Revised Water Budget for the Fernley Area, West-Central Nevada, 1979

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Aerial view of Fernley and vicinity, looking west.
Photograph by Patrick A. Glancy, August 5, 1980.

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CONVERSION FACTORS

"Inch-pound" units of measure used in this report may be converted to International-System (metric) units by using the following factors:

Multiply	*By*	*To obtain*
Acres	0.4047	Square hectometers (hm^2)
Acre-feet (acre-ft)	0.001233	Cubic hectometers (hm^3)
Acre-feet per year (acre-ft/yr)	0.001233	Cubic hectometers per year (hm^3/yr)
Cubic feet per second (ft^3/s)	0.02832	Cubic meters per second (m^3/s)
Feet per year (ft/yr)	0.3048	Meters per year (m/yr)
Feet squared per day (ft^2/d)	0.09290	Meters squared per day (m^2/d)
Miles (mi)	1.609	Kilometers (km)
Square miles (mi^2)	2.590	Square kilometers (km^2)

REVISED WATER BUDGET FOR THE FERNLEY AREA,

WEST-CENTRAL NEVADA, 1979

By A. S. Van Denburgh and Freddy E. Arteaga

ABSTRACT

Part of the 120-square-mile Fernley Hydrographic Area is undergoing a rapid transition from rural agriculture to an urban setting because of its 30-mile proximity to the Reno-Sparks metropolitan area. In a growing urban area, an evaluation of the existing water resources is useful in permitting wise management of those resources. A water budget for average conditions in the Fernley Area as of 1979 indicates that the total estimated inflow (about 45,000 acre-feet per year) was dominated by canal seepage and diversions for irrigation (18,000 and 26,000 acre-feet per year, respectively). Outflow included the following components (with estimated annual quantities in acre-feet): Ground-water underflow (about 10,000); surface-water outflow (4,000); net lake-surface evaporation (6,100); evapotranspiration from croplands (15,000) and from phreatophytes and discharging playa (7,600); and consumptive use of industrial and public-supply pumpage of ground water (600). The outflow estimates totaled 44,000 acre-feet per year.

The hydrologic system in the Fernley Hydrographic Area is thought to be in a state of long-term equilibrium except for the as yet minor effects of diminishing irrigated acreage and increasing consumption of industrial and public-supply pumpage. Because the estimate for total inflow is considered more accurate than that for total outflow, the value selected to represent both inflow and outflow for average conditions as of 1979 is 45,000 acre-feet per year.

Under natural (pre-canal) conditions, both inflow and outflow presumably were on the order of only 600 acre-feet per year (that is, natural ground-water recharge, balanced by an equivalent amount of natural discharge). The pronounced differences between natural conditions and those of 1979 are directly or indirectly a result of seepage and diversions from the Truckee Canal. Thus, the several interrelated components of present-day outflow from the study area are closely dependent upon the two components of canal inflow. As a result, any significant future alteration of inflow (for example, a reduction or elimination of seepage by lining the canal) would have a pronounced long-term impact on the balance among outflow components. Any attempt to salvage present-day outflow could also have an impact.

INTRODUCTION

In areas where significant water-resources development has occurred or is anticipated, an evaluation of the existing resources is useful in permitting intelligent decisions regarding water management. Anticipated population growth in the Reno-Sparks area is expected to be accompanied by a corresponding population increase--and expanding water-resources development--in the Fernley area, which is only about 30 miles east of Reno (figure 1). An earlier report presents a reconnaissance-level water budget for the Fernley Hydrographic Area as of about 1969 (Van Denburgh and others, 1973, pages 57 and 60). The study upon which the present report is based has been made by the U.S. Geological Survey, in cooperation with the Nevada Division of Water Resources, to acquire and evaluate geohydrologic data needed to develop a more definitive and up-to-date water budget for the Fernley Hydrographic Area.

Hydrologic data collected during the study, but not included in this report, are available for inspection at the Geological Survey office in Carson City, Nev.

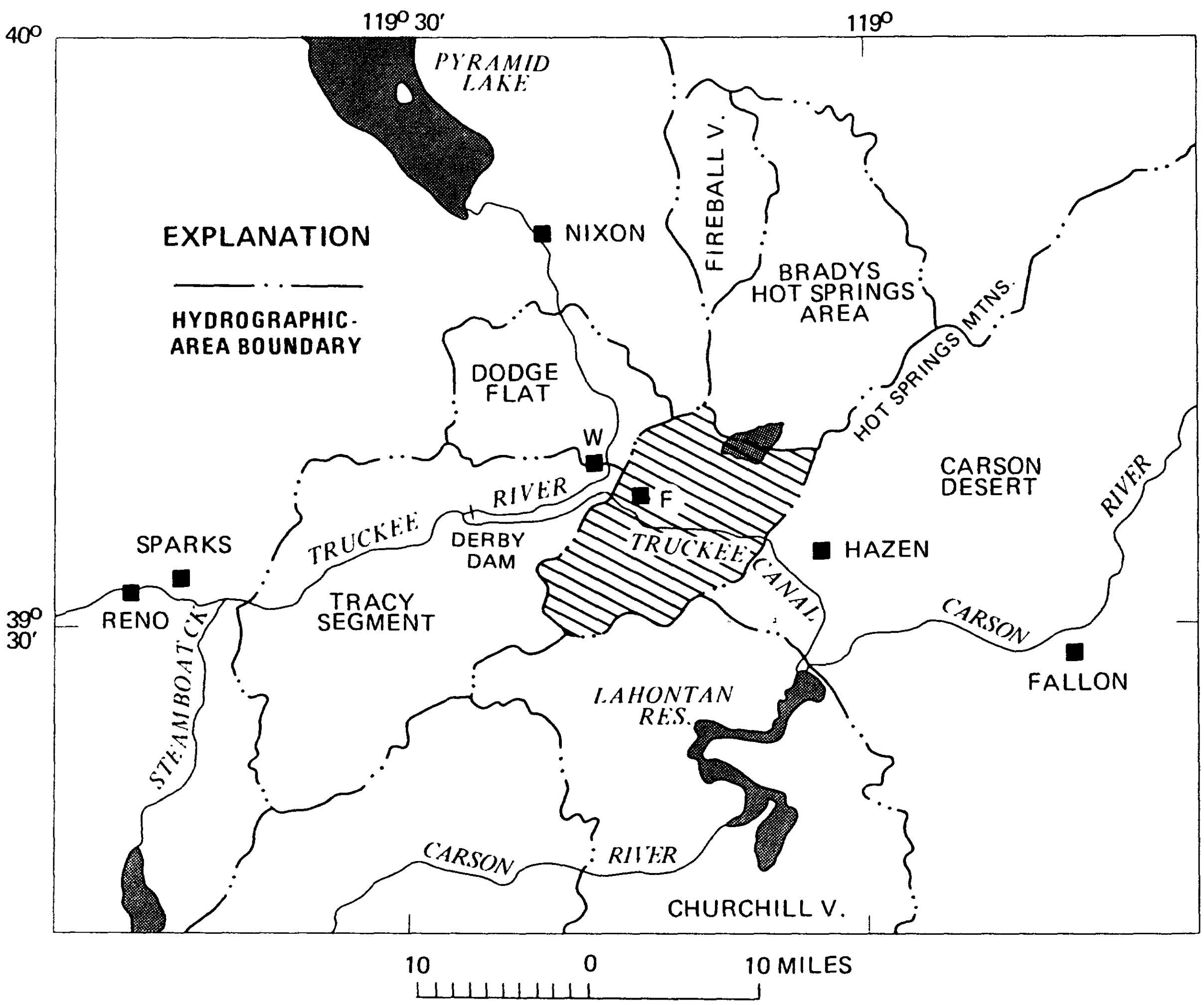

FIGURE 1.--Location of the Fernley Hydrographic Area (line pattern) and surrounding geographic features. Town abbreviations: F, Fernley; W, Wadsworth.

DESCRIPTION OF THE STUDY AREA

The study area, which includes the town of Fernley, coincides with the Fernley Hydrographic Area as shown by Rush (1968, plate 1). The area is bounded on the west by the Truckee River basin, on the north by the Truckee Range, on the east by the Hot Springs Mountains, and on the south by the Virginia Range. Adjacent hydrographic areas in addition to those of the Truckee River basin comprise the Bradys Hot Springs area to the northeast, the Carson Desert to the southeast, and Churchill Valley to the south (figures 1 and 2).

The 120-square-mile Fernley Hydrographic Area includes part of the Fernley Sink, an ephemeral lake which is the terminus for southwestward surface drainage from the Bradys Hot Springs and Fireball Valley Hydrographic Areas as well as northeastward drainage from the Fernley area (figure 1). As defined by Rush (1968, plate 1), the Fernley Hydrographic Area also includes a small drainage (2-3 square miles) west of the town of Fernley that is tributary to the adjacent Truckee River (figure 2).

Geologic and geohydrologic characteristics of the study area are discussed by Sinclair and Loeltz (1963, pages 5-9) and, in a more generalized way, by Van Denburgh and others (1973, pages 11-14).

The economy of the Fernley area is based primarily on agriculture. Irrigation water is provided from the Truckee River by way of the Truckee Canal, which also carries flow across the Fernley area to Lahontan Reservoir in the adjacent Carson River basin (figure 1). North-flowing drainage from the irrigated areas (and from the hot-spring area 7½ miles east of Fernley; see figure 2) supports marshland vegetation in the adjacent Fernley State Wildlife Management Area. The major industry in the Fernley area is the dry-process cement plant of the Nevada Cement Co., which has been in operation since 1964. As of 1980, it employed 120 people. Part of the study area is undergoing rapid urban development because of its proximity to the Reno-Sparks metropolitan area, resulting in a transition from rural agriculture to a suburban community. During each of the two decades between 1960 and 1980, the population has more than doubled, from about 650 in 1960 to about 1,470 in 1970 and about 3,310 in 1980 (U.S. Bureau of the Census, 1981, page 30-10; based on data for the Canal Township of Lyon County).

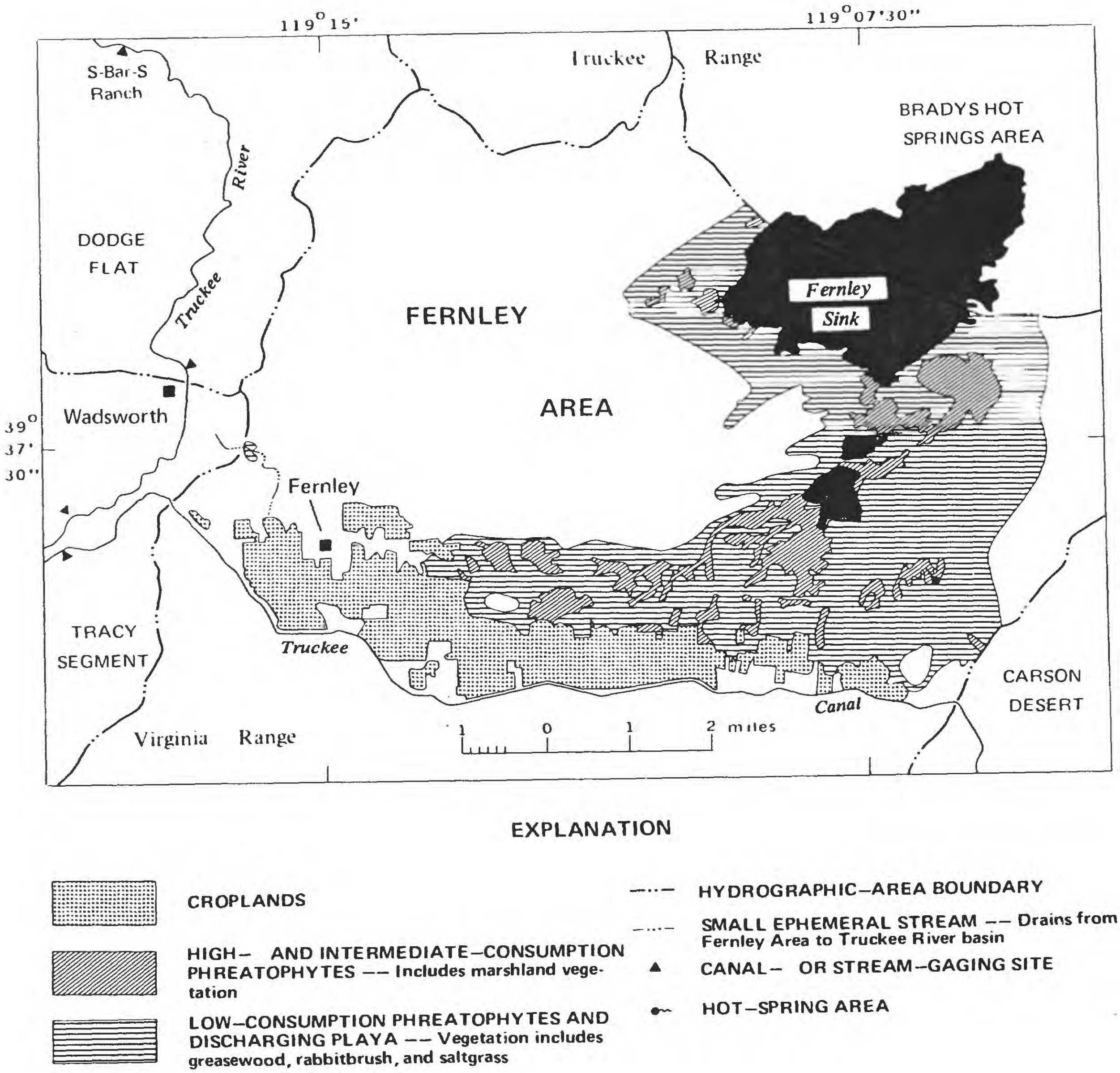

FIGURE 2.--Croplands and areas of natural evapotranspiration in the northern part of the Fernley Area as of August 1973, and geographic features in and adjacent to the area. Hazen gage on Truckee Canal is off map, about 3½ canal miles southeast of hydrographic-area boundary between Fernley Area and Carson Desert. Areal distribution of croplands and phreatophytes is based on color infrared photographs (U.S. National Aeronautics and Space Administration, scenes 573001336-1804 and 1828, August 23, 1973; scale, 2,570 feet per inch) and reconnaissance-level field mapping by A. S. Van Denburgh in 1970 and 1984.

WATER BUDGET

General Description

The interrelation between present-day components of inflow to and outflow from the Fernley Hydrographic Area is complex. Currently superimposed upon a rather straight-forward natural hydrologic system is the importation of surface water for irrigation, which began in the early 1900's, and the pumpage of ground water for industrial and public-supply purposes, which commenced much more recently. Before accelerated urbanization began in the Fernley area, the surface-water irrigation could be considered to have become, over the long term, a steady-state component of the hydrologic system. The urbanization, however, has begun to have an impact on the hydrologic system. Formerly irrigated acreage is being converted to residential and commercial use, and the newly urbanized areas are being served by public-supply pumpage from wells. As a result, less land is irrigated and more ground water is pumped for public supply; between 1969 and 1979, the pumpage more than tripled, from 143 to 496 acre-ft/yr (Van Denburgh and others, 1973, page 50; John Morrow, Fernley Water District, written communication, 1980). These factors, along with industrial pumpage (mostly by the Nevada Cement Co.), can be considered to have altered the former long-term steady-state conditions in the Fernley area. The effect as of 1979 is thought to have been slight, however.

Table 1 represents an attempt to identify and quantify the components of a water budget for average conditions as of 1979 and to delineate the relation between inflow to and outflow from the study area. The phrase "average conditions as of 1979" encompasses (1) long-term average conditions for budget items that are still little affected by the activities of man and for items related either directly or indirectly to surface-water irrigation in the study area, and (2) conditions as of 1979 with regard to urbanization of former croplands and increasing ground-water pumpage.

The budget in table 1 differs from that of Van Denburgh and others (1973, page 57) in several significant respects. The most apparent difference is that Van Denburgh and his coworkers dealt with the total quantities of imported and exported canal water, whereas table 1 deals with only the net amount that remains, at least temporarily, within the study area (that is, canal seepage and diversions). Another significant difference is that table 1 delineates several individual outflow components that were grouped together and calculated by difference in the reconnaissance budget (Van Denburgh and others, 1973, page 57, footnote b). Finally, ground-water outflow to the Truckee River basin and the Carson Desert has been reappraised relative to the reconnaissance estimates of Van Denburgh and others (1973, page 44).

The following sections discuss individual components of the budget and describe the relation between inflow and outflow.

TABLE 1.--*Water budget for average conditions as of 1979*

Budget component	Estimated quantity (acre-feet per year)
INFLOW	
Natural recharge	600
Ground-water inflow	0
Canal seepage	18,000
Canal diversions	26,000
Total inflow (rounded)	45,000
OUTFLOW	
Ground-water outflow to:	
Truckee River basin	9,000
Bradys Hot Springs area	1,000
Carson Desert	400
Surface-water outflow to:	
Tracy Segment	minor
Bradys Hot Springs area	4,000
Net lake-surface evaporation	6,100
Evapotranspiration from:	
Croplands	15,000
Phreatophytes and discharging playa	7,600
Consumptive use of industrial and public-supply ground-water pumpage	600
Consumptive use of rural domestic pumpage	minor
Total outflow (rounded)	44,000
IMBALANCE BETWEEN ESTIMATED INFLOW AND OUTFLOW [a]	1,000

[a] See report section titled "Relation Between Inflow and Outflow."

Components of Inflow

Natural Recharge from Precipitation

Natural recharge from precipitation in the higher-altitude parts of the Fernley Hydrographic Area was earlier estimated to average about 600 acre-ft/yr (Van Denburgh and others, 1973, page 39). That value is still considered to be correct in magnitude.

Ground-Water Inflow

Water-level data for wells indicate that the water-table altitude in valley-fill deposits is higher in the Fernley Hydrographic Area than in the surrounding hydrographic areas (Tracy Segment and Dodge Flat to the west, Bradys Hot Springs area to the northeast, and Carson Desert to the southeast; figure 2). Thus, shallow ground water flows outward from, rather than inward to, the study area by way of the valley fill. (Data regarding directions of flow in deep valley-fill deposits are unavailable.)

Within consolidated rocks north, south, and east of the valley fill (Van Denburgh and others, 1973, plate 1), the ground-water divide may not everywhere coincide with the topographic divide. Regardless, no appreciable amount of ground water is known to flow into or out from the Fernley area by way of the consolidated rocks.

Canal Seepage

The Truckee Canal, which extends from Derby Dam on the Truckee River to Lahontan Reservoir in the Carson River basin, passes through the Fernley area (figure 1). The canal flow has been gaged near Wadsworth and near Hazen by the U.S. Geological Survey since October 1966. Diversions between the two gages provide irrigation water for the Fernley agricultural area, which lies entirely within the Fernley Hydrographic Area (figure 2), and for the smaller Hazen agricultural area, which is in the adjacent Carson Desert Hydrographic Area east of Fernley. Records of diversion from the canal have been collected by the Truckee-Carson Irrigation District.

The canal also loses water as a result of seepage. In the 16.7-mile reach between the Wadsworth and Hazen gages, about 97 percent of the canal is unlined. The amount of seepage loss in this reach can be calculated by subtracting the estimated diversions from the difference in flow between the gages. Included in this net difference in addition to seepage, however, are (1) any errors in measurements of canal flow and diversions, (2) unmeasured diversions, and (3) a proportionally very small amount of canal-surface evaporation.

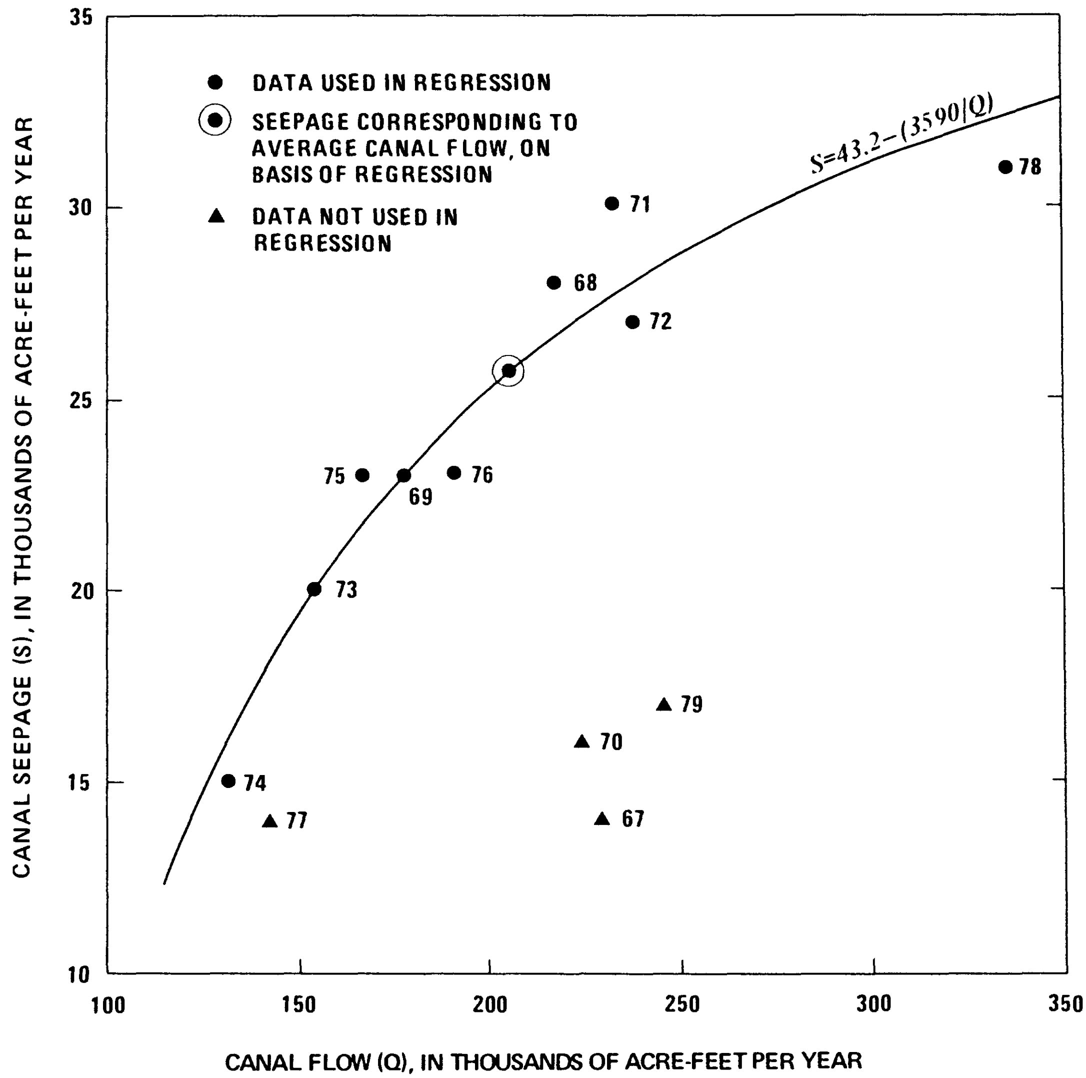

FIGURE 3.--Relation between canal flow at the Wadsworth gage and estimated canal seepage between the Wadsworth and Hazen gages, calendar years 1967-79. Each data point is identified by the last two digits of its calendar year. Regression line and equation are indicated for calendar years 1968-69, 1971-76, and 1978.

Canal seepage losses for calendar years 1967-79 have been evaluated by Jon O. Nowlin (U.S. Geological Survey, written communication, 1984). Figure 3 shows the relationship between estimated annual seepage losses and measured canal inflow at the Wadsworth gage. The seepage losses are, for most years, proportional to canal flow, but the increment of seepage per unit increase in canal flow is greater at low flows than at high flows. Data for 1967, 1970, and 1979 do not follow the general relationship expressed by the remainder of the data. A plot of canal outflow at the Hazen gage versus estimated seepage shows that the same three years, along with 1977, are anomalous to the general relationship. In addition, these four years have months of "negative" estimated seepage losses (that is, recorded diversions from the canal between the two gages exceeded the calculated difference in flow between the gages, indicating errors in the gage record, diversion record, or both). On the basis of these indications of error, the data for 1967, 1970, 1977, and 1979 have been removed from consideration in the following analysis. The remaining data, for calendar years 1968-69, 1971-76, and 1978, indicate that estimated annual seepage ranged from 15,000 to 31,000 acre-feet and averaged about 24,000 acre-feet (table 2).

TABLE 2.--*Annual flows, diversions, and estimated seepage losses for the Truckee Canal, 1968-69, 1971-76, and 1978*

[Quantities in thousands of acre-feet per calendar year]

	Gaged flow in Truckee Canal[1]			Diversions from canal[2]			
	Inflow (Wadsworth gage)	Outflow (Hazen gage)	Difference	To Fernley area	To Hazen area	Total, rounded	Estimated seepage loss[3]
Year	[*A*]	[*B*]	[*C*]=[*A*]-[*B*]	[*D*]	[*E*]	[*F*]=[*D*]+[*E*]	[*C*]-[*F*]
1968	216	152	64	31.6	4.4	36	28
1969	178	123	55	27.7	4.7	32	23
1971	231	170	61	26.5	4.4	31	30
1972	236	179	57	25.6	4.0	30	27
1973	155	103	52	27.6	4.6	32	20
1974	132	83	49	29.4	4.4	34	15
1975	166	113	53	26.5	3.7	30	23
1976	190	145	45	19.0	2.7	22	23
1978	335	283	52	18.4	2.6	21	31
Average	204	150	54	25.8	3.9	30	24

[1] Published data (U.S. Geological Survey, 1969-80).

[2] Records from Truckee-Carson Irrigation District (M. W. Bianchi, U.S. Bureau of Reclamation, written communication, 1979).

[3] Estimates include net effect of errors in canal-flow and diversion records.

For the same period of record, the data in figure 3 can be fitted by nonlinear least-squares regression to an equation of the form:

$$S = A + B/Q ,$$

where S = annual seepage loss between the Wadsworth and Hazen gages,
Q = the annual canal inflow at the Wadsworth gage, and
A, B = regression constants.
The resulting equation is:

$$S = 43.2 - (3,590/Q) ,$$

in which S and Q are expressed in thousands of acre-feet per year. For this relation, the statistical coefficient of determination (r^2) is 0.92, which indicates that 92 percent of the total variation in seepage can statistically be attributed to the relationship with canal inflow. The standard error of estimate for this relationship is 1.5, indicating that about two thirds of the estimated seepage values (table 2) are within 1,500 acre-ft/yr of the values predicted from the relationship with canal inflow. On the basis of the above equation, the average canal inflow of 204,000 acre-ft/yr at the Wadsworth gage would produce an estimated seepage loss of about 26,000 acre-ft/yr from the 16.7-mile reach between the Wadsworth and Hazen gages. This value is considered more accurate than the arithmetic average of 24,000 acre-ft/yr listed in table 2 because of the nonlinear relation between seepage and canal flow.

The amount of seepage from the 11.1-mile reach of canal within the Fernley Hydrographic Area can be estimated by assuming that the loss per mile is approximately constant over the entire unlined part of the 16.7-mile reach between the two gages. The resulting average rate of seepage is 1,600 acre-ft/yr per mile. Under this assumption, the canal contributed an average of about 18,000 acre-feet of seepage per year within the Fernley area.

Canal Diversions

Diversions to the Fernley agricultural area averaged about 26,000 acre-ft/yr for the overall period 1968-69, 1971-76, and 1978 (table 2). This total included an average of about 1,200 acre-ft/yr of stock water (Willis Hykes, Truckee-Carson Irrigation District, oral communication, 1984).

Components of Outflow

Ground-Water Outflow

Ground-water underflow through valley-fill deposits is thought to leave the Fernley Hydrographic Area in three directions: Northwestward to the Tracy Segment and Dodge Flat Hydrographic Areas in the Truckee River basin, northeastward to the Bradys Hot Springs Hydrographic Area, and southeastward to the Carson Desert.

Truckee River Basin

Van Denburgh and others (1973, pages 42-44) calculated an outflow of 2,100 acre-ft/yr to both the Dodge Flat and Tracy Segment Hydrographic Areas (figure 2), on the basis of a form of Darcy's law, but stated that seepage gains measured in the nearby Truckee River during a period of low flow indicate that the calculated values may be low. The measurements, made on September 2, 1971 (U.S. Geological Survey, 1972, page 174), indicate that the gain in Dodge Flat between the Wadsworth streamgage and the S-Bar-S Ranch (figure 2) was about 10 ft^3/s, much of which is thought to have originated east of the river. More recent data indicate gains in the same river reach of 11 to 14 ft^3/s. These data were collected in April, July, and August 1979 (Joseph I. Burns, of Murray, Burns and Kienlen, written communication, 1980) and in December 1979 (Bratberg, 1980, pages 24-25; these measurements were made cooperatively with the Geological Survey for use in both the current study and Bratberg's thesis study). Thus, the measured increment to the river in Dodge Flat between the Wadsworth gage and the S-Bar-S Ranch has ranged from 10 to 14 ft^3/s. The average of the measured gains is about 12 ft^3/s. On the basis of the hydrologic setting in the vicinity of Wadsworth, about two-thirds of the average gain, or 8 ft^3/s, is estimated to originate east of the river as inflow from the Fernley area. The estimated outflow to Dodge Flat would therefore be on the order of 6,000 acre-ft/yr, rather than the 2,100 acre-ft/yr of Van Denburgh and his coworkers.

A similar evaluation suggests that the earlier estimate of 2,100 acre-ft/yr for ground-water outflow to the Tracy Segment (Van Denburgh and others, 1973, page 44) also may be low. The low-flow measurements of September 2, 1971, for the river indicate that the gain between a site in NW¼SE¼ sec. 8, T. 20 N., R. 24 E. and the Wadsworth gage was about 8 ft^3/s (U.S. Geological Survey, 1972, page 174). [The upstream site on the river is adjacent to the Wadsworth canal gage (see figure 2) and downstream from the last canal return-flow to the river.] The average annual rate of gain is assumed to be about 8 ft^3/s. About one-third of that quantity is estimated to originate northwest of the river, on the basis of the hydrologic setting in the vicinity of the river and canal. The inflow from southeast of the river in the Tracy Segment would therefore be on the order of 3,900 acre-ft/yr. Some of that increment doubtless represents seepage from the 0.75 mile of unlined canal in the 1.5-mile reach between the Wadsworth canal gage and the Fernley area. Using a seepage rate of 1,600 acre-ft/yr per mile (see earlier section titled "Canal Seepage"), about 1,200 acre-feet of the 3,900-acre-foot annual quantity would originate within the Tracy Segment, and the remainder, about 3,000 acre-feet (rounded), would originate within the Fernley Area.

Thus, the combined ground-water outflow to the Truckee River basin from the Fernley Hydrographic Area is thought to be on the order of 9,000 acre-ft/yr (that is, about 6,000 acre-ft/yr to Dodge Flat plus about 3,000 acre-ft/yr to the Tracy Segment), rather than the 4,200 acre-ft/yr of Van Denburgh and his coworkers.

Bradys Hot Springs Area

Ground-water underflow to the Bradys area from the Fernley area was earlier estimated to be 1,000 acre-ft/yr (Harrill 1970, pages 16-17). That quantity is still considered to be correct in magnitude.

Carson Desert

Ground-water underflow to the Carson Desert in valley-fill deposits at the drainage divide was earlier estimated at about 800 acre-ft/yr (Van Denburgh and others, 1973, page 47). This value was calculated by using a form of Darcy's law that includes transmissivity as a term. The transmissivity value Van Denburgh and his coworkers estimated for the valley-fill deposits is equivalent to about 7,000 ft^2/d, which seems high for two reasons: (1) it is twice the value chosen for presumably similar deposits northwest of Fernley (Van Denburgh and others, 1973, page 44), and (2) recent geophysical work (Douglas K. Maurer, U.S. Geological Survey, written communication, 1984) suggests that the saturated thickness of valley-fill deposits that transmit the underflow in the vicinity of the drainage divide is significantly less than earlier assumed. For these reasons, the estimated ground-water underflow to the Carson Desert is herein revised to 400 acre-ft/yr--half the earlier value.

Surface-Water Outflow

Surface water leaves the Fernley Hydrographic Area as westward flow to the Tracy Segment of the Truckee River basin by way of a small ephemeral stream channel in the SE¼ of sec. 3, T. 21 N., R. 24 E. (Van Denburgh and others, 1973, page 36). The flow quantity is considered minor in comparison to other budget components in table 1.

The northeastern boundary of the Fernley Hydrographic Area bisects the Fernley Sink (figure 2). Evaporation from the lake, including that part in the adjacent Bradys Hot Springs Hydrographic Area, is fed almost exclusively by surface-water inflow to the lake from the Fernley area. Thus, the increment that evaporates northeast of the boundary enters the Bradys area as lake-water inflow from the Fernley area before evaporating. The average amount of lake-water inflow to the Bradys area was estimated as 4,000 acre-ft/yr by Harrill (1970, page 16). That quantity is still considered to be correct in magnitude for northeastward lake-water outflow from the Fernley area.

Net Lake-Surface Evaporation

Within the Fernley Hydrographic Area, evaporation in excess of lake-surface precipitation at the Fernley Sink and at two small reservoirs south of the sink (figure 2) was estimated to be 6,100 acre-ft/yr, on the basis of an estimated net evaporation rate of 3.6 ft/yr (Van Denburgh and others, 1973, pages 57 and 60). This value is still considered to be correct in magnitude.

Evapotranspiration

Large quantities of surface water and ground water are dissipated by evaporation and transpiration from croplands, native phreatophytic vegetation, and bare playa in the Fernley area.

Croplands

Irrigated croplands in the Fernley Hydrographic Area as of 1973 are estimated to have totaled about 3,660 acres (figure 2), on the basis of color infrared photographs (U.S. National Aeronautics and Space Administration vertical aerial photographs, scenes 573001336-1804 and 1828, August 23, 1973; scale, 2,570 feet per inch). Between August 1973 and August 1980, about 120 acres of cropland were converted to residential and commercial use (on the basis of a comparison of the photographs referred to above and the frontispiece photograph). If the urbanization took place at a relatively constant rate during that 7-year period, about 100 acres would have been converted by mid-1979. Therefore, the cropland total as of mid-1979 would have been 3,560 acres. Crop evapotranspiration is assumed to average 4.3 feet per year, on the basis of calculations made for the Fernley area by Pennington (1980, pages 54-55). Therefore, average annual cropland evapotranspiration was an estimated 15,000 acre-feet.

Phreatophytes and Bare Playa

In areas of shallow ground water, discharge from the ground-water reservoir (outflow) occurs by evaporation from the soil surface and by transpiration from plants known as phreatophytes, whose roots tap the ground-water reservoir. Areas of natural evapotranspiration are shown in figure 2, and estimates of ground-water discharge are as follows:

Category of discharge	Area (acres)	Estimated average annual discharge by evapotranspiration: Feet	Estimated average annual discharge by evapotranspiration: Acre-feet
1. Bare playa	[a]700	0.1	70
2. Low-consumption phreatophyte assemblage (mostly greasewood, rabbitbrush, and scattered saltgrass)	8,700	.3	2,600
3. Intermediate-consumption assemblage (includes very dense saltgrass and patches of wildrye)	900	.8	700
4. High-consumption assemblage (includes very dense saltgrass, wildrye, tules, and willow; very moist setting)	1,400	3	4,200
Total (rounded)	12,000	—	7,600

[a] From Van Denburgh and others (1973, page 52).

The areal distribution of phreatophytes is based on the color infrared photographs referred to in the section titled "Croplands," and on reconnaissance-level mapping in 1970 and 1984. (Urbanization has not as yet reduced phreatophyte acreage significantly.) Estimated rates of evapotranspiration for categories 1, 2, and 3, in feet per year, are based on values listed in earlier Geological Survey reports for hydrologic settings and vegetation assemblages similar to those in the Fernley area (for example, see Harrill, 1973, page 42, and Van Denburgh, 1981, page 42). The estimated rate for the marshland environment (category 4) is arbitrarily taken as an average of the rate for category 3 (0.8 ft/yr) and the estimated rate for croplands (4.3 ft/yr), rounded off to one significant figure.

Total ground-water discharge by evapotranspiration from phreatophytes and bare playa is an estimated 7,600 acre-ft/yr.

Consumptive Use of Ground-Water Pumpage

In the study area as of 1979, ground water was pumped mostly for industrial use (Nevada Cement Co.) and public supply (Fernley Water District). Consumptive use of pumpage at the cement plant may have been on the order of 500 acre-ft/yr in 1979, on the basis of information provided by the company (Edward M. Rajki, written communication, 1979). Public-supply pumpage in 1979 totaled 496 acre-feet (John Morrow, Fernley Water District, written communication, 1980). About 30 percent of the total pumpage (that is, about 150 acre-feet) is assumed to have been consumed by evapotranspiration, while the remainder (about 350 acre-feet) is assumed to have returned to the ground-water system as percolation, on the basis of estimates made by Harrill (1973, pages 63-64) for comparable urban areas in Lemmon Valley. Thus, consumption of industrial and public-supply pumpage may have been on the order of 600 acre-ft/yr (rounded).

Pumpage from individually owned domestic wells in rural areas outside the public-supply service area is not evaluated quantitatively because both the aggregate domestic pumpage and the net consumption thereof are assumed to be small in comparison to either the industrial or the public-supply quantities. In addition, the domestic pumpage is geographically widespread, rather than localized as are the industrial and public-supply withdrawals.

Relation Between Inflow and Outflow

The hydrologic system in the Fernley Hydrographic Area is thought to be in a state of long-term equilibrium except for the as yet minor effects of diminishing irrigated acreage and increasing consumption of industrial and public-supply pumpage. Under this assumption, average total outflow and average total inflow as of 1979 would have been approximately equal. Table 1 indicates that total estimated outflow is less than total estimated inflow by about 1,000 acre-ft/yr. The discrepancy is thought to represent a net error resulting largely from the inaccuracy of individual budget estimates in table 1. Because values for the two principal components of inflow (canal seepage and diversions) are based on measurements, whereas all components of outflow are estimated, the total inflow listed in table 1 (45,000 acre-ft/yr) is considered more accurate than the estimated value for total outflow. Therefore, the value selected to represent both inflow and outflow for average conditions as of 1979 is 45,000 acre-ft/yr.

CONCLUSIONS

The water-budget results in table 1 for average conditions as of 1979 contrast with the earlier reconnaissance estimates of Van Denburgh and others (1973, page 57) in several respects:

1. Recent evaluation of a 13-year record of canal flows and diversions indicates that the contribution to the study area by the Truckee Canal was about 11,000 acre-ft/yr less than the earlier estimate; that is, 44,000 acre-ft/yr, rather than about 55,000 acre-ft/yr (the latter value is the difference between the imported and exported quantities listed by Van Denburgh and coworkers).

2. Reevaluations of ground-water outflow suggest that the total is about 4,000 acre-ft/yr greater than was estimated earlier; that is, about 10,000 acre-ft/yr, rather than 6,000 acre-ft/yr (Van Denburgh and coworkers incorrectly listed the reconnaissance total as 5,800 acre-ft/yr).

3. In the earlier reconnaissance budget, the combined outflow attributable to evapotranspiration and consumption of ground-water pumpage was calculated by difference; the computed total was 39,000 acre-ft/yr. In contrast, table 1 lists individual values for each component. The several items in table 1 total about 23,000 acre-ft/yr, which is 16,000 acre-ft/yr less than the earlier reconnaissance estimate.

For average conditions as of 1979, the overall budget for the study area involved about 45,000 acre-ft/yr of inflow and an approximately equal amount of outflow. Under natural (pre-canal) conditions, in contrast, both inflow and outflow presumably were on the order of only 600 acre-ft/yr (that is, natural ground-water recharge, balanced by an equivalent amount of natural discharge). The pronounced differences between natural conditions and those of 1979 are directly or indirectly a result of canal seepage and diversions. Thus, the several interrelated components of present-day outflow from the study area (table 1) are closely dependent upon the two components of canal inflow. As a result, any significant future alteration of inflow (for example, a reduction or elimination of seepage by lining the canal) would have a pronounced long-term impact on the balance among outflow components. Any attempt to salvage present-day outflow could also have a long-term effect. Regardless, a discussion of the quantitative hydrologic impacts and the environmental, social, financial, and political merits and detriments of alternative water-management scenarios in the Fernley area is beyond the scope of this report.

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