

GROUND-WATER PUMPING IMPACTS ON  
SURFACE WATER IRRIGATION DIVERSIONS  
FROM BIG LOST RIVER

by

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## ABSTRACT

The water table in the Big Lost River valley is declining due to increased irrigation pumpage and decreased recharge from surface-water irrigation, resulting from the use of more efficient application methods and an accompanying expansion to about twice the irrigated acreage of two decades ago. The lower water table reduces the already deficient river flows, and impacts the senior water rights of many surface water irrigators.

Recorded irrigation diversions have decreased in relation to river flow in the last two decades. Diversions are estimated to be depleted by about 30,000 acre-feet per year in dry periods, such as 1987 through 1990. Depletion of diversions is estimated by a linear relationship to river flow, based on data from below normal water years. Extrapolating that relationship to all years, the depletion in a normal water year is estimated to be 13,000 acre-feet. A negative relationship between ground-water pumpage and river flow was extrapolated to estimate pumpage as 47,000 acre-feet during a normal water year.

Senior surface-water irrigators are due mitigation from those depleting river flows. The mitigation may take any of several forms, but should be supported by a self-funding group of ground-water, or combined surface and ground-water irrigators in the valley.



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## STATEMENT OF THE PROBLEM

Many irrigation wells have been constructed in Big Lost River valley since 1960. The ground-water resource over much of the valley is hydraulically interconnected with the Big Lost River; consequently, ground-water pumpers often are accused of depleting the already deficient supplies of surface water irrigators. The water right priorities of surface water irrigators generally are far senior to ground-water users, suggesting that the liability for stream depletion rests with the ground-water pumpers.

The stream depletion issue is clouded by several factors. The complicating conditions include:

- 1) River depletion by ground-water pumping is neither instantaneous nor equal in magnitude to the amount of water pumped. The attenuation of pumping effects are influenced by the location of the well with respect to hydraulically connected reaches of the river, the physical properties of the aquifer formation, and the depth from which the well extracts water.
- 2) The river reaches that are hydraulically connected to the ground water and the degree of hydraulic interconnection vary from year to year, and even from season to season, depending upon the depth of the water table. During droughts, the water table in the lower parts of the valley drops well below the river bottom, and the effects of further decline in water table are probably minimal.
- 3) Surface water often is conveyed through the canals rather than the river channel to reduce seepage losses. Therefore, pumping impacts on surface water also are related to canal seepage in the lower valley.



4) Ground-water pumping is only one component of a combination of factors that are impacting ground-water levels and the depletion of surface water supplies. The greatest impact results from variation in precipitation. In addition to climatic variability, the widespread conversion from flood irrigation to sprinklers, and the associated expansion of irrigated acreage, have diminished ground-water recharge and increased discharge.

Ground-water pumping undoubtedly is one of several developments which affects flows in the surface channels in Big Lost River valley. Water supply conditions of earlier years, however, can only be restored fully by returning to the practices and irrigated acreage of those years. The economic consequences of such drastic measures would certainly be severe and undesirable. Resolution of the conflict for the water resources should therefore focus on an efficient and equitable use of the resource, based on the appropriate legal considerations and the best available hydrologic knowledge.



## OBJECTIVES

The general objective of this report is to assess the impact of ground-water pumping on surface-water flows and evaluate the alternatives for resolution of the conflict.

Specific objectives include:

- 1) to develop an understanding of the operation of the irrigation system in Big Lost River valley, and the historic changes that have occurred in that system,
- 2) to collect, assemble, and summarize the available and pertinent information on the water supply and irrigation diversions in the valley,
- 3) to relate changes in available water to changes in irrigation practices in the valley, especially the expansion of ground-water pumping,
- 4) as far as possible, to quantify the impact of ground-water pumping on surface water supply, and describe the limitations and assumptions associated with that determination, and
- 5) to recommend a procedure or procedures for compensating surface water users for flows lost as a result of ground-water pumping.

## METHODS OF ANALYSIS AND DATA DESCRIPTION

In this study, the effects of pumping on surface-water supplies are evaluated by examination of historic changes in water supply and delivery that have occurred since the expansion of ground-water pumping, beginning about 1960. This method requires long-term records of precipitation, river discharge, and irrigation diversions.

Climatic variations have had a significant impact on water availability in the basin. However, the effects of climate variation on the results of this study were minimized by comparison of similar water years and the use of long periods of record.

Big Lost River discharge is available from U.S. Geological Survey Records for extended periods at three stations: 1) at Howell Ranch (13120500) in the upper part of the valley, 2) below Mackay Dam (13127000), and 3) below Arco (13132500). The locations of these stations are shown in figure 1. Data on summer flows at Howell Ranch are available for all years as early as 1920. Year-round data is available since 1949. There are about 3,000 acres of irrigated land above the Howell gage (U.S. Geological Survey, 1991). The station below Mackay Dam includes all water released from Mackay Reservoir except that diverted in the Sharp ditch. The discharge of the Sharp ditch has been recorded in watermaster records for Water District 34. A



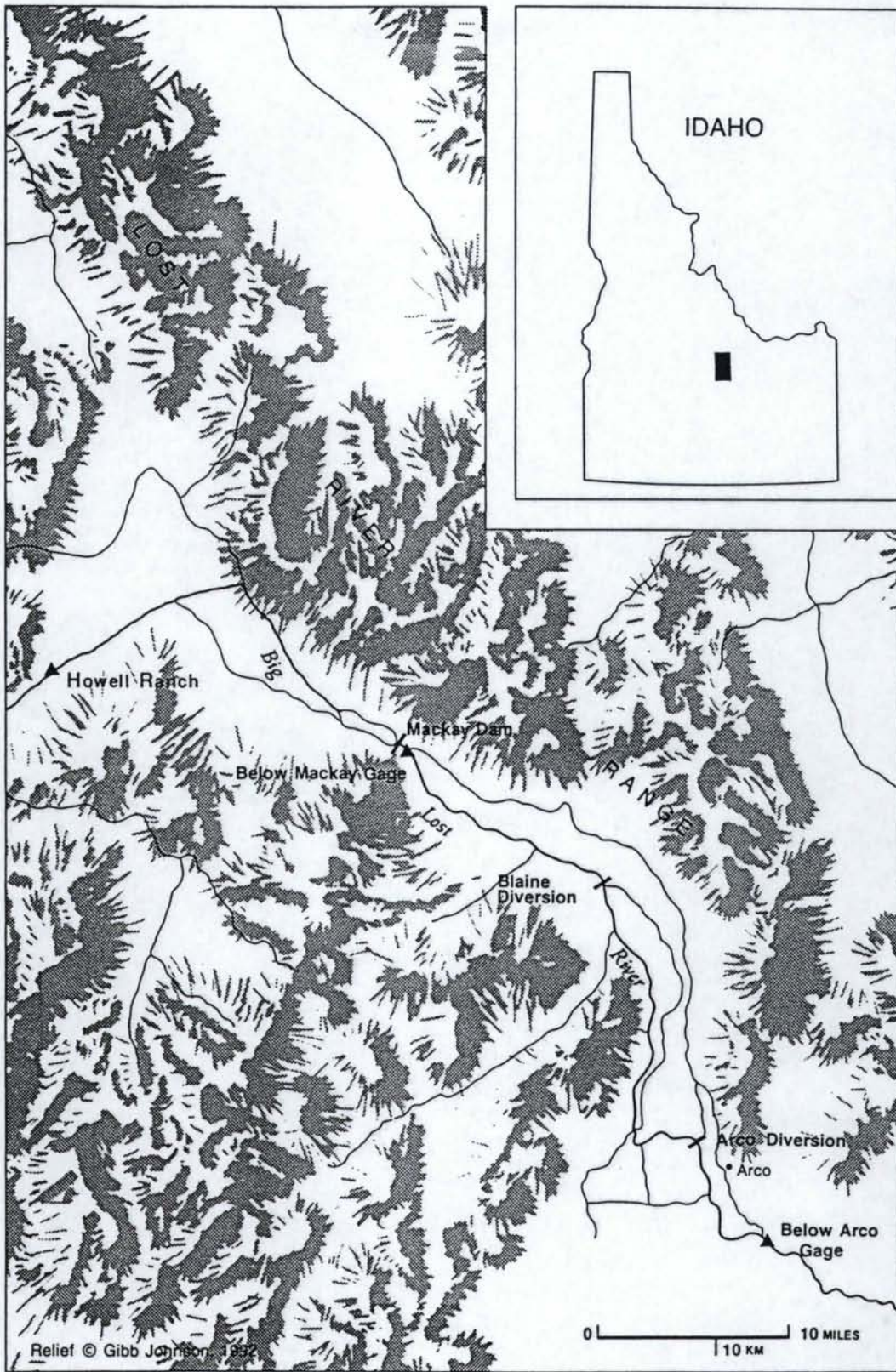


Figure 1. Map of Big Lost River Valley.



continuous record is available from the station since 1919. The station below Arco is below all major irrigation diversions in the Big Lost River valley. Discharge at the Arco station is available from 1946 through 1961, 1966 through 1980, and from 1982 through 1990. Storage in Mackay Reservoir also is available continuously since 1919. Monthly values of river flows and reservoir storage are listed in Appendix A.

Irrigation diversion records for the Big Lost River Water District dating back to 1923 were collected from the Idaho Department of Water Resources for this study. Annual summaries, prepared by the watermaster of Water District 34, were the source of information on the monthly volume of irrigation diversions for four reaches of Big Lost River (shown in figure 1): 1) Above Mackay Dam, 2) Mackay Dam to Blaine Diversion, 3) Blaine Diversion to Arco, and 4) below Arco. In the early records, the diversions were only distributed into two reaches: Above and below Mackay Dam. Annual summaries could not be obtained for 1938, 1939, 1941, 1955, and 1971 water years. Monthly diversion data from 1922 through 1990 are presented in Appendix B.

The validity of diversion records is uncertain. Changes in watermasters and measuring devices may have caused differences in diversion records over the years. Although the results of this study are sensitive to the

accuracy of the records, methods of analysis are employed that minimize that sensitivity.

Monthly values of river discharge, reservoir storage, precipitation at Mackay and Arco, and irrigation diversions were compiled and stored in a DBASE III+ format. These records were analyzed graphically and statistically using several commercially available software packages.

The water year used by the Big Lost River Water District 34, extending from November 1 to October 31 of the following year, was used as the base for all annual values presented in this report. Flow and storage volumes are consistently presented in acre-feet.



## WATER SUPPLY AND IRRIGATION IN BIG LOST RIVER VALLEY

The Big Lost River basin is a mostly mountainous area of 1,400 square miles in south-central Idaho (figure 1). The area is drained by the Big Lost River and tributaries. All surface-water and ground-water discharge from the basin is tributary to the Snake Plain aquifer. The estimated average annual water yield of the basin is 470,000 acre-feet (Crosthwaite and others, 1970). In 1970, Crosthwaite and others estimated that an average of 54,000 acre-feet were lost as surface water discharge to the Snake River plain, 308,000 acre-feet were discharged as subsurface flow, and 109,000 acre-feet were lost by evapotranspiration, annually. Mackay Reservoir, on the Big Lost River near Mackay, has a current storage capacity of about 44,000 acre-feet, and is principally used to store snowmelt runoff for irrigation.

Irrigated agriculture is concentrated on the coarse alluvial deposits of the Big Lost River valley. In 1970, Crosthwaite and others estimated the acreage irrigated by flow from Big Lost River above Mackay Reservoir to be 12,680 acres, and 36,540 acres irrigated below the reservoir. They determined that an additional 8,500 acres were irrigated from ground-water, at that time. Prior to 1960, stream flow supplied nearly all the irrigation water. However, since 1960, many wells have been constructed to supplement the surface water supplies and irrigate new lands.



Concurrently, there has been a partial conversion from flood irrigation to sprinkler application methods and an expansion of the irrigated acreage.

The Big Lost River basin is divided into two principal parts for this analysis, above and below Mackay Dam. These areas represent distinct and somewhat independent units from water supply and irrigation management perspectives. This report focuses on lands below the dam, where most of the recent irrigation development has occurred. Irrigation below Mackay Dam is regulated separately from that above the dam except in periods of high flow, when the river is considered to be a single water body throughout its entire length. Irrigation supplies below the dam are supplemented by reservoir storage. Big Lost River flow below Mackay Dam is measured by a gaging station near Mackay and a station on the Sharp irrigation ditch. A relatively small amount of underflow, 15 cfs (Crosthwaite and others, 1970), is estimated to occur in the alluvium at the gaging station near Mackay. Several small tributaries to Big Lost River also contribute to water supply below the dam.

## HISTORIC WATER SUPPLY PATTERNS

Annual and seasonal variations in precipitation on the Lost River watershed result in variations in streamflow and in the amount of water available for irrigation and for ground-water recharge. The total annual, and winter precipitation at Mackay for the period of 1925 through 1989 are shown in figure 2. Annual values are expressed on a water year basis, extending from November 1 through October 31 of the following year, matching the water year normally used by the water district. Low elevation annual precipitation records, such as at Mackay, do not show a high degree of correlation to annual stream flow. Only the general wet and dry periods of precipitation at Mackay are reflected in flow of the Big Lost River at the three primary gaging stations. Bar graphs illustrating discharge in each water year (November through October) at Howell Ranch (station 13120500) and at the gaging station below Mackay Dam (station 13127000) are shown in figures 3 and 4. Flow in the Big Lost River below Arco (station 13132500) is more variable (figure 5) and includes several years with zero discharge. The monthly discharge at each of the gaging stations and the volume of water stored in Mackay Reservoir are listed in Appendix A. The median flow at Howell Ranch (1925 - 1990) is 238,000 acre-feet, below Mackay Dam (1925 - 1990) is 214,000 acre-feet, and median flow below Arco (1947



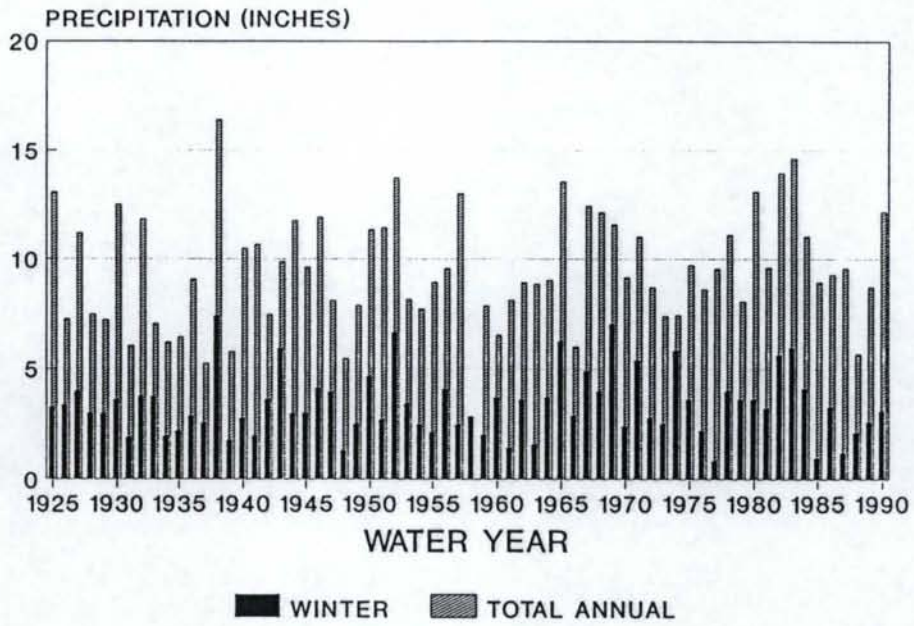


Figure 2. Precipitation at Mackay

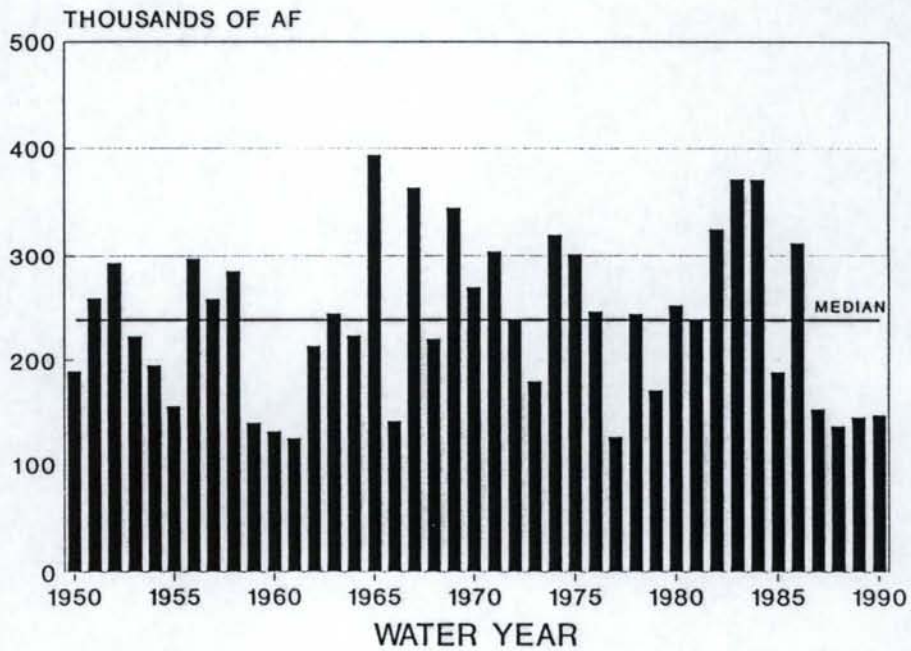


Figure 3. Big Lost River Discharge at Howell Ranch.



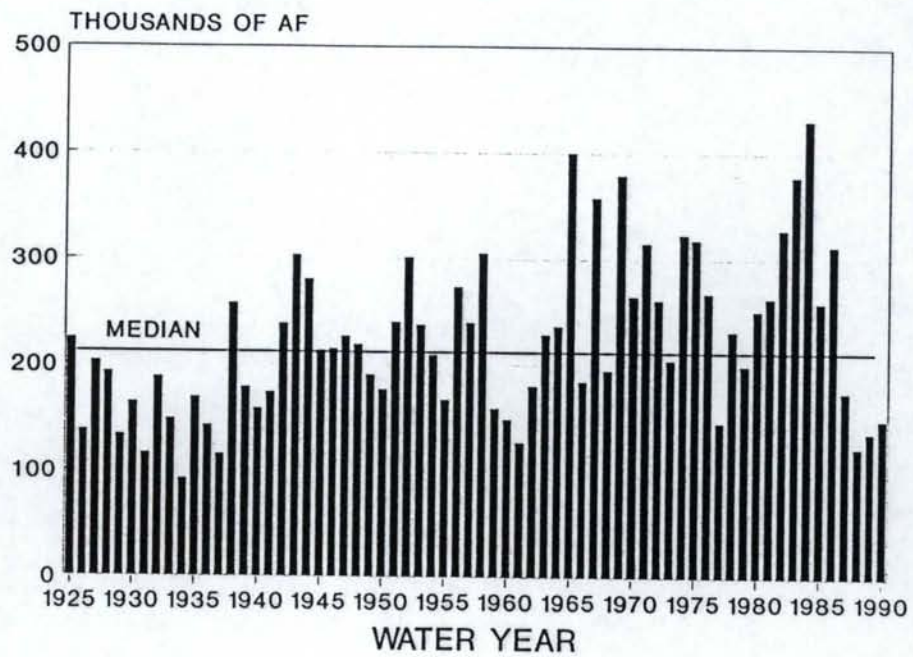


Figure 4. Big Lost River Discharge Below Mackay Dam.

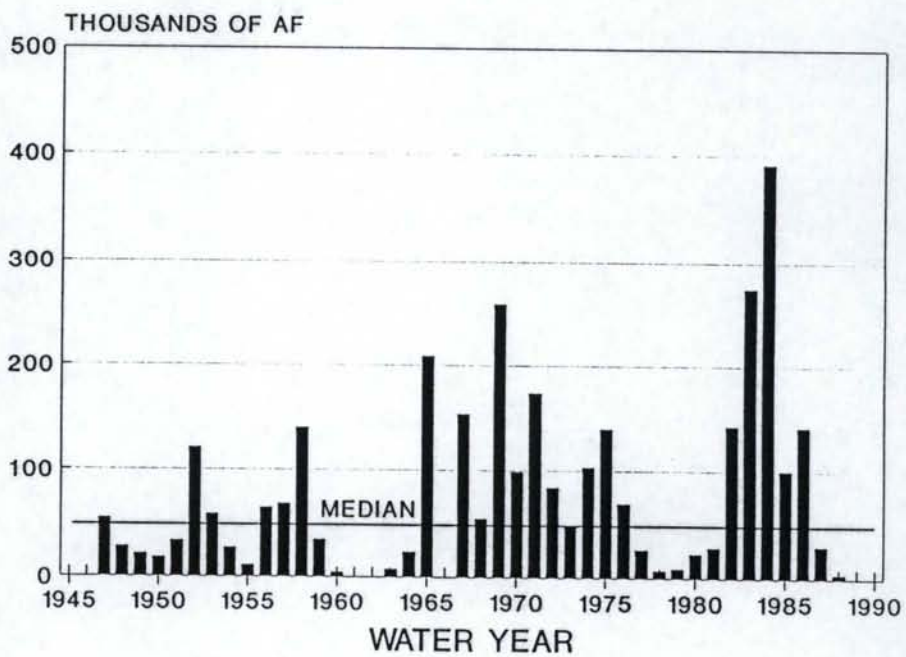


Figure 5. Big Lost River Discharge Below Arco.

- 1990) is 47,000 acre-feet. Annual and monthly flows below Mackay and below Arco are not adjusted for changes in storage in Mackay Reservoir.

Droughts, sometimes extending for several years, have been experienced several times during the history of irrigation in Big Lost River valley. Recent competition for water supply has been accentuated by the drought conditions experienced since 1986. River flow below Mackay Dam during the drought of 1987 through 1990 is similar to flow during the 1959 to 1962 period. The drought of the early 1930's is similar, but of longer duration than the current drought (through 1990). Mean river flows and irrigation diversions below Mackay Dam for the 1959 to 1962, and 1987 to 1990, periods are presented in table 1. River flows at the three gaging stations during the 1987 to 1990 period are slightly less than the flows during the 1959 to 1962 period. Diversions show a greater relative difference between the two periods than river flows. Average flow below Mackay dam varied only 4 percent between the two periods; but irrigation diversions below Mackay dam averaged 30 percent less in the later period.



Table 1. Mean River Flow and Diversion Comparison,  
1959 to 1962 and 1987 to 1990.

<u>Period</u>	<u>Howell</u>	<u>Mackay</u>	<u>Arco</u>	<u>Diversions Below Mackay</u>
	-----Acre-Feet/Year-----			
1959-1962	152,200	154,000	6,600	110,900
1987-1990	136,491	147,900	5,800	77,600
Ratio <sup>1</sup>	0.90	0.96	0.88	0.70

<sup>1</sup> Ratio = (mean for 1987 to 1990) / (mean for 1959 to 1962)

## HISTORIC PATTERNS IN IRRIGATION DIVERSIONS

### Surface Water Diversions

Monthly diversion data are available from the District 34 Watermaster Annual Summaries for each canal, and sometimes by river reach. The temporal comparability of these records, however, is compromised by the changes that have taken place in the irrigation system over the decades. Some canals have changed names or service areas. Water transfers and exchanges have also occurred, changing the point of diversion from the river. The most valid year-to-year comparisons probably can be made on the total diversions for the two river segments, above and below Mackay Dam. Comparisons of diversions may also be possible within the smaller river reaches frequently reported in the Annual Summaries:

- 1) Above Mackay Dam,
- 2) Mackay Dam to Blaine Diversion,
- 3) Blaine Diversion to Arco Diversion, and
- 4) below Arco Diversion.

However, the reach diversions may have changed because of changes within the irrigation system. This report concentrates on the diversions below Mackay Dam, since this part of the valley has experienced the most extensive ground-water development.



Diversion data reported in the Watermaster Annual Summaries represent the measured or estimated flows at the point of diversion of each canal from Big Lost River. The magnitude of the diversions are affected by:

- 1) the water supply in the river,
- 2) the demand for water, and
- 3) river gains and losses.

The third factor, river gains and losses, is the component which is impacted by ground-water pumping. The means of measuring or estimating diversions has changed with time and the reliability of the reported values has also changed. Apparently, less emphasis was placed on water measurement and record keeping from 1973 through 1985, and consequently the records may be less reliable during this period.

At times during most years, the demand for water exceeds the available supply, and diversions are strongly related to the flow in the river below Mackay Dam. This relationship is shown by the nearly parallel distributions of annual diversions and river flows presented in figure 6. Several years are absent from the graph of figure 6, where data are missing or incomplete. A notable feature of figure 6 is the increased difference between river flow below Mackay Dam and irrigation diversions after 1965. In years of below normal river flow below Mackay, the mean ratios of annual diversions to river flow below Mackay (including

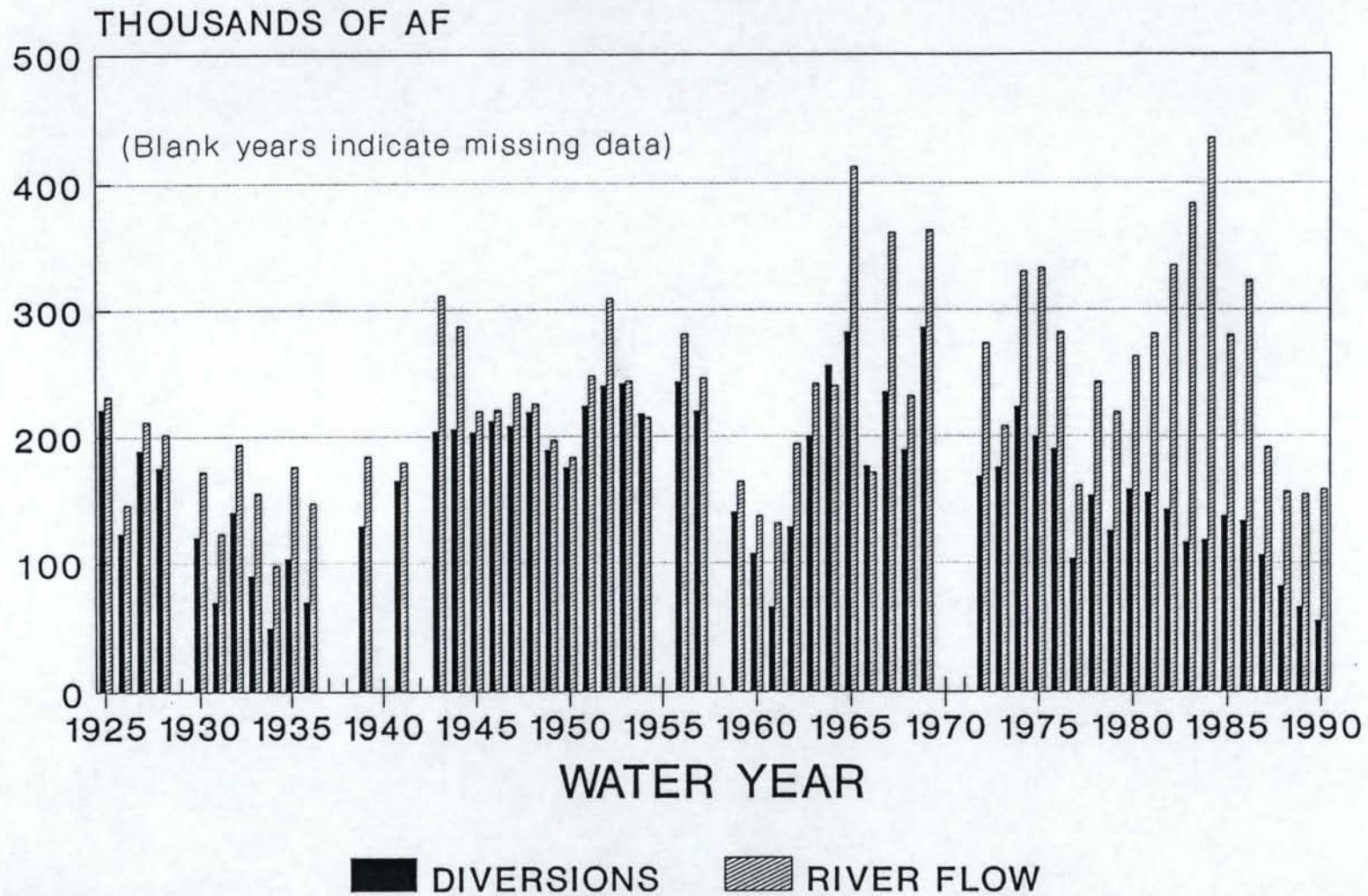


Figure 6. Annual Diversions and River Flow Below Mackay Dam.



Sharp ditch and pumpage additions) is 0.80 for the period before 1965, and 0.59 for 1965 and after.

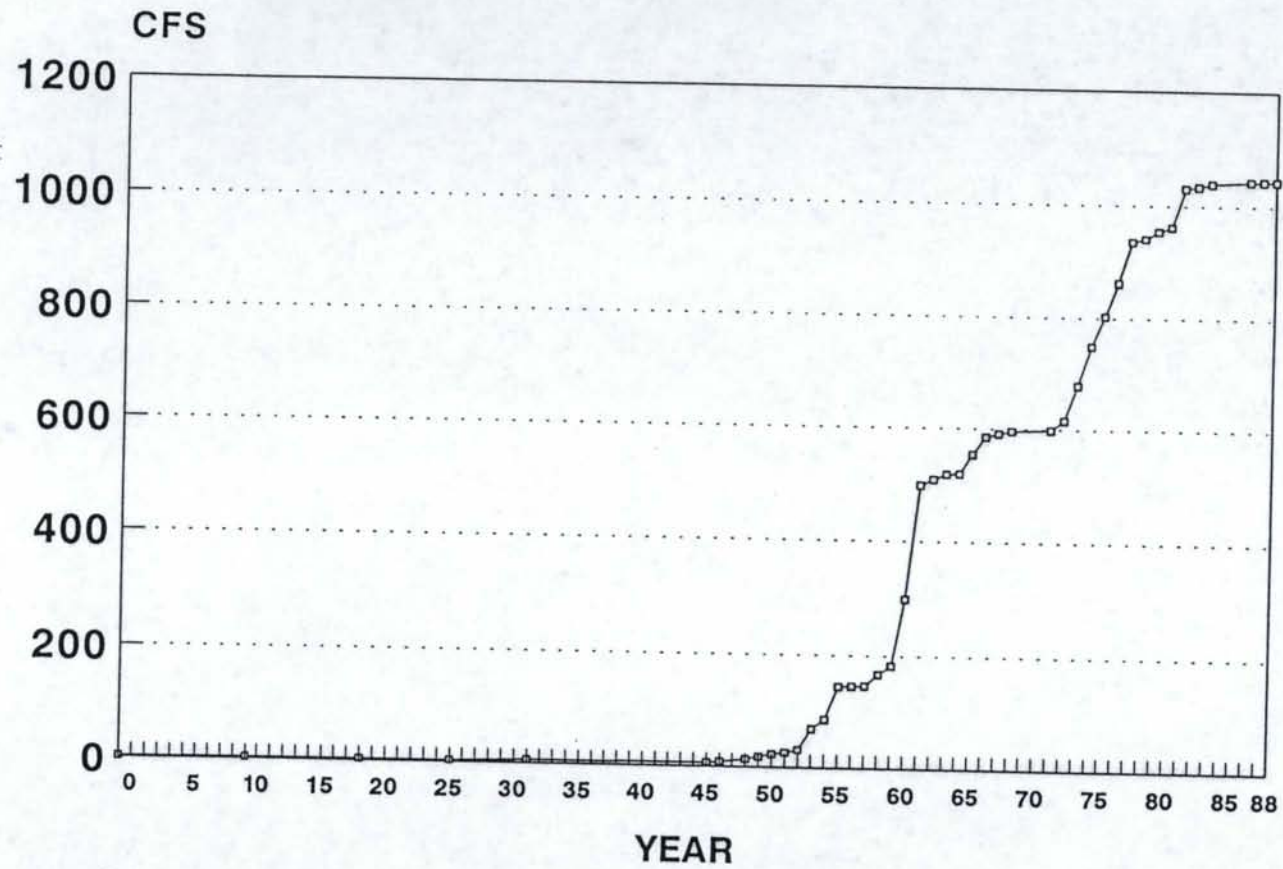
Diversions in high water years are generally limited by demand rather than water supply. In some high water years in the early 1980's, the recorded diversions were substantially less than in many previous years of lower water supply. In 1984, the watermaster report indicated that all rights were filled all season, with only 50 percent of the water diverted during the growing season as in previous high water years, like 1965. This difference suggests that either the watermaster records are in error, or the demand for surface water has declined during the 1980's. The former seems to be the more likely possibility.

#### Ground-Water Diversions

The amount of ground-water pumpage for irrigation changes from year to year in response to variations in irrigation demand and the changing degree of irrigation development in the valley. Prior to 1960, only a few irrigation wells were present in the valley. The drought of the early 1960's combined with other development incentives, however, resulted in a boom in ground-water development in the early 1960's, and again in the early to middle 1970's. The quantity of ground water pumped during these years is unknown, except for the 1984 through 1990 period which is addressed in a following chapter, "Estimation of Irrigation

Pumpage." Historic changes in ground-water development are reflected by the amount of ground-water claimed in water rights filings with the Idaho Department of Water Resources. Figure 7 illustrates changes in the cumulative total of ground-water rights claims in Big Lost River valley. The extensive claims with priorities dating to the early 1960's and 1970's indicate the rapid rate of growth of ground-water development during these periods. The amount of ground-water claims provide an approximate indicator of the potential for ground-water pumping. It does not imply the amount of actual pumping due to the effects of weather and other factors.





BASED ON ADJUDICATION CLAIMS

Figure 7. Historic Changes In Ground-Water Claims In Big Lost River Valley (from the Idaho Department of Water Resources).

## COMPARISON OF DIVERSIONS TO RIVER FLOW

In most years, surface water diversions for irrigation are limited by the available supply. During these years a strong relationship exists between flow in the Big Lost River below Mackay Dam and irrigation diversions below the dam. A scatter plot of annual river flow against diversion data for all years with complete record, from 1923 through 1990, is presented in figure 8. The water year associated with each point is given by the two digit number at the appropriate grid point. An approximately linear relationship is apparent during years where river discharge is less than about 250,000 acre-feet. In years with high flow, however, little or no relationship is apparent. The low ratio of diversions to river flow in the 1980's does not appear to be due to intense, short duration runoff. Diversions in high water years in the 1980's are substantially less than in earlier high water years, as was also apparent from figure 6. Scatter plots based on flow during the growing season appear similar, and consequently, are not presented.

The impacts of development on hydrologic observations, or systematic changes in the method of measurement, are often apparent in a double-mass balance graph. A double-mass balance plots the cumulative volume of one station



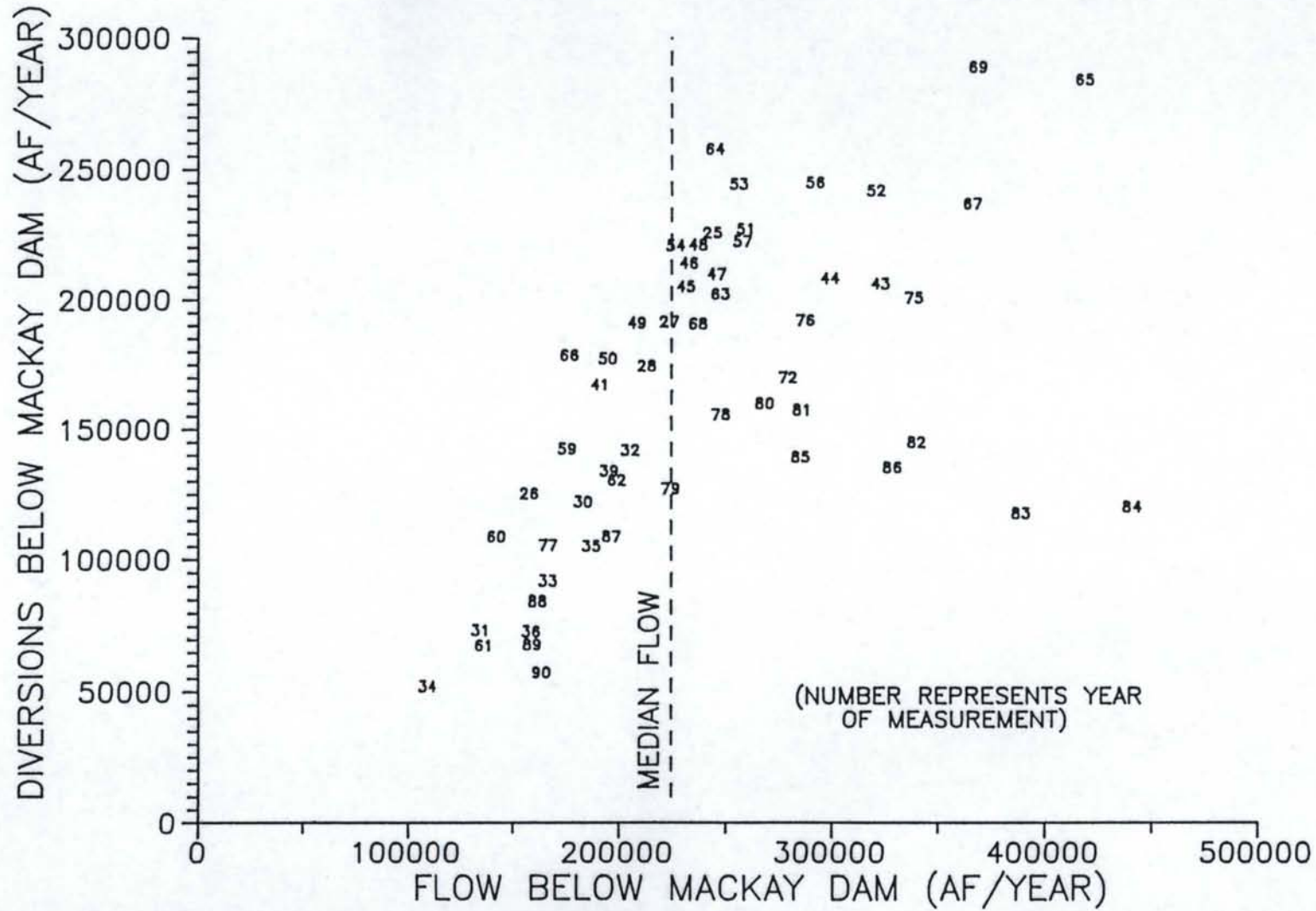


Figure 8. Scatter Plot of Diversions Against River Flow Below Mackay Dam.

against the cumulative volume at a second station, or set of stations. Figure 9 shows application of the double-mass balance to display changes in the relationship between river flow below Mackay Dam and irrigation diversions above and below the dam.

Long-term changes in slope of a double-mass balance would indicate that the relationship between diversions and river flow has changed. Changes in slope are most apparent in the line representing diversions below Mackay Dam. Some of the curvature is due to differences in the relationship between diversions and river flow at high and low flows. In addition to this, however, there appears to be a general flattening of the slope (below Mackay Dam) beginning about 1960, and more noticeably, after about 1970. This indicates that either the proportion of river flow diverted for irrigation has been reduced, or that a new watermaster made significant changes in measurement methods and record keeping.

A straight line plot on the double-mass balance indicates that no change has occurred in the relationship between river flow and diversions, nor in the validity of the measurements. The diversions above Mackay Dam, in contrast to those below the dam, plot as a relatively straight line in figure 9. However, a slight change in slope is apparent before 1940, and after 1983. The relative linearity of the plot representing diversions above the dam,



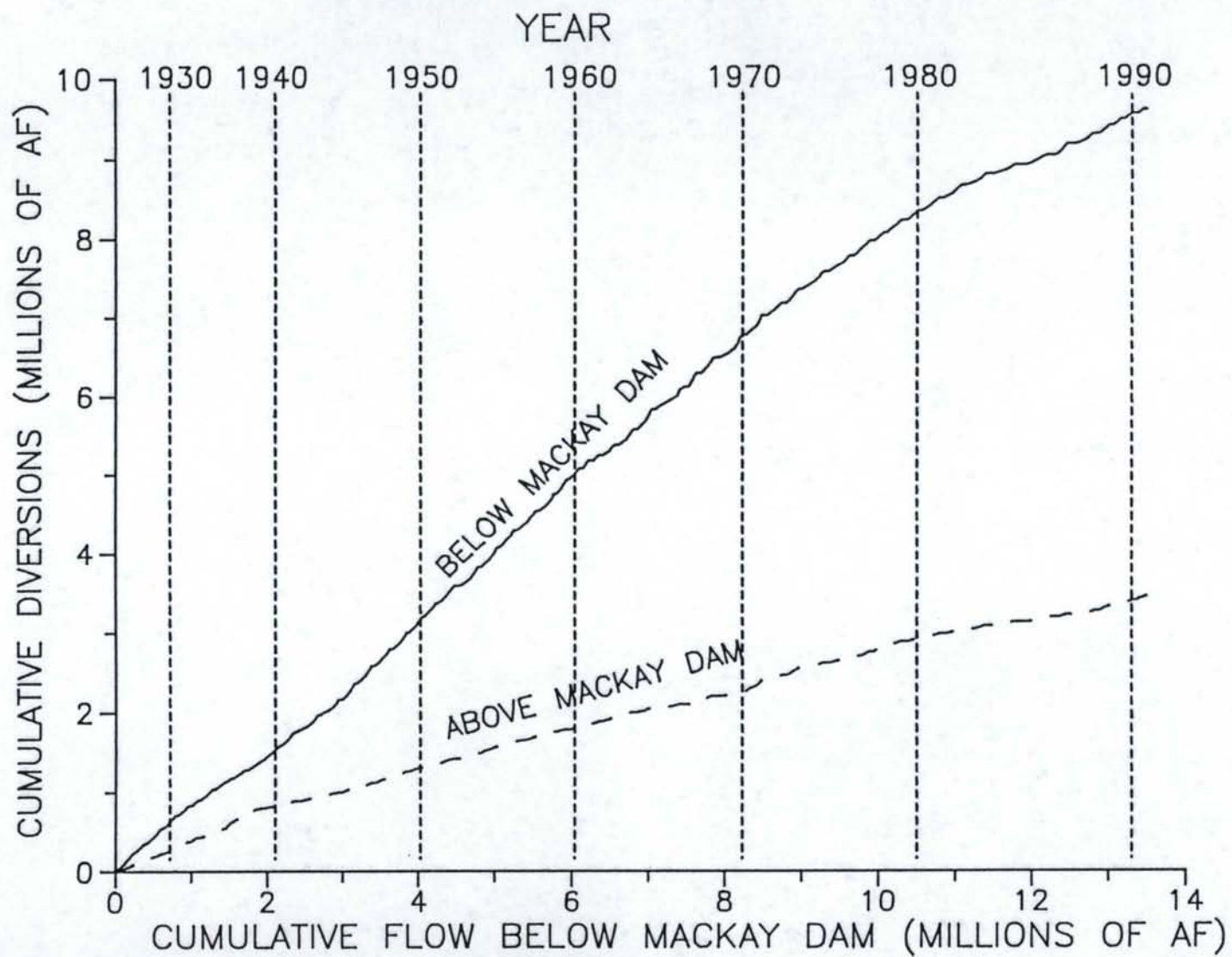


Figure 9. Double Mass Balance of Diversions Above and Below Mackay Dam Against River Flow Below Mackay Dam.

coupled with the relatively unchanging irrigation practices in that area, lends credibility to the double-mass balance as a method of observing the impacts of development.



## ESTIMATION OF DIVERSION DEPLETION

Irrigation of new lands in, and near Big Lost River valley, has been made possible by the conversion to more efficient sprinkler irrigation, and by the construction of irrigation wells. The expanded irrigated areas transpire more water than the smaller, and partially irrigated, areas of earlier years. Ground-water withdrawals for irrigation, and diminished recharge from sprinkler irrigated lands has caused a general decline in the water table in the valley. The lower water table results in increased seepage losses from the river and reduced ground-water inflow. The increase in river losses results in less water being available for diversion into the canal systems of the valley. The objective of this section of the report is to estimate the amount of depletion of diversions that has occurred from the combined effects of expanded irrigation, conversion to sprinklers, and ground-water pumpage.

Two methods are applied to estimate diversion depletion from the diversion and river flow data. The methods rely on different periods of record to minimize the effects that different record keeping and measurement procedures may have on conclusions.

#### **Method 1: Comparison of Periods of Similar Water Supply**

Depletion of diversions is estimated by comparison of periods of relatively similar water years, before and after the extensive development of the 1960's and 1970's. The periods from 1959 through 1962, and 1987 through 1990, are suitable for this type of comparison (table 1). The ratio of irrigation diversions to river flow below Mackay Dam is 0.72 for the pre-development period of 1959 through 1962. During the 1987 through 1990 period, the respective ratio is 0.52. The difference between these ratios (0.20), multiplied by the average annual river flow during the periods of estimation of 147,000 acre-feet, yields an estimate of average diversion depletion for that period equal to 29,600 acre-feet per year.

Flow during the periods of analysis was below normal, and the estimated depletion is, therefore, representative of below normal flow conditions in the river. This method provides no information on how depletion changes in times of different water supply.

#### **Method 2: Differences in Regression Lines**

The competition for water supply in Big Lost River valley is most intense in low water years. Low water years are also those which display a relatively strong linear relationship between annual irrigation diversions and river



flow below Mackay Dam. Figure 10 shows the relationships between diversions and river flow for two periods during years in which flow below Mackay Dam was less than normal (220,000 AF). The period before 1960 represents the era prior to extensive irrigation expansion and ground-water development. The second period presented in figure 10, from 1960 through 1990, represents the era of transition to sprinklers, expanding acreage, and increasing ground-water development. The solid line in figure 10 is a regression line based on below normal flows prior to 1960. The dashed line is based on below normal flows from 1960 through 1990. The mathematical expressions of the two lines are as follows:

Before 1960,

$$\begin{aligned} \text{DIVERSIONS} &= -86799 + 1.300 \times \text{FLOW} \\ r^2 &= 0.77, \text{ and} \end{aligned}$$

1960 and after,

$$\begin{aligned} \text{DIVERSIONS} &= -123,104 + 1.405 \times \text{FLOW} \\ r^2 &= 0.73, \end{aligned}$$

where:

DIVERSIONS = Annual irrigation diversions below Mackay Dam in acre-feet, and

FLOW = Annual discharge of Big Lost River below Mackay Dam, including Sharp ditch, in acre-feet.

The difference between the two regression lines of figure 10 indicates that changes in irrigation practices and ground-water pumpage probably have impacted the available

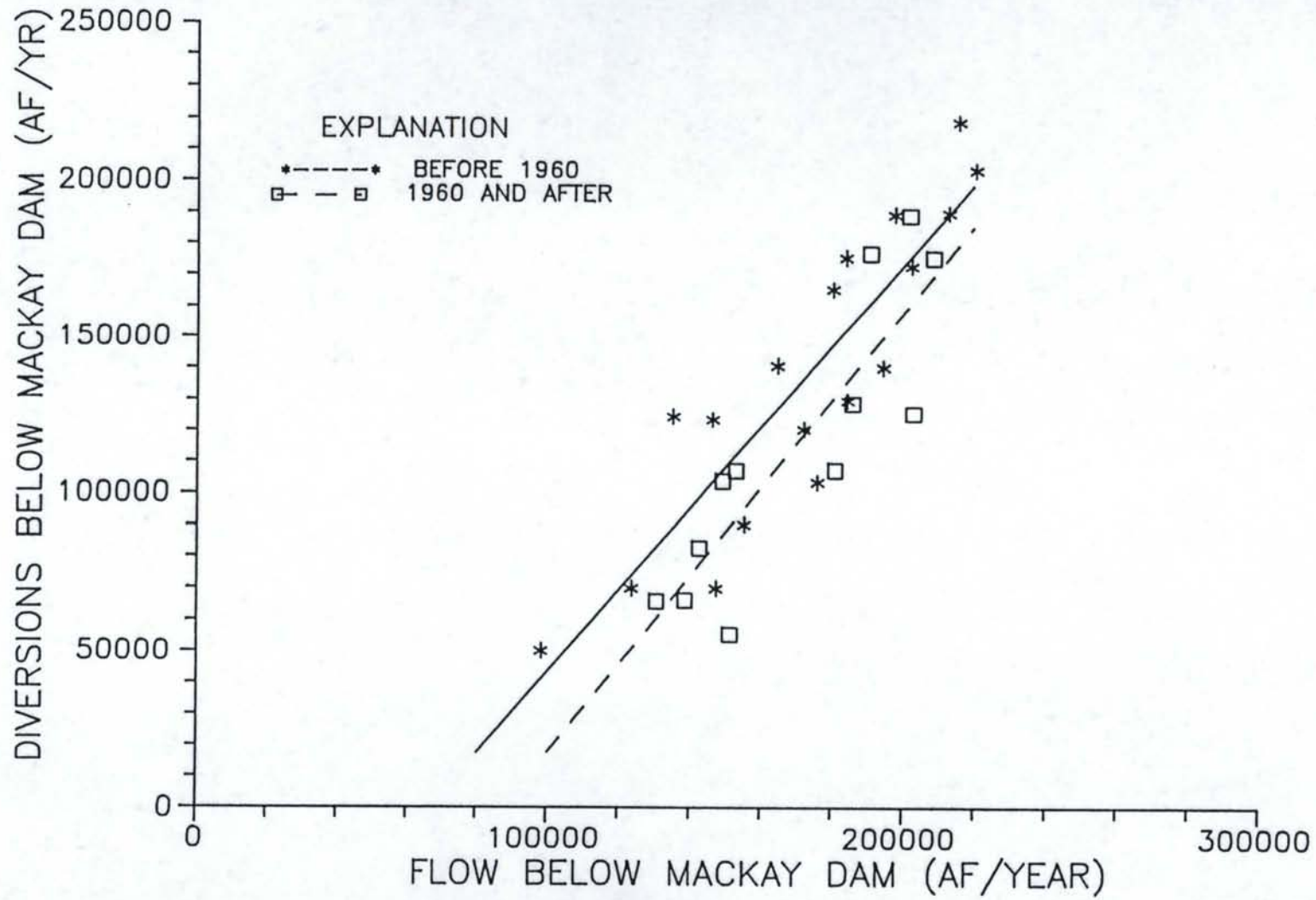


Figure 10. Irrigation Diversions and River Flow Regression For Below Normal Flow Years, Before and after 1960.



surface-water supply. That impact has been the result of a lower water table that induces more river losses and decreases gains. In below normal flow years, the average impact can be estimated as the difference between the two regression lines. Subtracting the second equation (1960 - 1990) from the first (before 1960), yields the following equation for difference, as a function of river flow:

$$\text{DEPLETION} = 36,300 - 0.1055 \times \text{FLOW}$$

where

DEPLETION = estimated annual diversion depletion in  
acre-feet, and

FLOW = annual river flow below Mackay Dam,  
including Sharp ditch, in acre-feet.

Diversion depletion estimated by the above equation decreases as annual river flow increases. This may be related to the increased ground-water pumpage needed to supplement surface water supplies during dry years. For the 1987 to 1990 period used in derivation of Method 1, the river flow below Mackay averaged 147,000 acre-feet. The estimated depletion of diversions is 20,800 acre-feet for that period. In the normal year the river flow below Mackay Dam is about 220,000 acre-feet, and the estimated depletion of diversions is 13,100 acre-feet.

This method "averages out" differences in diversions for two periods of 18 years (before 1960), and 12 years (1960 and after) of record. The effects of development,

however, are certainly not fully apparent by the 1960's and therefore, this method may tend to underestimate the impacts on diversions. The post-development period was not represented with more recent data in order to contrast the first method of estimation, and because of lack of confidence in regression based on only a few data points. The regression equations also only describe the general relationship between diversions and river flow. A little more than 70 percent of the variation in diversions can be accounted for by variation in river flow. The remainder is attributed to other factors such as residual effects from the previous year. The post-development period was not limited to more recent years in order to contrast the first method of estimation, and because of the lack of confidence in regression based on only a few data points. It is acknowledged that different regressions can be developed by the selection of different periods of record.

#### Comparison of Methods for Estimating Depletion

The most valid period for comparison of Methods 1 and 2 is for those years used in derivation of Method 1, from 1987 through 1990. In this period, depletion estimated by the first method is about 30,000 acre-feet per year. The second method, based on the difference between regression equations, estimates the diversion depletion to be about 21,000 acre-feet per year, for the same river flow



conditions. The smaller value of the second estimate may be due to the use of a longer period of post-development record, which included the transitional years in which irrigation development was taking place, and impacts were not fully evolved.

The first estimation method, based on comparison of two periods of similar river flow, provides a depletion estimate for specific low river flow periods. The second method is somewhat more versatile, estimating depletion as a function of flow based on below normal water years. Neither method specifically addresses estimation of depletion during periods of above normal river flow.

In above normal water years, a surplus of water often exists during spring and early summer. By late summer, however, surface water supplies may be inadequate to meet crop demands. The deficiencies during this time are probably amplified by increased seepage and decreased river inflow, induced by irrigation expansion and ground-water pumpage.

Extrapolation of the second, regression-based method, to years of above normal river flow provides reasonable estimates of diversion depletion; even though the method is based on below normal water years. It is recognized that extrapolation of this method to above normal flow years can not be supported conceptually; but this procedure may be the best available means of estimation. Depletion, calculated

by this method, decreases in years of increasing river flow. The estimated depletion ultimately becomes zero when the annual discharge of Big Lost River below Mackay Dam (including Sharp Ditch) exceeds 344,000 acre-feet.

The frequency of occurrence of depletion volumes can be predicted by applying the depletion equation of Method 2 to historic river flow records. A depletion duration curve, produced in this manner, is presented in figure 11. According to figure 11, no depletion occurs in about 4 percent of the years, and, in contrast, 18 percent of the time depletion estimated by this method would be in excess of 20,000 acre-feet per year.



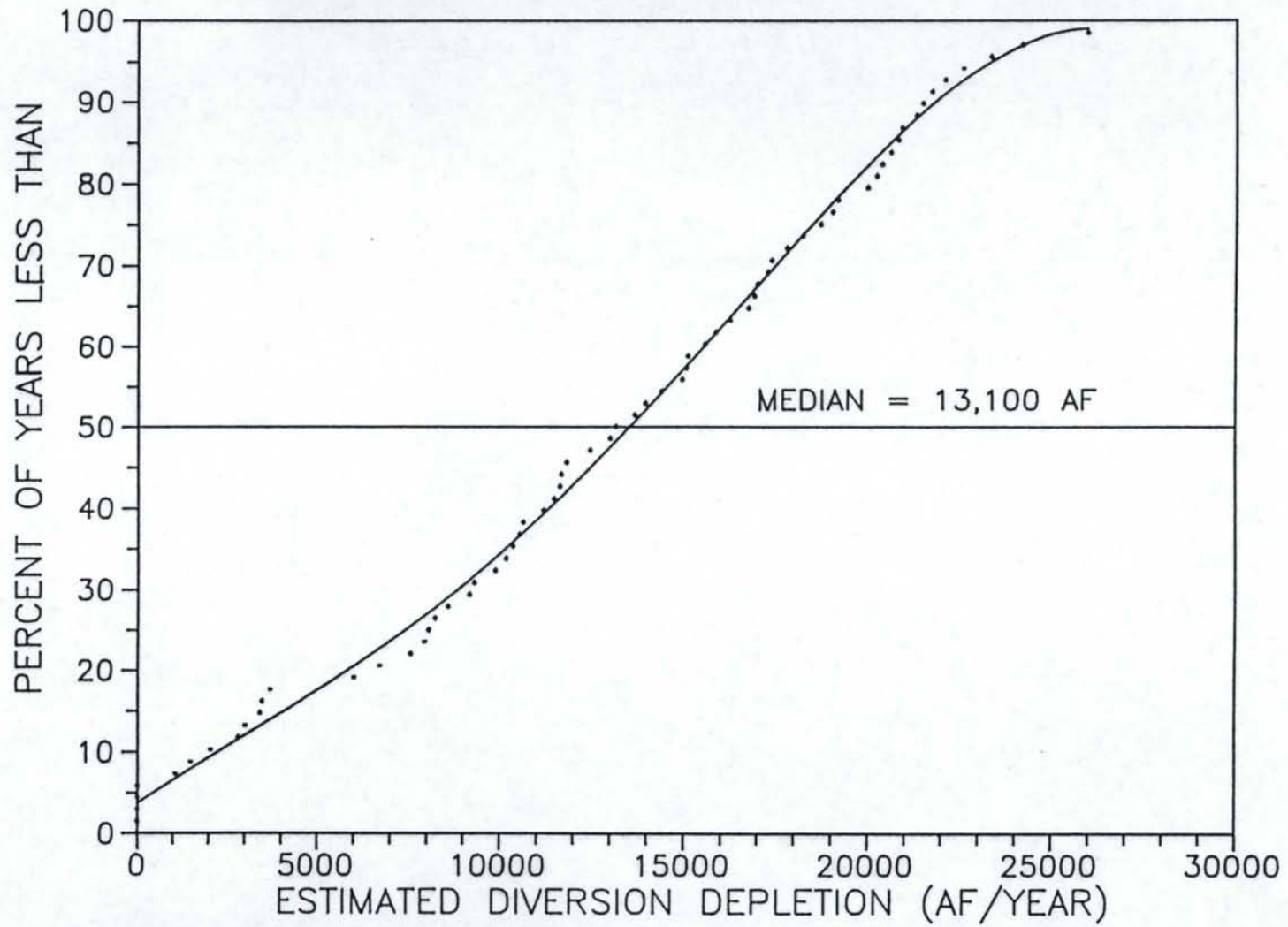


Figure 11. Duration Curve of Estimated Annual Diversion Depletion.

### ESTIMATION OF IRRIGATION PUMPAGE

Annual ground-water pumpage from the Big Lost River Valley below Antelope Creek has been estimated for the period of 1984 through 1990 (table 2). The annual pumpage fluctuates in response to variations in annual surface-water supplies and crop demands. A scatter plot and linear regression line of annual ground-water pumpage below Antelope Creek against river flow below Mackay (including Sharp Ditch) is presented in figure 12. The corresponding regression equation is:

$$\text{PUMPAGE} = 61,200 - 0.1284 \times \text{FLOW} \quad (r^2 = 0.88)$$

where

PUMPAGE = annual pumpage in acre-feet, and  
FLOW = annual discharge below Mackay Dam,  
including Sharp Ditch in acre-feet.

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Table 2. Annual Pumpage Below Antelope Creek.

<u>Calendar Year</u>	<u>Pumpage (af)</u>
1984	8,300
1985	27,500
1986	17,300
1987	28,700
1988	44,500
1989	48,600
1990	43,800

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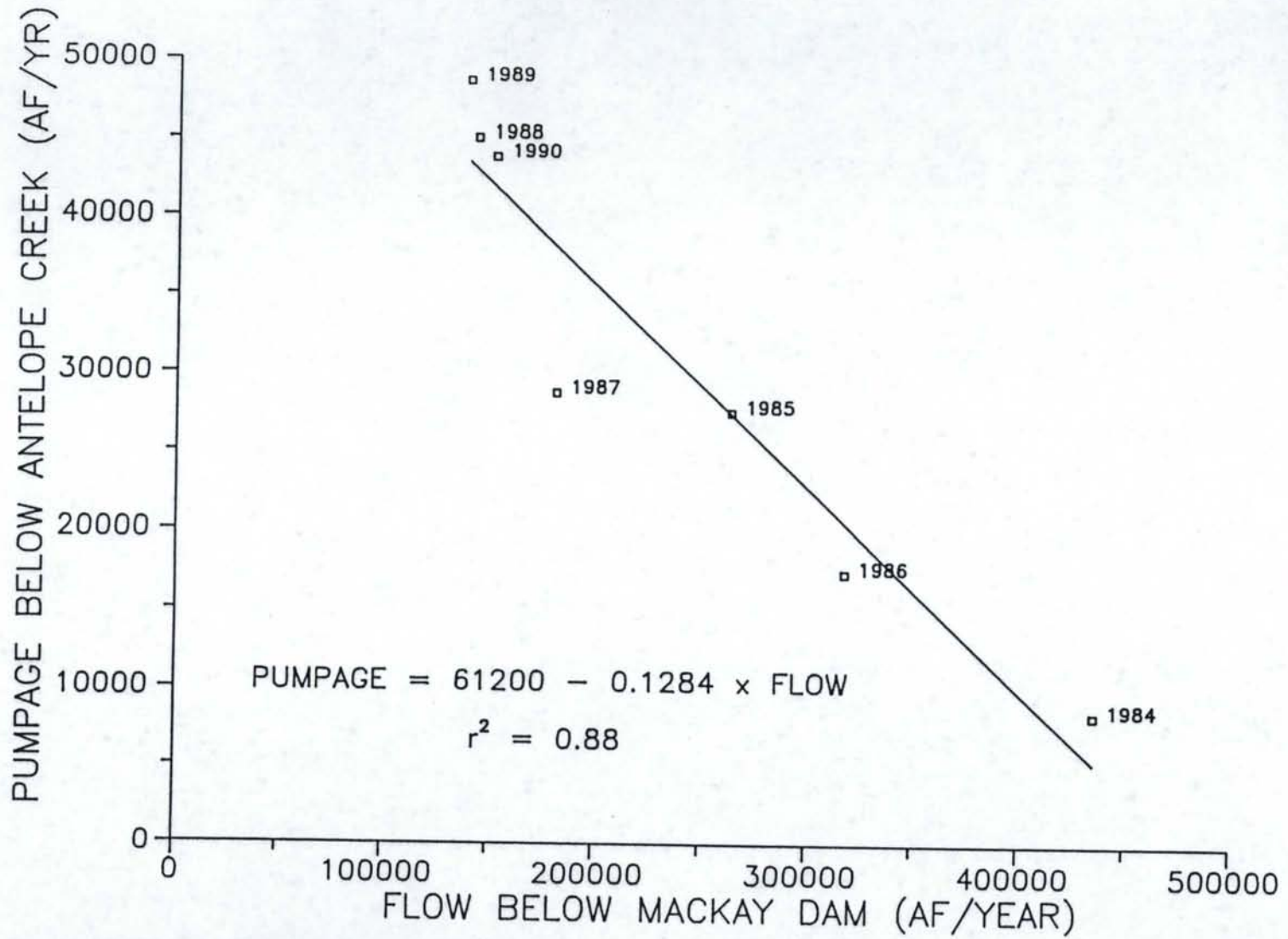


Figure 12. Linear Regression of Annual Pumpage Below Antelope Creek to Flow Below Mackay Dam.

Many irrigation wells in Big Lost River valley are located above the point where Antelope Creek is tributary to Big Lost River and therefore, are not included in the values of table 2. Approximately 700 out of a total of 1000 cfs of claimed ground-water rights in the valley are located below the junction of the two streams (Idaho Department of Water Resources, unpublished map). Total annual pumpage in the valley was estimated by assuming that the relative pumpage in an area is proportional to the claimed ground-water rights. Pumpage below Antelope Creek was, therefore multiplied by 1.428 (1000 cfs divided by 700 cfs) to estimate total pumpage. The multiplier was applied to the developed regression equation expressing the relationship between annual pumpage and flow below Mackay Dam to generate the following expression:

$$\text{TOTAL PUMPAGE} = 87400 - 0.1834 \times \text{FLOW}$$

where

TOTAL PUMPAGE = Annual pumpage from the entire

Big Lost River valley, in acre-feet, and  
FLOW = annual discharge below Mackay Dam,

including Sharp Ditch in acre-feet.

Pumpage estimates presented in table 2 span a period of only 7 years, and probably do not represent the long-term normal pumpage that would occur in the absence of further ground-water development. Long-term pumping estimates, at the current stage of well development, were determined by application of the regression equation relating total valley



pumpage to river flows below Mackay Dam. Annual discharges below Mackay Dam, for the 1923 through 1990 period, were substituted into the equation to estimate the long-term variability of pumpage. The resulting estimates were used to develop the pumpage-duration curve shown in figure 13. Normal annual pumpage in the Big Lost River valley, as estimated by this procedure, is 47,000 acre-feet. The estimated valley pumpage experienced in 1989 of 69,400 acre-feet would occur only a few times every 100 years.

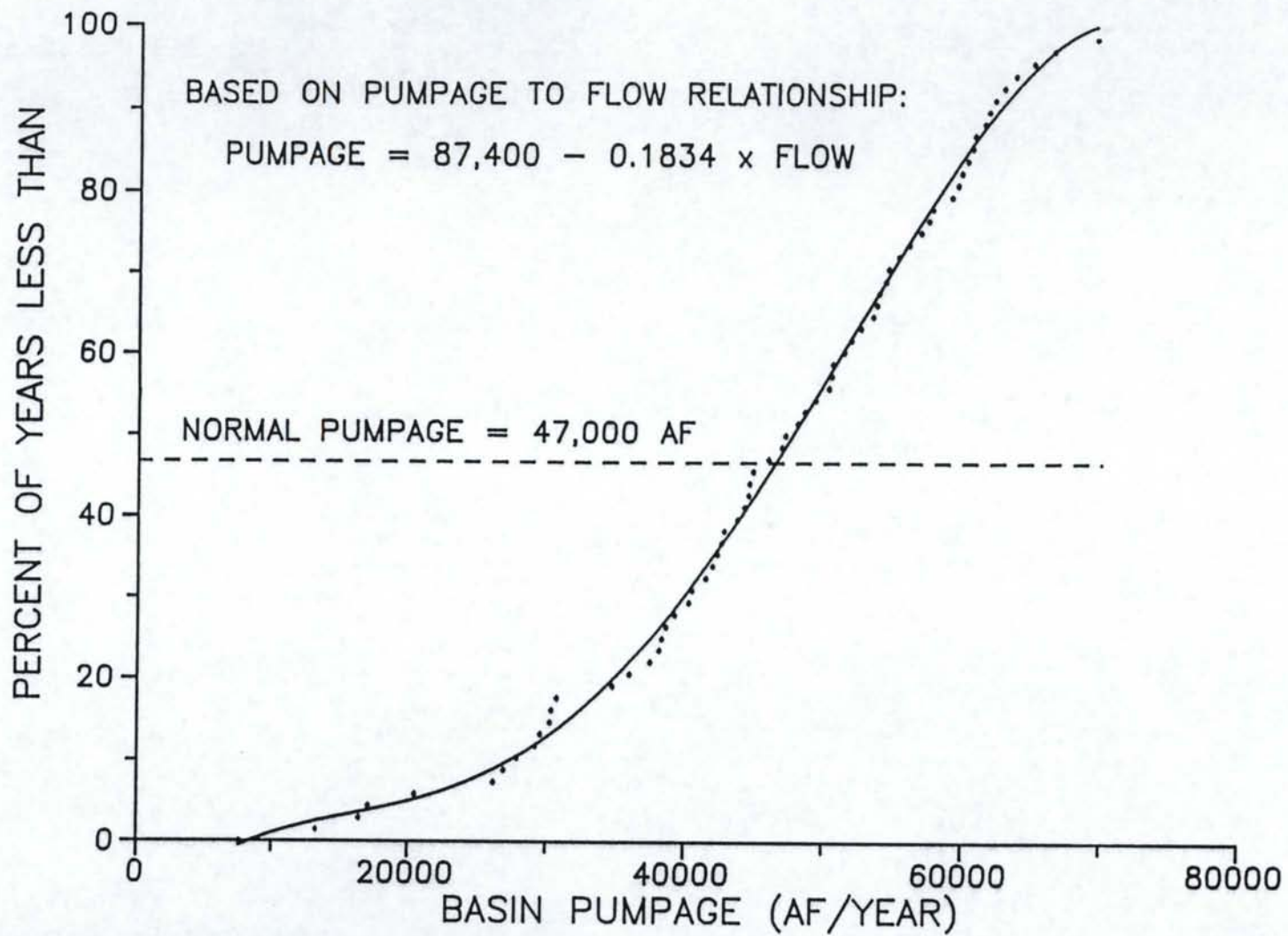


Figure 13. Duration Curve of Estimated Annual Pumpage.



## DISTRIBUTION AND EXPANSION OF IRRIGATED LAND

Water is lost from Big Lost River valley by four mechanisms: 1) river discharge to the plain, 2) ground-water underflow to the plain, 3) irrigation conveyance outside of the basin, and 4) by evaporation and transpiration. Ground-water pumping, and the accompanying conversion to sprinkler irrigation, has contributed to an expansion of irrigated lands and resulted in a sizable increase in the fourth component listed above, relating to crop consumptive use. About 80 percent of the water applied by sprinklers is lost through crop consumptive use, the remaining 20 percent returns to the ground-water as deep percolation (C.E. Brockway, personal communication). Transporting water out of the basin for irrigation on the Snake River plain results in loss of the entire application, as the deep percolation from the irrigated areas will not return to the ground-water system of the Big Lost River valley.

The land area irrigated by the water resources of Big Lost River basin has significantly expanded since about 1970. The change in irrigated acreage in Butte County is shown in figure 14. The majority of irrigated land in Butte County is in, or receives water from, the Big Lost River basin. The graph shows that irrigated acreage in Butte County, and probably Big Lost River valley, nearly doubled



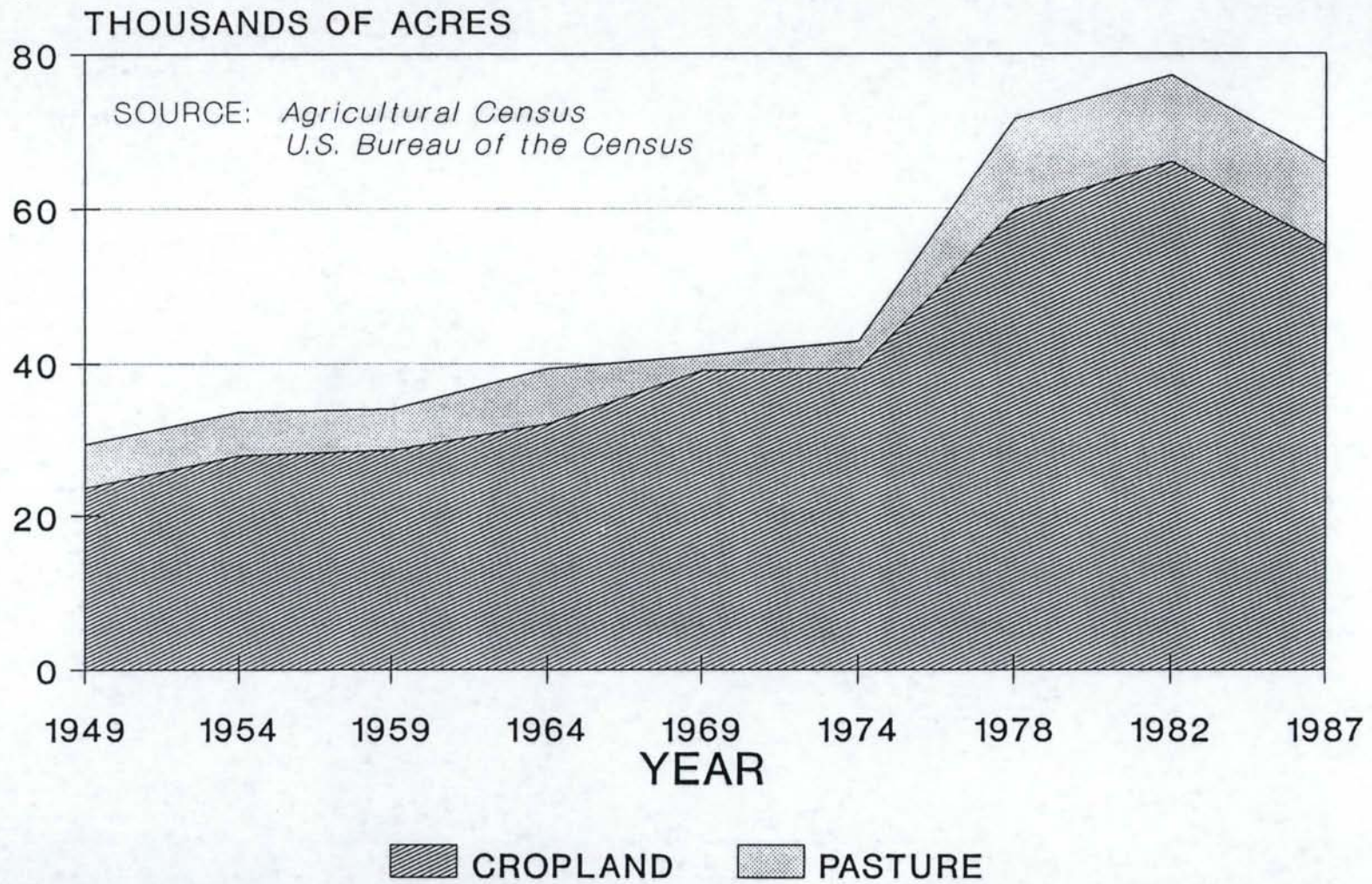


Figure 14. Historic Changes in Butte County Irrigated Acreage.



between 1974 and 1982. The acreage expanded from about 43,000 acres to about 77,000 acres in 1982. Much of this expansion is thought to have occurred with surface and ground water from the Big Lost River valley. An expansion of 34,000 acres in Butte County results in additional water consumption of about 41,000 acre-feet, assuming an irrigation requirement of 1.2 feet per year (Crosthwaite and others, 1970). Irrigation requirements calculated from the methods of Allen and Brockway (1983) are about 2.0 feet per year, implying that the additional water consumption may be as large as 68,000 acre-feet per year. Figure 14 is based on past records of the U.S. Census Bureau, Agricultural Census which determines irrigated acreage every four or five years.

## PUMPAGE IN PERSPECTIVE

Ground-water pumping depletes the ground-water resource of the valley by an amount equal to the crop consumptive use on the irrigated lands, unless the pumped water is applied outside of the valley. Water applied in excess of the crop consumptive use returns to the ground-water reservoir as deep percolation. Approximately 20 percent of the water applied by sprinkler irrigation returns to the aquifer as deep percolation (C.E. Brockway, personal communication). The total consumptive use resulting from the normal year pumpage of 47,000 acre-feet is, therefore, estimated to be about 40,000 acre-feet, depending upon the amount of pumpage exported out of the basin.

Consumptive use losses associated with ground-water pumping are relatively small compared with basin underflow in a normal year. Estimated losses resulting from irrigation pumping of 40,000 acre-feet per year represent about 13 percent of the basin underflow estimated by Crosthwaite and others (1970) for the period before 1970. On a long-term basis, more water is lost by surface discharge onto the Snake River Plain than is consumptively used by irrigation pumpers.

The estimated pumpage in a normal year compares reasonably well with increased crop demands resulting from expanded acreage shown in figure 14. The estimated normal



pumpage of 47,000 acre-feet is sufficient to irrigate between 19,000 and 31,000 acres, assuming 80 percent application efficiency and 1.2 to 2.0 feet of irrigation demand. Conveyance losses decrease that acreage somewhat more. The recent increase in irrigated acreage in Butte county is about 34,000 acres according to Agricultural Census statistics.

Depletions of surface water diversions estimated in the section on "Relationships Between Diversions and River Flow" are less than estimates of basin pumpage, as expected. Diversion depletion for the 1987 through 1990 water years averaged 29,600 acre-feet per year, according to the first method of depletion estimation. The pumpage during that period averaged 41,400 acre-feet per year, or about 1.4 times the estimated depletion.

A relationship between estimated diversion depletion and pumpage can also be developed by combining the depletion equation of Method 2:

$$\text{DEPLETION} = 36,300 - 0.1055 \times \text{FLOW},$$

with the adjusted pumpage regression equation representing pumpage in the entire valley:

$$\text{PUMPAGE} = 87,400 - 0.1834 \times \text{FLOW}.$$

Depletion, expressed as a function of pumpage, is therefore:

$$\text{DEPLETION} = 0.575 \times \text{PUMPAGE} - 14,000,$$

where

DEPLETION = annual depletion of diversions below Mackay Dam in acre-feet,

FLOW = annual flow of Big Lost River below Mackay Dam, including Sharp Ditch, in acre-feet, and

PUMPAGE = annual pumpage within the entire basin, in acre-feet.

According to the above equation, the ratio of diversion depletion to pumpage decreases in years of low pumpage. When surface water supplies are such that less than 14,000 acre-feet of ground-water are pumped, then depletion is estimated to be zero. As pumpage volumes increase the ratio of estimated depletion to pumpage increases. In the normal year, pumpage is 47,000 acre-feet, and estimated depletion (by Method 2) is 13,100 acre-feet, resulting in a ratio of depletion to pumpage of 0.28.

Ground-water pumping is only partially responsible for the depletion of river flow and irrigation diversions. Expansion of surface water irrigation rights to larger land areas also contributes to the problem by increasing crop consumptive use and generating less ground-water recharge. The actual expansion of acres irrigated from surface and ground-water of Big Lost River basin is presently unknown, making it impossible to proportion additional water use between surface and ground-water sources.



## ALTERNATIVE MANAGEMENT OPTIONS

Increased consumptive water use in Big Lost River valley has impacted the availability of water for senior surface water right holders. We believe that the increased consumptive water use has resulted from expanded acreage irrigated with both surface and ground-water. Possible alternatives for regulation and mitigation or compensation are described in this section; however, responsibility for recommendation of a specific alternative rests with the Idaho Department of Water Resources.

Steps associated with the development and implementation of possible alternative management strategies are illustrated in the flow chart presented in figure 15. A number of steps, and/or decisions are shown on the flow chart. The first two steps of this process are: 1) The Department must determine the extent of areas in which ground-water pumping and increased consumptive water use by surface water expansions have impacted flows of the Big Lost River, and 2) a means of proportioning impacts between ground-water pumping and expansion of surface water acreage needs to be developed.

We recommend that the impacting area include the entire alluvial deposits of the valley (single basin concept). The southern boundary of the impact area should coincide with the location of the steep water table decline into the Snake Plain aquifer, based on long-term average water levels. The

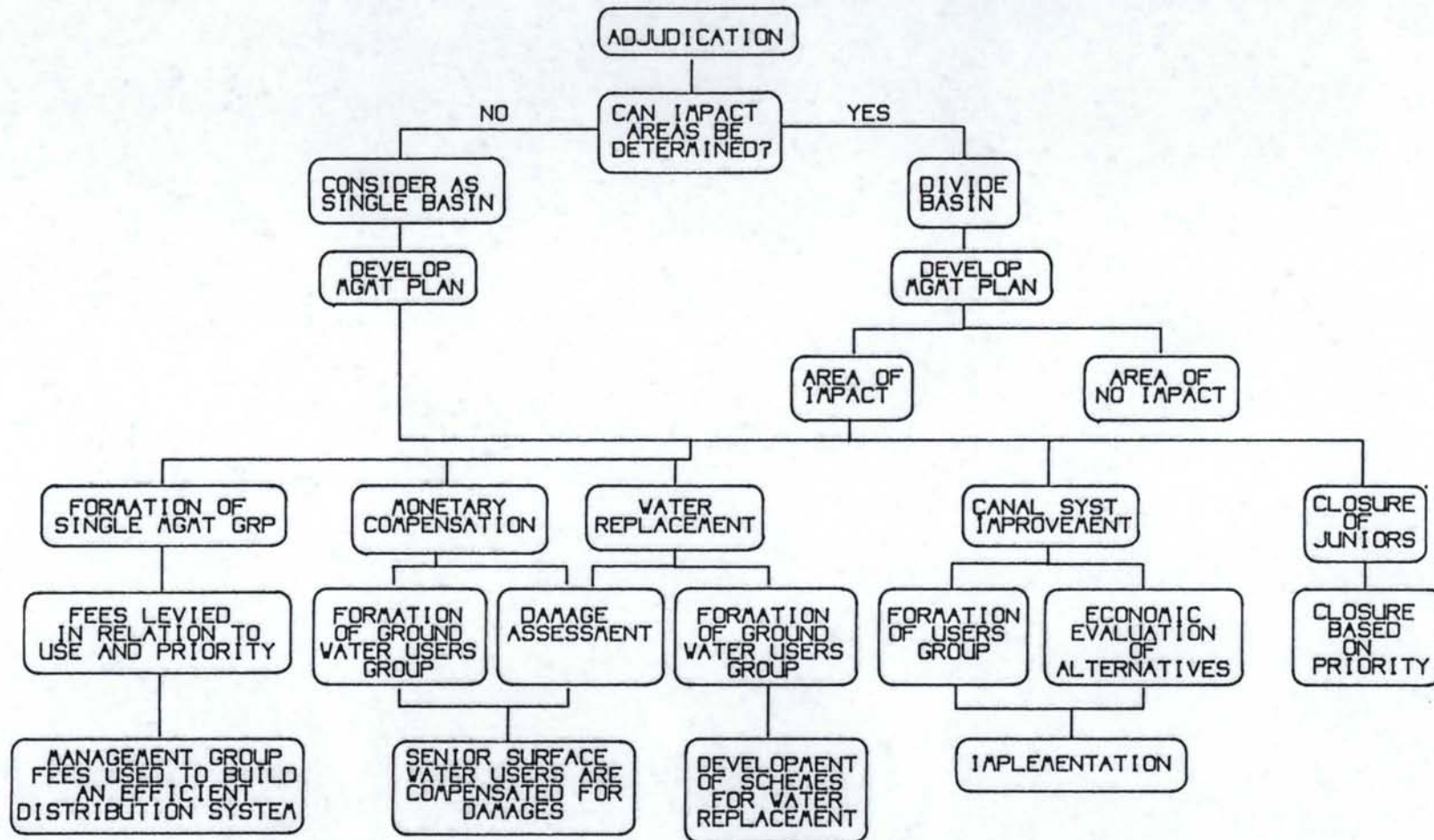


Figure 15. Diagram Illustrating Alternative Management Options.



basin may be further subdivided if the single basin concept is unacceptable to those involved. Subdivision into multiple units should be based on a detailed hydrologic analysis of the hydraulic connection of the river and the propagation of pumping and recharge effects.

A detailed management plan must be developed, regardless of whether the basin is considered as a single unit or multiple units. The plan should address whether compensation or mitigation are due to senior surface water irrigators, the type and degree of mitigation or compensation, and the structure of the organizational group responsible. The plan should be cooperatively prepared or reviewed by all parties involved.

If compensation or mitigation are to be awarded, then criteria must be established to determine liability. We believe that depletion is most directly associated with additional consumptive water use in recent decades, from both surface and ground water sources. Thus, the logical, although not necessarily legal, basis for assessing responsibility is in proportion to the amount of expanded irrigated acreage.

Five alternative courses of action are outlined on the flow chart (figure 15). They include: 1) Conjunctive management of surface and ground-water resources by a single management entity, 2) monetary compensation of impacted senior surface-water users by the liable parties, 3) water

replacement for impacted senior surface water users by pumping into surface channels with financial support based on liability, 4) improvement of the surface irrigation system to improve conveyance efficiency, and 5) closure of junior users in proportion to the estimated impacts. We believe that the effectiveness and efficiency of the first four alternatives is dependent on the degree of cooperation that is achieved among the water users of the basin.

We conclude that cooperative water management by surface and ground-water users is the best solution and would result in the most efficient use of the water resources of the basin. Development of a cooperative management unit requires that surface and ground-water users generally agree on the impacts of pumping and acreage expansions, and the remedial measures needed. In such a situation, those deemed responsible would be assessed fees in proportion to their perceived impact, and generated revenues would be spent according to the consensus of the managing unit. This alternative implies that the water users of the Big Lost River would be responsible for managing their own resource in a fair and equitable manner.

Monetary compensation by an organization of surface and ground water users deemed liable for depleted surface flows may be the most achievable of the alternatives. Those implicated as impacting surface flows would need to form a self-funding unit with the purpose of compensating senior



surface water users for damages. We recommend that the degree of compensation or mitigation be consistent with the diversion depletion estimated in this report.

Water replacement, funded by a similar organization, would rely on new wells to supplement the river flows, to a degree determined by depletion estimation procedures outlined in this report. These wells would be constructed and operated with funding provided by the liable parties, in proportion to their ground-water pumpage and surface water acreage expansion.

Several methods are available to improve the water supply of surface water users without additional pumping. These primarily deal with canal modification and lining, and the construction of additional surface water reservoirs. The economic feasibility of these measures should be evaluated relative to monetary compensation and water replacement schemes. Effective canal lining could improve the separation of the surface and ground-water resources, and reduce the question of interference. Both surface and ground-water users should share in the costs of system improvements.

We believe that the most economically unacceptable of the alternatives is the regulation of all rights in the valley on the basis of the priority. This alternative would result in closure of many or all of the irrigation wells, and drastically reduce agricultural production of the

valley. Although this may be a legal alternative, it would be highly undesirable to nearly all parties, and is not recommended.

In summary, we recommend that the highest possible degree of cooperation be developed among the involved parties. In this way, the resource largely will be managed by its users. All ground-water pumpers (irrigation wells) and those with expanded surface water irrigated acreage should assume responsibility for depleted flows of senior surface water irrigators, in an amount consistent with the depletion estimates of this report. The management plan should involve all interested parties.



## CONCLUSIONS AND RECOMMENDATIONS

Several conclusions are apparent from this investigation. They include:

1. Flow of the Big Lost river is affected by weather and by long-term changes in the amount of consumptive water use in the valley.
2. The consumptive water use has increased substantially in the last few decades due to an extension to full season irrigation and an expansion of the irrigated acreage.
3. Ground-water pumping has made the expansion of irrigated acreage possible, and provides a sizable proportion of the water applied on the expanded acreage.
4. Ground-water pumping is largely used to supplement surface-water diversions, and ground-water pumping increases in years of low surface water supply.
5. Ground-water recharge from surface water irrigation has diminished due to application over larger acreage and conversion to more efficient sprinkler application methods.
6. Diminished recharge from surface water irrigation and increased ground-water withdrawals, together have caused a reduction in flow of Big Lost River and consequently have depleted the supplies of surface water irrigators.
7. Diversion records indicate that surface water diversions for irrigation have decreased in recent years. The magnitude of the depletion varies with the water year.
8. The reliability of the diversion records, and consequently of the depletion estimates, is uncertain. Diversion depletion estimation procedures of this report, however, are probably the best available. With the available information it was not possible to proportion the amount of diversion depletion into components resulting from ground-water pumping and that caused by expansion of surface-water irrigated acreage.

9. The impact attributable to ground-water pumping or expansion of surface water irrigated area varies with the year and the proportion of the total irrigation water derived from pumping. Pumping is reduced in years of plentiful surface water supply, however the recharge from surface water is probably diminished in those years (relative to pre-1960), due to application over larger cropped areas.

Recommendations for managing the water resources of the basin, and for future investigation include:

1. A cohesive organization of all water users in the basin could greatly contribute to development of water management strategies, and improve the effectiveness and efficiency of implementation of the selected strategies.
2. Relationships developed in this report provide a method that may be used for determining the magnitude of mitigation to damaged surface water users.
3. Further investigation into changes in the irrigation practices and areas of the basin should be initiated. This research would help refine estimates of depletion and would further the understanding of the individual impacts of ground-water pumping and expansion of areas irrigated with surface water.
4. Irrigation pumpage and diversions should be closely monitored in future years to refine the understanding of pumping impacts on diversions.



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APPENDIX A

BIG LOST RIVER

MONTHLY DISCHARGE AND STORAGE VOLUMES



APPENDIX A: BIG LOST RIVER MONTHLY DISCHARGE AND STORAGE  
IN ACRE-FEET.  
(-1 Indicates Missing Data)

YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1922	1	-1	7037	-1	-1
1922	2	-1	7252	-1	-1
1922	3	-1	8319	-1	-1
1922	4	5438	8160	-1	-1
1922	5	51074	28209	-1	-1
1922	6	117572	93601	-1	-1
1922	7	32932	42676	-1	-1
1922	8	16691	29187	-1	-1
1922	9	8156	14763	-1	-1
1922	10	6964	6472	-1	-1
1922	11	-1	7240	-1	-1
1922	12	-1	6920	-1	-1
1923	1	-1	7303	-1	-1
1923	2	-1	7375	-1	-1
1923	3	-1	9190	-1	-1
1923	4	6605	8749	-1	-1
1923	5	41210	25479	-1	-1
1923	6	63057	49622	-1	-1
1923	7	52917	52971	-1	-1
1923	8	15697	31540	-1	-1
1923	9	9067	14370	-1	-1
1923	10	9047	29964	-1	-1
1923	11	-1	7930	-1	-1
1923	12	-1	5043	-1	-1
1924	1	-1	6168	-1	-1
1924	2	-1	6385	-1	-1
1924	3	-1	7448	-1	-1
1924	4	8972	7154	-1	-1
1924	5	31292	25445	-1	-1
1924	6	17009	21082	-1	-1
1924	7	8934	20233	-1	-1
1924	8	4266	9035	-1	-1
1924	9	4254	8630	-1	-1
1924	10	5109	10493	-1	-1
1924	11	-1	3315	-1	-1
1924	12	-1	4712	-1	-1
1925	1	-1	5766	-1	-1
1925	2	-1	5853	-1	-1
1925	3	-1	6847	-1	-1
1925	4	12831	6327	-1	-1
1925	5	69505	39896	-1	-1
1925	6	68220	52935	-1	-1
1925	7	39988	41781	-1	-1
1925	8	14465	28066	-1	-1
1925	9	9245	19548	-1	-1
1925	10	8329	8993	-1	-1

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(-1 Indicates Missing Data)

YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1925	11	-1	3855	-1	-1
1925	12	-1	5496	-1	-1
1926	1	-1	6656	-1	-1
1926	2	-1	6545	-1	-1
1926	3	-1	8156	-1	-1
1926	4	-1	7365	-1	-1
1926	5	30597	25774	-1	-1
1926	6	19384	25332	-1	-1
1926	7	9793	19318	-1	-1
1926	8	5012	9610	-1	-1
1926	9	3744	9087	-1	-1
1926	10	4216	10305	-1	0
1926	11	-1	3016	-1	6800
1926	12	-1	3901	-1	11900
1927	1	-1	5143	-1	15700
1927	2	-1	5369	-1	18300
1927	3	-1	6704	-1	20400
1927	4	5335	6414	-1	20800
1927	5	33905	15791	-1	18000
1927	6	97768	69751	-1	19100
1927	7	39613	46939	-1	5100
1927	8	13809	17576	-1	200
1927	9	9609	11053	-1	100
1927	10	9364	11065	-1	1600
1927	11	-1	4291	-1	9300
1927	12	-1	5176	-1	15600
1928	1	-1	6385	-1	19900
1928	2	-1	6898	-1	22900
1928	3	-1	7851	-1	25100
1928	4	9904	6916	-1	26000
1928	5	70511	47402	-1	26300
1928	6	36121	45890	-1	12000
1928	7	21181	28447	-1	1200
1928	8	9105	11656	-1	400
1928	9	5676	10061	-1	0
1928	10	5744	11785	-1	100
1928	11	-1	3232	-1	7700
1928	12	-1	4476	-1	13500
1929	1	-1	6063	-1	17300
1929	2	-1	6242	-1	19700
1929	3	-1	7478	-1	22100
1929	4	-1	6877	-1	22900
1929	5	25225	11686	-1	18700
1929	6	41823	38355	-1	7600
1929	7	17306	19985	-1	1000
1929	8	7269	9436	-1	200



APPENDIX A: BIG LOST RIVER MONTHLY DISCHARGE AND STORAGE  
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(-1 Indicates Missing Data)

YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1929	9	5410	9281	-1	0
1929	10	4581	9978	-1	0
1929	11	-1	2891	-1	6600
1929	12	-1	4168	-1	12000
1930	1	-1	5605	-1	15700
1930	2	-1	5516	-1	18000
1930	3	-1	6789	-1	20000
1930	4	17608	6202	-1	19900
1930	5	41674	19749	-1	18000
1930	6	56996	55935	-1	6300
1930	7	20848	23473	-1	900
1930	8	12747	12325	-1	300
1930	9	7853	10043	-1	100
1930	10	10148	11454	-1	1700
1930	11	-1	3978	-1	9100
1930	12	-1	5250	-1	14700
1931	1	-1	6430	-1	18600
1931	2	-1	6448	-1	21100
1931	3	-1	7365	-1	23400
1931	4	-1	6654	-1	23900
1931	5	27256	12049	-1	19400
1931	6	23316	25121	-1	7900
1931	7	6392	13864	-1	2500
1931	8	4395	10930	-1	100
1931	9	3210	8670	-1	0
1931	10	3897	9182	-1	0
1931	11	-1	3506	-1	5200
1931	12	-1	4166	-1	9800
1932	1	-1	5022	-1	13000
1932	2	-1	5315	-1	15600
1932	3	-1	6265	-1	17000
1932	4	5355	6091	-1	17900
1932	5	46336	24594	-1	12700
1932	6	84588	52935	-1	22000
1932	7	34952	40097	-1	11100
1932	8	10206	18636	-1	3100
1932	9	6698	10212	-1	2700
1932	10	6662	11186	-1	2800
1932	11	4885	3730	-1	10000
1932	12	-1	4946	-1	14800
1933	1	-1	5758	-1	18800
1933	2	-1	6057	-1	21000
1933	3	-1	7396	-1	22800
1933	4	5164	6881	-1	23500
1933	5	18314	7160	-1	23100
1933	6	69031	62657	-1	5500

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IN ACRE-FEET.  
(-1 Indicates Missing Data)

YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1933	7	14989	16644	-1	900
1933	8	5990	9662	-1	0
1933	9	3730	8404	-1	0
1933	10	3569	9142	-1	0
1933	11	-1	7055	-1	3500
1933	12	-1	3666	-1	9500
1934	1	-1	4827	-1	13500
1934	2	-1	5125	-1	16100
1934	3	-1	5956	-1	17200
1934	4	12870	6105	-1	17100
1934	5	22461	16922	-1	6100
1934	6	13132	12069	-1	800
1934	7	5748	7789	-1	0
1934	8	3331	6936	-1	0
1934	9	2837	7335	-1	0
1934	10	3799	8204	-1	0
1934	11	3704	3434	-1	4800
1934	12	-1	3722	-1	9400
1935	1	-1	4835	-1	12700
1935	2	-1	5029	-1	14700
1935	3	-1	6150	-1	16600
1935	4	6277	6190	-1	17300
1935	5	34867	8866	-1	16500
1935	6	89046	48658	-1	28600
1935	7	32869	39575	-1	13500
1935	8	8884	21580	-1	1800
1935	9	4895	9777	-1	1200
1935	10	5077	11005	-1	700
1935	11	4902	4526	-1	6600
1935	12	-1	5950	-1	10900
1936	1	-1	5617	-1	15000
1936	2	-1	5773	-1	17400
1936	3	-1	6769	-1	19400
1936	4	15695	6547	-1	19900
1936	5	44166	20808	-1	15500
1936	6	40521	26963	-1	17200
1936	7	11656	26635	-1	1800
1936	8	8771	10587	-1	2000
1936	9	5091	9507	-1	2700
1936	10	4303	12803	-1	300
1936	11	-1	3906	-1	7000
1936	12	-1	4194	-1	12800
1937	1	-1	5470	-1	16500
1937	2	-1	5537	-1	19000
1937	3	-1	6621	-1	21200
1937	4	3708	6329	-1	22000



APPENDIX A: BIG LOST RIVER MONTHLY DISCHARGE AND STORAGE  
IN ACRE-FEET.  
(-1 Indicates Missing Data)

YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1937	5	33887	13140	-1	18400
1937	6	24546	25189	-1	10300
1937	7	12114	18937	-1	1000
1937	8	4119	8984	-1	100
1937	9	3462	8303	-1	200
1937	10	3807	8654	-1	200
1937	11	-1	5351	-1	3700
1937	12	-1	3686	-1	8900
1938	1	-1	4619	-1	12600
1938	2	-1	4569	-1	15200
1938	3	-1	5791	-1	17500
1938	4	15239	6176	-1	19700
1938	5	72216	20148	-1	41000
1938	6	124635	101779	-1	38700
1938	7	63551	60937	-1	36900
1938	8	18368	26044	-1	27900
1938	9	9904	8918	-1	30000
1938	10	13406	9335	-1	34900
1938	11	-1	14511	-1	34000
1938	12	-1	8952	-1	36500
1939	1	-1	9297	-1	38400
1939	2	-1	9454	-1	38700
1939	3	-1	11184	-1	38800
1939	4	-1	9603	-1	39100
1939	5	37408	20130	-1	38800
1939	6	24362	26625	-1	30000
1939	7	14446	26338	-1	16100
1939	8	5853	19005	-1	7800
1939	9	4770	10420	-1	8000
1939	10	5271	13055	-1	6700
1939	11	-1	4121	-1	13100
1939	12	-1	4369	-1	18500
1940	1	-1	5619	-1	22100
1940	2	-1	6365	-1	24600
1940	3	-1	7252	-1	26200
1940	4	-1	6833	-1	26800
1940	5	56641	25381	-1	25600
1940	6	49755	42315	-1	21100
1940	7	13773	28105	-1	6500
1940	8	5051	15237	-1	1300
1940	9	9605	5938	-1	6800
1940	10	10230	6613	-1	11200
1940	11	-1	3901	-1	17500
1940	12	-1	5202	-1	22500
1941	1	-1	6646	-1	25900
1941	2	-1	6698	-1	28200

APPENDIX A: BIG LOST RIVER MONTHLY DISCHARGE AND STORAGE  
IN ACRE-FEET.  
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YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1941	3	-1	7853	-1	29900
1941	4	-1	7327	-1	31000
1941	5	51894	20007	-1	37400
1941	6	56276	42721	-1	37500
1941	7	25371	31704	-1	28700
1941	8	14061	21259	-1	22700
1941	9	8414	11277	-1	23800
1941	10	7964	9029	-1	27700
1941	11	6492	6767	-1	32200
1941	12	-1	7946	-1	36000
1942	1	-1	11892	-1	35600
1942	2	-1	10866	-1	35000
1942	3	-1	10628	-1	35000
1942	4	23498	16058	-1	38200
1942	5	35758	26298	-1	37600
1942	6	69101	57195	-1	37700
1942	7	45273	47011	-1	28500
1942	8	11372	27310	-1	14200
1942	9	6379	8839	-1	16600
1942	10	6426	7517	-1	21400
1942	11	6158	5244	-1	27500
1942	12	-1	7928	-1	31000
1943	1	-1	9874	-1	32400
1943	2	-1	9561	-1	32800
1943	3	-1	10819	-1	32800
1943	4	28853	11727	-1	38200
1943	5	66641	46523	-1	39200
1943	6	88451	79554	-1	38200
1943	7	71906	65851	-1	38400
1943	8	20451	32766	-1	27000
1943	9	9432	15124	-1	25800
1943	10	8876	8587	-1	30600
1943	11	7275	8023	-1	35900
1943	12	-1	12715	-1	35400
1944	1	-1	11041	-1	36300
1944	2	-1	8468	-1	38600
1944	3	-1	11136	-1	38400
1944	4	5756	10241	-1	38400
1944	5	46352	24675	-1	39500
1944	6	82213	72997	-1	39700
1944	7	61641	63327	-1	37900
1944	8	16781	36508	-1	20900
1944	9	9442	15164	-1	20200
1944	10	8184	6091	-1	28000
1944	11	6954	7077	-1	34800
1944	12	-1	12815	-1	35300



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YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1945	1	-1	10835	-1	36200
1945	2	-1	9765	-1	36400
1945	3	-1	9791	-1	37300
1945	4	6492	9642	-1	37400
1945	5	32680	16801	-1	38800
1945	6	53973	40813	-1	39000
1945	7	38559	42073	-1	31300
1945	8	12993	34684	-1	13000
1945	9	8351	14326	-1	12100
1945	10	7408	4775	-1	19500
1945	11	6091	5843	-1	25600
1945	12	-1	6351	-1	30800
1946	1	-1	7396	-1	34400
1946	2	-1	7226	-1	36700
1946	3	-1	8970	-1	38400
1946	4	23877	12757	-1	40000
1946	5	52715	36881	-1	39500
1946	6	57762	49259	-1	37700
1946	7	25542	41515	-1	22000
1946	8	10884	27107	-1	8800
1946	9	8815	7285	3420	14800
1946	10	11124	4180	4472	24500
1946	11	6813	5416	4428	32100
1946	12	-1	7041	4494	37100
1947	1	-1	10351	3383	37700
1947	2	-1	10069	5482	37800
1947	3	-1	11676	9247	37400
1947	4	13493	11348	6724	35500
1947	5	66456	42247	6670	39100
1947	6	49142	43039	8791	36600
1947	7	28772	42303	2065	19500
1947	8	10597	21766	2180	9800
1947	9	6807	15283	2353	6300
1947	10	7849	6184	2786	13800
1947	11	5369	3750	2470	21800
1947	12	-1	5271	1807	27800
1948	1	-1	6291	1563	32000
1948	2	-1	6188	1577	35200
1948	3	-1	7257	1631	38000
1948	4	10474	8708	1178	37300
1948	5	46977	24290	621	38200
1948	6	85631	70894	5271	38700
1948	7	31085	41604	2262	25400
1948	8	10160	28752	2165	9100
1948	9	7009	12033	3555	8400
1948	10	7575	3942	3893	17600



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YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1948	11	6107	4694	2103	24800
1948	12	5565	5841	1869	30400
1949	1	4900	7107	1599	34200
1949	2	4079	7255	1500	36600
1949	3	4345	9113	2256	38200
1949	4	14467	8878	1815	37100
1949	5	55159	29218	1623	40200
1949	6	42940	42753	3131	31900
1949	7	16751	35672	1171	13000
1949	8	7345	22399	1486	1700
1949	9	5204	12194	1177	500
1949	10	5748	5607	1557	7600
1949	11	4809	3958	1917	15200
1949	12	3623	5022	1375	20900
1950	1	3494	5992	1230	24900
1950	2	2827	6123	1000	27500
1950	3	4166	7009	1234	29800
1950	4	10011	6761	2797	31100
1950	5	35252	22016	798	21100
1950	6	61062	33867	1165	31900
1950	7	36946	46197	1696	16400
1950	8	11668	27601	1922	1900
1950	9	8374	8414	1444	5400
1950	10	7117	3660	1379	14000
1950	11	6688	4898	1347	20800
1950	12	7063	5758	1337	27100
1951	1	6150	6718	909	31400
1951	2	5297	6575	704	34400
1951	3	4345	7676	788	37000
1951	4	20396	11860	1226	38800
1951	5	64379	42031	2869	41200
1951	6	63381	55250	3543	39300
1951	7	42545	44430	1893	33800
1951	8	20794	31573	7277	29600
1951	9	8656	15654	5375	27700
1951	10	8777	7597	6339	32900
1951	11	6426	6904	6496	38000
1951	12	6061	11122	5637	38900
1952	1	5228	12301	5387	38700
1952	2	4454	11950	5992	36900
1952	3	4791	12654	7569	34600
1952	4	17921	14245	13100	34500
1952	5	83715	62917	27512	37500
1952	6	89232	74344	25453	39900
1952	7	42739	46090	11936	31900
1952	8	17771	35232	4149	18000



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YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1952	9	7793	7700	4764	22700
1952	10	6559	6448	3032	28200
1952	11	5303	6851	4855	33600
1952	12	5396	7757	6299	37800
1953	1	5625	11785	7694	37100
1953	2	4563	9285	8946	37400
1953	3	4936	9317	7847	38300
1953	4	10206	8807	5873	38100
1953	5	26730	21308	2101	27600
1953	6	80656	51884	5168	38100
1953	7	53066	57391	3101	28800
1953	8	12549	32718	1762	11300
1953	9	6958	13817	1825	9300
1953	10	6377	6547	2716	15000
1953	11	5603	4496	3141	21800
1953	12	4387	5625	4434	27700
1954	1	4093	6377	4732	32200
1954	2	3980	6323	3214	35000
1954	3	4418	7674	2821	37300
1954	4	12188	8902	1730	36500
1954	5	58941	36059	782	34400
1954	6	48314	31762	1167	40000
1954	7	33002	46255	1532	24700
1954	8	9476	26048	1050	10100
1954	9	5430	16485	1220	3800
1954	10	5016	13051	1682	2800
1954	11	4303	2684	2000	11200
1954	12	3492	4291	1934	17500
1955	1	3258	5567	1349	22000
1955	2	2885	5819	1085	24600
1955	3	3278	6799	1075	26800
1955	4	3795	6331	760	28100
1955	5	22979	10975	450	24700
1955	6	62339	42682	337	23600
1955	7	29877	31633	669	19800
1955	8	9636	27032	357	3100
1955	9	5004	12767	552	400
1955	10	4768	10547	641	600
1955	11	3873	3194	766	8200
1955	12	5601	3875	3014	14800
1956	1	3948	5039	1147	19500
1956	2	3178	5371	770	22700
1956	3	4389	6388	7763	26100
1956	4	18497	6680	5093	30800
1956	5	86411	48517	7103	41700
1956	6	106184	93530	28841	42300



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YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1956	7	38775	50898	2282	25400
1956	8	12831	29905	2107	11300
1956	9	6797	12412	2240	10100
1956	10	6589	7555	2903	15700
1956	11	5299	4476	3972	22200
1956	12	4341	5375	3313	27500
1957	1	3859	6343	2159	31300
1957	2	3621	6260	2149	34000
1957	3	4404	7452	2633	36400
1957	4	5333	7357	2155	37800
1957	5	53856	24631	13019	40600
1957	6	107261	78545	23245	44300
1957	7	42497	50977	5389	30300
1957	8	11642	33843	1798	10800
1957	9	7380	7111	3801	15400
1957	10	8267	7371	4454	20400
1957	11	6021	7027	5220	25500
1957	12	5091	7672	6194	29500
1958	1	4898	8307	5682	32200
1958	2	4349	8053	5760	34200
1958	3	4863	9249	6871	35700
1958	4	6833	9843	7121	36200
1958	5	104561	73350	30714	38300
1958	6	84122	75309	40204	38300
1958	7	34311	43981	7224	23700
1958	8	14559	29679	4325	12100
1958	9	8152	18578	7426	7000
1958	10	6750	14850	13563	6400
1958	11	5660	3291	6466	15700
1958	12	4579	5109	6807	22700
1959	1	4103	6416	6067	27700
1959	2	3615	6379	5238	31300
1959	3	3998	7676	5466	34200
1959	4	7271	8638	1444	34200
1959	5	17136	21846	843	20800
1959	6	53147	39170	841	17000
1959	7	16116	26240	526	4200
1959	8	7047	14618	155	400
1959	9	9114	11273	226	400
1959	10	7619	8317	925	5600
1959	11	5351	3289	1061	14000
1959	12	4307	4978	897	20500
1960	1	4506	6166	673	24900
1960	2	4164	6400	679	28200
1960	3	5027	7134	708	31100
1960	4	10557	7136	500	31900



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YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1960	5	25060	17062	58	26000
1960	6	45809	41601	0	17200
1960	7	12092	25802	16	2000
1960	8	6017	12126	0	600
1960	9	4281	9940	0	600
1960	10	4135	7031	0	4900
1960	11	3857	4041	0	11100
1960	12	3589	5268	4	15800
1961	1	3141	6295	0	19000
1961	2	2718	6121	0	21000
1961	3	2895	6930	6	22900
1961	4	4416	6561	0	23300
1961	5	26242	14553	0	17600
1961	6	48179	32252	0	11800
1961	7	9734	19449	0	1200
1961	8	6069	10460	0	400
1961	9	7803	8462	0	2100
1961	10	6061	6444	-1	5700
1961	11	4831	3782	-1	11800
1961	12	3535	4839	-1	16700
1962	1	3339	5718	-1	20300
1962	2	4220	5472	-1	22900
1962	3	4718	6275	-1	25100
1962	4	18495	8232	-1	24400
1962	5	32801	19860	-1	21300
1962	6	81574	46473	-1	29400
1962	7	31526	33881	-1	22900
1962	8	14277	26681	-1	11100
1962	9	6244	11483	-1	9900
1962	10	7718	7670	-1	14000
1962	11	5787	4244	-1	20700
1962	12	4799	5299	-1	26300
1963	1	4037	5990	-1	30500
1963	2	4533	5793	-1	33600
1963	3	3942	7025	-1	36200
1963	4	5504	7400	-1	37800
1963	5	54947	21102	-1	44300
1963	6	88572	73785	-1	44400
1963	7	39799	49874	-1	28100
1963	8	14061	24988	-1	19000
1963	9	10358	10862	-1	21300
1963	10	7998	12402	-1	22500
1963	11	7079	5666	-1	29100
1963	12	5843	6849	-1	34400
1964	1	5535	7535	-1	38300
1964	2	4603	7720	-1	40800

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YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1964	3	4305	12910	-1	38700
1964	4	8359	9061	-1	40300
1964	5	43592	29034	-1	38200
1964	6	75957	55260	-1	44000
1964	7	42910	50527	-1	30800
1964	8	11908	30889	-1	13900
1964	9	7236	12118	-1	14200
1964	10	6061	8962	-1	18500
1964	11	5018	5107	-1	25400
1964	12	5766	6583	-1	31200
1965	1	6777	7696	-1	35300
1965	2	4908	9735	-1	35300
1965	3	5174	15519	-1	30200
1965	4	13757	11376	-1	29700
1965	5	60974	40537	-1	33000
1965	6	139753	119695	-1	42900
1965	7	90488	90084	-1	43000
1965	8	36049	44880	-1	35200
1965	9	14642	37803	-1	20000
1965	10	10440	11416	-1	27600
1965	11	7974	6079	-1	36900
1965	12	6408	13354	-1	37000
1966	1	6303	11735	-1	37600
1966	2	5531	7255	-1	40600
1966	3	5740	7998	-1	43400
1966	4	10987	8581	-1	44200
1966	5	38920	36666	278	32300
1966	6	29337	31308	1022	27300
1966	7	13055	26353	327	11900
1966	8	6718	18122	230	4400
1966	9	5283	10114	190	4800
1966	10	4930	7192	347	8500
1966	11	4418	3835	583	15500
1966	12	4262	5027	855	21300
1967	1	4428	6047	722	25300
1967	2	5022	6248	631	27800
1967	3	4764	8553	415	29300
1967	4	4595	9817	226	28800
1967	5	74763	52266	5444	23300
1967	6	138007	96254	51286	44500
1967	7	80671	84173	56469	39100
1967	8	19265	43634	8791	15100
1967	9	10854	23358	12952	4800
1967	10	12352	19036	15816	4300
1967	11	7652	3514	9291	15300
1967	12	5740	5202	6333	23600



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YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1968	1	5264	6607	3881	28700
1968	2	4363	7077	4597	32200
1968	3	5375	7876	7549	35200
1968	4	8926	7303	5271	37600
1968	5	33706	19790	752	35700
1968	6	79900	58393	2480	41500
1968	7	28314	38059	1440	28400
1968	8	18094	16848	3234	28700
1968	9	12477	11555	3647	32700
1968	10	9978	12942	6019	34700
1968	11	7408	14763	11110	34900
1968	12	6281	14473	14396	33300
1969	1	6226	12102	11051	33800
1969	2	4912	14807	11497	29200
1969	3	6107	33440	23439	10100
1969	4	26647	30464	38851	8500
1969	5	115631	72759	44670	28000
1969	6	90000	66024	45789	43200
1969	7	47981	54631	28651	31900
1969	8	15660	41589	7275	7400
1969	9	9426	19513	12969	2000
1969	10	8410	5037	8815	11000
1969	11	6470	3964	7234	20400
1969	12	5849	5793	7853	26500
1970	1	5406	6557	7127	31100
1970	2	6156	6500	7095	34300
1970	3	5595	7454	5303	37300
1970	4	5988	7355	3623	39900
1970	5	52195	31016	2770	40200
1970	6	104343	81235	17675	44800
1970	7	46108	54616	21022	35900
1970	8	13416	37047	3315	15000
1970	9	9658	12612	8424	15300
1970	10	7986	10886	6996	18400
1970	11	6341	5424	7553	26800
1970	12	5591	6964	6664	32800
1971	1	6170	7710	7539	36800
1971	2	4680	7327	7119	39500
1971	3	4867	8599	7807	41600
1971	4	7184	25407	20046	27100
1971	5	60540	48501	20050	21400
1971	6	109926	72908	25568	44300
1971	7	57782	57893	26911	40800
1971	8	19836	45297	11327	17400
1971	9	10253	14699	15824	17900
1971	10	10716	14985	17400	20300



APPENDIX A: BIG LOST RIVER MONTHLY DISCHARGE AND STORAGE  
IN ACRE-FEET.  
(-1 Indicates Missing Data)

YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1971	11	8734	11188	15848	23500
1971	12	6162	10335	10003	26500
1972	1	6273	11287	6654	27600
1972	2	4430	10972	9247	28000
1972	3	6428	11245	10295	30200
1972	4	9271	11285	7204	31500
1972	5	44372	36906	1694	22400
1972	6	94835	60254	4057	43200
1972	7	26734	42241	2855	25800
1972	8	12368	30964	2224	10300
1972	9	8910	15733	6712	9500
1972	10	9493	9099	6811	16300
1972	11	6692	5194	6113	25200
1972	12	5539	6843	6158	30700
1973	1	4567	7813	5708	34400
1973	2	4268	7496	6262	36900
1973	3	4954	8866	6724	39100
1973	4	6656	8601	7855	40500
1973	5	47519	35276	1581	32400
1973	6	53270	43198	1536	30400
1973	7	21755	28470	1282	20400
1973	8	9974	31089	859	2400
1973	9	8081	13414	1510	900
1973	10	6097	8384	1633	4700
1973	11	6877	3706	2706	13500
1973	12	5158	5692	2040	19600
1974	1	7799	6569	3458	23900
1974	2	4504	6950	3627	26700
1974	3	6037	7986	11914	31400
1974	4	20903	8361	8634	41600
1974	5	68468	63246	10515	33800
1974	6	125190	103783	34325	42900
1974	7	44184	49289	12757	33300
1974	8	15568	38517	3291	13300
1974	9	8107	17487	3188	8600
1974	10	6801	12255	6950	10200
1974	11	5960	7123	7827	16800
1974	12	5956	6137	7730	22300
1975	1	6144	7668	7545	25800
1975	2	5008	7900	6341	27900
1975	3	3899	10085	6710	29900
1975	4	4117	11733	6972	32000
1975	5	29314	27211	17279	27000
1975	6	111402	73753	17144	40500
1975	7	89466	82530	35662	40100
1975	8	20148	48039	5936	12000



APPENDIX A: BIG LOST RIVER MONTHLY DISCHARGE AND STORAGE  
IN ACRE-FEET.  
(-1 Indicates Missing Data)

YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1975	9	10230	22778	10327	3200
1975	10	9698	14321	10559	5400
1975	11	7509	7079	11841	12000
1975	12	6472	6021	7797	19100
1976	1	5355	6867	6220	24200
1976	2	4518	6791	6436	27700
1976	3	5160	7500	7275	30700
1976	4	13164	7880	4438	39900
1976	5	69208	52086	4276	41400
1976	6	60978	59536	3480	31500
1976	7	29845	43706	1438	12400
1976	8	17376	30714	1774	600
1976	9	16525	21183	3688	600
1976	10	10134	18538	10309	3300
1976	11	6896	10222	11225	4800
1976	12	5188	3625	4035	15500
1977	1	4531	4910	2569	21700
1977	2	3785	5289	3006	25800
1977	3	3573	6246	3041	29400
1977	4	6956	6293	708	30700
1977	5	12271	11287	720	28900
1977	6	47197	31119	585	29400
1977	7	16340	31929	230	11700
1977	8	8313	20316	91	900
1977	9	5518	10565	161	500
1977	10	5478	4210	264	5800
1977	11	3613	3137	373	14000
1977	12	4506	4629	306	20500
1978	1	5105	5627	198	25300
1978	2	3752	5712	153	28600
1978	3	5023	6962	183	31800
1978	4	8775	7067	252	34400
1978	5	34789	18828	73	32800
1978	6	83487	57258	762	41100
1978	7	50709	59536	1091	27100
1978	8	14263	41460	782	2900
1978	9	19719	11513	1968	14300
1978	10	10267	10239	754	20600
1978	11	7896	6019	458	28400
1978	12	6470	6071	722	34100
1979	1	5454	6914	512	38400
1979	2	5099	6976	579	41500
1979	3	6109	8839	1714	43600
1979	4	8527	9047	1458	44000
1979	5	51618	36692	1234	44300
1979	6	40587	51169	758	24500



APPENDIX A: BIG LOST RIVER MONTHLY DISCHARGE AND STORAGE  
IN ACRE-FEET.  
(-1 Indicates Missing Data)

YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1979	7	15174	32825	448	5300
1979	8	11714	16366	581	1800
1979	9	6565	11303	268	1100
1979	10	5474	7250	196	4600
1979	11	4863	4504	276	11600
1979	12	4317	4533	240	18300
1980	1	4333	5686	228	23300
1980	2	3797	5910	232	26900
1980	3	3740	7097	248	29900
1980	4	12313	6724	220	34200
1980	5	59568	39553	1922	43500
1980	6	69329	59292	7585	44600
1980	7	52179	64605	5712	27400
1980	8	15436	34424	3478	8500
1980	9	13217	9958	1589	15800
1980	10	9013	9126	1341	21500
1980	11	7535	5047	-1	30400
1980	12	6547	6609	-1	36300
1981	1	5430	7176	-1	40500
1981	2	4432	6734	-1	43700
1981	3	5135	10900	643	44000
1981	4	17402	16354	5204	44800
1981	5	56151	42894	9565	44900
1981	6	79388	69390	10349	43500
1981	7	30450	50812	690	17000
1981	8	11392	28161	472	1300
1981	9	7283	11755	679	1000
1981	10	7656	7750	-1	6500
1981	11	6329	4172	-1	14400
1981	12	6087	5148	-1	21400
1982	1	5186	6250	-1	25900
1982	2	4145	6299	-1	30600
1982	3	5014	7478	-1	34600
1982	4	11196	16380	-1	34200
1982	5	63841	51370	28383	35800
1982	6	102880	82802	29663	44900
1982	7	72543	71916	38291	43800
1982	8	23881	49663	7252	18700
1982	9	12142	19529	11154	15300
1982	10	11932	7688	12331	28500
1982	11	8299	5976	8232	37900
1982	12	6867	13079	10634	37700
1983	1	5268	13102	11081	36900
1983	2	3569	7563	6984	39900
1983	3	3734	23810	18812	31300
1983	4	6684	22112	20064	25000



APPENDIX A: BIG LOST RIVER MONTHLY DISCHARGE AND STORAGE  
IN ACRE-FEET.  
(-1 Indicates Missing Data)

YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1983	5	64409	40805	27526	31000
1983	6	131619	104596	66518	41800
1983	7	81638	71390	56290	42300
1983	8	32488	38873	17513	32000
1983	9	13398	21481	17312	27800
1983	10	13743	15977	21477	34900
1983	11	22213	39307	45386	32800
1983	12	17126	29476	37385	30600
1984	1	15727	18221	-1	33300
1984	2	13126	17519	-1	36100
1984	3	12711	14120	-1	36800
1984	4	15023	0	-1	37200
1984	5	70019	48979	41331	42900
1984	6	94347	90417	59197	44900
1984	7	63450	66700	29030	44400
1984	8	28457	55076	30913	28100
1984	9	7013	29538	21850	23600
1984	10	11820	22120	22820	25300
1984	11	9980	15080	21610	30900
1984	12	9030	15420	18000	29800
1985	1	6760	12130	12830	31200
1985	2	5550	5870	5160	38500
1985	3	7540	14440	9970	39300
1985	4	16590	18990	18700	43200
1985	5	40100	30970	8120	43800
1985	6	36060	42800	911	32500
1985	7	15780	31090	216	16500
1985	8	8950	25290	453	3700
1985	9	22470	27990	13630	1300
1985	10	9810	19370	12340	500
1985	11	7540	3770	3200	13700
1985	12	7820	5690	1890	21300
1986	1	7120	6450	1190	26900
1986	2	6360	6620	2850	31100
1986	3	8830	7640	5950	38400
1986	4	22520	17910	13810	44000
1986	5	67490	51840	21560	44600
1986	6	114800	101600	54570	44300
1986	7	34000	43190	4840	30900
1986	8	15470	35320	3510	11900
1986	9	10790	27130	19510	200
1986	10	9830	6580	9160	13600
1986	11	7520	5610	5360	22200
1986	12	4880	7280	6040	27900
1987	1	4390	7380	4080	32600
1987	2	3800	6650	4230	35800



APPENDIX A: BIG LOST RIVER MONTHLY DISCHARGE AND STORAGE  
IN ACRE-FEET.  
(-1 Indicates Missing Data)

YEAR	CALENDAR MONTH	HOWELL RANCH (13120500)	BELOW MACKAY DAM (13127000)	BELOW ARCO (13132500)	RESERVOIR STORAGE (13126000)
1987	3	4880	7690	5210	38900
1987	4	14460	7140	2310	40800
1987	5	42540	26690	516	44500
1987	6	28950	30430	527	37100
1987	7	15480	28510	799	23600
1987	8	9820	29700	415	6400
1987	9	7980	12860	243	4800
1987	10	5870	8280	717	8500
1987	11	4590	4850	1310	15300
1987	12	4240	5650	791	20600
1988	1	4180	6390	622	24200
1988	2	3800	6660	566	26600
1988	3	4550	7940	385	28600
1988	4	9740	5870	283	31800
1988	5	31520	17740	250	27700
1988	6	35340	33760	6	15700
1988	7	9430	24640	0	1500
1988	8	5130	10470	0	600
1988	9	4010	9010	0	700
1988	10	4050	6674	0	3920
1988	11	4030	3560	0	10400
1988	12	4030	3870	0	16100
1989	1	4100	5070	0	20800
1989	2	3420	5460	0	23900
1989	3	4050	6100	0	26700
1989	4	11520	5550	0	28000
1989	5	30640	14000	0	25800
1989	6	43410	29370	0	22400
1989	7	18570	28520	0	6750
1989	8	7850	16900	0	500
1989	9	6600	10410	0	500
1989	10	7300	8600	0	3800
1989	11	5700	3700	0	9610
1989	12	4400	3600	0	15700
1990	1	3800	4600	0	20700
1990	2	2900	4900	0	24400
1990	3	4900	6000	0	27600
1990	4	13900	5800	0	29700
1990	5	21200	16600	0	22200
1990	6	47800	19800	0	35100
1990	7	21200	35300	0	16400
1990	8	9600	24900	0	2930
1990	9	6300	12700	0	626
1990	10	-1	11316	0	830
1990	11	-1	-1	0	-1
1990	12	-1	-1	0	-1



APPENDIX B

MONTHLY IRRIGATION DIVERSIONS

APPENDIX B: MONTHLY IRRIGATION DIVERSIONS  
IN ACRE-FEET  
(-1 Indicates Missing Data)

YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1922	1	-1	-1	-1	-1	-1	-1	0
1922	2	-1	-1	-1	-1	-1	-1	0
1922	3	-1	-1	-1	-1	-1	-1	0
1922	4	-1	-1	-1	-1	-1	-1	0
1922	5	-1	-1	-1	-1	-1	-1	0
1922	6	-1	-1	-1	-1	-1	-1	0
1922	7	-1	-1	-1	-1	-1	-1	0
1922	8	-1	-1	-1	-1	-1	-1	0
1922	9	-1	-1	-1	-1	-1	-1	0
1922	10	-1	-1	-1	-1	-1	-1	0
1922	11	0	-1	-1	-1	-1	7137	0
1922	12	0	-1	-1	-1	-1	1865	0
1923	1	0	-1	-1	-1	-1	583	0
1923	2	0	-1	-1	-1	-1	542	0
1923	3	0	-1	-1	-1	-1	644	0
1923	4	2400	-1	-1	-1	-1	4608	0
1923	5	15992	-1	-1	-1	-1	22255	0
1923	6	28861	-1	-1	-1	-1	49454	0
1923	7	25775	-1	-1	-1	-1	65764	0
1923	8	15592	-1	-1	-1	-1	47058	0
1923	9	9446	-1	-1	-1	-1	24311	0
1923	10	4820	-1	-1	-1	-1	16339	0
1923	11	2400	-1	-1	-1	-1	7139	0
1923	12	0	-1	-1	-1	-1	3312	0
1924	1	0	-1	-1	-1	-1	1138	0
1924	2	0	-1	-1	-1	-1	1321	0
1924	3	0	-1	-1	-1	-1	2187	0
1924	4	3500	-1	-1	-1	-1	5612	0
1924	5	11971	-1	-1	-1	-1	25672	0
1924	6	14408	-1	-1	-1	-1	26070	0
1924	7	9828	-1	-1	-1	-1	21986	0
1924	8	5293	-1	-1	-1	-1	10120	0
1924	9	4556	-1	-1	-1	-1	8758	0
1924	10	3813	-1	-1	-1	-1	10925	0
1924	11	1800	89	-1	-1	-1	5424	0
1924	12	700	0	-1	-1	-1	2991	0
1925	1	0	0	-1	-1	-1	1177	0
1925	2	0	0	-1	-1	-1	1076	0
1925	3	0	0	-1	-1	-1	1257	0
1925	4	2000	440	-1	-1	-1	6388	0
1925	5	15472	1455	-1	-1	-1	29006	0
1925	6	22106	1630	-1	-1	-1	51375	0
1925	7	16190	1635	-1	-1	-1	48655	0
1925	8	13867	1400	-1	-1	-1	37345	0
1925	9	8194	1075	-1	-1	-1	23418	0
1925	10	5178	624	-1	-1	-1	14179	0



APPENDIX B: MONTHLY IRRIGATION DIVERSIONS  
IN ACRE-FEET  
(-1 Indicates Missing Data)

YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1925	11	1900	240	-1	-1	-1	6535	0
1925	12	900	250	-1	-1	-1	4705	0
1926	1	700	89	-1	-1	-1	1733	0
1926	2	0	0	-1	-1	-1	1290	0
1926	3	400	0	-1	-1	-1	2000	0
1926	4	2900	756	-1	-1	-1	9725	0
1926	5	18553	1390	-1	-1	-1	25363	0
1926	6	16053	1320	-1	-1	-1	26205	0
1926	7	9808	1300	-1	-1	-1	18495	0
1926	8	5587	1240	-1	-1	-1	9163	0
1926	9	4984	1120	-1	-1	-1	8790	0
1926	10	3777	974	-1	-1	-1	9272	0
1926	11	1200	446	-1	-1	-1	5230	0
1926	12	500	325	-1	-1	-1	3105	0
1927	1	0	0	-1	-1	-1	528	0
1927	2	0	0	-1	-1	-1	380	0
1927	3	0	8	-1	-1	-1	842	0
1927	4	1560	524	-1	-1	-1	4553	0
1927	5	7754	1375	-1	-1	-1	13277	0
1927	6	24403	1820	-1	-1	-1	58442	0
1927	7	13639	1675	-1	-1	-1	49800	0
1927	8	10747	1345	-1	-1	-1	23291	0
1927	9	7273	1270	-1	-1	-1	16513	0
1927	10	4856	721	-1	-1	-1	13584	0
1927	11	1800	238	-1	-1	-1	6337	0
1927	12	700	30	-1	-1	-1	2938	0
1928	1	0	0	-1	-1	-1	1430	0
1928	2	0	0	-1	-1	-1	1423	0
1928	3	1200	139	-1	-1	-1	4943	0
1928	4	2700	832	-1	-1	-1	6937	0
1928	5	21184	1600	-1	-1	-1	34539	0
1928	6	13700	1670	-1	-1	-1	45514	0
1928	7	11560	1415	-1	-1	-1	31168	0
1928	8	10559	1143	-1	-1	-1	14036	0
1928	9	6830	1080	-1	-1	-1	10907	0
1928	10	5468	761	-1	-1	-1	12354	0
1928	11	-1	65	-1	-1	-1	-1	0
1928	12	-1	0	-1	-1	-1	-1	0
1929	1	-1	0	-1	-1	-1	-1	0
1929	2	-1	0	-1	-1	-1	-1	0
1929	3	-1	196	-1	-1	-1	-1	0
1929	4	-1	692	-1	-1	-1	-1	0
1929	5	-1	1365	-1	-1	-1	-1	0
1929	6	-1	1330	-1	-1	-1	-1	0
1929	7	-1	1245	-1	-1	-1	-1	0
1929	8	-1	1040	-1	-1	-1	-1	0

APPENDIX B: MONTHLY IRRIGATION DIVERSIONS  
IN ACRE-FEET  
(-1 Indicates Missing Data)

YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1929	9	-1	927	-1	-1	-1	-1	0
1929	10	-1	847	-1	-1	-1	-1	0
1929	11	2000	147	-1	-1	-1	2750	0
1929	12	700	149	-1	-1	-1	1450	0
1930	1	100	0	-1	-1	-1	495	0
1930	2	100	0	-1	-1	-1	447	0
1930	3	400	0	-1	-1	-1	915	0
1930	4	1688	619	-1	-1	-1	4882	0
1930	5	19467	1140	-1	-1	-1	13201	0
1930	6	19481	1450	-1	-1	-1	40432	0
1930	7	12627	1280	-1	-1	-1	21365	0
1930	8	13634	1220	-1	-1	-1	13043	0
1930	9	6534	1060	-1	-1	-1	11262	0
1930	10	2817	490	-1	-1	-1	9854	0
1930	11	0	60	-1	-1	-1	2032	0
1930	12	0	0	-1	-1	-1	123	0
1931	1	0	0	-1	-1	-1	137	0
1931	2	0	79	-1	-1	-1	412	0
1931	3	0	560	-1	-1	-1	1683	0
1931	4	3100	969	-1	-1	-1	5043	0
1931	5	13928	1049	-1	-1	-1	7536	0
1931	6	16715	947	-1	-1	-1	20293	0
1931	7	8668	890	-1	-1	-1	10126	0
1931	8	4625	927	-1	-1	-1	8258	0
1931	9	3378	990	-1	-1	-1	6912	0
1931	10	2230	914	-1	-1	-1	7196	0
1931	11	0	42	-1	-1	-1	2371	0
1931	12	0	0	-1	-1	-1	147	0
1932	1	0	0	-1	-1	-1	123	0
1932	2	0	0	-1	-1	-1	115	0
1932	3	0	31	-1	-1	-1	735	0
1932	4	2385	399	-1	-1	-1	3537	0
1932	5	11598	836	-1	-1	-1	12173	0
1932	6	19570	1310	-1	-1	-1	41518	0
1932	7	14462	1210	-1	-1	-1	37537	0
1932	8	9289	855	-1	-1	-1	20741	0
1932	9	6405	833	-1	-1	-1	11414	0
1932	10	5191	590	-1	-1	-1	9581	0
1932	11	0	83	-1	-1	-1	3991	0
1932	12	0	0	-1	-1	-1	1504	0
1933	1	0	0	-1	-1	-1	123	0
1933	2	0	0	-1	-1	-1	111	0
1933	3	0	92	-1	-1	-1	656	0
1933	4	1431	464	-1	-1	-1	3718	0
1933	5	9731	953	-1	-1	-1	4396	0
1933	6	16334	1410	-1	-1	-1	38926	0



APPENDIX B: MONTHLY IRRIGATION DIVERSIONS  
IN ACRE-FEET  
(-1 Indicates Missing Data)

YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1933	7	13193	1090	-1	-1	-1	15336	0
1933	8	8097	855	-1	-1	-1	7794	0
1933	9	3760	839	-1	-1	-1	6397	0
1933	10	2287	810	-1	-1	-1	7022	0
1933	11	0	188	-1	-1	-1	3853	0
1933	12	0	149	-1	-1	-1	2318	0
1934	1	0	123	-1	-1	-1	1345	0
1934	2	0	119	-1	-1	-1	1312	0
1934	3	0	227	-1	-1	-1	2930	0
1934	4	13065	553	-1	-1	-1	3095	0
1934	5	20069	924	-1	-1	-1	12134	0
1934	6	15746	904	-1	-1	-1	8371	0
1934	7	10467	950	-1	-1	-1	4247	0
1934	8	8388	781	-1	-1	-1	2980	0
1934	9	4022	728	-1	-1	-1	3312	0
1934	10	2867	495	-1	-1	-1	4048	0
1934	11	0	173	-1	-1	-1	1643	0
1934	12	0	101	-1	-1	-1	766	0
1935	1	0	0	-1	-1	-1	512	0
1935	2	0	16	-1	-1	-1	460	0
1935	3	0	186	-1	-1	-1	1425	0
1935	4	7986	204	-1	-1	-1	1973	0
1935	5	13724	827	-1	-1	-1	4516	0
1935	6	21632	1270	-1	-1	-1	33903	0
1935	7	12165	1480	-1	-1	-1	28362	0
1935	8	10544	1220	-1	-1	-1	15776	0
1935	9	6401	926	-1	-1	-1	6513	0
1935	10	5211	595	-1	-1	-1	7365	0
1935	11	0	114	-1	-1	-1	852	0
1935	12	0	0	-1	-1	-1	433	0
1936	1	0	0	-1	-1	-1	371	0
1936	2	0	0	-1	-1	-1	349	0
1936	3	0	0	-1	-1	-1	556	0
1936	4	8049	280	-1	-1	-1	1779	0
1936	5	17562	700	-1	-1	-1	12162	0
1936	6	15984	990	-1	-1	-1	16336	0
1936	7	17109	966	-1	-1	-1	16913	0
1936	8	12875	748	-1	-1	-1	7004	0
1936	9	5810	490	-1	-1	-1	4860	0
1936	10	4295	359	-1	-1	-1	8070	0
1936	11	-1	-1	-1	-1	-1	-1	0
1936	12	-1	-1	-1	-1	-1	-1	0
1937	1	-1	-1	-1	-1	-1	-1	0
1937	2	-1	-1	-1	-1	-1	-1	0
1937	3	-1	-1	-1	-1	-1	-1	0
1937	4	-1	-1	-1	-1	-1	-1	0

APPENDIX B: MONTHLY IRRIGATION DIVERSIONS  
IN ACRE-FEET  
(-1 Indicates Missing Data)

YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1937	5	-1	-1	-1	-1	-1	-1	0
1937	6	-1	-1	-1	-1	-1	-1	0
1937	7	-1	-1	-1	-1	-1	-1	0
1937	8	-1	-1	-1	-1	-1	-1	0
1937	9	-1	-1	-1	-1	-1	-1	0
1937	10	-1	-1	-1	-1	-1	-1	0
1937	11	-1	-1	-1	-1	-1	-1	0
1937	12	-1	-1	-1	-1	-1	-1	0
1938	1	-1	-1	-1	-1	-1	-1	0
1938	2	-1	-1	-1	-1	-1	-1	0
1938	3	-1	-1	-1	-1	-1	-1	0
1938	4	-1	-1	-1	-1	-1	-1	0
1938	5	-1	-1	-1	-1	-1	-1	0
1938	6	-1	-1	-1	-1	-1	-1	0
1938	7	-1	-1	-1	-1	-1	-1	0
1938	8	-1	-1	-1	-1	-1	-1	0
1938	9	-1	-1	-1	-1	-1	-1	0
1938	10	-1	-1	-1	-1	-1	-1	0
1938	11	0	417	3491	1987	2380	7858	0
1938	12	0	369	1803	3603	1864	7270	0
1939	1	0	21	887	3003	1269	5159	0
1939	2	0	20	920	1973	1924	4817	0
1939	3	0	184	1930	1616	2162	5708	0
1939	4	6867	476	3832	1908	1997	7737	0
1939	5	6870	565	4836	6302	2622	13760	0
1939	6	1309	1110	10376	8653	2773	21802	0
1939	7	5356	1040	9360	8763	3080	21203	0
1939	8	3917	756	7014	6663	2061	15738	0
1939	9	2995	461	2910	3612	1277	7799	0
1939	10	2222	179	5556	3543	1535	10634	0
1939	11	-1	78	-1	-1	-1	-1	0
1939	12	-1	208	-1	-1	-1	-1	0
1940	1	-1	126	-1	-1	-1	-1	0
1940	2	-1	26	-1	-1	-1	-1	0
1940	3	-1	38	-1	-1	-1	-1	0
1940	4	-1	55	-1	-1	-1	-1	0
1940	5	3815	830	5571	12412	1643	19626	0
1940	6	3613	1070	11150	23686	4408	39244	0
1940	7	3202	946	8736	14595	1768	25099	0
1940	8	1576	727	5752	7936	1006	14694	0
1940	9	487	186	278	4428	272	4978	0
1940	10	0	242	726	4497	103	5326	0
1940	11	0	342	1216	1714	100	3030	0
1940	12	0	158	269	1699	90	2058	0
1941	1	0	49	252	2424	28	2704	0
1941	2	0	33	179	2119	0	2297	0



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YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1941	3	0	25	171	2250	0	2420	0
1941	4	5347	113	1163	2984	0	4147	0
1941	5	6545	548	3877	7996	69	11942	0
1941	6	15884	1520	14029	20405	599	35033	0
1941	7	16733	1850	17471	26145	2290	45906	0
1941	8	6527	925	10265	20481	2899	33645	0
1941	9	2381	443	3139	6006	1502	10646	0
1941	10	1577	150	2545	3694	224	6464	0
1941	11	-1	-1	-1	-1	-1	-1	0
1941	12	-1	-1	-1	-1	-1	-1	0
1942	1	-1	-1	-1	-1	-1	-1	0
1942	2	-1	-1	-1	-1	-1	-1	0
1942	3	-1	-1	-1	-1	-1	-1	0
1942	4	-1	-1	-1	-1	-1	-1	0
1942	5	-1	-1	-1	-1	-1	-1	0
1942	6	-1	-1	-1	-1	-1	-1	0
1942	7	-1	-1	-1	-1	-1	-1	0
1942	8	-1	-1	-1	-1	-1	-1	0
1942	9	-1	-1	-1	-1	-1	-1	0
1942	10	-1	-1	-1	-1	-1	-1	0
1942	11	0	154	1111	1190	0	2301	0
1942	12	0	50	746	2238	0	2984	0
1943	1	0	12	349	2768	0	3117	0
1943	2	0	12	139	2500	0	2639	0
1943	3	0	12	147	2768	0	2914	0
1943	4	1359	142	1085	3202	0	4287	0
1943	5	6006	1110	9325	12239	2167	23731	0
1943	6	17441	1610	13749	23157	4089	40995	0
1943	7	16912	1750	17344	24758	4851	46953	0
1943	8	8519	1430	16084	21628	5488	43200	0
1943	9	4777	790	6299	12747	2450	21497	0
1943	10	1087	710	2674	6519	181	9374	0
1943	11	0	329	1163	4811	1990	7964	0
1943	12	0	127	530	5801	556	6886	0
1944	1	0	18	202	0	0	202	0
1944	2	0	18	190	0	0	190	0
1944	3	0	24	351	0	0	351	0
1944	4	0	24	911	7990	0	8900	0
1944	5	9329	780	6390	12047	476	18913	0
1944	6	17146	1430	11712	18844	2903	33458	0
1944	7	17723	1708	19632	22669	5809	48110	0
1944	8	8595	1506	18084	21679	6811	46574	0
1944	9	2732	593	7240	14096	3016	24352	0
1944	10	952	409	3218	6424	665	10307	0
1944	11	0	36	274	0	0	274	0
1944	12	0	31	214	0	0	214	0



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YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1945	1	0	55	56	0	0	56	0
1945	2	0	39	40	0	0	40	0
1945	3	0	37	38	0	0	38	0
1945	4	1260	18	1206	4135	0	5341	0
1945	5	9247	8	7261	9577	1480	18318	0
1945	6	17136	1900	17789	13934	4242	35964	0
1945	7	11706	1340	17967	29526	4900	52393	0
1945	8	9394	1030	29816	24264	4026	58105	0
1945	9	6238	803	9521	8904	2117	20542	0
1945	10	2000	1120	5498	4831	1413	11741	0
1945	11	0	199	198	0	0	198	0
1945	12	0	12	12	0	0	12	0
1946	1	0	0	0	0	0	0	0
1946	2	0	0	0	0	0	0	0
1946	3	0	31	30	0	0	30	0
1946	4	0	155	784	4535	0	5319	0
1946	5	14321	1610	12063	17838	4599	34500	0
1946	6	15066	1620	18880	26907	6039	51826	0
1946	7	14894	1270	19471	30167	7902	57540	0
1946	8	13013	1030	12811	19431	7555	39797	0
1946	9	6722	141	3438	8142	3851	15432	0
1946	10	1434	362	2286	4658	369	7313	0
1946	11	0	131	1381	1994	0	3375	0
1946	12	0	161	478	2458	0	2936	0
1947	1	0	43	44	0	0	44	0
1947	2	0	39	40	0	0	40	0
1947	3	0	40	40	0	0	40	0
1947	4	3284	36	1107	3799	0	4906	0
1947	5	16527	1690	13475	16634	6083	36192	0
1947	6	15469	1490	18652	18947	7025	44624	0
1947	7	12846	1530	21907	22169	6664	50741	0
1947	8	8626	1100	11723	14215	6033	31972	0
1947	9	5333	968	7299	10872	5730	23901	0
1947	10	1210	157	2623	4716	1641	8980	0
1947	11	0	66	65	2581	0	2647	0
1947	12	0	18	18	3412	0	3430	0
1948	1	0	0	0	0	0	0	0
1948	2	0	0	0	0	0	0	0
1948	3	0	0	0	0	0	0	0
1948	4	7845	648	3184	2299	0	5484	0
1948	5	15928	643	5813	8928	2145	16886	0
1948	6	15836	1990	22772	27236	9749	59758	0
1948	7	15213	1750	21217	23520	6682	51419	0
1948	8	12620	1320	16140	20215	4861	41216	0
1948	9	6012	773	6625	17364	5133	29121	0
1948	10	0	210	3776	4202	942	8920	0



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YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1948	11	0	71	964	2032	0	2996	0
1948	12	0	0	186	0	0	186	0
1949	1	0	0	0	0	0	0	0
1949	2	0	0	0	0	0	0	0
1949	3	0	4	4	0	0	4	0
1949	4	3811	891	3438	2950	0	6388	0
1949	5	13434	690	5861	14384	4645	24889	0
1949	6	15961	1370	22149	20074	5873	48096	0
1949	7	10323	1430	20848	18667	5428	44944	0
1949	8	6815	1050	15862	13350	4754	33966	0
1949	9	4101	678	6525	9656	2167	18348	0
1949	10	881	1	3629	4837	708	9174	0
1949	11	0	0	1754	2063	0	3817	0
1949	12	0	0	444	1667	0	2111	0
1950	1	0	0	0	0	0	0	0
1950	2	0	0	0	0	0	0	0
1950	3	0	0	0	0	0	0	0
1950	4	1516	153	361	3293	0	3655	0
1950	5	8513	1210	7267	7373	2676	17316	0
1950	6	12257	1310	16957	15594	6424	38976	0
1950	7	11710	1640	19076	23977	7214	50267	0
1950	8	7027	1520	15789	14164	5444	35397	0
1950	9	3801	794	6146	5567	3657	15370	0
1950	10	1391	83	1909	4371	2103	8382	0
1950	11	0	107	107	3813	0	3920	0
1950	12	0	0	0	0	0	0	0
1951	1	0	0	0	0	0	0	0
1951	2	0	0	0	0	0	0	0
1951	3	0	0	0	0	0	0	0
1951	4	3444	408	2956	4498	0	7454	0
1951	5	10448	1090	10581	16785	4867	32232	0
1951	6	18223	1610	23913	23778	7025	54717	0
1951	7	14356	1960	24371	23157	7464	54993	0
1951	8	9198	1350	17517	15807	4611	37934	0
1951	9	3313	881	7400	9392	4305	21098	0
1951	10	0	558	3194	5754	3063	12011	0
1951	11	0	86	85	0	0	85	0
1951	12	0	31	30	0	0	30	0
1952	1	0	0	0	0	0	0	0
1952	2	0	15	14	0	0	14	0
1952	3	0	42	42	0	0	42	0
1952	4	2321	48	48	3222	0	3270	0
1952	5	15747	530	6678	12890	4710	24278	0
1952	6	18614	1850	24354	29667	8740	62760	0
1952	7	16586	1850	24102	26788	7466	58355	0
1952	8	10478	1820	25855	22463	10122	58441	0



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YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1952	9	3972	558	7333	8154	4815	20302	0
1952	10	0	488	5254	4508	2353	12114	0
1952	11	0	212	1548	2178	940	4666	0
1952	12	0	15	14	0	0	14	0
1953	1	0	4	4	0	0	4	0
1953	2	0	0	0	0	0	0	0
1953	3	0	0	0	0	0	0	0
1953	4	4962	284	1913	1833	476	4222	0
1953	5	16170	565	8865	10319	3119	22302	0
1953	6	21213	1190	17461	22346	7470	47277	0
1953	7	17144	2040	31190	29522	9577	70289	0
1953	8	13402	1320	24191	19290	6966	50447	0
1953	9	7273	879	11700	10505	6339	28544	0
1953	10	3835	459	4857	6908	2700	14465	0
1953	11	0	250	1617	2607	0	4224	0
1953	12	0	36	36	1516	0	1551	0
1954	1	0	0	0	0	0	0	0
1954	2	0	0	0	0	0	0	0
1954	3	0	5	4	0	0	4	0
1954	4	4861	328	3901	2297	0	6198	0
1954	5	12795	712	13763	17900	4664	36327	0
1954	6	18457	1090	14850	15838	5000	35688	0
1954	7	15890	1340	22143	23330	7301	52774	0
1954	8	7986	896	14406	16723	5498	36627	0
1954	9	5212	600	9527	11114	5480	26121	0
1954	10	1421	632	8902	7218	2913	19033	0
1954	11	-1	-1	-1	-1	-1	-1	0
1954	12	-1	-1	-1	-1	-1	-1	0
1955	1	-1	-1	-1	-1	-1	-1	0
1955	2	-1	-1	-1	-1	-1	-1	0
1955	3	-1	-1	-1	-1	-1	-1	0
1955	4	-1	-1	-1	-1	-1	-1	0
1955	5	-1	-1	-1	-1	-1	-1	0
1955	6	-1	-1	-1	-1	-1	-1	0
1955	7	-1	-1	-1	-1	-1	-1	0
1955	8	-1	-1	-1	-1	-1	-1	0
1955	9	-1	-1	-1	-1	-1	-1	0
1955	10	-1	-1	-1	-1	-1	-1	0
1955	11	0	45	1633	1542	506	3680	0
1955	12	0	31	438	1032	0	1470	0
1956	1	0	37	0	0	0	0	0
1956	2	0	42	0	0	0	0	0
1956	3	0	41	0	0	0	0	0
1956	4	2837	283	1730	1286	24	3039	0
1956	5	9361	730	9134	17517	4172	30823	0
1956	6	13414	1660	24179	38551	7476	70206	0



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YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1956	7	12934	1800	23711	26669	8232	58611	0
1956	8	10797	1030	18868	16489	6813	42170	0
1956	9	8416	598	8567	8101	3282	19949	0
1956	10	1538	958	4994	6012	1849	12854	0
1956	11	0	67	1125	2081	12	3218	0
1956	12	0	24	728	1805	0	2534	0
1957	1	0	10	8	1722	0	1730	0
1957	2	0	2	2	1555	0	1557	0
1957	3	0	0	0	1476	0	1476	0
1957	4	0	15	341	1222	0	1563	0
1957	5	11120	26	1954	6472	333	8759	0
1957	6	21036	1460	24840	26754	5123	56717	0
1957	7	13368	1610	25233	25980	8138	59351	0
1957	8	8914	1280	21320	21354	9186	51860	0
1957	9	5617	987	6367	8378	2966	17711	0
1957	10	1518	958	4577	7924	1196	13698	0
1957	11	0	203	2026	3363	278	5666	0
1957	12	0	3	363	1917	0	2280	0
1958	1	0	0	0	1790	0	1790	0
1958	2	0	0	0	2083	0	2083	0
1958	3	0	0	0	2411	0	2411	0
1958	4	0	67	1415	2401	0	3815	0
1958	5	9206	273	8696	-1	3426	-1	0
1958	6	19596	1830	26443	-1	6208	-1	0
1958	7	17820	1570	26473	26538	8617	61627	0
1958	8	8283	1360	23512	20181	7732	51425	0
1958	9	2248	407	9858	13459	4700	28018	0
1958	10	1667	274	5593	13237	1903	20733	0
1958	11	0	12	12	1101	0	1113	0
1958	12	0	8	8	766	0	774	0
1959	1	0	0	0	923	0	923	0
1959	2	0	0	0	833	0	833	0
1959	3	0	0	0	1821	0	1821	0
1959	4	0	609	609	1821	0	2430	0
1959	5	6863	565	8049	8618	2813	19481	0
1959	6	7898	1230	15430	21977	6037	43444	0
1959	7	9289	1150	11033	14771	3738	29542	0
1959	8	6283	1030	7708	8301	2879	18888	0
1959	9	1924	420	6174	6166	2131	14471	0
1959	10	0	105	1805	3787	1143	6736	0
1959	11	0	74	1266	833	119	2218	0
1959	12	0	31	817	655	0	1472	0
1960	1	0	31	0	436	0	436	-1
1960	2	0	15	0	357	0	357	-1
1960	3	0	0	893	476	60	1428	-1
1960	4	0	203	823	1298	536	2657	-1



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IN ACRE-FEET  
(-1 Indicates Missing Data)

YEAR	CLNDR MO.	ABOVE MACKAY RESERV	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1960	5	8839	360	4994	6138	1585	12717	-1
1960	6	10029	1050	14340	19689	5260	39289	-1
1960	7	10186	884	9511	13182	3315	26008	-1
1960	8	4952	673	2869	4738	1272	8878	-1
1960	9	2067	541	3601	3303	746	7650	-1
1960	10	0	192	1756	1623	208	3587	-1
1960	11	0	149	833	238	0	1071	-1
1960	12	0	96	0	0	0	0	-1
1961	1	0	0	0	0	0	0	-1
1961	2	0	0	0	0	0	0	-1
1961	3	0	9	377	258	0	635	-1
1961	4	0	290	724	960	0	1684	-1
1961	5	6502	130	3252	3357	157	6765	-1
1961	6	10251	887	10686	15360	3708	29754	-1
1961	7	8119	755	7220	7311	982	15513	-1
1961	8	4220	356	3192	1815	171	5178	-1
1961	9	813	320	1502	1440	101	3043	-1
1961	10	0	564	1585	387	83	2055	-1
1961	11	0	169	1230	714	0	1944	-1
1961	12	0	55	833	556	0	1389	-1
1962	1	0	0	0	0	0	0	-1
1962	2	0	0	0	0	0	0	-1
1962	3	0	0	913	214	62	1188	-1
1962	4	0	218	972	1349	60	2381	-1
1962	5	12295	176	5379	8311	1960	15650	-1
1962	6	13862	1220	13541	20890	2335	36766	-1
1962	7	18818	1290	14243	16902	776	31921	-1
1962	8	13660	999	11731	11821	175	23727	-1
1962	9	1641	473	4309	4518	99	8926	-1
1962	10	409	716	2478	2113	0	4591	-1
1962	11	0	184	2276	1210	0	3486	-1
1962	12	0	26	552	107	0	659	-1
1963	1	0	20	20	0	0	20	-1
1963	2	0	18	18	0	0	18	-1
1963	3	0	18	593	0	0	593	-1
1963	4	962	24	1750	2833	0	4583	-1
1963	5	10936	652	6573	8464	0	15037	-1
1963	6	15164	1034	19898	26820	1212	47929	-1
1963	7	13577	1372	24875	34512	960	60347	-1
1963	8	8414	1042	12908	20163	972	34043	-1
1963	9	3518	450	5305	8999	938	15243	-1
1963	10	393	166	9299	8309	540	18148	-1
1963	11	0	185	3262	2520	0	5781	-1
1963	12	0	21	468	95	0	563	-1
1964	1	0	0	0	0	0	0	-1
1964	2	0	0	0	0	0	0	-1



APPENDIX B: MONTHLY IRRIGATION DIVERSIONS  
IN ACRE-FEET  
(-1 Indicates Missing Data)

YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1964	3	0	0	0	280	0	280	-1
1964	4	0	104	3377	9164	0	12541	-1
1964	5	8545	665	15382	15346	71	30800	-1
1964	6	16233	1470	26153	25613	5877	57643	-1
1964	7	14967	1830	32440	25401	5454	63296	-1
1964	8	6297	1610	23671	18981	5922	48574	-1
1964	9	1726	458	10410	8303	3706	22419	-1
1964	10	0	712	6339	7382	0	13721	-1
1964	11	0	234	3135	2758	0	5892	-1
1964	12	0	15	69	0	0	69	-1
1965	1	0	0	0	0	0	0	-1
1965	2	0	0	0	0	0	0	-1
1965	3	0	0	436	0	0	436	-1
1965	4	0	78	5486	6543	476	12505	-1
1965	5	11277	271	10523	17241	1222	28986	-1
1965	6	16564	1058	28476	32980	7801	69257	-1
1965	7	17130	868	23102	33365	8240	64706	-1
1965	8	9890	874	23276	32238	8045	63559	-1
1965	9	0	224	8488	11783	5077	25348	-1
1965	10	0	133	2482	5059	3809	11350	-1
1965	11	0	229	3688	2418	0	6107	-1
1965	12	0	8	0	0	0	0	-1
1966	1	0	0	0	0	0	0	-1
1966	2	0	0	0	0	0	0	-1
1966	3	0	0	952	1270	635	2857	-1
1966	4	0	431	4226	4226	1825	10277	-1
1966	5	11854	1030	16412	15684	1617	33712	-1
1966	6	9359	1090	21195	18513	5339	45047	-1
1966	7	12817	1230	14237	16908	3589	34734	-1
1966	8	6017	973	10337	9180	3700	23217	-1
1966	9	0	432	5006	6049	1976	13031	-1
1966	10	0	263	4206	3381	48	7634	-1
1966	11	-1	84	-1	-1	-1	3958	-1
1966	12	-1	0	-1	-1	-1	698	-1
1967	1	-1	0	-1	-1	-1	0	-1
1967	2	-1	0	-1	-1	-1	0	-1
1967	3	-1	4	-1	-1	-1	1359	-1
1967	4	-1	60	-1	-1	-1	5593	-1
1967	5	-1	561	-1	-1	-1	34603	-1
1967	6	-1	1290	-1	-1	-1	49993	-1
1967	7	-1	1540	-1	-1	-1	50211	-1
1967	8	-1	2150	-1	-1	-1	50219	-1
1967	9	-1	809	-1	-1	-1	25854	-1
1967	10	-1	373	-1	-1	-1	12148	-1
1967	11	0	242	1468	1032	0	2500	-1
1967	12	0	1	0	0	0	0	-1



APPENDIX B: MONTHLY IRRIGATION DIVERSIONS  
IN ACRE-FEET  
(-1 Indicates Missing Data)

YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1968	1	0	0	0	0	0	0	-1
1968	2	0	0	0	0	0	0	-1
1968	3	0	0	532	1426	0	1958	-1
1968	4	0	235	1930	3234	60	5224	-1
1968	5	14549	598	7585	11620	3928	23133	-1
1968	6	19622	1750	27554	22024	6886	56465	-1
1968	7	14203	1400	19907	19175	7240	46322	-1
1968	8	7333	621	12757	9817	5700	28274	-1
1968	9	1807	589	7317	5827	3760	16904	-1
1968	10	0	729	3014	3718	1161	7892	-1
1968	11	0	514	1212	2258	0	3470	-1
1968	12	0	0	0	1171	0	1171	-1
1969	1	0	0	0	1206	0	1206	-1
1969	2	0	0	0	1111	0	1111	-1
1969	3	0	0	113	1718	0	1831	-1
1969	4	2262	16	1208	3881	0	5089	-1
1969	5	10981	1350	18336	22826	4855	46017	-1
1969	6	14882	1700	29149	25855	5672	60677	-1
1969	7	14005	1330	22199	27798	7912	57909	-1
1969	8	7117	1930	29220	27018	6269	62508	-1
1969	9	5341	564	10091	16023	2799	28913	-1
1969	10	2222	220	3978	10624	2470	17072	-1
1969	11	0	0	0	2698	0	2698	-1
1969	12	0	0	0	1845	0	1845	-1
1970	1	0	0	0	1845	0	1845	-1
1970	2	0	0	0	1667	0	1667	-1
1970	3	0	0	139	2214	0	2353	-1
1970	4	3397	0	1256	3484	0	4740	-1
1970	5	25812	239	10273	24086	222	34581	-1
1970	6	31244	660	21806	40087	536	62429	-1
1970	7	33411	473	27407	30919	587	58913	-1
1970	8	22641	736	28968	24899	788	54655	-1
1970	9	13590	345	12198	12533	337	25068	-1
1970	10	-1	470	-1	-1	-1	-1	-1
1970	11	-1	-1	-1	-1	-1	-1	-1
1970	12	-1	-1	-1	-1	-1	-1	-1
1971	1	-1	-1	-1	-1	-1	-1	-1
1971	2	-1	-1	-1	-1	-1	-1	-1
1971	3	-1	-1	-1	-1	-1	-1	-1
1971	4	-1	-1	-1	-1	-1	-1	-1
1971	5	-1	-1	-1	-1	-1	-1	-1
1971	6	-1	-1	-1	-1	-1	-1	-1
1971	7	-1	-1	-1	-1	-1	-1	-1
1971	8	-1	-1	-1	-1	-1	-1	-1
1971	9	-1	-1	-1	-1	-1	-1	-1
1971	10	-1	-1	-1	-1	-1	-1	-1



APPENDIX B: MONTHLY IRRIGATION DIVERSIONS  
IN ACRE-FEET  
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YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1971	11	0	0	0	0	0	0	-1
1971	12	0	0	0	0	0	0	-1
1972	1	0	0	0	0	0	0	0
1972	2	0	0	0	0	0	0	0
1972	3	0	0	0	0	0	0	0
1972	4	0	0	0	0	0	0	0
1972	5	13077	790	13582	15729	2815	32127	412
1972	6	20001	1482	24135	21596	4291	50023	286
1972	7	19237	1220	19636	18921	3821	42378	410
1972	8	12338	1118	14842	11969	2462	29274	373
1972	9	12285	80	6634	3472	317	10424	21
1972	10	0	104	2639	1173	0	3811	0
1972	11	0	0	0	0	0	0	-1
1972	12	0	0	0	0	0	0	-1
1973	1	0	0	0	0	0	0	-1
1973	2	0	0	0	0	0	0	-1
1973	3	0	0	0	0	0	0	-1
1973	4	0	0	0	0	0	0	-1
1973	5	10906	815	13263	10638	5059	28960	-1
1973	6	20146	938	20239	15987	12005	48231	-1
1973	7	17066	388	13606	14303	8789	36698	-1
1973	8	15642	642	15727	14920	9480	40126	-1
1973	9	13892	364	5734	4535	4285	14555	-1
1973	10	0	214	3438	2353	708	6500	-1
1973	11	0	0	0	0	0	0	-1
1973	12	0	0	0	0	0	0	-1
1974	1	0	0	0	0	0	0	-1
1974	2	0	0	0	0	0	0	-1
1974	3	0	0	0	0	0	0	-1
1974	4	0	0	0	0	0	0	-1
1974	5	11025	1242	20100	16261	4621	40982	-1
1974	6	16808	1646	25830	25475	7601	58905	-1
1974	7	16406	1524	23782	20513	5996	50290	-1
1974	8	11259	1118	21497	19090	6492	47078	-1
1974	9	9730	392	8886	7464	2284	18634	-1
1974	10	0	326	4938	1792	837	7567	-1
1974	11	0	0	0	0	0	0	0
1974	12	0	0	0	0	0	0	0
1975	1	0	0	0	0	0	0	0
1975	2	0	0	0	0	0	0	0
1975	3	0	0	0	0	0	0	0
1975	4	0	0	0	0	0	0	0
1975	5	0	150	2000	2450	109	4559	22
1975	6	20380	1548	27982	19400	6634	54016	307
1975	7	22040	1114	23364	17824	6490	47678	7175
1975	8	15852	1462	26639	24163	8878	59681	983



APPENDIX B: MONTHLY IRRIGATION DIVERSIONS  
IN ACRE-FEET  
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YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1975	9	13803	802	14315	6297	3176	23788	153
1975	10	0	502	5710	2992	234	8936	0
1975	11	0	0	0	0	0	0	0
1975	12	0	0	0	0	0	0	0
1976	1	0	0	0	0	0	0	0
1976	2	0	0	0	0	0	0	0
1976	3	0	0	0	0	0	0	0
1976	4	0	0	0	0	0	0	0
1976	5	8418	848	14898	11045	3137	29079	520
1976	6	17324	1308	29579	27728	10009	67317	2340
1976	7	17898	990	17473	17497	7438	42408	3640
1976	8	15814	788	16739	11146	6160	34045	2568
1976	9	11126	610	8063	3978	1673	13713	366
1976	10	0	180	1823	1551	42	3416	0
1976	11	0	0	0	0	0	0	0
1976	12	0	0	0	0	0	0	0
1977	1	0	0	0	0	0	0	0
1977	2	0	0	0	0	0	0	0
1977	3	0	0	0	0	0	0	0
1977	4	1815	0	0	0	0	0	0
1977	5	10618	270	2740	2274	1454	6468	1358
1977	6	17215	622	9355	10894	5049	25298	2649
1977	7	17168	746	13404	14428	5420	33252	3329
1977	8	17753	722	12585	9495	4732	26812	3561
1977	9	10884	352	4450	2577	1593	8620	1439
1977	10	0	276	1165	1591	282	3038	34
1977	11	0	0	0	0	0	0	0
1977	12	0	0	0	0	0	0	0
1978	1	0	0	0	0	0	0	0
1978	2	0	0	0	0	0	0	0
1978	3	0	0	0	0	0	0	0
1978	4	0	0	0	0	0	0	0
1978	5	6428	362	3172	4212	54	7438	32
1978	6	16219	846	19735	23522	7474	50731	1930
1978	7	17973	794	19778	20179	8017	47975	2153
1978	8	13108	868	16344	15610	7073	39027	2194
1978	9	1173	602	3282	2119	984	6385	551
1978	10	0	238	883	1240	101	2224	47
1978	11	0	0	0	0	0	0	0
1978	12	0	0	0	0	0	0	0
1979	1	0	0	0	0	0	0	0
1979	2	0	0	0	0	0	0	0
1979	3	0	0	0	0	0	0	0
1979	4	0	0	0	0	0	0	600
1979	5	5198	626	6988	6809	1202	14999	660
1979	6	17019	938	19215	17332	8200	44747	3237



APPENDIX B: MONTHLY IRRIGATION DIVERSIONS  
IN ACRE-FEET  
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YEAR	CLNDR MO.	ABOVE MACKAY RESERVVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1979	7	12579	516	12096	16285	6728	35109	5384
1979	8	9575	432	7121	5738	5041	17900	4717
1979	9	6206	604	4543	2823	2430	9797	1504
1979	10	0	176	1516	1173	0	2688	189
1979	11	0	0	0	0	0	0	0
1979	12	0	0	0	0	0	0	0
1980	1	0	0	0	0	0	0	0
1980	2	0	0	0	0	0	0	0
1980	3	0	0	0	0	0	0	0
1980	4	0	0	0	0	0	0	0
1980	5	0	626	7789	7450	1480	16719	130
1980	6	17039	1348	18548	19517	5359	43424	1370
1980	7	17675	1264	22257	25131	7537	54925	1700
1980	8	9597	944	15140	14291	5801	35232	2924
1980	9	4426	102	1319	2008	958	4285	805
1980	10	0	400	1762	1482	188	3432	157
1980	11	0	0	0	0	0	0	0
1980	12	0	0	0	0	0	0	0
1981	1	0	0	0	0	0	0	0
1981	2	0	0	0	0	0	0	0
1981	3	0	0	0	0	0	0	0
1981	4	0	0	0	0	0	0	0
1981	5	0	1134	7172	7565	1968	16705	108
1981	6	17515	1852	20937	21199	5260	47396	775
1981	7	17636	1034	17556	21078	7375	46009	3581
1981	8	9644	884	12045	11712	6956	30712	4525
1981	9	4424	366	3799	5043	3293	12136	2645
1981	10	0	168	1073	1210	272	2555	309
1981	11	0	0	0	0	0	0	0
1981	12	0	0	0	0	0	0	0
1982	1	0	0	0	0	0	0	0
1982	2	0	0	0	0	0	0	0
1982	3	0	0	0	0	0	0	0
1982	4	0	0	0	0	0	0	0
1982	5	0	198	4065	4988	758	9811	0
1982	6	15850	1224	14699	16961	5857	37517	0
1982	7	16392	1244	14279	17318	6069	37666	0
1982	8	15850	1278	17753	16057	6051	39861	452
1982	9	4750	1174	8337	5387	2343	16066	206
1982	10	0	322	1617	389	28	2034	112
1982	11	0	0	0	0	0	0	0
1982	12	0	0	0	0	0	0	0
1983	1	0	0	0	0	0	0	0
1983	2	0	0	0	0	0	0	0
1983	3	0	0	0	0	0	0	0
1983	4	0	0	0	0	0	0	0



APPENDIX B: MONTHLY IRRIGATION DIVERSIONS  
IN ACRE-FEET  
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YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1983	5	0	752	3676	3105	694	7476	25
1983	6	15850	1223	16437	13858	4686	34982	110
1983	7	16392	831	13797	10692	5769	30258	138
1983	8	15850	1216	13055	15021	3637	31712	68
1983	9	4750	739	5416	3732	1448	10597	0
1983	10	0	28	113	552	0	665	0
1983	11	0	0	0	0	0	0	0
1983	12	0	0	0	0	0	0	0
1984	1	0	0	0	0	0	0	0
1984	2	0	0	0	0	0	0	0
1984	3	0	0	0	0	0	0	0
1984	4	0	0	0	0	0	0	0
1984	5	0	174	3853	4893	673	9418	0
1984	6	15850	1336	17352	13457	2694	33504	0
1984	7	16392	1302	18840	18693	4301	41835	60
1984	8	15850	760	12501	8430	3204	24135	42
1984	9	4750	360	4305	2292	956	7553	0
1984	10	0	60	1353	311	95	1760	0
1984	11	0	0	0	0	0	0	0
1984	12	0	0	0	0	0	0	0
1985	1	0	0	0	0	0	0	0
1985	2	0	0	0	0	0	0	0
1985	3	0	0	0	0	0	0	0
1985	4	0	0	0	0	0	0	0
1985	5	0	868	7424	10212	2734	20370	1900
1985	6	9845	820	14239	22245	7874	44358	4975
1985	7	10025	710	11797	18860	8466	39122	5985
1985	8	10025	958	14789	9307	5777	29873	3660
1985	9	3508	156	1653	962	1020	3635	581
1985	10	0	0	0	0	0	0	0
1985	11	0	0	0	0	0	0	0
1985	12	0	0	0	0	0	0	0
1986	1	0	0	0	0	0	0	0
1986	2	0	0	0	0	0	0	0
1986	3	0	0	0	0	0	0	0
1986	4	0	0	0	0	0	0	0
1986	5	4843	234	4700	6236	2295	13231	27
1986	6	15729	1642	18029	18995	7377	44400	474
1986	7	13416	804	15124	19659	7002	41785	2987
1986	8	11077	716	13211	10942	4885	29038	2291
1986	9	3787	452	2379	1270	1123	4772	0
1986	10	0	0	0	0	0	0	0
1986	11	0	0	0	0	0	0	0
1986	12	0	0	0	0	0	0	0
1987	1	0	0	0	0	0	0	0
1987	2	0	0	0	0	0	0	0



APPENDIX B: MONTHLY IRRIGATION DIVERSIONS  
IN ACRE-FEET  
(-1 Indicates Missing Data)

YEAR	CLNDR MO.	ABOVE MACKAY RESERVR	SHARP DITCH	MACKAY DAM TO BLAINE DIVRSN	BLAINE TO ARCO DIVRSN	BELOW ARCO DIVRSN	TOTAL DIVRSN BELOW DAM	PUMPAGE INTO RIVER
1987	3	0	0	0	0	0	0	0
1987	4	0	0	0	0	0	0	0
1987	5	12888	276	7079	3488	7902	18469	1299
1987	6	15828	612	11202	4375	12523	28099	2715
1987	7	14688	312	7605	4900	10003	22508	2872
1987	8	8317	746	9755	4726	8680	23161	2057
1987	9	6307	462	4331	1674	4402	10408	1220
1987	10	0	90	1260	480	2472	4212	452
1987	11	0	0	0	0	0	0	0
1987	12	0	0	0	0	0	0	0
1988	1	0	0	0	0	0	0	0
1988	2	0	0	0	0	0	0	0
1988	3	0	0	0	0	0	0	0
1988	4	0	0	0	0	0	0	0
1988	5	1819	242	2726	2867	1504	7097	1347
1988	6	13362	788	9654	13059	5803	28516	3935
1988	7	8833	576	8285	11354	9696	29335	4742
1988	8	3242	562	4603	2875	3916	11394	2489
1988	9	4198	434	1950	1345	1367	4662	1216
1988	10	0	192	589	623	216	1428	242
1988	11	0	0	0	0	0	0	0
1988	12	0	0	0	0	0	0	0
1989	1	0	0	0	0	0	0	0
1989	2	0	0	0	0	0	0	0
1989	3	0	0	0	0	0	0	0
1989	4	0	0	0	0	0	0	0
1989	5	6325	102	2857	3162	1932	7952	1387
1989	6	12271	265	8617	10081	5559	24256	3449
1989	7	11410	386	7674	9940	3474	21088	7486
1989	8	7795	213	4688	4563	2545	11797	3128
1989	9	0	70	879	36	0	915	0
1989	10	0	0	0	0	0	0	0
1989	11	0	0	0	0	0	0	0
1989	12	0	0	0	0	0	0	0
1990	1	0	0	0	0	0	0	0
1990	2	0	0	0	0	0	0	0
1990	3	0	0	0	0	0	0	0
1990	4	0	0	0	0	0	0	0
1990	5	7273	110	1813	2782	484	5079	772
1990	6	15727	176	3184	4387	1107	8678	878
1990	7	14914	966	7970	10944	3361	22274	2632
1990	8	9249	688	5894	7928	3254	17076	2709
1990	9	4906	166	1073	365	665	2103	60
1990	10	0	0	0	0	0	0	0
1990	11	0	0	0	0	0	0	0
1990	12	0	0	0	0	0	0	0