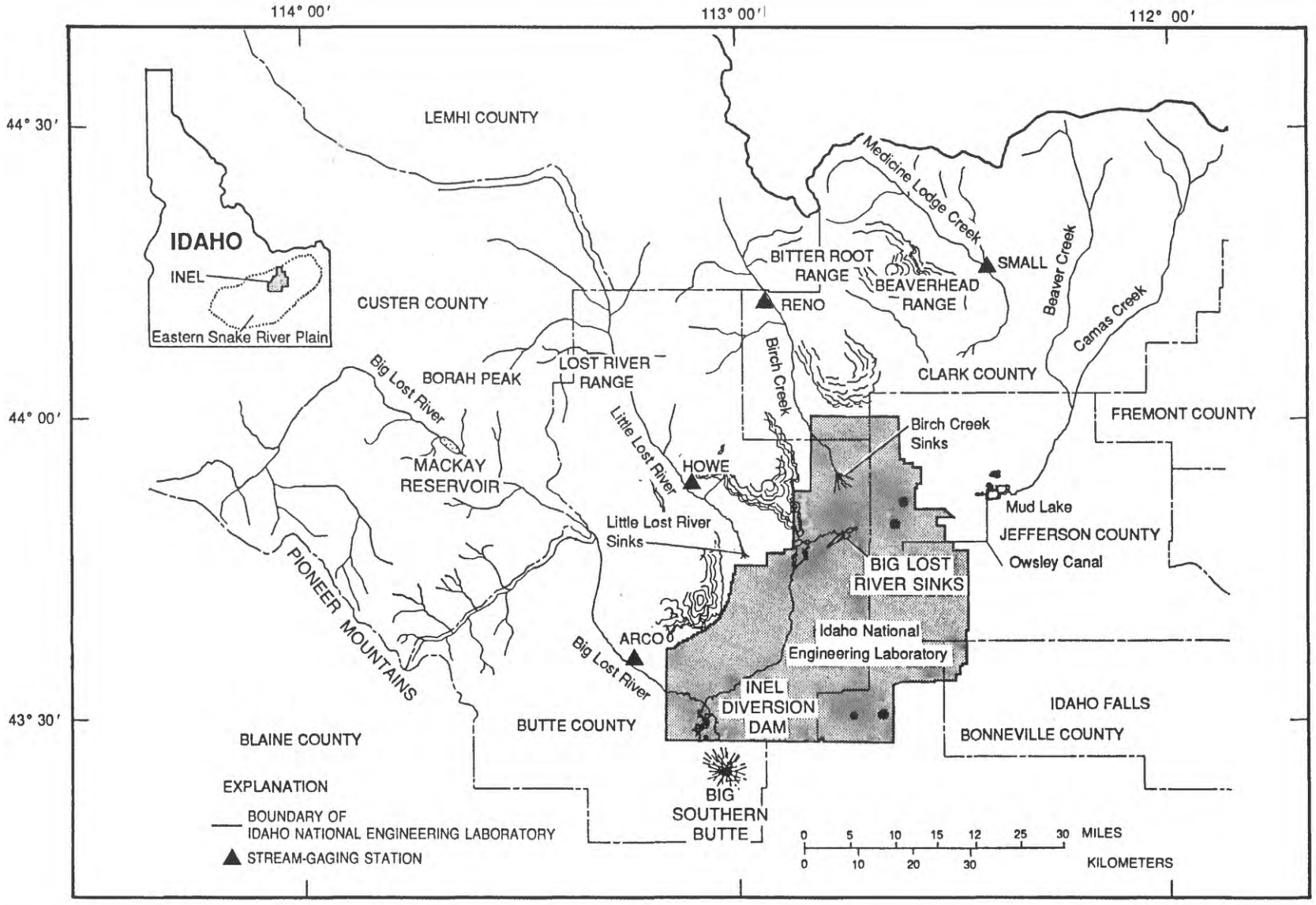

Figure 1.--Location of the Big Lost River and the Idaho National Engineering Laboratory.

infiltration losses is needed to define effects of infiltrating water on movement of chemical and radionuclide wastes in the aquifer at the INEL.

The U.S. Geological Survey, as part of the characterization of the hydrology of the INEL, conducted a study in cooperation with the U.S. Department of Energy, to define infiltration of water through the streambed of the Big Lost River and availability of water for recharge from playas and spreading areas. The study included compilation of streamflow data, analyses of seepage-run data, and comparison of streamflow-infiltration losses with ground-water levels. This report describes the results of the study.

Description of the Big Lost River Basin

The Big Lost River basin includes parts of Custer and Butte Counties in south central Idaho. The drainage area of the Big Lost River basin upstream from the INEL is about 1,400 mi^2. Of the 890 mi^2 within the boundaries of the INEL, only about 70 to 80 mi^2 actually contribute surface runoff of any significance to the Big Lost River (fig. 2), except during infrequent floods. Three other drainage basins, Camas Creek, Birch Creek, and Little Lost River, also contribute surface runoff to the INEL, but their drainage areas constitute a comparatively small percentage of the surface area within the INEL.

Non-contributing areas of the Big Lost River basin within the INEL consist of small, topographically closed basins 1 to 10 mi^2 in area. Land-surface altitudes range from about 4,780 ft above sea level at the terminal playas of the Big Lost River to 12,656 ft at Borah Peak in the Lost River Range. The mountains in the basin upstream from the INEL are composed primarily of limestone, shale, and volcanic rock (Rember and Bennett, 1979).

The channel of the Big Lost River is incised about 60 ft into the basalt of the Snake River Plain, 1 to 2 mi downstream from the gaging station near Arco. After reaching the western boundary of the INEL, the river emerges from the narrow, 200- to 300-ft wide, canyon into a broad plain where it is incised less than 20 ft. About 6.5 mi downstream from the

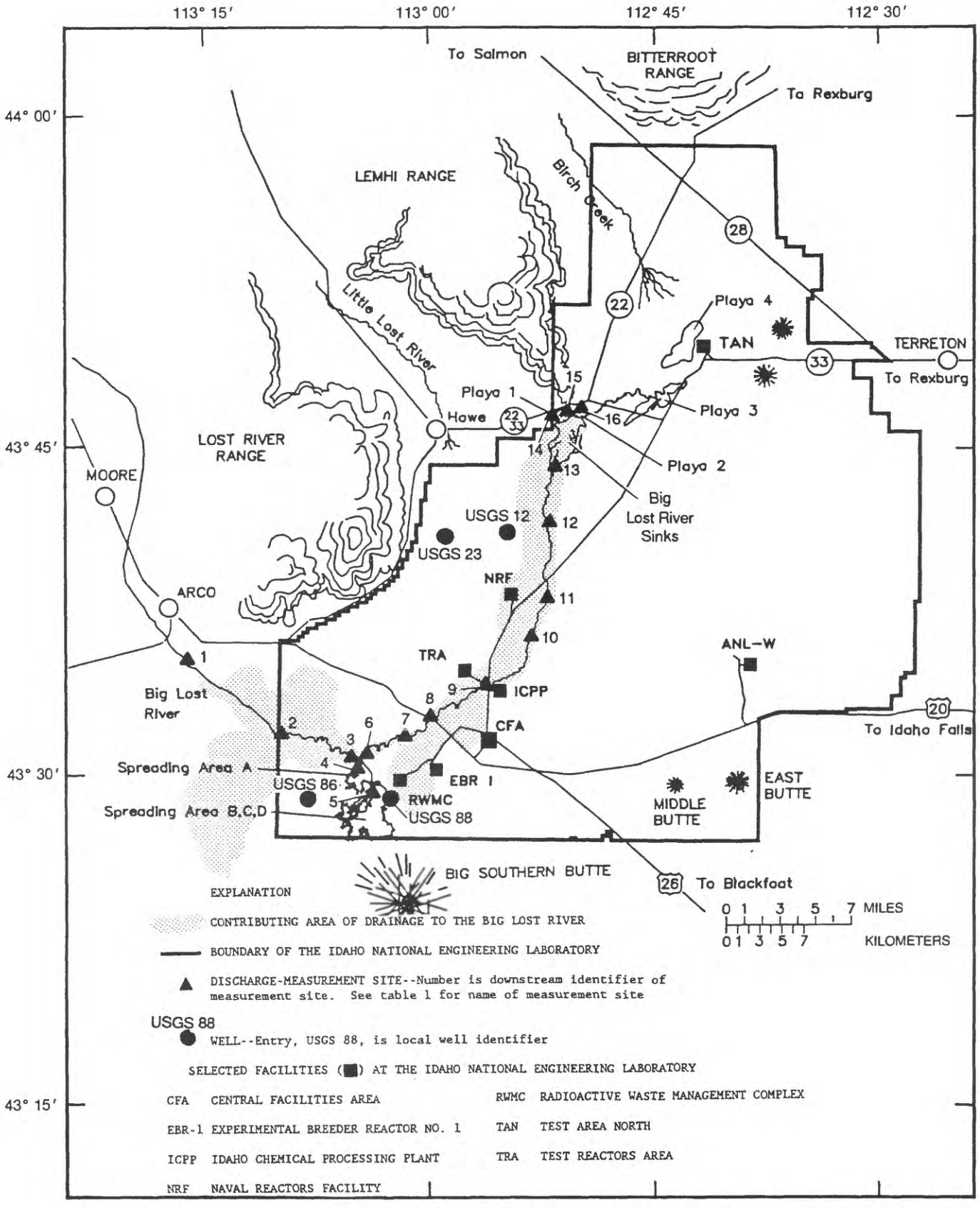

Figure 2.--Location of selected discharge measurement sites, selected wells, and approximate contributing drainage area to the Big Lost River at the Idaho National Engineering Laboratory

INEL boundary, a low earthen dam and headgate, referred to as the INEL diversion dam, is used to divert water from the river into a series of natural depressions. The depressions are designated as spreading areas A, B, C, and D (Bennett, 1986, p. 5). Near State Highway 20, about 6 mi downstream from the INEL diversion dam, the river channel is incised less than 10 ft into the floodplain. Downstream from State Highway 20, the river enters a broad floodplain that ranges in width from 1 to 4 mi. This floodplain is characterized by remnants of old meander channels. Upstream from four terminal playas (playas 1, 2, 3, and 4), the channel branches into many small channels, and flow spreads across several ponding areas locally known as the Big Lost River Sinks (fig. 2). Surface areas for playas 1 and 2 are about 350 and 110 acres, respectively, at an altitude of 4,788 ft. Surface areas for playas 3 and 4 are about 1,000 and 1,350 acres, respectively, at an altitude of 4,780 ft.

The Big Lost River is perennial upstream from a point a few miles southeast of Arco. Downstream, flow in the river continually is lost by infiltration through the channel bottom. The point at which flow ceases depends on the discharge and infiltration conditions of the river channel.

Infiltration rates are largest when the channel is initially wetted and when the hydraulic head is at a maximum. At times, flow does not reach the western boundary of the INEL, and at other times, flow continues as far north as playa 4. Water only infrequently enters playa 4 from either the Big Lost River or Birch Creek. Except for minor losses to evaporation and transpiration, streamflow that passes the western boundary of the INEL infiltrates from the channel and ponding areas, providing recharge to the Snake River Plain aquifer.

Streamflow in the basin is affected by storage and release of irrigation water in Mackay Reservoir (capacity 44,370 acre-ft), 30 mi upstream from Arco and 4 mi northwest of Mackay and by the irrigation of about 57,500 acres of land by diversion from the river (Harenberg and others, 1987). Another 10,200 acres upstream from Mackay Reservoir are subirrigated (Harenberg and others, 1987). The INEL flood-control diversion system, constructed in 1958 and enlarged in 1984, diverts flow from the main river

through the INEL diversion channel into spreading areas A, B, C, and D to prevent flooding at downstream facilities. Gates also control the release of water from playa 2 to playa 3.

Methods of Investigation

Those subbasins included as part of the contributing drainage area shown on figure 2 were determined from topographic map contours, field observations, and discussions with long-time employees at the INEL. In most years, flow in some noncontributing drainage basins terminates at drain wells or other manmade obstacles. These basins were excluded from the contributing drainage area. For instance, the embankments of an abandoned canal constructed along the western edge of the Big Lost River have not been breached for much of its length. Consequently, the canal effectively intercepts flow from upgradient drainage basins that would have reached the Big Lost River. In other locations, depressions or playas as large as 600 to 800 acres intercept the overland flow and prevent runoff from reaching the river except during the most extreme flows.

Streamflow data were compiled for the following gaging stations on the Big Lost River and diversions: (1) the Big Lost River below Mackay Reservoir, near Mackay (13127000); (2) the Big Lost River near Arco (13132500); (3) the INEL diversion at its head near Arco (13132513); (4) the INEL diversion at the outlet of spreading area A, near Arco (13132515); (5) the Big Lost River below the INEL diversion, near Arco (13132520); and (6) the Big Lost River at Lincoln Boulevard bridge (13132535). Locations of selected discharge-measurement sites, including the six gaging stations, are shown on figure 2. The locations of Big Lost River gaging stations, river miles downstream from the gaging station near Arco, and altitudes of the gaging stations are given in table 1. Data prior to July 1984 have not previously been published for: (1) the INEL diversion at its head near Arco; (2) the Big Lost River below the INEL diversion, near Arco; and (3) the Big Lost River at Lincoln Boulevard bridge.

Table 1.--Location of selected streamflow measuring sites and stations at the Idaho National Engineering Laboratory

Measurement Site No.	Station No.	Station name	Station location	River miles downstream from Big Lost River near Arco	Altitude (in feet)
1	13132500	Big Lost River near Arco[1]	Lat 43°35'00" Long 113°16'10"	0	5,242
2	13132507	Big Lost River at western boundary of INEL, near Arco	Lat 43°31'56" Long 113°10'33"	7.4	5,110
3	13132510	Big Lost River above Railroad Bridge, near Arco	Lat 43°31'10" Long 113°05'40"	13.1	5,055
4	13132513	INEL Diversion at Head near Arco[1]	Lat 43°30'50" Long 113°05'00"	13.9	5,050
5	13132515	INEL Diversion at outlet of spreading area A, near Arco[1]	Lat 43°21'45" Long 113°04'19"	--	5,000
6	13132520	Big Lost River below INEL diversion, near Arco[1]	Lat 43°30'57" Long 113°04'52"	14.1	5,042
7	13132525	Big Lost River below Pioneer ditch, near Arco	Lat 43°32'00" Long 113°01'50"	17.9	5,000
8	13132530	Big Lost River at State Hwy 20 & 26, near Arco	Lat 43°32'50" Long 113°00'20"	20.2	4,970
9	13132535	Big Lost River at Lincoln Blvd. bridge, near Howe[1]	Lat 43°34'26" Long 112°56'33"	24.8	4,914
10	13132545	Big Lost River at old Idaho Falls stage road ford, near Howe	Lat 43°36'20" Long 112°54'00"	28.2	4,870
11	13132550	Big Lost River at Magazine Road crossing, near Howe	Lat 43°38'10" Long 112°52'50"	30.6	4,845
12	13132560	Big Lost River at West Monument crossing, near Howe	Lat 43°42'10" Long 112°52'20"	35.9	4,815

Table 1.--Location of selected streamflow measuring sites and stations at the Idaho National Engineering Laboratory--Continued

Measurement Site No.	Station No.	Station name	Station location	River miles downstream from Big Lost River near Arco	Altitude (in feet)
13	13132565	Big Lost River above Big Lost River Sinks, near Howe	Lat 43°43'40" Long 112°52'20"	38.0	4,805
14	13132575	Big Lost River above Playa No. 1, near Howe	Lat 43°47'00" Long 112°52'20"	43.5	4,790
15	13132573	Big Lost River south inlet channel to Playa No. 2	Lat 43°47'28" Long 112°50'15"	--	--
16	13132583	Big Lost River below Playa No. 2, near Howe	Lat 43°47'40" Long 112°50'10"	45.9	4,790

[1] Continuous recording gaging station.

Streamflow losses and gains were estimated using monthly discharge data included in tables 2-7 at the end of this report. Water is diverted to an ungaged irrigation canal upstream from the Big Lost River gaging station near Arco. Ungaged waste-return flow from this canal is discharged to the Big Lost River 2.5 mi downstream from the gaging station. Diversions to and waste-return flow from this canal were not accounted for in this infiltration-loss study. However, the canal is dry during the nonirrigation season, and miscellaneous measurements indicate that return flow during the irrigation season probably is less than 1 ft^3/s. Streamflow losses and gains are in tables 8-10 at the end of this report.

The altitude and configuration of the regional water table for the Snake River Plain aquifer at the INEL vary in response to changes in volume and source of recharge. Comparisons were made between volumes of flow in the Big Lost River for the periods July 1972 to July 1978 and July 1981 to

July 1985. The first period is one of net decline and the second period is one of net increase in the altitude of the water table. The net decline in the altitude of the regional water table reflects a period when recharge to the aquifer has been less than discharge from the aquifer and the water table is declining. Conversely, the net increase reflects a period when recharge to the aquifer has exceeded discharge from the aquifer and the water table is rising.

STREAMFLOW LOSSES

The gaging station on the Big Lost River below Mackay Reservoir provides a measure of the water flowing from the Big Lost River basin and has the longest record of any station in the basin. Complete years of record are available at this gaging station for 1904-05, 1913-14, and 1919-87 (fig 3). The average streamflow for these 71 years is 315 ft^3/s or about 228,000 acre-ft/yr. Streamflow exceeded 300,000 acre-ft/yr during 11 years (1943, 1965, 1967, 1969, 1971, 1974, 1975, 1982, 1983, 1984, and 1986) and exceeded 400,000 acre-ft/yr during 3 years (1965, 1983, and 1984). Records for downstream gaging stations can be extended to improve evaluation of long-term trends in streamflow by using data from this station. A comparison of annual streamflow below Mackay Reservoir and annual streamflow near Arco is shown in figure 4. The difference in streamflow between the gaging stations below Mackay Reservoir and near Arco is attributed to inflow from the tributaries between the Mackay to Arco stations minus consumptive use and infiltration losses from that reach of the river.

Monthly Infiltration Losses

Depth to the regional aquifer below the river channel ranges from about 680 ft at the western boundary of the INEL to about 210 ft at playa 4. Streamflow is not affected by regional changes in the aquifer because of the thickness of the unsaturated zone. The difference in discharge between gaging stations on the Big Lost River (table 1) is due largely to infiltration along the wetted perimeter of the streambed. Losses to evaporation and

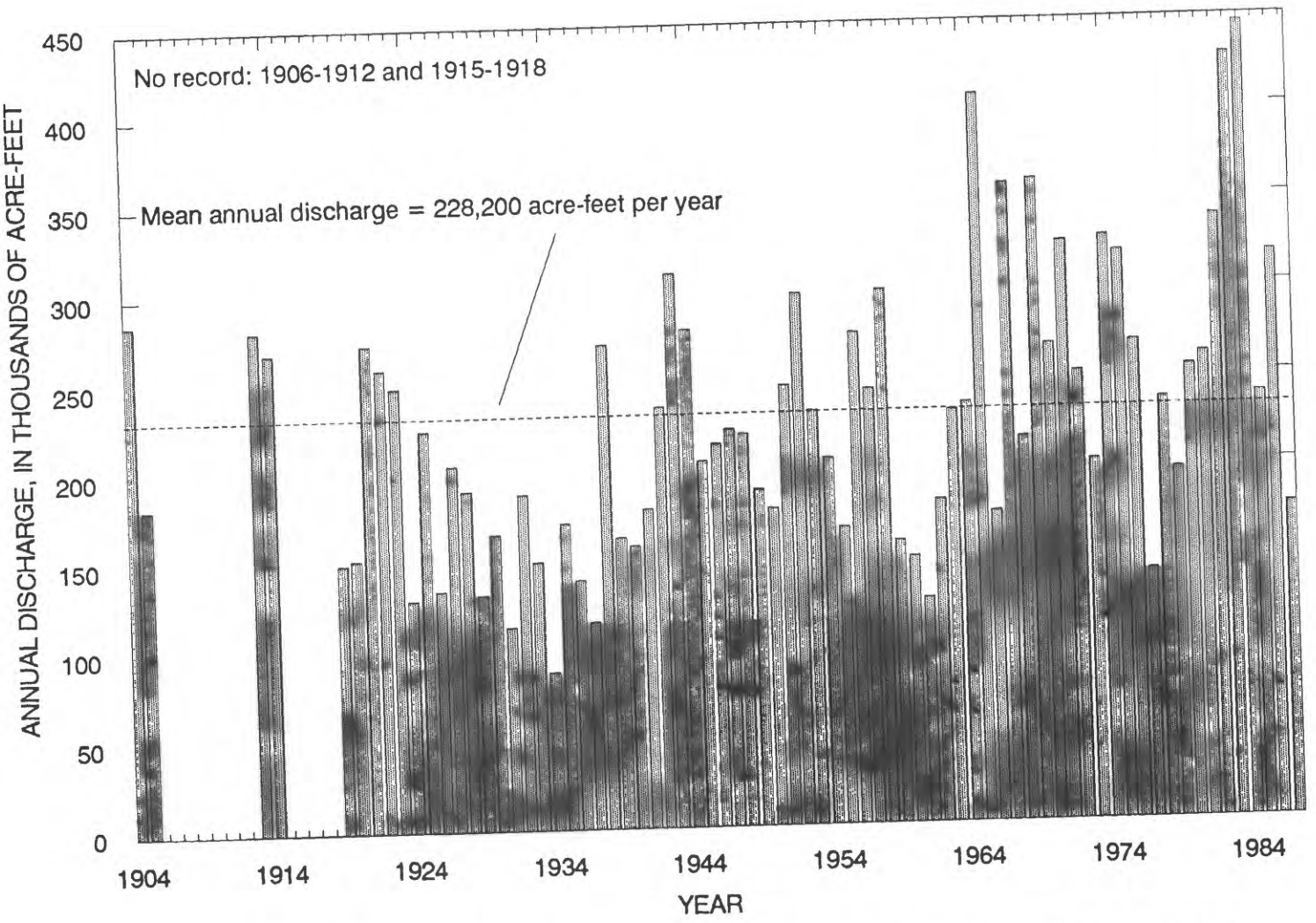

Figure 3.--Annual discharge for the Big Lost River below Mackay Reservoir near Mackay, 1904-87.

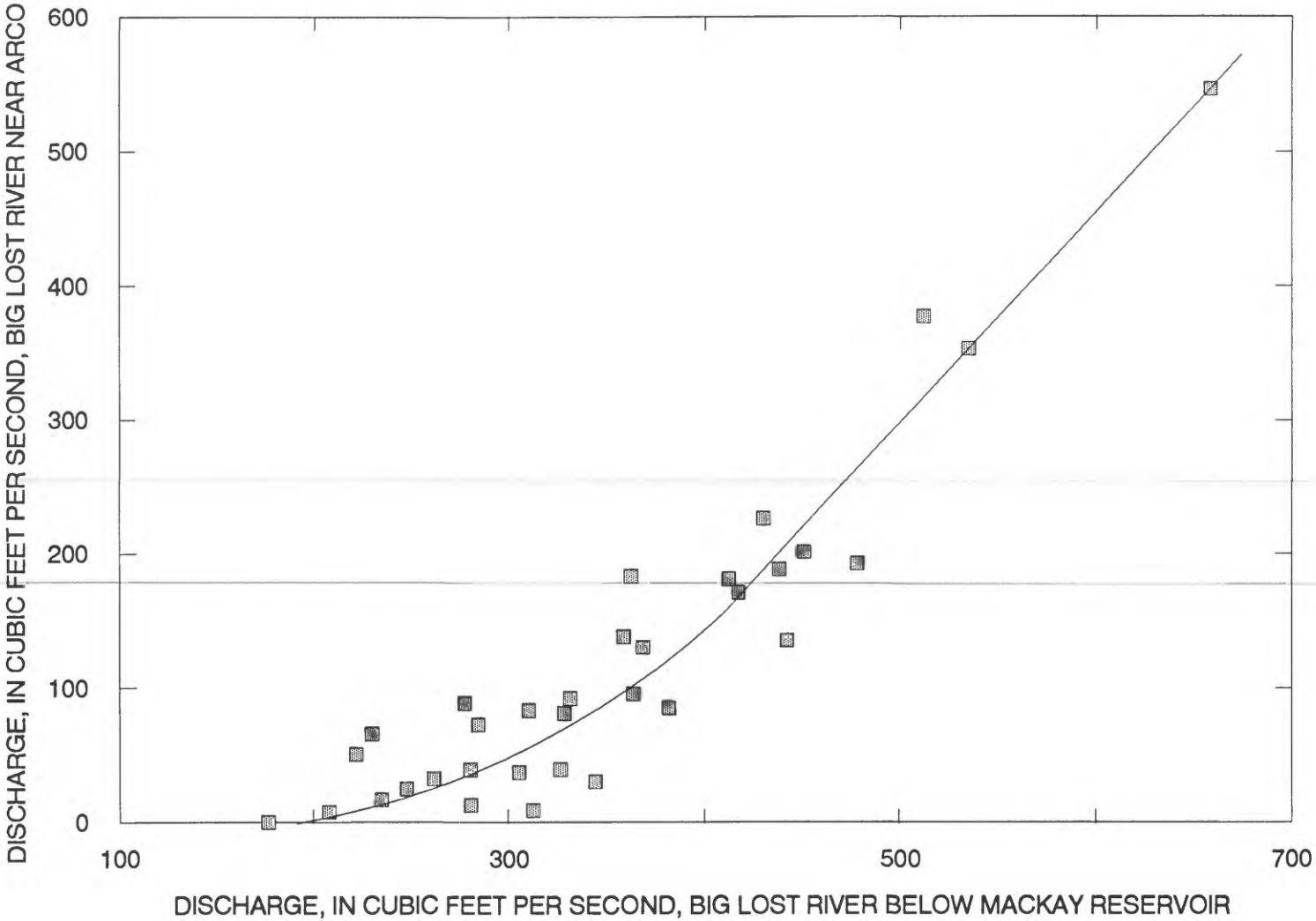

Figure 4.--Mean annual discharges for the Big Lost River near Arco and below Mackay Reservoir.

transpiration are small by comparison. Intermittent streamflow does not encourage the growth of vegetation along the periphery of the river and transpiration probably is not significant. The width of the river generally is less than 60 ft at a discharge of 300 ft^3/s and less than 30 ft at a discharge of 40 ft^3/s.

Annual net evaporation (evaporation minus precipitation) for large water surfaces in the eastern Snake River Plain is 33 in/yr (Stearns and others, 1938, p. 18). Assuming flow for the entire year and this net evaporation rate, the calculated maximum possible evaporation from the 44-mi reach between Arco and playa 1 is less than 900 acre-ft/yr. However, the river generally is dry during peak evaporation periods, May to September, and the actual evaporation would be less. The evaporation rate during periods of flow in the spring and winter is small and the surface area of the stream exposed to evaporation is not large. Therefore, evaporation of water during periods of flow is negligible when compared to the total volume of flow available for infiltration. Water lost to evaporation is greater from surfaces of the spreading areas, the Big Lost River Sinks, and playas, primarily because of the greater surface area and prolonged exposure time.

Arco to INEL Diversion

Infiltration losses in the 14-mi reach of the river between the Arco gaging station and the INEL diversion dam are shown on table 8 and figure 5. Periodic gains, shown as a negative, may have resulted from: (1) return flow to the Big Lost River from an ungaged canal downstream from the Arco gage, (2) tributary inflow, or (3) measurement error in the discharge record. Gains ranged from 8 to 2,380 acre-ft/mo or 3.2 to 5.3 percent of the flow at Arco. Inflow to the river from overland runoff or other tributary inflow probably was negligible for most months. However, the tributary area (fig. 2) is about 55 to 60 mi^2 with a topographic relief of about 550 ft and would be expected to produce some inflow to the river.

Infiltration losses averaged 832 acre-ft/mo from July 1972 to July 1978 and 1,880 acre-ft/mo from July 1981 to July 1985, a 126-percent increase in

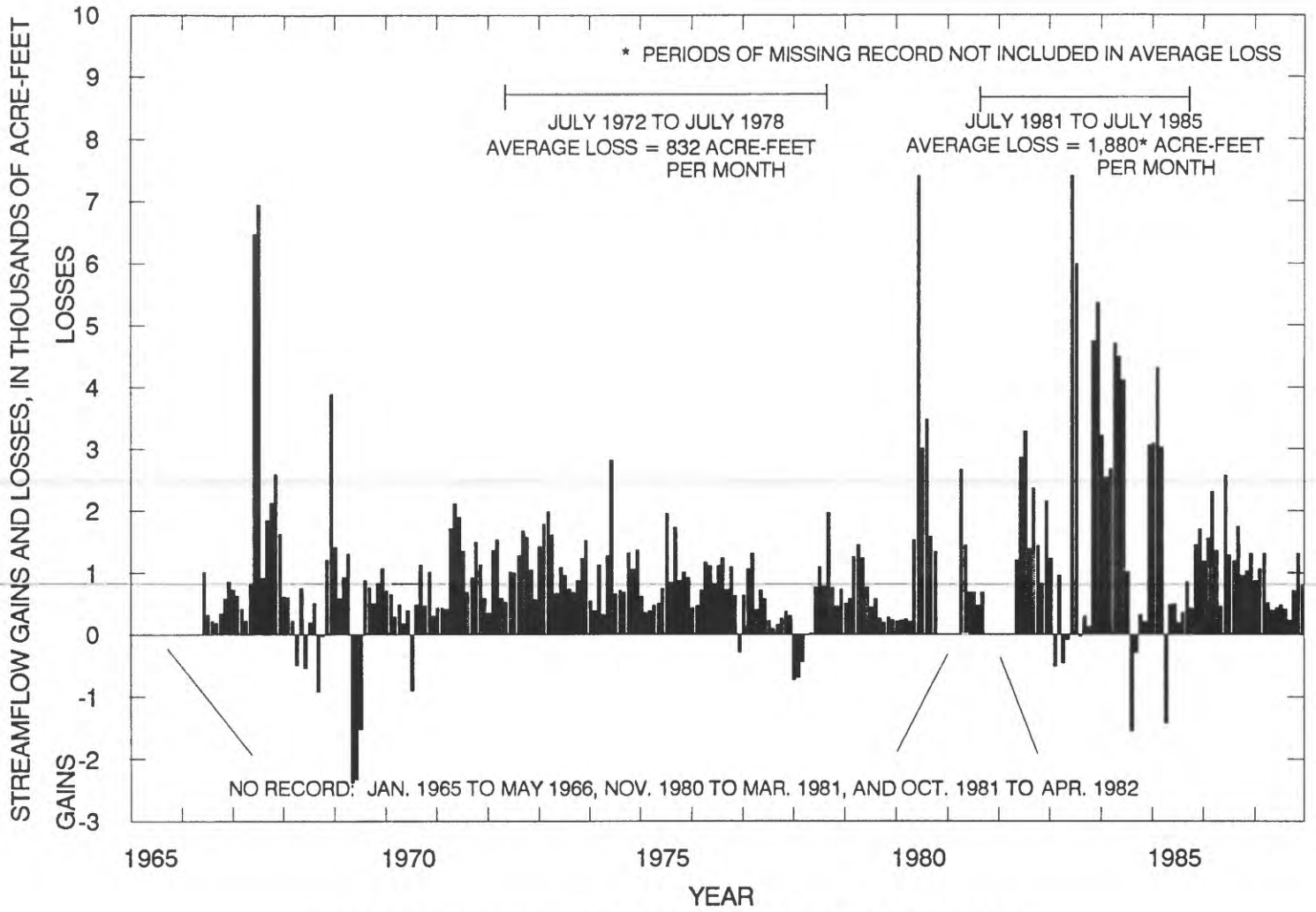

Figure 5.-- Monthly streamflow-infiltration loss for the Big Lost River, Arco to the INEL diversion, 1966-87.

loss between the two periods. However, loss as a percentage of streamflow remained about the same: 29 percent from July 1972 to July 1978 and 32 percent from July 1981 to July 1985. Average streamflow at Arco for corresponding time periods increased from 5,653 to 22,047 acre-ft/mo.

Spreading Areas

Water available for potential recharge in spreading areas A, B, C, and D is equal to the amount of water diverted through the INEL diversion channel (table 4) minus losses to evapotranspiration. The distribution of discharge (fig. 6) to the INEL diversion channel is an estimate of the volume and spatial distribution of water actually available for potential recharge from the spreading areas. No water was diverted through the INEL diversion channel from its construction in 1958 until 1965 (Rodger Jensen, U.S. Geological Survey, oral commun., 1988). Average discharge to the spreading areas from 1965 to 1987 was 52,000 acre-ft/yr. During that period, there was no flow for 137 months, or 50 percent of the time.

Discharge to the INEL spreading areas averaged 4,800 acre-ft/mo from July 1972 to July 1978, a period of net decline in regional water levels, and 16,995 acre-ft/mo from July 1981 to July 1985, a period of net increase in regional water levels. Average streamflow upstream from the INEL diversion increased from 4,840 acre-ft/mo during 1972-78 to 17,390 acre-ft/mo during 1981-85. The comparison of infiltration losses between spreading area A and spreading areas B, C, and D from July 1984 to May 1987 is shown in figure 7. Spreading areas B, C, and D receive water only after the depression in spreading area A is filled; consequently, for some months, the loss from spreading area A exceeded the loss from other spreading areas. No record of the distribution of flow between the spreading areas is available prior to 1984.

INEL Diversion to Lincoln Boulevard

Infiltration losses in the 11-mi reach of the Big Lost River between

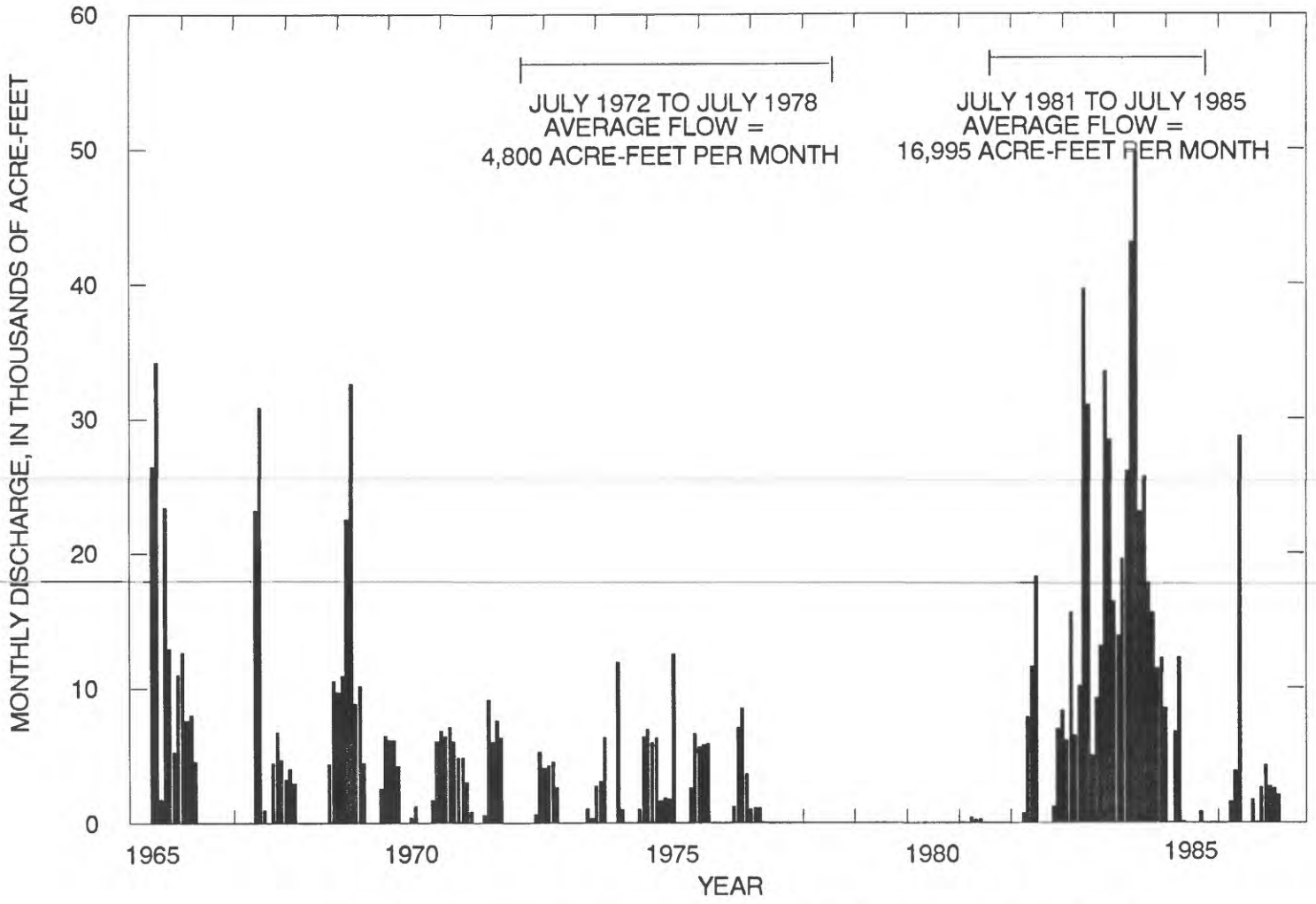

Figure 6.--Monthly discharge from the Big Lost River to spreading areas above the INEL diversion, 1965-87.

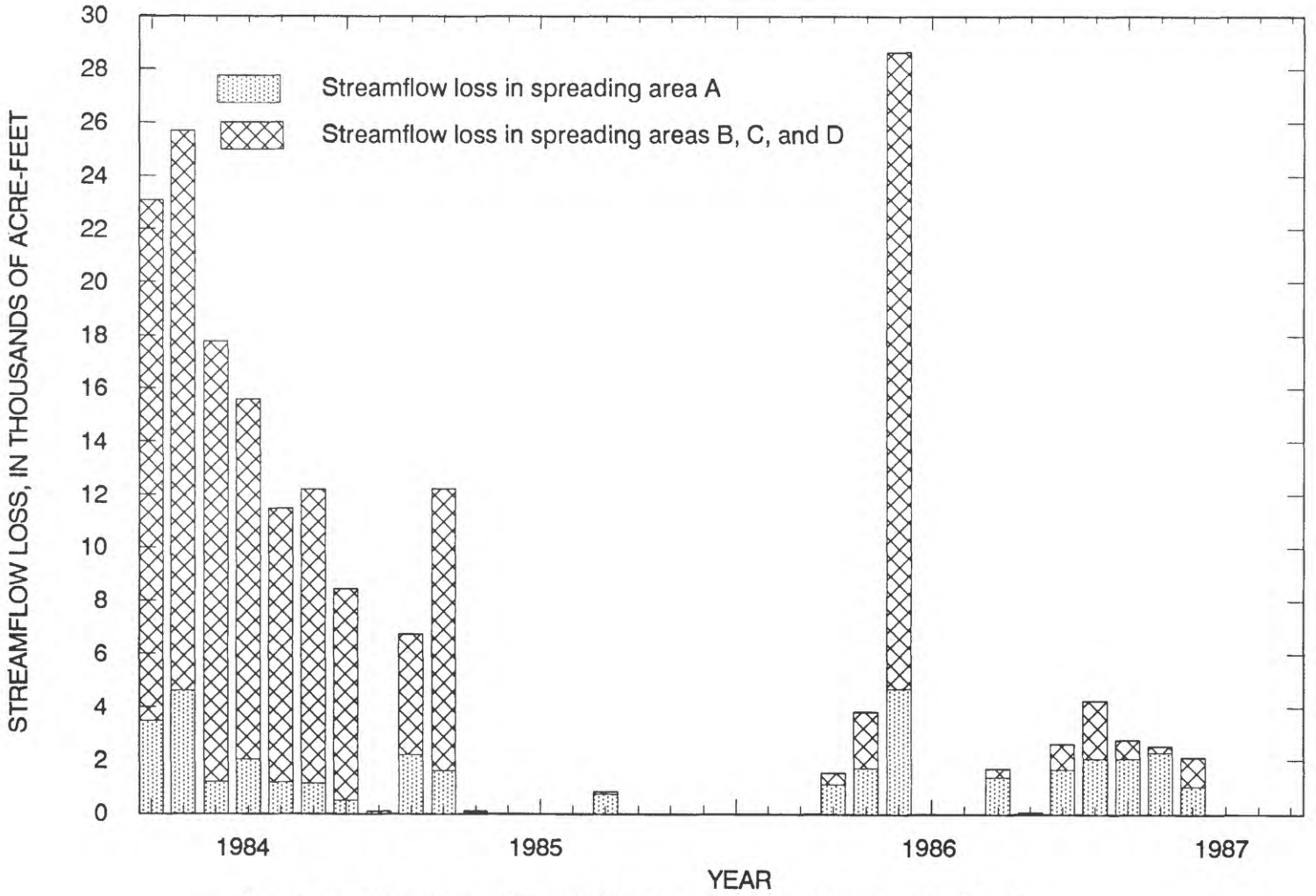

Figure 7.-- Streamflow-infiltration losses between spreading area A and spreading areas B, C, and D, 1984-87.

the INEL diversion dam and Lincoln Boulevard are shown in figure 8. Average loss for the 23-year period, 1965-87, was 9,820 acre-ft/yr. Average discharge for the Big Lost River below the INEL diversion dam for the period was 52,400 acre-ft/yr. There was no flow for 76 months or 28 percent of the period (table 6). Loss in the reach for the periods of net decline and rise of regional water levels averaged 856 acre-ft/mo from July 1972 to July 1978 and 906 acre-ft/mo from July 1981 to July 1985, an increase in average loss of 50 acre-ft/mo, or 6 percent (fig. 8). Average streamflow downstream from the INEL diversion doubled from 2,860 acre-ft/mo during 1972-78 to 5,820 acre-ft/mo during 1981-85.

Lincoln Boulevard to Playas 1, 2, and 3

Streamflow for the Big Lost River at Lincoln Boulevard is shown in table 7 and figure 9. Data are not available to determine the volume of water received by the playas or the exact distribution of the infiltration loss within the reach. Average streamflow downstream from Lincoln Boulevard during 1965-87, was 42,580 acre-ft/yr. There was no flow for 135 months, or 49 percent of the time. Flow in the reach averaged 2,004 acre-ft/mo from July 1972 to July 1978, a period of net decline in regional water levels, and 5,119 acre-ft/mo from July 1981 to July 1985, a period of net rise in regional water levels, for an increase in average loss of about 3,100 acre-ft/mo (fig. 9).

From the time Mackay Reservoir was built in 1917 until 1965, water reached playa 1 in 1921, 1922, 1923, 1927, 1938, 1943, 1944, 1947, 1952, 1953, 1958, and 1965--12 times in 45 years--and playas 2 and 3 in 1952, 1958, and 1965 (Barraclough and others, 1965, p. 53). In 1958, a small dike, two headgates, and two culverts were built at the outlet to playa 2 increasing the storage capacity of both playas 1 and 2. Since 1965, water reached playas 1 and 2 during 11 of 22 years--1967, 1969, 1970, 1971, 1974, 1975, 1982-86. Water reached playa 3 in 1969, 1971, and 1983 (Rodger Jensen, U.S. Geological Survey, oral commun., 1988).

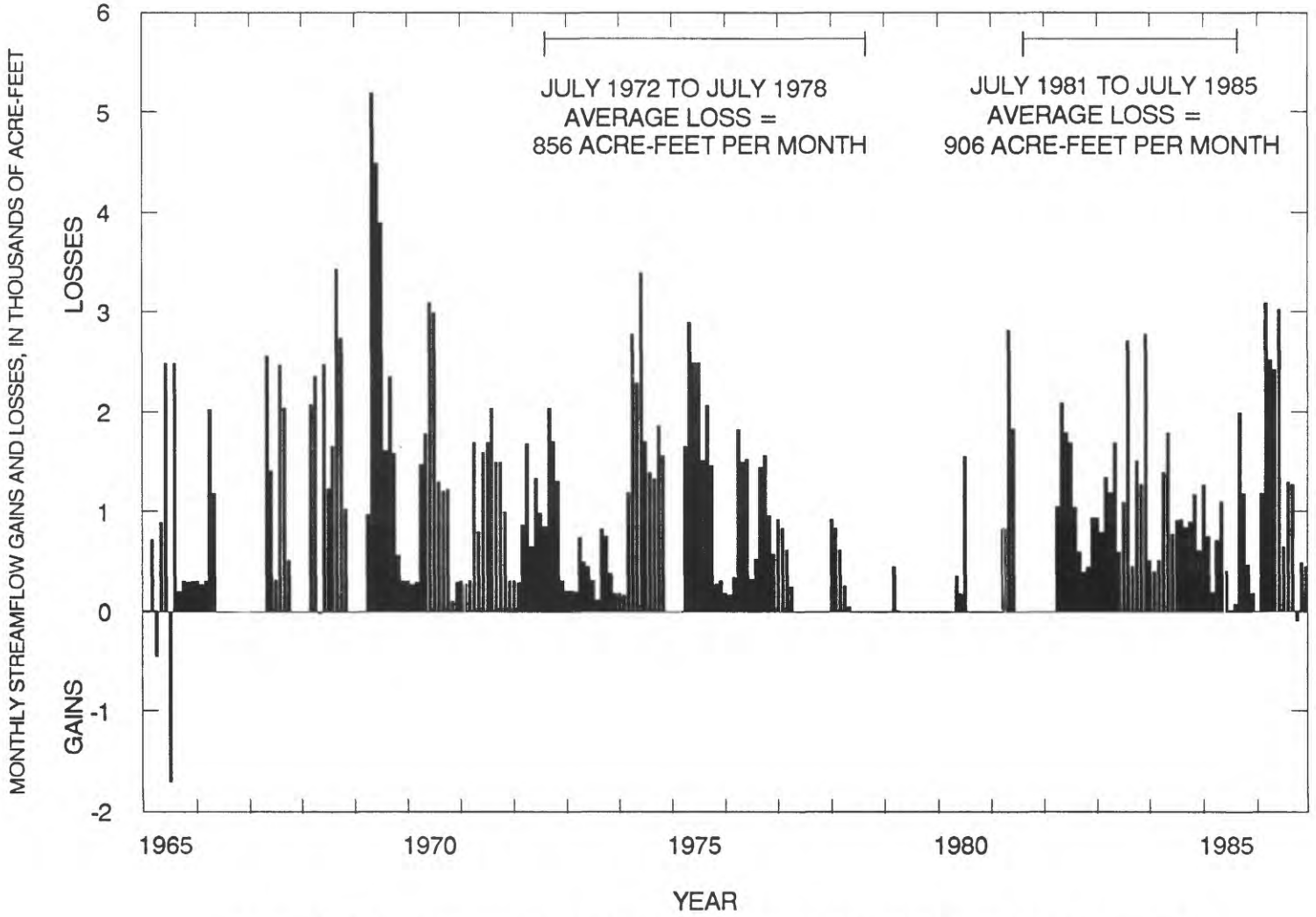

Figure 8.--Monthly streamflow-infiltration losses for the Big Lost River, INEL diversion to Lincoln Boulevard, 1965-86.

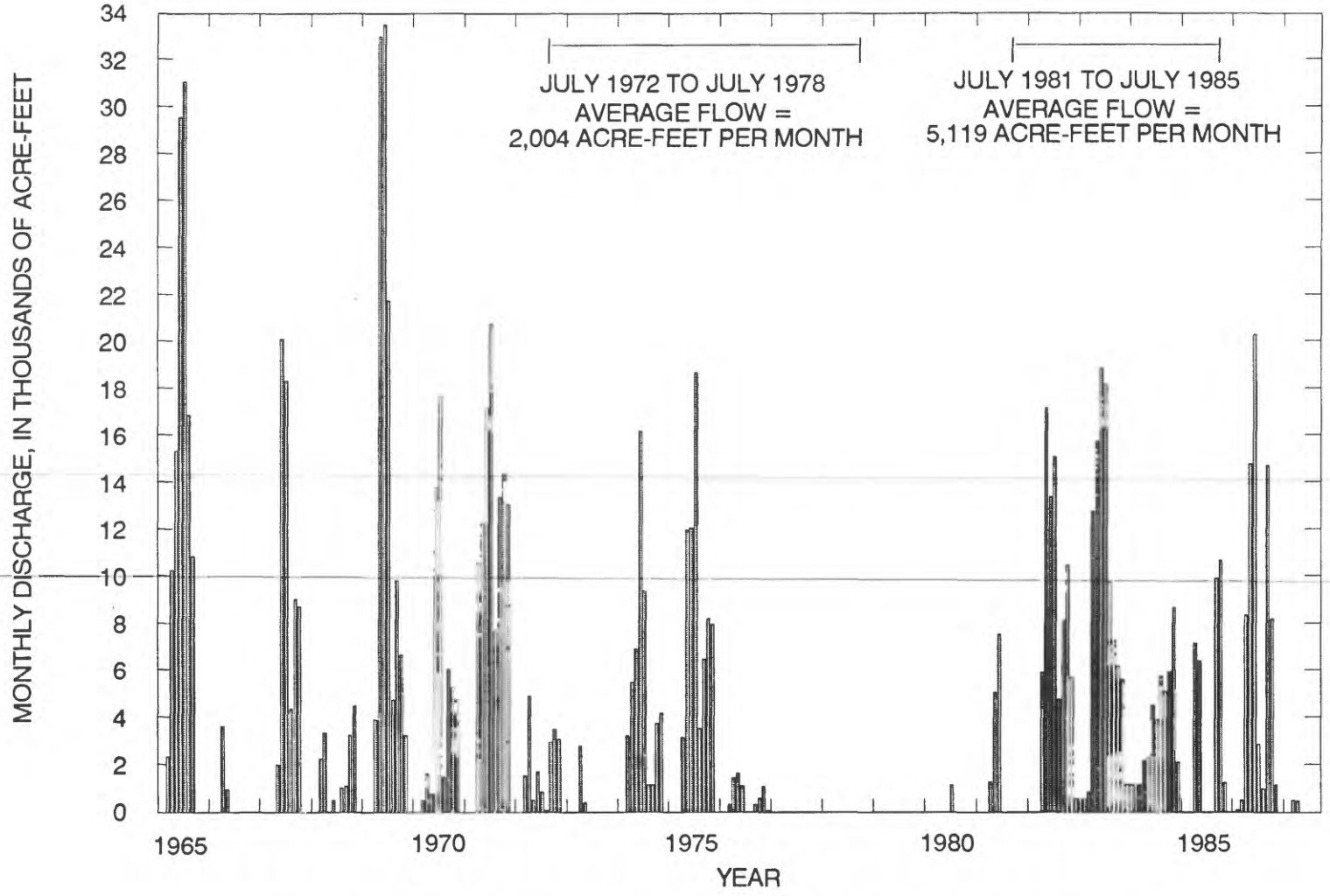

Figure 9.-- Monthly discharge for the Big Lost River at Lincoln Boulevard, 1965-87.

Comparison of Monthly Losses between Reaches

Average streamflow for the Big Lost River during 1965-87, measured upstream from the INEL diversion dam (Railroad Bridge), was 104,400 acre-ft/yr, of which: (1) 52,000 acre-ft/yr (49.8 percent) were diverted to the INEL spreading areas; (2) 9,800 acre-ft/yr (9.4 percent) infiltrated from the stream channel between the INEL diversion dam and Lincoln Boulevard; and (3) 42,600 acre-ft/yr (40.8 percent) infiltrated from the stream channel downstream from Lincoln Boulevard or flowed into playas 1, 2, and 3. The large volume of flow diverted into the INEL spreading areas during 1965-87 was especially significant, considering that no water was diverted into the spreading areas prior to 1964.

Net infiltration losses increase with increased discharge from Arco to the INEL diversion and from the INEL diversion to Lincoln Boulevard (figs. 10 and 11). The slope of the linear regression equation for the reach between the INEL diversion and Lincoln Boulevard is steeper than for the reach between Arco and the INEL diversion--0.947 as compared with 0.907--indicating increased losses for the lower reach. The respective coefficients of determination (R^2) for the linear regression equations--0.990 and 0.987--indicate excellent correlation.

The loss in streamflow predicted from the regression equation corresponds well with the measured loss. The equation, $Y = -553 + 0.947X$, for the reach near Arco to the INEL diversion dam predicts an average loss of 853 acre-ft/mo for 1972-78 and 1,721 acre-ft/mo for 1981-85. Standard error of the Y estimate is 1,173 acre-ft. Actual loss for the two periods was 21 acre-ft/mo less (2.5 percent) and 161 acre-ft/mo greater (8.6 percent), respectively, than the predicted values.

The linear regression equation, $Y = -416 + 0.907X$, for the reach below the INEL diversion dam to Lincoln Boulevard predicts an average loss of 682 acre-ft/mo for the 1972-78 period and 952 acre-ft/mo for the 1981-85 period. Standard error of the Y estimate is 722 acre-ft. Actual loss for the two periods was 174 acre-ft/mo greater (20.3 percent) and 49 acre-ft/mo less (5.4 percent), respectively, than the predicted values. The reasons for the

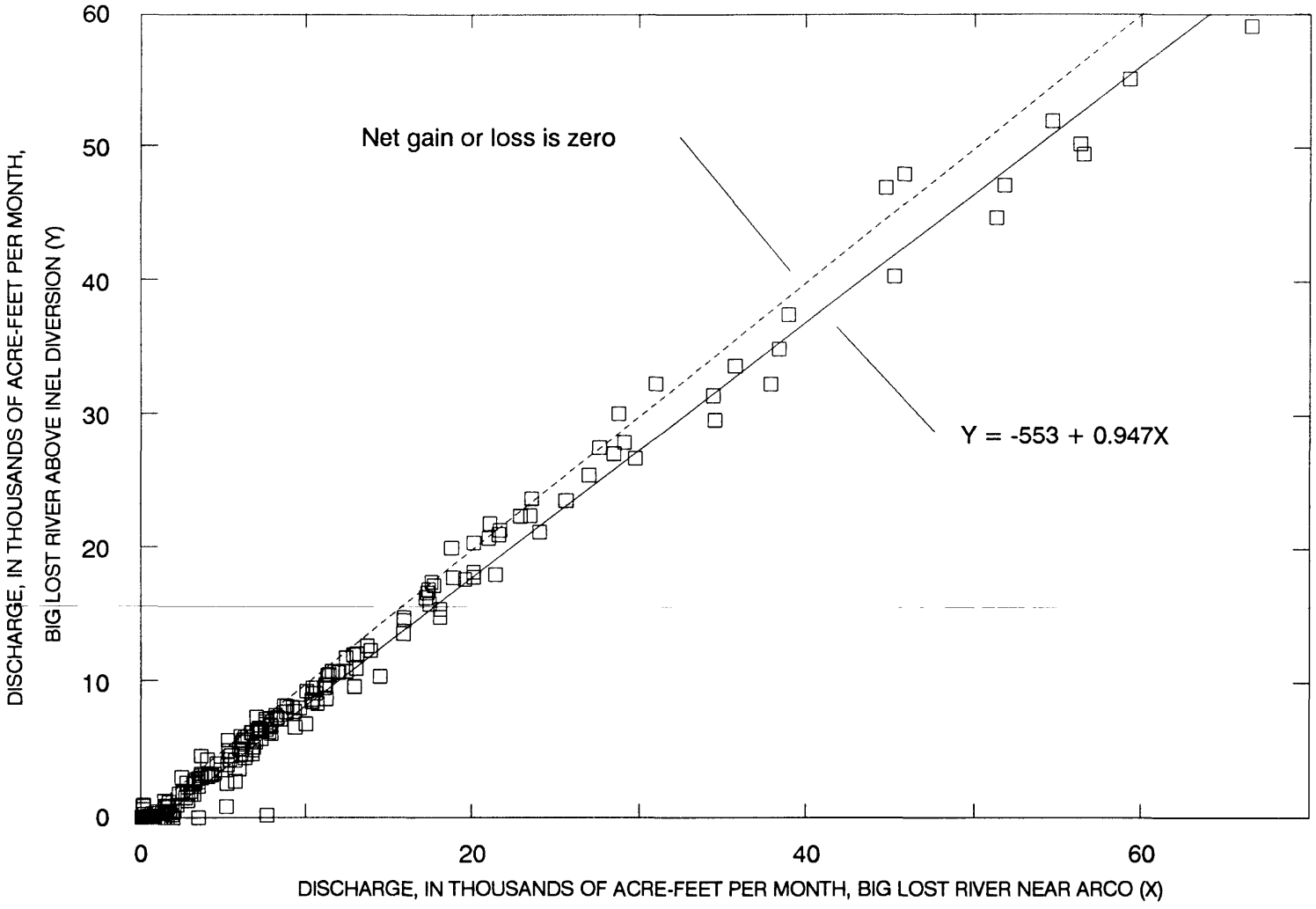

Figure 10.-- Relation between monthly discharges for the Big Lost River near Arco and above INEL diversion, 1965-87.

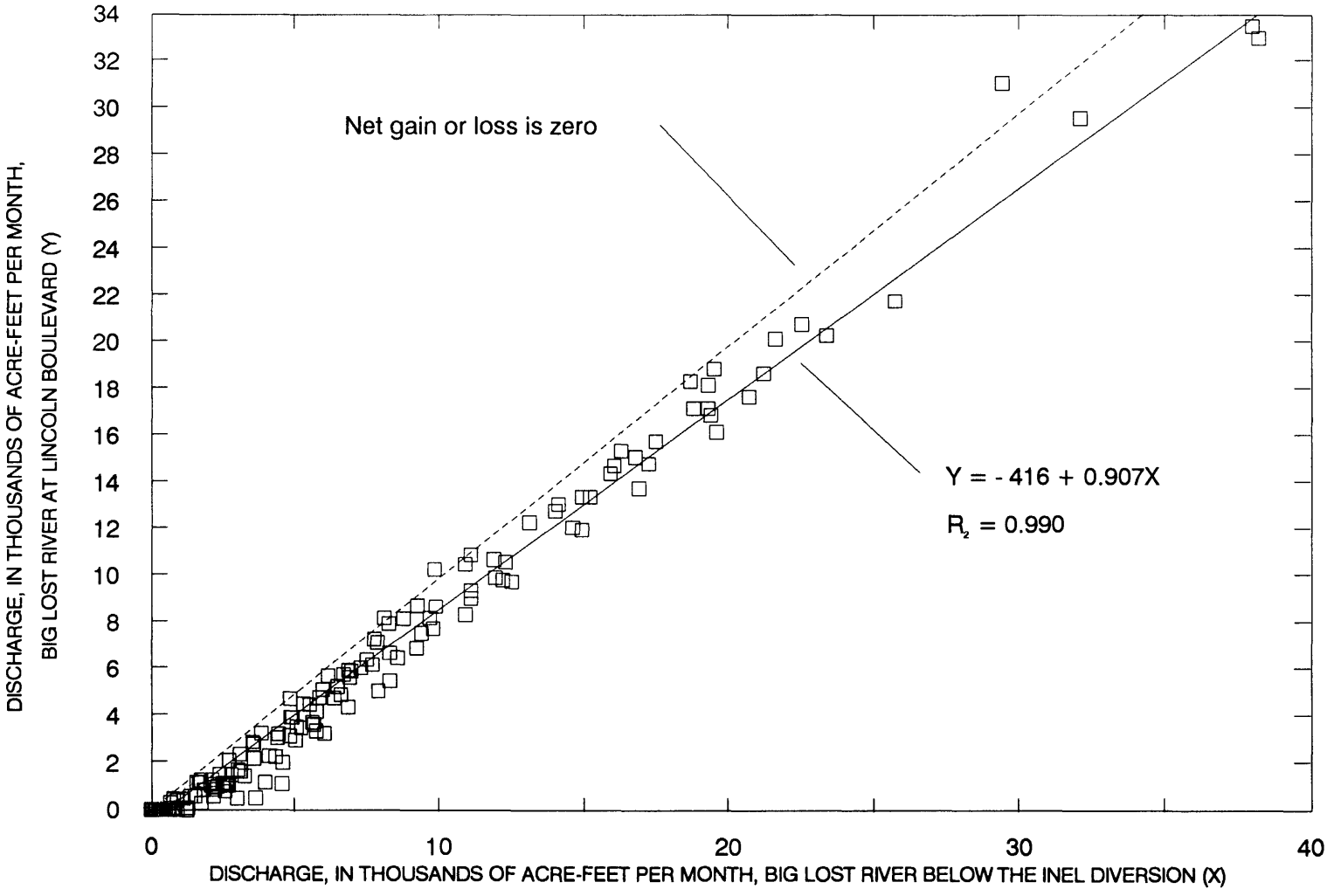

Figure 11.--Relation between monthly discharges for the Big Lost River below the INEL diversion and at Lincoln Boulevard, 1965-87.

differences are not well understood but may be related to streamflow measuring error, error derived from data scatter, or prolonged periods of low flow. Prolonged periods of low flow would increase the percentage of streamflow lost to infiltration. A linear regression equation based on 1986 data indicates that, for average conditions, streamflow had to exceed about 18 ft^3/s of streamflow at Arco and 12 ft^3/s below the INEL diversion dam before flow would continue as far as the INEL diversion dam and Lincoln Boulevard, respectively. During periods of low flow, about 30 ft^3/s would infiltrate to the stream channel before any flow would pass Lincoln Boulevard. This would result in a disproportionate increase in the loss of flow above that predicted by the linear regression equation. The July 1972 to July 1978 period was broken by several occurrences of no flow; for the July 1981 to July 1985 period, streamflow was practically continuous.

Infiltration-Loss Investigations

Measurements to determine infiltration losses were made at various discharges that ranged from 37 to 372 ft^3/s. The earliest measurements were made in 1951 and the most recent in 1985. Losses in selected reaches of the 44 mi of river from near Arco to the playas are shown in figure 12. Discharge measurements and chemical characteristics of streamflow at measurement sites in 1985 are shown in table 11 (at end of this report). Discharge measurements were made at a relatively constant river stage. Measurement errors and small fluctuations in flow may have influenced loss estimates.

Streamflow-infiltration losses from the Big Lost River were 1 to 2 $(ft^3/s)/mi$ at discharges of less than 100 ft^3/s between Arco (measurement site 1) and the Big Lost River Sinks (fig. 12). However, losses in the reach between measurement site 6, 14.1 mi downstream from Arco, and measurement site 7, 17.9 mi downstream from Arco, ranged from 1 to 4 $(ft^3/s)/mi$. Although not conclusive, the discharge measurements indicated that infiltration was somewhat higher in this section of the river. The section with the greatest loss was in the Big Lost River Sinks reach, between measurement site 13, 38 mi downstream from Arco (upstream from the

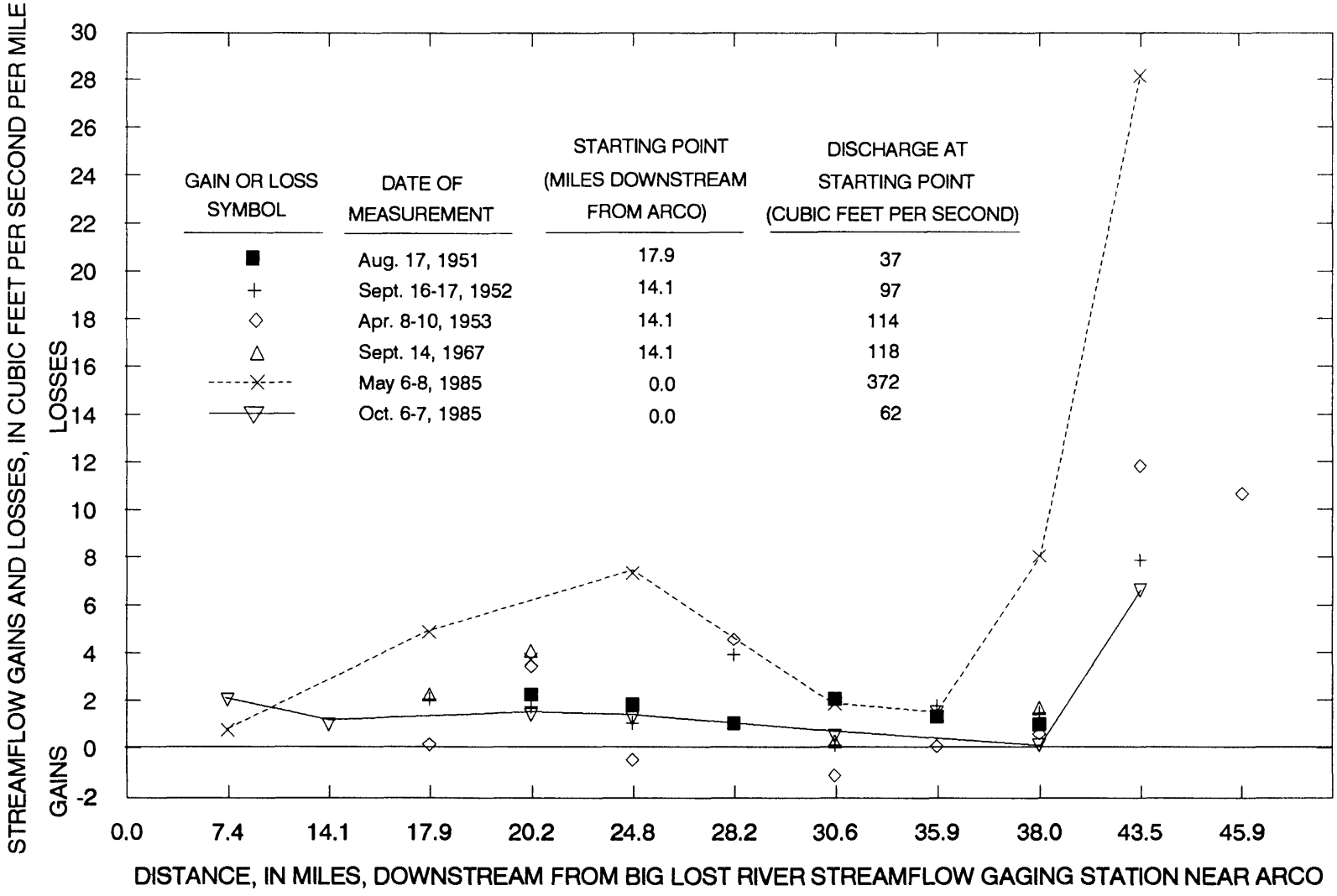

Figure 12.-- Streamflow gains and losses in selected reaches of the Big Lost River between stations near Arco and playas 1 and 2 [Point data show streamflow change in reach immediately upstream from measurement site].

Big Lost River Sinks), and measurement site 14, 43 mi downstream from Arco (upstream from playa 1). Infiltration loss in this reach ranged from 7 to 12 $(ft^3/s)/mi$.

With the exception of the reach between Arco and the western boundary of the INEL, infiltration losses were largest at a discharge of 372 ft^3/s (fig. 12). A maximum loss of 28 $(ft^3/s)/mi$ was measured in the area of the Big Lost River Sinks.

The gradient of the Big Lost River channel between gaging stations near Arco and playa 1 is shown in figure 13. The slope of the riverbed remains a fairly constant 13 ft/mi with minor variations between measurement site 1 and measurement site 11. Downstream from measurement site 11, there is an appreciable flattening of the slope to about 3.2 ft/mi. Upstream, the predominant bed-material sizes in the present stream channel are coarse pebble to cobble gravel; the sediment downstream grades into sand and sandy silt. The finer grained sediment in the stream channel is probably responsible for the smaller infiltration losses noted in the 7.7-mi reach between measurement site 10 and measurement site 12. The apparent infiltration loss in this reach was slightly larger, about 1 $(ft^3/s)/mi$, at high stages than at low stages.

Specific conductance, chloride concentrations, and alkalinity data (table 11) collected May 6-8, 1985, at a fairly constant river stage, show that the concentration of chemical constituents in streamflow remained relatively constant from measurement site 1 to measurement site 13. Specific conductance was approximately 320 μS, the chloride concentration was 5 mg/L, alkalinity ranged from 178 to 190 mg/L, and the pH ranged from 7.8 to 8.0 in throughout the reach. At measurement site 14, pH increased to 8.5 and alkalinity decreased to 154 mg/L.

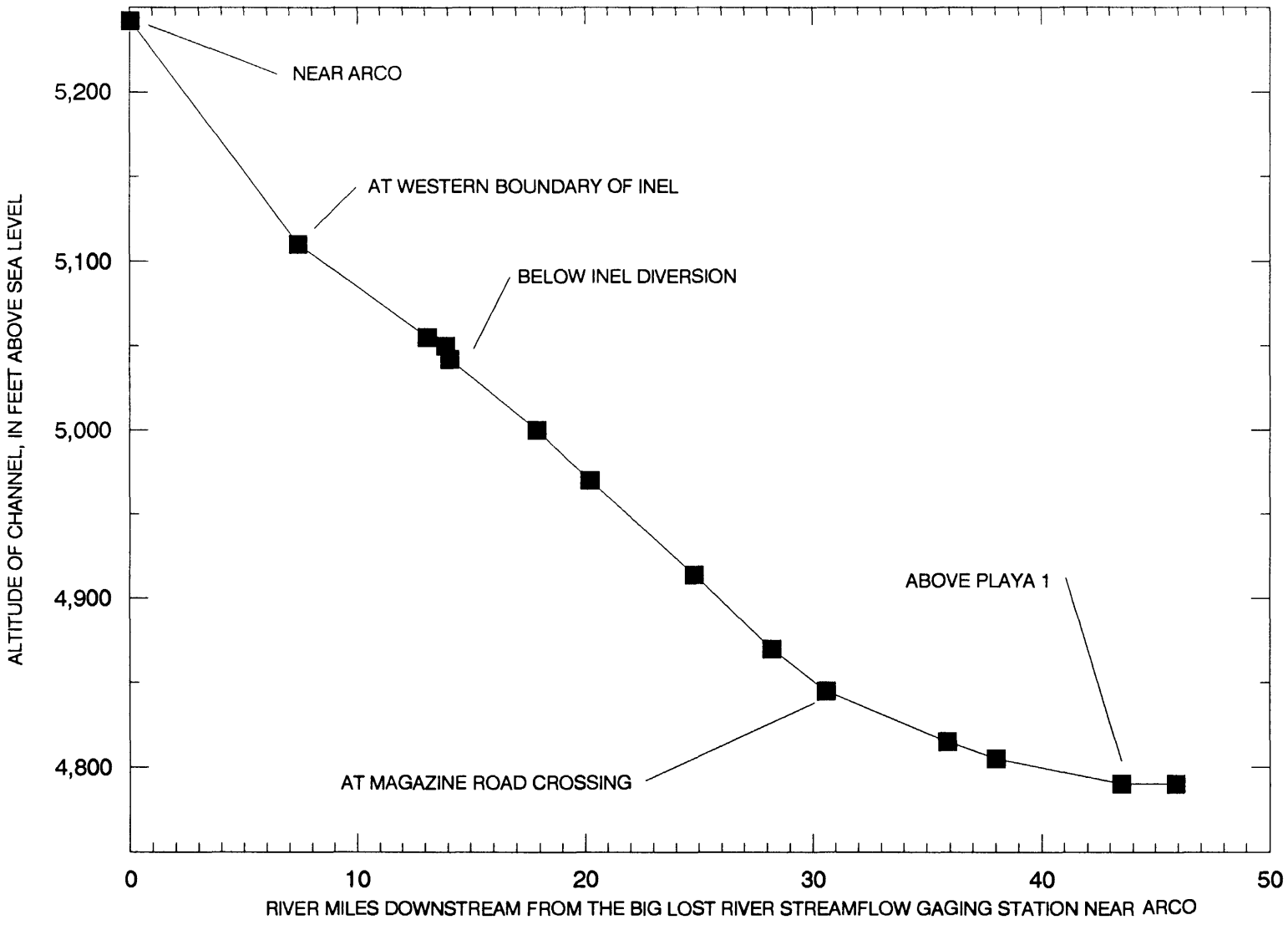

Figure 13.--Gradient of the Big Lost River channel between streamflow gaging stations from Arco to playa 1.

CHANGES IN GROUND-WATER LEVELS

In 1985, flow in the Snake River Plain aquifer at the INEL was to the southwest and the gradient was about 4 ft/mi (Pittman and others, 1988, p. 30). The direction of flow locally is affected by recharge to and discharge from the aquifer. Recharge at the INEL is provided primarily from underflow from the northeastern part of the plain and from the Big Lost River. Infiltration from upland stream channels to the north and west also adds minor amounts of recharge. Direct infiltration of precipitation on the Snake River Plain probably contributes a minor amount of recharge. Ground water is discharged by pumping and by springs discharging to the Snake River at the southern edge of the plain (Pittman and others, 1988, fig. 1).

Locally, ground-water levels and the direction of ground-water flow are temporarily altered by recharge from the Big Lost River. In areas of significant recharge, a mounding of ground water can result that will locally change the direction of flow. In years with no or small recharge from the Big Lost River, local gradients reflect regional flow directions.

The altitude and configuration of water levels in the Snake River Plain aquifer at the INEL vary in response to changes in volume and source of recharge. Withdrawals by pumping at the INEL are a small part of the total volume of the aquifer and should not affect water levels significantly. Net water-level changes for two periods, July 1972 to July 1978 and July 1981 to July 1985 are shown in figures 14 and 15. The first period was characterized by a net decline in the water table; the second period was characterized by a net increase. Two areas, one immediately southwest of the RWMC (Radioactive Waste Management Complex) and the other north of the NRF (Naval Reactors Facility), that had significant water-level changes as compared with the regional water table, coincide with areas that seem to be significantly affected by recharge from the Big Lost River.

The net decline in the regional water table from July 1972 to July 1978 generally reflected a period when recharge to the aquifer was less than discharge from the aquifer. Conversely, the net increase from July 1981 to July 1985 reflected a period when recharge was greater than discharge.

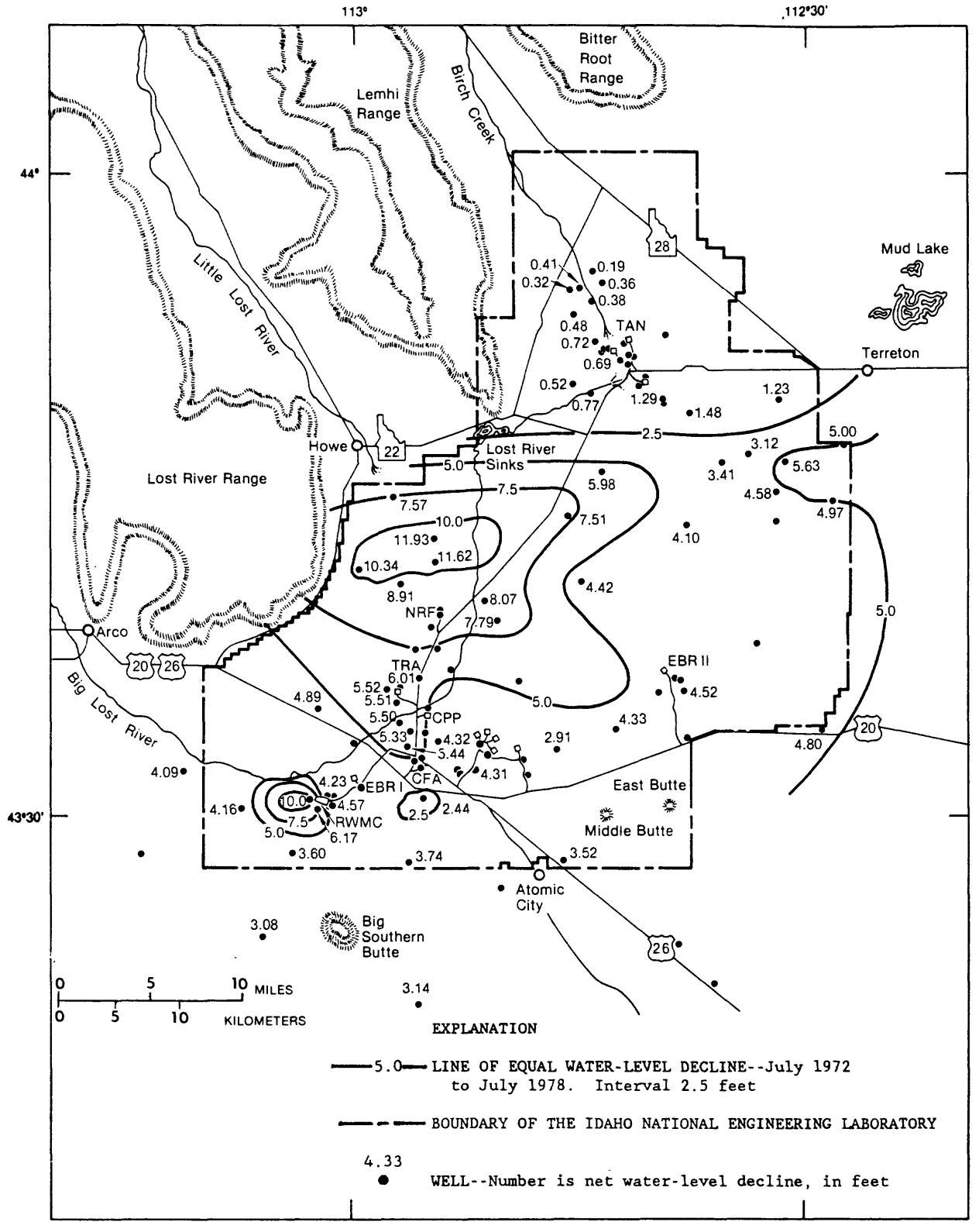

Figure 14.--Generalized net decline of the regional water table, Snake River Plain aquifer, at the Idaho National Engineering Laboratory, July 1972 to July 1978 (from Barraclough and others, 1981, figure 9).

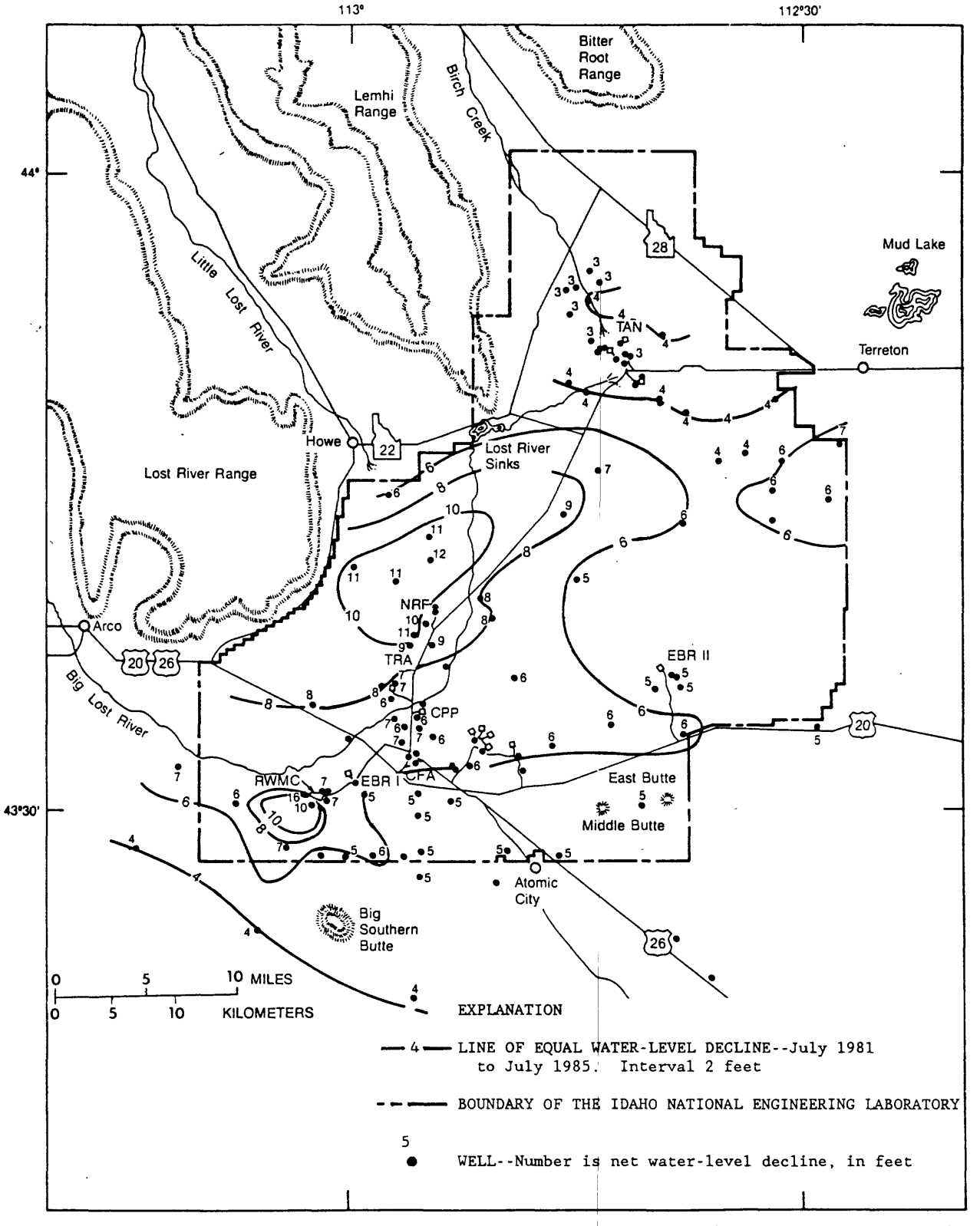

Figure 15.--Generalized net increase of the regional water table, Snake River Plain aquifer, at the Idaho National Engineering Laboratory, July 1981 to July 1985 (from Pittman and others, 1988, figure 10).

The net decline in the regional water table for the first period, July 1972 to July 1978, was preceded by a decade of above-normal precipitation and high flow in the Big Lost River from 1965 to 1975 followed by dry years in 1977 and 1978. During the 1972-78 period, net water levels declined as much as 10 ft near the RWMC at the INEL spreading areas and north of NRF (fig. 14). Localized fluctuations of the regional water table in the eastern part of the INEL, where water levels for the period declined about 5 ft, probably are influenced least by recharge from the Big Lost River and other surface-water sources. The smallest declines were in the northern part of the INEL near TAN (Test Area North) where net declines generally were less than 1 ft.

A net increase in the regional water table for the second period, July 1981 to July 1985, reflected a major change in volume of recharge from the dry late 1970's to the comparatively wet early 1980's (fig. 3). Pittman and others (1988, p. 17) indicated the altitude of the water table rose as much as 16 ft in response to recharge from surface water diverted to the spreading areas near the RWMC and 10 to 12 ft near the NRF. Water levels at TAN increased 3 to 4 ft, slightly less than the 5- to 6-ft increase in the eastern part of the INEL. This increase contrasted sharply with the few hundredths of a foot change noted for many wells in the TAN area during the first period.

Response of ground-water levels at the INEL to changes in recharge is reflected in hydrographs for two wells located near the spreading areas (fig. 16) and two wells located several miles southwest of the Big Lost River Sinks (fig. 17). Wells USGS 86 and USGS 88 (fig. 16) are located within 2 to 3 mi of the spreading areas. Comparison of ground-water levels for well USGS 86 with volumes of surface water received by the spreading areas illustrates aquifer response to recharge from the Big Lost River (fig. 16 and table 5). Prominent peaks are shown in 1967, 1969, 1983, and 1984, years during which large volumes of water were discharged to the spreading areas.

Comparison of hydrographs for wells USGS 12 and USGS 23 (fig. 17) and the cumulative departure curve for the Big Lost River (fig. 18) indicate a

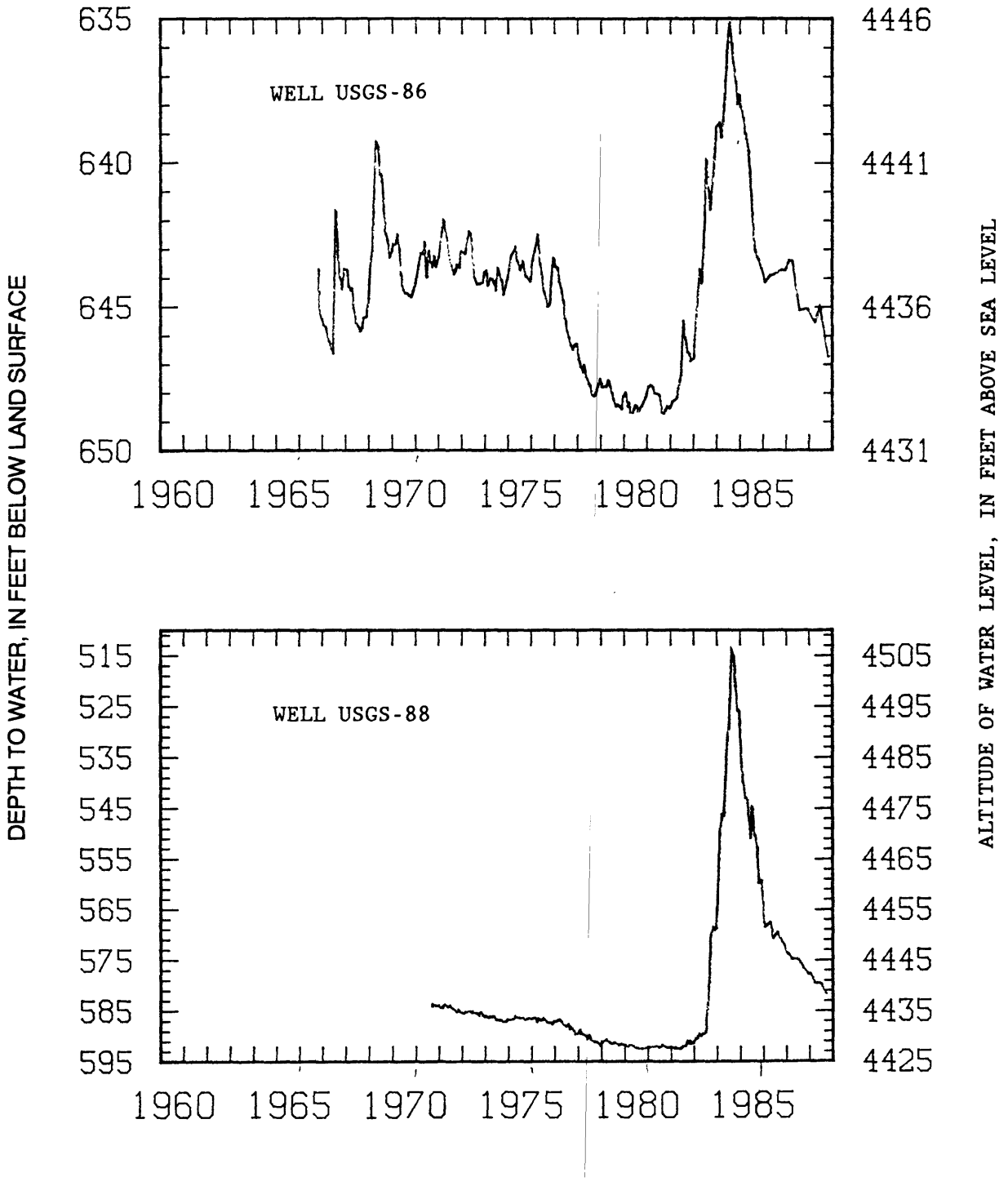

Figure 16.--Water-level hydrographs for wells USGS 86 and USGS 88.

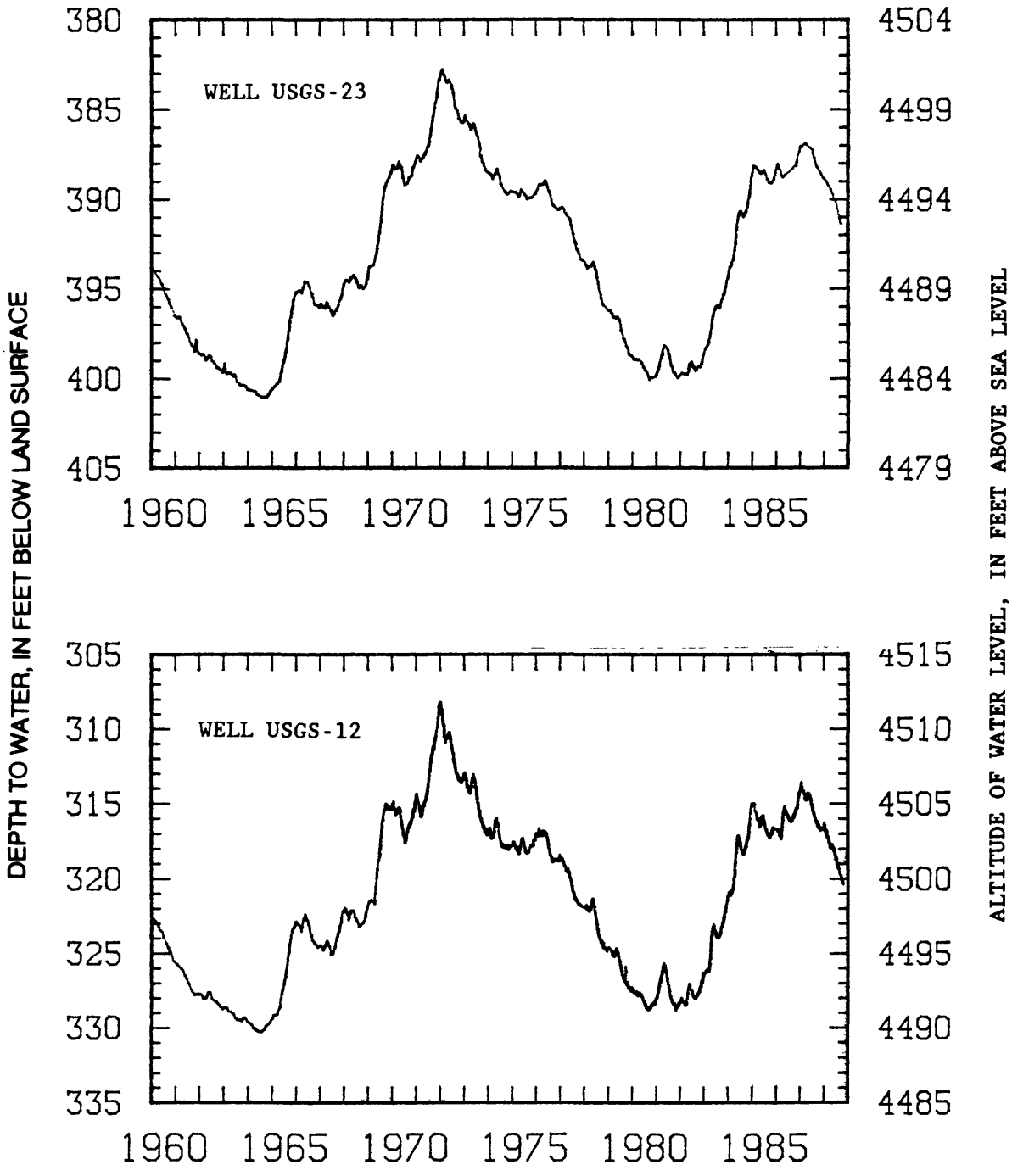

Figure 17.--Water-level hydrographs for wells USGS 12 and USGS 23.

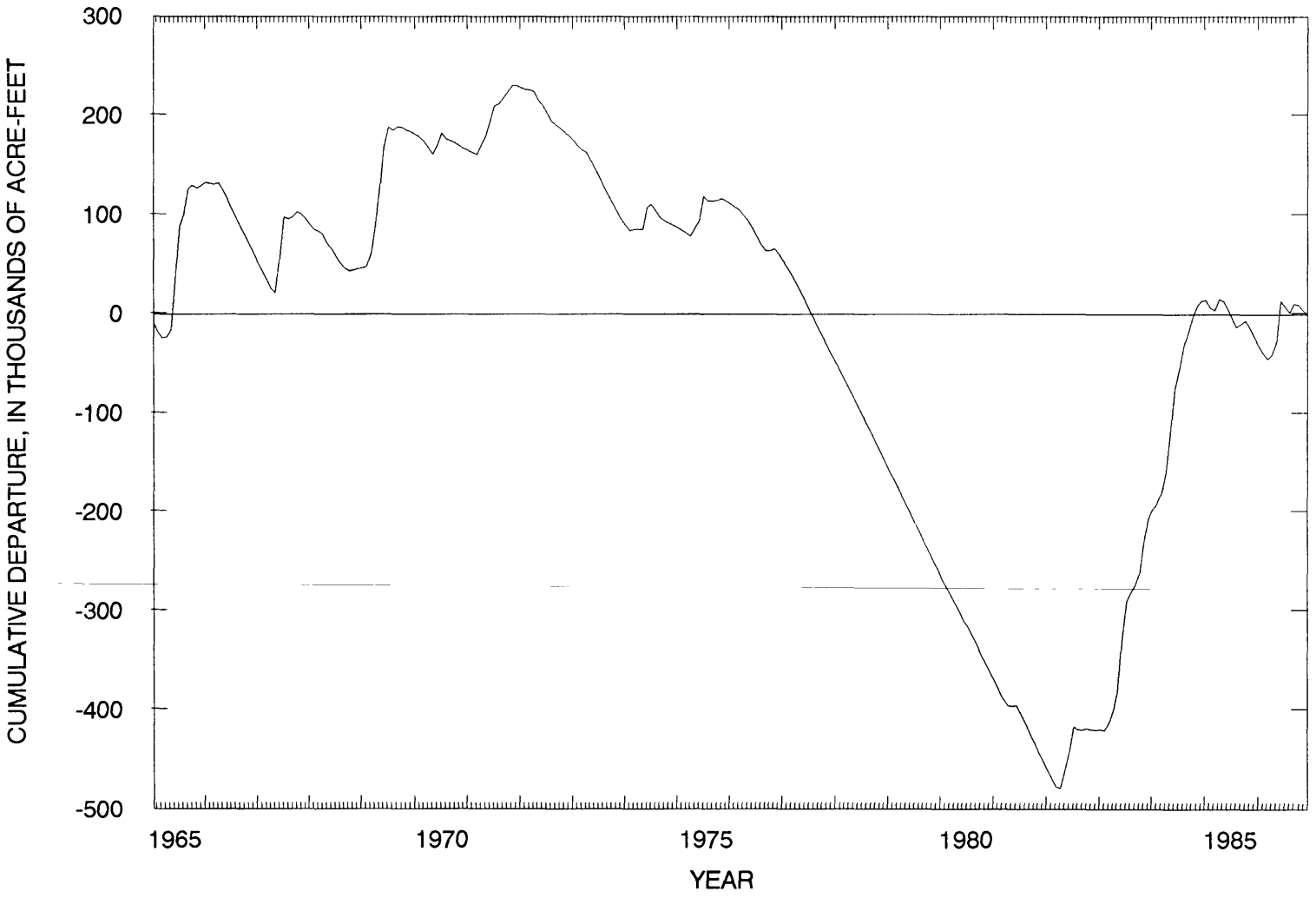

Figure 18.--Cumulative departure from average monthly flow of the Big Lost River below the INEL diversion, 1965-86.

close correlation between recharge near the Big Lost River Sinks and water levels in those wells. Streamflow in the Big Lost River during 1965-71 predominantly was above average for the period of record (fig. 18). Streamflow during 1972-81 was below average, particularly during 1977-81. The trend was reversed during 1982-84, with above average streamflow. Streamflow during 1985-86 was average. During periods of increased streamflow in the Big Lost River at Lincoln Boulevard (fig. 9), ground-water levels rose rapidly. During periods of decreased streamflow, ground-water levels declined.

SUMMARY

The Big Lost River is perennial from its headwaters to a point several miles southeast of Arco. After entering the Snake River Plain (near Arco), the river continually loses water by infiltration through the channel bottom. The distance to where surface flow ceases depends on discharge and infiltration conditions. The river terminates in a series of four playas. Streamflow in the basin is affected by: (1) storage of irrigation water 30 mi upstream from Arco in Mackay Reservoir, (2) irrigation of about 57,500 acres, (3) subirrigation of 10,200 acres, and (4) the INEL flood-control diversion system.

Monthly streamflow-infiltration losses calculated from continuous-record gaging stations for selected reaches of the Big Lost River for July 1972 to July 1978 and July 1981 to July 1985 are as follows: (1) Arco (measurement site 1) to the INEL diversion (measurement site 6)--832 and 1,880 acre-ft/mo respectively, (2) spreading areas--4,800 and 16,995 acre/ft/mo respectively, (3) the INEL diversion (measurement site 9) to Lincoln Boulevard (measurement site 9)--856 and 906 acre-ft/mo respectively, and (4) Lincoln Boulevard (measurement site 9) to the playas (measurement site 14)--2,004 and 5,119 acre-ft/mo respectively. Average streamflow for the Big Lost River for 1965-87, measured upstream from the INEL diversion dam was 104,400 acre-ft/yr; of which: (1) 52,000 acre-ft/yr (49.8 percent) were diverted to the INEL spreading areas, (2) 9,800 acre-ft/yr (9.4 percent) infiltrated in the reach between the INEL diversion dam and Lincoln Boulevard, and (3) 42,600 acre-ft/yr (40.8 percent) either infiltrated

downstream from Lincoln Boulevard or flowed into the playas.

Streamflow-infiltration losses in selected reaches of the 44 mi of river between the Big Lost River stations near Arco and playa 1 were measured at various discharges that ranged from 37 to 372 ft^3/s. Infiltration losses from the channel were 1 to 2 $(ft^3/s)/mi$ at discharges less than 100 ft^3/s throughout most of the reach between Arco and the Big Lost River Sinks. However, loss from the river in the reach between measurement site 6 and measurement site 7 ranged from 1 to 4 $(ft^3/s)/mi$. Infiltration loss in the reach between measurement site 13 and measurement site 14 ranged from 7 to 12 $(ft^3/s)/mi$ at lower stages. Discharge measurements made May 6-8, 1985, at a discharge of 372 ft^3/s, indicated that the infiltration loss is largest at high stages. A maximum loss of 28 $(ft^3/s)/mi$ was measured in the area of the Big Lost River Sinks.

In July 1985, flow in the Snake River Plain aquifer generally was to the southwest and the average gradient of the water table was about 4 ft/mi. The direction of flow locally is affected by recharge from the Big Lost River, by aquifer withdrawals from pumping, and by underflow.

The configuration of the regional water table for the Snake River Plain aquifer at the INEL varies in response to changes in volume and source of recharge. Two areas, one immediately southwest of the RWMC and the other north of the NRF, are significantly affected by recharge from the Big Lost River. Net declines of about 10 ft were measured in wells near the RWMC and NRF for the July 1972 to July 1978 period. Rises of 16 and 12 ft were measured near the RWMC and NRF, respectively, for the July 1981 to July 1985 period.

REFERENCES CITED

Barraclough, J.T., Lewis, B.D., and Jensen, R.G., 1981, Hydrologic conditions at the Idaho National Engineering Laboratory, Idaho, emphasis--1974-1978: U.S. Geological Survey Open-File Report 81-526, IDO-22060, 77 p.

Barraclough, J.T., Teasdale, W.E., and Jensen, R.G., 1965, Hydrology of the National Reactor Testing Station, Idaho--Annual progress report, 1965: U.S. Geological Survey Open-File Report, IDO-22048, 107 p.

Bennett, C.M., 1986, Capacity of the diversion channel below the flood-control dam on the Big Lost River at the Idaho National Engineering Laboratory: U.S. Geological Survey Water-Resources Investigations Report 86-4204, DOE/ID-22071, 25 p.

Harenberg, W.A., Jones, M.L., O'Dell, Ivalou, and Cordes, S.C., 1987, Water resource data, Idaho, water year 1987: U.S. Geological Survey Water-Data Report ID-87-1, 651 p.

Mann, L.J., Chew, E.W., Morton, J.S., and Randolph, R.B., 1989, Iodine-129 in the Snake River Plain aquifer at the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigations Report 88-4165, DOE/ID-22076, 27 p.

Pittman, J.R., Jensen, R.G., and Fischer, P.R., 1988, Hydrologic conditions at the Idaho National Engineering Laboratory, 1982 to 1985: U.S. Geological Survey Water-Resources Investigations Report 89-4008, DOE/ID-22078, 73 p.

Rember, W.C. and Bennett, E.H., 1979, Geologic map of the Idaho Falls Quadrangle: Idaho Bureau of Mines and Geology, Geologic Map Series, 1 plate.

Robertson, J.B., Schoen, Robert, and Barraclough, J.T., 1974, The influence of liquid waste disposal on the geochemistry of water at the National Reactor Testing Station, Idaho, 1952-1970: U.S. Geological Survey Open-File Report, IDO-22053, 231 p.

Stearns, H.T., Crandall, Lynn, and Steward, W.G., 1938, Geology and ground-water resources of the Snake River Plain in southeastern Idaho: U.S. Geological Survey Water-Supply Paper 774, 262 p.

DATA TABLES

Table 2.--Monthly discharge, in acre-feet, for the Big Lost River below Mackay Reservoir, near Mackay (13127000), 1904-87

[Symbol: *, period of missing discharge record]

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL
1904	11990	10700	11990	11330	41120	84060	50030	19580	13700	11570	10650	10230	286950
1905	9900	8410	8920	8380	9190	50400	32050	14240	9560	10760	10890	10580	183280
1906	10000	8550	9080	9310	31170	54360	52260	19070	*	*	*	*	*
1907	*	*	*	*	*	*	*	*	*	*	*	*	*
1908	*	*	*	*	*	*	*	*	*	*	*	*	*
1909	*	*	*	*	*	*	*	*	*	*	*	*	*
1910	*	*	*	*	*	*	*	*	*	*	*	*	*
1911	*	*	*	*	*	*	*	*	*	*	*	*	*
1912	*	*	*	*	*	*	22650	17920	13050	15430	13450	11850	*
1913	11680	10550	10880	9510	37570	79960	38010	24050	16020	16290	14790	12620	281930
1914	11650	10060	9240	12110	42280	65200	42050	15570	13660	17960	16390	13270	269440
1915	12720	10890	*	*	*	*	*	*	*	*	*	*	*
1916	*	*	*	*	*	*	*	*	*	*	*	*	*
1917	*	*	*	*	*	*	*	*	*	*	*	*	*
1918	*	*	*	*	*	*	*	*	*	*	*	*	*
1919	7910	7800	9270	8680	23180	28860	18330	9340	9210	11270	9470	7340	150660
1920	7380	8170	6150	5800	16220	42350	26000	11280	10860	7980	4440	6280	152910
1921	7640	7300	8500	7990	26510	96780	46690	27420	13500	20990	4460	6050	273830
1922	7040	7250	8320	8160	28200	93580	42670	29180	14760	6470	7240	6920	259790
1923	7300	7370	9190	8750	25470	49610	52960	31530	14370	29960	7930	5040	249480
1924	6170	6380	7450	7150	25440	21080	20230	9030	8630	10490	3310	4710	130070
1925	5760	5850	6850	6330	39890	52920	41770	28060	19540	8990	3850	5490	225300
1926	6650	6540	8150	7360	25770	25330	19310	9610	9080	10300	3010	3900	135010
1927	5140	5370	6700	6410	15790	69730	46930	17570	11050	11060	4290	5170	205210
1928	6380	6900	7850	6910	47390	45880	28440	11650	10060	11780	3230	4470	190940
1929	6060	6240	7480	6870	11680	38350	19980	9430	9280	9980	2890	4170	132410
1930	5600	5510	6790	6200	19740	55920	23470	12320	10040	11450	3980	5250	166270
1931	6430	6450	7360	6650	12050	25120	13860	10930	8670	9180	3500	4170	114370
1932	5020	5310	6260	6090	24590	52920	40090	18630	10210	11180	3730	4940	188970
1933	5760	6060	7390	6880	7160	62640	16640	9660	8400	9140	7050	3670	150450
1934	4830	5120	5950	6100	16920	12070	7790	6930	7330	8200	3430	3720	88390
1935	4830	5030	6150	6190	8860	48650	39560	21570	9770	11000	4520	5950	172080
1936	5620	5770	6770	6550	20800	26960	26630	10580	9500	12800	3910	4190	140080
1937	5470	5540	6620	6330	13140	25180	18930	8980	8300	8650	5350	3690	116180
1938	4620	4570	5790	6170	20140	101800	60920	26040	8920	9330	14510	8950	271760
1939	9290	9450	11180	9600	20120	26620	26330	19000	10420	13050	4120	4370	163550
1940	5620	6360	7250	6830	25370	42300	28100	15230	5940	6610	3900	5200	158710
1941	6640	6700	7850	7330	20000	42710	31700	21250	11270	9030	6770	7940	179190
1942	11890	10860	10630	16050	26290	57180	47000	27300	8840	7520	5240	7930	236730
1943	9870	9560	10820	11720	46510	79530	65830	32760	15120	8580	8020	12710	311030
1944	11040	8470	11130	10240	24670	72980	63310	36500	15160	6090	7080	12810	279480
1945	10830	9760	9790	9640	16800	40800	42060	34680	14320	4770	5840	6350	205640

Table 2.--Monthly discharge, in acre-feet, for the Big Lost River below Mackay Reservoir, near Mackay (13127000), 1904-87--Continued

[Symbol: *, period of missing discharge record]

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL
1946	7390	7220	8970	12750	36870	49250	41500	27100	7280	4180	5410	7040	214960
1947	10350	10070	11670	11350	42240	43030	42290	21760	15280	6180	3750	5270	223240
1948	6290	6190	7260	8710	24280	70880	41590	28740	12030	3940	4690	5840	220440
1949	7100	7250	9110	8880	29210	42740	35660	22390	12190	5610	3960	5020	189120
1950	5990	6120	7010	6760	22010	33860	46190	27590	8410	3660	4900	5760	178260
1951	6720	6570	7670	11860	42020	55240	44420	31570	15650	7590	6900	11120	247330
1952	12300	11950	12650	14240	62900	74330	46080	35220	7700	6450	6850	7760	298430
1953	11780	9280	9310	8800	21300	51870	57380	32710	13810	6550	4490	5620	232900
1954	6370	6320	7670	8900	36050	31750	46240	26040	16480	13050	2680	4290	205840
1955	5570	5820	6800	6330	10970	42670	31620	27030	12760	10540	3190	3870	167170
1956	5040	5370	6390	6680	48500	93510	50880	29900	12410	7550	4470	5370	276070
1957	6340	6260	7450	7350	24630	78520	50960	33830	7110	7370	7030	7670	244520
1958	8300	8050	9250	9840	73330	75290	43970	29670	18570	14850	3290	5110	299520
1959	6410	6380	7670	8640	21840	39160	26230	14610	11270	8310	3290	4980	158790
1960	6160	6400	7130	7130	17060	41590	25800	12120	9940	7030	4040	5270	149670
1961	6290	6120	6930	6560	14550	32240	19440	10460	8460	6440	3780	4840	126110
1962	5720	5470	6270	8230	19850	46460	33870	26670	11480	7670	4240	5300	181230
1963	5990	5790	7020	7400	21100	73770	49860	24980	10860	12400	5660	6850	231680
1964	7530	7720	12910	9060	29030	55250	50510	30880	12120	8960	5110	6580	235660
1965	7690	9730	15510	11370	40530	119700	90060	44870	37790	11410	6080	13350	408090
1966	11730	7250	8000	8580	36660	31300	26350	18120	10110	7190	3830	5030	174150
1967	6050	6250	8550	9810	52250	96230	84150	43620	23350	19030	3510	5200	358000
1968	6610	7080	7870	7300	19790	58380	38050	16840	11550	12940	14760	14470	215640
1969	12100	14800	33430	30460	72740	66010	54620	41580	19510	5040	3960	5790	360040
1970	6560	6500	7450	7350	31010	81210	54600	37040	12610	10880	5420	6960	267590
1971	7710	7330	8600	25400	48490	72890	57880	45290	14700	14980	11180	10330	324780
1972	11280	10970	11240	11280	36900	60240	42230	30960	15730	9100	5190	6840	251960
1973	7810	7490	8860	8600	35270	43190	28460	31080	13410	8380	3710	5690	201950
1974	6570	6950	7980	8360	63230	103800	49280	38510	17480	12250	7120	6130	327660
1975	7670	7900	10080	11730	27200	73730	82510	48030	22770	14320	7080	6020	319040
1976	6860	6790	7500	7880	52070	59520	43690	30710	21180	18530	10220	3620	268570
1977	4910	5290	6240	6290	11280	31110	31920	20310	10560	4210	3140	4630	139890
1978	5630	5710	6960	7070	18820	57240	59520	41450	11510	10240	6020	6070	236240
1979	6910	6970	8840	9040	36680	51160	32820	16360	11300	7250	4500	4530	196360
1980	5680	5910	7090	6720	39540	59280	64590	34420	9960	9120	5050	6610	253970
1981	7170	6730	10900	16350	42880	69370	50800	28150	11750	7750	4170	5150	261170
1982	6250	6300	7480	16380	51360	82780	71900	49650	19520	7690	5970	13080	338360
1983	13100	7560	23800	22110	40790	104600	71370	38860	21480	15970	39300	29270	428210
1984	17960	17510	23620	30690	61560	90390	66680	55060	29530	22120	15080	15420	445620
1985	12130	5870	14440	18990	30970	42800	31090	25290	27990	19370	3770	5690	238400
1986	6450	6620	7640	17910	51840	101600	43190	35320	27130	6580	5610	7280	317170
1987	7380	6650	7690	7140	26690	30430	28510	29700	12860	8280	4850	5700	175880

Table 3.--Monthly discharge, in acre-feet, for the Big Lost River near Arco (13132500), 1965-88

[Symbol: *, period of missing discharge record]

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL
1965	*	*	*	*	*	*	*	*	*	*	*	*	*
1966	*	*	*	*	*	1020	328	231	192	348	583	855	*
1967	722	631	416	228	5440	51270	56450	8790	12950	15810	9290	6330	168327
1968	3880	4600	7550	5270	754	2480	1440	3230	3650	6020	11110	14390	64374
1969	11050	11490	23430	38840	44660	45780	28640	7270	12970	8810	7230	7850	248020
1970	7120	7090	5300	3620	2770	17670	21020	3310	8420	6990	7550	6660	97520
1971	7540	7120	7810	20040	20050	25560	26900	11320	15820	17400	15840	10000	185400
1972	6650	9250	10290	7200	1690	4060	2850	2220	6710	6810	6110	6160	70000
1973	5710	6260	6720	7850	1580	1540	1280	861	1510	1630	2710	2040	39691
1974	3460	3630	11910	8630	10510	34320	12750	3290	3190	6950	7820	7730	114190
1975	7540	6340	6710	6970	17270	17140	35650	5930	10320	10560	11840	7800	144070
1976	6220	6430	7270	4440	4270	3480	1440	1770	3690	10310	11220	4030	64570
1977	2570	3010	3040	710	720	586	231	93	162	264	374	307	12067
1978	199	153	184	252	75	762	1090	782	1970	755	459	724	7405
1979	513	579	1710	1460	1230	758	448	583	268	198	277	241	8265
1980	229	234	250	220	1920	7580	5710	3480	1590	1340	*	*	*
1981	*	*	*	5200	9560	10350	692	472	679	*	*	*	*
1982	*	*	*	*	28380	29660	38280	7250	11150	12330	8230	10630	*
1983	11080	6980	18810	20060	27520	66500	56280	17510	17310	20950	45190	37760	345950
1984	21340	18050	24000	34410	51720	59240	28990	30870	23510	22820	21610	18000	354560
1985	12830	5160	9960	18700	8120	911	216	453	13630	12340	3200	1890	87410
1986	1190	2850	5950	13810	21560	54570	4840	3510	19510	9160	5360	6040	148350
1987	4080	4230	5210	2310	516	527	799	415	243	717	1310	791	21148
1988	622	566	385	283	250	6	0	0	0	0	0	0	2112

Table 4.--Monthly discharge, in acre-feet, for the INEL diversion at head near Arco (13132513), 1965-88

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL
1965	0	0	0	0	0	26500	34200	1800	23400	12900	5270	11000	115070
1966	12620	7590	8000	4560	0	0	0	0	0	0	0	0	32770
1967	0	0	0	0	23	23200	30800	990	0	4420	6700	4700	70833
1968	3260	4000	2960	0	0	0	0	0	0	0	4360	10500	25080
1969	9640	10900	22500	32600	8840	10100	4460	0	0	0	2540	6470	108050
1970	6100	6150	4200	0	0	377	1220	0	0	0	1680	6040	25767
1971	6800	6410	7080	6020	4840	4860	3050	830	0	0	609	9095	49594
1972	5990	7600	6350	0	0	0	0	0	0	0	656	5280	25876
1973	4087	4266	4534	2655	0	0	0	0	0	0	1090	328	16960
1974	2720	3070	6340	0	0	11900	986	0	0	0	1000	6360	32376
1975	6920	5970	6320	1660	1860	1790	12500	0	0	0	2560	6570	46150
1976	5600	5780	5873	0	0	0	0	0	1210	7030	8510	3640	37643
1977	1000	1120	1110	38	0	0	0	0	0	0	0	0	3268
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	32	0	0	0	0	0	0	0	32
1981	0	30	2	403	196	262	0	0	0	0	0	0	893
1982	0	0	0	755	7870	11600	18200	0	0	0	1210	6930	46565
1983	8300	6090	15600	6510	10100	39600	31000	5030	9220	13100	33500	28400	206450
1984	16400	13900	19600	26100	43100	49800	23100	25700	17800	15600	11500	12200	274800
1985	8460	82	6740	12230	92	0	0	0	825	0	0	0	28429.24
1986	0	0	0	1550	3840	28650	0	0	1720	73	2640	4270	42743
1987	2770	2550	2120	0	0	0	0	0	0	0	0	0	7440
1988	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.--Monthly discharge, in acre-feet, for the INEL diversion at outlet of spreading area A near Arco (13132515), 1984-88

[Symbol: *, period of missing discharge record]

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL
1984	*	*	*	*	*	*	19620	21090	16600	13560	10320	11060	*
1985	7950	0	4530	10620	32	0	0	0	83	0	0	0	23215
1986	0	0	0	437	2110	23950	0	0	325	66	959	2180	30027
1987	683	230	1080	0	0	0	0	0	0	0	0	0	1993
1988	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 6.--Monthly discharge, in acre-feet, for the Big Lost River below the INEL diversion near Arco (13132520), 1965-88

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL
1965	0	0	3110	9860	16300	32100	29400	19400	11100	310	300	310	122190
1966	310	280	310	5690	2170	0	0	0	0	0	0	0	8760
1967	0	0	0	0	4600	21600	18700	6880	11100	9260	0	0	72140
1968	0	0	4360	5760	0	3010	1240	2720	4570	6040	5540	0	33240
1969	0	0	0	4940	38200	38000	25700	6400	12200	8300	3860	310	137910
1970	310	280	800	3130	2580	16900	20700	2820	7300	6510	4860	310	66500
1971	310	280	310	12300	13100	18800	22500	9800	14900	15900	14100	310	122610
1972	310	290	2410	6610	1160	3050	1850	940	5030	5230	4410	310	31600
1973	200	200	200	3580	910	460	320	120	830	760	390	190	8160
1974	190	170	4440	8310	9240	19600	11100	2570	2500	5630	5770	0	69520
1975	0	0	0	4840	14900	14600	21200	5080	8590	9680	8270	310	87470
1976	190	170	680	3280	3160	2650	330	530	1750	2190	2070	665	17665
1977	930	840	620	260	0	0	0	0	0	0	0	0	2650
1978	930	840	620	260	54	0	0	0	0	0	0	0	2704
1979	0	0	450	10	0	0	0	0	0	0	0	0	460
1980	0	0	0	0	360	180	2700	0	0	0	0	0	3240
1981	0	0	0	2140	7920	9400	0	0	0	0	0	0	19460
1982	0	0	6	6990	19300	15200	16800	5870	8790	10900	6190	1550	91596
1983	1550	1400	2250	14000	17500	19500	19300	12500	7780	7720	6940	3990	114430
1984	1720	1610	1720	3600	4120	5330	4874	6720	5990	6890	9890	2740	55204
1985	1280	759	198	7890	7540	413	16	83	11950	11900	1750	187	43966
1986	8	1290	3640	10900	17260	23350	3550	2320	16040	8130	1690	458	88636
1987	433	613	1780	1790	118	85	312	0	0	0	0	0	5131
1988	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 7.--Monthly discharge, in acre-feet, for the Big Lost River at Lincoln Boulevard bridge near Atomic City (13132535), 1965-88

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL
1965	0	0	2380	10300	15400	29600	31100	16900	10900	0	0	0	116580
1966	0	0	0	3660	981	0	0	0	0	0	0	0	4641
1967	0	0	0	0	2030	20180	18376	4400	9050	8740	0	0	62776
1968	0	0	2280	3390	16	524	0	1053	1130	3290	4500	0	16183
1969	0	0	0	3960	33000	33500	21800	4780	9840	6710	3290	0	116880
1970	0	0	501	1650	793	13800	17700	1510	6080	5280	4750	8	52072
1971	0	0	0	10600	12300	17200	20800	7760	13400	14400	13100	0	109560
1972	0	0	1540	4920	504	1710	861	84	2990	3520	3099	0	19228
1973	0	0	0	2830	405	0	0	0	0	0	0	0	3235
1974	0	0	3240	5520	6940	16200	9390	1170	1160	3760	4200	0	51580
1975	0	0	0	3180	12000	12100	18700	3560	6520	8210	7990	0	72260
1976	0	0	333	1450	1660	1120	0	0	300	620	1100	76	6659
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	1140	0	0	0	0	0	1140
1981	0	0	0	1300	5092	7560	0	0	0	0	0	0	13952
1982	0	0	0	5930	17200	13400	15100	4820	8190	10500	5740	600	81480
1983	600	600	900	12800	15800	18900	18200	9780	7320	6200	5660	1200	97960
1984	1200	1200	1200	2200	2320	4550	3950	5790	5140	5980	8710	2120	44360
1985	3	0	0	7170	6430	0	0	0	9950	10707	1275	0	35536
1986	0	96	537	8370	14825	20315	2900	1016	14753	8220	1190	2	72224
1987	0	0	531	491	0	0	0	0	0	0	0	0	1022
1988	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8.--Monthly streamflow-infiltration loss, in acre-feet, in the Big Lost River reach, Arco to INEL diversion, 1965-88

[Symbol: *, period of missing discharge record; negative number indicates channel gain]

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL
1965	*	*	*	*	*	*	*	*	*	*	*	*	*
1966	*	*	*	*	*	1020	328	231	192	348	583	855	*
1967	722	631	416	228	817	6470	6950	920	1850	2130	2590	1630	25354
1968	620	600	230	-490	754	-530	200	510	-920	-20	1210	3890	6054
1969	1410	590	930	1300	-2380	-2320	-1520	870	770	510	830	1070	2060
1970	710	660	300	490	190	393	-900	490	1120	480	1010	310	5253
1971	430	430	420	1720	2110	1900	1350	690	920	1500	1131	595	13196
1972	350	1360	1530	590	530	1010	1000	1280	1680	1580	1044	570	12524
1973	1423	1794	1986	1615	670	1080	960	741	680	870	1230	1522	14571
1974	550	390	1130	320	1270	2820	664	720	690	1320	1050	1370	12294
1975	620	370	390	470	510	750	1950	850	1730	880	1010	920	10450
1976	430	480	717	1160	1110	830	1110	1240	730	1090	640	-275	9262
1977	640	1050	1310	412	720	586	231	93	162	264	374	307	6149
1978	-731	-687	-436	-8	21	762	1090	782	1970	755	459	724	4701
1979	513	579	1260	1450	1230	758	448	583	268	198	277	241	7805
1980	229	234	250	220	1528	7400	3010	3480	1590	1340	*	*	*
1981	*	*	*	2657	1444	688	692	472	679	*	*	*	*
1982	*	*	*	*	1210	2860	3280	1380	2360	1430	830	2150	*
1983	1230	-510	960	-450	-80	7400	5980	-20	310	130	4750	5370	25070
1984	3220	2540	2680	4710	4500	4110	1016	-1550	-280	330	220	3060	24556
1985	3090	4319	3022	-1420	488	498	200	370	855	440	1450	1703	15015
1986	1182	1560	2310	1360	460	2570	1290	1190	1750	957	1030	1312	16971
1987	877	1067	1310	520	398	442	487	415	243	717	1310	791	8577
1988	622	566	385	283	250	6	0	0	0	0	0	0	2112

Table 9.--Monthly streamflow-infiltration loss, in acre-feet, in the INEL diversion reach at head to above spreading area B, 1984-88

[Symbol: *, period of missing discharge record]

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1984	*	*	*	*	*	*	3480	4610	1200	2040	1180	1140	*
1985	510	82	2210	1610	60	0	0	0	742	0	0	0	5214
1986	0	0	0	1113	1730	4700	0	0	1395	7	1681	2090	12716
1987	2087	2320	1040	0	0	0	0	0	0	0	0	0	5447
1988	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 10.--Monthly streamflow-infiltration loss, in acre-feet, in the Big Lost River reach, INEL diversion to Lincoln Boulevard, 1965-88

[Negative number indicates channel gain]

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANNUAL
1965	0	0	730	-440	900	2500	-1700	2500	200	310	300	310	5610
1966	310	280	310	2030	1189	0	0	0	0	0	0	0	4119
1967	0	0	0	0	2570	1420	324	2480	2050	520	0	0	9364
1968	0	0	2080	2370	-16	2486	1240	1667	3440	2750	1040	0	17057
1969	0	0	0	980	5200	4500	3900	1620	2360	1590	570	310	21030
1970	310	280	299	1480	1787	3100	3000	1310	1220	1230	110	302	14428
1971	310	280	310	1700	800	1600	1700	2040	1500	1500	1000	310	13050
1972	310	290	870	1690	656	1340	989	856	2040	1710	1311	310	12372
1973	200	200	200	750	505	460	320	120	830	760	390	190	4925
1974	190	170	1200	2790	2300	3400	1710	1400	1340	1870	1570	0	17940
1975	0	0	0	1660	2900	2500	2500	1520	2070	1470	280	310	15210
1976	190	170	347	1830	1500	1530	330	530	1450	1570	970	589	11006
1977	930	840	620	260	0	0	0	0	0	0	0	0	2650
1978	930	840	620	260	54	0	0	0	0	0	0	0	2704
1979	0	0	450	10	0	0	0	0	0	0	0	0	460
1980	0	0	0	0	360	180	1560	0	0	0	0	0	2100
1981	0	0	0	840	2828	1840	0	0	0	0	0	0	5508
1982	0	0	6	1060	2100	1800	1700	1050	600	400	450	950	10116
1983	950	800	1350	1200	1700	600	1100	2720	460	1520	1280	2790	16470
1984	520	410	520	1400	1800	780	924	930	850	910	1180	620	10844
1985	1277	759	198	720	1110	413	16	83	2000	1193	475	187	8430
1986	8	1194	3103	2530	2435	3035	650	1304	1287	-90	500	456	16412
1987	433	613	1249	1299	118	85	312	0	0	0	0	0	4109
1988	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 11.--Summary of selected physical and chemical characteristics and discharge measurements for Big Lost River stations between Arco and playas 1 and 2, May 6-8 and November 6-7, 1985

[Measurement site No.: see figure 2 for location of measurement sites. °C -- degrees Celsius. µS/cm -- microsiemen per centimeter at 25 degrees Celsius. mg/L -- milligrams per liter. ft^3/s -- cubic feet per second.]

Measurement-site No.	Date	Water temperature (°C)	Air temperature (°C)	pH (units)	Specific conductance (µS/cm)	Chloride (mg/L)	Alkalinity as HCO_3^- (mg/L)	Discharge (ft^3/s)
1	May 6	10	25	7.8	323	5	188	372
	Nov.6	--	--	--	--	--	--	62.0
2	May 6	12	31	7.9	323	5	185	366
	Nov.6	--	--	--	--	--	--	46.7
4	May 6	--	--	--	--	--	--	25.7
	Nov.6	--	--	--	--	--	--	dry
6	May 6	12	18	7.9	322	5	183	307
	Nov.6	--	--	--	--	--	--	39.8
8	May 7	13	21	8.0	323	5	181	310
	Nov.6	--	--	--	--	--	--	31.0
9	May 7	15	26	7.9	320	5	188	276
	Nov.6	--	--	--	--	--	--	25.0
11	May 7	16	20	7.8	318	5	190	265
	Nov.6	--	--	--	--	--	--	21.7
12	May 7	16	21	7.9	319	5	178	257
13	May 8	12	24	7.8	323	5	--	240
	Nov.6	--	--	--	--	--	--	20.8
14	May 8	18	21	8.5	314	5	154	50
	Nov 7	--	--	--	--	--	--	.58
15	May 8	19	26	8.3	--	--	183	35
	Nov 7	--	--	--	--	--	--	6.21
16	May 8	--	--	--	--	--	--	0
	Nov 7	--	--	--	--	--	--	0